Scientia Canadensis
Canadian Journal of the History of Science, Technology and Medicine
Revue canadienne d'histoire des sciences, des techniques et de la médecine

A First Step in Comparative History: The Royal Australian and Canadian Navies and High Technology in the Second World War

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Volume 17, Number 1-2, 1993

Dominions Apart: Reflections on the Culture of Science and Technology in Canada and Australia 1850-1945

URI: https://id.erudit.org/iderudit/800370ar
DOI: https://doi.org/10.7202/800370ar

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Publisher(s)

CSTHA/AHSTC

ISSN

0829-2507 (print)
1918-7750 (digital)

Explore this journal

Cite this article

Zimmerman, D. (1993). A First Step in Comparative History: The Royal Australian and Canadian Navies and High Technology in the Second World War. *Scientia Canadensis*, *17*(1-2), 255–267. https://doi.org/10.7202/800370ar

A First Step in Comparative History: The Royal Australian and Canadian Navies and High Technology in the Second World War[1]

David Zimmerman

On the 13 July 1941 Professor J. Madsen, Professor of Physics at the University of Sydney and member of the Australian Scientific Research Liaison Office in London, wrote to C.S. Wright, the Director of Scientific Research at the Admiralty, asking that 271 radar sets and magnetrons be made available to the Royal Australian Navy. The 271 was the first radar to use the magnetron, and was, therefore, the earliest mass-produced radar to operate at centimetric wavelengths. It was far superior to existing long-wave radar equipment in the detection of submarines and other small surface craft. The prototype 271 was tested on board HMS *Orchis* in May and June, 1941. Eight days after Madsen's request Wright informed the Director of Signals that the Australian request was to be given the highest priority. Within a few weeks a 271 set was on its way to Australia, with more to follow.[2]

The RAN was the first Allied navy to request the new generation set because the Australian Scientific Research Liaison Office had watched developments closely since it was formed in December 1940. Not coincidentally it was also in December that the Australian Radio Physics Advisory Board of the Council for Scientific and Industrial Research was informed of the existence of the magnetron. The board quickly sent Dr. J.L. Pawsey to the Radiation Laboratory at the Massachusetts Institute of Technology to investigate microwave technology. Pawsey, a research physicist with over five years of prewar industrial laboratory experience, was an expert in electronic production methods. On Pawsey's return to Australia in October 1941, he was able to use his knowledge and a sample 271 to design the A271A microwave radar, which was first tested at South Head, Sydney, in July 1942. Within a year of this date 60 of these sets were in service in the RAN making up the principal surface-search sets of the navy's growing fleet of Bathurst or AMS class escort vessels.[3]

1 This paper was previously published in the collection, *Refelections on the Royal Australian Navy*, edited by T.R. Frame, J.V.P. Goldrick, and P.D. Jones (Sydney: Kangaroo Press, 1991), 206-19. It is re-published here with the kind permission of the editors.

2 Madsen to Wright, 13/8/41; DSR to DSD, 22/8/41, PRO ADM 220/78; Type 271 Trials on HMS Orchis 5/5/41; Commander HMS *Orchis*, Results Obtained with Type 271, 3/6/41, PRO Adm 1/11063; D.P. Mellor, *The Role of Science and Industry* (Canberra: Australian War Memorial, 1958), 446.

3 Mellor, 428, 446-8.

In comparison to this swift and competent technological transfer the account of the Royal Canadian Navy's initial effort to obtain a 271 and produce their own microwave radar reads like a Gilbert and Sullivan comic opera. Although the Canadians had been aware of the potential of microwave radar as early as August 1940, when they were briefed by Sir Henry Tizard during his visit as part of the British Technical Mission, and in fact were building magnetrons and designing an anti-aircraft set for the army, the GLC Mark III, they were caught by surprise by the Royal Navy's rapid development and introduction into service of the 271. The Canadians were unaware of the development of the 271 until well after the testing on the *Orchis* was completed. In fact at the same time the 271 was undergoing trials the RCN tested and ordered into production an obsolete long-wave (1.5 metre) surface search set, the SW1C.

It was not until September 1941 that the RCN agreed to begin development of a Canadian ten centimetre set based on the British radar. Although a 271 was ordered in a similar fashion to the Australian request of two months earlier, the inexperienced Canadian scientific liaison officer, Dr. H.E. Howlett, failed to ensure that a set was actually dispatched. Once the Admiralty approved the request Howlett, who had only arrived in London in August, assumed that the British would arrange for the shipment of the set. Only in late October Howlett learned that the radar had been sitting in a warehouse waiting for the Canadians to ship the set. By the time the 271 finally arrived in Ottawa in January 1942 scientists at the Canadian National Research Council had already finished design on the ill-fated RX/C naval microwave radar and refused to adopt "inferior" British technology. After a lengthy development process the RX/C entered operational service in late 1943, intended to be the primary radar on Canada's River class frigates. Six months later the RX/C was withdrawn from service because of critical design and production problems and was scrapped in favour of the American SU set.[4]

As a result of this failure to provide timely supplies of centimetre radar Canadian escort vessels were forced to go to sea at the height of the Battle of the Atlantic with obsolete equipment that was incapable of detecting surfaced U-Boats. This equipment gap, which was not simply confined to radar but included difficulties in supplying up-to-date sonar and high frequency direction finding sets, resulted in the two great crisis of the RCN's wartime experience: the removal of the RCN's mid-ocean escort groups from the North Atlantic in the first four months of 1943, the critical moment in the Battle of the Atlantic; and the dismissal of the Chief of Naval Staff, Admiral Percy Nelles, by the naval minister, Angus Macdonald in January 1944. These events have now been carefully examined by a variety of Canadian naval historians.[5]

4 David Zimmerman, *The Great Naval Battle of Ottawa* (Toronto: University of Toronto Press, 1989), 74-77, 111-123.

5 See Zimmerman; Marc Milner, *North Atlantic Run* (Toronto: University of Toronto Press,

The question that needs to be explored then is why was the experience of the RAN and RCN with high technology was so different, particularly in consideration of the remarkable similarities in the types of problems and resources to solve them?

The paper that follows is not intended to be definitive on the Australian experience with advanced technology naval equipment acquisition during the Second World War but is based on the assumption that the RAN did not have an experience similar to the RCN's "equipment crisis". Instead it is intended that this work provide a model based on the conclusions of Canadian naval historians from which scholars with better access to Australian archival material can evaluate the RAN's experience with radar, sonar, and other equipment. The author has not had the opportunity to base this work on research on Australian documentation but instead on documentation found at the Public Records Office and from secondary literature.

Basing an argument on such shaky foundations is very risky business particularly since the main body of secondary literature on the RAN is still contained in official histories, a genre that the current generation of Canadian naval historians have come to greatly mistrust. Australians, however, have been better served than Canadians by their official historians concerning the naval war. G.H. Gill's strictly operational histories of the RAN are of little use in examining equipment supply but there is an excellent but lessor known work that provides a wealth of information on the subject—D.P. Mellor's, *The Role of Science and Industry*.[6]

Mellor's work, while by no means infallible, is the best official history of science and high technology industry's role in the war effort available from any of the Commonwealth countries. It is unique its breath and depth of analysis far better than J.N. Kennedy's *History of (Canada's) Department of Munitions and Supply*, and the various official and semi-official histories of the Canadian National Research Council.[7] Mellor's work is only equalled in its scope by some of the American official scientific histories and by much

1986); Michael Hadley, *U-Boats Against Canada* (Montreal: McGill-Queen's University Press, 1986); W.A.B. Douglas, *The RCN in Transition* (Vancouver: University of British Columbia Press, 1988).

6 D.P. Mellor, *The Role of Science and Industry*,(Canberra: The Australian War Memorial, 1958). Unfortunately this work has not been re-issued along with the operational histories, an over-sight I trust the War Memorial will soon correct. G.H. Gill, *Royal Australian Navy, 1939-1945*, two volumes, (Canberra: Australian War Memorial, 1957-1968).

7 J.N. Kennedy, *A History of the Department of Munitions and Supply*, 2 vols. (Ottawa: King's Printer, 1950). See for instance *The War History of the Radio Branch*, (Ottawa: NRC, n.d.), W.E.K. Middleton's, *Radar Development in Canada: The Radio Branch of the National Research Council of Canada, 1939-1946* (Waterloo: Wilfrid Laurier University Press, 1981).

later works by academic historians.[8] It is from Mellor's firm foundation that the conclusion can be drawn that there was no 'equipment crisis' in the RAN.

The Prewar Period

One lesson from the Canadian experience is that the availability of resources in peacetime will often determine how successful a country is able to provide the material needed for defence in wartime. Superficially there appears to be a remarkably analogous situation of the two navies in the prewar period. Both the RAN and RCN were comparatively small services, closely tied to the Royal Navy and were, prior to the war, dependent on the Admiralty for almost all of their advanced technology equipment. The navies would undertake major wartime expansion, building indigenously a large number of small anti-submarine escort vessels such as the AMS minesweepers and Flower class corvettes. Each would find that the Admiralty could not supply all of the electronic detection systems needed to make these ships effective anti-submarine warfare platforms. This would force them to turn to domestic manufacturers and scientific institutions to design, develop and build independent designs or adapt British technology to local industrial standards.

Australia and Canada had a limited but well established industrial infrastructure that was mainly unfamiliar with manufacturing sophisticated equipment to rigorous military specifications. It would take some major restructuring to permit the mass production of the equipment needed by the navies.

The scientific community in the two countries was relatively small, with a few first class universities and comparatively large federal government research organizations, the Australian Council for Scientific and Industrial Research and the Canadian National Research Council. Neither institution had a great deal of experience with military weapons systems development but would be called on to supervise the research and design phases of most of the high technology projects undertaken to supply the naval services.

However, this superficial comparison does not provide a complete picture. While both navies were small in relation to the RN, the RAN was far larger than the RCN, the former having around 10,000 all ranks in its regular and reserves while the later had less than 3,500. But raw numbers are not the only measure. The RAN had far more technically trained officers than did the Canadian navy. The RAN had successfully supervised several complex naval shipbuilding programs, including the building of the seaplane carrier *Albatross* and four sloops while the RCNs experience had been confined to supervising the construction of four small Fundy class minesweepers. Prior to 1940 there

8 The American official histories include, Irvin Stewart, *Organizing Scientific Research for War* (Boston: Little Brown and Company, 1948) and Henry E. Guerlac, *Radar in World War II* two volumes (New York: American Institute of Physics, 1987).

were only two officers in the RCN with asdic training, and they had undertaken just the short or basic course in the late 1920s and had not worked with the equipment since.

Canadian industry, much larger and more diverse than Australia's, should have been more capable of supplying the equipment required for anti-submarine operations. In fact, while overall Canadian industrial production was far more significant to the Allied war effort than was Australia's, it was less capable in meeting the naval requirements for high technology equipment. This in large measure was the result of different defence industry priorities in the late 1930s. After the 1936 Imperial Conference both countries received educational contracts to establish an imperial armament industry reserve. Canadian orders were confined to equipment for the army and air force, the only naval contract being for the Fundy class minesweepers. Australian orders included an educational contract to establish mine production, as well as the significant industrial spin-offs from naval shipbuilding.

The *Albatross* and the sloops where built to naval specifications and several Australian companies had to learn how to manufacture components to these rigorous standards.[9] Before 1939 Canadian industry was not called on to learn how to manufacture to the Admiralty specifications and found it very difficult to learn under the pressures of wartime expansion.

There were also crucial structural weaknesses that hindered the ability of Canadian manufacturers to provide technically complex military hardware. During the war Canadian industry excelled in the mass production of basic military equipment, building far more small escort vessels built to mercantile standards than Australia. But Canadian industry was, paradoxically, less capable of producing more sophisticated equipment because of its close affiliation with American manufacturing which had provided the techniques of mass production. Much of Canadian industry was owned by Americans and was heavily reliant on American industrial practices and standards. Since the RCN used British designed equipment Canadian manufactures often had to adapt the plans to American industrial standards. This was a problem particularly with electrical equipment such as radar where entire subsystems had to be redesigned to produce similar performance to the original using different components. To compound the difficulty, Canadian industry had little industrial research and development capacity, most plants being manufacturing units only, branch-plants of their American parents, with limited engineering capability. There were few Canadians with the expertise of J.L. Pawsey and as a result Canadian industry was far less capable of independent development and indigenous adaptation than their Australian counterparts.[10]

9 Mellor, 454.

10 "History of the British Admiralty Technical Mission", unpublished monograph, PRO CAB 102/116, 110.

Wartime Expansion

While peacetime structural problems created a situation where the 'equipment crisis' could occur in the RCN there were also elements in the Australian prewar situation, such as a generally smaller industrial base and fewer scientists, that could have led the RAN into a similar predicament. Wartime events were the deciding factors in determining that the RCN, and not the RAN, experienced a major shortfall in modern equipment.

Both the RCN and the RAN went through a rapid wartime expansion but the former was in both relative and absolute terms far greater. The RAN grew from around 10,000 to just under 40,000 all ranks while the RCN increased from a mere 3,500 to slightly less than 100,000. With a smaller pool of talent to drew from and with far greater dilution of talent the RCN was much less capable of handling sophisticated weapons systems than the RAN. This problem was compounded by a poor utilization of scarce trained regular service personnel by the RCN, far too many of which served on destroyers rather than the smaller corvettes and minesweepers. There was also a lack of exchange of information between operational and staff officers which greatly hindered naval service headquarters appreciation of the growing equipment problems.[11]

The far larger growth in RCN personnel was also matched by a much greater increase in the number of warships requiring high technology weapon systems.

Liaison with the British

One of the fundamental factors in causing the RCNs equipment crisis was the failure to establish adequate technical liaison with the British. Almost a complete technical dependency and geographical isolation from the United Kingdom demanded excellent channels of communications be established with the Admiralty and British scientific and technical experts. The need was extenuated by the inability of the Admiralty to supply the rapidly growing Commonwealth navies with enough equipment. The acute shortage of scientific and engineering personnel available to the Admiralty and British industrial practices which inhibited the availability of blueprints and written specifications made it essential that the Commonwealth navies take the lead in establishing liaison channels.

Both navies were closely linked to the RN in the prewar period, holding joint training exercises, and sending its personnel to the United Kingdom for technical and staff training. But the RAN remained far closer to its parent service, in fact RN officers retaining senior command until after the end of the war. The Canadian government, always leery of imperial entanglements,

11 Preliminary finding from a computer study of the RCN naval lists currently underway at the University of Victoria.

demanded that Canadians run the RCN, and strictly limited integration with the RN. Only one position in the Canadian naval staff, the Director of Naval Intelligence, was normally held by an RN officers. While it has been stated that the British officers who held command in the RAN were not always of the highest calibre they were at least familiar with the complexities of running a large naval force and with the Admiralty bureaucracy.

This greatly assisted the RAN in following the latest developments in equipment. As a result the RAN was often, is in the case of the 271 radar, the first Commonwealth navy to order Admiralty equipment into service. This compares favourably with Canadian naval leadership which proved unable to keep pace with the rapid growth and with rapid evolution of weapon system technology, and failed until late 1943 to establish adequate technical liaison with the RN.

The RAN was also better served by its scientists than the RCN. The Council for Scientific and Industrial Research established the Australian Scientific Liaison Office in London in early 1940, under the leadership G.H. Munro.[12] The opening of NRC's liaison office did not occur until the summer of 1941. It was long delayed by the council's president, C.J. Mackenzie, who believed that occasional visits by Canadian scientists were sufficient for keeping track of technical developments in the United Kingdom. Only pleas from senior Canadian and British officials, such as General Andrew MacNaughton, and NRC, British and Australian scientists convinced Mackenzie to send Howlett to London in July 1941. By then the CSIR had established an effective world-wide liaison network, with additional offices in Ottawa and Washington. The NRC's office in London remained small and it was never able to keep the RCN informed of naval technical developments.[13]

Relationship with Scientists

Since neither navy had a prewar research and development establishment they were heavily reliant on government civilian scientists. The inability of the RCN and NRC to establish an effective working relationship was another reason for the shortfalls in Canadian equipment supply. Despite an excellent beginning in 1940, when the RCN made the NRC its official scientific research centre, the relationship gradually deterioration until the spring of 1944 when senior naval technical officers where no longer on speaking terms with NRC scientists. In the summer of 1943 the RCN, dissatisfied with the priorities being given to naval research by the NRC, went as far as to attempt to set up its own scientific research organization.

12 Mellor, 429.

13 Zimmerman, 68-69

Scientific-naval cooperation collapsed because of the failure of the naval service headquarters to integrate senior scientists into the naval staff planning process, dissimilar institutional goals, and a complete lack of understanding of the intricacies of turning a laboratory prototype into an effective mass-produced weapon system. There is a pressing need for a study of RAN-CSIR relations in order to determine how the two organizations worked effectively together.

Scientific Organization

Scientific organization was central to the effective supply of advanced technology weapon systems. In 1940 the United States formed the National Defence Research Committee and later the Office of Scientific Research and Development to manage and coordinate the civilian scientific effort. The military services control of their own research facilities but coordinated their work with the OSRD. The British integrated civilian scientists into both pre-existing and wartime emergency government research centres. There was no central controlling agency but was managed by an *ad hoc* series of committees, meetings and informal personal contact. Both systems appeared to have worked well in the development of new technologies for the war effort in large measure because they well utilized all of the available resources. In both systems there was a great deal of self-criticism and study which lead to improved ways of utilizing scientific capabilities.[14]

In Canada there was no such self-criticism in large measure because of domination of the scientific effort by one poorly managed institution—the NRC. Mackenzie was a skilled engineer not an administrator and while the NRC grew tremendously during the war he attempted to manage the entire operation with almost the same size staff as he had in 1939. The NRC dominated university facilities, in large measure because in the 1930s it had emerged as the central focus of the Canadian scientific community.[15] The only service technical organization of any importance, the Master-General of the Ordnance Office, collapsed in disarray because of wartime pressures. Thus the NRC totally controlled science in Canada in World War Two. While Mackenzie was willing to accept advice he was almost the only person in the country who had the power and knowledge to suggest ways to improve the utilization of science by the military. But Mackenzie was submerged in the day-to-day running of the NRC, in the politics of Ottawa, and in planning for the postwar world and did not have the time to see the larger picture of the scientific war.

14 See Daniel J. Kevles, *The Physicists* (New York: Alfred A. Knopf, 1978) for the wartime American organization and R.W. Clark, *The Rise of the Boffins* (London: Phoenix House, 1962) for the British.

15 Yves Gingras, "Les physiciens canadiens: genealogie d'un groupe social, 1850-1950", (Unpublished doctoral thesis, Université de Montréal, 1984).

Mackenzie also had powerful friends in Ottawa, like C.D. Howe, the Minister for the Department of Munitions and Supply, who shielded him from any criticism.

The Australian experience is considerably different than the Canadian since the CSIR never dominated the scientific effort to the same extent as the NRC. Nor was their an Australian scientific mandarin with the all-encompassing power of Mackenzie. Perhaps more importantly the CSIR was held up to some very serious criticism by academic and industrial scientists. These critical assessments of the CSIR led to some major improvements to the management of the scientific war. An example of this was the criticism by the Australian National Research Council's[16] president Professor Eric Ashby, that government scientific agencies had not established enough 'bridges' between civilian scientists, the military and industry. Ashby was asked to form a committee to investigate the problem along with industrial scientist Dr. J. Vernon. They recommended the formation of an independent Scientific Liaison Bureau to insure the effective utilization and coordination of all scientific resources. This agency was formed in July 1942, and became an important part of the over-all management of Australian science.[17]

Operational Environment

The RAN had one important advantage in dealing with the introduction of high technology equipment, its ships did not usually operate in the most technically demanding operational environment—anti-submarine operations in the Atlantic. ASW technology evolved more rapidly than any other naval technology from 1939-45. Prior to 1939 there were no small ship radar sets. These were introduced in 1940, the first being the ineffective type 286 long-wave set, replaced in 1941 by the 271, which was improved steadily throughout the war to be in turn superseded beginning in 1943 by ultrashortwave sets like the American SU.

Asdic or sonar equipment and anti-submarine weapons such as depth charges went through a similarly rapid evolution. Both navies began the war with a few reasonably effective sets such as the type 124. These sets were steadily upgraded until the type 144/145 series was introduced in 1943, geared to work with the new hedgehog anti-submarine mortar. The sonar were grealty improved by the introduction of the Q device in 1943. The Q device assisted in the tracking of very deep submarines. The 144/145 asdics were later

16 The Australian National Research Council was quite unlike its Canadian namesake in that it was not a government agency but a private organization. It was composed of 200 leading scientists who acted as the unofficial voice of the scientific community.

17 Mellor, 57-64. See R. Home, 'Science on Services, 1939-1945,' in Rod Home, ed., *Australian Science in The Making* (Sydney: Cambridge University Press, 1988), 220-251

augmented with an entirely new type of system using the very accurate type 147B asdic which controlled the firing of the equally new squid anti-submarine mortar. In the Atlantic, given the rapid evolution of U-Boat tactics and technology, not having the latest in asw technology could be catastrophic as Canadian escort groups such as those that escorted convoys SC 107, ONS 127 and ONS 154 in late 1942 discovered. But the Japanese navy, the main opponents of the RAN after Pearl Harbor, waged an ineffective submarine campaign that never demanded constant upgrading of escorts asw equipment.

This can be seen with the success of the A271A radar discussed above. It is doubtful that this set would have been completely effective against trimmed-down U-boats in the stormy North Atlantic. The 271 set went through at least two distinct major upgrades to make it more effective. It was found wanting and had to be replaced by 3 centimetre radar when U-boats began to use snorkels. The RCN had to try, albeit unsuccessfully, to keep at least its mid-ocean escorts supplied with the latest equipment. The RAN was not under similar pressures to improve its asw radar.

This can be seen also be seen in the two navies asdic programs. Both established asdic production beginning in the summer of 1940. Australia produced 200 type 128 sets for use in destroyers, sloops and corvettes, adequate for all of the RAN's requirements and there was no pressing need to upgrade the set during the war.[18]

The Canadian program was far larger and diverse, nearly 2,600 sets of twenty-one different types being produced for the RCN, RN, USN and other Allied navies.[19] But Canadian warships remained far behind their British counterparts because the Canadian asdic program was unable to supply the latest equipment for a considerable period of time after it entered RN service. The main problem was of liaison with Admiralty research and production facilities, a situation that lingered well into 1944. This was despite the fact that the Admiralty, which took a large share of Canadian production, had helped establish the program and had sent technical experts from HMS *Osprey* to supervise. If the British Admiralty Technical Mission in Ottawa could not ensure the timely delivery of blueprints, specifications and samples then any attempt by a Canadian agency operating in Canada to get similar information from the Admiralty was doomed to failure.

By late 1943 the solution to the problem was found. The RCN sent draughtsmen to the United Kingdom and the Admiralty agreed to supply some new equipment to the RCN until Canadian production commenced. By the time this was working smoothly it was early 1944, well passed the crucial period of the Battle of the Atlantic.

18 Mellor, 466.

19 Zimmerman, 83.

There were also technologies that the RAN, because of its different operational environment, did not have as pressing a need to have. A case in point is ship-mounted high frequency direction finding sets, which were vital in the North Atlantic but far less significant in the Pacific and Indian Oceans. Often the only advance warning given to submarine attacks in the Atlantic was from the 'Huff Duff' set. One of the most effective tactics against U-Boats was to send a destroyer with an HF/DF set ahead of the convoy just before dusk. The destroyer would then force down U-boats that were attempting to guide other members of its wolf pack to the convoy for a night attack. Prior to mid-1943 most RCN escort groups did not have HF/DF sets, unless they were mounted on accompanying British destroyers.

They may, however, be other non-asw equipment that was more crucial to the RAN than the RCN. The RAN may have had as much problem with settling policy, making acquisitions and keeping pace with technical improvements as the RCN did with radar, asdic and HF/DF. Although most RCN corvettes had a severely deficient anti-aircraft armament until the spring of 1943 there was little discussion of the issue by the naval staff. Anti-aircraft weaponry was simply not as crucial to RCN escorts which usually operated in the western Atlantic. Only when some corvettes were sent as escorts to the Torch convoys in 1942 was the issue discussed but only in relation to these particular vessels. There is no information on the Australian experience with anti-aircraft equipment but in the Mediterranean, Indian and Pacific, the normal operational environment of the RAN, these weapons were crucial. This is an issue that must be examined in detail by historians of the RAN and compared to the Canadian experience.

Industrial Management

Another weapon that the RAN apparently had little urgency to mount its escort was the hedgehog asw mortar. First fitted in the RN in January 1942, the hedgehog if properly used could greatly increase the chances for a successful attack against a submerged submarine. While the Canadian naval staff soon realized the value of this weapon they found that Canadian east coast shipyards were incapable of fitting hedgehog to existing corvettes because major structural alterations had to be made to the forecastle to accommodate it. Political considerations had confined major early wartime investment in the shipbuilding industry to the Great Lake and St.Lawrence River areas. The vessels, in the days before the completion of the St. Lawrence Seaway, could not get back into the Great Lakes and the yards in Quebec were engaged in building the new River class frigates. It was only in 1944 with a crash program to upgrade Maritime shipyards and a great deal of American help that the majority of first-generation corvettes were rebuilt.

The problems with mounting hedgehog was not the only example of industrial mismanagement. There were serious difficulties within Research Enterprises

Limited, the crown corporation responsible for radar production. Sets were being delivered far behind schedule, often below specifications, and with substandard components. To make matters worse REL's engineering staff traded charges of incompetence with NRC radar specialists. REL's mismanagement greatly compounded the RCN's overall troubles with radar procurement as outlined below.[20]

Control of Canadian industry was through the Department of Munitions and Supply, headed by C.D. Howe. In defence of Howe, neither the navy nor the NRC kept DMS informed of their requirements and concerns. In the case of the shipyards there is no evidence to indicate that the naval staff understood the seriousness of the situation until the summer of 1942, when the decision was tentatively taken to proceed with the upgrading program. The NRC knew that REL had serious problems but did not inform Howe until the spring of 1943. It was not late 1943 that he acted and placed the company under close NRC supervision.

Although Australian industrial resources for the supply of advanced technology equipment for the navy seems to have been more effective than the Canadian a major study still needs to be done in this area. Neither Mellor nor S.J. Butlin's two volume study of the Australian war economy examine the issue of RAN-industry coordination sufficiently for a comparison to be made.[21]

Conclusion

Industrial, scientific and naval mismanagement, and prewar structural problems caused the Royal Canadian Navy's equipment problems. The assumption that the RAN did not have similar problems cannot be proven on the evidence presented here but it likely that this is the case. The types of failures in the Canadian system are not evident in the Australian although many gaps remain in which study may reveal a quite different story. It may very well have been that the RAN had similar problems than the RCN but with different types of equipment such as anti-aircraft guns. Until scholarly work began on the RCN little was known of the equipment crisis, its very existence hidden, unmentioned by the official historians. It was only when the crisis was first revealed that work could be undertaken to understand why it occurred. It is hoped that this model of the Canadian experience will encourage studies of a more substantive nature than Gill's operational history, particularly more detailed examination of the RAN's high technology war. Only when these studies are completed will the validity of the hypothesis be proven and perhaps then the

20 David Zimmerman, "Radar and Research Enterprises: A Case Study of Wartime Industrial Failure," *Ontario History* (June 1988), 203-21.

21 S.J. Butlin, *War Economy*, Two Volumes (Canberra: Australian War Memorial, 1955-58). Note Second volume co-written with C.B. Schedvin.

Australian experience can serve as a guide to further academic study of the history of the RCN.