malization and a tentative calculation yielded a value almost in agreement with experiment.

This problem of the level shift is different from the scattering process, but it was conceivable that the renormalization which was effective in avoiding infinities in the scattering process would be workable in this case as well. In fact, the contact transformation method that Pauli and Fierz devised to solve the scattering problem could be applied to this case, clarifying Bethe's calculation and justifying his idea. Therefore the method of covariant contact transformations, by which we did Dancoff's calculation over again would also be useful for the problem of performing the relativistic calculation for the Lamb shift. This was our prediction.

The calculation of the Lamb shift was done by many people in the United States (*24*). Among others, Schwinger, commanding powerful mathematical techniques, and by making thorough use of the method of covariant contact transformations, very skillfully calculated not only the Lamb shift but other quantities, such as the anomalous magnetic moment of the electron. After long, laborious calculations, less skillful than Schwinger's, we (*25*) obtained a result for the Lamb shift which was in agreement with that of the Americans. Furthermore, Feynman (*26*) devised a convenient method based on an ingenious idea which could be used to extend the approximation of Schwinger and ours to higher orders, and Dyson (*27*) showed that all infinities appearing in quantum electrodynamics could be treated by the renormalization procedure to an arbitrarily high order of approximation. Furthermore, this method devised by Feynman and developed by Dyson was shown by many people to be applicable not only to quantum electrodynamics, but to statistical mechanics and solid state physics as well, and provided a new, powerful method in these fields. However, these matters will probably be discussed by Schwinger and Feynman themselves and need not be explained by me. So far I have told you the story of how I played a tiny, partial role in the recent development of quantum electrodynamics, and here I would like to end my talk.

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NEWS AND COMMENT

University of Montreal: Where the Two Canadas Meet

Montreal, Quebec. The Canadian Confederation, established in 1867 with the political union of several formerly separate British colonies, has been called a *marriage de convenance* between French- and English-speaking Canadians. The marriage may prove lasting, but it has been far from blissful, and, while relatively few Canadians actively seek a divorce, many fear for the future of the confederation. Nowhere in Canada are the problems of cultural, economic, and hence political compatibility between Canada's two founding "races" so important as here in this burgeoning metropolis where some million and a half French-speaking *Québecois* and about 500,000 English-speaking Quebecers live together. Montreal stands squarely at Canada's cultural interface, and it is largely because of this fact that the fast-growing University of Montreal is virtually certain to become one of Canada's most important universities.

Indeed, the influence of this young French-speaking university, which a few years ago began to emerge from a state of financial misery and intellectual isolation, ultimately may be critical to confederation. In the decades just ahead, tens of thousands of French-Canadian students, eager and impatient members of the rapidly developing Quebec middle class, will receive their intellectual training at Montreal. Moreover, research done at the university and its affiliated institutions may have a profound effect on the social, political, and economic development of Quebec.

Historically, Laval University, in Quebec City (the provincial capital), has been Quebec's most important French-speaking institution, and Laval has important ambitions for the future. However, from the standpoint of influencing Quebec's development and the province's relations with the rest of Canada, Laval will lack the University of Montreal's strategic advantage of being at the heart of Quebec's ethnically diverse and dynamic metropolitan center.

In Montreal the hard problems associated with the French presence in North America are quite visible. As a member of a French-speaking minority of about 5 million, the *Québecois*'s all-important problem is that of maintaining his cultural identity while sharing the benefits of a continental social and economic system dominated by more than 200 million English-speaking Canadians and Americans. In Quebec City, relatively few of the 350,000 or so inhabitants are English-speaking, and business is usually done in French. The *Québecois* living there can avoid acquiring the "minority complex" typical of the French Canadians of Montreal, who deeply resent the domination of industry, finance, and much

of the retail business of their home city by the English-speaking inhabitants.

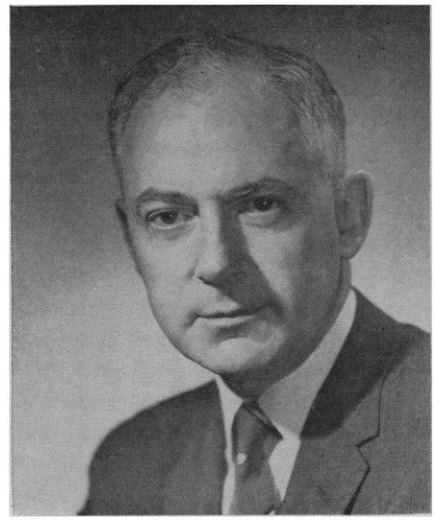
The *Québecois* of Montreal resent the fact that, to earn a living, they often must speak English on the job. Moreover, even for many bilingual French Canadians, access to the management ranks of English-Canadian-owned companies has been difficult, though in recent years attractive opportunities have been opening up to well-qualified *Québecois*.

The tensions arising from the English-speaking minority's economically dominant position in Montreal are, in the judgment of a number of thoughtful Canadians, the single most important cause of friction between Quebec and English Canada. If these tensions should worsen, perhaps from an economic recession or from other circumstances deepening the *Québecois*'s frustrations, the consequences for confederation might be dangerous indeed. While political independence for Quebec is regarded by all separatists as a psychological necessity, it is also viewed, at least by the Rassemblement pour l'Indépendance Nationale, the principal separatist party, as a step toward socialism and the planned economy. In a time of crisis, the promises of economic betterment held out by the separatist-socialist leaders could be highly seductive.

There are, of course, causes for the *Québecois*'s discontent other than his economic frustrations at home. An important and long-standing grievance stems from the failure of Ontario and other provinces to provide publicly supported French schools for the French-Canadian minorities living within their borders. Still other complaints, such as charges of discrimination against French Canadians in the federal service and the armed forces, always show up on the long list of alleged, and often real, wrongs.

However, if the *Québecois* did not suffer from a case of wounded pride arising from his inferior economic position in Montreal, where about 40 percent of the people of Quebec live, less bitterness might attach to his other grievances. Building up the French Canadian's self-confidence and pride—his psychological capital—may turn out to be an enormously important by-product of the University of Montreal's efforts to help Quebec meet the challenges of a technological age.

The reasons for the *Québecois*'s economic inferiority in his own province are complex, some of them going back to the British conquest of 1760. But the English Canadian's old stereotype of Quebec as an ultraconservative, inward-looking society once contained no little truth. Though the French Canadians long have had a provincial government at their disposal, only within the last decade have they begun to make use of it to bring education and other social services up to modern standards.



Roger Gaudry

The University of Montreal's brief history illustrates the point. In 1935, 15 years after the university was established as a separate institution (from 1878 to 1920 it was a branch of Laval), its annual subsidy from the provincial government amounted to only $25,000. In 1945 the subsidy was still less than $500,000, which meant that student fees comprised most of the university's resources. Though the influence of the Catholic Church was dominant in its administration, the university received from the church little or no direct financial support.

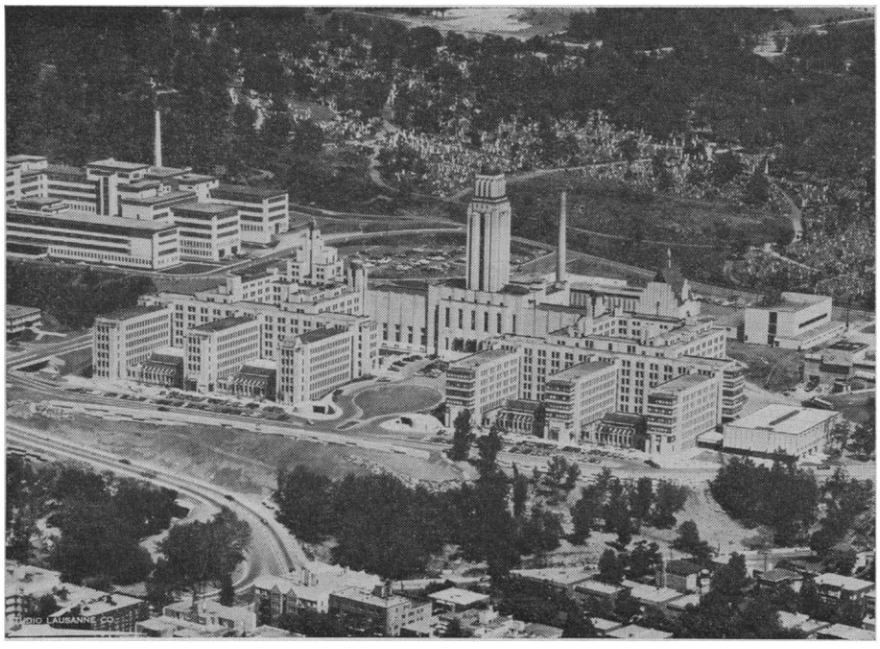
It was a university only in the most liberal sense of that well-stretched term. For 30 years social science courses were offered only at night, by lawyers, journalists, priests, and the like. The Faculté des Sciences had a nucleus of career professors from its beginnings in 1920, but until the 1950's the *faculté* performed mainly a service function, especially for students of medicine, dentistry, and pharmacy. There was little research, and few Ph.D.'s were awarded. In traditional Quebec, those who aspired to professional status rarely looked to the sciences. They trained, as a matter of course, for the priesthood, the law, or medicine.

Although the university's resources and programs are still modest by comparison with those of leading American and Canadian institutions, its growth since 1955, and especially during the past 6 years, has been dramatic. Its annual operating budget now exceeds $20 million, more than half of which comes from the provincial government; several additional millions, largely from federal sources, are available for the support of research. The university's career faculty numbers about 900, and its regular student body totals 12,000, exclusive of the 3000 students attending its affiliated engineering and commercial schools.

Quebec might have expanded its educational and other services sooner had provincial politics not been dominated for so long by Maurice Duplessis, leader of the Union Nationale party and prime minister of Quebec during most of the period from 1936 until his death in 1959. Quebec's industrial and urban growth has accelerated since 1940. But Duplessis, favored by a system of representation that denied urban voters their rightful voice, was able to ignore the wishes of labor and progressive middle class elements.

His political philosophy was the kind that John D. Rockefeller would have admired and Nelson Rockefeller would despise. In Duplessis's Quebec, taxes were low, labor was cheap, and entrepreneurs (well supplied with capital from foreign and English-Canadian sources) were encouraged to exploit the province's markets and its human and material resources largely as they saw fit. Duplessis, through tactics resembling those of a Dixiecrat or states'-righter, kept political control by denouncing federal initiatives in the welfare field as contrary to provincial rights. He stirred up and pandered to the *Québecois*'s deeply rooted fear of being culturally and politically submerged by Canada's English-speaking majority. In mock battles with Ottawa, Duplessis waved the flag of provincial autonomy.

Quebec's "quiet revolution" began in earnest after the Liberal Party swept to power in 1960 under the leadership of Jean Lesage. The Liberals, primarily the party of the urban intellectuals and middle class, set out to revitalize the provincial government with an infusion of bright young men,



University of Montreal dominates the west flank of Mount Royal.

to put an end to old-fashioned patronage practices, and to build the programs and structures necessary for a modern system of public services. Improving education was a major goal. A ministry of education was created, and a commission to study education at all levels was set up. The commission's report is leading to major reforms, though now the responsibility for carrying them through has fallen to the Union Nationale party, which has returned to power in a more progressive reincarnation by capturing the government from the Liberals in the provincial elections last June.

The University of Montreal is working out a proposal, for submission to the government, to bring about some of the reforms which the commission recommended. Though discussion of its terms continues, the proposal's principal features seem to be set. The university, whose chancellor and board chairman is now the Archbishop of Montreal, Cardinal Paul-Emile Léger, would have a new civil charter. The charter revision would ratify the fact that, to all intents and purposes, the university has become a secular institution. The university would be governed by a new administrative council, a third or more of whose members would be chosen by the Quebec government, the university's principal source of financial support. Faculty, alumni, the Church, the university administration, and, after a fashion, even the students, would all be represented in the new "democratic" governing body.

Whoever was chosen by the council as its president would become the university's chancellor. The university's administrative head, the *recteur* (now chosen by the Church) would also be named by the council. Cardinal Léger last year took a major step in the secularization of the university when he appointed Roger Gaudry, a distinguished chemist, as the institution's first lay *recteur*. The Cardinal's influence on the university's evolution has been paradoxical. As Archbishop and chancellor, this liberal churchman has sought to reduce the Church's voice in the university's affairs.

The university entered its current phase of rapid and dynamic growth at the time of a strong resurgence of Quebec nationalist feeling. The bombings and other terrorist acts by separatist fanatics in 1963 and 1964 were an extreme manifestation of this feeling. In a sense, every French Canadian is a nationalist. The *Québecois* knows that his provincial government and institutions are his chief instruments for cultural survival.

The ultimate expression of Quebec nationalism is separatism. Three years ago separatism was enjoying something of a vogue in the student milieu, though many observers believe that only a minority of students held separatist views. That separatist sentiment reached significant proportions at the University of Montreal is not disputed. The head of the political science department, Dale C. Thompson, an Albertan who earned his doctorate at the University of Paris, told *Science*: "There was a time three years ago that a girl had to show she was a separatist to get a date." According to Thompson, French-Canadian professors in the Faculté des Sciences Sociales tended to write off confederation.

Thompson and other observers agree that, since 1964, separatist sentiment, or at least its aggressive expression, has subsided, at the university and elsewhere in Quebec. A partial explanation is that in the spring of 1963 the Conservative Party, headed by John G. Diefenbaker, a bluff westerner whose "one-Canada" doctrine is the despair of French Canadians, lost the national elections to Lester B. Pearson's Liberal party.

Pearson is no hero to the *Québecois*, but he is considered well-meaning. He has made a number of concessions to Quebec's desire for a greater share of tax revenues and for a greater degree of provincial autonomy (through having its own social security plan, for example). Moreover, Pearson has promised a new deal for French Canadians in the federal service.

Gaudry and many other Canadians believe that, if Quebec should ever choose to become independent, economic disaster for Quebec, as well as for the rest of Canada, would result. In such an event some Canadians would not be surprised if some provinces eventually sought annexation by the United States. Given the high stakes, the University of Montreal's influence on the questions of separatism and confederation is of great importance.

Edouard Cloutier, the 25-year-old political science student who heads the student government, indicates that perhaps no more than a third of the Montreal student body shares his separatist convictions. Some university people say the separatist element is much less than a third. In winning office in elections last spring, Cloutier ran as a student organizer, though his separatist views were known. However, many students are indifferent to campus politics (46 percent voted in the spring election), and university officials discount the significance of Cloutier's victory.

Cloutier is nevertheless in a strate-

gic position to work for the separatist cause. His full-time paid adviser is André d'Allemagne, a founder and the first president of the Rassemblement pour l'Indépendance Nationale. These activists will have to proceed prudently, for Montreal students have shown they can become surfeited with separatist polemics. Last November a mob of 1000 engineering students burned an entire issue of the student newspaper, *Le Quartier Latin*, whose staff had become stridently separatist.

Gaudry says that none of the deans of the various *facultés* are separatists and that few of his department heads hold separatist views. While not necessarily a separatist himself, Michel Brunet, head of the history department, through his writings on Quebec's past, has provided the separatist movement with many "anticolonialist" arguments. Maurice Séguin, also a history professor, is another popular lecturer whose students often turn up in separatist ranks. On the other hand, the history department has been getting new professors, including an American Ph.D. from Columbia. Students are getting some views of Quebec and the world other than those provided by Séguin and Brunet.

Indeed, though recruiting faculty for a French-speaking university on a largely English-speaking continent presents special problems, the resulting diversity of backgrounds is a safeguard against intellectual isolation. The danger of inbreeding is obvious, and to avoid it the university has been recruiting many of its faculty members from Europe, English Canada, and the United States. Moreover, many of the French-Canadian professors have received their graduate training outside Quebec.

The university seldom can attract established scholars from foreign universities, but it believes that it is succeeding in its efforts to recruit good younger scholars. Meeting the language problem sometimes requires special concessions. For example, two young American mathematicians hired in 1965 were given research tasks for the year, with the understanding that by this fall their French would be good enough for them to teach undergraduate classes.

As the university's enrollment rises to about 20,000 on-campus students during the next 10 years, the teaching staff in some disciplines will be tripling. The science faculty, consisting now of about 100 professors, will increase to 300 by 1970. Similar growth is expected in the Faculté des Sciences Sociales.

Despite enrollment pressures and the demands of teaching, the university is encouraging its faculty to become increasingly research-oriented. Ninety percent of the members of the science faculty are reported to be doing research. The Ecole Polytechnique, the engineering school, has been weak in research, but the hope is that, under a new director, research will receive greater emphasis. Doctoral candidates have been few in engineering, however, and development of a strong research program may be slow.

(Moreover, the Ecole, while affiliated with the university, is not under the university's administration and need not always be responsive to its policies. The same is true of other affiliated institutions. "Administratively, Montreal is a patchy sort of university," a prominent English-Canadian educator observes.)

Gaudry, who is vice chairman of Canada's new advisory Science Council (*Science*, 2 September), will be seeking, to the discomfort of some of his English-Canadian colleagues on the council, to have the federal government give favored treatment to the French-Canadian universities in the support of research. Essentially, his argument is that these institutions are at a disadvantage because they have had no wealthy benefactors to help build up their research capabilities (in the way that the wealthy English Canadians of Montreal helped McGill University). They have relatively few established scientists and scholars whose research can command large grants.

Other initiatives in the interest of research also are expected. The Quebec government, at the urging of the education study commission and of the French-Canadian Association for the Advancement of Science, is expected to create two new scientific agencies: a provincial science council, to advise the government on priorities and to make grants, and a Quebec Industrial Research Center, to undertake applied research in its own laboratories and to sponsor work done in other research establishments, such as those of universities.

Success in fostering a rapid advance in science and technology in Quebec could have great political significance. Because of the weak and inadequate staffing of schools, universities, and the provincial bureaucracy in the pre-1960

Election Returns: Congress Loses Its Only Scientist

While scientists were active in the political season that ended with last week's election, none of those running for office themselves seem to have survived. Conspicuous among the losers was Weston E. Vivian, incumbent Democratic congressman from the Michigan district that includes the University of Michigan in Ann Arbor (*Science*, 26 Feb. 1965).

Vivian, the only member of Congress with a Ph.D. in science or technology—he is a graduate engineer—was defeated after one term in office by another Ph.D., Marvin Esch, a state legislator who was formerly a professor of speech at Wayne State. Elise Boulding, wife of Michigan economics professor Kenneth Boulding, ran as a write-in candidate on a platform advocating American withdrawal from Vietnam. Her campaign was intended in some measure as a challenge to Vivian, who, while liberal on domestic issues and far from enthusiastic about the war, was by no means an outspoken leader of opposition to it. Despite the fact that the race was already a close one, however, Mrs. Boulding's campaign seems to have had relatively little impact on it: she attracted between 500 and 1000 votes; Vivian lost to Esch by about 2600 votes. Vivian was a member of the House Science and Astronautics Committee. His plans for the future are still undecided.

Another loser was Cameron B. Satterthwaite, professor of physics at the University of Illinois in Urbana, who ran as a Democrat in Illinois' 22nd Congressional district. Satterthwaite lost to Republican incumbent W. L. Springer by about 40,000 votes.—E.L.

era, most recent graduates of the French-Canadian universities are believed to have been absorbed by the long-neglected "Quebec system." It is in this system, embracing French-Canadian business and industry as well as public agencies and institutions, that the *Québecois* is most comfortable. There he can advance professionally without having to adapt to English-Canadian culture.

Many French-Canadians hope that foreign-owned and English-Canadian-owned enterprises in Quebec will come to use French as the principal language of business. This hope may be illusory, inasmuch as some of the most important firms have a continental market and many of their employees come and go between Quebec and English Canada or the United States. The surest way, it seems, to provide promising and compatible job opportunities for the *Québecois* is to redouble efforts to build up his own establishments.

If the development of the Quebec system should ever lag behind the growth of the Quebec middle class, increasing numbers of young university-trained men and women are likely to become profoundly dissatisfied with their lot. The predictable consequence would be a release of political energy certain to prove destructive.

The University of Montreal's actual and potential role in fostering the development required for a prosperous and politically stable Quebec is obvious. Furthermore, this dynamic new university and its sister institutions (Laval and the new University of Sherbrooke) can, by insisting on the intellectual rigor and objectivity which scholarship requires, encourage the examination of the problems of confederation in the most realistic possible light.
—LUTHER J. CARTER

"Hindsight": DOD Study Examines Return on Investment in Research

In recent years, the Defense Department has been spending $6 billion to $7 billion a year on what is categorized as research, development, testing, and evaluation. Most of this money, $5.5 billion out of the current $6.9 billion, is for development, testing, and evaluation—activities that generally result in equipment whose military value can be measured in one way or another. Furthermore, the equipment is tangible evidence of value received when the politicians who appropriate the money inquire about the Department's vast expenditures in this area. The research category, however, presents an altogether different problem, technically and politically.

Over the past two decades, the Defense Department estimates that it has spent about $10 billion on research, with a large chunk of this sum going for undirected basic research. In the current fiscal year, Defense is spending about $1.5 billion for "research and exploratory development"; of this amount, nearly $400 million, mostly spent in universities, is for the support of basic research, and perhaps as much as $100 million in this category is for undirected research. Thus the Defense Department, which is ostensibly supposed to confine itself to the business of defense, is in fact one of the principal supporters of basic research in this country; its expenditures in this area even exceed those of the National Science Foundation, which was especially established for the purpose of supporting basic research.

The Defense Department's large presence in basic research can be traced to two facts: (i) it has always been politically easier to get money for defense than for science, and (ii) there has been faith, though little systematic evidence, that basic research ultimately pays off in military value. Over the past few years, however, the large expenditures inspired by this faith have aroused a good deal of skepticism, and, as a consequence, there has been a growing interest in studies aimed at identifying the utilitarian consequences of nondevelopmental research.

In August 1963, at the suggestion of Chalmers W. Sherwin, deputy director for research and technology, the Defense Department undertook a massive retrospective study for this purpose, with the specific object of identifying the origins of science and technology embodied in 20 major weapons systems that, in large part, comprise the backbone of this country's military defenses. Two weeks ago, the first interim report on this study, entitled Project Hindsight,* was quietly released. (Earlier this year, Sherwin was appointed Deputy Assistant Secretary of Commerce for science and technology. The director of the study is Colonel Raymond S. Isenson, an engineer with long experience in technological planning for the Army, who joined Sherwin's staff at Defense in May 1965.)

What must first be observed is that Project Hindsight is not likely to sit well with those statesmen of science who have long propounded the ideology that science pays off best when it is left free to follow its own curiosity. For the major theme that emerges from this first report on Hindsight is that the Defense Department's huge investment in basic research has had little direct consequence for advanced weaponry. A hundred arguments can be thrown at this conclusion, but the fact is that Hindsight arrives at the finding that the "contribution from recent [essentially, post-1945] undirected science to the systems we have studied appears to have been small." The report acknowledges that "The sequence of contributions in atomic and nuclear physics culminating in the discovery of fission in 1939 has had a revolutionary impact on military arms and strategy." And it points out that contemporary weaponry is almost wholly dependent on the "organized body of physical science extant in 1930—classical mechanics, quantum mechanics, relativity, thermodynamics, optics, electromagnetic theory and mathematics. . . ." But, in terms of providing a rationale for the Defense Department's huge financial support of undirected basic research, Hindsight has little to offer.

* Available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.