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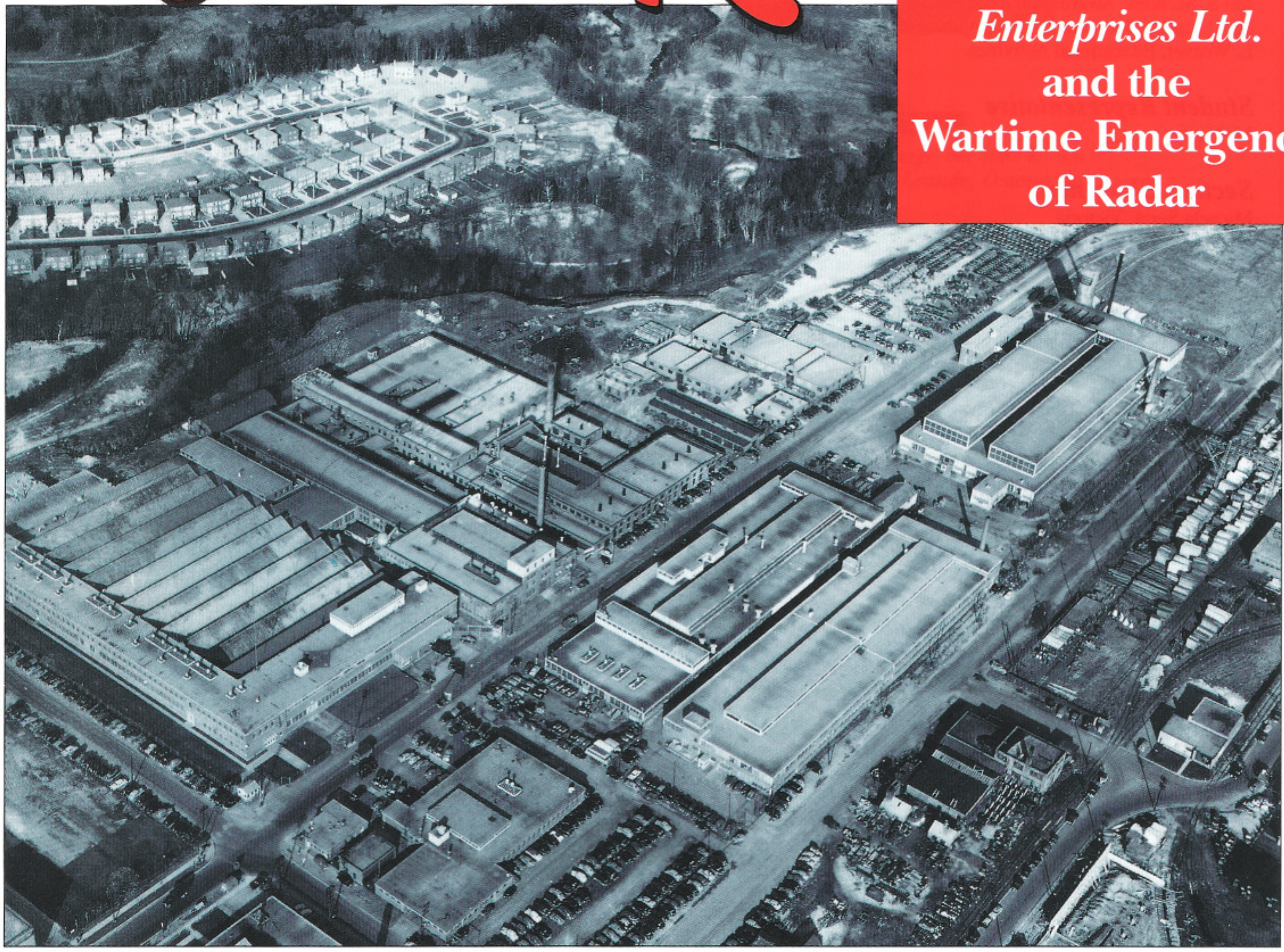
IEEE Canadian Review

Research Enterprises Ltd. and the Wartime Emergence of Radar



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IEEE Canadian Review General Information

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(i) Canadian members of IEEE;

(ii) Canadian members of the profession and community who are non-members of IEEE;

(iii) the associated academic (i.e. universities, colleges, secondary schools, etc.), government and business communities in Canada.

In this context, the *IEEE Canadian Review* also serves as a forum to express views on issues of broad interest to its targeted audience. These issues, while not necessarily technologically-oriented, are chosen on the basis of their anticipated impact on engineers, their profession, the augmented academic, business and industrial community, or the community at large.

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2- International affairs
3- Technology
4- Industry scene
5- Education

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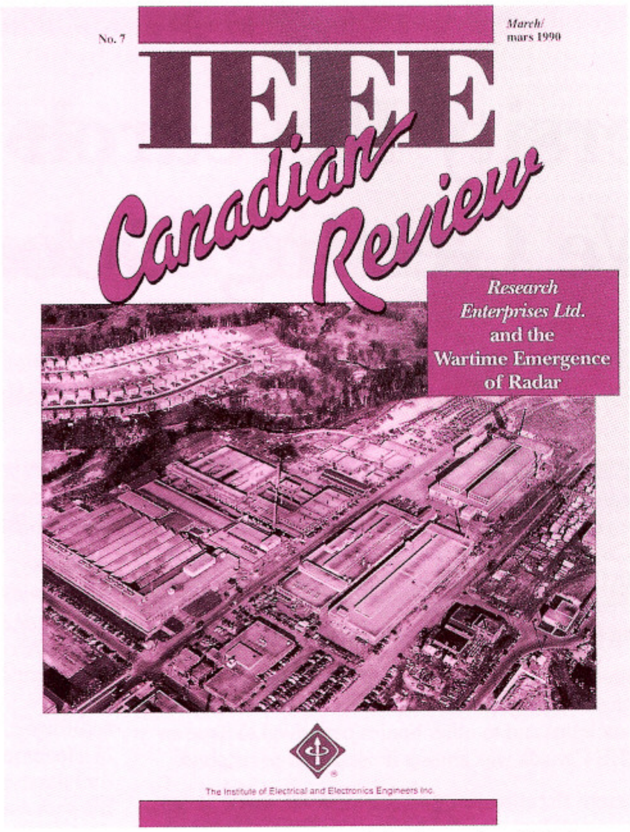

The cover shows an aerial view of the large but little-known Research Enterprises Limited complex at Leaside, Ontario, as photographed in 1944.

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University Research in Canada: Are We Getting Good Value?

by Dr. Tony R. Eastham
Director, IEEE Canada

The Royal Society of Canada has embarked upon an extensive study of research in Canada. Substantial core support for a period of five years is being provided by Industry, Science and Technology Canada (ISTC). As the first phase of its Evaluation of Research in Canada, the Royal Society, under the chairmanship of Dr. Peter A. Larkin, from the University of British Columbia, is undertaking a Study of University Research.

A discussion paper, entitled "A Study of University Research in Canada: The Issues", was distributed widely late last year - not only to universities but also to professional societies and to other bodies perceived to have an interest in the issues. IEEE Canada was among those asked to respond.

In these days of government fiscal restraint as attempts are made to get Canada's deficit under control, both federal and provincial expenditures are being scrutinized for effectiveness and relevance. Thus, support for the federal granting councils, the Medical Research Council (MRC), the Natural Sciences and Engineering Research Council (NSERC) and the Social Sciences and Humanities Research Council (SSHRC), and for a number of Departmental and Ministerial research programs, is being examined. The question that is being asked: Is the country getting good value for this investment?

The Royal Society's discussion paper reviews a wide range of issues relevant to research and funding programs in Canadian universities. Many questions are asked and, in responding to these on behalf of IEEE Canada, I have tried to lay aside my faculty cap and take the perspective of a large technical society - one which represents over 16 000 members of the electrical engineering profession in Canada, including engineers in the private and public sectors, university faculty and researchers, and post-secondary students. Here is how I have expressed my position.

Figure 1 Canada's Gross Expenditure on R&D (GERD) as a percentage of Gross Domestic Product (GDP) has changed little since the early 1970s, and has actually dropped slightly since 1986, despite greater public discussion of the issue. With the exception of the United States, other countries of the Organization of Economic Cooperation and Development (OECD) have been increasing the GERD share of GDP during the 1980s.

The Role of Universities

The twin missions of all universities should be education (in its true meaning) and research/scholarship. These two functions are synergistic; an institution without research cannot be a university.

The first of these expresses itself tangibly through the "output" of educated, enlightened people who can enter, participate in and lead a highly skilled workforce. Canada needs a continuous flow of such persons to build its industry and economy. These persons learn and benefit from contact and collaboration with faculty who are at the forefront of research in their particular fields. This contact provides graduates with not just professional training but with positive attitudes and enquiring minds.

However, as we examine their second mission more closely, universities must also be storehouses of knowledge. While Canadian universities contribute only perhaps 2% to the world bank of knowledge, if one measures productivity by the number of patents and papers in journals and conference proceedings, one finds - in Canada - experts in essentially all fields of human endavour. These faculty train both undergraduates and graduates, and it is the movement of these people from university to the public and private sectors that provides the most effective knowledge-transfer from universities for the benefit of the country.

Canadian researchers must be contributors to the world bank of knowledge and one can easily see why. Research funding provided by the federal government, largely through the three granting councils, and to a lesser extent by the provincial governments and by private sector companies, allows Canadian researchers to participate, and as a result, become experts and leaders in specific fields. In turn, a knowledgeable professoriate and staff in private/public sector research establishments are thereby able to

Continued on page 6

Electric Utilities: The Next Hundred Years

As the Canadian Electrical Association approaches the anniversary of its first century of existence, it is timely to consider the present and future challenges facing the industry.

by Maurice Huppé
Executive Vice-President,
Technology and International Affairs, Hydro-Québec
and Chairman, Canadian Electrical Association

The centennial of the Canadian Electrical Association (CEA) in 1991 will be an opportunity to celebrate the achievements of the Canadian electric utility industry and to speculate on what the future holds.

CEA, as a national association representing the interests of the electric utility industry in Canada, has seen the amazing changes this industry has undergone in the past century. A little over one hundred years ago, the several thousand people who witnessed J.A.I. Craig demonstrate Canada's first electric street lamp at the Champs-de-Mars in Montréal probably never dreamed that electric technology and the electric utilities would become what they are today. Similarly, with developments in nuclear power and in EHV transmission, for example, and research into fusion and superconductivity, one can safely say that we can look forward to an equally dramatic future and CEA will undoubtedly play a key role in that future.

But, what is our current situation? What are the issues facing our industry?

The Challenge of the Future

Utilities must produce and supply power for a prosperous Canada and, above all, in a manner compatible with a healthy environment. Furthermore, our country draws its energy from a wide range of sources, nuclear, hydro, fossil fuels and some alternative sources, which makes the scope of the challenge even greater.

Canada generates 80% of its energy from renewable hydro resources and CANDU nuclear. For both of these sources, we have been very innovative in keeping possible negative environmental impacts to a minimum. But there is still much room for improvement. And as for the number one environmental issue today, namely atmospheric emissions, the predominance of hydro and nuclear sources means that our record is good.

Coal, however, remains an abundant and cost-effective source in several parts of the country. Electric utilities and CEA are actively researching and developing ways to use this source more efficiently and with minimum environmental impact.

When we look at the massive fossil-fuel resources available elsewhere in the world, it becomes clear that Canada will have an opportunity to lead in finding solutions to the emissions challenge so that the inevitable growth of developing countries will not result in atmospheric disaster.

These, however, are mainly what could be called raw supply issues. Supply needs can and must also be met on the other side of the equation, namely by smart demand management, or what people simply call energy conservation. This is also an excellent response to environmental concerns. With supply and environment in mind, many Canadian utilities have adopted effective programs to reduce demand.

In short, the challenge is to optimize energy efficiency and reduce negative environmental impacts by taking action on both sides of the energy equation. And this, in fact, is a precondition to expansion of the utility infrastructure.

Utilities and R&D

Research and Development will be an important aspect of the industry's efforts to meet this challenge. Let us briefly review Canada's overall R&D efforts, which are somewhat disappointing.

Only 1.3% of Canada's Gross Domestic Product goes into R&D, exactly the same as in 1971, whereas Japan, the United States, West Germany, France, Sweden, Switzerland and several other countries are fast approaching 3.0%. The Soviet Union has been spending an average of 3.7% for the past 18 years. In the United States and the Soviet Union, a lot of R&D money is budgeted for defence, which means that resulting technology is slow to be applied to other industries. It is to be hoped that with the easing of world tensions, defence-related R&D efforts will be re-oriented directly towards normal industrial applications.

What's more, Canadian industry funds represent only 43% of the national R&D effort versus 70% in Japan, Switzerland and Sweden, 62% in West Germany and 50% in the United States.

Canada's electric utilities can be instrumental in correcting this situation. For example, Hydro-Québec finds it necessary to spend $135 million annually on R&D and is convinced that these investments pay off handsomely. Large sums of money are budgeted for a wide variety of engineering testing programs.

In addition, utilities can also form R&D consortiums, together, or with other industrial partners. The technologies developed can help our private and secondary sector industries become more competitive and, at the same time, encourage them to take a greater interest in research and development activities.

Meeting the Challenge

Let us now examine a few concrete examples of how R&D will help us meet the challenge described earlier.

In an age of EHV transmission, an important environmental question is the biological effect of electric and magnetic fields. A major study is being conducted jointly by Hydro-Québec, Ontario Hydro and Électricité de France.

The most popular utility buzzwords today are clearly demand-side management. However, without well-oriented R&D, the capacity that can be freed by this action is limited. Hydro-Québec projects in this area aimed at shaving off the peak or conserving energy include the evaluation of hot water heaters on peak demand and development of industrial prototypes, integrated dual-energy heating and energy-efficiency testing of home electric appliances.

Long-term R&D projects are also crucial. Last year the energy world was rocked when two researchers claimed to have succeeded in carrying out cold nuclear fusion. Obviously, the mastering of nuclear fusion will be an important step in solving the world's supply and environmental problems.

In this respect, the Varennes Tokamak is not only part of Canada's National Fusion Program, but it will also be used in the ITER project launched by Europe, the U.S., Japan and the Soviet Union.

Other important long-term research includes superconductivity, ACEP batteries and hydrogen from electricity.

Utilities and the Environment

One theme frequently recurred through all of the deliberations at the 14th Congress of the World Energy Conference held six months ago: the environment.

All participants agreed that the time had come to act. Futhermore, the Energy and Environment Division concluded that the most-efficient, lowest-cost solution to the world's energy-related environment problems is conservation. This division also stressed that initiatives in this area should not be left to the consumer but must also come from the producers and suppliers.

In the past, CEA has been a leader in responding to such important energy concerns. For instance, its Engineering and Operating Division facilitates information-sharing among individuals to help the utilities assume their responsibilities. CEA research focuses specifically on areas of environmental protection, cost control, productivity and customers' needs. The Association's Customer Service Division operates national energy efficiency programs and is organizing a series of demand-side management conferences throughout the year. And CEA also ensures that the industry's voice is heard at the federal policy level.

If the past is any guarantee of what the future might be, the Canadian Electrical Association will continue to take a leadership role among utilities here and abroad.

Perspective

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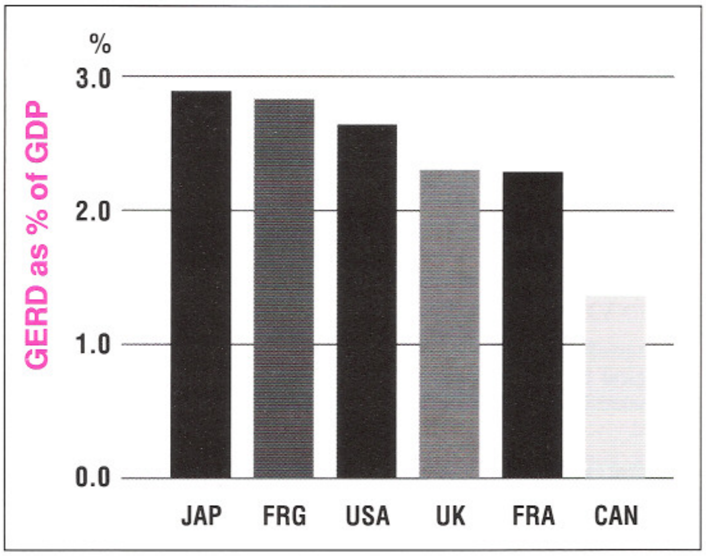
understand, appreciate and take advantage of the 98% of scientific development not undertaken in Canada. And in the same vein, it is part of the function of technical societies, particularly those with an international scope such as the IEEE, to disseminate this information for the benefit of all mankind.

The National Outlook

It is often noted that, with a Gross Expenditures on R&D (GERD) index of only 1,3% of the Gross Domestic Product (GDP), Canada occupies a lowly position in the big-league table of industrialized nations (Figures 1 and 2). This is certainly indicative of a lesser committment to R&D than our competitors.

However, from the perspective of industrial development, it is perhaps just as important for companies to be able to comprehend and take advantage of research and technological developments undertaken elsewhere, as it is for those companies to maintain competitive research units. Canada needs many more competent engineers who can recognize advantageous developments, and many more competent managers who have the foresight to employ such engineers and the courage to implement their ideas. And, as we can no longer depend on immigration of highly qualified individuals to the extent that we have in the past, Canadian universities are at the forefront of the challenge of producing graduates with these capabilities for Canadian needs.

Figure 2 GERD comparison of key OECD countries for 1987.



Consequently, research in Canadian universities is essential. We must have the commitment and flexibility to support a broad range of programs throughout the R&D spectrum, from basic/fundamental research all the way to product development. University attitudes to research are not stagnant, but evolve in response to the expectations and desires of academia on the one hand, and of industry and government on the other. Certainly, targeted funding can have a steering effect. A good example is the federal Networks of Centres of Excellence program, which succeeded in stimulating the best scientists and engineers in the country to propose collaboration to focus on many areas of research which were deemed to be strategically important to Canada. The response to this program alone can be taken as evidence of the underfunding of Canadian research.

To Conclude...

Government policy should consequently be such as to maintain a strong base of research in Canadian universities, and to maintain or enhance programs which create collaborative research linkages between the universities and the private sector.

However, one cannot neglect the question of the public's awareness of the overall benefits of science in our society. With this in mind, the Royal Society is currently undertaking a project to this effect. This is certainly just as important as maintaining a healthy research environment in Canadian universities. The secondary school system must bear the responsibility for the present low level of scientific literacy in school leavers. We must ensure that the general population is reasonably made aware of the importance of science and technology, and that a steady flow of competent, stimulated students continues to move into our universities. These people are the researchers of the future and, to a significant extent, will control the economic destiny of our country.

Have I covered all the bases? I understand that the Royal Society of Canada, having reviewed all the responses to their discussion paper, will be holding a series of regional public meetings across Canada. If you feel as strongly as I do about this issue, I urge you to come out to these meetings and to express your support for university research.

The Royal Society will still be pleased to receive your written submissions. A copy of the discussion paper can be obtained from, and any written briefs should be sent to:

Dr. Michael R. Dence
Executive Director
The Royal Society of Canada
P.O. Box 9734
Ottawa, Ontario
K1G 5J4

I would appreciate receiving a copy of any submissions.

Research Enterprises Ltd. and the Wartime Emergence of Radar

Canadians played a little-known strategic role in the early evolution of radar.

by Frank H. R. Pounsett
Life Fellow, IEEE

Remembering some of our achievements.

Few people know about the pioneering Crown corporation, founded fifty years ago, that played an important role in the wartime supply of radar to the Allied forces. This article inaugurates a series that will deal with crucial Canadian contributions to the advancement of technology and our profession.

N'oublions pas nos réussites.

On connaît mal la grande contribution d'une compagnie de la Couronne, créée il y a cinquante ans, pionnière à son époque et aujourd'hui disparue, à la fourniture d'équipements de radar aux forces alliées lors de la dernière Guerre. Cet article est le premier d'une série qui présentera les contributions canadiennes importantes à l'avancement de la technologie et de notre profession.

Research Enterprises Ltd. (REL) was incorporated as a Crown corporation on July 16, 1940 as the principal source of radar equipment for the Allies and to produce optical glass and instruments such as rangefinders. This article will concentrate on the Radio Division and particularly the engineering function. The word research in the name of the company was really, by the way, a misnomer as no basic research was to be performed. Its mandate was engineering development and manufacturing. The research information upon which the development at REL was based was supplied by the National Research Council (NRC) at Ottawa with which REL kept a very close liaison.

The Emergence of Radar

Before describing the operation at REL, it will be of interest to record some of the scientific background of radar. In Great Britain, in 1935, Sir Henry Tizzard was appointed Chairman of the Committee on Research and Air Defence. This group had developed radar. In February of that year, Sir Robert Watson Watt, then Superintendent of the Radio Department of The National Physics Laboratory, demonstrated reflections of radio waves from an aircraft. By June 1935, a radiolocation laboratory was set up on the Suffolk coast. By 1938, twenty-five early warning radar stations were installed along the south-east coast where enemy air raids were considered most likely to approach Britain. But there were as yet no facilities for the quantity production of radar equipment in Britain.

At the same time, research had been progressing at the Radio Section of the Physics Department at NRC in Ottawa under the direction of Dr. John T. Henderson. Radio location was their project and, by 1939, it had developed into radar. Dr. Henderson was invited to visit the radar research establishments in Britain in order to co-ordinate the work in the two countries and avoid wasteful duplication. The British were surprised at the progress that had been made at NRC and agreed to a close liaison and exchange of information. This led to their supplying NRC with a laboratory model of their ASV (air-to-surface vessel) set.

Although the United States of America were still neutral at this time, it was decided - by mutual agreement between President Roosevelt and Sir Winston Churchill - that Britain would disclose her radar secrets to the U.S. As a result, the British Scientific Mission headed by Sir Henry Tizzard went to Washington, and then to Canada. One of the most important disclosures was the cavity magnetron, which, along with the proximity fuse, is generally conceded to be the most important new weapon to be adopted by the Allies in World War II. The receipt of the cavity magnetron was a tremendous boost to radar research in the U.S. and was immediately taken up by their new Radiation Laboratory at MIT. It led to the U.S. eventually becoming the leader in the supplier of microwave radar.

The Birth of REL

During the visit of the Tizzard Mission to Canada, it was decided that, for security reasons, the main production of radar equipment should be located in Canada rather than in Britain. After several sites were examined, Leaside, a suburb of Toronto, was chosen. Just previous to this time, a decision had been made to set up a secure production source in Canada for optical glass, rangefinders and other optical instruments for the Armed Services. Consequently, Prime Minister Mackenzie King requested the Hon. C.D. Howe, an engineer and Minister of Munitions and Supply, to provide the facilities for the production of both radar and optical glass and instruments.

As a result, REL was launched as a Crown company for this purpose on July 16, 1940 with Col. W.E. Phillips as President, Mr. R.A. Hackbush as Manager of the Radio Division and Mr. A.W. Ballantine as manager of the Optical division. In 1942, Mr. Hackbush was succeeded by Col. F.C. Wallace who had been a member of the Tizzard Mission.

The provision of radar equipment was of top priority to combat the anticipated bombing and invasion of Britain and probable attack later of the east coast of North America. The rapid buildup of REL was accomplished by the most outstanding cooperation of industry, NRC, the universities, the military and Canada's engineers and scientists, all under extremely tight security. The first sod was turned on September 16, 1940 and the first building was ready for occupancy by early 1941. This building was later labelled No.8 and housed the radar engineering and production departments as well as the administrative offices.

Getting Down to Business

The production department included tool and die, screw machine, metal stamping, and plating and painting sections. There were also transformer and coil winding sections and a large area devoted to chassis assembly lines and final assembly and test. A large area was set up for the manufacture of cathode ray tubes. In another building for large land-mobile equipment, the tracks and trailers, purchased outside, were equipped with chassis racks, antennas and facilities for the operators.

The incoming inspection and quality control departments were located in a separate building and functioned independently of both engineering and production.

At the peak, some 4,500 were employed at REL of which about 400 were in the engineering department.

Engineering at REL

The nucleus of the Engineering Department was formed in November 1940 when a small group of engineers was recruited from industry. They were posted temporarily at NRC in Ottawa to work along with the radar group there. Reluctantly the names of these men, and the many that joined them later, will not be recorded here. The emphasis on effort and achievement could be unintentionally misplaced and some names even overlooked after a lapse of nearly fifty years. This original group, gradually expanding, was later moved to the John Inglis building in southwest Toronto and finally into building 8 at Leaside in April/May 1941.

The Department was then organized into three main design and development sections, namely, Army, Navy and Airforce, and later Admiralty. Eleven specialty sub-sections were set up to service them. The men were challenged by many unfamiliar design problems which would be considered routine today in 1990. These included transmitters capable of pulsed peak outputs of five to five hundred kW; receivers of extreme sensitivity; antennas from simple 1.5 metre dipoles to very large broadside arrays of dipoles; 10 cm waveguide-fed parabolic and slot radiators, and eventually 3 cm; special vacuum tubes of various types, including magnetrons and delay screen cathode ray tubes.

There were also mechanical problems, such as the use of selsyns to control the positioning of antennas and the passing of information to the gun-laying predictors. There were the trailers in which equipment racks were installed, and antennas mounted on the rooves (Figure 1).

At the beginning, the engineers had access to laboratory models from NRC upon which to base their development. As time went on, new types, many based on previous designs, and requested directly by the Services, were undertaken. REL also developed special test equipment such as calibrators, monitors and trainers to maintain the sets and train operators. Of the approximately thirty different types of radar sets processed at REL, only a few will be covered here. On the average, each of the three main sections were developing at least two types at any one time.

Some REL Achievements

The first set tackled was the ASV. Work began in November 1940 jointly with the radar section at NRC. A British handmade laboratory model was available for only forty-eight hours, after which it had to be returned to Washington. A Canadianized version was designed, and flight-approved, by both the RCAF and the U.S. Navy air arm, and all drawings and parts lists ready for production when building 8 at Leaside was ready in May 1941. First shipments of the 600 ordered by the U.S. Navy began in September 1941 followed by a total of 3,000 for the USAF and 1,000 for the RCAF.

At the same time, development work began in the Army section on the GL Mark III C, an anti-aircraft gun-laying set desperately needed in Britain. It had a major role in the defeat of enemy air raids on London, and later in the destruction of their V bombs. The GL Mark III C was a 10 cm successor to the British GL Mark II which operated on a longer wavelength. It was designed at NRC with the co-operation of engineers from REL. It was released to REL for production development from August to November 1941. The early-warning equipment to complete an installation in the field was designed at REL. Each of these sets was housed in a separate trailer with its truck. A fifth unit was a truck carrying the diesel power supply. Eventually, a total of 665 of the complete five-unit convoys were produced.

Probably the most important set built for the Navy, in 1942, was the 268. This was a 40 kW, 3 cm anti-submarine and surface vessel type, mounted on small vessels such as corvettes and employing a rotating slot antenna fed with waveguide. It succeeded a 10 cm set of which seventy were produced at REL. Two thousand 268s were produced of which 600 remained in Canada after the war.

Fred Heath Remembers...

I first met Frank in October of 1940, when he came to the National Research Council to study a British airborne radar set that had been brought over to be replicated at Research Enterprises Limited (REL). I took it to the U.S. Naval Research Laboratory at Anacostia (just outside of Washington, D.C.), where we installed it on a PBY Flying Boat, and demonstrated its ability to locate ships at sea.

I was loaned to the Radiation Lab at MIT for the whole of 1941, and it was not until February of 1942 that I was loaned to the Royal Canadian Air Force (RCAF) to become their representative at REL and I again met Frank, who was Chief Engineer of the Radio Branch of REL.

An amusing anecdote comes to mind. The radar set was in production, and shipments were being made to the US Air Force. The RCAF had not type-approved the equipment at that time. A number of problems were in the process of being cleared up when I arrived, but we had a problem with one unit that wasn't supposed to be shock-mounted. The vibration test destroyed its mounting bracket. We eventually realized that the problem was in the vibration table: the table was connected to an eccentric shaft by connecting rods that were equipped with Babbited Bearings, which had been destroyed by the action of the table. The table motion was no longer sinusoidal, but delivered jack-hammer-like blows to the equipment. No wonder the mounting brackets were destroyed!

Frank was Canadian Region Director for the Institute of Radio Engineers (IRE) in 1949 and 1950. He was very supportive of the Toronto Conference series, which started with the 1956 Conference, but his business responsibilities prevented his becoming General Chairman of the Conference.

The President of REL was Eric W. Phillips, who had come from General Motors, Canada. The first Manager of the Radio Division was Ralph Hackbush, who was succeeded about the middle of 1942 by Brigadier F. C. Wallace. Later, Ralph Hackbush returned to his position as President of Stromberg-Carlson (Canada).

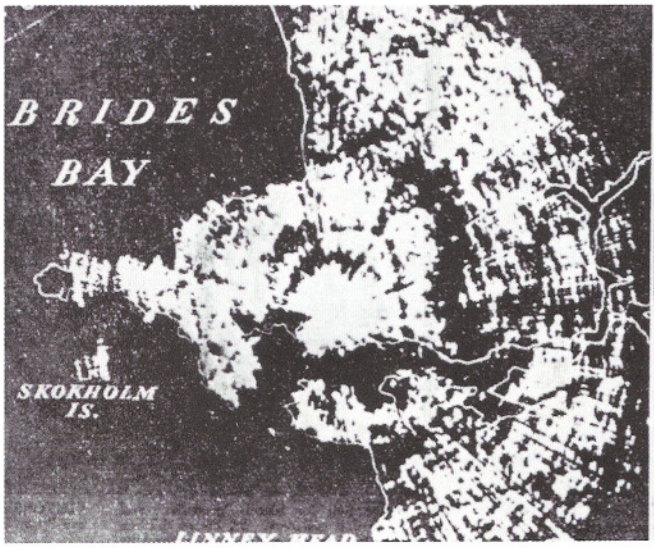
It is perhaps difficult to imagine today the situation that existed during the War years. War was declared at the beginning of September 1939, with the invasion of Poland. By June of 1940, France had fallen, the British army had escaped from Dunkirk with the loss of most of its armament, and it seemed that the invasion of Britain was next on Hitler's agenda. At one point, several thousands of British children were sent to Canada and the United States for refuge from the bombing by the German Air Force.

The United States remained officially neutral, until the end of 1941, when Pearl Harbour was attacked by the Japanese Navy. This attack resulted in the American public becoming fully committed to participation in the war. Prior to Pearl Harbour, Roosevelt was sympathetic to Britain, and was doing what he could, but was in danger of being impeached by those who were strongly isolationist in their beliefs.

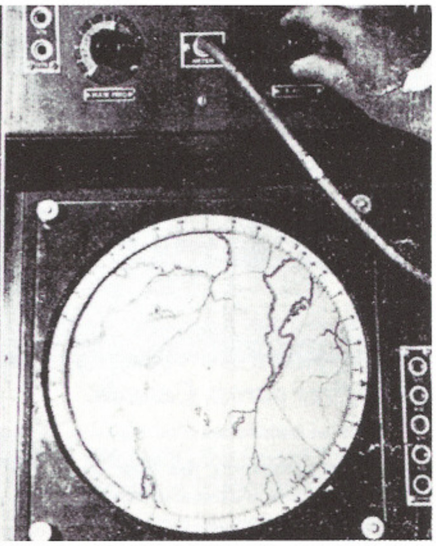
It seems ironic, in the light of later events, but the Radiation Laboratory at MIT was so named in an effort to disguise its true purpose - which was the development of radar. I was one of six loaned by the National Research Council of Canada to assist them in getting started. We went to MIT in January, 1941, and I went over to Britain in June of that year with an engineering prototype of an airborne microwave radar which had been developed at MIT. We performed flight trials in England, comparing it with similar equipment that had been developed there. It was planned to equip British fighter planes with production equipement, but these plans were changed after the attack on Pearl Harbour.

I returned to Canada shortly after Pearl Harbour, and worked at NRC for about six weeks before being loaned to the RCAF to act as their representative at REL, starting in February of 1942. I continued there until the end of the war.

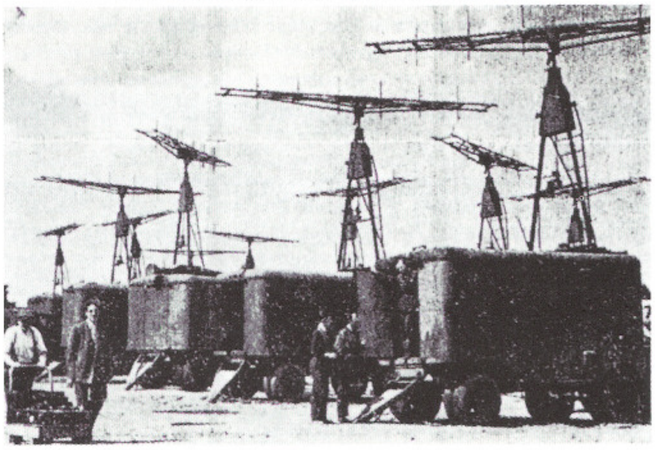
Fred J. Heath
Former Director, IEEE Canada, 1982-83



THIS MAP WAS drawn by radar and photographed directly from the cathode-ray tube of an apparatus in an R.A.F. aircraft during a test flight at night. It shows a part of Wales and gives practically all the information required with the exception of names. In addition, outline of the actual coast is somewhat thin



HERE'S WHAT a cathode-ray tube looks like. As the antennae revolve, the narrow light beam (note white line) moves across the tube. When there is a bulge in the light beam it indicates the whereabouts of approaching aircraft



TRUCK-TRAILER units, with the spidery antennae whirling like Dutch windmills, send out the radar signals. They move in four pieces—two trucks and two trailers. The exacting work of assembling the intricate mechanisms of radar units was one of the jobs assigned to Canadian war plants. One was Research Enterprises Ltd., Leaside

Figure 1 A newspaper clipping reporting on radar in the Saturday edition of the Toronto Daily Star, Sept. 8, 1945. Note the truck-trailer units built by REL.

Many other types of equipment were developed and produced at REL including several small-quantity runs required by the Services in a great rush. These included four early-warning sets for the U.S. to be installed at the Panama canal, and a small quantity of lighter, early-warning sets which were air-transported to North Africa.

At War's End

Following VE Day, there were discussions regarding maintaining REL as a post-war Crown corporation. An organization plan for a reduced operation was drawn up but never adopted. The plant closed in 1946, and the production equipment and inventory was turned over to Canadian Arsenals Ltd., another Crown corporation set up for the temporary disposal of wartime equipment of various kinds. Some of the buildings were sold to the Canadian Radio Manufacturing Corp. (CRMC), the successor to Rogers Majestic Ltd. One of the large buildings was purchased by Corning Glass. Later, Philips Electronics of the Netherlands took over CRMC.

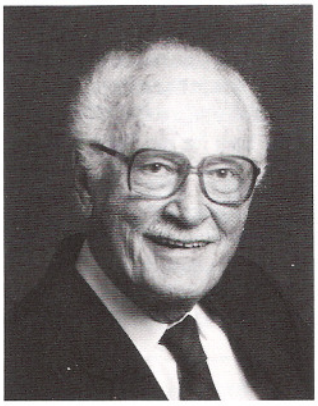
Most of the engineering personnel returned to industry, many to their previous companies. Those who located in the electronics industry bore with them a valuable knowledge and experience in many new fields such as UHF and microwave communications, pulse techniques and the use of cathode ray tubes. This, for example, was a boost for the fledgling television industry.

Many commercial ships were equipped with the surplus 268s for navigational use, and radar beacons were installed in harbours to assist ships in bad weather. The AYF altimeter, installed in commercial aircraft, rendered a more exact measure of elevation and was especially useful in blind landings.

When, after about twenty five years, Philips moved to Markham, the various remaining buildings were taken up by different companies and the only reminder of REL is a street named Research Road. The writer recently had occasion to visit a company on this street and was asked if he knew how the street got its name.

Of course, the next question was "What kind of research?"

About the Author...



Frank H. R. Pounsett was Chief Engineer of the Radio Division at REL during its operation at Leaside.

As a youth, he was an amateur radio operator, with hand-made equipment from 1918 to 1924 before licenses were issued, and was later known as 3JI. Upon graduation from the University of Toronto in 1928, earning a B.A.Sc. Electrical, he joined the de Forest Radio Corp. in Toronto, designing radio receivers, including the first car radios for General Motors of Canada. In 1934, he went with Stewart Warner Alemite Corp. in Belleville Ont. as Chief Engineer of the new radio division, continuing to specialize in car radio, now also for Ford and Chrysler.

In December 1940, he was recruited by Ralph Hackbush to join REL and was appointed Chief Engineer of the Radio Division. Though primarily occupied with radar, the radio division was so named for security purposes. During the early years at REL, he was also posted at Washington to assist Mr. E. P. Taylor, president of War Supplies Ltd., in connection with the supply of radar equipment to the United States. At the end of the war, he joined Stromberg Carlson in Toronto as Chief Engineer and Manager of Manufacturing where some of the earliest television receivers were produced.

In 1952, he joined the Canadian Radio Manufacturing Corp. at Leaside Ont., soon to be absorbed by Philips Electronics Industries Ltd.., as Manager of Manufacturing of the Professional Equipment Division. He retired from Philips as Vice President and General Manager of the Consumer Products Division in 1969 but from 1967 was actively engaged in the establishment of the Centenial College of Arts and Technology, the first of these new institutions of post-secondary education. He retired in 1971 as Dean of the Engineering Technology Division.Over the years, in addition to many other professional activities, he was involved in IRE-IEEE as:

1926	Associate member
1947	Fellow
1945-46	Chairman, Toronto Section
1949-50	Director, Canadian Region

Fire: The Unchecked Threat

Electrical faults in improperly grounded low voltage systems result every year in hundreds of fires across Canada.

by Jorge M. Campos, M. Eng.
Chief Electrical Engineer
Westmount Light and Power
Westmount, Québec

Apart from the direct danger of electrocution, the flow of electrical currents through undesired paths is a threat to human life as these currents are a major cause of fires and explosions. Every year, hundreds of fires originate in electrical problems that take their toll world wide in loss of life and property (Figure 1).

Electrical Fires in Canada

Unfortunately, Canada does not constitute an exception to the list of countries afflicted by such tragic, and for the most part preventable events. The 1987 Annual Report of the Fire Commissioner of Canada (the most recent issue at the time of this article) reported "Mechanical, electrical failure, malfunction" as the most important act or omission causing fires in Canada. It accounted for 17 482 fires, representing 26% of the fires in Canada for 1987. The result was $235 467 051 in property loss (25% of the total for the year), 542 persons injured and 51 dead.

In the statistical data classifying fires by their sources of ignition (Figure 2), electrical distribution equipment alone comes in fourth place (with 11% of the total fires), after miscellaneous (28%), smoker's material (20%) and cooking equipment (13%). Electrical distribution equipment was responsible for 7,258 fires, with $105,246,510 in property loss, 318 persons injured and 27 dead.

These are astonishing numbers that stand by themselves. They need no comments, other than the fact that behind the already appalling statistics hides a much greater cost in hospital bills, family life degradation and human suffering. Fires originating in electrical problems are a major source of destruction and misery in Canada. They are a silent, constant, threat hovering over each of us. No one is immune to them, no one is safe from their ravaging consequences.

Nevertheless, in Canada the problem seems to remain practically unnoticed. We have been passively seeing our houses and buildings going up in smoke, without taking effective steps to limit the danger of electrical fires. While we have kept this attitude, other countries have not lost time. For example, in many European countries, decisive steps have been taken in making better and more effective circuit protection mandatory. What are we waiting for to follow the example and to collect the benefits from the experience of others? Is it not time that we start to protect ourselves from these terrible killers? It is indeed about time that serious measures be taken not only by our legislators, but also by all of us. Specifically, we – the electrical engineers and designers of the systems that eventually will ignite fires – have a decisive responsibility in leading the way out of this undesirable situation.

Electrical faults in low voltage systems and their disastrous consequences...

Every year, electrically-induced fires result in millions of dollars in property loss and hundreds of personal injuries and deaths. The situation is fully described in the 1987 Annual Report of the Fire Commissioner of Canada, where "Mechanical, electrical failure" ranks as one of the most important fire-causing agents.

However, most fires ignited by electrical faults in low voltage systems are preventable. Many countries have already adopted mandatory design procedures to deal effectively with the problem. Is it not about time that we follow their example? Can we afford to have our buildings engulfed in smoke and needlessly destroyed by flames?

Les défauts électriques dans les systèmes à basse tension et leurs conséquences désastreuses...

Chaque année, les incendies d'origine électrique provoquent des pertes qui se chiffrent dans les millions de dollars, sans parler des centaines de blessés, voire de décès. Cette situation est décrite dans le Rapport Annuel de 1987 du Commissaire aux incendies du Canada où l'on voit bien sous la rubrique "Pannes mécaniques et électriques" qu'il s'agit là d'une des plus importantes causes d'incendies.

Cependant, nous pouvons éviter la plupart des incendies provoqués par les défauts électriques dans les réseaux à basse tension. Plusieurs pays ont déjà adopté des procédures de conception obligatoires afin d'arriver à régler ce problème. N'est-il pas temps de suivre leur exemple? Peut-on se permettre de continuer à voir nos édifices disparaître en fumée et en flammes?

The Fire-Causing Process

The devices presently used for the protection of low voltage distribution circuits in buildings - fuses and breakers - were designed to open circuits in fault only when the fault current equals or surpasses their rated pick-up current. Essentially, they offer only overcurrent protection. This is an effective protection if the fault current reaches relatively high values, in a short period after fault initiation.

The high fault currents needed for the reliable operation of the protection system are in principle guaranteed by the installation of low impedance paths to ground. The low impedance path to ground at point of fault will provoke high initial fault currents, which will promptly open the fuse or breaker protecting the circuit in fault. The hazardous fault situation will then be safely and quickly terminated. The Canadian Electrical Code fully supports this approach by making mandatory the installation of low impedance ground paths connected to low resistance grounding in each building.

However, after the initial grounding installation, the need for low impedance ground paths is often overlooked by the residents or by the owners of the buildings. Accidental interruption of the ground conductors, deliberate removal of grounding connections, action of vermin or rodents, loose

Figure 1 Typical examples of electrically-induced fires.

connections, mechanical or chemical damage, are only a few of the many factors contributing over the years to the gradual deterioration of the low impedance ground paths in buildings.

Depending on where the discontinuity of the ground path takes place, the whole electrical installation or only part of it will be affected. In the areas served by the circuits affected, the resistance to ground increases and the fault currents are limited to lower and lower values. On moderate short-circuit currents, the presently-used fuses and breakers will only operate after a relatively long period. Under high resistance faults, with fault currents lower than the pick-up rating, the protection devices will not operate at all. In such circumstances, not only stable and continuous impressed shock voltages will appear on the conductive surfaces surrounding the point of the insulation breakdown, but there is also the potential for the formation of tremendously powerful fire starters, often referred to as arcing faults.

Arcing Faults

Arcing faults are no more than high resistance faults. They typically occur in poorly grounded systems when one phase and the ground come together, and the difference in potential between them is higher than the voltage required to break down the dielectric strength of the insulation. After insulation breakdown, the arc will start between the conductor and the surrounding material, in an aleatory and intermittent way. The fault current, not having a low impedance path to ground, flows through many unplanned, high resistance ground paths.

The arcing process will persist as long as the difference of potential is enough to re-establish the fault after each passage through zero current. Generally, for voltages higher that 240 Volts, arcs will remain until the circuit is cleared by the overcurrent protection. For systems at 240/120 Volts, arcs will extinguish themselves upon slight changes in the circumstances that provoked the initial arc, such as movement of conductors, or voltage drop in the system.

The destructive power of arcing faults is awesome. The mainly resistive impedance of the arc and its intermittent character contribute to limit the RMS value of the fault current to levels so low that overcurrent protection devices are either not activated or are activated only after extensive burndown. In high and medium voltages, arcs result in violent explosions. The accompanying heat is so intense that it vaporizes copper and aluminum almost instantaneously in the surrounding equipment. For lower residential voltages, even if the current involved in the process is minor, the arc still releases enough energy to melt the conductors in only a couple of seconds.

The fire-starting potential of an arcing fault can be better illustrated if we consider that, for instance, a 3.5 second arcing fault, in a 120 Volt household circuit, developing 5 Amperes RMS would approximately release 16 450 Joules. This is roughly equivalent to the energy released by an 80 Watt solder iron continuously heating during 3 minutes and 25 seconds. All this energy would be concentrated in the point of fault and would be released in the extremely short time of 3.5 seconds. In such an event, fire would quickly develop in the surrounding combustible materials.

The seriousness and frequency of arcing faults at low residential voltages is well reflected in the statistics of the Fire Commissioner's report. It can be safely assumed that most electrical fires in Canada originate with arcing faults either in pieces of equipment, such as household appliances, or in the internal wiring of buildings. Also, after any major fire, there is almost always evidence of several electric arcs and short circuits. It is known that as the insulation of conductors is destroyed by the heat, the length of the wire exposed to arcing faults increases with the length of time that the protection of the distribution circuits takes to operate. In adverse conditions, it is possible that several meters of conductors will be causing many other sources of fire, before the overcurrent protection opens. So, whether arcing faults are the cause or consequence of a fire, they still possess a destructive power that must not remain unchecked.

NUMBER OF FIRES IN CANADA IN 1987

BY SOURCE OF IGNITION		*BY ACT OR OMISSION CAUSING FIRE*	
Smoker's material	13 783	Mechanical, electrical failure	17 482
Cooking equipment	8 914	Arson or other set fires	8 994
Electrical distribution eq.	7 258	Misuse of material ignited	8 437
Heating equipment	6 787	Misue of source of ignition	7 893
Appliances & equipment	2 285	Construction, design or installation deficiency	4 617
Exposure	2 030	Human failing	4 062
Other electrical eq.	1 782	Misuse of equipment	879
No igniting object	595	Vehicle accident	616
Undetermined	5 034	Miscellaneous	14 188
Miscelllaneous	18 700		

Figure 2 The 1987 Fire Commissioner's Annual Report confirms electrical problems as a major source of fires in Canada.

Ground Fault Interrupters: The Ignored Alternative

The peculiarities of arcing faults - the high rates of energy released and low fault currents - make it desirable that "arcing fault protection" be characterized by two important features: high degree of sensitivity to low fault currents and fast speed of operation. Both features undoubtedly play an important part in reducing the probability of arcing and, in the case of its occurrence, in limiting its destructive effects.

Circuit breakers offering such features have now been available for many years, for all residential voltage levels, from 600 to 240/120 Volts, and for almost any application, single or three phase. These devices are commonly known as Ground Fault Interrupters (GFIs). They can be selected to be sensitive to ground fault currents in the range of milliamperes and with times of response of 25 milliseconds or less.

In addition to overcurrent protection, GFIs also provide differential protection. They have a small, built-in, window-type current transformer that, by encircling all phase conductors and the neutral, sense the phase and neutral currents (Figures 3 and 4).

Under normal conditions, or during a balanced fault not involving ground, all currents going in a load are equal to all currents coming out of it (differential principle). This results in zero net magnetic flux in the current transformer, with no current flowing to the trip coil. When a fault to ground develops, there is an unbalance of the currents sensed by the current transformer (Figures 3 and 5). The resulting magnetic flux is proportional to the ground fault current. A current is generated in the transformer which, once equal or greater than the device sensitivity, will operate the trip coil of the breaker. "High sensitivity" GFIs (with a sensitivity lower than 30 milliamperes) use solid state circuits to amplify the weak signal from the current transformers to the levels required to energize the trip coil.

GFIs constitute an effective protection against the dangers of prolonged fault conditions due to limited fault currents. Detectable ground currents are always present in a ground fault, independent of the type of ground. GFIs with high sensitivities can guarantee the clearing of the arcing faults in a short time, preventing any damage or fire. They thus overcome the shortcomings of pure overcurrent protection.

The general application of GFIs in household distribution circuits has been mandatory for several years in some European countries. In Canada, where the widespread use of inflammable construction materials makes our buildings more prone to fires, GFIs have been just about ignored. Their mandatory application has been limited to the protection of receptacles and outlets at wet locations, such as swimming pools, garages, bathrooms and outdoors.

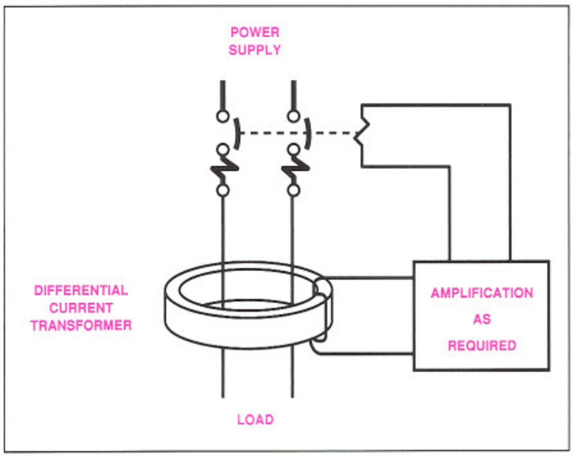


Figure 3 The concept of the single-phase Ground Fault Interrupter (GFI).

Some designers blame the lack of popularity of GFIs on their high cost, as compared with other forms of protection, such as fuses and breakers. Others justify their reservations by referring to the major inconvenience of repeated interruptions of service, due to small and unimportant leakage currents often experienced with "high sensitivity" GFIs. Neither of these excuses justify the neglect of the potential benefits of using GFIs.

Even if it is true that GFIs are significantly more expensive than other types of protection, it should not be forgotten that this is probably due to the present limited demand, not justifying their mass production in Canada. In Europe, where the general application of GFIs is mandatory, the resulting increase in demand drives their cost down. Today, even if GFIs are still sold at a premium, the difference is minimum and well worth the acquired protection. There is good reason to believe that a widespread application of GFIs in Canada would trigger a similar cost reduction. In any case, it is hard to justify the lack of acceptance of GFIs in a few additional hundred dollars per electrical panel, when such a sum is hardly relevant to the total cost of a new building or renovation costs of a factory.

In what is regarded as the inconvenience of unjustified service interruptions, associated with the use of "high sensitivity" GFIs, the problem can be approached by a more rational selection of the sensitivity level. GFIs are available with sensitivities ranging from as low as 5 milliamperes to several amperes. Further, the sensitivity of a GFI can be chosen independently of its overcurrent protection and voltage characteristics. So, it is up to the designer to face the challenge of achieving a suitable balance between the selection of the sensitivity and the demands for reliability of service.

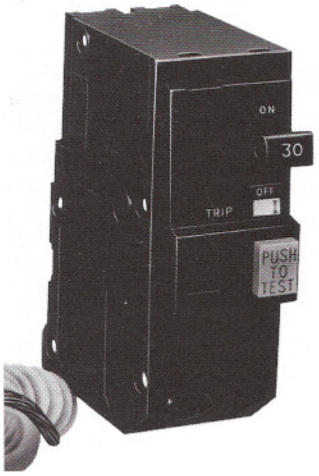


Figure 4 A typical Ground Fault Interrupter (GFI).

As a general rule, as we move towards the supply transformer, lower sensitivities are required. In distribution circuits with more than one protection level, the designer must use GFIs with different levels of sensitivity and coordinated for selective operation to avoid losing the whole installation due to a fault. "High sensitivity" protection may be justified only at the first protection level, the one closest to the load, where the need for service continuity can be compromised with less inconvenience. With such a design, only the device nearest the fault, on the supply side, will operate to remove it. This guarantees the maximum protection, with the maximum power reliability. Preferably, the protection must be selective by areas to prevent the instance of a fault affecting an area not related to the fault location.

Conclusion

There is no doubt that, even with the minor inconveniences related to the use of GFIs, the present situation reflects well the need for their general application. It is imperative to adopt better low level protection than today's overcurrent protection devices. Measures for the prevention of arcs and other high resistive faults must be a major point of concern in the design of any low voltage electrical installation, exactly as it is in medium and high voltage installations. The Canadian Electrical Code should be revised to make mandatory the general application of GFIs. Any additional costs in housing due to such measures would be more than justified by the assured long term benefits.

Insurance companies can also play a major role in educating the general population and in providing incentives for voluntary adherence to the improved protection. They could, for instance, reduce insurance premiums for home owners who would comply with the installation of GFIs, and thus gain by paying less fire compensation. Finally, society would gain by being subject to less fire damage, destruction, misery and human suffering which are associated with the loss of a residence, a business or, worst of all, a human life.

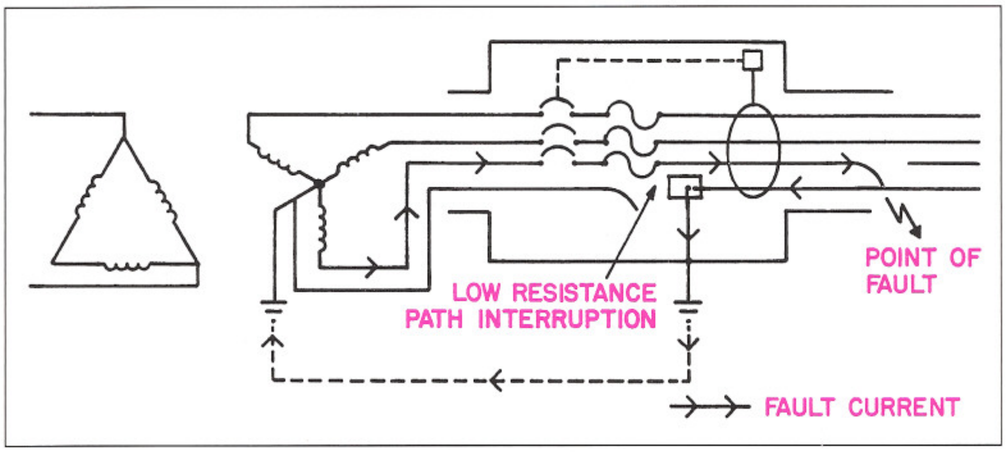


Figure 5 The three-phase GFI will detect an unbalanced fault current flowing to ground through the unplanned paths and will open the breaker.

About the Author...

Jorge Campos took his bachelor's degree in Electrical Engineering in 1977 at the University of Porto, Portugal. In 1985, he completed a Master's degree in Electrical Power Engineering at McGill University in Montréal. In March of 1990, he will be finishing a Master's in Business Administration (M.B.A.) at the same University.

He has been working since 1981 for City of Westmount Light and Power where he is presently Chief Electrical Engineer. In the fulfillment of his functions, he has been deeply involved in the design of high, medium and low voltage distribution circuits and protection systems. Previously, he worked as an electrical engineer for Atomic Energy of Canada Ltd. He was one of the design engineers of the grounding network for the electrical systems of the CANDU reactor.

Letters addressed to the Managing Editor will, according to their interest, be published in "Readers' Corner". All readers are invited, and indeed encouraged, to make use of this forum to share their positions or concerns. Please address all correspondence to IEEE Canada, 7061 Yonge St., Thornhill, Ontario, L3T 2A6.

Nuclear Submarines

In his letter on SSNs in your September issue, Peter Brogden displays none of the logic or objectivity which one expects to be part of a graduate engineer's characteristics. Both the need to safeguard our sovereignty and the military threat in the Arctic enforce the requirement for a Canadian force of SSNs.

What nonsense to imagine that the detection of an intruder is itself a deterrent. An efficient radar system has not deterred the Russian Air Force from frequently flying into Canadian territory. In an editorial in the Canadian Defense Quarterly in June of this year, John Marteinson wrote, "The concept of installing underwater sensors in the arctic channels is now next to meaningless, since we will not have SSNs. Who would be sent to check on incursions that might be detected? Who would install and service the sensors?" One might add, "Certainly not RADARSAT!".

Surely an electrical engineer, of all people, should be able to see the difference between a "nuclear weapon" and nuclear propulsion.

David Reid
Uxbridge, Ont.

Cover of First Anniversary Edition

I welcome the inclusion of the Readers' Corner in the Review as it provides an essential vehicle for comment, dialogue and feedback. I take this opportunity to convey my comments regarding the motif on the front cover of the subject issue which I received on November 7, 1989.

I was surprised and disappointed by the example of pseudo-surrealistic art which bore no relation to the concepts and activities of IEEE. While it is laudable to be proud of the artistic talents of one's offspring, the "commissioning", by persons unidentified, and the presentation of such an exhibit is completely our of place on the front cover of this prestigious technical publication.

The writer hopes that this example of misguided patronage will not be repeated.

John F. MacMaster,
Calgary, Alberta

I understand your concern about the particular cover of the anniversary issue of the Canadian Review. My own point of view was that it seemed good to have a change of pace, and I found it a rather nice way to celebrate our anniversary issue. This may, in part, have been due to my own personal knowledge of how involved the Managing Editor has been in every single paragraph of every single page of every issue. One does not have the kind of quality on the very first issues of

Erratum: Canadian Developments in Power System Simulation

We appreciate the efforts being made by you and your staff to publish the *IEEE Canadian Review* and we do hope the venture continues to be well received in Canada. We were pleased with our article in the December 1989 issue entitled "Canadian Developments in Power System Simulation" but a misprint may have given a misconception to the reader as to the economic benefits of digital real-time simulation compared with conventional analog simulation. A key sentence at the foot of page 17 should read:

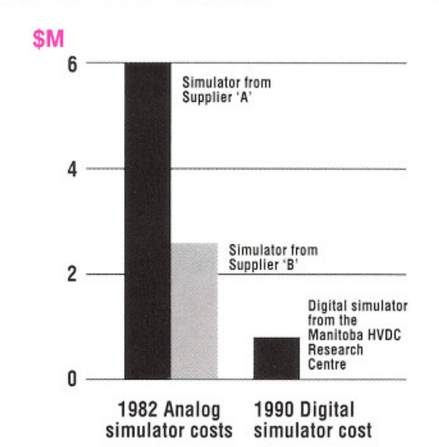
"It is estimated that a simulator capable of modelling a bipolar HVDC system, with the associated AC networks at either end, would *lessen the cost to 20%* and occupy less than 20% of the space of an equivalent analog simulator."

This sentence originally implied that only 20% savings could be achieved with the new real-time digital technology. In reality, significant savings will be realized.

On an historical note, the Manitoba HVDC Research Centre when it was created 10 years ago felt that an HVDC Simulator on its premises would be essential. Suppliers of analog HVDC simulators were contacted and in 1982 provided the Centre with quotations for a real-time analog simulator with controls to model a DC bipole. Minimum level costs for a conventional HVDC single bipole simulator in 1982 dollars were received as shown in Figure 1. Also shown is an estimated cost in 1990 dollars of an equivalent digital simulator with built-in real-time programmable controls.

The Centre wisely chose to invest its funds into developing the real-time digital simulation technology and did so at a total development cost less than the purchase price of an analog simulator. Financial support for this new venture was provided by the National Research Council, Manitoba Hydro and the Manitoba HVDC Research Centre.

Figure 1 Comparison of costs between analog and digital HVDC single bipole simulators



An exciting aspect of real-time digital simulation technology is the potential spin-off applications for the utility industry. One such spin-off is the relay test simulator mentioned on page 18 of the article. At a cost significantly lower than the digital HVDC simulator, relay engineers will have a powerful, low-cost, real-time AC system TNA at their fingertips to which any relay or relay package can be directly connected and tested. Relay engineers will thus have the capability of thoroughly exploring any relay on any part of the AC system, and observe its response to any disturbance.

The first commercial simulator study using real-time simulation will commence in March 1990 for Manitoba Hydro. A small system with a DC link, 3 synchronous machines with exciters, AC filters and capacitors and an AC system equivalent will be used to test - in real-time - a joint reactive power controller for the synchronous machines.

We trust this explanation brings out the significance of the misprint referred to above and we appreciate the opportunity to clear up any misconceptions which may have occurred as a consequence. We hope the *IEEE Canadian Review* will continue as a vehicle to disseminate new technologies in Canada.

Dennis A. Woodford
Executive Director
Manitoba HVDC Research Centre

One of the challenges of publishing the IEEE Canadian Review is to ensure a high standard of quality - of the content, of the presentation and of the written language. Unfortunately, things don't always work out the way they should.

The text of the article as printed in the December 1989 issue of the Review had an unfortunate typing error in a two-letter word (i.e. where one should have read the word "to", one found the word "by") which, in the best of the tradition of Murphy's Law, not only profoundly changed the sense of a sentence, but as it happens, perhaps the most important sentence of the article. These things don't happen very often but they do happen, no matter how hard we try, with all of the embarrassing consequences that can be imagined. Of course, all of this is of little consolation to the author whose conclusion has been substantially modified.

To the dedicated team of researchers of the Manitoba HVDC Research who entrusted the news of their technological breakthrough to the IEEE Canadian Review and for whom I have nothing but admiration, I hope that the publication of this erratum will help set the record straight. Please accept my sincerest apologies.

Richard J. Marceau
Managing Editor

such a magazine without an extraordinary amount of personal commitment on behalf of the Managing Editor.

I believe that the wording that Richard Marceau used and the term "commissioning" was, in fact, not intended to carry the implication that you perceived. I would say generally, speaking of my conversations with many of our IEEE members, that I have not detected a reaction similar to yours.

On the other hand, I am delighted with the reactions that we have received in many different ways to many different aspects of our magazine. I find that very rewarding because it suggests that people care about the magazine and are reading it.

Bob Alden
Director, IEEE Canada (1988-89)

IEEE Canadian Review

I would like to pass on my best regards to your staff who make the *IEEE Canadian Review* magazine.

I did not realize how much a Canadian magazine was needed until I read the *Canadian Review*. This magazine is definitely an inspiration to Electrical Engineers in Canada.

Brenon Knaggs,
Waterloo, Ont.

IEEE Conferences in Canada - 1990

March 5-7	IEEE Optical Data Storage - Vancouver
May 6-10	IEEE PES Substation Committee Annual Meeting - Vancouver
May 13-16	IEEE 6th Semi-Insulating Materials - Toronto
June 3-6	IEEE International Symposium on Electrical Insulation - Toronto
June 11-14	IEEE Conference on Precision Electromagnetic Measurement - Ottawa
June 19-21	IEEE Industrial Automation Conference - Toronto
June 27-28	Canadian Conference on Engineering Education - Toronto
July 6-7	IEEE Telecommunications For Health Care: Telemetry, Teleradiology and Telemedecine - Calgary
August 14-16	5th Canadian Semiconductor Technology Conference - Ottawa
August 20-24	IEEE 36th Holm Conference on Electric Contacts - Montreal
October 4-7	IEEE 3rd Sections Congress - SC90 - Toronto
October 11-13	1st IEEE International Workshop on Photonic Networks, Components and Applications - Montebello, Quebec
October 22-24	4th Biennial IEEE Conference on Electromagnetic Field Computation - Toronto

For further information on conferences, please contact IEEE Canada

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About the IEEE

The Institute of Electrical and Electronics Engineers, Inc. (IEEE), with headquarters in New York, is a transnational organization with 300,000 members in 137 countries. The world's largest engineering society, its objectives are technical, professional and societal.

The IEEE's technical objectives center on advancing the theory and practice of electrical, electronics, communications and computer engineering and computer science. To meet these objectives, it sponsors conferences and meetings, publishes a wide range of professional papers and provides educational programs. In addition, the Institute works to advance the professional standing of its members. It also has a mandate to enhance the quality of life for all people through the application of its technologies, and to promote a better understanding of the influence of these technologies on the public welfare.

Today, the IEEE is a leading authority in areas ranging from aerospace, computers and communications to biomedical technology, electric power and consumer electronics. When it began its second century in 1984, it rededicated itself to Innovation, Excellence, the Exchange of information and the quest for improved Education. In so doing, it underscores the initials IEEE.

IEEE Canada is the Canadian entity of this transnational organization, with approximately sixteen thousand members. The Canadian Region is divided into twenty Sections, each centered in a Canadian city, from Victoria, B.C., in the west, to St. John's, Newfoundland, in the east. For information on whom to contact in your area, the many IEEE products and services available, or how to join IEEE, write, phone, or fax our IEEE Canada office (page 3).

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HYDROLOY, a high-resistance steel developed in our laboratories

Technologie,
Affaires internationales
et IREQ

L'ÉLECTRIFFICACITÉ