# Saskatchewan's role in radiotherapy research

C. Stuart Houston, MD and
Sylvia O. Fedoruk, MA

Few Canadians, much less the rest of the world, realize that Saskatchewan has led other jurisdictions in North America in several aspects of health care.

Saskatchewan's list of firsts include

- the first municipal doctor in the rural municipality of Sarnia (1914)
- the first union hospital district legislation (1916)
- the first municipal doctor legislation (1919)
- the first free tuberculosis treatment (1929)
- the first bacille Calmette Guerin (BCG) protection of student nurses (1938)
- the first province-wide radiographic survey for tuberculosis (1941)
- the first province-wide medical care plan for indigents, old age pensioners and mother's allowance recipients (1945)
- the first province-wide Medicare medical plan in the Swift Current region (1946)
- the first province-wide hospital plan (1947)
- the first province-wide medicare plan (1962).

Such developments arose from the cooperation and mutual help necessary among pioneer settlers, sparsely distributed in a relatively hostile environment. House-raising, barn-raising and the building of community amenities, such as schools and rinks, made it logical for other cooperative developments to occur.

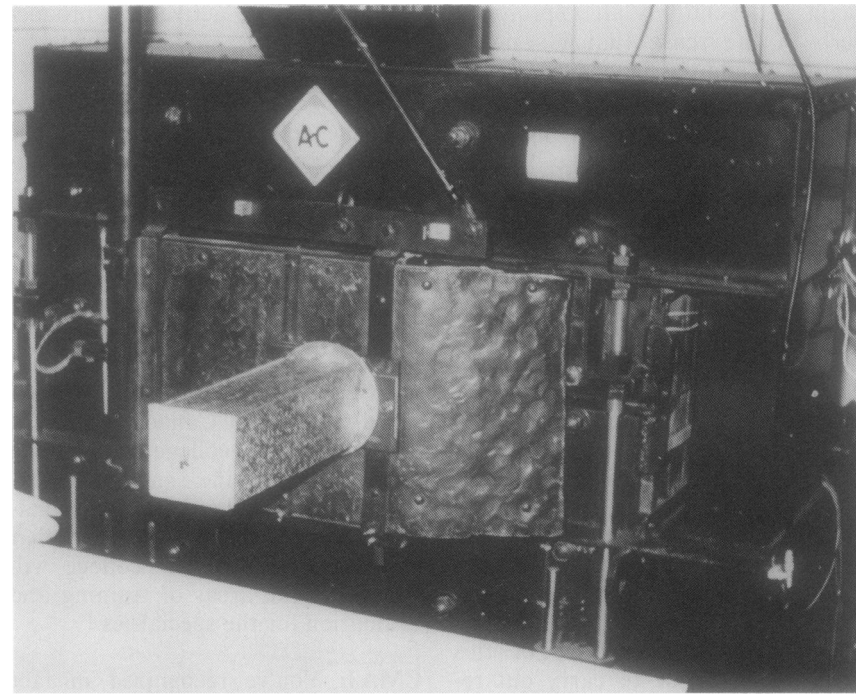
However, what is not well known is that Saskatchewan led the world in the development of high technology cancer treatment. This was due to the foresight of Dr. Allan Blair, director of cancer services for Saskatchewan and Dr. E.L. Harrington, professor of physics at the University of Saskatchewan.

The first correspondence, from Blair to Harrington on Dec. 12, 1944, suggested that a full-time physicist should be hired jointly by the Saskatchewan Cancer Commission and the university. Harrington replied 6 days later, offering his full cooperation.

Harrington displayed great wisdom in his choice of a suitable physicist Dr. Harold E. Johns, then at the University of Alberta, was offered the joint position. Johns was offered $1800 per annum as half salary by Blair on Mar. 26, 1945 and was "to give half-time to supervision of the radium and x-ray therapy equipment of the two cancer clinics". In May 1946, Johns was awarded a travelling scholarship of $800, allowing him to visit the leading centres of radiation physics in the United States and Canada. Shortly thereafter, Johns gained permission from the university and Saskatchewan Premier T.C. (Tommy) Douglas to purchase a betatron.

However, the project required further support from higher levels. University of Saskatchewan President James S. Thomson wrote to Blair on Nov. 18, 1946: "I called last week upon Dr. C.J. Mackenzie, National Research Council president, to discuss the use of a betatron in connection with the cancer treatment in this province. Dr. Mackenzie expressed some doubts as to whether research was fully advanced to make such a project practicable Matters affecting the use of atomic energy are really under the control of the Atomic Energy Commission of which General A.G.L. McNaughton is the chairman."

Blair then wrote to Mackenzie on Dec. 11, 1946 concerning the possible betatron installation: "It is not




*The Allis-Chalmers 24 million volt betatron, University of Saskatchewan*

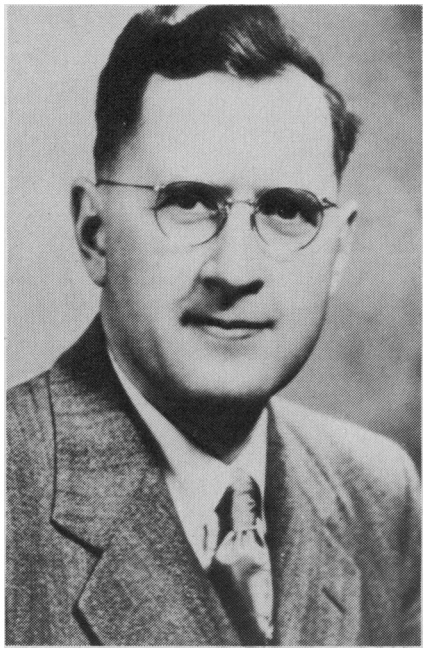
Dr. Houston is head of the department of medical imaging at the University of Saskatchewan and director of the Canadian Society for the History of Medicine.

Sylvia Fedoruk is director of physics services at the Saskatchewan Cancer Foundation, professor in the division of oncology at the University of Saskatchewan and a member of the Atomic Energy Control Board of Canada

planned to use it for any actual treatment until the physical measurements have been completed to everyone's satisfaction". (This principle of exact calibration before patient treatment became the cornerstone of all future development of radiation treatment facilities in Saskatchewan. Depth-dose data produced in Saskatoon were used around the world for many years.)

Meanwhile, other centres viewed this development in Saskatchewan with suspicion, as shown by a letter from Harrington to Thomson on Feb. 10, 1947: "In the earlier part of the discussion regarding the betatron, it appeared that a certain member of the Atomic Energy Commission, to which this matter must be referred for decision, had expressed the belief that if the reason for the betatron was mainly medical it would be in the interest of the country as a whole to locate it in a large medical centre, say in Toronto. In the mind of Dean Mackenzie, the chance of obtaining a favourable action on our request for this equipment would be better if any possible uses in medicine of the betatron were given but little emphasis".

At the end of April 1948, Johns, accompanied by Drs. R.N.H. Haslam and L. Katz of the physics department, left Saskatoon to visit the Allis-Chalmers Plant in Milwaukee where they examined their betatron. Johns wrote back to Blair on



*Dr. Harold E. Johns*

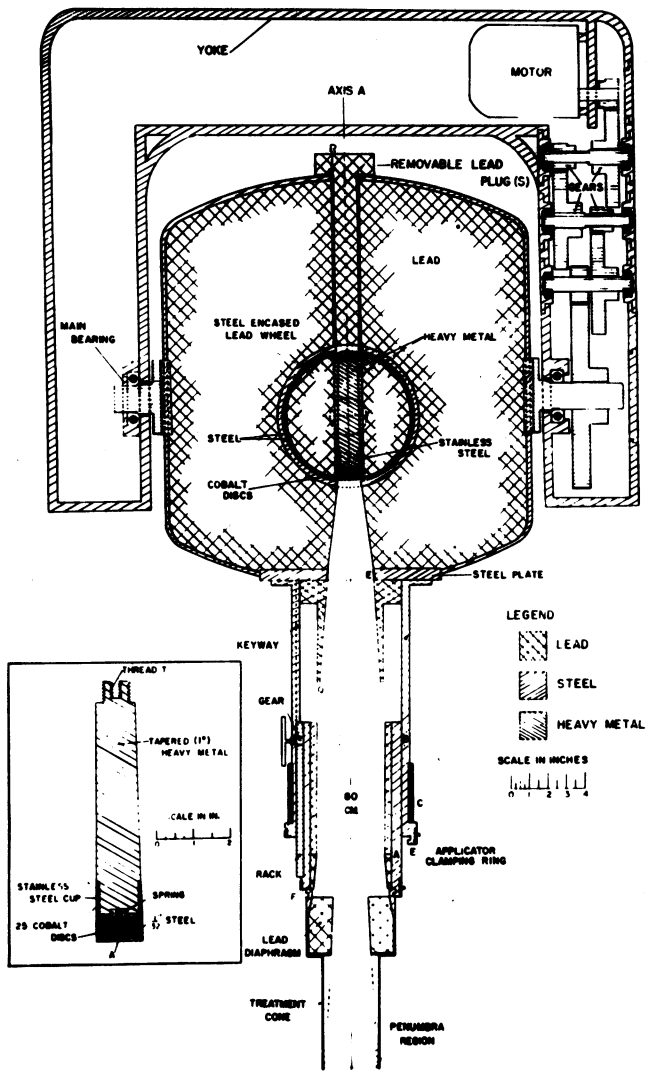



*Diagram of a cobalt unit, University of Saskatchewan. The central wheel was rotated to bring radioactive cobalt opposite the open port.*

May 12, 1948: "The betatron is finished but has not been tested . . . . the machine which we are getting is the one ordered by the University of Pennsylvania but they have no building finished to house it and have allowed us to have it . . . . We reached the University of Illinois on Monday, May 3 (1948) where we have been since . . . . Professor Kerst has been more than cooperative. First he introduced us to all his men and gave us full access to *all* blueprints, *all* reprints, keys to the building, . . . . Kerst then presented us with two doughnuts for nothing and one electron doughnut for a nominal sum . . . .

"Dr. Kerst is amazed at the rapidity with which we have pursued our program and in the fact we are getting the first betatron to be installed in any university or hospital . . . . The University of Illinois medical school gets the third betatron (second to the University of Pennsylvania) and I heard yesterday that the University of California medical school is getting one, at Berkeley."

Dr. D.W. Kerst, of the physics department of the University of Illinois at Urbana, had developed a small 2.3 million volt betatron by 1940 and 2 years later had developed a device which accelerated electrons to 20 million volts, the prototype of the Allis-Chalmers machine. Kerst had, with Dr. Henry Quastler, treated his first patient just 4 days before the Saskatchewan physicists arrived.

An addition to the University of Saskatchewan physics building was built quickly. The 24 million volt betatron was installed in the summer of 1948 and the first Saskatchewan patient was treated on Mar. 29, 1949. As M.D. Schultz said in a historical review in the *American Journal of Roentgenology* in 1975, ". . . thus started the really first concerted clinical investigation of the usefulness of the multimegavoltage as a radiotherapeutic tool".

The Saskatchewan betatron installation was used as much for physics research as for patient treatment. Until the new university hospital was completed in 1955, patients were brought across the South Saskatchewan River from Saskatoon City Hospital. Thereafter, it remained difficult to move patients several hundred metres across the campus from the hospital to the betatron in the physics building. In 17 years, only 301 patients were treated.

The operating costs of the betatron were considered exorbitant in the 1940s. Dr. T.A. Watson, now director of cancer services at Saskatoon, reported on Nov. 10, 1949 that each doughnut cost $3800 and, although guaranteed to last for 150 hours, "No doughnut which has so far been used has lasted nearly as long as this . . . the cost of the doughnut alone is $25.70 an hour . . . . Eleven patients were treated at an average cost of $224 per patient."

Nevertheless, Johns reported to the president of the Saskatchewan division of the Canadian Cancer Society that the betatron offered "a method of delivering easily a high dose to tumours at a depth, without appreciably affecting the overlying skin . . . . Radiation sickness and blood changes are much less likely".

Johns and his coworkers were not content with development of the betatron for clinical use. In June 1949, Johns visited the Chalk River reactor and had discussions with

Drs. Cipriani and Lewis of the Atomic Energy Project. The Chalk River reactor was the only installation in the world capable of producing large quantities of radioactive cobalt. Johns felt cobalt would offer even better and more economical opportunities for cancer therapy.

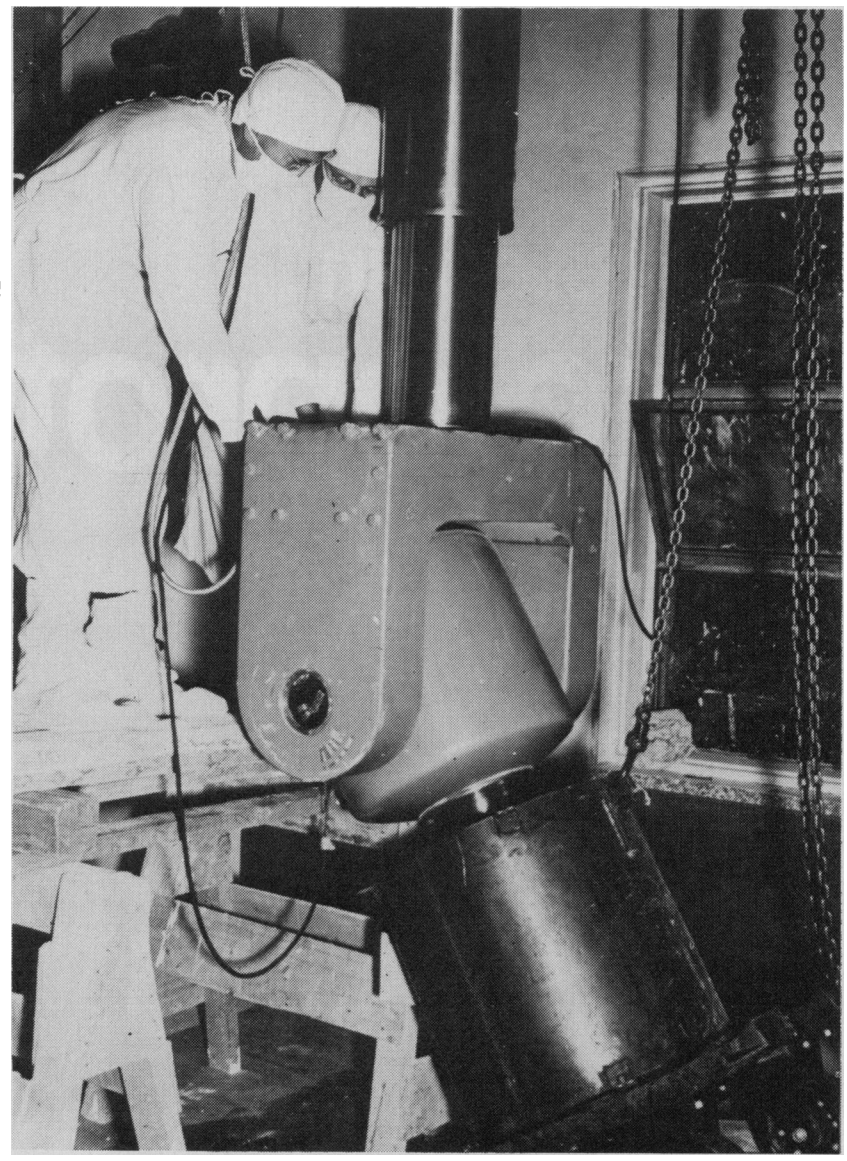
Johns wrote to University of Saskatchewan President Walter P. Thompson on July 15, 1949, presenting his proposal. He wanted an effective source of 1000 curies of cobalt 60, about 100 times the activity of any previously designed radium unit, which would allow treatment of a patient at a large focal-skin distance. Johns estimated the total cost of construction to be about $3000 and asked for "between $2500 and $7000 to cover this expense". Johns, Cipriani and Lewis agreed that this project would receive greater priority if it were considered as a research project.

A quick visit to Premier Douglas in Regina obtained assent for this expenditure. The cabinet, the treasury and the university board of governors were bypassed; there were no visits from outside accreditors. Saskatchewan's simple two-page, three-copy application for the isotope was sent to the National Research Council at Chalk River on Aug. 13, 1949.

Lewis, the father of the Canadian nuclear energy program, praised the strong case made in the application but mentioned skepticism: "Doubts have been expressed in some quarters about the wisdom of applying cobalt in this way for therapeutic work".

Three radioactive cobalt sources had been put in the Chalk River pile to "cook" in the fall of 1949. The first of these sources was delivered to the University of Saskatchewan on July 30, 1951 and the second to the University of Western Ontario (UWO) on Oct. 16, 1951. The third source, destined for the United States, was not released until 1952.

Each cobalt source was 2.5 cm in diameter and 1.25 cm thick and, as Johns had forecast, had an approximate strength of 1000 curies. The Saskatoon unit was designed by Johns and Lloyd Bates, a graduate student; it was built by Johnny MacKay, the proprietor of Acme Machine and Electric in Saskatoon; and was installed in Room 167 in the newly constructed cancer wing, adjacent to the medical college, on Aug. 17, 1951. The room was hardly ready for use; the walls were still being plastered, the concrete floor yet to be poured.

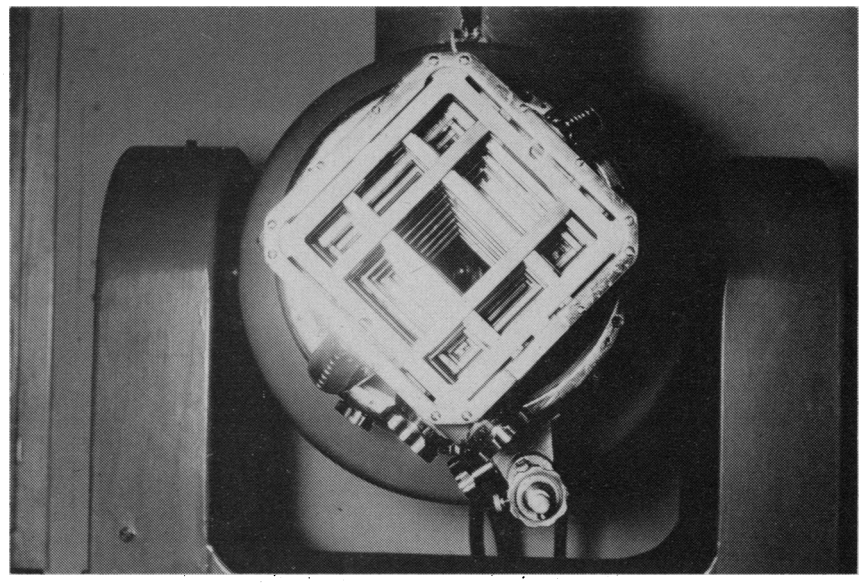


*The installation of radioactive cobalt on Aug. 18, 1952. "Wearing specially treated smocks and masks as protection against deadly gamma rays . . ."*

The unit, weighing approximately 0.9 tonnes, consisted of a steel-encased cylinder suspended from an overhead carriage; a rotating circular platform, flush with the floor, permitted rotation therapy. A variety of treatment fields could be obtained by using interchangeable lead plugs which were manufactured by MacKay.

How to turn the machine on and off caused problems, but Johns rediscovered the wheel with his solution. The radioactive cobalt source was mounted on the circumference of a wheel near the centre of the head. By rotating the wheel, the source could be moved 180° from its shielded resting position until it was opposite an opening through which the radiation emerged.

The *Saskatoon Star Phoenix*, on Aug. 18, 1951, printed a photograph of the installation with the caption: "[W]earing specially treated smocks and masks as protection against deadly gamma rays, Dr. H.E. Johns



*The final version of the MacKay-Johns collimator was a system of fixed and moving steel-encased lead bars that provided rectangular and square fields by simply twisting two dials.*

and Mr. J.A. MacKay are shown here carefully transferring a small piece of radioactive cobalt from a lead container to a treatment head . . ."

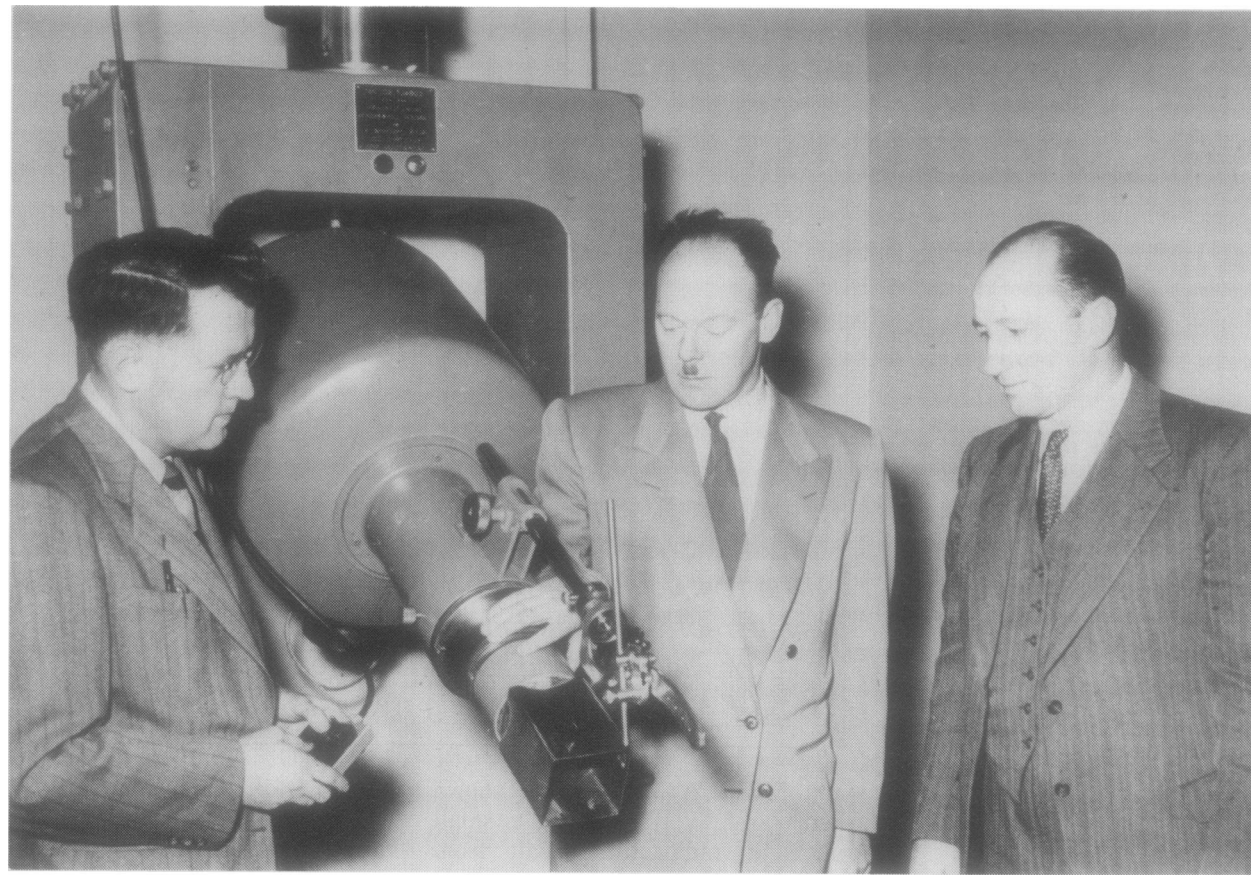
The Saskatoon unit was officially commissioned on Oct. 23. Rigorous measurements continued until Nov. 8 when the first patient was treated by Watson. Watson played down attempts to publicize the importance of Saskatoon's achievement, saying this was but a device that might prove more efficient and economical to operate.

Meanwhile, Canada's second cobalt source had been installed at UWO on Oct. 23. Dr. Ivan H. Smith quickly treated the first patient in London, Ont., on Oct. 27.

This first cobalt treatment at UWO was widely publicized in the Canadian press. The *Saskatoon Star Phoenix* commented on the "cobalt race" in an editorial on Nov. 7, 1951: "We hope Messrs. Truman, Stalin, Peron et al won't think someone is trying to steal their thunder, but we think they ought to know theirs is not the only atomic race going on in the world. Another has been declared by the *London Free Press* which claims editorially 'the world's first cobalt bomb' for . . . the Ontario city. With all due respect to the preservation of national peace and goodwill, that is a boast which this newspaper cannot allow to go unchallenged — especially since the *Free Press* is brazen enough to remark that a cobalt bomb 'is also being installed at Saskatoon, Sask.' One is indeed. Or, to be more accurate, one has been installed."

Eldorado Mining and Smelting had built the second unit for installation at Victoria Hospital in London, but they used a somewhat different design. Their unit consisted of a head pivoted between the arms of a horizontal "Y" which could be raised and lowered. The beam was turned on and off by an air compressor that forced mercury in and out of the reservoir. The radiation beam was turned off when a pool of mercury was introduced between the source and a conical opening in the head. The field size was varied by means of four lead blocks at right angles to each other. This was the prototype of the Atomic Energy of Canada Limited (AECL) cobalt unit.

The first formal publication giving details of cobalt therapy appeared in the Dec. 15, 1951 issue of *Nature*. The authors were H.E. Johns, L.M. Bates, E.R. Epp, D.V. Cormack and S.O. Fedoruk, all from Saskatchewan, and three Uni-



*Saskatchewan cobalt unit with initial lead plug collimator system. From left to right: Johns, John MacKay and Dr. T.A. Watson admiring their handiwork.*

versity of Saskatchewan graduates (A. Morrison, W.R. Dixon and C Garrett) from the radiology laboratory in the physics division of the National Research Council in Ottawa. This paper described both Canadian cobalt units. More detailed papers on the calibration and use of the two units and the Saskatchewan betatron filled an entire issue of the *Journal of the Canadian Association of Radiologists* in March 1952. Isodose curves were made available and the Saskatchewan cobalt 60 depth-dose data were included in a special supplement to the *British Journal of Radiology* in June 1952.

It was obvious to the Saskatoon group that the collimation system had to be redesigned, as therapists wanted a smaller penumbra. The technicians did not like the interchangeable lead plugs that were 5 cm to 8 cm thick and very heavy. MacKay turned his attention to designing a new collimator system, using a large number of interleaved diaphragms rather than a single diaphragm in one plane. The final version of the MacKay-Johns collimator was a system of fixed and moving steel-encased lead bars that provided rectangular and square fields from 4 cm × 4 cm to 20 cm × 20 cm by simply twisting two dials. MacKay's small engineering firm in Saskatchewan single-handedly produced these collimators for over 100 Picker Cobalt units that were distributed world-wide.

The *Journal of the Canadian Association of Radiologists* presented the medical world with the first 5-year report on the clinical application of cobalt 60 therapy units in a special issue in June 1957. The original Saskatoon cobalt unit was in service until 1972, treating 6728 patients over 21 years. Finally, it was replaced by a commercial AECL machine.

The first Saskatoon patient who completed her full course of treatments for carcinoma of the cervix on Nov. 29, 1951 is still alive and well. The first UWO patient's disease was far advanced and she died within a few months of treatment. No doubt she was chosen for this reason since the London cobalt machine had not yet been fully calibrated.

Saskatchewan physicists were in the forefront of development of the cobalt 60 teletherapy units. Although one highly respected commercial consultant predicted in 1952 that in 10 years there would only be 30 cobalt machines in use worldwide, these machines proved to be not only compact but economical to purchase and maintain. There are about 2500 units in routine use in the free world, 1500 of which have been built in Canada by AECL.

Though born of war-time nuclear research, the cobalt bomb was in practice a ploughshare rather than a sword. ■