DEAN ARTHUR LEWIS CLARK

MAKER OF QUEEN'S

by J.K. Robertson

Each year a Montreal group of Queen's graduates awards a medal to someone who has rendered outstanding service to Queen's University. In 1947 the award was made to Arthur Lewis Clark, Professor of Physics from 1906 to 1943 and Dean of the Faculty of Applied Science from 1919 to 1943. Few, if any, of the recipients have made contributions as outstanding as those of Dean Clark. He came to Queen's in 1906 particularly well qualified for the development of the department of physics, for stimulating scientific research throughout the university, and for playing an important part for fifteen years in the activities of the National Research Council.

Born in Worcester, Mass., in 1873, he was educated in the local public and high schools, and in Worcester Polytechnic Institute. In view of his later work in physics it is significant that the degree of B.S. obtained after his course at this Institute was in Electrical Engineering. After graduation, a year in industry with the New Rochelle Gas and Fuel Company, New York, followed by a year in teaching Science and Mathematics at Bridgton Academy, North Bridgton, Maine.

provided him with funds to spend two years at Clark University, a well-known graduate school of high standing in Worcester. Following two more years spent in teaching at Worcester Academy, he joined the department of physics at Bates College in 1900, thus realizing his ambition to do university work. Four years at Bates were followed by a third year at Clark at the end of which he received his Ph.D. A final year at Bates preceded his appointment at the age of 33 to the chair of physics at Queen's.

At Clark University Clark came under the influence of Professor A.G. Webster, an outstanding physicist at that time. As early as February, 1898, a paper by A.L. Clark, on the Specific Inductive Capacity of Certain Oils appeared in the Physical Review. In the opening paragraph Clark wrote: "It was suggested to me by Professor A.G. Webster that the dielectric constant or specific inductive capacity of these liquids might be conveniently studied by Quincke's bubble method". In a more important paper, published in Jan. 1906, in the Proceedings of the American Academy of Arts and Sciences, acknowledgement is made of Webster's unfailing kindness and interest and also of a generous appropriation for apparatus from the Rumford Fund of the American Academy. This paper on Surface Tension at the Interface Between Certain Liquids and Vapors is the forerunner of much of Clark's later research work at Queen's.

When Clark came to Queen's the department of physics was not outstanding. There were two other members of the department, W.C. Baker and Norman Carmichael, both enthusiastic and able physicists, but the department had not recovered from the negative influence of a former head, a man who apparently had been totally uninfluenced by the exciting discoveries of the nineties. Clark was well-fitted to inaugurate, with the aid of Baker and Carmichael, a new era. He was an experienced and skilful teacher, who understood and sympathized with student difficulties, and he was an enthusiastic research worker. He had an uphill job, but the status the department at Queen's has had for a good many years now is ample evidence of his success.

In spite of heavy teaching and administrative duties, Clark carried on active research for many years. Some of his early work reflected his training in electrical engineering. For example, for some years he examined the resistance of carbon contacts in the solid-back telephone transmitter, dealing with such problems as the variation of resistance with time, the possible effect on wave form of the changes in resistance which occur with increasing and decreasing pressure on the diaphragm, and with the effect of gas.

Clark's main research work, however, was in the field of thermodynamics and in the study of the molecular properties of liquids and vapors, especially in the region of the critical point. As we have already noted, work in that field had been started at Clark University. After he came to Queen's the financial aid he had received from the American Academy was continued. The Transactions of the Royal Society of Canada, vol. IX, 1915 contain one of his important papers on the Viscosity of Ethyl Ether near the Critical Temperature. According to what had been termed the classical theory held by such workers as Andrews and van der Waals, at the critical point liquid and vapor phases were identical and, moreover, there could be no liquid above the critical temperature. If this view is correct, the density of liquid and of vapor should be equal at the critical temperature. But experimental results did not always confirm the classical theory and many experimenters had come to the conclusion that the critical state was not the unique state it had been believed to be and that the liquid state might persist above the critical temperature. One result of the altered views was a theory due to de Heen and Traube, which postulated that each of the two phases consisted of a mixture of two kinds of molecules, the "liquidogenique" and "gazogenique". This theory, which did not receive universal support from the experts, was attacked by such important workers as Kamerlingh Onnes of Leiden, who with Fabius repeated some of the experiments supporting the theory, and came to the conclusion that "marked differences of density do not exist if sufficient care be taken in filling the tubes with pure gas-free liquid".

In an attempt to settle the conflicting views Clark undertook a precision study of the viscosity of Ethyl Ether in the neighborhood of the critical point. As his method in this investigation is an example of the extreme care and precision with which all his research work was carried out, the following description of his apparatus is quoted from an article in Chemical Reviews, vol. 23, 1938. This paper is an account of a Symposium on the Critical State, arranged in 1936 in Section III of the Royal Society of Canada of which Clark was then President. (He had been made a Fellow in 1915.)

"A gold cylinder was suspended by a hard-drawn silver wire in a tube in the form of an inverted U which contained the liquid. The cylinder had a small iron pin imbedded in a transverse position so that it might be oriented by means of an external magnetic field, and would perform angular oscillations when released. The surface of the cylinder was highly polished and a spiral line was ruled on it. When a narrow beam of light was directed on to the cylinder, the ruled line appeared as a dark point on the line of light. When the cylinder oscillated this point moved up and down with a damped harmonic motion. By observing the excursions of this point by means of a low power telescope with an eyepiece scale, the decrement was easily calculated."

This is not the place to discuss the details of this investigation and we note only the conclusion given in the above paper. "If we deal with final states reached after stirring or long continued heating, there is much evidence in favour of the classical theory of Andrews and van der Waals."

Clark's earlier work in this field attracted the attention of Kamerlingh Onnes and in 1916 led to an invitation from him to visit the famous laboratory at Leiden, to carry out similar work at low temperature. Here in collaboration with Professor Kuenen, he worked on the liquefaction of air. "Our investigations were entirely successful", Clark later reported, "and we were able to fix definitely the temperature and pressure at which liquefaction of air is possible".

Although Clark spent only three months in Holland, his visit had a marked influence on his subsequent work and on his general outlook. He was greatly impressed with the freedom Dutch professors had to do research and also with the school which existed at Leiden for the training of glass blowers, technicians and instrument makers. Above all he was impressed with the importance of furthering our knowledge of the structure of matter by investigations at low temperature. At that time there were no low temperature laboratories in Canada or the United States. Clark was a man of vision, as well as an able research worker, and it was not unnatural that at this time he had hopes of the establishment at Queen's of a complete low temperature laboratory. In the report in 1917 of a newly-formed Committee on Scientific Research which had been appointed by the trustees of Queen's in December 1916, reference is made to such a recommendation by Professor Clark. It must have been a bitter disappointment to him that his dream of a cryogenic laboratory at Queen's was never realized.

In April 1918 a report to the Principal of Queen's on work carried on under the supervision of the Research Committee shows Clark to have been busy with several investigations, including continued work on the resistance of carbon in the telephone transmitter, a study of the electrical properties of the capillary electrometer, work on the law of corresponding states applied to air, measurements of the angle of contact made with glass by mercury when covered with dilute acids, study of a method of preparing clean glass surfaces for surface tension measurements, study of the viscosity of liquids and vapors near the critical points, and a survey of the earth's magnetic field near Kingston.

A more detailed reference must be made to an important series of papers, which appeared in the Canadian Journal of Research in the period 1938 to 1943, describing work done in collaboration with L. Katz on the Joule and Joule-Thomson effects and the measurement of the ratio (gamma) of the specific heats of various gases. These papers reveal the extent to which A.L. Clark was an authority on thermodynamics. The first of the Clark-Katz papers is an extended discussion of the Joule and the Joule-Thomson effects, the background for which had been given in Clark's paper on The Definition of a Perfect Gas, published in the Transactions of the Roy. Soc. of Canada for 1924. The later papers in the series describe measurements of gamma by a method which again reflects the thoroughness, skill and precision which characterized all his scientific work. The method consists in subjecting a gas to alternate compressions and rarefactions. This was accomplished by having the gas in two similar chambers separated by a freely moving but closely fitting piston, whose movement was controlled by an external periodic magnetic field. The frequency was varied until resonance occurs, and gamma was readily calculated from the resonance frequency, the pressure of the gas, and the constants of the apparatus. Since precision measurements of low frequencies were necessary, Clark and Katz designed a low-frequency dynatron oscillator with a range from 10 to 100 cycles per second, and a power output of 10 watts. Frequencies could be maintained and measured to one part in 30,000, over a period of several hours.

Using this method, which is particularly suitable for examining the variation in the value of gamma with pressure at constant temperature, Clark and Katz made measurements on helium, argon, hydrogen, nitrogen, carbon dioxide, sulphur dioxide and nitrous oxide. This piece of work deserves to rank as classic in the field of thermodynamics.

Important as Clark's personal researches were, his biggest contribution to the advancement of research at Queen's and in Canada is probably an indirect one. In 1916 the power behind the throne at Queen's University was Mr. G.Y. Chown, an astute far-seeing business man, who for many years was Registrar and Treasurer. To him, Clark, a close personal friend, suggested more than one activity of far-reaching importance. The first, which was fully implemented in 1917, was the appointment by the Board of Trustees of a Committee for the promotion of scientific research in the University. At the outset an annual grant of $10,000, no small sum in those days, was made. Clark was appointed Chairman of this committee, a position he held until 1943. Under his wise leadership this committee did much to stimulate research in all scientific departments. At the outset a two-fold policy was

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adopted. Grants for apparatus were made to members of staff, but only to those who had demonstrated their ability to do research. Of even greater importance in a university where teaching loads were heavy and where research could often be done only in the long vacation, money was provided for senior undergraduate and graduate students as summer research assistants. This policy naturally promoted graduate work in the sciences and set a pattern for the committee on Scientific Research which it has followed to this day.

It will be recalled that in 1916 the National Research Council, originally the Honorary Advisory Council for Scientific and Industrial Research, was organized by the Federal Government. In 1924 Clark was appointed as a member of the Council on which he served with distinction until 1939. On the formation of the Research Council of Ontario in 1921 he was made one of the governing body, a position he held for many years.

Returning to specifically Queen's activities, we note two further important developments for which Clark was primarily responsible. The first was the establishment of a Research Chair, the second the inauguration of the first course in Engineering Physics in Canada. The research chair was the direct result of Clark's friendship and many discussions with Chown who, anxious to assist the development of research at Queen's, endowed the Chown Research Chair, stipulating that the holder be either a physicist or a chemist. The first to occupy this chair was Dr. A.L. Hughes, who was appointed in 1919, his runner-up being Dr. A.H. Compton. Hughes was succeeded in 1924 by Dr. J.A. Gray, who held the chair until his retirement in 1952.

The establishment in 1919 of a course in Engineering Physics was another example of Clark's wisdom and vision. Its success at Queen's and later in other

Canadian universities is ample evidence of the far-sightedness of A.L. Clark.

Although not a man to slap one on the back, Dean Clark could be approached freely by both students and members of staff and his counsel was sought by both groups. As Chairman for many years of the Service Control Committee of the Engineering (Students) Society, he took a keen interest in its dual activities of operating an Employment Service and a bookstore known as Technical Supplies. Over the doorway of a pleasing stone building which houses the club room of Queen's Engineering students and the University Book Store, the name Clark Hall is inscribed, a fitting tribute to one who rendered great service to Queen's and her students.

His services extended far beyond the University. When he retired in 1943 he was Chairman of the National Unemployment Insurance (Kingston office), Vice-Chairman of the Kingston Welfare Committee and Chairman of the Sub-committee for the Home for the Aged, a member of the Board of Governors and Vice-Chairman of the Building Committee of the Kingston General Hospital. For many years he was Director of the School of Navigation at Queen's, which during the winter months gave training to mariners.

One of his earliest forms of relaxation was baseball, which he took so seriously that he bought a book on how to throw curves. This he studied to such good effect that he became an ace pitcher and captain of a local team. As a youth another interest was Indian-Club swinging, in which he was sufficiently proficient to do an act in a minstrel show which travelled around the countryside. In later years he was a keen golfer with a creditable handicap. For many summers his mornings were spent in the laboratory, his afternoons on the golf links.

Throughout his life woodworking was his main hobby. In this he was no mere amateur, his work being well up to professional standards. On his retirement the members of the Faculty of Applied Science very fittingly presented him with a modern woodworking lathe.

His family life was an exceptionally happy one. He and his wife grew up in the New England town of Worcester, and when they came to Kingston they grafted into their Canadian life something of the flavour of New England hospitality. They had one son and two daughters, and in course of time their life was rounded out by a number of grandchildren. A short time ago I was told of family gatherings at their home every Saturday evening in which three generations took part.

Mentally keen and physically active until almost the end of his life Dean Clark was spared a long illness. His death on September 19, 1956 brought to an end the life of a man whose contributions to Queen's and to Canada entitle him to a place of honour in the annals of Canadian Science of the twentieth century.

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