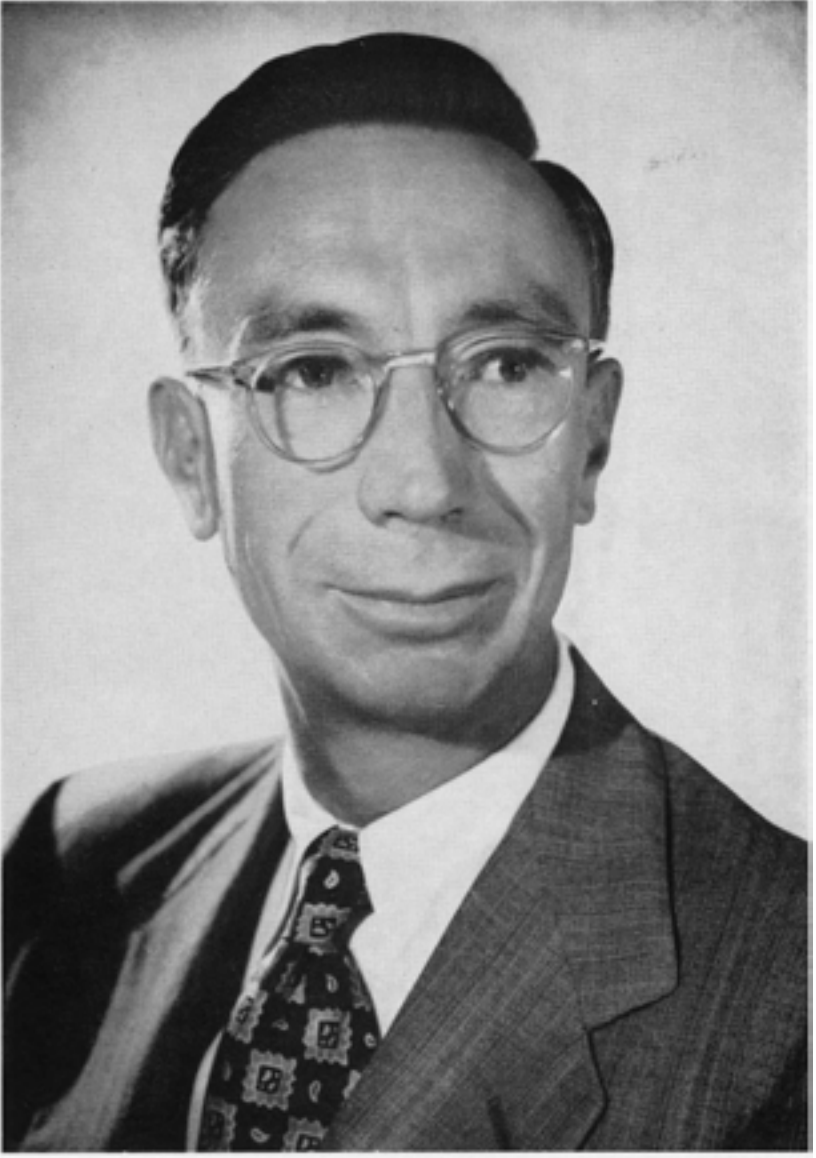

J. L. Pawsey

JOSEPH LADE PAWSEY

Joseph Lade Pawsey died in Sydney on November 30th, 1962. It is difficult indeed to overestimate the value of his contribution to the recent development of the radio sciences and astronomy in Australia. Apart from his direct influence in the Radiophysics Division of the Commonwealth Scientific and Industrial Research Organization where he founded and brilliantly led the radio astronomy group of the Division, his influence was felt in the field of optical astronomy, in ionospheric research and in many applications of radiophysics techniques in other fields. Who of his associates can forget his painstaking and intellectually humble approach to the problems of a new field of discovery, his flashes of intuition, the depth of his physical understanding, his scientific honesty and his quiet but obstinate determination to see that the right decisions were made by scientific administrators?

It was a sad day for many of us to learn that Pawsey's contributions to Australian sciences were ending and that he had accepted an appointment as Director of the American National Radio Astronomy Observatory at Green Bank, West Virginia. While he was making a preliminary visit to this institution in March 1962, the first signs of his illness became apparent. His temporary recovery under the skilful ministrations of the best available medical care in America enabled him to return to Australia and to complete successfully his final work, the editing of a radio astronomy issue of the Proceedings of the Institution of Radio Engineers Australia. This publication has now become a minor landmark in the instrumental aspects of radio astronomy.

Pawsey was born in Ararat, Victoria, on May 14th, 1908, of farming parents, Joseph Andrews and Margaret Lade, and was their only child. His parents were politically active, his father being a foundation member of the Victorian Country Party and his mother at one time being president of the women's section of the party. His early education was typical of that of a country child of the time. He did not commence formal schooling until he was more than eight years old, when his family moved from their home at Willaura to the larger town of Staveley in which there was a small State school. Further schooling took place at Coleraine and Camperdown, schools near his different homes. At the age of 14 he won a Government Junior Scholarship at Wesley College, Melbourne. He qualified for University entrance at the age of 17 years, winning a scholarship to Queen's College of the University of Melbourne. Pawsey began his University studies in 1926 and in April 1929 was admitted to the degree of Bachelor of Science, obtaining First Class Honours in Natural Philosophy and Second Class Honours in Chemistry. Pawsey worked under T. H. Laby as a research student in the School of Natural Philosophy during the next two years and in 1931 presented his thesis for the degree of Master of Science and was awarded First

Class Honours in Natural Philosophy and the Dixson Research Scholarship. In the same year he won an 1851 Exhibition Research Scholarship, and was admitted to Sidney Sussex College, Cambridge as a research student. At Cambridge he worked in the Cavendish Laboratory under the direction of J. A. Ratcliffe.

This period effectively marked the beginning of Pawsey's research career, although he had, during his Melbourne University days, already participated in the publication of a paper on the measurement of broadcast station carrier frequencies. Under Ratcliffe's influence Pawsey turned his attention to the effects of the ionosphere on radio propagation and his dissertation for the degree of Ph.D. was concerned with his observations on the variations in intensity and direction of waves reflected from the ionosphere. From these observations he deduced the presence of irregularities in the E region which moved rapidly under the influence of strong horizontal winds. His results were published in two papers and formed the basis for the later development of this very important branch of ionospheric physics. It is interesting that in later life Pawsey returned intermittently to observational studies of various aspects of the ionosphere.

After graduating from Cambridge, Pawsey took a position at the research laboratories of E.M.I. Electronics Ltd., where he remained for the next five years. It was during this period that he married Greta Lenore Nicoll, of Battleford, Saskatchewan, Canada; she survives him together with their three children.

While at E.M.I. Pawsey immersed himself in the practical problems of aerial design: in particular he was concerned with the new television transmitter at Alexander Palace then under development. His work is exemplified by a large number of patents granted jointly to him and the leader of his group, E. C. Cork. Many of the devices patented by Cork and Pawsey thirty years ago are in widespread use at the present time. During this period Pawsey became a master of the technique of antenna design; later he was to head a group noted for its contributions to this subject.

In February 1940 Pawsey returned to Australia to join the recently formed Radiophysics Division of the Commonwealth Scientific and Industrial Research Organization (then called the Council for Scientific and Industrial Research). Here he was instrumental in building up a strong research team concerned with the very practical and urgent problems of producing effective radar systems for the armed services and in investigating, as much as was possible in wartime, some of the more fundamental aspects of radio wave propagation and radar detection. It was during this time that Pawsey's extraordinary ability as a leader of a research team came to fruition. Although he himself was becoming increasingly overloaded with administrative work, he was able to guide and stimulate his staff, composed mainly of young graduates in Engineering and Physics, in a way which enabled them to produce their best. He was always ready to discuss any problem which arose and his comments were lucid and to the point: such was his physical insight that the

problems often vanished after a brief discussion. A large proportion of his time must have been spent in this way and his contribution to the research and development work of the laboratory was very much greater than is suggested by his own writings. These were necessarily in the form of confidential reports, as publications of the material was, of course, impossible at the time.

His own direct scientific researches during the war years were concerned with lightning flashes, their metre-wave spectra and the radar echoes received from them, with anomalous centimetre-wave propagation due to super-refraction, and with radio astronomy. The latter was represented by an unsuccessful attempt in 1944 to measure sky temperatures, using a conventional 10 cm. receiver connected to a small paraboloid. The negative result showed that the apparent temperature was very low.

Pawsey had displayed great interest in the discovery and observations of radio emission from the Galaxy by Jansky and Reber; his interest also had been stimulated by wartime reports of intense interference produced in metre-wave radar receivers by disturbances on the sun. Consequently, when the ending of the war removed the immediate pressure of developmental work, it was inevitable that he should recognize this as potentially a worthwhile field for investigation. In 1945, with McCready and Payne-Scott, he set up a radio receiving antenna operating at a frequency of 200 Mc/s on a cliff overlooking the ocean near Sydney and during the next year two important results were published. The first of these was the result of using Lloyd's mirror technique, where interference fringes are produced between direct rays from a source and those reflected from a flat surface, in this case the sea. The observations showed that intense radiation was emitted from the region of a large sunspot group on the sun and this radiation was so intense as to be obviously non-thermal in origin. In the paper describing the results Pawsey pointed out the possibility of obtaining complete one-dimensional information on the distribution of emission from the source by two-beam interferometry by means of Fourier synthesis. This method was developed later by the Cambridge group of radioastronomers into one of the most powerful tools in radio astronomy.

The second of the early discoveries was that the sun at a wavelength of 200 Mc/s appears to have a lower limit of emission which, if black-body radiation, corresponds to a temperature of about one million degrees. The publication of this discovery by Pawsey was accompanied by an explanation of it, by D. F. Martyn, in terms of a million-degree electron temperature in the solar corona. A little later Pawsey with D. E. Yabsley showed clearly from statistical evidence the existence of a slowly-varying component in decimetre-wavelength solar emissions, related closely to the area of sunspots. From that analysis, the intensity of thermal emission from the "quiet" sun was found.

These early investigations formed the basis of a long series of solar investigations by Pawsey's group on the size, position, movement,

spectrum, and growth and decay of the various sources of radio emission on the sun. During these investigations new techniques now in general use in radio astronomy were invented by members of the group. These included the swept-lobe interferometer which allowed the location of rapidly moving sources of emission on the sun, the swept-frequency receiver which gave the spectrum of such disturbances, and the grating interferometer which provided a hitherto unapproached resolving power of one-twentieth of a degree in solar observations. Much of this work was reviewed by Pawsey with S. F. Smerd in a chapter of a book "The Solar System" edited by Kuiper and published in 1955.

Simultaneously with the observations of the sun, members of Pawsey's group were making important discoveries about the discrete sources of radio emission in the Milky Way and external galaxies; these included the first accurate location and optical identification of a radio source. The early work was done by means of the Lloyd's mirror technique; later, two-aerial and radio-link interferometers were used, the latter for the first time, and a cross type antenna was invented for high resolution pencil-beam observations. Pawsey was intensely interested in this work, although he did not take part directly in any of the observational programmes. Shortly after the discovery of 21 cm. line emission from neutral hydrogen, the so-called hydrogen line, hurriedly-built equipment was assembled in Sydney to make the first survey of neutral hydrogen in the sky and, as a result, the first clear indication of spiral structure in the galaxy was obtained. Later a multi-channel receiver was constructed and used for a careful delineation of the parts of the galaxy visible from Sydney and an investigation of the Clouds of Magellan. In all these investigations the techniques were new and in most cases these techniques now form part of normal equipment in the radio astronomy observatories of the world.

During the last ten years of the work of his group, Pawsey's written contributions were mainly of a review nature; in particular the book he wrote with R. N. Bracewell, "Radio Astronomy", published in 1955 and still a standard text, should be mentioned. However, he undertook a few investigations of his own: all of these were in the string and sealing wax tradition which he loved. One of them, concerned with the ionosphere and conducted by Pawsey with McCready and Gardner, consisted of measuring the temperature of the ionosphere by means of a technique which allowed the radio emission to be measured in the short intervals between pulses of radio interference from terrestrial sources. A second investigation was an unsuccessful attempt to detect the effects of magnetic fields in interstellar space. Pawsey realized that this was an experiment of the greatest importance: had he chosen a shorter wavelength he would probably have been successful.

Most of Pawsey's time was spent, however, in the affairs of his research group. The team of radio astronomers which he built up was unusual in many ways. There were, and are, few scientific

groups of comparable size where the head of the group had such a detailed knowledge of the work of each member and where every paper was criticized in detail by him. Yet this intense scrutiny and discussion of the scientific work of each member did not lead to any authoritarian regime. Pawsey's criticisms were usually accepted not only because they were sound but because they were so clearly and intelligibly expressed that acceptance was inevitable. But Pawsey never forced his opinions on a younger colleague : if the matter were open to doubt he was willing to leave it to experiment. He was, in fact, the arch-empiricist. "Suck it and see" was one of his favourite expressions. Brought up in the school of Rutherford he had little faith in theoretical predictions. In his view, the predictions of the theoreticians became really interesting only after experiment had shown that they were correct. He did not in general accept theoretical predictions as a guide to experiment; he preferred to investigate the questions that arose from previous experiments. "Following his nose" was how he described this process.

He was cautious in undertaking new experiments and subjected all suggestions for them to a highly critical examination : however, he felt that any large research organization could afford to have one "wild-cat" experiment in progress. One of his own "wild-cats" was an investigation of the effect of electromagnetic waves on the growth of plants.

The second charcteristic of the radio astronomy group was the exceptionally harmonious personal relationships between its members. This originated partly in Pawsey's emphasis on "research teams" rather than the efforts of individuals. For a research paper to come out under a single name was quite exceptional. But the atmosphere of the laboratory was determined also by the good relations between the individual members and Pawsey himself. All members knew that Pawsey's actions and decisions were based on what he considered to be scientific necessity. His integrity was never questioned. Yet sometimes difficulties arose. The scientifically correct decision might not necessarily be the humane one. On such occasions Pawsey, who was a very kind-hearted person, would be found pacing with his long legs back and forth across his study jangling his keys in his pockets, with a most lugubrious expression on his face. He would go to great lengths to postpone having to make an unpleasant decision.

Apart from his integrity the characteristics which most endeared Pawsey to his associates were his simplicity and enthusiasm. He always insisted on treating any problem in its simplest terms, and was a master of the rapid "order of magnitude" calculation. This was one of the main factors in his success as a scientist and as the head of a scientific group. His simplicity was natural but also was the result of his having been trained in the tradition of English physics, the tradition that had persisted from Faraday to Rutherford. Pawsey was never loath to ask the most elementary question at a scientific lecture on some advanced topic which he had not quite understood,

while his colleagues hesitated to reveal their lack of comprehension. The consequences of his simple questions were sometimes startling.

With this simplicity went the intense curiosity about all natural phenomena which characterises the good scientist, and also an enormous enthusiasm. It was always a delightful experience to bring to Pawsey some new idea or some interesting new observation. His immediate reaction would be one of intense interest, followed by suspicion as he looked for some mistake or misinterpretation, or what he called the "inherent cussedness of nature". Finally, if convinced that all was well, his face would shine with boyish pleasure. He would immediately make plans to confirm the correctness of the new discovery or idea, because, although an enthusiast, he was always most cautious in accepting these discoveries. When the time came to publish such work, it had to pass through the hands of a number of internal examiners before submission for publication. Many a half-baked idea perished in this filtering system devised by Pawsey; on the other hand, impatient young authors sometimes felt frustrated by the delays which were involved.

Another characteristic of Pawsey which permeated his radio astronomy group was that of complete frankness of discussion. No unpublished results were ever denied to anyone, whether the enquirer was a member of the Radiophysics Laboratory or some foreign radio astronomy group. It is probable that Pawsey's experience during the years when the laboratory worked in an atmosphere of war-time secrecy made him particularly determined that no trace of secretive behaviour would ever be seen again in his group. It follows from this that Pawsey was very interested in all forms of international co-operation in science. He was a regular participant in meetings of the International Astronomical Union, of which he presided over the Radio Astronomy Commission between 1952 and 1958, and of the International Union for Scientific Radio. At such meetings his stamina amazed his colleagues; each day he would discuss scientific problems from breakfast until midnight with the greatest intensity, with no break during meals or excursions.

He entered with great enthusiasm into co-operative scientific activity. He was one of the most active members of a group of astronomers in the I.A.U. concerned with redefining the positions of the galactic pole and the zero of galactic longitude. He produced a catalogue of reliably known discrete radio sources from data from various observatories, at a time when this was needed, and he published also a list of the radio observatories of all countries. He was one of ten authors of a paper in which solar observations from four countries were combined.

At the age of fifty Pawsey had already become the "Grand Old Man" of radio astronomy; he had pioneered a new branch of astronomy and had built up in Sydney a scientific group which had made considerable contributions to science and had become well known and respected throughout the scientific world.

He received many honours during his lifetime. In 1954 he was elected to Fellowship of the Royal Society and he was made a Foundation Fellow of the Academy. In 1953 he was awarded the Lyle Medal by the Australian National Research Council and in 1957 was the Academy's first Matthew Flinders Lecturer. In 1960 the Hughes Medal of the Royal Society was awarded to him. All of these honours Pawsey received with surprised delight: to the end he remained the most modest of men.

W. N. CHRISTIANSEN.
B. Y. MILLS.

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