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WORKING PAPER 15/2003

AN EARLY SONAR DEVICE

by Julian C. Smith Jr.

April 2003

Request copies from: History & Archives Committee, 9 Cedar Grove Court, Nepean, Ontario K2G 0M4

Abstract

This paper describes briefly the development of a sonar device by the author's father, Julian C. Smith Sr., and a colleague in the 1930s. This device was used successfully to map the contours of the bottom of Lake Memphremagog in the Eastern Townships of the Province of Québec. A number of illustrations have been added to amplify the text.

Also added is an appendix giving biographical information on Julian C. Smith Sr., president of the Engineering Institute of Canada in 1928 and one of Canada's foremost hydro-electric power engineers, in whose memory the Institute established the Julian C. Smith Medal to recognize distinguished contributions to the development of Canada.

About the Working Paper Series

In June 1995 the Council of the Engineering Institute of Canada agreed that Working Papers on topics related to its history and development, to the history and development of other institutions serving the engineering profession in Canada, and to engineering generally should be published from time to time.

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The editors of this present Working Paper were Peter R. Hart and Andrew H. Wilson

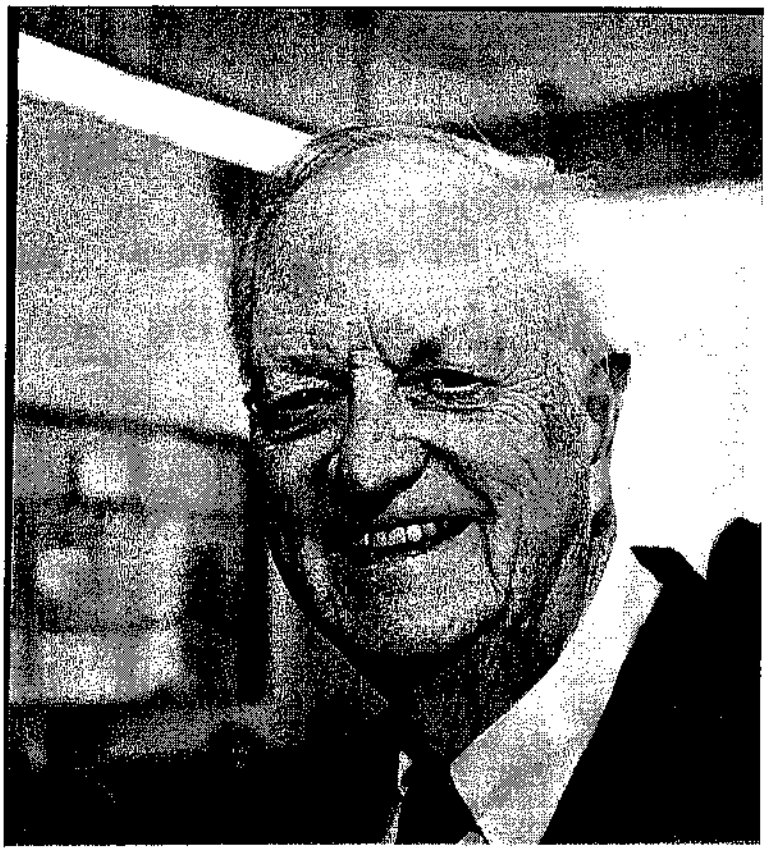

Photo Credit: Gary Hodges/Jon Reis Studio

About the Author

Julian C. Smith Jr. was born in Westmount, Québec, in 1919 and attended Westmount High School and Phillips Exeter Academy. He received degrees in chemistry and chemical engineering from Cornell University in Ithaca, New York, in 1941 and 1942. During World War II, he worked for the Du Pont Company in Wilmington, Delaware, on chemical process development - including one year spent on the Manhattan Project, making elementary fluorine and distilling uranium hexafluoride.

He returned to Cornell in 1946 as an assistant professor of chemical engineering, became an associate professor in 1949 and full professor in 1953. From 1965 to 1971 he was director of continuing engineering education for the College of Engineering. In 1973 he became associate director of the School of Chemical Engineering, and was director from 1975 to 1983. He retired as professor emeritus in 1983.

Julian C. Smith Jr. has been a consultant to the United States Army Engineers, Du Pont, and many other firms and government agencies. He is the author of 50 technical articles, holds two patents, and has been a contributor to, and section editor of, Perry's *Chemical Engineers' Handbook*. With Dr. W.L. McCabe and Professor P. Harriott, he is an author of a textbook *Unit Operations of Chemical Engineering*, now in its sixth edition, which is used world-wide and has been translated into five other languages including Mandarin Chinese. He is a member of the American Chemical Society and a fellow of the American Institute of Chemical Engineers.

He married Joan Elsen in 1946; they have two sons and a daughter and four grandchildren. He currently lives in a retirement community in Ithaca and is working with Professor Harriott on the seventh edition of their textbook.

During the summers of 1936 and 1937 my father, Julian C. Smith, made soundings of Lake Memphremagog and published his results as a map in 1938. He was then president of the Shawinigan Water & Power Company, which had its headquarters in Montréal, and was a member of the Engineering Institute of Canada.

Lake Memphremagog is a 31 mile (50 km) long lake in the Eastern Townships area of Québec, extending southward from the city of Magog, at the north end, across the United States' border to Newport, Vermont. Rumours were current that the lake was very deep, well over 400 feet (122 metres), near its southern end, but nobody knew for sure. Late in the summer of 1935, my father had the idea of mapping the bottom of the lake and, on September 28, he equipped his motorboat with a sounding line - a large reel of cord with a lead weight. I recall going out with him as he tested this apparatus near the family cottage at the Hermitage Club, on the east shore of the lake about three miles south of Magog.

His motorboat, the *Bertha Louise* (Fig. 1), had been built in 1921 to his specifications by Arly Davidson of Georgeville, Québec, on the lake about ten miles south of Magog. It was 36 feet long and was powered by a 200 horsepower Scripps marine engine which could push it over the water at about 35 miles (56 km) per hour.

The depth mapping itself began in the summer of 1936. Father spent his weekends and vacation time on the lake operating the sounding line, aided by Georges Paradis, our chauffeur, and Bert Heath, our gardener (Figs. 5 and 6). I went along a few times to assist them. My pay was 50 cents an hour, travel time included! My job was to keep the boat on the chosen course as we traversed the lake, stopping at measured intervals to drop the weight and record the result. Landmarks such as farmhouses on the two shores served as reference points for each traverse. Most of the soundings were made at the shallower north end of the lake, but we made one excursion south to near Owl's Head Mountain, looking for a really deep area. We were disappointed; the largest reading was only 268 feet (82 metres). By the end of the summer, much of the northern part of the lake had been sounded.

The sounding line gave good information, but had many drawbacks. The time required to lower the weight and haul it back up was considerable, especially in the deeper areas. On windy days, the boat would drift off course during the measurement period, making sounding difficult and sometimes impossible. Clearly, a more rapid means of depth measurement was needed if sounding the deeper parts of the lake was to be completed in a reasonable amount of time.

During the winter of 1936-37, my father and another electrical engineer, Arthur S. Runciman of the Shawinigan Water & Power Company, developed what they called an "electric echo sounder." Whose idea it was - his or Mr. Runciman's - I do not know. To my knowledge, it was never patented. I recall seeing him testing a strange looking device in the basement of our home in Westmount, as he must have done many times that winter. The development did not go smoothly and there were many disappointments and frustrations. I saw only a few of them, for I was away at school in the United States. By May 1937, however, their hard work had paid off. Fig. 2 shows the two engineers

on the dock at our cottage, with my father sitting of the deck of the *Bertha Louise*. A little of the echo sounder is visible behind his right arm. On the back of the original photograph is written, "May 23, 1937. Echo sounder operated May 22." This was the first successful operation.

The device consisted of two similar elements, one to send a sharp acoustic pulse downward into the lake, and the other to pick up the echo reflected from the lake bottom. These elements were made from a six-foot (1.8 metre) length of ½ inch (13 mm) pipe with a metal hemisphere attached to the lower end. The open face of each hemisphere was covered with a thin metallic plate, which sent the signal from one element and picked up the echo on the other. When submerged, the two elements were about 7 feet (2 metres) apart. Inside each hemisphere was a piezometric device and equipment to convert an electric pulse into an acoustic signal and vice versa. I do not know the details of their design. The pulse was ultrasonic, operating at frequencies well above the range of human hearing. Fig. 3 is a schematic sketch of the arrangement of the equipment.

To measure the time delay between sending and receiving the acoustic pulse, a glass neon tube of small diameter, in the form of a circle, was made to flash when the signal was sent and again when the echo was received. A metal disc with a narrow radial slot, driven at constant speed, was set in front of the circular tube. The impulses in the neon tube could thus be seen through the slot as two distinct flashes, even though the entire tube was lighted up; the apparent angle between the flashes was a measure of the time delay between sending and receiving. This angle was calibrated using the sounding line to indicate the depth in feet. The entire device was probably constructed in the shops of the Shawinigan Water & Power Company.

Although the echo sounder operated in late May 1937, it was not apparently satisfactory for, after some adjustments, it was reinstalled on the motorboat by my father and Bert Heath on July 1. I went out with them and later noted, "It works when the depth is less than 100 feet (30 metres)." False readings were received at greater depths, but their cause was never established. These readings may have indicated schools of fish or, conceivably, a sharp discontinuity in the temperature and density of the lake water. Further adjustments were made and, when I went out again on August 2, the device was working well. By the end of August, the job was largely done. We went south as far as the United States line on August 29 and spent a long day on August 30 going as far down as the mouth of Fitch Bay. The following summer, in 1938, my father completed the soundings and checked the results. I did not participate in the work that year.

During the following autumn, the results were assembled, entered on a map of Lake Memphremagog, and published later in the year. This map is shown, about half size, in Figs. 4 (a), (b) and (c) [1]. The lake is relatively shallow at both ends, but the southern part of the middle section is quite deep. Despite the rumours of extreme depths, the greatest recorded value was 351 feet (107 metres) in the centre of the lake opposite Jewett Point to the east and Sugarloaf Mountain to the

[1] Editors' Note: Because of the size reduction and the copying process, not all of the information shown in the maps is clearly legible to the naked eye, and for this we apologise. It is, however, quite readable using a magnifying glass.

west. Recently, M. Jacques Boisvert, a diver who has made over 6000 dives in the lake, told me that he has found the depth measurements to be highly accurate. The depth information is included in the current maps of the area published by the Ministry of Natural Resources of Québec.

The legend in Fig. 4(a) acknowledges the assistance of M. J. Napoléon Longval, a civil engineer. This gentlemen was not from Magog, but I have been unable to find out anything more about him. The legend also lists "a novel type supersonic sounding machine" as responsible for the successful completion of the work. We would now call it "ultrasonic" rather than "supersonic."

The echo sounder was a very early example of a sonar device that became so important during World War II. Sonar equipment now available to fishermen indicates not only the depth at which the fish are swimming, but also the water temperature and the approximate size of the fish. My father would have been amazed by such a sophisticated device!

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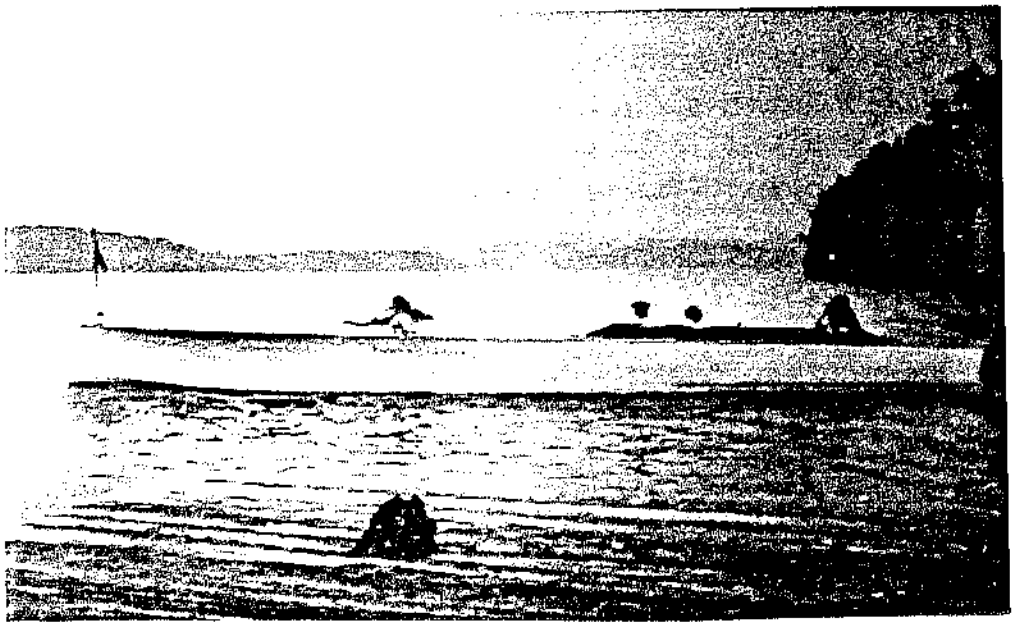

Fig. 1. The motorboat *Bertha Louise*

Fig.2. Julian C. Smith Sr. and Arthur Runciman, 23 May 1937

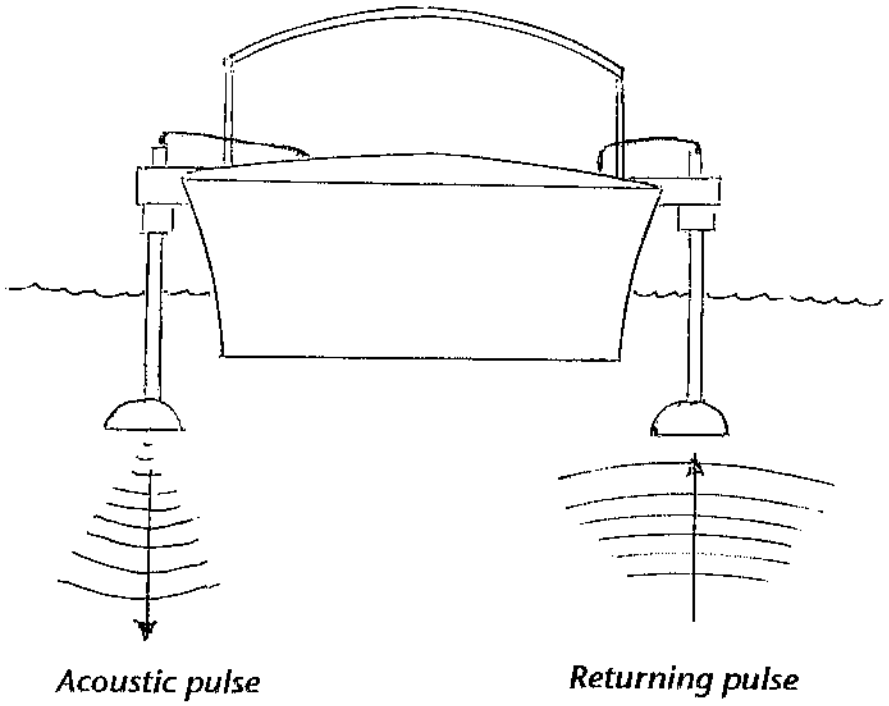

Fig. 3. Schematic sketch of the echo sounder

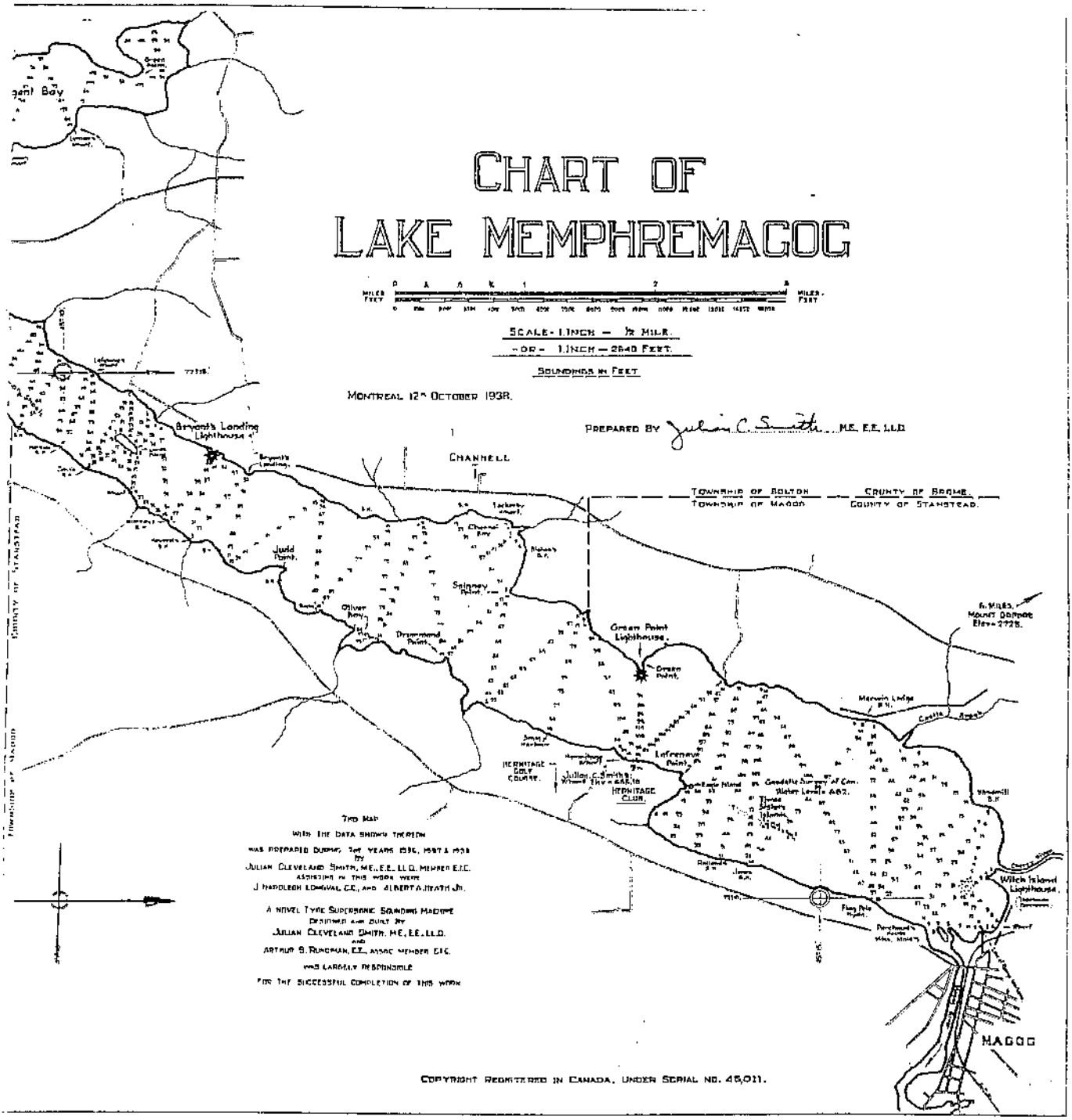

Fig. 4(a). Chart of Lake Memphremagog (north end)

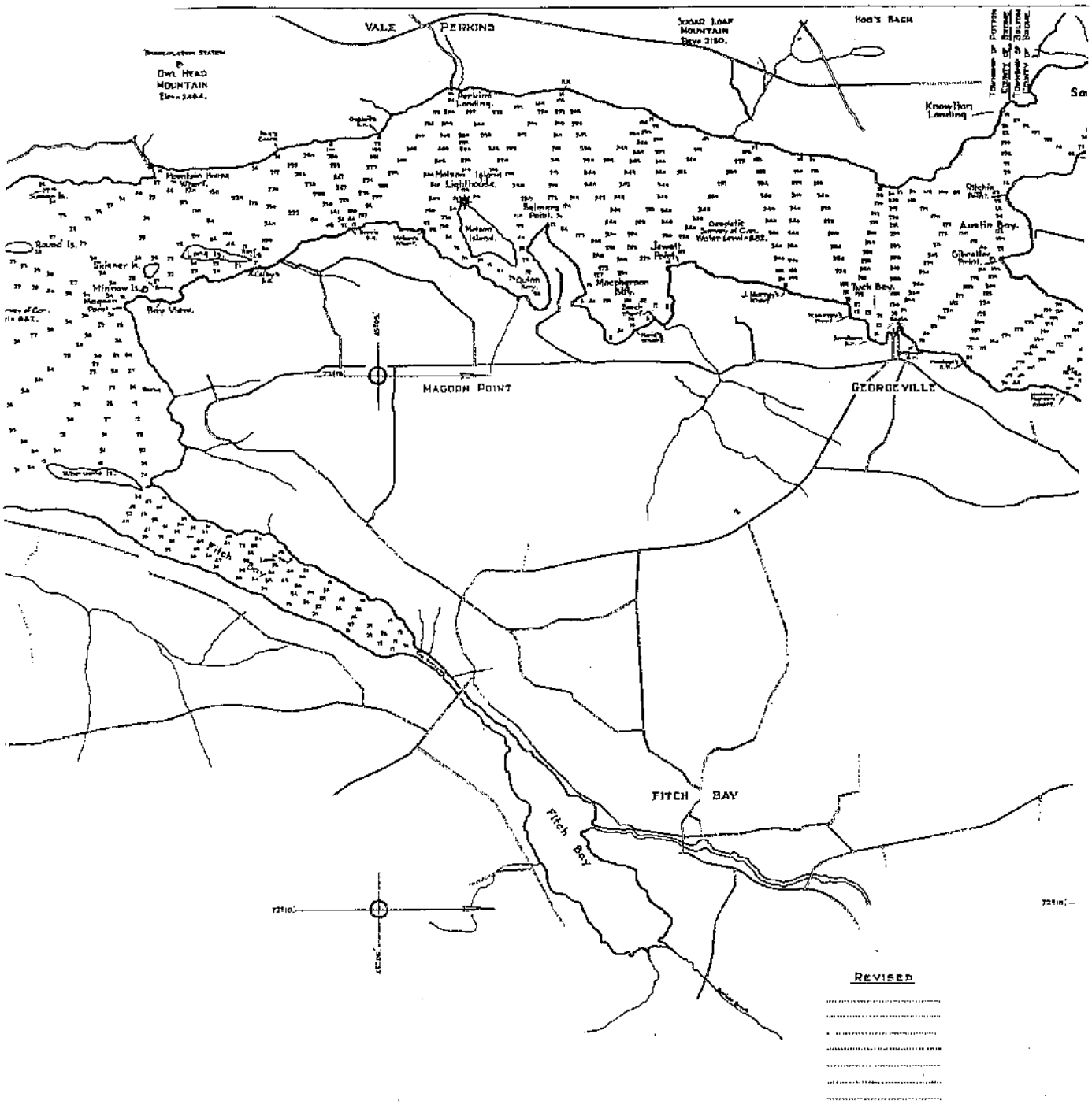

Fig. 4(b). Chart of Lake Memphremagog (centre section)

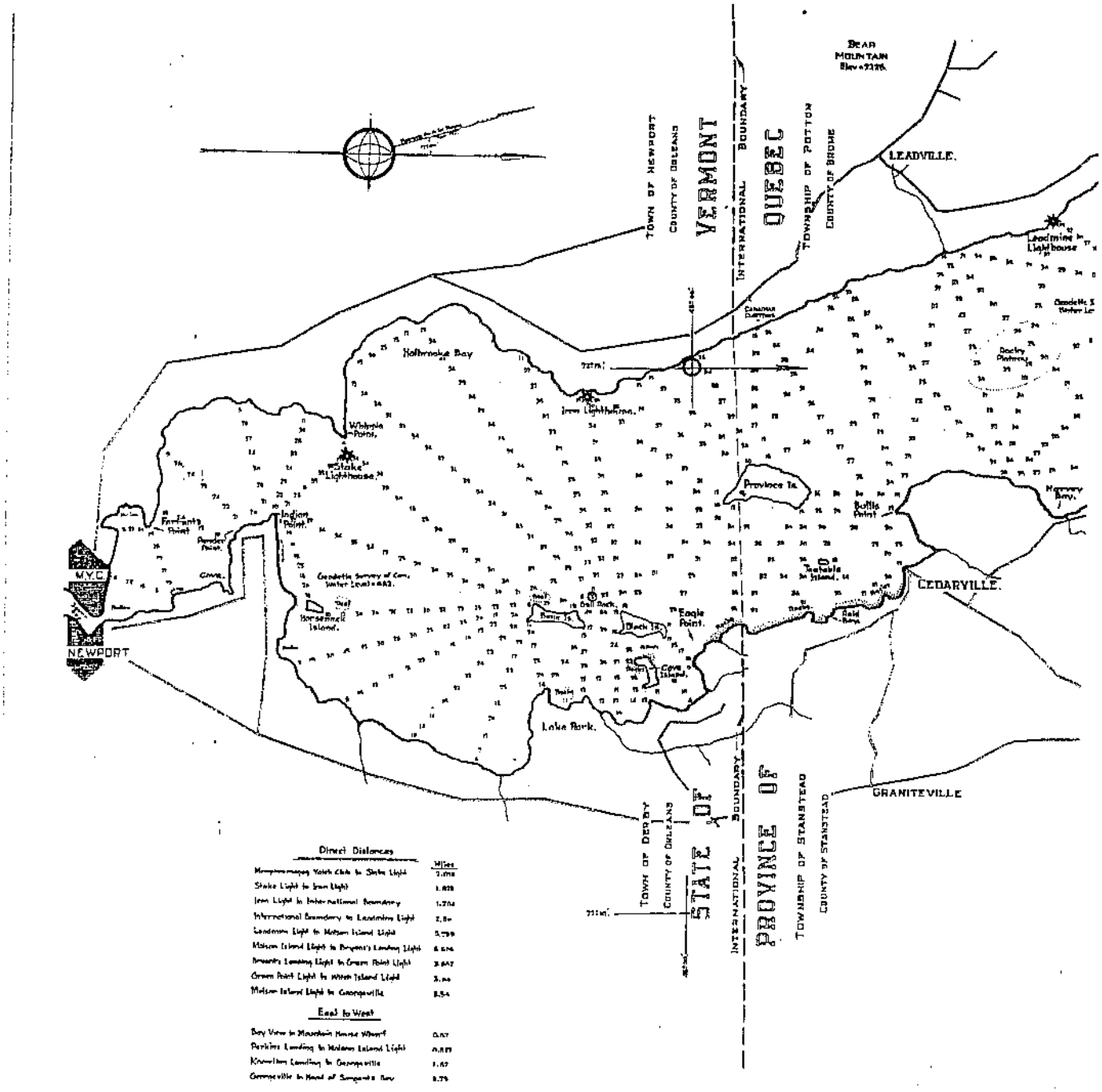

Fig. 4(c). Chart of Lake Memphremagog (south end)

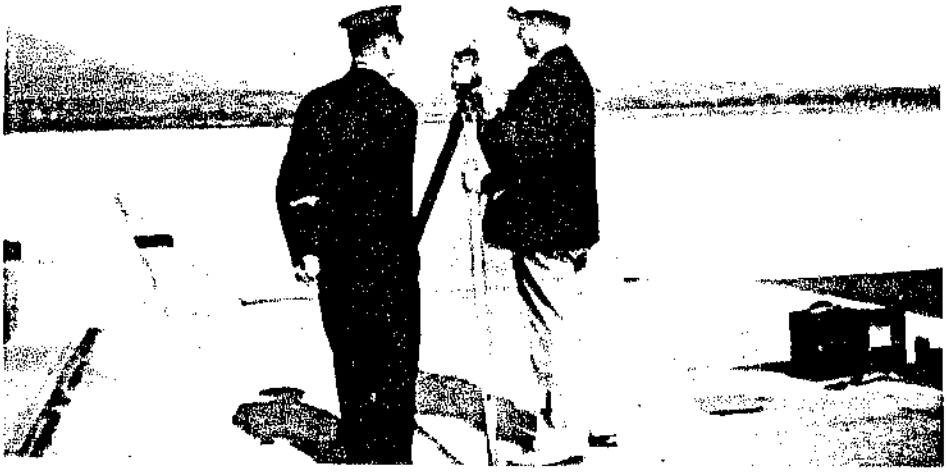

Fig. 5. Georges Paradis and Julian C. Smith Sr.

Fig 6. Albert Heath Jr.

APPENDIX

Brief Biography of Julian C. Smith Sr.

- compiled by Andrew H. Wilson from material provided by the author and the records of the Engineering Institute of Canada

Julian Cleveland Smith and his twin brother, Joslyn, were born at Elmira in New York State in October 1878, but moved to Buffalo shortly thereafter. They received their early and high school education in Buffalo and entered Cornell University at Ithaca in the fall of 1896. Joslyn died the following January, at the end of his first term there. Greatly upset, Julian persevered with his studies and went on to graduate with the degree of Mechanical Engineer (ME), with the electrical option, in 1900. For the next two years he worked as a draftsman with the West Manufacturing Company in Buffalo and the Pan American Exposition. He then joined Wallace C. Johnson's consulting engineering firm in Niagara Falls, New York, as an assistant engineer. In September 1902, Johnson moved to Shawinigan Falls, Québec, taking Smith with him as an assistant to work on a dam and generating station project for the Shawinigan Water & Power Company (SWP) on the St. Maurice River. For Smith, the expected short stay at Shawinigan Falls ended when the power project was

completed in 1903 and he was appointed superintendent of SWP's plant, based in Montréal, the city that was his home until his death, on 24 June 1939, some 36 years later. He was appointed general superintendent of the company in 1906 and in 1909, at the age of 30, added the title of chief engineer. He was named vice-president and chief engineer in 1915, VP and general manager in 1916, and president in 1933.

He married Bertha Louise Alexander in 1909, and they had two daughters, Florence and Louise, and two sons, Joslyn and Julian.

J.B. Challies, immediate past president of the Institute, wrote this of the late Julian Smith in the *Engineering Journal* in July 1939:

> "For over a third of a century Julian Smith's creative mind had so powerful an influence on the hydro-electric industry of the Dominion that he was everywhere recognized as one of its foremost leaders. Perhaps the broad scope of the engineering and executive ability is indicated best by the transformation that since the turn of the century has taken place in the St. Maurice Valley in the Province of Québec. A great river flowing for two hundred and forty miles from its sources in the northern forests into the St. Lawrence, unharnessed in 1900, has, as a result of his foresight, enthusiasm and courage, become the main source of power for one the notable electric utility systems on the continent. While hundreds of engineers have given of their best in working out the many phases of the basic plan for utilizing the potential two-million horse-power of the St. Maurice, Julian Smith was their guiding genius for thirty-five years."

The July 1939 issue of the SWP *Bulletin* added these words:

> "Simple dans ses manières, et d'un bonté proverbiale, il était également aimé et respecté par ses collègues du bureau d'administration et par le plus humble des employés de la compagnie."

Julian Smith was recognized for his abilities by appointments to the boards of companies in the industrial, banking, utility and transportation industries. He was also a pioneer in industrial and scientific research, was a member of the governing bodies of McGill University and the Montréal General Hospital, and a member of the National Research Council. He served as president of the Engineering Institute of Canada in 1928, and chaired the Canadian Advisory Committee of Britain's Institution of Civil Engineers. He was also a member of the American Institute of Electrical Engineers, the British Institution of Electrical Engineers, the author of numerous technical papers, and a director of SWP subsidiary companies as well as other companies such as the Dominion Engineering Works, the Royal Bank of Canada, Canadian General Electric and the Consolidated Paper Corporation. He received honorary doctorates from McGill and Queen's Universities.

Shortly after his death, a memorial fund was established in his memory. Originally intended to assist the technical education of sons of employees of SWP and its subsidiaries, this fund was redefined in 1963 to become the Julian C. Smith Memorial Fund Corporation, and was administered by the

Engineering Institute of Canada. The income was distributed annually on the basis of merit to men and women engineering students in universities in Québec. His son, Joslyn, was president of this Corporation for many years and attended the Montréal meetings from his home in the United States. In 1992, the Corporation's funds were merged with other funds managed by the Institute, but were still used to support engineering education. Medals bearing his name continue to be awarded annually by the Institute for "achievement in the development of Canada."

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Obverse and Reverse Sides of the Julian C. Smith Medal