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An Independent Inventor in a University Setting: Jean-Charles Bernier at the École Polytechnique de Montréal, 1925-1975

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Over the last few decades historians have devoted attention to topics like the commercialization of university inventions, the creation of institutional policies regarding patents, the tensions within engineering schools between proponents of pure research and applied engineering, and the intricate ties between institutions of higher education, industry and government agencies.[1] Although invention was a common denominator of all these studies, none paid close attention to the academic inventor per se. Having perhaps assumed that university professors are all scientists who teach and do research, historians failed to appreciate the role played by the "independent inventor" in the implementation and development of invention within university.

We think that the relative autonomy which university professors enjoy may have drawn some independent inventors towards academia, where they were able to set up a laboratory and invent freely. The development of engineering teaching may have also enabled such inventors to find an institutional niche where they could pursue their work. Furthermore, engineering schools and faculties that favored the contribution of scientific and technological expertise to industry through consulting, tests or research may have also attracted this kind of inventor. These conditions all came together in the case of Jean-Charles Bernier, professor at École Polytechnique de Montréal (EPM), a prime example of an inventor who managed to create for himself a space devoted to invention in a university.[2]

Even though he did not work in private laboratories or machine shops, Bernier's methods and interests in inventing certainly categorize him as an example of the independent inventor studied by Hughes.[3] The only difference is that Bernier esthablished his laboratory inside rather than outside a university. The very nature of this institutional environment permitted him to remain free of commercial constraints. Like most professional independent inventors, Bernier arranged his laboratory to suit his personal agenda and surrounded himself with specialized collaborators. He did not focus exclusively on a single invention but involved himself, rather, with a variety of machines with widely different operational methods and applications. On the whole, his inventions tended towards the development of radical technological systems that had the potential of revolutionizing certain industrial sectors.[4] Moreover, he did not need patent revenues to insure his livelihood since he could rely on his professor's salary. This factor gave him a status closer to that of the non professional inventor. Finally, according to Hughes entrepreneurship is one of the major characteristics of independent inventors. Bernier certainly possessed it but not to the degree that would ensure the commercial success of his inventions.

Engineering Training and Research at the École Polytechnique de Montréal

In 1871, in the context of a widespread debate on the need to better adapt the educational system to the new economic realities, Montreal's McGill University established the Department of Practical and Applied Science. Two years later the Académie Commerciale Catholique de Montréal, an elementary school, added to its curriculum a "scientific and industrial" program. In 1876, the Quebec government transformed the program into a university-level institution that granted a diplôme d'ingénieur. The new school was given the prestigious name of École Polytechnique de Montréal (EPM).[5]

The developments of the new School and of the Engineering faculty at McGill were widely different however. With strong support from Montreal's mostly English speaking upper class, McGill enjoyed a remarkable expansion at the turn of the century and quickly gained recognition as one of North America's most prestigious engineering schools. Its students came not only from Quebec but from all over Canada, the United States and the British Commonwealth. Most of its graduates found employment within the private sector, generally in industry.[6] However, EPM was far from enjoying the favorable conditions of its English speaking counterpart. Whereas from the beginning, McGill hired academics trained by the most prestigious American and British universities[7], EPM had to make do with self-taught ones. Without contacts in industrial centers, the institution produced engineers who found employment mainly in departments of public works and, to a lesser degree, as engineering consultants.[8]

As late as the 1920s, EPM had difficulties gaining recognition as a full-fledged engineering school. A letter sent by Archibald Byron Macallum, then Chairman of the National Research Council (NRC), to Prime Minister of Quebec, Lomer Gouin, paints a rather bleak picture of the training provided by EPM.

> The courses of training given in the Ecole Polytechnique does not qualify adequately students . . . as the corresponding courses in McGill and Toronto do. . . . The curriculum, as it appears on paper, is not appreciably inadequate, but the instruction given, the laboratory accommodation, and the equipment in apparatus, are not such as to meet the full requirements of the curriculum . . . the result is that students are not fully trained as compared with those of McGill and Toronto.
>
> The explanation is that the Ecole Polytechnique is attempting to work with resources that are utterly inadequate. . . . The consequences are, the staff is undermined, salaries are low and a considerable number of teachers give only part of their time to the institution.[9]

Immediately after the First World War, in an effort to increase EPM's prestige, its administrators set about bringing the school up to par. A program revision committee was appointed to initiate reform. The objective was not to implement a research program however. At the end of the 1930s, neither the School's financial situation nor the philosophy of its directors allowed for a development in this direction. The lack of properly trained specialists among the teaching staff kept the institution from developing curricula in the various branches of engineering and, thereby, limited it to general training in civil engineering. Special circumstances, such as those surrounding the Second World War, would have to occur before the governing body became convinced of the necessity to invest in research to improve EPM's standing as an institution of higher learning. They would also provide the incentive to develop four new specialties.

Second World War in fact created profound changes in the over all situation. The Federal Government required scientists and engineers to contribute directly to the war effort through increased industrial production. Research became a national priority and organizations, such as the NRC and the Defense Research Board (DRB), took-on an expanding role in the development of university research.[10] At EPM, the aftermath of the conflict in Europe led to the hiring of Georges Welter from Luxembourg. After having obtained his Ph.D. at the Technische Hochchule Berlin-Charlottenburg under the direction of O. Kammerer and having subsequently worked in German industry, he established the institute of metallurgy and metallography at the Warsaw Polytechnical School. When he arrived in Montreal in 1941, he already enjoyed international recognition as one of the leading researchers in his field. At EPM. he established the Laboratoire de résistance des matériaux and spent his first few years developing it. Not only would Welter introduce and legitimize research practices at EPM, but he would also, through out the 1950s and 1960s, contribute to its reproduction by training new researchers who would themselves contribute to the institutionalization of research a decade later.[11]

The post-war era favored the establishment of an institutional structure to manage the contracting out of research to industry and public agencies. It must be noted that both EPM's ranking among institutions of higher education and the position of francophone engineers' within the social hierarchy ultimately depended on the links graduates maintained with industry. This explains why such ties have always been a crucial stake for EPM's administrators. As early as 1943, Chairman Armand Circé strongly asserted that "fostering ties with industry" is as much a part of the professor's duty as are teaching and research.[12] Three years later, by creating the Centre de recherches, the Board clearly demonstrated its interest for industrial research and, by the same token, for invention.[13] Professors were encouraged to "develop processes or original ideas with a potential for patents."[14] Towards the end of the 1940s, however, the new Chairman of the School, Augustin Frigon, stated that in view of limited resources professors must concentrate on pursuing projects which "are primarily applications of science and technology".[15] Through out the 1950s and 1960s, the Centre de recherches furnished an institutional environment favorable to the development of independent inventors' activities. The period surrounding Second World War, with its steady growth of research and its valorization of invention, thus saw the implementation of an institutional context favorable to the rise and development of the activities of an independent inventor.

Emergence of an Independent Inventor

In the Montreal of the early 1920s, commercial radio was a widely popular media, both for its entertainment value and the easily accessible technology on which it was based.[16] Coupled with the presence of a francophone engineering school, which attracted telecommunication enthusiasts, it became a catalyst for Jean Charles Bernier's career. Bernier's passion for radio can be traced to his adolescence when the progress of wireless and radio transmission captivated his imagination. At the age of sixteen, he built his first receptor-transmitter with which he was able to communicate as far as Australia. Upon graduating from high school, he had already made a respectable amount of money by working as a radio operator on bootlegging ships. In 1925, the nineteen-year-old registered at EPM. During his university years, he worked for Marconi and then as a radio operator for the Canadian Merchant Marine. Having obtained his engineering degree in 1929, he joined the municipal road-signs division at Northern Electric, which he later left to return to EPM where he found support to pursue his radio interest.

Augustin Frigon[17], chairman of EPM, and Professor J.-Arthur Villeneuve, MIT graduate who had studied under the direction of Vannevar Bush, both shared Bernier's passion for telegraphy and radio.[18] Thanks largely due to Frigon's recommendations, Bernier obtained a NRC grant to work on synchronous machines.[19] Although seemingly engaged in a research process, he displayed far more interest and capability for invention. His superiors readily acknowledged that technical talents were his trademarks. In a letter to the NRC Chairman, Frigon wrote, "I do not think that he has much of the 'mathematical mind' but he certainly has a well balanced 'mechanical mind'."[20] Villeneuve, the project director, added that "he has not neglected the theoretical part of his work", but he has however "shown much skill in the designing of the mechanical features."[21] Such comments clearly indicated that Bernier's qualities were, from the onset, much closer to those of an inventor than those of a researcher.

After a year's work on synchronous machines, Bernier was awarded a second NRC grant for the theoretical and experimental study of electronic saturation and its applications to thermoelectric filters. He would, however, abandon this work, begun during the 1930-31 academic year, in order to concentrate on a topic more in tune with his experimental capacities and his passion for electromechanics. After publishing his results in December 1930[22], Bernier launched himself into the television adventure. This did not fail to arouse a response from administrators of the NRC grant program. Instead of the expected report on electronic saturation, he described a series of experiments on various mechanical methods of image sweeping in television. This despite the fact that NRC rules clearly stated that, "the substitution of a report on a subsequent investigation in lieu of work actually carried out under a scholarship should not be permitted."[23] The young Bernier chose to ignore NRC regulations. The granting agency might have failed to foster his abilities as a researcher, but he was now free to pursue his inventive activities.

In the early 1930s, it was television's turn to generate widespread curiosity within the general population and strong enthusiasm on the part of independent inventors and industrial researchers.[24] Keeping a close watch on new developments in the field of telecommunications, Bernier was well aware of ongoing experiments worldwide. Fascinated by image transmission, he easily convinced a fellow EPM graduate, Fernand Leblanc, to collaborate on a series of television experiments.[25] The team worked unhindered by the constraints that would have been imposed by a project director or a granting organization. They purchased parts and supplies with their own monies, and EPM provided them with a locale. There they built television systems using any available supplies.

Between 1931 and 1934, the two colleagues concentrated specifically on image transmission through mechanical means.[26] Founded on the optical properties of light, the underlying paradigm had been uncovered during the last two decades of the nineteenth century and brought to maturity by the sweeping process invented by Germany's Paul Nipkow. In 1925, Charles Francis Jenkins, in Boston, and John Logie Baird, in London, introduced television to the general public. That same year, Bell Laboratories engineers finalized the flying spot technique and thereby gave a second impetus to research in the field. Between 1928 and 1933, the mechanical paradigm was so widely accepted that it overshadowed the path put forth by Russia's Boris Rosing in 1907: the use of Ferdinand von Braun's cathode-ray tube based on the magnetic properties of electrons. In 1912, this same technology led Campbell Swinton to present a complete, albeit theoretical, system of electronic television. In 1923, Vladimir Zworykin, a former student of Rosing and Swinton's lecturer, demonstrated to Westinghouse administrators his own television system, the Iconoscope.[27] Five years later he refocused his research on electronic television, this time at the Radio Corporation of America (RCA). An independent inventor, Philo Farnsworth, followed him closely and competed with the RCA system using his "image dissector". Thus, in the early 1930s, the electronic paradigm was clearly on the rise but had yet to demonstrate its superiority over its mechanical counterpart.

In 1933, Bernier and Leblanc built two apparatuses which were clearly based on the mechanical paradigm but which used two distinct trajectories. One was inspired by Nipkow's works, and the other by Bell laboratories' flying spot technique. Later they foresaw the possibility of a third much improved apparatus based on a brand new process patented by Bernier.[28] As any inventor working on television, Bernier was faced with an important reverse salient, that of image resolution. The emerging industry was indeed confronted with a major difficulty in its efforts to go beyond the experimental stage, that of producing a high definition image. Under the name of "système coordonné", Bernier's invention improved definition by multiplying by two the resolution of the mechanical system. To produce the flying spot, he replaced the single light behind Nipkow's wheel by two lights at a 90 angle to the center of the disk. This generated a horizontal and vertical crossing effect. Consequently, instead of producing a series of rather crude horizontal lines as did other mechanical processes, Bernier's technique displayed a mosaic of small detailed squares generated by two crisscrossing beams.

In 1934, a year after Bernier had applied for patent, Zworykin and Farnsworth staged separate public demonstrations of a revolutionary electronic television. Their invention increasingly forced inventors and researchers to abandon the mechanical paradigm since the new system had succeeded in improving image resolution quality threefold. Compared to the 180 definition lines of mechanical television, it offered an impressive 560 lines (hence the name, "high definition".) This meant that competition was no longer between the mechanical and the electronic paradigms, but between Zworykin's and Farnsworth's trajectories.

This revolution had a profound impact on Bernier's technological imagination. Turning his back on the mechanical paradigm, from then on he would devote his interests to electronic technologies. As a direct consequence of his work on television, he was hired as a professor at EPM where the Laboratoire d'électronique appliquée (LEA) was set-up in 1937.[29] There he pursued studies on photo-electronic cells, on the electronic microscope and on cathode-ray tubes. In the 1940s, he undertook a series of projects on electronic television, which made him among the first to explore the field in Canada. His various other inventions such as the Servomec, the Lectron and the Berfax incorporated the basic technologies used in the television industry.

The University Based Inventor

Invention, according to Hughes, can be defined as the resolution of new problems.[30] Thus, contrary to the popular image of the heroic inventor, we now know that inventors rely upon the development of problem solving techniques. These techniques shape the laboratories, workshops and production units where scientists, engineers, mechanics and craftsmen resolve specific problems. This led Hughes to state that the way in which inventors choose their invention problems is one of the characteristics that differentiates them among fellow inventors.[31] In Jean-Charles Bernier's case, his laboratory provides numerous clues of his working methods as well as of the specificity of invention in a university setting.

Bernier's office was filled not only with documents, sketches and notes but also with specialized journals and patent documents. Next door, in a workroom where they spent most of their time between 1940 and 1950, assistants were busy resolving technical problems. This room contained drawing tables, instruments for electronic measurements and various mechanical and electronical instruments. A third room was a workshop where mechanics provided the inventor and his team with technical support. The organization of the laboratory made it possible to quickly give life to ideas that dealt with electronics or electromechanics.

The laboratory also included a space devoted to teaching. EPM students could witness practical experiments to familiarize themselves with elements of electricity, electronics and electromechanics. This room was next to the one devoted to invention and thus permitted free circulation between those two worlds. In Bernier's mind, teaching and "research" were two different entities however, and the laboratory's practical organization reflected this point of view. He hired additional staff to deal with teaching related tasks while his assistants could devote themselves to their inventive work. A technician was hired, for instance, for the preparation of pedagogical experiments. Bernier himself taught classes ranging from mechanical physics to electronics applied to communications. One year after the end of the war, he became the Chairman of the Physics and Electronics Department. The university based inventor had indeed fulfilled his teaching mandate, but he always strove to minimize its effect on his laboratory activities.

The LEA was equipped with all the apparatuses, instruments and tools required by the inventor's field of interests.[32] Bernier was determined to have access to the latest electronic equipment. Deeply affected by the technological revolution of the televisual field, he chose to specialize the laboratory in the production of tubes, which were, at the time, the basic component of electronics.[33] He immediately undertook the construction of two glass blowing lathes, fitted with a gas source for flame beaks. In addition, he built three high-tension generators which fed cathode tubes used in experiments. Symmetrical linear oscillators completed the equipment. Later, the team worked on making elevated vacuum pumps which had became indispensable for tube production.[34]

All this allowed him to envision making his laboratory one of most advanced in the field of electronics in Canada.

Bernier's interests were diverse. In the 1940s, he invented a high frequency wood-dryer, an electric arc for spectrographic analysis called the Polyarc and various elevated vacuum pumps. After Second World War, he worked on the Servomec, an automated material cutting apparatus. During the 1950s and 1960s, he focused on the Lectron and the Rectron, two magnetic audio and video band reading and recording machines, as well as on the Graphax, the Perspix, the Iconac and the Véricon, all instruments for tridimensional representation. Finally, he chose the Berfax, an electromechanical reproduction process, to win public recognition as an inventive genius. He also invested time and effort in a few more projects, such as the Maxifax, the Minifax, the Telesphore, the Exto-B, the Tocatron and a vibrating visual machine intended for the blind. Bernier kept individual and detailed notes on the progress of all his inventions. This practice, common to most inventor, not only allowed him to keep track of his inventions but also protected him in case of patent litigation.

As most independent inventors, Bernier was surrounded with collaborators and mechanics. They contributed to his work and resolved various problems on both the conceptual and practical level. Because of his concentration on inventive activities, however Bernier never perceived the growing importance of graduate studies in engineering training. None of his assistants, who were mostly students, went on to pursue inventing as a career. They usually preferred to engage in teaching, school administration or scientific research. Training specialists had never been one of Bernier's main interest. Most of his efforts, rather, tended towards limiting the impact of teaching activities on his workload. He never strove to hand-down work methods or to develop in his students the abilities that characterize an inventor. This was despite the fact that graduate training and the diffusion of research methods were by then important stakes at EPM, and several of his assistants were well aware of that. One of his main assistants, Roger P. Langlois who worked at EPM between 1947 and 1963, sought specialization at MIT at the Master's level. Upon his return in 1953, he went back to the LEA but left ten years later to contribute to the reform of Quebec's school system. Back once again at EPM in 1969, he worked at strenghtening research .[35]

Bernier's activities differed in several aspects from that of a university researcher. Because they work in a university laboratory and use scientific knowledge in their inventive activities, inventors working in academic settings may justly view themselves as researchers. By the same token, some researchers may consider themselves as inventors because they secure patents and collaborate with industry. We must look beneath the surface of such activities, however, to see the difference between a university researcher and an inventor like Bernier. From a sociological point of view, Bernier's practices were not the same as those of university researcher because he did not belong to a scientific field and thus was not familiar with disciplinary stakes.[36] Without a Ph.D, he did not internalized the common practices of researcher.[37] His basic motivation was to invent and obtain patents as a means of recognition. Unlike university researchers, he had limited concern for the dissemination of knowledge through scientific journals, and only published a few articles throughout his career, mostly in periodicals outside scholarly fields.[38] Finally, although he did obtain grants from funding agencies to finance his research work, this was but an occasional occurrence as he had notable difficulties meeting the criteria of such agencies. Instead, he relied upon his personnal ressources and, after 1940s, upon the Centre de recherche s.

Despite such practices, Bernier contributed to the development of a discourse on research by presenting invention as a crucial aspect of this activity.[39] From the very beginning, he upheld the classical distinction between “fundamental” and “applied” research in order to bring to invention the prestige of “science”. In his view, if “fundamental research” produces new scientific knowledge, then the role of “applied research” is to “innovate, invent and develop new products, new processes and to insure the sustained improvement of existing techniques as well as the creation of new ones.”[40] For him, the fundamental function of research is, without doubt, the promotion of the economic development and industry.[41] To fulfill their role as agents of economic development, he stressed that universities needed laboratories, equipment and skilled labor. He suggested that institutions should emulate major corporations, like General Electric, which had successfully developed inventive activities within their laboratories. In his view, if such industries managed to finance themselves by commercializing products protected by patents, universities should also be able to fulfill at least part of their research-funding needs in this way.

Through his professional involvement, Bernier in fact played an active role in the institutionalization of inventive activities. Appointed Chairman of the Centre de recherches in 1953, he used his power to change some of the rules governing the institution in order to better promote invention. Within two years, he tabled a report in which he justified the abolition of a number of institutional constraints upon research activities that did not fit normal academic standards.[42] He went on to suggest changes to the Centre’s funding elegibility criteria to take into consideration projects whose success had usually been deemed doubtful. This proposal met with a strong negative reaction from colleagues who had been socialized through research practices and who were unwilling to accept all but the commonly recognized criteria of the scientific community.[43] Lastly, he attempted to have patents acknowledged as an indicator of a professor’s scientific and technological productivity. He insisted that the Centre de recherches must not only continue to encourage invention but also get involved in the process of filling for patents. Although Bernier did not turn the Centre de recherches into a structure capable of promoting his inventions at the commercial level, as had been the case at MIT or at the University of Wisconsin[44], his view on research and invention had lasting repercussions within the institution. We shall now examine how he attempted to commercialize his inventions within the university setting.

A University-Based Inventor-Entrepreneur

In 1958, EPM moved on the campus of the University of Montreal and allowed Bernier to expand his laboratory.[45] Due to the abolition of the teaching section, notably, the LEA became more suitable to the organization of his inventive work. His assistants were now more specialized in a work organization that was increasingly hierarchical. The laboratory employed around ten collaborators, in addition to mechanics and a secretary. Bernier could therefore delegate specific tasks to his aids who worked in the new rooms: the mechanical workshop, the vacuum tube room, the small chemistry lab, the electromechanic workshop and the Berfax’s room. In terms of organization, this second laboratory was not like those of large corporations — it was a university inventor's laboratory.[46] So neither his laboratory nor the university had, for example, an office for technology transfer, for commercialization or for patent filling. Bernier's freedom was high, but his sensitivity to the needs of industry was, consequently, low.

As previously noted, entrepreneurship is, according to Hughes, one of the characteristics of the independent inventor.[47] As a general rule, whenever inventors acquire a patent, they try to collect on their work by commercializing their invention. They face major difficulties in academic settings. The commercialization of patented products does not lie within the mandate of the university, for instance. After having invented the Lectron, the Graphax and the Berfax between 1958 and 1966, Bernier had to seek partners outside the academic world in order to succeed in marketing his inventions. In many ways, his tribulations in the world of business were not far removed from those encountered in present day technology spin-offs from universities.[48]

In 1958, along with two collaborators, Bernier invented the Lectron. He immediately saw its patenting potential and, that same year, contacted the Canadian Patent and Development Limited (CPDL), an NRC company. This company was designed to promote the commercialization of patents obtained by federal civil servants. As noted by the historian Wilfrid Eggleston, "The new arrangements also offered Canadian Universities a service whereby a channel was provided through which the scientific work of university staffs could be utilized by industry."[49] In virtue of this, CPDL made contractual agreements with Canadian universities to commercialize patents obtained by professors. The inventor in no way relinquished his rights since the standard contract included a clause stating that "the term 'University Inventor' means a person in the employ of or otherwise connected with the University who has agreed to assign any patentable developments to the University and who has made an invention."[50] This suggests that Bernier's case was far from unique. But Bernier's unwillingness to cooperate with the CPDL shows that its system of marketing inventions was inadequate. In 1958, Bernier investigated the terms which bound EPM to CPDL. Having examined all the implications, he quickly reached the conclusion that these conditions did not suit him. He did try to renegotiate the accord but CPDL firmly refused to alter the nature of its ties with EPM.[51]

Bernier then turned to another alternative, industry. In 1960, the Institute of Radio Engineers invited him to its convention on electronic communication. His presentation brought him a certain measure of visibility within the industry.[52] He seized the opportunity to unveil the potential of his invention to RCA, Northern Electric and Canadian Marconi researchers and engineers. In view of the interest shown by these industrialists for the Lectron, Bernier decided to take legal steps to insure his rights.[53] The conference also served to enhance the prestige of the LEA and EPM. In 1961, over fifty major companies, including Ampex, International Business Machines, Minnesota Milling and Manufacturing (3M), General Electric and Telechrome Manufacturing, requested additional information on the Lectron. RCA, in its eagerness to acquire a promising invention, sent a delegation of high ranking research administrators to the LEA to "discuss the head [the Lectron] and to determine whether you [Bernier] have made any inventions in your development which may be of interest to us".[54] Although an agreement was never reached, such meetings provided the opportunity to establish contacts with corporations.

Correspondence between Bernier and industrial leaders reveal a lot on his attitude towards innovation. Bernier did not spontaneously perceive himself as an entrepreneur. Thus, when Frank C. Bumb, vice-president of American Concertone, inquired about the steps he had undertaken to commercialize the Lectron, Bernier acknowledged his inability to move forward on this aspect, mainly because of his institutional affiliation. In his answer to Bumbs he wrote, “As an educational institution we are very well equipped in research facilities, but the industrial and commercial promotion of such a device is somewhat out of our line.”[55] At EPM, the CPDL was the only resource accessible to the academic inventor wishing to commercialize an invention. This largely explains why the Lectron never reach developmental stage, despite the fact that work on the invention continued until the late 1960s.

The Bermont-Électromécanique Company case was another defeat for the inventor. In the late 1950s, Bernier invented a tridimensional axonometric representational instrument, the Graphax.[56] In 1963, he published a technical description in the journals Design Engineering and Graphic Science.[57] This generated an impressive quantity of mail from engineers working for major American corporations, such as Cincinnati Milling Machine and Good Year Aerospace, inquiring about his commercial intentions for the product. Surprised by the enthusiasm for his invention, Bernier gave serious consideration to the possibility of manufacturing and marketing it himself.[58] Overcoming his former reluctance to go into business, he established the Bermont-Électromécanique Company. He must soon had to acknowledge, however, that his expectations were unrealistic. Instead of the 1 350 instruments which he had projected to sell annually[59], he only sold a few over several years.

In 1967, while his company fell far short of producing the expected results, a 3M representative contacted him, offering to evaluate the commercial value of the Graphax at the company’s facility in Saint Paul, Minnesota. This offer gave Bernier new hope and he spared no efforts to prepare the presentation. The results were very disappointing, however. The Graphax was deemed all but useless in the Company’s eyes. “It is our opinion”, wrote one representative of 3M, “that the demand for axonometric drawings produced by orthographic views is very limited and we have decided not to pursue the matter any further.”[60] This signaled the end of the Graphax and of Bermont-Électromécanique.

To fully understand the difficulties of marketing inventions generated in a university setting, we must still examine an another attemp of Bernier to market his invention. In the 1960s, the LEA team succeeded in perfecting an image reproduction process on which it had worked for over ten years. The expectation was that it would revolutionize graphic reproduction techniques. Bernier therefore undertook patenting procedures to protect the new “Berfax”. However, the process was ridden with technical and legal difficulties and that prevented it from ever succeeding. The American patent office found at least fifteen interferences which Bernier’s lawyers were unable to justify.[61] Bernier was forced to seek financial support from EPM. Among the reasons he invoked to obtain the needed funds, he did not hesitate to present the patent as a means of gaining public recognition for inventive activity and, thereby, of strengthening the public image of the School.

> To establish our property rights and the rights over ‘inventions’ which [result from efforts in ‘applied science’], it is essential to protect them through patents. In addition to their potential commercial value, these patents carry an indisputable advertisement value for their

author and the institution because they constitute a certificate of originality (something like a mining claim!).[62]

In 1966, the Berfax was presented to the general public during a widely publicized press conference that attracted the interest of industrial circles. Intrigued by the promises held by the reproduction process, business and public services representatives established contacts with the EPM professor.[63] Four years later, James Keane, an engineer at Aviation Electric, succeeded in convincing him to enter into partnership for the manufacture and sale of the device.[64] Keane also had a business degree from the London County College of Commerce. His role in the establishment of the Berfax Corporation was crucial.

With two new partners, Walter Haggerty and especially Robert L. Slater, a consultant for major companies in the field of photo-reproduction, the Berfax Corporation became in 1973 a public corporation with headquarters on Wall Street.[65] Share holders managed to acquire a capital of US $35,000 and to obtain an additional US $166,000 loan from the New York Bank. It had a Canadian subsidiary, Berfax Ltd., to which the federal and provincial governments granted close to Can $630,000. The new partners thus rapidly provided the Corporation with considerable recognition. Their objective was to become a major player in the reproduction market, which includes competitors in the lithographic, photographic (Kodak) and xerographic (Xerox and 3M) industries.[66] The business plan projected a net worth of US $10 million for 1979.[67] A major obstacle hindered the project, however. The patent was still pending, and this jeopardized the future of the company.[68] The Berfax Corporation folded by the end of the 1970s and few factors beyond the patenting failure help to explain the demise of the spin-off company. The economic and technological risks were not greater than what any new company usually meet.

Although EPM did use the Centre de recherches to promote the contributions made by its professors to scientific and technological development, it failed to provide them with the resources and structures required to facilitate the transfer of technologies and the management of patents. To launch his inventions beyond the university, Bernier learnt basic marketing techniques and negotiated almost singlehandedly with business representatives and lawyers. Under such conditions, his inventions had a far more limited chance of success than if they had been developed in an industrial institution. They lacked the indispensable support of a legal department capable of influencing research programs on the basis of existing patents, marketing administrators able to assess commercial potential and technicians able to operate the transfer of technology from the laboratory to the production chain.

Conclusion

Between 1937 and 1971, an independent inventor occupied a central position at École Polytechnique de Montréal. His wide range of activities is a testimony to the fact that such an individual can be productive in an academic institution. The creation of a laboratory in electronics, the development of a team of collaborators, mechanics and technicians, the production of numerous inventions, the patent applications and the establishment of companies constitute the many achievements of a life-long undertaking.

As an independant inventor, Bernier had specific reactions to the opportunities and constraints provided by his institutional affiliation. In the context of burgeoning and developing research at EPM, Bernier was able to promote invention as an integral part of "applied research", and thereby assist the EPM Board in increasing the visibility of the institution and in generating new links with industry. When he became Chairman of the Centre de recherches in 1953, Bernier not only provided invention with legitimacy but was also influential in providing it with better institutional conditions.

He did, however, meet with important difficulties in commercializing his inventions. Marketing failures of the Lectron, the Graphax and the Berfax bear witness to the fact that the university milieu often fails to provide favorable conditions for the commercialization of inventions made in its laboratories. In Bernier's case, the relative isolation of EPM from industrial circles and the limited interest of its administration in providing capital and in establishing structures suitable for technology transfer might explain why the inventor-entrepreneur had to go outside the institution's structure to find he expertise to commercialize his inventions.

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[1] For examples of these themes of research, see John W. Servos, "The Industrial Relations of Science: Chemical Engineering at MIT, 1900-1939," Isis 71 (1980), 531-549; Terry Shinn, "Des sciences industrielles aux sciences fondamentales: la mutation de l'École supérieure de physique et de chimie, 1882-1970," Revue française de sociologie 22 (1981), 167-182; J. F. Donnelly, "Representations of Applied Science: Academics and Chemical Industry in Late Nineteenth Century England," Social Studies of Science 16 (1986), 195-234; Charles Weiner, "Patenting and Academic Research: Historical Case Studies," Science, Technology, & Human Values 12 (1987), 50-62; Rima D. Apple, "Patenting University Research: Harry Steenbock and the Wisconsin Alumni Research Foundation," Isis 70 (1989), 375-394; Christophe Lecuyer, "The Making of a Science-Based Technological University: Karl Compton, James Killian, and the Reform of MIT, 1930-1957," Historical Studies in the Physical and Biological Sciences 23 (1992), 153-180; Rebecca S. Lowen, "'Exploiting a Wonderful Opportunity': The Patronage of Scientific Research at Stanford University, 1937-1965," Minerva 30 (1992), 391-421; Bruce Seely, "Research, Engineering, and Science in American Engineering Colleges: 1900-1960," Technology and Culture 34 (1993), 344-386; Henry Etzkowitz, "Knowledge as Property: The Massachusetts Institute of Technology and the Debate Over Academic Patent Policy," Minerva 32 (1994), 383-421; John W. Servos, "Changing Partners: The Mellon Institute, Private Industry, and the Federal Patron," Technology and Culture 35 (1994), 221-257; Ronald Kline, "Construing 'Technology' as 'Applied Science': Public Rhetoric of Scientists and Engineers in the United States, 1880-1945," Isis 86 (1995), 194-221; and John W. Servos, "Engineers, Businessmen, and the Academy: The Beginnings of Sponsored Research at the University of Michigan," Technology and Culture 37 (1996), 721-762.

[2] Historical sources for this case are from the Archives de l'École Polytechnique de Montréal (AEPM), especially the Fonds Jean-Charles Bernier (FJCB) and the Fonds du service de la recherche contractuelle (FSRC). We have also interviewed, in 1996-1998, some of the collaborators of J.-C. Bernier: Renato Bosisio, Louis Courville, Jean-Guy Deschênes, Bernard Lanctôt, Roger-P. Langlois and Jules O'Shea.

[3] Thomas P. Hughes, American Genesis: A Century of Invention and Technological Enthusiasm, 1870-1970 (New York, 1989) and Elmer Sperry: Inventor and Engineer (Baltimore, 1971). The concept of independent inventor was used before Hughes by J. Jewkes, D. Sawers, and R. Stillerman, The Sources of Invention (New York, 1969).

[4] In a recent publication on technological systems, Hughes attributed to some university scientists and engineers the independent inventor's characteristic of being "radical inventors", because their institution allowed them to work on freely chosen "reverse salient" of non commercialized technological systems. T.P. Hughes, "L'histoire comme système en évolution," Annales: histoire, sciences sociales 53 (1998), 839-857; at page 847.

[5] For a complete survey of EPM history, see Robert Gagnon, Histoire de l'École Polytechnique de Montréal: La montée des ingénieurs francophones, 1873-1990, (Montreal, 1991). On McGill University, see S. B. Frost, McGill University: For the Advancement of Learning, 2 vol. (Montreal, 1980).

[6] In 1909, for instance, 45 percent of the graduates came from the province of Quebec, 40 percent from the rest of Canada and 15 percent from outside Canada. In 1911, almost 80 percent of graduates worked in the private sector. Yves Gingras and Robert Gagnon, "Engineering Education and Research in Montreal: Social Constraints and Opportunities," Minerva 26 (1988), 53-65; at page 61.

[7] Thus, in 1898, they hired the New Zealander Ernest Rutherford, who was trained in the Cavendish Laboratory at Cambridge University.

[8] In 1904, almost half of the graduates worked in the public sector. Association des anciens élèves de l'EPM, Annuaire 1913 (Montreal, 1913).

[9] A. B. Macallum to L. Gouin, 10 February 1919, Archives of the National Research Council of Canada (ACNR).

[10] About these two governmental agencies, see Wilfrid Eggleston, National Research in Canada: The NRC, 1916-1966 (Toronto, 1978); and O. J. Goodspeed, DRB: A History of the Defense Research Board (Ottawa, 1958). Concerning the impact of the First World War on university research, see Robert Gagnon, "La Seconde Guerre mondiale et l'émergence de la recherche au Quebec," in L'impact de la Deuxième Guerre mondiale sur les sociétés canadienne et québécoise, ed. Serge Bernier (Ottawa, 1998), 143-158.

[11] Concerning Welter, see Jean-Marie Desroches and Robert Gagnon, "Georges Welter et l'émergence de la recherche à l'École Polytechnique de Montréal (1939-1970)," Recherches sociographiques 24 (1983), 39-54; et Gagnon, Histoire de l'École Polytechnique de Montréal, 275-305. Regarding the emergence of research in Quebec universities, see Raymond Duchesne, "D'intérêt public et d'intérêt privé: l'institutionnalisation de l'enseignement et de la recherche scientifique au Quebec (1920-1940)," in L'avènement de la modernité culturelle au Quebec ed. Yvan Lamonde et Esther Trépanier (Quebec, 1986), 189-230; and for the prevailing context of the development of science in twentieth century Quebec, see Luc Chartrand, Raymond Duchesne, and Yves Gingras, Histoire des sciences au Quebec (Montreal, 1987), 239-429.

[12] Armand Circé, L'activité de Polytechnique en 1942-1943 (Montreal, 1943), 8.

[13] EPM, Projets de statuts pour le Centre de recherches, 30 October 1946, FSRC.

[14] EPM, Centre de recherches (Montreal, 1947), 7, FSRC.

[15] Augustin Frigon, "Conférence prononcée lors du banquet de clôture des fêtes du soixante-quinxième [sic] anniversaire," Revue trimestrielle canadienne 34 (1948), 356.

[16] About wireless telegraphy and radio at that time, see Patrice Flichy, Une histoire de la communication moderne: Espace public et vie privée (Paris, 1991), 136-159; and Erik Barnow, History of Broadcasting in the United-States, vol. 1, A Tower in Babel (New York, 1966).

[17] After his studies at EPM in 1910, Frigon went to MIT where he specialized in electricity. The following year, he joined the EPM professors' staff. In 1920, he made his doctoral diploma at the École supérieure d'électricité de Paris. When he returned in 1923, he was nominated director of EPM. Five years later, the federal government invited him to sit as commissioner for the Royal Commission on Broadcasting (Aird Commission). Then in 1936, Frigon played a central role in the creation of the Canadian Broadcasting Corporation (CBC). For more details on Frigon's involvement in Canadian broadcasting, see Alain Canuel, "Augustin Frigon et la radio nationale au Canada," Scientia Canadensis 19 (1995), 29-50.

[18] J.-A. Villeneuve to A. Frigon, 10 December 1926, AEPM.

[19] J.-C. Bernier to Armand Circé, 22 March 1945, AEPM; and La Presse, 3 April 1929.

[20] A. Frigon to Henry M. Tory, 5 February 1930, AEPM.

[21] J.-A. Villeneuve to S. P. Eagleson, 3 February 1930, AEPM.

[22] J.-C. Bernier, "La saturation thermionique," Revue trimestrielle canadienne 16 (1930), 369-395.

[23] S. P. Eagleson to A. Frigon, 30 October 1933, AEPM.

[24] In Montreal, the newspaper La Presse imitated its American counterparts and experimented with the broadcasting of images. See La Presse 10 and 24 October 1931; and Broadcasting 1 (15 November 1931), 28.

[25] For further details on television at EPM, see Robert Gagnon and Jean-François Auger, "L'invention en milieu universitaire: les recherches sur la télévision à Polytechnique dans les années 1930," Scientia canadensis 48 (1995), 51-75.

[26] About the history of television, see Albert Abramson, The History of Television: 1880-1941 (Jefferson, 1987); Joseph H. Udelson, The Great Television Race: A History of the American Television Industry, 1925-1941 (Alabama, 1982) ; and David E. and Marshall John Fisher, Tube: The Invention of Television (Washington, 1996). Regarding the concept of paradigm applied to technology, see Edward Constant, "A Model for Technological Change Applied to the Turbojet Revolution," Technology and Culture 14 (1973), 553-572 ; and G. Dosi, "Technological Paradigms and Technological Trajectories," Research Policy 11 (1982), 147-162.

[27] But the executives of Westinghouse believed that the mechanical paradigm held more promise than Zworykin's invention. The latter wrote, "the work was stopped

temporarily in order to work with the mechanical method of picture transmission that was still in progress". Quoted in Abramson, 79.

[28] J.-C. Bernier, "Scanning Methods and Apparatus," Canadian Patent No. 344307, 4 September 1934.

[29] J.-C. Bernier, "Un Laboratoire d'Électronique à l'École Polytechnique," Revue trimestrielle canadienne 24 (1938), 434-451.

[30] Hughes, American Genesis (n. 3 above), 53.

[31] Hughes, 55.

[32] J.-C. Bernier, "Un laboratoire d'électronique," and from the same Bibliographie des travaux de recherches accomplis jusqu'ici, n.d., AEPM.

[33] When he spoke about his laboratory, Bernier had no doubt about the technological orientation of his work. "L'Électronique est, en premier lieu, la science théorique et technique des tubes électroniques, de leur étude expérimentale et de leur construction; naturellement, nous considérons aussi du domaine de l'électronique, les applications nombreuses et variées des tubes à vide et à atmosphère raréfiée." EPM (n. 14 above), 22. Concerning the development of electronics at that time, see John P. Collet, "The History of Electronics: From Vacuum Tubes to Transistors," in Science in the Twentieth Century ed. John Krige and Dominique Pestre (Amsterdam, 1997), 253-274.

[34] J.-C. Bernier, R.-P. Langlois and P.-L. Piché, "Pompes à vide élevé: contribution à cette technique," Revue trimestrielle canadienne 40 (1954), 11-16.

[35] "R.-P. Langlois," Commerce 75 (February 1973), 26-34.

[36] For a sociological characterization of university researchers as agents within a scientific field, see Pierre Bourdieu, "La spécificité du champ scientifique et les conditions sociales du progrès de la raison," Sociologie et sociétés 7 (1975), 91-118.

[37] Bernier received his master degree in 1945 for scholarly work done fifteen years earlier when the master degree did not yet exist at EPM. J.-C. Bernier to Armand Circé, 22 March 1945, AEPM.

[38] His publications were closely associated with EPM, such as Revue trimestrielle canadienne (where Bernier published 7 articles), Poly (3), L'Ingénieur (2) and Les ingénieurs de Polytechnique et le progrès du Quebec (1).

[39] We refer to J.-C. Bernier, "La recherche scientifique," Les ingénieurs de Polytechnique et le progrès du Quebec (Montreal, 1945), p. 105-108. Notice that in "La recherche en génie," Poly 11 (1964), 4-5, he held similar statements. Regarding the discourse of engineers on pure science and applied science, see Kline (n. 1 above).

[40] Bernier, "La recherche en génie," 4.

[41] He wrote, "Puisque la recherche est essentielle à l'établissement de nouvelles industries et à la survivance des industries existantes, il est certain que notre déficience industrielle est attribuable, entre autres causes, à notre négligence de ce facteur vital." Bernier, 4.

[42] J.-C. Bernier, Rapport général du Centre de recheches depuis sa fondation, 29 September 1955, AEPM.

[43] The Centre de recherches Work Committe stated that, "si le même projet n'avait pu être financé par l'extérieur qu'au prix de certaines difficultés telles que, par exemple, le cas d'un travail de résultat très incertain ("idée folle"), le C. de R. [Centre de recherches] considérerait cette difficulté comme une raison bien valable pour qu'il se charge du projet." Centre de recherches, Procès-verbaux du Comité des travaux, 14 November 1955, AEPM, 5.

[44] See Weiner, Apple, Lecuyer, and Etzkowitz (all at n. 1 above).

[45] J.-C. Bernier, "Le département de génie électrique et de génie physique," L'ingénieur 44 (1958), 70-72.

[46] For examples of industrial laboratories, see David A. Hounshell and John Kenly Smith, Science and Corporate Strategy: Du Pont R&D, 1902-1980 (Cambridge, 1988), and Leonard Reich, The Making of American Industrial Research: Science and Business at G.E. and Bell, 1876-1926 (Cambridge, 1985).

[47] Hughes, American Genesis (n. 3 above).

[48] On university spin-off analyses, see Henry Etzkowitz, Andrew Webster, and Peter Healed ed. Capitalizing Knowledge: New Intersections of Industry and Academia (New York, 1998); Brian Rappert and Andrew Webster, "Regimes of Ordering: The Commercialization of Intellectual Property in Industrial-Academic Collaborations," Technology Analysis and Strategic Management 9 (1997), 115-30; Rikard Standkiewicz, "Spin-off Companies From Universities," Science and Public Policy 21 (1994), 99-107; Alistair M. Bret, David V. Gibson, Raymond W. Smilor, eds., University Spin-off Companies: Economic Development, Faculty Entrepreneurs, and Technology (Savage, 1991); Everett-M Rogers, "The Role of the Research University in the Spin-off of High-Technology," in Innovation: A Cross-Disciplinary Perspective, ed. Kjell Gronhaug and Geir Kaufmann (Oslo/New York, 1988), 443-55.

[49] Eggleston (n. 10 above), 287.

[50] CPDL, Agreement Handling of Patent Matters, (Ottawa, n.d.), 2, ACNRC.

[51] Regarding Bernier and the CPDL, we refer to J.-C. Bernier to General Secretary of CPDL, 2 October 1958, FJCB; F. R. Charles to J.-C. Bernier, 15 October 1958, 8 March, 20 June, and 20 September 1960, FJCB; J.-C. Bernier to F. R. Charles, 23 October 1958, 3 May 1960, and 15 July 1960, FJCB; and note of J.-C. Bernier, "Nos raisons," 3 November 1960, FJCB.

[52] C.F. Kipp to K.-C. Bernier, 19 October 1960, FJCB; J.-C. Bernier, "A New Electronic Tube, the LECTRON," Institute of Radio Engineers Symposium on Communications (Montreal, 1960), FJCB.

[53] See U.S. Patent Application No. 71576, 25 November 1960. The Lectron was never patented, in part because the lawyers failed to demonstrate that the principal claims were not in interference with the reference of record made by the US Commissioner of Patents. J.-M. Robic to J.-C. Bernier, 29 November 1961, 23 January and 20 February 1962, FJCB.

[54] R. A. Correa to J.-C. Bernier, 27 December 1960, FJCB.

[55] J.-C. Bernier to F. C. Bumb, 17 January 1961, FJCB.

[56] In 1961, his attorneys registered a patent application for an "Axonometric Drafting Instrument" at the Patent Office in Washington. See U.S. Patent Application No. 104562, 2 April 1961; Raymond A. Robic to J.-C. Bernier, 8 May 1961, FJCB. Two years later, the U.S. Patent Commissioner gave a patent to Bernier for his Graphax. J.-C. Bernier, "Axonometric Drafting Instrument," U.S. Patent No. 3070894, granted 1 January 1963; and R. A. Robic to J.-C. Bernier, 4 January 1963, FJCB.

[57] J.-C. Bernier, "A New Axonometric Drawing System," Design Engineering (May 1963), and "A New Axonometric Drafting Instrument," Graphic Science 5 (February 1963).

[58] To someone who asked for information about his device, Bernier responded, "I intend [to commercialize the Graphax] as a consequence of the wide interest indicated by yourself and many others." J.-C. Bernier to A.H. Taylor, 14 April 1964, FJCB.

[59] Manuscript note of J.-C. Bernier, n.d., FJCB.

[60] W. L. Peterson to J.-C. Bernier, 9 August 1967, FJCB. Concerning the relations between Bernier and 3M, see also W.L. Peterson to J.-C. Bernier, 10 January 1967, FJCB.

[61] J.-M. Robic to J.-C. Bernier, 22 January 1965, 18 January 1966, 2 February 1967, and 20 November 1970, FJCB; U.S. Patent Application No. 592 411, 7 November 1966.

[62] J.-C. Bernier to EPM, 19 January 1966, FJCB.

[63] J.-C. Bernier to E. Darsigny, 19 December 1966, FJCB; P. Thibault to J.-C.Bernier, 14 June 1966, FJCB; Y. Marcoux to J.-C. Bernier, 20 June 1966, FJCB; W. D. Ardell to J.-C. Bernier, 26 September 1966, FJCB.

[64] J. Keane, Berfax: A Business Proposition, n.d., FJCB; J.-C. Bernier et J. Keane, Agreement, 15 February 1970, FJCB.

[65] Berfax Corporation: Confidential Memorandum, 12 September 1974, p. 9, FJCB.

[66] Berfax Corporation, 6-7.

[67] Berfax Corporation, 20.

[68] In fact, Bernier made a mistake in publishing the details of his invention in a paper before having secured a patent. U. S. Bernier, "Berfax... Un nouveau procédé," L'Ingénieur 52 (October 1966), 26-34. Patent Application No. 592411, 7 November 1966. J.-C. "There is no doubt that your publication of a paper on Berfax in October 1966 issue of the periodical 'l'Ingénieur' has had disastrous results insofar as your right to secure patent protection on the whole of the invention as disclosed therein is concerned." J.-M. Robic to J.-C. Bernier, 20 November 1970, FJCB.