A HISTORY OF THE PHYSICS DEPARTMENT OF THE UNIVERSITY OF QUEENSLAND

by

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PREFACE

It has been suggested to me that it would be of interest to the present and future members of the University, and particularly those associated with the Physics Department, if I wrote a brief history of the Department as it appears from my own memories and from what I learned from my predecessors. It has been difficult to avoid making this history unduly egocentric. For this, I apologise. Probably, no balanced history has ever been written by one who played a major part in it. I also apologise to all those associated with the Physics Department, whose achievements have been omitted, or inadequately, or incorrectly, stated. Perhaps, at some future date, a true historian will write a more critical and unbiassed account. Because of the practice of omitting from the Minutes of the Professorial Board, Faculty Boards, etc., details of arguments, I have not used these documents. The University Calendars, and Faculty handbooks, have proved more useful, particularly the Bibliographical Records included in the former, which indicate research publications.

This history does not continue past 1970, this being the year in which I retired, and proceeded to the U.S.A. to take up the position of Counsellor (Scientific) at the Australian Embassy. Occasional references are made to events in later years, especially retirements, resignations, etc., when these round off a story. It is hoped that this history will be continued, by supplements written at appropriate intervals.

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H. C. Webster

Brisbane, 31/3/77

Thomas Parnell M.A.
First Professor of Physics, University of Queensland

CHAPTER I. 1910–1920

The first appointments of academic staff at the University of Queensland were made in 1910. They included a Professor of Chemistry, Bertram Dillon Steele, D.Sc. F.R.S., a Professor of Mathematics (later entitled "Mathematics and Physics"), Henry James Priestley, M.A.; a Professor of Biology, Thomas Harvey Johnston, M.A., D.Sc. was appointed later. The inclusion of Physics in the Mathematics Department was not uncommon in that era; in the University of Tasmania, for example, it persisted until the late twenties. The 1910 appointments also included Alexander James Gibson, M.E. as Professor of Engineering. Gibson later went into partnership with Julius (later Sir George, Chairman of CSIR) and Poole (Consultant Engineers).

The first four Professors were appointed at a salary of £900 p.a. In the light of the low cost of living in 1910, this was a very handsome salary. Some of the later Professors were appointed at lower salaries.

At the commencement of teaching within the University, in April 1911, a Lecturer in Physics was appointed, Thomas Parnell, M.A.(Cantab), and in the following year – specifically on 1 March – an Assistant Lecturer, Sydney Gordon Lusby, M.A. was appointed. The salary of a Lecturer was £350, less than half that of a Professor.

Parnell was a Cambridge (St. John's) graduate (B.A. 1907) who, prior to coming to Queensland, had held a Tutorship at Trinity College, Melbourne. He was a good oarsman and had rowed in his College eight. (Incidentally, this crew also included Mervyn Henderson, M.A., later Principal of Emmanuel College, University of Queensland.) Parnell was also a keen and powerful wrestler. He was of a somewhat shy and retiring disposition and his heavy University duties precluded his entering into the social life of the city to the extent that professors in some southern Universities had done (e.g. Sir William Bragg, Sir David Orme Masson). He became, however, well known and greatly respected in Brisbane society. When, in 1936, I was living at Trinity College, Melbourne and was considering applying for a Lectureship at the University of Queensland, I met Archbishop Wand, then of Brisbane, who referred to Parnell in the words "He is a gentleman". In 1913 Parnell married Miss H. F. Ulrich, since 1911 Assistant Lecturer in Modern Languages at the University (she referred to her discipline as "Literae Humaniores").

Lusby was originally a Sydney graduate. He went to Cambridge (Emmanuel College) to take the degree of B.A. by research under Sir J. J. Thompson. This course was not dissimilar to the Ph.D. course later introduced at Cambridge. In pre-World War I times Cambridge was reluctant to accept a rival to its M.A. Degree, but later it found that it lost out in the competition, for bright research students from overseas, to German Universities, where a Ph.D. was the reward of a similar period of research work. The Cambridge B.A. (and automatic M.A.) did not discriminate between the Pass undergraduate and the overseas graduate doing research there.

In its first year, the whole University was housed in the old Government House building at the lower end of George Street, a well-built stone structure, with its own handsome gardens and ready access to the Botanic Gardens of Brisbane. The Physics Laboratory and workshop was housed in the cellar under the Senate Room (previously the meeting-room of the Governor's Executive Council). It would appear that, in 1911, Parnell had no assistant, but Adolf Edward Breuer was appointed as Laboratory Assistant some time in 1912 or 1913. By 1916 the number of assistants had grown to two, the other being George Wright (then on active service and temporarily replaced by Harold Tait). The number of students of Physics in 1911 was 19 day and 4 evening. They included Isaac Waddle, in 1914 a Junior Demonstrator in the Department, and later the author of a textbook on Junior Physics.

In 1912 Physics moved to the Chemistry Building (described as the "Woolclassing" Building) and in 1915 the new "Physics block" was opened. This was a brick building, adequate according to the standards of those days, but containing also Biology, Mathematics and Electrical Engineering. Physics gradually ousted the other Departments (except Biology) but it was not until after World War II that this process was completed. The building is still used by part (not Physics) of the Queensland Institute of Technology.

It is clear that, in spite of the Laboratory Assistants, Parnell and Lusby were grossly overworked and it was only because they were strong young men that they could cope with their duties. Parnell told me that on one occasion, when giving his last lecture of the day, he was so tired that he went to sleep. On waking he asked the class what stage he had reached, but they had been to sleep, too.

In 1916, Parnell enlisted in the A.I.F. as a private. This would not have been permitted in the Second World War, but in 1916 scientists (such as Moseley) were not regarded as of any value to the armed forces (in spite of the fact that a group of scientists, including Rutherford, developed the ASDIC system for detecting submerged submarines). Professor Richards told me that Parnell was not a great success at infantry drill, as he was not very sure which hand was right and which left and frequently turned the wrong way. Towards the end of the War, Parnell received a commission as a "gas" officer. This was arranged by Captain Richard Casey (later Lord Casey) who, as a Queenslander, knew Parnell fairly well.

The University made up the difference between Parnell's Army pay and his University salary. However, he most generously donated this difference to an endowment for the Physics Library. Mrs. Parnell, who had to resign on her marriage, was reappointed for the period of the War.

Parnell's departure left Lusby in an impossible position for carrying on all courses in Physics and it was necessary to withdraw Physics III from the curriculum for the last two years of the War. Otherwise the normal teaching was continued, to relatively small numbers of undergraduates. Lusby was promoted to Lecturer in 1917. It should be mentioned that, in 1916, Frederick William James, later Lecturer in Surveying, was a Demonstrator in Physics.

In 1919, soon after his return from the War, Parnell was promoted to a Chair and Physics became a separate Department. As already mentioned, Lusby was promoted from Assistant Lecturer to Lecturer in 1917. In 1922, Lusby was made an Assistant Professor, but this carried no more than Lecturer's salary. I have the impression that Lusby felt that the University failed to acknowledge properly the sterling service he rendered during World War I and that perhaps Parnell could have done more to improve Lusby's position. As Lusby had taken a B.A. by research at Cambridge he could well have been regarded as having superior qualifications to Parnell.

It is difficult for staff and students of the University of 1976 to conceive the atmosphere of the University in the first decade of its existence. It was a closely-knit body with complete comradeship between students, staff and Senate, each realizing the difficulties confronting the others and each doing all in his power to help. The youthfulness and athletic prowess of most of the staff made this easier than might otherwise have been the case, but the friendly feelings extended to all. Perhaps the real reason was the nature of Queensland people at that period, when the pioneering spirit still prevailed and there was a fraternity among Queenslanders lacking in the richer and more formal communities in southern Australia. In Brisbane at that time it was unnecessary to lock doors; burglary was unheard of.

Most of the academic staff used to meet in the Staff Common Room for morning and afternoon tea. Physics was exceptional in that respect, as Parnell had established a routine of having tea in the Preparation Room behind the small Lecture Theatre (in the George Street Physics building). This was convenient, as matters of Departmental concern could then be resolved in comfort and at leisure. The practice was, in fact, continued until the staff grew so large that more formal meetings became necessary.

CHAPTER II. 1920–1930

The most important event for the Physics Department during this decade was the appointment of Travis Rimmer, M.Sc.(Manchester) as Assistant Lecturer in Physics. Rimmer was a north countryman, of stature below the average, who had spent a number of years in Fiji, apparently combining the duties of surveyor and meteorologist. (Unfortunately, his personal file is missing from 'Records' although those of Parnell and Lusby have been retained.) From my conversations with Rimmer, I gathered that he was initially more of a Demonstrator than a Lecturer. About 1930, he was promoted to the position of Lecturer in Physics and Meteorology (in some Calendars the order is reversed) as there was a demand for lectures in Meteorology from the Agriculture Faculty. He was always more keen on Meteorology than other branches of Physics and for some years he operated a meteorological observatory in the grounds of the University. (The instruments were still in the Physics Store when I became Professor, but the observatory had to be taken down to make room for a new building.) At the beginning of the decade, although both Pass and Honours courses existed in the Faculty of Science, they were of the same duration, differing only in the amount of material in the third-year courses. It was the custom to invite an external examiner to visit the University to examine Honours students (who were rather rare). In 1924, an additional year was added to the Honours course. I gather that the system of external examiners was dropped, either then, or a few years previously. In 1933, when I first visited the University, first-class Honours in Physics had been awarded to a student early in the year.

I cannot ascertain the salary of an Assistant Lecturer in 1921, but Professors' salaries were specified as "up to £900", and Lecturers', £400–550; thus the gap had been reduced.

At the beginning of the decade, the name of Breuer disappears from the records and is replaced by Robert Gibb. Gibb was a Scotsman, with a strong Glasgow accent, who had served as Lab.-boy to Professor James Dewar (of Dewar flask fame) when the latter worked at the Royal Institution, Albemarle Street, London. Gibb always spoke of Dewar with great awe and reverence and his views were frequently quoted. Gibb had the curious habit of giving the term "Mrs" its full pronunciation as "Mistress" rather than the usual "Missus". Actually, he came to the University of Queensland as Lab. Assistant in Chemistry at about the end of World War I. As we shall see later, he became completely crippled with arthritis during World War II and had to retire.

George Wright resumed work in the Physics Department after demobilization, but retired in 1928. Parnell always said he missed Wright very much. John Jennings, who was appointed to the staff in 1927, took over the duties from Wright after the latter's retirement. Prior to 1927, the Lab.-boy was W. Lamb, but, in 1927, George Henry Klemm was appointed to the post and remained until 1935, when he transferred to the Physiology Department.

About the time of the separation of Physics from Mathematics, or possibly a little later, Parnell managed to acquire, from one of the Navy ships which was scrapped after World War I, a number of machine tools which, although not of first-class standard, were suitable for making and repairing simple physical equipment. A workshop was set up in the basement of the "new" Physics Building, which was little changed between the twenties and the end of World War II.

At some time during this decade, Physics gained additional accommodation from the removal of Electrical Engineering to the "new" (adjacent) Engineering Building. The latter was shared with the Central Technical College – University by day, CTC by night. This additional room allowed the conversion of the E.E. Laboratory into a "large" Lecture Theatre (holding about 150 students, the maximum complement of first-year Physics). The CTC, at one stage, also used part of the "Physics" Building in the evenings.

It was, I think, during this decade that Parnell was appointed a member of the "X-ray and other Electro-medical Equipment Advisory Board". This body was set up by the Queensland Government to advise on the choice between competing tenders for hospital equipment in this category. Parnell did not remain long on the Board. He disagreed violently with certain purchases made by the Health Department, which he considered implied bias in favour of one firm, and he resigned on that account. The duties of the Board were transferred, in 1944, to the Queensland Radium Institute.

CHAPTER III. 1930–1940

This decade opened with Australia in the middle of a profound economic depression, one that far exceeded in severity the troubles which followed the Bank bankruptcies near the end of the nineteenth century, or any other Australia-wide catastrophe. The measures introduced to pull the country out of its trouble included reduction in wages and salaries of those employed and this meant that all University salaries were cut by up to 15% in 1932. Thus a Lecturer went from £500/650 in 1930 to £430/560 in 1932 and a Professor from £800/1000 to £630/850. Salaries rose gradually, recovering to about the 1930 level by 1939. Assistant Lecturers were cut from £350/450 to £310/415: their cuts were eliminated by 1936. Needless to say, no expansion of University activities was permitted and vacancies were not necessarily filled. It was lucky for Physics that Jennings replaced Wright before things became too bad.

In 1935, George Klemm moved to the Physiology Department, and his place was taken by his brother Francis, who was to remain on the staff of the Physics Department until the time of writing – over 40 years. George graduated, with Physics major, in 1937, and has subsequently become a Senior Lecturer in Physiology.

At the time of my arrival, in 1937, the Department had a half-time Secretary (Miss McKay) – shared with Biology.

As economic conditions gradually improved, it was urged, by the Commonwealth X-ray and Radium Laboratory, that physicists be appointed in each State to assist Hospitals, and medical practitioners generally, in accurate application of X-rays, γ-rays and other ionizing radiations in the treatment of malignant disease and other diseases relieved by these radiations. Encouragement was also given to the establishment of Radon Preparation Plants in each State, thus avoiding transport of all radon gamma-ray sources from the CXRL, Melbourne. In 1935, the Queensland Cancer Trust, which had raised considerable funds for cancer treatment, and the Brisbane and South Coast Hospitals Board, agreed to provide funds towards the cost of physical services and Parnell was approached concerning ways and means. It was finally decided that a physicist be appointed, at Lecturer level, the salary to be provided equally by the University, the Trust, and the Board, and equipment and maintenance costs to be met equally by the latter two, with items such as electric power, stationery, etc. coming from the University. The University also agreed to provide the necessary accommodation, which fortunately was available, owing to a new building being in process of erection for the University. (In fact, most of it was taken away to provide a building for the Commercial High School, Mr. George and, later, Cyril Connell, being its Principal. Connell later became University Registrar.)

I had returned to Australia in 1933, after taking a Cambridge Ph.D., as a Research Physicist of the Radio Research Board, working under Professor Laby of the University of Melbourne. The Research project undertaken involved setting up a small temporary research station in Toowoomba by George Hector Munro and myself, and, in proceeding there, we called on Professor Parnell to see if any graduate students would like to participate in the research. Unfortunately, it was not possible to arrange this. (It would probably have been practicable to arrange it, if the research station had been located near Brisbane.) When, therefore, the Lectureship associated with Hospital Physics, as mentioned above, was advertized, offering better conditions than the Radio Research Board, I knew enough about the University to decide to apply. I was appointed in 1936, but in order to complete one stage of my research (which was to be carried on by my colleagues) I did not take up appointment until 1937. Since my experience in X-rays and radioactive emissions had been purely from the Physics point of view, it was arranged that I spend some months in Melbourne and Sydney becoming more familiar with the Clinical Physics needed in providing a satisfactory service to the Hospitals.

I arrived in Brisbane in June 1937, to find that the laboratories and office which I was to use were nearly completed and the necessary ventilation systems installed in the laboratories where the radon was to be prepared and measured. Hence, work could start on the construction, in the workshop, of parts for the plant almost immediately. Parnell allowed the workshop (then staffed only by Robert Gibb and the "Lab.-boy" Francis Klemm) to work almost exclusively for me. Even with this assistance, the radon plant took over a year to construct and install, and indeed it was not until 1939 that much time could be devoted to dosimetry, and on planning treatments to produce the dose prescribed by the radiotherapists.

I was extremely fortunate in having the most cordial reception from the radiologists with whom I was to work. All were most helpful and especially Drs. Val McDowall and B.L.W. Clarke (Private Radiologists, working part-time for Hospitals) and E.W. Casey (Radiologist at the Brisbane Hospital).

The long period occupied in completing the radon preparation plant (adapted from the design of that used at the Commonwealth X-ray and Radium Laboratory, Melbourne) was partly due to my rather amateur glass-blowing. Although the main portions of the glassware were obtained from a Melbourne glassblower, I had to seal them together and the work never seemed to go right until I lost my temper and swore at it. On one such occasion, I glanced behind me and saw Parnell quietly standing there. The radon plant has been rebuilt many times since then (mainly to Robertson's designs), made more efficient, and the exposure of the operator to ionizing radiation greatly reduced. However, at no time did the exposure (which was checked) exceed the prescribed limit.

At the end of 1938, Capt. E.R. Pike, Secretary of the Queensland Cancer Trust, took me with him on a round of visits to North Queensland Hospitals where radium applicators had been supplied by the Trust, so that I could meet the medical practitioners using them. I was also able to calibrate, for dosage, some X-ray therapy plants. This initiated the practice of physicists visiting northern treatment centres, which grew greatly after World War II.

At the time of my arrival in Brisbane, the academic staff of the Department, apart from Parnell, Lusby and Rimmer, included a part-time Demonstrator, Donald Fyfe Robertson, at that time still an undergraduate. In 1939 Parnell persuaded the University to appoint Robertson to a full-time Demonstratorship, partly to supply more assistance in Lab. classes, but mostly to assist me with the physical service to Hospitals. This made it possible to put the services on a fairly satisfactory footing by 1940.

By 1937 Australia had recovered sufficiently from the depression for the Commonwealth Government to supply a small amount of money to the Universities, through CSIR, for research, and I found, on arrival, that, since my 1933 visit, Rimmer, with the assistance of K.N.S. Hall and, later, Miss A.W.W. Hossack, had got going some research on long-term weather forecasting. This was a purely theoretical study, based on published data on weather, and while the results were not entirely negative, it was not possible to evolve a satisfactory forecasting procedure. It was, I think, the first research carried out in the Department. As mentioned earlier, although Lusby had research training, the enormous teaching load prevented his ever embarking on any research. In later years, he often expressed his great disappointment that this was the case.

Early in 1938, Rimmer had a severe attack of cardiac asthma. This was followed, during that year, by further attacks, each leaving him weaker, and he died before the end of the year. This had an important consequence, as far as I was concerned, since both Parnell and Lusby had sons sitting for the Junior Public Examination that year, the Examination being then still the responsibility of the University. It was therefore necessary that I should set and mark the papers. I followed the safe course of composing the paper from a hotch-potch of previous papers, but the marking kept me busy till well after Christmas. Fortunately Thomas Meredith Parnell and Henry Lindsay Lusby both did well!

The vacancy left by Rimmer's death was advertized as a Lectureship in Physics. Parnell showed me the applications, which were 26 in number, and included some physicists of considerable international standing. Of these, Arnold Luehrs Reimann, D.Sc.(Adelaide), Ph.D.(Berlin) was selected, and arrived early in 1939. Reimann had for many years been in the Research Laboratories of the General Electric Company and was the author of one important monograph and working on another.

In 1938, Parnell was elected President of the Professorial Board (formerly known as the "Board of Faculties") and continued to hold that office until 1944. His period of office was a very exacting one, since the onus of much of the necessary negotiations with the Commonwealth Government fell on him. This strain undoubtedly undermined his health. I remarked, in 1943, that he seemed years older than when I left Australia in 1941. He still managed with one Secretary (still

Miss McKay) with assistance from the central typing staff.

Although the 1938/9 staff seems extremely small on the standards of 1976, it should be remembered that no fourth-year lectures were given and third-year numbers were so small that the Lecturer-in-charge need spend only a part of the Lab. period with the students. In one year that I remember (1939), the class consisted of only one student – Benjamin Geddes Tyrrell, now in the Queensland Department of Harbours and Marine. First-year and second-year lecture classes were not subdivided, and only one of these two courses, alternately, was made available to evening students.

The establishment of a Lectureship to provide physical service to Hospitals, as well as teach, was commended in many quarters, but it had drawbacks which led to its being discontinued from the time of my retirement from the University. Fortunately, the general concept had survived at the Queensland Institute of Technology, which offers an M.Sc. course in Hospital Physics. James Peter McGilvray, a former Lecturer in our Physics Department, on the Hospital Physics side, is responsible for some of the teaching.

Prior to World War II, the visitation to the University by a distinguished physicist from abroad was a very rare event. It was thus very much appreciated, in 1939, when Nobel Prizeman Robert Andrews Millikan visited the University. He had recently retired from the Presidency of the California Institute of Technology, the immense prestige of which owed much to his skilled administration. The old University grounds adjacent to the tennis lawns were perfectly suited to an outside reception of such distinguished visitors and the smallness and friendly relationship of the Senate and staff made the occasion a very pleasant one.

The declaration of War in 1939 and the steady deterioration of the military situation in 1940 naturally caused deep anxiety in the minds of all University staff and caused them to consider where their duty lay. Both Reimann and I had had previous experience in fields which might be of value in military communications and I decided that, rather than emulate Parnell's example and attempt to enlist in the Army, I should write to Professor Madsen, Chairman of the Radio Research Board, and ask whether my services could be put to use. Madsen replied favourably, but a little later pointed out that he was asking the University to second Reimann for Military research and development, and this would probably preclude my coming also. In the outcome, both of us were seconded to the Radiophysics Division of CSIR, a new Division whose work was highly classified. In fact we learnt, when we arrived there, that it was concerned with what was then described as R.D.F. (radio direction-finding, a deliberate misdirection) but later as RADAR (radio direction and ranging). Our work there will be discussed in the next Chapter.

Reference has already been made to Rimmer's work on long-range forecasting. Three papers (completed after Rimmer's death) were published on this subject. Other publications from the Department were three papers I published which related to work done prior to my arrival in Brisbane, and Parnell's Presidential Address to Section A of ANZAAS. The latter was entitled "Physical Constants" and is a scholarly review of the whole subject and contains some original ideas. Incidentally, it points out the advantages of the MKS system of units, now the official system of Australia. (To be precise, the latter is the MKSA system, while Parnell recommended a slightly different system.).

CHAPTER IV. 1940–1949

Upon my departure, and that of Reimann, it was necessary to reorganize the Department. Parnell arranged for Robertson to devote full time to the Hospital work. Mary Agnes Trotter, B.Sc. (married to Lieut. A.B. Chater R.A.N.V.R. in 1940) who had been, in early 1940, a part-time Demonstrator, was appointed a full-time Demonstrator. Mrs. Chater was a Queensland graduate, who had had some experience of teaching in schools before taking the University post. In 1946 her appointment as Assistant Lecturer was made permanent, but she resigned in 1947, for personal reasons. In 1943, at about the time of the establishment of the Queensland Radium Institute, Robertson was raised in status to temporary Lecturer. Although Reimann and I were seconded to CSIR, we were still recorded on the University staff list and noted as "on special service".

Robertson's teaching duties were assumed by Robert William Edgar McNicol, B.Sc., who was appointed early in 1940 as a full-time Demonstrator. McNicol had been an "Evening" (i.e. part-time) student during his undergraduate course, supporting himself by a full-time job as an operator at a commercial broadcasting station. (He had the necessary certificates for the job). His experience with electronic equipment afterwards proved extremely valuable, as shall be seen shortly. He remained on the staff of the Physics Department until his death in 1974, being promoted, in stages, to the status of Reader.

On arrival at the Radiophysics Laboratory, a newly-constructed building within the grounds of the University of Sydney, Reimann and I were, in turn, informed of the purpose of the Laboratory and the history of its inception. Reimann was asked to form a valve-development group, and I was attached to the group of Dr. Joseph L. Pawsey, at that time occupied on producing radar equipment, in the metre band of wavelengths, for the Coast Artillery. Pawsey had been a Research Physicist of the Radio Research Board, before going to Cambridge to work for a Ph.D. After obtaining his doctorate, he went to the E.M.I. Research Labs and played a prominent part in the introduction of television in Britain. He was recalled to Australia when the Radiophysics Lab. was set up.

The Radiophysics Division of CSIR had, as Chief, Dr. D.F. Martyn, previously a Research Physicist of the Radio Research Board. The policy of the Division was determined by a Radiophysics Advisory Board, chaired by Professor J.P.V. Madsen (of Sydney University) and including among its members the Chiefs of Staff of the three armed forces. The brick building in which the development work was carried out was constructed in about 6 months – a speed impossible in peace time. A high proportion of the research staff had been, at one stage of their careers, research physicists of the Radio Research Board. Australia thus obtained enormous dividends on the relatively small amount of government money expended on the Board's operations.

The discovery of radar in 1935 (then, as mentioned, called R.D.F.) was due to Watson Watt and a small body of collaborators, including Arnold F. Wilkins and E.G. (Taffey) Bowen (later Chief of the Division of Radiophysics, CSIRO). The first application was in the "chain" stations for giving warning of approaching bombers, which stations were nearly complete at the start of the War. (It is said, though probably falsely, that Chamberlain signed the Munich Agreement in 1938 to allow time for these stations to be completed). Some months before the start of the War, Britain decided to inform suitable individuals in the Dominions (Canada, Australia, New Zealand and South Africa), under conditions of great secrecy, about radar, with a view to encouraging those countries to develop production of radar equipment and to train personnel. Dr. D.F. Martyn, a Research Physicist of the Radio Research Board, was chosen for Australia and, as a result, the Radiophysics Division was set up. In order to keep in touch with further developments in radar in Britain, the Division stationed an officer, G.H. Munro (my former research partner), in London. Somewhat later, he was replaced by V.D. Burgmann. In 1941, owing to the decision of the British Government to disclose to the Dominions almost all the discoveries in defence science being made in Britain, CSIR, with the consent of the Minister, decided to expand its London office to embrace all aspects of defence science. It was arranged that Madsen should go to London to open a Scientific Research Liaison Office. I was asked to accompany him, together with Frank Nicholls, M.Sc., then occupying an administrative post in CSIR, and the staff was to include Burgmann, who was already in London. At the same time, Munro was to be established at the Australian Legation in Washington, to carry out a similar function in the United States. (Britain had already disclosed many of its discoveries in military science to the U.S.) The team left in April 1941, and, after some weeks in Washington, arrived in London in July. After a few months, Madsen found he had to return home and I was placed in charge of the office until June 1943.

Mark Oliphant was then Professor of Physics in Birmingham, and Randall and Boot, members of his group there, had made a discovery which was revolutionizing radar equipment. This was the cavity magnetron, an extremely efficient device for generating radio pulses at "microwave" freqquencies (specifically, at about 10 cm wavelength). One of my first jobs was to obtain, from a technical officer at Oliphant's laboratory, a very full description of how to make a magnetron. The resultant document was sent out post haste to Australia. At this stage, Dr. L.H. Martin (later Sir Leslie), of Melbourne University, expressed willingness to join the Radiophysics work, and he established a valve laboratory, in Melbourne, for magnetron development, taking over from Reimann. A.W.A. undertook the production of magnetrons, and, in fact, made a considerable number for Australian radar equipment, during the latter part of the War.

Reimann turned his attention to Solid-State devices, which were already used in microwave radar receivers. He continued this work after returning to Brisbane, and was assisted by two Honours students, Victor John Bahr and John Vincent Sullivan. Bahr later became Director of Meteorology for New South Wales, and Sullivan has had a distinguished career in the CSIRO Division of Chemical Physics. Reimann's work was published in 1952.

On my return to Australia, I found considerable changes in the Division and it was difficult to determine where I could be of use. After a somewhat frustrating period, I joined a radar countermeasure group, initiated to serve the joint RCM service of the three American and the three Australian services, known by the code "Section 22". I had been fascinated by the RCM work being done in England, during my sojourn there, and I found the new assignment most exciting. I was eventually asked to head the group. RCM, although useful in the Pacific War, played a less important role than in Europe.

In 1945, when the War was obviously approaching its end, I was given to understand that the University wished me to return, and I applied for, and was granted, release from my undertaking to CSIR, and arrived back in Brisbane almost on the day when the War in Europe was concluded. Reimann had already returned.

Meanwhile, a very important development had occurred in the Physics Department. The Radio Research Board, which had been deprived of a large proportion of its staff by the Radiophysics Division, still possessed a nucleus of the staff, headed by F.W. Wood, which carried on routine ionospheric sounding in Sydney and used the results to make forecasts of the future state of the ionosphere in the south-west Pacific War arena, and the optimum frequencies to use in certain radio communication channels. As the military operations took place well north of Sydney it was found desirable to have ionospheric soundings made in Brisbane, and Parnell was asked (and agreed) to accept responsibility for this — on the understanding, of course, that the Department be supplied with the necessary buildings, equipment and funds. Parnell became a member of the Board in 1942. In 1943, an ionosonde belonging to the Board was rebuilt by its Sydney staff, and set up on a site near Lambert Road, Indooroopilly, the Board providing the necessary antennas, and the RAAF assisting in various ways. McNicol operated the equipment, with the assistance of Dorothy Arthur, the former getting the status of Assistant Lecturer, and the latter (then a final Honours student), Demonstrator. Two-thirds of their salaries were paid by the R.R.B. In 1945, Helen Rosemary Venton was added to the group, with Demonstrator status. In 1946, Dorothy Arthur (then Mrs. Gipps) resigned, and was replaced by her husband, Graham de Visme Gipps. In 1946, McNicol was fortunate enough to be awarded a British Council Scholarship, and spent the next three years in Ratcliffe's radio research group at the Cavendish Laboratory, Cambridge. He returned to Brisbane in mid-year 1949, and was promoted to a full Lectureship in that year. In 1948, Venton resigned, and Coralie Williams was appointed, shortly before that resignation, to take her place. Meanwhile, in May 1947, Howard MacGregor was appointed, in the capacity of Radio Mechanic, to look after the maintenance of the equipment. In 1949, Graham Gipps resigned, to undertake a full-time Ph.D. course. He received the degree in 1954, being the first Ph.D. graduate of the Physics Department. He then secured a post at the Weapons Research Establishment, Salisbury, South Australia, and later moved to the Philips organization, where he was appointed to a senior post.

The practice of the R.R.B. paying two-thirds of academic salaries ceased in 1954.

On 5 September 1943, Sir Henry Tizard, Scientific Adviser to the British Air Ministry, and, later, Principal of Imperial College, University of London, accompanied by Sir David Rivett, Chairman of CSIR, visited the station and asked many cogent questions. During his sojourn in Brisbane, Sir Henry was given an honorary LL.D. by the University.

As already mentioned, the RAAF took a direct interest in the station. Dorothy Gipps recalls that, one day, there was a preemptory knock on the door of the station, and, on opening it, she found an RAAF messenger, with two weapons at his belt, who solemnly handed over a copy of McNicol's thesis, which the staff had been carrying around casually in folders.

In 1947, the original ionosonde was replaced by a new model, developed, to the specifications of F.W. Wood, by Arthur J. Higgs of CSIR, and built in the workshops of the Radiophysics Laboratory.

In 1949, MacGregor was promoted to the grade of Scientific Assistant. About a year previously the University had provided a Radio Mechanic for the Physics Department, the first appointee (1948) being Bernard Hyde, followed in 1949 by William W. Wellstead, who left after a few months.

Another important development was the establishment, in March 1944, by Order-in-Council (validated, retrospectively, by an amendment to the Health Acts) of the Queensland Radium Institute, with the responsibility for directing all medical treatment by ionizing radiations carried out in Queensland Government Hospitals. The Director-General of Health and Medical Services, then Sir Raphael Cilento, was ex-officio Chairman and the University was represented on the Institute. (The phrase "Queensland Radium Institute" covers both the committee of management and the actual treatment centres and their staffs.)

The Queensland Cancer Trust was abolished and its treatment facilities transferred to the Q.R.I. Dr. Arthur G.S. Cooper, who was then the Radiologist at the Brisbane Hospital, was appointed Chief Radiologist and Dr. Eileen Reimers was appointed Assistant Radiologist. At first, Dr. Cooper continued to direct also the diagnostic X-ray Department of the Hospital, but after some years the two functions were separated, and Dr. Cooper's title changed to Director. Considerably later, Dr. Reimers (then Mrs. Harrison) asked for her appointment to be changed from full-time to half-time.

The Institute took over the responsibilities of the Queensland Cancer Trust and the Brisbane and South Coast Hospitals Board, as far as the physical services were concerned. It was agreed that, on my return, both Robertson and I should continue as Lecturers, devoting two-thirds time to the Hospital work, one-third to University. Our designations were, as from 1946, changed from "Biophysics" to "Radiation Physics" since the Physiology Department had obtained the establishment of a Lectureship in Biophysics, to handle all applications of Physics in Physiology. The Senate Committee formerly entitled "Biophysics Advisory Committee" (established in 1937) became the "Radiation Biophysics Advisory Committee".

Richard Gibson Strangman Taylor, who had been appointed a Cadet Assistant to the physical services to Hospitals in 1939, completed his B.Sc. degree in 1945 and was raised in status to Technician (and later given Lecturer status and, still later, the title and privileges of a Lecturer).

In 1946, I was promoted to the status of Associate Professor (this designation has been replaced by "Reader"). It should be noted that the pre-War Grade of "Lecturer" became, in the post-War period, "Senior Lecturer" while "Assistant Lecturer" in effect became "Lecturer"; thus my promotion was not a double jump. In 1947, Lusby also became Associate Professor. (This carried a higher salary than the obsolete office of "Assistant Professor".)

Founded upon experience after World War I, the University was, in the months following the final victory over Japan, preparing for a sudden large increase in student numbers. In the case of Physics, this would mean subdivision of Physics I into several groups, both for lectures and for laboratory classes. It had long been felt that medical students should have a distinct lecture (and, in part, laboratory) course and Parnell asked Robertson and me to give such a course in 1946. To provide for the remaining first-year undergraduates, he asked for three Assistant Lecturers. Appointments were made of Jim Crouchley, M.Sc., then a Demonstrator at Adelaide University, and Kenneth Stanley Warner Champion, M.Sc., then a Demonstrator at the University of New England. The third position was filled by Mrs. Chater, whose temporary post normally would have expired upon Reimann's return. Parnell asked the other Physics I Lecturers to follow his syllabus, and synchronize, as far as possible, their lectures with his.

A Branch of the Institute of Physics (London) existed in Australia from soon after the formation of the Institute, but its activities were negligible until the thirties. At that stage, Divisions of the Branch were formed in Sydney, Melbourne and Adelaide which held a number of scientific meetings each year. While, earlier, the Australian Committee consisted of Heads of University Physics Departments, it was decided by the members, about 1935, that there should be a wider representation, including physicists from outside Universities. The Branch organized Australia-wide meetings of physicists in the years when there was no meeting of ANZAAS. At the time of my arrival in Brisbane, there was no Queensland Division, there being then, in Queensland, insufficient corporate members of the Institute to form one. However, by 1947, with the addition of the new Assistant Lecturers, the number of members was adequate and, at my suggestion, a Division was formed. (With the formation of the Australian Institute of Physics, this became a "Branch"). It has attracted good attendances at its meetings and is firmly established.

The number of Demonstrators was increased as people became available. In 1948, there were four full-time and one part-time Demonstrators, together with a Radio Research Board Assistant with the status of Demonstrator (Mrs. Venton).

Because of inadequate records, I am not including full lists of demonstrators or tutors, but I should mention that among the 1949 Demonstrators were John Vincent Sullivan, Clifford Francis Barrett, James Desmond Balfe, and Vera Patricia Lowthen (now Gunn). Sullivan and Barrett became Senior Scientists in CSIRO, Balfe (who, as mentioned later, was Acting Lecturer here for a short time) was later appointed Senior Lecturer at the University of Newcastle, and Mrs. Gunn is on the staff of the Education Department of the University of Queensland.

The Commonwealth Repatriation Training Scheme (C.R.T.S.) provided selected students, who had been on active service during the War, with full fee charges and a living allowance, but not many went beyond the Pass Degree, in Physics. Of those who did, Zebulon Ross Jeffrey and Edward George Gottstein are two that are remembered. Jeffrey joined the staff of the Weapons Research Establishment and I met him there several times in the fifties.

The technical staff of the Department was in poor shape at the end of the War. Gibb had become so crippled with arthritis in the early forties that his hands were useless, and the best he could do was to instruct Frank Klemm how to carry out the work: so that Frank became, in effect, Gibb's hands. The date of Gibb's actual retirement is a little vague, but certainly in the 1945 Calendar, Frank Klemm is the only Mechanic listed. Jennings remained throughout as Lecture-room Assistant, and there was a vacancy for a Lab.-boy. As soon as there was a reasonable prospect of obtaining the services of a good University Mechanic, Parnell had Gibb's position advertized, and, in May 1947, Cyril Clyde Croskell was appointed. It was singularly fortunate that we got such an exceptional man at such a time. Needless to say, Croskell reported to Parnell many deficiencies in the workshop equipment. Some of these were rectified, using C.R.T.S. funds made available to the University to equip it for the post-War wave of students. In 1947, the workshop staff was increased by the addition of M.J. Gardiner, who remained until 1949. The next appointment was that of Norman Baker, in 1949. Baker transferred to another Department in the fifties.

Reference has already been made to the Lectureship in Biophysics within the Department of Physiology. Crouchley applied for this Lectureship and was appointed as from the beginning of the 1947 academic year. Parnell, in agreeing to release him, stipulated that he should still give some lectures in the Physics Department and this arrangement was duly honoured. However, it was found necessary to fill the Assistant Lectureship he had vacated and Jack Harley Noon was appointed to the position in 1947. Noon was a first-class Honours graduate of the University, who had served for two years as a Demonstrator in Physics. In 1947, Mrs. Chater resigned, and in February 1948, Richard Donald Malcolmson was appointed Assistant Lecturer in her place. Malcolmson, after graduating B.Sc. at the University of Melbourne in 1947, had taken up school-teaching; he remained at the University for three years. In 1947, Champion gained a British Council travelling fellowship, and proceeded to England to work with Oliphant's Nuclear Physics group at Birmingham. Champion resigned in 1951, without having resumed his post, and later proceeded to the United States, where, after a University appointment, he joined the staff of the Air Force Cambridge Research Center, and at the time of writing holds a very senior post there. During his absence in Birminghan, John Desmond Balfe was temporarily promoted from a Demonstratorship to a Lectureship.

During the early years of the Radio Research section, McNicol and Arthur made a careful study of the appearance, on the Brisbane ionograms, of reflections from the so-called sporadic-E layer of the ionosphere. (This is a relatively shallow layer in the ionized atmosphere, capable of reflecting radio waves; it is normally found at about 100–110 km altitude.) They found that this layer shows itself on ionograms for a high percentage of the time, rather nullifying the term "sporadic", as far as Brisbane is concerned. This study was continued by Gipps in McNicol's absence. The final results were published later in a joint paper which proved to be a landmark in the understanding of this phenomenon. The early records also showed, occasionally, an interesting anomaly in the F-layer, which, during the next decade, formed the subject of Gipps' Ph.D. work, and other research within the Department. (The F-layer is situated from around 200–300 km upwards.)

An important change in the function of the Radio Research Board occurred towards the end of the 1940–1949 decade. The wartime responsibility of the Board for preparing forecasts of ionospheric propagation conditions, and the optimum frequencies for use for certain specific communication channels, was transferred, on 1st September, 1947, to a new organization, the Ionospheric Prediction Service, (I.P.S.), which operated, for its first few years, as a branch of the Commonwealth Observatory (though located in Sydney). Dr. A.L. Green, a former Research Physicist of the Radio Research Board, was its first Director. After Green's death, in August 1955, Dr. W.G. Baker became Director. The I.P.S. gradually assumed responsibility, not only for the analysis of results, but also for the operation of all Australian ionosondes. The Brisbane ionosonde remained the responsibility of the Physics Department for the early part of the next decade, but, in March 1955, was taken over by an I.P.S. physicist, Henry Emanuel Brown, and from June 1955 he was assisted by a technician (Gilbert G. Cairns). An arrangement was arrived at whereby, in return for the Physics Department continuing to house the ionosonde at Moggill, and provide an office for the I.P.S. staff, it was guaranteed access to the Brisbane ionograms, and could, when needed for research purposes, also borrow ionograms from other I.P.S. stations, notably Townsville, Canberra and Hobart. This arrangement is still (1976) in operation. A somewhat similar arrangement exists between I.P.S. and the University of Tasmania.

When the Commonwealth Observatory was handed over to the Australian National University, the I.P.S. became part of the Meteorological Service. It is currently a division of the Department of Science.

The Radio Research Board reverted to a true research organization, and gradually developed into a purely grant-giving body, with no scientific staff.

Some research was also carried out in the Radiation Physics section, all directly related to the Hospital work. Most of it was brought to a successful conclusion, but an attempt, by Miss E. Carnegie and myself, to produce minature Geiger counters suitable for dosimetry of radiation fields having a high gradient, had to be abandoned, as it was found that other methods showed more promise. Work was published on the State dosage standard, and accuracy in radon work, as was also a general paper on the possibilities of nuclear reactors, and a John Thomson lecture on the energy problem.

At the time when the Queensland Radium Institute was constituted (1944), a second body, to be known as the Queensland Health Education Council, was also set up, with the function of educating the public as to the means of preserving good health. Parnell, as a member of the former Queensland Cancer Trust, was appointed a member. However, he resigned about the end of 1946, and, at his recommendation, I was appointed a member, in 1947. I remained a member until, following another Act of Parliament, the Council was dissolved in 1976.

Parnell had had indications of a heart condition early in the War period and, in late 1947, he suffered a severe attack while lecturing. He was hospitalized and while, at first, he seemed to be holding his own, his condition gradually deteriorated, and he died about mid-year in 1948 at the age of 68. Lusby was appointed Acting Professor and the position was advertized. In February 1949, the Vacation Committee of the Senate appointed me to the Chair. The University staff, Parnell's former students, and others, donated, in response to an appeal, a substantial sum to add to the endowment of the Physics Library, which, as mentioned earlier, was initiated by Professor and Mrs. Parnell. Parnell had always been keenly interested in the Library, and the Senate agreed to name it the Parnell Memorial Library. At a later date, the Senate decided to name the St. Lucia Physics Building (completed in 1955) the "Parnell Building". The University, and indeed all Queensland, owes more to Parnell than is generally appreciated, and it is only fitting that he should be thus commemorated.

It will be convenient if I terminate this Chapter at this point.

CHAPTER V. 1949–1960

In 1949, when I became Head of the Department, staff included:—

Associate Professor:	S.G. Lusby
Senior Lecturers:	A.L. Reimann, D.F. Robertson
Lecturers:	R.W.E. McNicol (on leave), J.H. Noon, R.D. Malcolmson, K.S.W. Champion (on leave), J.D. Balfe (acting)
Radon Technician:	R.G.S. Taylor, B.Sc.
Cadet Radon Technician:	K.A Stevens
Mechanical Workshop:	C.C. Croskell, F. Klemm, M. Gardiner
Electronic Workshop:	H. MacGregor, B. Hyde
Lecture-room Assistant:	John Jennings.

By this date, the academic staff structure had been modified and new salary scales introduced. The grade of Assistant Lecturer was abolished and all Assistant Lecturers made Lecturers, while former Lecturers became Senior Lecturers. (The grade of Lecturer was initially in two levels Grade I and Grade II, without automatic promotion beyond the top of the lower level. The two were later merged.)

When it was known that Champion did not intend to return, it was decided to advertise his position. John Angas Thomas, a first-class Honours graduate of Adelaide University, was appointed. Thomas had already had some experience in radio research while a student under Professor L.G.H. Huxley, and fitted well into the team. He enrolled as a Ph.D. student and obtained the degree in 1957. He was promoted to a Senior Lectureship in 1958, a Readership in 1962. In 1963 he resigned, to take up a similar position at the RAAF Academy, University of Melbourne. An additional staff vacancy was filled by Crouchley moving back to the Physics Department in 1950.

The most urgent problems facing the Department were:—

(1) Revision of plans for the new Physics building at St. Lucia. The site was determined by the pre-War Master Plan, and this also fixed the size and general shape of the front, facing the Great Court. However, the old plans obviously did not provide adequate space and needed drastic revision.

(2) Formulation of a research plan for the Department. While a little research activity had been generated by the Radio and Radiobiology activities in the Department, it was clearly necessary to increase this activity greatly in order to bring the Department into parity with southern Universities of equal size.

At a meeting of ANZAAS held about this time, Professor Schrum, Head of the Physics Department of the University of British Columbia, described his new building, which incorporated, inter alia, lecture theatres without windows, the rationale being that the theatre needed to be darkened so often for showing lantern slides, that it was preferable to have only artificial lighting, which could be switched off without delay. By having two large lecture theatres of this type, surrounded by the laboratories and staff offices, it was possible to design a building which would comply with the requirement of consistency with the general design of the Great Court, and would be more compact and, presumably, cheaper, than could be devised by merely adding to the pre-War plans. This plan meeting with the approval of the Senate and of the Coordinator-General (responsible, under the University Act, for all University buildings), the Architects (Hennessy & Hennessy) were instructed to produce working plans on this basis. Another innovation was the replacement of the traditional large teaching laboratories by small ones, suitable for about 12 students each. I felt that, with a Tutor/Demonstrator to each laboratory, and, if possible, arranging that all student-pairs in any given laboratory worked on the same experiment, better instruction could be given and that the "social-occasion" atmosphere that prevailed in the large laboratories at George Street could be minimized. However, in case it became necessary to revert to large laboratories, the structure of partitions between laboratories was such that they could be readily removed. In fact, only minor changes have been made in the 22 years subsequent to the occupation of the building. Before the end of the decade, it was found possible to provide 7 sets of equipment for each experiment in the first-year course, so that the plan could be implemented completely.

Unfortunately, owing to a misunderstanding, the seating in the large lecture theatres was constructed with much too steep a slope, being based on the (earlier) Chemistry Lecture Theatre and not on Parnell's design. It also became evident, later, that the lecture theatres were unnecessarily high.

The plans of the building were approved in 1950 and work nominally started in 1951, but little was done until 1953 and the building was not ready for occupation until 1955. In the original (pre-War) plans, a separate building was provided for the preparation and measurement of radon and this plan was preserved, with only minor variations. The Radon Building, stone-faced, was proceeded with somewhat faster than the main Physics Building (due to pressure to vacate the George Street accommodation) and was completed and occupied in 1954. The main Physics Building, though occupied late in 1955, was not completely stone-faced until 1966.

As concerns research, it was my view (confirmed by later visits to Universities abroad) that the building-up of a good research reputation for the Department could best be achieved by concentrating our efforts into one field of research, or, at most, two. In the post-War years there was a strong tendency for Physics Departments of Universities to concentrate their efforts on Nuclear Physics and, as a former student under Lord Rutherford at the Cavendish Laboratory, this naturally had a great attraction to me. However, I felt that with the A.N.U. and Melbourne University well advanced in this field and assured of adequate financial support, we would not be in the race. Instead we would do better by choosing (1) Ionospheric Physics and/or (2) Radiation Biophysics, in both of which we had acquired some experience and had some of the essential facilities. The other work initiated in the Department, the Solid-State work of Reimann, had the drawback that with the intense effort in the United States which led to the development of the transistor and which was obviously going to continue (in the interests, inter alia, of space research) it would be virtually impossible to keep pace, with the limited financial resources likely to be available. As mentioned earlier, Reimann published his work on the electrical properties of galena in 1952. Thomas, who originally intended to work on Solid-State problems, was persuaded to change to Ionospheric Physics, in which he was highly successful.

An even more important reason for choosing (1) and (2) above was that the Radio Research Board was already funding the former and seemed likely to continue to do so, and, apart from the Queensland Radium Institute, the University itself had several bequests for Cancer Research which could legitimately be channeled into the latter.

A further justification for my choice was my appointment, in 1949, as a member of the Radio Research Board and, in 1951, as a member of the (Committee of the) Queensland Radium Institute. The Radio Research Board, at that time, consisted of the Chairman (Sir John Madsen, Emeritus Professor of Sydney University) representatives of other Universities (Professor Huxley and myself), of the P.M.G. Department (Mr. E.P. Wright), of CSIRO (Drs. E.G. Bowen and F.W.G. White), the Commonwealth Observatory (Dr. R.v.d.R. Woolley), the Army (Lt. Col. E.G. Foster), the Navy (Lt. Commdr. A. Brook) and the Department of Air (W/C W.C. Blakeley). Representatives of the Overseas Telecommunications Commission (Mr R. Long) and the Australian Broadcasting Control Board (Mr. D. McDonald) were added a few years later. At about the same time, the representatives of the fighting services were withdrawn, but subsequently a representative of the Department of Defence was added.

It was fortunate for the Radio Research group (staff and students) in the Physics Department that the International Union of Radio Science (generally known as URSI) had its Assembly in 1952 at Sydney and most of the group were able to attend the Assembly. The Japanese delegation was asked by the then External Affairs Minister not to attend (owing to fear of political disturbance) but D.F. Martyn (of C.S.I.R.O.) later visited Japan on a good-will mission, which restored friendly relations. Martyn later related to our group something of what he learned during his mission.

The contacts made by our Radio Research group were maintained and led to many of the staff on Study Leave receiving hospitality in U.S. and other overseas countries, in many cases including financial assistance. Several members of the group attended each of the subsequent triennial

Assemblies of URSI and some attended meetings of the related body, the International Association of Geomagnetism and Aeronomy (IAGA).

As concerns Radiation Biophysics, my transfer from service to the Queensland Radium Institute was compensated for by the appointment of Keith Allan Stevens (previously a cadet) at the approximate status of Lecturer (Taylor then having similar status) and in 1953 a third physicist, at Lecturer status, was added, viz. Donald Seaforth Mathewson, a graduate of this University and previously a Demonstrator. While Robertson and the three Lecturers were mainly concerned with routine matters, they spent some of their time on researches directly related to the routine activities. At a later stage, Robertson embarked on a long research, concerned with the ultraviolet content of sunlight as a carcinogenic agent, and McGilvray (a later appointment) developed the technique of thermo-luminescent dosimetry.

I retained my interest in the work of the Queensland Radium Institute and during my Study Leave in 1951-2 interviewed, in London, Dr. K.S. Mowatt, later to become Director of the Institute, and studied the 8 MeV linear accelerator at Hammersmith Hospital used to generate high energy X-rays for radiotherapy. Not long afterwards, the Institute purchased a 4 MeV accelerator, which has proved of great service and has involved a considerable amount of work by the physicists. Subsequently, other accelerators, etc. have been purchased. I was also able, occasionally, to accompany the Radiotherapists on visits to country sub-centres of the Institute, and thus remain familiar with this aspect of the Institute's work.

Later, I was asked to assist the Parliamentary Draughtsman with the drafting of the Radioactive Substances Act, and was appointed a member of the Radiological Advisory Council constituted under the Act. Robertson was also appointed a member and remained on the Council even after his direct connection with the Queensland Radium Institute was severed.

Mathewson resigned from the Department in 1956 and subsequently took up Radio Astronomy at Manchester University, with great success. Later he was appointed to a major position at the Australian National University. His place in the Physics Department was taken by Bernard John Perrett, B.Sc., who had previously been a physicist at the Hammersmith Hospital, London. It should also be noted that D.H. Walker, a graduate (1938) of this University, who was first appointed to the Hospital primarily as a Radiographer, gradually became a full-time physicist during this era. Thus, there was introduced a dual system of physicists at the Institute.

During the decade 1950–1960, the numbers of students attending courses in the Physics Department, at all levels, continually increased, partly from growing interest in the subject and partly from the growth of secondary school populations, and hence in the number of persons qualified for matriculation. Thus the number of students in Physics III (major) increased to about 50 during the decade and about one third of those successful in passing Physics III carried on to Physics IV (Honours) and/or M.Sc. During the decade, also, the Ph.D. degree became firmly established and Physics had several Ph.D. students (mostly members of the academic staff).

In addition, the requests, from Faculty Boards, for Physics courses adapted to the particular needs of the Degrees under their jurisdiction, increased the number of lectures and laboratory courses required in the early years. The overall consequence was a need for a considerably increased staff and this, combined with the expansion of research activity, necessitated additional accommodation.

On the staff side, there were a number of changes in membership and in status, which are enumerated below:—

1. In 1951, Reimann was appointed Research Professor. This title was created, as a result of a motion I put to the Professorial Board, to reward highly distinguished research among sub-Professorial staff. The position was to be on a par with that of Associate Professor but, unlike the latter, would not be awarded because of administrative responsibilities. At a later date, the Senate raised the status and salary of some Research Professors to that of full Professors. As mentioned previously, Reimann had a distinguished research record and had published two important monographs, as well as a number of papers.

2. In 1955, Lusby retired. This retirement coincided with the transfer of the Department to the new building at St. Lucia and thus to a considerably greater distance from his home.

Unfortunately we saw very little of him after his retirement and thus the only link with the pre-World-War I University was severed.

3. A very important addition to the staff was made by the appointment of Donald Mugglestone as Senior Lecturer in Theoretical Physics in 1958. This University had lagged seriously behind other Australian Universities in having no position reserved for a theoretical physicist. While the other staff were naturally involved in theoretical aspects in their teaching and research, they were primarily experimentalists and not experienced in handling the more sophisticated theoretical problems, so that we were notably weak on that side. The position was actually established before 1957 and offered to Mugglestone, but, in the interim between his application and the offer, he had accepted a one-year appointment at Manchester University, and thus his arrival was postponed.

Mugglestone established a sound programme of work on Theoretical Astrophysics and several of his students now occupy important posts in Australia and elsewhere.

4. It became clear to me during the first years as Head of the Department that a great deal of the administrative work was of a trivial character and that, once the policy was set, it could readily be carried out by a non-academic person, provided he had some general technical experience in a Physics Department. My investigations, while on Study Leave, etc., indicated that a Laboratory Manager (or someone with equivalent duties) was desirable. Representations were made through the appropriate channels and in 1953 the Vice-Chancellor approved such a post and Alfred Weller, of the Physics Department of the University of Adelaide, was appointed. Weller did a great job, especially in supervising the transfer of the equipment of the Department to St. Lucia in 1955, which had to be done very hurriedly. Unfortunately, the load placed upon him during this, and the settling-down period, was too much for Weller and he suffered a severe heart-attack, which left him a permanent invalid and led to his resignation.

As there was evidence that, because Weller was not academically qualified, there had been some friction between the academic staff and Weller, I recommended that the post be up-graded to Lecturer level, and this was approved. An appointment was made in 1958 of Joseph Aubrey Warburton, B.Sc., then a Research Scientist in the Radiophysics Division of CSIRO. After two years, however, Warburton decided to return to research work, and returned to the Radiophysics Division. Subsequently, he went (at first, on leave of absence) to the Desert Research Institute of the University of Nevada at Reno. Later, he became Deputy Director of that Institute. After his departure, arrangements were made for the Manager to be appointed from among the regular members of academic staff, adjustment being made to his teaching load. The duties of the Manager were reduced when the heads of the two workshops were promoted to positions of greater responsibility, but remained very heavy.

5. In 1959, the Senate approved the establishment of a position of Reader, to be filled by advertisement. Mostly, University Readerships (as, previously, Assistant Professorships) had been created by promotions of existing staff with outstanding research records, or administrative responsibility for a distinct section within a department. The Readership in Physics was filled later that year by Ralph Whaddon Parsons, a graduate of Adelaide and Oxford, then holding the Chair of Physics at Hong-Kong University, but, at the time, on Study Leave at the University of Saskatchewan. Further reference to Parsons' work will be made in the next Chapter.

6. A previous important appointment, in 1956, was that of Graeme Reade Ellis (Ph.D. Tasmania) as Senior Lecturer in Physics. Ellis had had a brilliant career as a Ph.D. student while he was Officer-in-Charge of the I.P.S. Station in Hobart and was highly skilled as an experimentalist and a good theoretician. Unfortunately, owing to certain commitments, we were unable to provide him with adequate finance and workshop assistance, and he decided that his career could best be advanced by taking a position with CSIRO under D.F. Martyn at Camden, NSW. Subsequently, he succeeded McAulay in the Chair of Physics at the University of Tasmania.

7. Malcolmson resigned in January 1951, to take up a position on the technical staff of ICI (Australia). He became Personnel Manager of the Company, and later an executive Director of Fibremakers Ltd., a subsidiary Company.

8. Noon went on Study Leave in 1951, then on leave-of-absence, and finally resigned to complete his Ph.D. degree at the University of Rochester, New York. He then joined the staff of Sydney University, but applied for, and obtained, a Senior Lectureship at the University of Queensland in 1958. He resigned in 1965 to accept a full Professorship at Rensellaer Polytechnic Institute, Troy, New York, but since 1971 has been Chairman of the Physics Department at Florida Technological University, Orlando, Florida.

9. Maxwell James Burke, a graduate (B.Sc.) of Sydney University, enrolled as an Honours (fourth-year) student at the University of Queensland and, after three years as Demonstrator in Physics, was appointed Lecturer Grade II (equivalent to the old Assistant Lecturer) in 1953. He remained at Lecturer level for 8 years, and was then promoted to Senior Lecturer. He resigned in 1974 to take up a position in the Canadian civil service.

10. John Stuart Colville, a graduate of Adelaide University, was appointed Acting Lecturer in Physics in 1951. He remained two years at this University, but did not seek continuation of his employment. He now (1976) has a position with CSIRO in Adelaide.

11. Robert Leslie Falconer, B.Sc.(Hons), a graduate of the University of Western Australia, was appointed Demonstrator in Physics in 1954, and Acting Lecturer in 1956. He did not apply for renewal of his appointment at the end of 1957, but joined the staff of the Meteorological Service, where he became Head of the Forecasting Training School.

12. Donald George Singleton, a graduate of the University of Queensland, was appointed Demonstrator in 1951, and Lecturer in 1955. He was promoted to Senior Lecturer in 1964 and resigned in 1965 to take up a position at the Weapons Research Establishment, Salisbury S.A.

13. James Peter McGilvray completed his B.Sc. course while a cadet in the Chemistry Department. On graduation (in Physics) he was appointed Demonstrator in Physics, but had to resign in 1954 on account of ill-health. He was, in 1956, reappointed to fill a newly created Lectureship in Radiation Physics. He resigned in 1970 to take up a more senior appointment directly with the Queensland Radium Institute and later returned to teaching at the Queensland Institute of Technology.

14. Geoffrey Leonard Goodwin, an M.Sc. graduate of Adelaide University, and a Research Assistant at the University College of Swansea was appointed Lecturer in Physics in 1958. He was awarded a Ph.D. and promoted to Senior Lecturer in 1966. He resigned in 1967 to accept a position as a Senior Research Scientist at the Weapons Research Establishment, Salisbury, and in 1971 became Head of the School of Physics at the South Australian Institute of Technology.

15. Gordon George Bowman was a part-time Demonstrator during 1953-56 while completing his final Honours and M.Sc. courses. He was then granted a Post-Graduate Award, which enabled him to complete his Ph.D. full-time by 1960. He was appointed Lecturer in that year, and was promoted to a Senior Lectureship in 1968.

16. Wallace Armstrong Macky, a Ph.D. graduate of New Zealand University, and retired from Directorship of the Meteorological Service of Bermuda, was appointed Lecturer in Physics in 1960. He was promoted to a Senior Lectureship in 1965 and retired in 1969.

17. William Charles Hoffman, Ph.D. (University of California) was on the staff of a commercial research laboratory in the U.S.A. when, in 1959, he was appointed a Senior Lecturer in Physics. In 1960, the University offered him a Chair in Applied Mathematics, but he declined it and, later in that year, returned to the U.S.A., to take up a position at Boeing Research Laboratories, Seattle.

It may be of interest here to note the names of some people who have occupied Demonstratorships (Tutorships) in the Physics Department, during the decade 1950—1960 and later were appointed to important posts, viz:—

Neil Mather Brice (Hons. I, 1957) took his M.Sc. in 1959, but proceeded to Stanford University (California) for his Ph.D., which he took in Electrical Engineering. He later became

Professor of Electrical Engineering at Cornell University (Ithaca, New York). He was killed in an air crash in 1974. In 1975, The International Union of Radio Science awarded him, posthumously, the Appleton medal for distinguished work on the Ionosphere.

Keith David Cole, who obtained Honours in Mathematics, but was a Demonstrator in Physics, received an M.Sc. degree in 1954 and D.Sc. in 1968. He became Professor of Theoretical and Space Physics at La Trobe University, and Vice-President of the International Association of Geomagnetism and Aeronomy.

Kenneth Baird (Hons. I, 1952, M.Sc., 1953) joined CSIRO Division of Textile Physics as a Research Scientist and remained there until 1976, when he became Director, Research and Development, of the International Wool Secretariat, England.

Ross Edwin Dunlop (Hons. IIa, 1960) became Senior Lecturer in Physics at the Queensland Institute of Technology.

Leo Esmond Howard obtained first-class Honours in Physics in 1951, and Mathematics in 1952, and a Ph.D. in Geophysics at the Australian National University. After some years with the Bureau of Mineral Resources, Geology, and Geophysics, Canberra, he returned to the University of Queensland in 1960 as a Lecturer in Mathematics, and was later promoted to Senior Lecturer. He is the Assistant Warden of Union College, at the time of writing.

The following table* gives a comparison between the numbers of academic staff in each category in 1950 and 1960, and also the salary ranges (in pounds) pertaining to each category. The increases in salary were the result, partly of rise in living costs, but largely of the findings of the Murray Committee and the commencement of Commonwealth Government assistance to the finance of Universities.

	1950		1960	
Category	Number	Salary range £	Number	Salary range £
Professor	1	1400/1650	1	4000
Reader (etc)	1	1050/1250	3	2960/3200
Senior Lecturer	2	900/1050	5	2520/2870
Lecturer	6†	775/900	10	1830/2330
Demonstrator††	4½	490/550	10	1270/1370

† includes graduates providing physical service to hospitals.
†† equivalent number of full-time demonstrators shown.

Mention has been made earlier of the rarity of visits to the University of physicists from overseas. In the post-war period, this isolation was broken down and several visitors of renown came to the Department in the 1950–60 era. They included, amongst others:—

Professor Walther Gentner, at the time "Ordentlich Professor" at the University of Freibury-im-Breisgau; later, at the University of Heidelberg.

Professor P. Blackett (later Lord Blackett), one of Rutherford's collaborators, and distinguished in World War II as a leader of Operational Research for Coastal Command, R.A.F., and for the Admiralty.

Sir Geoffrey I. Taylor, of Cambridge, a most distinguished hydrodynamicist and a leader in the early development of aviation.

Sir Clifford C. Paterson, Director of Research at the General Electric Company's laboratories at Wembley (near London), England's most distinguished commercial research laboratories.

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* See also Chapter VII.

Professor (later Sir Hermann) Bondi, already famous for his cosmological theories and later to become Scientific Adviser to the U.K. War Office.

Professor E.N. daC. Andrade, one-time Quain Professor of Physics, University of London, later Director of the Royal Institution, Hon. Librarian of the Royal Society.

Sir Charles Darwin (a member of the famous Darwin family) a distinguished theoretical physicist, from Cambridge.

Professor (later Sir Harrie) Massey, Quain Professor of Physics at University College, London: later, Chairman of the British Space Research Committee.

Professor R.A. Helliwell, later to develop the leading team of researchers on the phenomenon of whistling atmospherics.

Professor Robert McWhirter, Professor of Radiotherapy at the University of Edinburgh, the leading radiotherapist in Scotland at that time.

Dr. Walther Müller, co-inventor of the Geiger-Müller counter, at the time of his visit, was at the Research Laboratories of Philips at Adelaide.

Professor Harry Messel, Professor of Physics, Head of the Department of Physics at the University of Sydney.

Apart from the stimulus of these visits and the lectures given by the visitors, they led, in some cases, to subsequent return visits and generous hospitality to staff members on Study Leave.

It would be a serious omission not to mention contacts between the Department and institutions in Southern Asia. Reimann accepted an invitation from UNESCO to spend two years (1957–1959) in Thailand, to assist the development of the Physics Department of Chulalongkorn University at Bangkok. He was able to introduce several improvements and arrange for a visit to Australia of the Departmental Head, apart from stimulating interest in Modern Physics. At the beginning of 1960, Reimann was invited by UNESCO to conduct, in collaboration with Dr. J.H. Leck, of Liverpool University, a 5-weeks course on Vacuum Technique for trainees from South-east Asian countries, at the National Physical Laboratory, New Delhi. In 1960, also, he and Professor Green, Professor of Education at Singapore University, were invited to act as Special Consultants to a Conference, in Manilla, on the teaching of basic science in South-east Asia, and to visit several Universities in 6 countries in that region.

In 1950, I was invited to serve as External Examiner in Physics at the University of Malaya at Singapore (now the University of Singapore). I spent two weeks there on that occasion and marked papers mailed me in the next two years. Professor (now Sir Norman) Alexander had been my contemporary in Cambridge. I found the system of practical examinations used there (in all years of the course) very interesting and working well, though I was not convinced that it added much information on a candidate's abilities to what was obtained from written papers.

At a later date, during Study Leave, I visited Karachi and Lahore Universities in Pakistan and gave some lectures. A consequence of this visit was the enrolment of several Pakistani students at the University of Queensland for graduate courses, mostly to M.Sc. level, some of whom have remained in Australia after graduation.

I have already mentioned the interest taken by the Radio Research group in URSI (International Union of Radio Science). URSI was one of the Unions which sponsored the International Geophysical Year of 1957–58, and the Physics Department played an important role in that undertaking. The I.G.Y. was a development of the 1933 International Polar Year and centred around those geophysical phenomena peculiar to periods of maximum sunspot activity. However, the opportunity was taken by geophysicists interested in other fields to "jump on the band-waggon" and the overall programme was a very full one. It included many polar expeditions, both north and south.

Australia's National Committee for the International Geophysical Year was set up by the Australian Academy of Science with David F. Martyn, F.R.S. as Chairman and Convener. I was appointed a member in 1955. Martyn was still an employee of the Radio Research Board, but was located at Canberra, loosely attached to the Commonwealth Observatory. A few months after my appointment as a member, Martyn found it necessary to relinquish his position as Chairman and Convener and it was arranged that Keith Bullen (celebrated as a theoretical seismologist) be Chairman and I be Convener. This was, I think, the first occasion on which the National Secretariat of an International Organization was located in a Department of the University of Queensland. Fortunately, my work load was greatly reduced by the generous assistance of CSIRO whereby Mr. Browning Mummery of CSIRO Central Administration assisted me in this work and much of the success of the Australian National Committee's organization was due to him. The I.G.Y. turned out a great success; it was very favourably reported by the Press and Radio. (I was invited to give a "Guest of Honour" talk.) One of its most important achievements was to make a small break in the Iron Curtain and permit Soviet and other Eastern Block scientists to fraternize with their Eastern counterparts. This was most conspicuous at the 1968 general assembly of the I.G.Y. in Moscow, at which I led the Australian delegation. Fortunately, the Australian delegation suffered no difficulties due to the previous breaking-off of diplomatic relations between the USSR and Australia. The British Embassy was then the official representative of Australia and gave a reception for Russian scientists to which we were invited. The good relations then established between Eastern and Western scientists have, on the whole, been maintained, though there is still considerable restriction (perhaps for financial reasons) upon Soviet scientists travelling to the West. The Commonwealth Government, in addition to permitting its own scientists to participate in the I.G.Y. (notably in the Antarctic programme), provided a generous sum to the Academy for the use of non-government scientists. We were greatly assisted in our solicitation for this fund by the persuasiveness of Dr. Lloyd Berkner, Vice-President of the I.G.Y. International Committee and Director of the North-western Research Institute at Dallas, Texas, (later, President of URSI), at an interview with Mr. Menzies. Incidentally, the Physics Department received a substantial grant for the whistler project, carried out by Crouchley, Brice, McInnes, Finn and others.

It should also be mentioned that I was the Australian representative at the plenary meeting of the International Committee in 1955 and McNicol was one of the Australian representatives at the Barcelona meeting of 1956. In the New Year's Honours for 1959, I received a C.M.G. for my work as Convener of the National Committee.

My Presidential Address to Section A of ANZAAS at the Perth meeting of 1959 described the I.G.Y.

There have been subsequent international undertakings in the field of geophysics, but they have excited less public interest than the I.G.Y. (Perhaps because the I.G.Y. saw the first satellites launched, as part of its programme. Also, in Australia, there were spectacular auroral displays at the period of its commencement, in July 1957. I remember being driven nearly frantic by the number of telephone calls received upon one of those occasions – including one from Townsville.)

Reference was made, earlier, to the steady increase in student numbers during this decade. Of special interest is the increase of enrolments in Physics III, since this is an indication of the numbers aspiring to be professional physicists. This reached a peak of around 50 at the end of the decade, and declined, during the following decade, to about one quarter this number. The increasing demand in Australia for physicists, while partly due to the requirements of Government Departments, particularly Defence, CSIRO, and Health (including Hospitals), arose mainly from the scarcity of teachers, at secondary and tertiary levels. It was inevitable, therefore, that, once the demand commenced to slacken, the rate of falling-off would tend to increase. Another factor has been the reduced drift of Australian physicists overseas.

Enrolments in first- and second-year classes are greatly influenced by the policies of Faculties other than Science, and, while all Science-based Faculties included Physics in their curricula, during the 1950–60 decade, there was some opposition to its inclusion within certain Faculty Boards.

During the 1950–60 decade, increasing attention was given to lecture courses for graduate students, especially those enrolled for the Honours year (i.e. Physics IV), and seminars at which these students are the speakers. Brief pre-term courses in the "Laboratory Arts", including electronic equipment construction, simple metal work, and, later in the decade, computer programming, were also instituted. With the rapid expansion of knowledge and the variety of new concepts in the Science, the old objective of graduates being trained in all branches of Physics had to be abandoned.

Instead, the objective became to produce graduates who can, with the aid of a Library, become proficient in any branch required in their professional activities.

This decade saw a substantial increase in the technical staff of the Department. Unfortunately, in many instances, official records no longer exist, and dates given below may be seriously in error. The names, however, are probably accurate. Some appointments were initially temporary, being based on external research grants, and later converted to permanent appointments as the establishment of the Department was increased. In such cases, the date of the initial appointment is given. Uncertain dates are marked x.

Appointments in the mechanical workshop were:—

Gerald Baird (1951^{x}-1955^{x}), Trevor Edwards (1952^{x}-1956^{x}), Ken Million (1953-1962^{x}), Ian Henderson (1953-1956^{x}), Edgar Harrold (1.6.53-1969), R. Broom (1955^{x}-1958^{x}), Colin Campbell (1951^{x}-1955), Robert Jones (19.3.56 to present), Chris Rowlandson (1960-1966^{x}), Robert Grimmer (1959-1964^{x}), K. Skov (1951^{x}-1955^{x}).

Edgar Harrold and Robert Grimmer are still (1976) employed by the University, but Harrold is located, full time, at the Queensland Radium Institute, and Grimmer was transferred in 1964(?) to the staff of the Electron Microscope Section. Until 1969, Edgar Harrold was Croskell's deputy, and following his translocation, Robert Jones.

In the electronics workshop, the following were appointed:—

Alfredo Luchich (12.5.52-14.7.58), George (Dick) Graf (9.1.53-1.2.56), Keith Perry (22.7.56-31.7.64), Thomas Ian (Bill) McWilliam (3.9.58-1963, reappointed later), Kevin McKay (1958^{x}-3.8.60), Howard Foley (1958^{x}-1962^{x}), Keith Filmore (1958^{x}-1959^{x}), Donald McCorley (6.7.59-24.8.59), Graham Odgers (14.9.59-30.3.64). University records show McKay's original appointment as 1950, so he was probably transferred from another Department. Graham Odgers was, for part of the period indicated, Purchasing Officer (see next Chapter). He was also a part-time student for the Economics Degree during his appointment in Physics, and left to take up a job based on that qualification.

In 1956, after the move from George St. to St. Lucia, it was found necessary to organize better arrangements concerning the Departmental Store, in which not only materials, but also electronic components, etc. were kept, so that proper records could be maintained and research work be not held up while small components were purchased. It, of course, also benefitted construction and repair of teaching equipment. Jennings was asked to take charge of the store, and did so competently until his retirement in 1960. The Department owes a great deal to Jennings and he will always be remembered affectionately by the lecturers whom he assisted. The store was taken over by Cyril Hembrow (1960 and is till (1976) in his charge).

The duties of Lecture-room Assistant were, in 1956, transferred to Gordon Milburn (1956-1964). A cadet Assistant was also provided for, the first appointee being Bruce Strachan (1956^{x}-1963^{x}).

Other positions established during this decade were (a) Radon Technician, and (b) Glass Blower. The first appointee to the former position was David Dickenson, who resigned in 1959 and was replaced, in November, 1959, by Gilbert Perrin. The latter position was filled, in June, 1959, by Jan Wilschut. Wilschut was later the victim of a shooting incident, but prior to this the University glass-blowing laboratory had been moved to another Department. He survived, as a paraplegic, for some years, but died in 1973.

I must not conclude this listing of Departmental staff without making reference to the Secretarial staff, to which I, as Head of the Department, owed so much. Unfortunately, it is impossible for me to remember the names of some of those who gave so much assistance, but I remember Miss M. Moody, Miss J. Mitchell (later, Mrs. Singleton), Miss O'Connor, and, after the move to St. Lucia, Miss V. O'Mahoney.

Turning now to the products of research, I shall refer first to the ionospheric projects. An important step, taken early in the decade, was the transfer of the ionosonde from the Indooroopilly location, which, because of housing development in the vicinity, was becoming too noisy (in the radio sense). The Indooroopilly site was later sold by the Commonwealth to the State Government, and now forms the playground for the Indooroopilly High School. The new location for the ionosonde was on the University's Moggill property (like the St. Lucia campus, a gift from Dr. Mayne) which at that time was very little used by the University. It was necessary to clear a site from trees, and indeed it was some years before the rubbish was fully disposed of. The huts used at Indooroopilly were moved to the new site by Commonwealth Works Department, as arranged by CSIRO, and a hut already on the site was rendered serviceable by the Physics Technical staff. Owing to absence of special funds for the purpose, the maintenance of the huts, antennas, etc., and even the improvement and maintenance of the road, had to be carried out by the Departmental staff, technical and academic. I can remember wading across a flooded creek with McNicol and Thomas, to plan the relocation of a road. During one flood, H.E. Brown (see later) had to swim across the creek to reach the ionosonde station, and was somewhat disconcerted to discover a snake swimming alongside him!

With the extension of activities of the Veterinary School at Moggill, the freedom from electrical noise, which made it so desirable, has been destroyed, but it is still a useful site for the ionosonde. As will be seen in the next Chapter, a better site has been obtained on Bribie Island.

During the first half of the decade, two problems were tackled, viz:–

1. The structure and morphology of the sporadic-E (Es) layer of the ionosphere. This was a continuation of the work of McNicol and others, mentioned in Chapter IV.

2. Anomalous reflections from the night-time F–layer, represented on ionograms by a trace intermediate between those corresponding to one-hop, and two-hop, reflections. The cognate problem, the "spreading" of the F-layer traces, was also studied, particularly in the latter part of the decade.

During these researches, the following equipment was employed:–

1. The standard swept-frequency ionosonde, mentioned in Chapter IV.

2. A similar ionosonde, modified to vary sensitivity in steps, either by changing the transmitter power, or by changing the receiver gain.

3. A network of sounding stations recording continuously on a fixed frequency. For a considerable period, stations operated at Moggill, at Buderim (about 95 km to the north) and at Toowoomba (about 95 km to the west). The same frequency was used on all three (mostly 2.28 or 3.84 MHz, but occasionally 5.8 MHz). Since Moggill recorded oblique reflections of pulses from the other stations, a total of 5 records was normally obtained.

4. Fixed-frequency sounding with automatic gain control on the receiver.

5. Fixed-frequency sounding with gain gradually decreased during a 2-minute period, then restored. (Swept-gain).

6. Fixed-frequency sounding, with the sounder modified according to the technique developed by Findlay some years earlier, thus producing "phase-path" records, from which changes in phase – as well as group – path can be determined. (This can also be regarded as a Doppler technique.)

7. Automatic direction-finding, using, for reception, two pairs of loop antennas placed at right angles, as in the Adcock system, but with the necessary electronics to present the direction-of-arrival of echoes direct on the CRT screen.

8. An automatic direction-finding system, using only one pair of loops, mounted at the ends of a rotating arm, the direction being indicated by nulls on the recorded trace.

9. Ionospheric drift measurements by the Mitra method, using the transmissions of the fixed-frequency sounder.

10. An airglow recorder.

11. A fluxgate magnetometer.

Although the grants to the Department by the Radio Research Board were generous, in proportion to the Board's resources, the amounts available for equipment and components were relatively small, and it was necessary to depend largely on "disposals" equipment (which usually had to be largely re-built), and components, for the experimental programme. The network described in (3) above was set up by this means. Actually, MacGregor recalls that the first remote sounding station was erected by Gipps and Macgregor at Pampas, on the Darling Downs. Another station was set up at Goondiwindi, but proved disappointing, mainly because of the difficulty of visiting it sufficiently frequently. Indeed, it was found that, without occasional assistance from some local resident, it was difficult to maintain remote stations.

The rotating pair of loops listed in (8) above was first set up by McNicol and MacGregor on the St. Lucia campus, roughly where St. John's College now stands, but was later moved to Moggill.

Upon the return of McNicol from England, he and Gipps concluded, from a final analysis of their Es data, that at Brisbane there occur two distinct forms of Es, viz:–

a. Sequential Es (Ess) having a high opacity, as indicated by the elimination of F echoes, except just below the Es critical frequency (and above it), and systematic decrease in its (virtual) height, from its initial appearance at about 150 km, to about 100 km.

b. Constant-height Es (Esc), showing little or no change in height, and little reduction of F echoes, except much below the Es critical frequency.

Later work, in which Thomas and McNicol played the major roles, confirmed these conclusions. Ess was found to be dominant in summer, Esc a night-time phenomenon in summer, but dominant in winter daytime. The curious transparency shown by Esc was thought, at first, to be due to a structure of large numbers of separate clouds, of high electron density, separated by channels of lower density. This was supported by the occasional appearance, on the records, of isolated patches of Es which, from changes in apparent height, and other indications, appeared to be moving with considerable speed, predominantly towards the NW, while the drift measurements of Thomas and Burke, using the Mitra technique, indicated a similar speed and direction in the motion of widespread layers of Es, around midnight (though, in early evening, the direction was predominantly NE). A typical speed was 300 km/hr. On the other hand, earlier work in the Department by M. Strohfeldt *et al.*, using a transponder at Camden (about 750 km to the southwest) gave no indication of laterally-deviated oblique echoes from Es (at 5.8 MHz). An alternative explanation, that most Es echoes are associated with sharp vertical gradients of electron density, rather than a high density at any one level, was found to fit all the observations well, and has later been confirmed from rocket data. Consistent with this, it is possible to explain the variations in Es, over the sunspot cycle, as due to changes in D-region absorption.

Other occasional observations were (a) a slight tilting of the effective reflecting surface, and (b) the simultaneous presence of two Es layers, giving rise to a complex pattern of echoes, through multiple reflections.

An assessment of the thickness of the Es layer was made by R.H. Hosking, using records which showed echoes reflected from top as well as bottom of the layer, led to a figure of around 5 km. J.R. Wilkie and McNicol found that the Es patches mentioned above tended to be accompanied by slight reductions in the horizontal component of the geomagnetic field. Thomas established the existence of a lunar semi-diurnal tide in the height of the Es layer.

The anomalous F-region echoes were first noted by Gipps, on standard ionograms. The traces exactly paralleled the normal F echoes, and their separation from the normal trace was found to change systematically from one ionogram to the next, sometimes opening and sometimes closing. They appeared to have much the same intensity as the normal F echoes. (This was later confirmed by measurements using a swept-gain receiver.) Two possible interpretations of the phenomenon appeared to be:–

1. A second "layer" lying above the height of maximum electron density of the F-layer.
2. A tilted portion of the F-layer, not immediately above the station, which reflected rays at an angle to the vertical.

The first of these suffered from the difficulty of explaining how the pulses penetrated the normal F-layer without severe attrition. However, in pointing out his discoveries to me, Gipps urged the setting up of the three-station network, which we were able to do.

The results were found to be entirely in support of the second hypothesis. They required the tilted reflection surface to be part of an irregularity in the contours of equal electron density, having a dimension in the plane of reflection, of the order of 100 km, but with a lateral dimension substantially greater; in other words, a frontal irregularity. Using this picture, the velocity of travel of the front could be determined. This was found to be fairly constant over the interval during which the anomalous echo was recorded (average, 20 min; maximum observed, 100 min). However, phase-path measurements made later showed rather larger variations in the velocity deduced from phase-path changes.

After the departure of Gipps, further studies were undertaken by McNicol, Bowman, Thomas, and others, employing the equipment listed earlier. In a 16-month programme, it was found that divergent traces were more prevalent than convergent, having an occurrence peak about 3 hours after sunset. Convergent traces had an occurrence peak about 6 hours after sunset. The relative amplitudes of the anomalous to the normal echoes showed a very considerable scatter, for all distances between the points of reflection, though with a general trend downwards with increasing distance, as would be expected. The frontal velocities varied between 50 and 500 km/hr and had a general westerly direction. The maximum separation between reflection points giving an observable anomalous echo was about 200 km. Only very rarely was the passage of the irregularity over the station indicated by a convergent, followed by a divergent anomalous echo. Sometimes more than one irregularity was present simultaneously.

Later work of Bowman showed that frontal irregularities also occur just after sunrise, and just after the termination of a solar eclipse, being found in Es as well as in F-layers. He also found cases in which, by mapping the front and projecting its slope line downwards, it intersected the Es layer at a region of abnormally high critical frequency. His experiments also indicated strongly an influence on the phenomena of the geomagnetic field direction.

It later became evident that the frontal irregularities observed in Brisbane were of the same general character as those observed by G.H. Munro in the Sydney area and named by him "travelling ionospheric disturbances". It now appears that all these phenomena are produced by internal gravity waves in the neutral atmosphere.

The fixed-frequency sounders were also used by Kenneth Baird to study high multiple reflections from the F-layer. He considered that some focussing by abnormally-shaped reflecting surfaces was necessary to explain his results, but later work has thrown some doubt on this conclusion. Thus, McGilvray found that a reflection coefficient very near unity, for the F-layer, is of fairly frequent occurrence.

(Three names are mentioned in the last two pages for the first time, viz:— Max Strohfeldt, James Ronald Wilkie, and Ross Hargreaves Hosking. All were graduate students and Demonstrators.)

Although distinct and long-lasting range duplications, as described above, occur relatively rarely in Brisbane ionograms, night-time F traces frequently show spreading, i.e. their width is substantially greater than corresponds to the pulse width. Spreading implies reflections from several different points, closely spaced as to distance from the station. Sometimes, but by no means always, the reflection from minimum distance is the strongest. Two forms of spreading are distinguished, in standard (h'f) ionograms, viz:—

1. Range-spreading, identified by the trace narrowing to its normal width as it sweeps upwards at the critical frequency.
2. Frequency-spreading, in which there is a spread in critical frequencies as well as in range, i.e. the trace remains wide at its upward sweep.

Some studies were made of spread-F in fixed-frequency ionograms in Brisbane. Perhaps the most important conclusion was that the width of spread shows a general increase with increasing layer height. Assuming that range-spreading has the same cause as range duplication (though with ripples of smaller scale), this implies that the amplitude of ripples increases with increasing height. Their wavelength was found to lie between 20 and 100 km, with a waveform controlled by the geomagnetic field. Range-spreading was found most often near midnight, and most often in winter, with a summer sub-maximum. Amplitude measurements generally showed a rapid falling-off with increasing range (within the spread echo).

Singleton later made a study of the morphology of frequency-spreading, using data from ionosonde stations in various parts of the Earth. The latitude dependence is roughly symmetrical, but the line of symmetry does not coincide with either the geographical, or geomagnetic, Equator. This "spread-F Equator" has later been studied by other groups.

In preparation for the International Geophysical Year (mentioned earlier in this Chapter) two ionospheric projects were launched. One was the measurement of ionospheric "drifts" using the Mitra technique, further developed here by Burke. The second project was a systematic study of whistlers (whistling atmospherics). Both projects were operational by the start of the IGY and it was possible to communicate data to the International Data Centre.

In the Mitra technique three antennas (designed to receive one circularly polarized component only), spaced in a triangle, of sides around 100 metres, are connected to three receivers and the amplitudes of pulses, emanating from the same emitter, are recorded after reflection from the ionosphere, all pulses outside a selected interval in delay time being excluded. The drift is then determined by comparison of the three fading patterns thus obtained. There is still considerable controversy concerning the most reliable method of analysis and the interpretation of the velocities thus calculated. In a later decade, Burke turned his attention to this theoretical problem.

Whistlers were recorded on magnetic tape, which was afterwards studied to obtain frequency-time spectrograms of whistlers and "dawn chorus". This was in the hands of Crouchley. Brice and McInnes* (in successive years) maintained the Macquarie Island equipment. Whistlers involve all parts of the ionosphere and, in subsequent decades, have proved of great value in probing the remote parts of the atmosphere (i.e. upwards of some thousand kilometres). Brice continued work on whistlers in the U.S.A., and Canada, and made important discoveries.

To explain whistlers, it is found necessary to postulate energy "ducts" in the outer mesosphere. An interesting theory of the origin of the ducts was put forward by Hoffman. He postulated that occasional powerful lightning strokes continued beyond the top of the thundercloud and reached up well into the ionosphere, and even above, thus creating a tube of excess electrons, constituting the duct. He commenced experiments to test the theory, but resigned before they had proceeded to the stage of giving results.

The analysis of the whistler results was not completed until after the end of this decade, but a brief paper, concerning low-frequency noise ("chorus", or "dawn chorus") from the atmosphere, appeared in 1960.

Towards the end of the decade, the Department was fortunate in obtaining considerable finance under a Research Contract with the U.S. Air Force. This permitted the construction of a rotating array, carrying four Yagi antennas and, at its centre, a cabin containing transmitter, receiver, etc. The ends of the array were supported by wheels, running on a concrete track and motorized to rotate the system. The system was initially designed to operate at 16 MHz, with a beam having its maximum at low angle of elevation, and a horizontal beam width (to 6 dB) of 8°. The system was designed by Thomas and McNicol, with assistance from a Consultant Engineer, Russell John McWilliam. It was, I think, the most ambitious system of this type in the southern hemisphere at that time.

It was interesting to see the dexterity with which the cattle owned by the Veterinary School managed to avoid being hit by the moving arm. However, the speed was less than one revolution per minute.

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* see next Chapter.

Since the definitive conclusions were not formed until after 1960, I shall leave until the next chapter a discussion of results. The system was operated by E.W. Dearden (graduate student) during most of its use.

In the Bibliographic Record of the Physics Department for 1957, several papers by G.R. Ellis were included. However, although Ellis was a Senior Lecturer in the Department at the time, the work was mostly done in Tasmania, before his arrival, and it would not be appropriate to discuss it here.

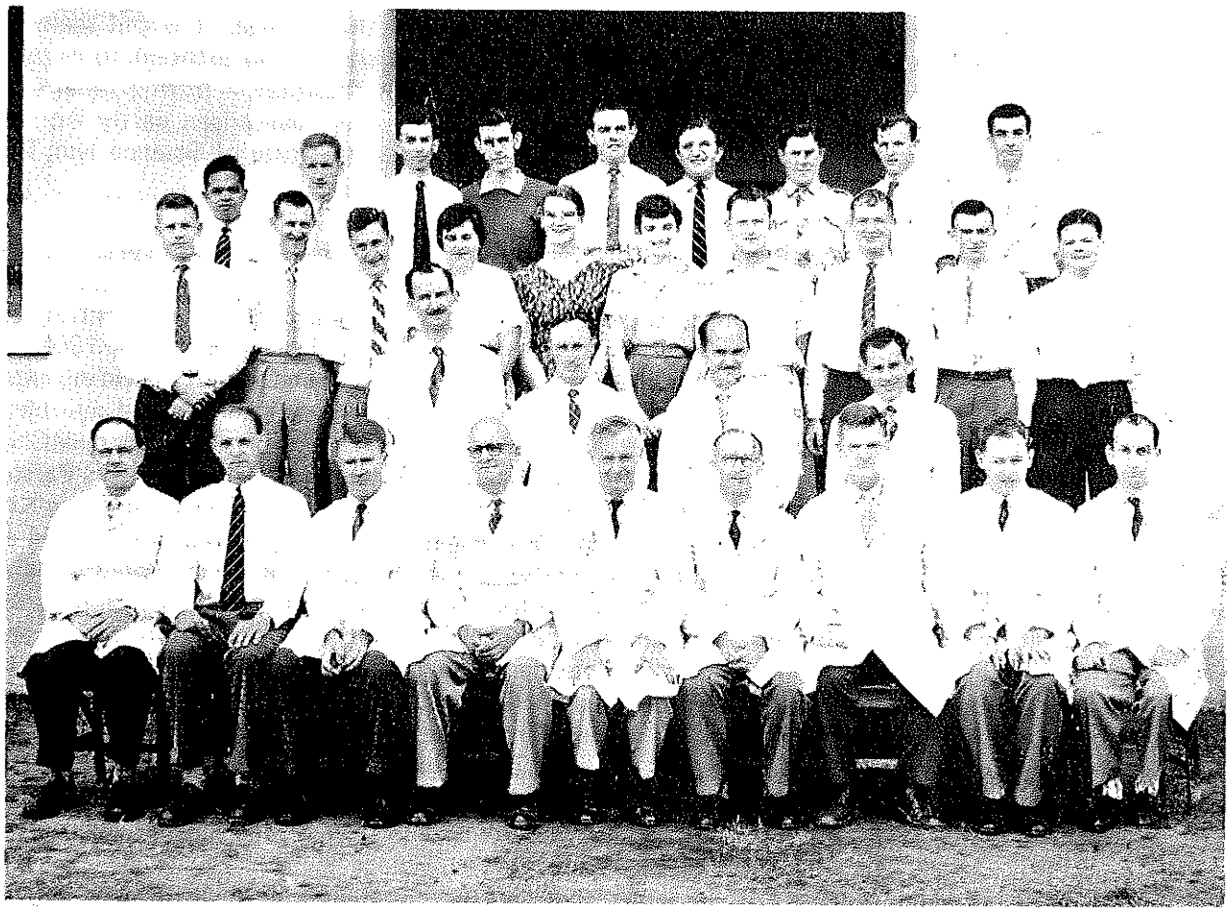
On the Radiation Biophysics side, a number of developments arose from the association of the University physicists with the radio therapists at the Hospital, including some effects noted in photographic dosimetry of clinical beta-ray sources, techniques for implantation of radon sources in patients which reduced exposure of the staff in the operating theatre (which were widely adopted in other centres), lipstick for protecting lips from sunburn (which can produce carcinoma of the lip). Physicists also participated in planning radiotherapy of eye conditions and post-operative treatment of mammary carcinomata.

In 1960 Mugglestone published a paper on atomic abundances in the sun which proved the forerunner of a long list of papers in Theoretical Astrophysics by him and his students.

An event of considerable importance to Australian Physics, though not having any immediate impact on the Physics Department of the University of Queensland, was the establishment of the Australian Institute of Nuclear Science and Engineering, a statutory body, the members being the Universities (strictly, those Universities which applied for and were granted Membership) and the Australian Atomic Energy Commission. The governing body is a Council, of representatives of the members. Because of the initial interest of the AAEC in uranium mining, while the AAEC Research Establishment at Lucas Heights was being built up, the Vice-Chancellor nominated Professor White (Mining Engineering) as the representative of the University of Queensland, but, later, White and I represented the University in alternate years. This had the disadvantage that, under the conventions adopted regarding the Presidency of the Institute, neither of us could ever be President (though I was, for one year, a Vice-President). The Institute's main function was to facilitate the use, by Universities, of the unique research facilities available at the Research Establishment. Because of the established research policy of the Physics Department, there was, at first, little call by us upon these facilities, though, in the following decade, they were used by Lasich and others, to some extent, and undergraduates were, on occasions, taken to see the Research Establishment. The Institute is able to make financial grants for the costs of such usages, and also makes grants for researches not directly associated with Lucas Heights, but relevant to Atomic Energy in general.

During this decade, the University arranged to purchase a digital computer (type GE225) which, when it arrived, was housed and managed by the Electrical Engineering Department. The computer did not become fully operative until the next decade, and will be referred to again in the next Chapter.

It might be mentioned that, towards the end of the decade, CSIRO invited me to join the Editorial Advisory Committee of the Australian Journal of Physics for a term of years. It also asked me to join the Queensland State Committee of CSIRO: I remained on the latter until my retirement.



Academic Staff and Graduate Students, 1960

Left to right:

Back row:— M. Ali bin Ibrahim, B.Sc., M. Andrews, B.Sc., D.J. Faulkner, B.Sc., D.R. Horgan, B.Sc., I.D.S. Johnston, B.Sc., S. Bloomberg (now Reynolds), B.Sc., B.H. Horton, B.Sc., P.E. Monro, J.R. Wilkie, B.Sc.

Second back row: J.W. Boldeman, B.Sc., G.G. Bowman, R.J. Finn, B.Sc., E. Matthew (now Swenson), B.Sc., E.R. Fletcher (now Arden), B.Sc., M.M. Lander (now Bartlett), B.Sc., E.W. Dearden, A.T. Linde, K.L. Jones, G.G. Swenson, B.Sc.

Third row: M.J. Burke, J.A. Warburton, K.A. Stevens, D.G. Singleton.

Front row: J. Crouchley, D. Mugglestone, R.W. Parsons, A.L. Reimann, H.C. Webster, D.F. Robertson, R.W.E. McNicol, J.A. Thomas, J.H. Noon.

Absent: W.C. Hoffman, J.P. McGilvray, B.A. McInnes, R.G.S. Taylor.

CHAPTER VI. 1960–1970

The two eventful decades which preceded 1960 were followed by something of an anti-climax. Although the expansion of the Physics Department continued unabated during 1960–1965, the latter half of the decade showed a marked falling-off in growth – followed in 1970–1976 by an actual decline. Many suggestions can be made as to the cause of this change. It would seem that there has been a revulsion in young people against Physics. It was always too difficult to be really popular, except with the elite, and the change in the employment situation – from a seller's to a buyer's market – strengthened the opposition. Also, possibly, it may have arisen partly from the feeling, voiced by Professor Lipson of the University of Manchester Institute of Science and Technology, "Does Physics know where it is going?".

Many changes in staff occurred during this decade and indeed there was an overall increase. The most important development was the establishment, in two steps, of two additional Chairs within the Department, following, in this respect, the example of many other Universities. This trend followed the increasing emphasis, within Australia, on the Ph.D. degree which, by 1960, had become, internationally, the "passport" of a physicist. With the need, therefore, of providing expert direction in several fields of research which could be suited to the varying interests and abilities of different students, several experienced research teachers were required. The first of these new Chairs was approved by the Senate in 1961 and widely advertized. The successful applicant was Parsons, then a Reader in the Department, but having had experience as Professor of Physics at Hong-Kong University. Parsons was appointed Professor in 1962, but resigned for personal reasons in 1964 and the position was re-advertized. It was offered to one of the applicants, but after a lengthy period of consideration and correspondence, was eventually refused. At this stage it was learned that Parsons would like to return and it was suggested to him that he apply. In the peculiar situation thus created, I felt that Mugglestone's position should also be considered, as it was clear that many students were more suited for theoretical, than experimental research. I therefore put to the Senate the somewhat unusual proposal that two appointments be made, Parsons as Professor of Experimental Physics and Mugglestone as Professor of Theoretical Physics. The Senate accepted the proposal and the appointments became effective in 1965. I was able to delegate to the new Professors much of the general guidance of the Department, which facilitated the change-over on my retirement in 1970.

The next important change was the retirement, in 1968, of Reimann, in accordance with the University rules. The Department owes a lot to Reimann, particularly to his dedicated teaching of first-year students and his expert knowledge of Vacuum Technique.

With the support of the other two Professors, I urged that the vacancy be filled, not by a permanent appointment, but by the establishment of a Fellowship which could be held for a period of up to one year by a distinguished overseas physicist, who could aid in promoting a research programme. (The overall costs, including travel expenses, were to be kept at the level of a Reader's salary.) This was approved and the Fellowship has already proved of considerable value to the research activities of the Department. The University has honoured the writer by attaching his name to the Fellowship.

Of the new recruits to the staff during this decade, the most notable is Frank Donald Stacey. Stacey is a graduate of London University and, not long after appointment, received its D.Sc. degree. He had spent some years as a Research Fellow in Geophysics at the A.N.U. and at the time of application held the Gassiot Research Fellowship of the Royal Society. His interest was in the Physics of the Earth's crust, and especially seismic phenomena and earthquake forecasting, including, incidentally, piezomagnetic effects in the crust. After arrival, he energetically set about establishing research in these fields and attracted a number of graduates from within the University and from abroad. Stacey became Professor of Applied Physics in 1971.

The remainder of the academic staff changes will be dealt with alphabetically. Owing to the large numbers involved, I shall deal in detail only with appointments at Lectureship level and above, giving passing reference to Senior Demonstratorships (now called Senior Tutorships) and omitting the some hundred appointments of full and part-time Demonstrators.

Edgar William Dearden (mentioned in Chapter V) became a Senior Demonstrator in 1962 and was appointed Lecturer in the following year. Dearden remained very active in research, taking advantage of Study Leave to carry out some excellent work at Stanford University. He also made himself an expert on portion of the second-year Physics Lecture course and was asked to assist Townsville University College by repeating the lectures there.

Gerard David Finn, after completing his Ph.D. in Brisbane, took up a post as Research Assistant at the University of Hawaii and was appointed Lecturer in Theoretical Physics at the University of Queensland in 1968. In 1970 he resigned, to return to Hawaii.

Bertram Stewart Frost, a first-class Honours graduate, in 1961, of the Physics Department, who had proceeded to Sydney University for his Ph.D. degree (in Theoretical Physics), was appointed a temporary Lecturer at the University of Queensland in 1967. He had, at the time, the intention of seeking a post abroad, but eventually decided to stay in Brisbane, and his appointment was made permanent. The practice of moving from one University to another for successive degrees has much to recommend it. Unfortunately, though many Queensland Physics graduates have gone to southern Universities, there has been little traffic in the opposite direction.

Ronald Bruce Gardiner, a Ph.D. graduate of Edinburgh University, was appointed Senior Lecturer in Physics at the University of Queensland in 1969. His work at the University is best discussed in the next Chapter.

Keith Leslie Jones, who completed his Honours course in 1960, honoured his obligation to the Education Department by teaching in Schools for three years, but finding this work distasteful, he applied for, and obtained, a Senior Demonstratorship in 1963, and was appointed a Lecturer in 1964. Later he was promoted to Senior Lecturer. Unlike most young Lecturers, who spend their Study Leave in the United States, Jones spent his 1970 Study Leave at the Appleton Laboratories at Slough, England.

William Blondel Lasich, a graduate of Melbourne University and distinguished for his successful construction of particle accelerators, and his many contributions to nuclear physics there, and later in London, was appointed Senior Lecturer at the University of Queensland in 1962, after having held a Lectureship at University College, London. He has probably made more use, through A.I.N.S.E., of the facilities at Lucas Heights than any other member of the Departmental staff. I had known Lasich for many years, he having been a member of my Radar Countermeasures Group at the Radiophysics Laboratory during the War.

When, in consequence of the passing of the Radioactive Substances Act, it became necessary to nominate a University Radiation Protection Officer, it was decided to offer Alan Trevor Linde (B.Sc. 1959) the post, at first on a temporary basis, and at Senior Demonstrator level, to be raised to Lecturer status if, and when, confirmed. In 1962, he thus became a Lecturer. Although, initially, he commenced some research associated with his duties, he later became interested in a problem suggested by Stacey and in consequence of this, he went, on Study Leave (and, later, on leave-without-pay) to the Carnegie Institution of Washington to work on a geophysical problem, in which he was very successful, so much so that not long after returning to Brisbane he was offered and accepted a position at the Institution.

McGilvray has been mentioned in a previous Chapter. In 1970, he resigned and was not replaced, owing to the decision to discontinue, as soon as practicable after 1970, the cooperative arrangement between the Physics Department and the Queensland Radium Institute. This severance was associated, in part, with my retirement in 1970, it being unlikely that future Heads of the Department would be happy to continue to direct it.

Brian Aloysius McInnes, a Sydney graduate who, while employed by the Antarctic Division of the Foreign Affairs Department, had operated the "whistler" recorder (see Chapter V) at Macquarie Island, came to Brisbane in 1959 to work up the results, which gained him an M.Sc. degree. He was appointed a Lecturer in 1961. In 1967, upon the resignation of Carman from Townsville University College, he was invited to take over the vacant position temporarily, which he did very satisfactorily. In 1968, a Chair in Physics having been created at Townsville and Dr. James Ward appointed to it, McInnes returned to Brisbane and was promoted to Senior Lecturer status. In 1970 he was offered an Associate Professorship at Sydney University, which he decided to accept.

It is interesting to record that three members of the Australian National Antarctic Research Expeditions, Brice, McInnes and Dunlop have been associated with the Physics Department.

Reference has already been made to McNicol's appointment as Reader in 1965. He took over the duties of Laboratory Manager from Macky in 1969, when Macky retired. He died suddenly of a heart attack in 1974. One of the many important contributions made by McNicol to the Department was the suggestion to me, in the late fifties, that semi-formal meetings of the lecturing staff of the Department should take place at regular intervals. In the early years of the Department the staff was small enough for Departmental matters to be discussed at morning and afternoon tea, but, as the staff grew, this was no longer adequate. These meetings prevented the troubles which arose in some other Departments due to lack of communication.

John Sydney Mainstone, a Ph.D. graduate of Adelaide University, whom I met first at the Cavendish Laboratory, Cambridge in 1960 when we were both long-term visitors there, was appointed a Lecturer in 1961. He was promoted to a Senior Lectureship in 1966 and a Readership in 1971. Mainstone had had experience in ionospheric research, but in Brisbane he and McNicol undertook a programme of research on geomagnetic micropulsations, which have reference to phenomena more distant from the earth than the ionosphere.

Peter Erle Monro, an Honours I graduate, and Demonstrator, was appointed a Lecturer in 1961, was promoted to Senior Lecturer in 1969. During the next decade he distinguished himself by making, in collaboration with Mainstone, some very useful TV tapes for first-year instruction. Throughout his career he has been a member of the ionospheric group.

Victor Ivor Metchnik had an unusual background. Born in Egypt, he had French citizenship and had taken his primary degrees at the Massachusetts Institute of Technology (Cambridge, Mass.). At the date of his application, he was a Lecturer at the South Australian Institute of Technology and had recently obtained a Ph.D. degree from Adelaide University. He was appointed a Lecturer in 1965, but promoted in the following year to a Senior Lectureship. He has the unusual qualification of speaking both French and Arabic fluently.

Bernard James O'Mara, who had graduated with first-class Honours in Theoretical Physics, proceeded to the University of California at Los Angeles for his Ph.D., working under Professor Aller. He returned to Brisbane as a Lecturer in Theoretical Physics in 1967. His arrival was unexpectedly delayed by delay in setting-up his oral examination for Ph.D., which caused a mild flurry.

John Gladstone Steele (B.Sc., 1961) after completing a Ph.D. within the Department, working on an ionospheric problem, spent a year at Stanford University, California and another year at Queen's University, Kingston, Ontario, before being appointed a Lecturer in 1968. Apart from his interest in Physics, he is a Clerk-in-Holy-Orders and has published books on the early history of the Brisbane district.

Robert John Stening was appointed Senior Demonstrator in 1963 and Acting Lecturer in 1969. During this period, he completed a Ph.D. in theoretical work on the ionosphere. Although his Lectureship would have been made permanent, he decided he needed overseas experience and resigned at the end of 1969. After some years in Canada, and later in Jamaica, he returned to Australia to take up a Lectureship at Robinson University College, Broken Hill.

In 1962, K.A. Stevens resigned, to take up the newly created post of Radiation Health Physicist in the Queensland Department of Health. This post is associated with the administration of the Radioactive Substances Act.

Norman Herman Weinstein was appointed a Senior Lecturer in Theoretical Physics in 1963. His career was an unusual one, his first degree, taken in New York, being in English, not Physics. He returned to Physics while in Stockholm, and attained the equivalent of a Ph.D. in Physics at the Royal University of Stockholm. In 1967, he resigned his Senior Lectureship, for personal reasons, and remained in Sweden. Some years later, he was appointed Associate Professor of English at Copenhagen University and, more recently, he returned to Australia to take up a Lectureship in English at Flinders University. His sudden departure in 1967, left two research students without satisfactory supervision, but fortunately they were able to complete their thesis work without aid. One of them, David Thomas Pegg, is now a Senior Lecturer in Physics at Griffith University.

Reference was made in the preceding Chapter to the resignation, in 1963, of Thomas, then a Reader. Permission was given for the vacancy to be advertized at the same level and the appointee was John David Whitehead, a Ph.D. graduate of Cambridge, and formerly Lecturer at Otago University. At the time of application, he held a position at Sydney University, financed by the Radio Research Board. Whitehead rapidly assumed dominance in the Radio Research Group and developed further his already outstanding international reputation (shown, for example, by the International Union of Scientific Radio commissioning him, alone, to prepare a report on the sporadic-E layer). He has been frequently invited to meetings abroad and his research subsidized from overseas. It had been my intention in 1970 to urge his appointment to a personal Chair, but the new Vice-Chancellor indicated that he would not, at that stage, consider such recommendations. It is gratifying that, a few years later, such an appointment was made.

While most of the other new members of staff listed above represented an expansion of the teaching and research staff, it should be recalled that, during this decade, Goodwin, Noon, Singleton, Warburton, and Weinstein resigned and Macky retired.

The office of Senior Demonstrator, while it was introduced early in the history of the University, fell into disuse, but was revived about 1960, to allow for Demonstrators of long experience, who, while excellent at their jobs, could not aspire to Lectureships, to be adequately remunerated. In practice, it was used largely to provide supervisors of very large laboratory groups — such as those in first-year Physics. At one stage in the history of the Department, there were eight Senior Demonstrators. At the end of the decade the employment position was such that many Ph.D. graduates were happy to accept appointments as Senior Demonstrators/Tutors.

Reference has already been made to several Senior Demonstrators who were later appointed Lecturers within the Department. Among others who held Senior Demonstratorships, commencing in one of the years 1960–69, were:—

Ian Matthew Brazier. Graduated B.Sc. 1960. Appointed Acting Senior Demonstrator 1962. Resigned 1968 to take a post at Lae Institute of Technology.

John Roger Catchpoole. An Honours graduate of Adelaide University. Appointed 1964. Resigned 1969 to proceed to Canada to take up an N.R.C. Fellowship at York University.

Dean Robert Dowling. A graduate of Adelaide University. Appointed 1964. Left 1968, to take up a post at Ballarat Technical College.

Ross Edwin Dunlop. Already referred to in Chapter IV. Senior Demonstrator 1963–1968.

Robert Stephen Fitchew. M.Sc. 1963. Senior Demonstrator 1964–1970. Left to take up a post with the Queensland Radium Institute.

Robert Alan Fleming. M.Sc. 1969. Senior Demonstrator 1965–1969. Resigned, to take up a Lectureship at the Queensland Institute of Technology.

Michael Thomas Gladwin. B.Sc. Sydney 1965, Ph.D. 1973. Appointed Senior Demonstrator 1968.

Leonard Anthony Meara. B.A., B.Sc., A.Ed., M.Sc. 1969. Senior Demonstrator 1966–1969. Left to take up a Lectureship at the Queensland Institute of Technology.

In accordance with the policy laid down in Chapter V, it is not proposed to name the large number of Demonstrators appointed during this decade, most of whom remained only a few years. Most Demonstrators were given the appointment to help them take a final Honours or M.Sc. course, but as mentioned in Chapter V, several Pakistani graduates enrolled for Ph.D's in Physics and needed full-time Demonstratorships to support them. This experiment proved a failure, in that none of them succeeded in obtaining the Ph.D. degree. It indicated that in the U.Q. Department of Physics, as in many other Universities, at least three years of *full-time* research is needed for a Ph.D., even for a student entering with qualification equivalent to first-class Honours. Fortunately, most of the students concerned obtained an M.Sc., and secured satisfactory jobs, either in Australia, or in their home country.

Asian students with scholarships, which eliminated the need for accepting Demonstratorships, were much more successful. Probably the most successful was Kedar Lal Shrestha, who has been appointed to the Chair of Physics at Tribhuvan University, Kirtipur, Nepal.

In Chapter V, a table was given showing the difference between academic salaries in 1960 and 1950. The following table* makes a similar comparison between 1960 and 1970 – this time in dollars.

Position	1960 Number on staff	1960 Salary range $	1970 Number on staff	1970 Salary range $
Professor	1	8000	3	14,400
Reader, etc.	2	5920/6400	5	11,016/11,850
Senior Lecturer	5	5040/5740	9	9000/10,500
Lecturer	10	3660/4660	9	6318/8760
Senior Demonstrator	-	2800/3200	8	5,002/6605†
Demonstrator (full-time)	10	2540/2740	15	3949/4475

† bar at $5663.

The technical staff, like the academic, expanded considerably during this decade. As for the earlier decades, there is difficulty, in many cases, in obtaining dates of joining, and leaving, the Department, but rough estimates have been made. Again as before, a number of appointments were made using funds provided in research grants from external sources. These people were not located in the workshops, but worked directly with the project supervisor. Some names are:– Keith Campbell (1960–63), David Gemmell (1963–67), John Dahl (1967 to present), Douglas Rickard (17.4.67–31.12.74), Eric Little, Vince Lipton and Jim Field.

The electronics workshop staff apointed during this decade included:– Bruce Moore (15.8.60 to present), Donald Turner (1.8.60–21.2.64), Dane Horgan, B.Sc. (24.7.61–30.6.69), John Speight (16.4.63–5.2.65), Thomas Ian McWilliam (3.2.64–2.8.74), Donald Chambers (2.7.64 to present), Ronald Trenkner (29.3.65–15.4.76), Richard Thompson (6.7.65 to present), Kenneth Wells (11.7.66 to present), Carl Boersma (10.4.69–2.10.70), Wade Rawlins (7.7.69–24.6.73).

Chambers acted as MacGregor's deputy until 1973, when he became Equipment Officer (see below). He was replaced by Wells.

The mechanical workshop staff appointed during the decade included:– (x indicates uncertainty). Andrew Roth (25.6.61 to present), Graham Smith (1961–1962), Geoffrey Smiley (13.2.61–1.3.63), Raymond Hillier (12.10.59–1965^{x}), Arthur Frey (19.2.62–23.11.62), Roger Willoby (11.3.63 to present), Ian Finch (10.2.64–11.10.74), Barry Phipps (16.12.64–1969), Fred Kingshott (31.8.66 to present), Andrew Burgess (3.5.68 to present), Keith Cuerel (15.5.68–19.9.69), Kevin Selway (10.3.69–30.1.76).

Barry Phipps, though nominally still (1976) a University employee, is permanently located at the Queensland Radium Institute. Graham Smith transferred to Townsville on 2.7.62 and is now on the staff of James Cook University. Raymond Hillier transferred to the Mechanical Engineering Department, but resigned after a few years, and now has his own business.

As mentioned in the previous Chapter, Gordon Milburn replaced John Jennings as Lecture-room Assistant in 1956 and Jennings retired in 1960. Milburn left in 1964, and was replaced by Malcolm Sadler (29.6.64–21.1.66) and then by R.E. Edgeworth (21.2.66 to present). The cadet

* see also Chapter VII.

assistant, Strachan, resigned in 1960 and was replaced by Robert Bowers (2.3.64–13.9.74), who left to take up a more senior post at Griffith University.

As mentioned, also, in the previous Chapter, Cyril Hembrow became Storeman in 1960, and still occupies that position.

There were a number of changes in the Secretarial staff during this decade. Miss O'Mahoney transferred to another University Department, and her position as Departmental Secretary was taken by Mrs. M.D. Thompson (later to become Mrs. Power). The Secretarial staff was divided into two sections, the Departmental Secretary, with one assistant, on the one hand, and a general secretarial pool on the other. A secretary was also provided for the Hospital Physics section under Mr. (now Dr.) Robertson. Among those who worked in the Department during this period were Susan McGaw (now Mrs. Clarke), Caroline Lavender, Sherryl Beck (now Mrs. Stephensen), Mrs. Diane Beresford, Mrs. Robyn Coffey, Lynette Crompton, Dallas Ealing, Christine Henderson (now Mrs. Holt), Sandra Latham, Amanda Marshall and Carolyn Mickel (now Mrs. Davey). I must personally express my gratitude to Miss O'Mahoney and Mrs. Thompson for their great assistance.

In the enlarged Department, it was found necessary to create the following positions:–

(a) A Purchasing Officer, locating goods at the best price, preparing orders, chasing-up orders and checking accounts. There have been many changes in this position. The present holder, Richard R. Lane was appointed in 1968. Originally classified as a technical position, it is now classified as a clerical post.

(b) An Equipment Officer, to record, check and test equipment at suitable intervals and file literature concerning it. George Gwacki held this post for a number of years, but transferred to the Anatomy Department in 1973, and was succeeded by Donald Chambers.

(c) A Professional Officer. The need for this arose from the rapid development of electronic engineering in the period following the successful launching of the first space satellite, and the launching of the "Apollo" programme in the United States. Physics research students found themselves needing sophisticated electronic equipment, for experimental work on problems not directly concerned with electronics. To avoid waste of time and money in constructing such equipment, an expert was required to advise. The Professional Officer is required to have an appropriate degree, or diploma, and has a tenured appointment straddling Senior Tutor and Lecturer levels. The first appointee in Physics was Dane Horgan, B.Sc. (1965^{x}–1969) followed by Allen Smith, B.E. (1969–1974).

(d) An analyst, appointed originally to analyse ionosonde records, but later having broader responsibilities. Mrs. Dahna Dearden was appointed to this position in October 1960.

It will be clear, from the staff increases, that the change in rate of growth did not become evident until late in the decade. Even by the end of the previous decade, an increase in laboratory, lecture room, and office accommodation had become urgent. The Universities Commission had urged the establishment of a first-year Science Building, to which I grudgingly agreed, while the other Departments concerned were also not keen on the proposal. On looking into the matter in detail, it was evident that a much more convenient arrangement, for both staff and students, would be to convert the 1955 Parnell Building into a teaching building, and provide an annexe to house research labs. and offices. After much delay, due to the change of plan, the Universities Commission recommended the funds, and building commenced in 1963. The architect, Mr. R. Voller, was most thorough and most cooperative and the building turned out extremely well. In arranging for services, furniture, etc. the Physics staff were consulted; Dearden and Monro, in particular, gave a very considerable amount of time to this matter. Unfortunately, rising costs resulted in the funds being inadequate to complete the building as planned, and the liftwells were left without lifts. (One was installed in 1976.)

As already indicated, in this decade, the teaching of the later years of the Bachelor's course, and the graduate courses, were given prominence, in contradistinction to the special efforts at first-year level in the previous decade. A system of optional courses in third-year Physics was instituted, allowing Physics to be taken as either the major or the minor subject, and permitting some selection between different parts of the Science. This was introduced to a more substantial extent in the fourth (Honours) year, when a considerable number of very short lecture courses were offered, with some of these being compulsory, and with rules governing the number to be selected (and hence sat for in the examinations). As a corollary to this expansion of lecture courses, the "research" in fourth year was greatly curtailed, becoming more in the nature of an exercise. Somewhat different arrangements applied as between students opting for Theoretical Physics, from those opting for Experimental. There were many changes in detail during the decade (for example, for a few years, a number of lectures were given by visiting lecturers). The overall effectiveness was assessed after each change.

A more radical change as introduced in 1965, when separate Honours courses were offered in first, second and third years, so that the more able students, who entered the University with a view to becoming professional physicists, would have their studies more evenly spread over the four years, and reach a higher level. This practice had been, for a long time, observed in Mathematics and was regarded in that Department as essential to the attainment of an adequate level of mathematical knowledge by the end of the fourth year. It was felt that the case of Physics was closely similar. Provision was made for transfer from Pass to Honours courses at the end of each year, subject to a very high level pass being achieved.

The general expansion of the University in the fifties led to the suggestion by the Vice-Chancellor (J.D. Story) to the Senate that the University establish feeder institutions in some country centres, partly, perhaps, to relieve pressure on first-year accommodation, but principally to encourage people to undertake University courses who would not otherwise have done so. Initially, it was proposed that, if the first-year course was successfully passed in one of the country centres, the student would then come to Brisbane knowing he was capable of benefiting from University education. The country city selected as the first experiment was Townsville, and a University College was established there in 1962. Although the concept changed somewhat between its inception and the enrolment of the first students, it coloured the nature of accommodation and initial staffing. (No Professors, or even Senior Lecturers, were appointed in the first group.) It was arranged that, while the general administration of the College would be regulated by the Warden, located in Townsville, the academic details of teaching and examination would be the responsibility of the Head of the relevant Department in Brisbane.

A considerable load was placed on the Physics staff in advising the architects on details of furnishing, services required, etc. and in selecting, ordering, and, in some cases, making in the Physics workshops, the scientific equipment needed. Even before the first-year classes started, it was decided to go ahead with second-year, and this again meant much work – mainly for Bowman.

The Lecturer appointed, Eric Hewstone Carman (Ph.D. London) visited Brisbane regularly and staff members from Brisbane visited Townsville. Even when the course had been extended to third year, Brisbane Lecturers were asked to give short courses on topics to which they had given particular attention in their courses.

The second appointment made in Townsville was that of Bruce Cater Gibson-Wilde, who had held a Demonstratorship in Brisbane during his Honours course. Gibson-Wilde is still in Townsville, at what is now the James Cook University of North Queensland, but Carman resigned in 1966 and, after appointments at African Universities, became Professor of Physics at the University of Papua-New Guinea.

The commencement of this decade saw the inauguration of the Australian Institute of Physics. I was disappointed to be abroad (on Study Leave) during the inaugural meeting, as I had urged this step during my period of office as President of the Australian Branch of the Institute of Physics. From my discussions in London, I gathered that the Institute of Physics (London) was not only agreeable to the separation, but actually found some embarrassment in the continued attachment of the Australian Branch, which had different views in respect to qualifications of entry (because of the higher rating of "Pass" degrees in Australia). The severance arrangements offered by London were generous in the extreme, so much so, that I urged the Branch Committee to make a token gift to the (London) Institute. In the outcome, a conference table for the Council, made of Australian blackwood, was sent and, I gather, was found useful and attractive. I greatly appreciated the Council of the Australian Institute of Physics later appointing me an Honorary Fellow.

In Chapter V, brief reference was made to the University's purchase of a digital computer. Although managed by the Electrical Engineering Department, it served all Departments and, in some years, the Physics Department was the best customer. The academic staff attended courses in programming (at first, the special systems for the GE225, but later for "Fortran") and a short course in programming was included in the third- and fourth-year courses. The Department hired a card punch and a room was set aside for computer purposes. Towards the end of the decade, arrangements were made for a remote terminal, to be used with the PDP-10 computer, then installed, replacing the old GE225. The computers have proved of great value, not only to the Theoretical Physics Group (most of whose calculations do not admit of an explicit solution) but also in many experimental researches.

Early in the decade, the Commonwealth Government decided to make grants to secondary schools, both State and Independent, for science laboratories and other science facilities. While States were given block grants for their schools, Independent schools were allotted grants by a Schools' Committee in each State, but subject to their proposals being acceptable to a Committee on Standards. I was invited to become a member of that Committee and, in that capacity, visited many schools in Queensland, as well as attending Canberra meetings of the Committee. The scheme was very successful and was later extended to other school facilities.

I resigned from that Committee in 1965, when Senator Gorton invited me to join a new committee he was setting up, to advise him concerning the allocation of funds which the Commonwealth Government proposed to make available for outstanding research projects, to be carried out in Universities and other non-government research institutions. The Committee, which was named the Australian Research Grants Committee, was chaired by Professor (now Sir Rutherford) Robertson and the discussions on methods of procedure in the early meetings were most interesting and greatly impressed me with Robertson's ability. In 1966, I visited the National Science Foundation in Washington, and found great interest in the Australian scheme. It is my impression that the Committee has done much to strengthen University research throughout Australia, not only by its grants, but also by forcing research workers to clarify their ideas on what they want to investigate. My term of office (nominally 3 years) was actually extended till the end of 1969; I was, effectively, absent (on Study Leave) for all of 1966.

Apart from annual visits of the interviewing committee of A.R.G.C., visits to the Department were made occasionally by the Radio Research Board and the Australian Institute of Nuclear Science and Engineering, all of which bodies have continued to provide financial assistance for research within the Department. In 1961, prior to the ANZAAS meeting, a Symposium on the Ionosphere was held in the Department, at which most Australian ionosphericists attended, and also Professor Takesi Nagata of Tokyo, Professor Ken-ichi Maeda of Kyoto and Professor Yusumo Kato of Sendai, who came as guests of the Australian Government. Professor Maeda again visited Queensland in 1976, for the International Symposium on Equatorial Aeronomy at the James Cook University, Townsville. In 1965, the R.R.B. sponsored a Symposium at this University on Geomagnetic Micropulsations.

Other distinguished scientists who visited the Department during this decade were:—

Sir Lawrence Bragg, recently retired as Director of the Royal Institution, (Albemarle Street, London) in 1960. Sir Lawrence, with his father, while in Adelaide, discovered the selective reflection of X-rays by crystals, which laid the foundations of X-ray spectroscopy and greatly assisted crystallography.

Dr. Egon Bretscher, (1961) a distinguished nuclear physicist and head of the Nuclear Physics Division of the Atomic Energy Research Establishment at Harwell, England. He was brought out by AINSE.

Professor Fred Hoyle, (1962) Plumian Professor of Astronomy in Cambridge University and world-renowned cosmologist (in addition to writing science fiction and producing pantomimes). I well remember taking him to see the Lamington National Park, as we had to walk through a small bush fire, which he took in his stride.

Professor S. Keith Runcorn, (1964) of the University of Newcastle-upon-Tyne, a leader in Solid-Earth Geophysics in the United Kingdom.

Sir John Cockcroft, (1964) Master of Churchill College, Cambridge and formerly Director of the Atomic Energy Research Establishment, Harwell, England, and later Chairman of the U.K. Atomic Energy Authority.

Dr. Colin Franklin, (1965) of the Defence Research Telecommunications Establishment, Shirley Bay, near Ottawa, Canada, renowned as the builder of "Alouette", the first ionospheric-sounding satellite.

Professor K.E. Bullen, (1965) of Sydney University, renowned for his interpretation of seismological data in terms of the internal structure of the Earth.

Professor Morton Kligerman, (1965), Radiotherapist and Biophysicist of Yale University (now at the University of New Mexico and the Los Alamos Research Establishment).

Mr. J.A. Ratcliffe, (1966) formerly of the Cavendish Laboratory, Cambridge, Director of the Radio Research Laboratory (now Appleton Laboratory) Slough, Bucks, England, distinguished as the teacher of a large proportion of English-speaking ionosphericists.

Professor H.E.M. Barlow, Emeritus Professor of Electrical Engineering, University College, London, noted for his microwave researches.

Professor William Fowler, California Institute of Technology, Pasadena, California, distinguished nuclear physicist and astrophysicist.

Professor W. Ross, Pennsylvania State University.

Professor Hans Buchdahl, Australian National University.

Sir Harrie Massey (a second visit) Quain Professor of Physics, University College, London and Chairman of the U.K. Space Research Committee.

Professor W.V. Mayneord, Professor of Physics Applied to Medicine, University of London, and universally recognized as the founder of accurate dosimetry in the treatment of disease by ionizing radiations.

Dr. L.H. Gray, of the British Empire Cancer Campaign Research Laboratory. He was the first medical physicist to be admitted as a Fellow of the Royal Society and had the unusual distinction of having a physical unit (viz: the unit of dosage, in the S.I. system) named after him, posthumously.

In 1966, I was elected Deputy President of the Professorial Board, Professor Mahoney being President. Although I should normally have been a candidate for the Presidency in 1969, I decided to decline nomination, partly with the hope of resuming some research, which I might carry on after my retirement. My efforts to avoid administrative responsibility were, however, thwarted when Professor Teakle, who had become Acting Vice-Chancellor when Sir Fred Schonell became so ill that he had to take leave-of-absence, asked me, as a personal favour, to take on the job of Acting Deputy Vice-Chancellor (Academic). I felt bound to accept, and I continued to act in that capacity until I left the University (on leave-without-pay) in April 1970.

During this decade, with the increase in members of staff and graduate students, additional lines of research were instituted. These were as follows:—

1. Microwave spectroscopy. This followed a suggestion received from the Radio Research Board that the electromagnetic behaviour of mixed gases at microwave frequencies (1 GHz and above) would be of interest. The Post Office uses microwave channels for many telephone links.

2. Theoretical Astrophysics; specifically, the atomic abundances in the sun deduced from spectral data. This research was, as mentioned previously, commenced in the previous decade, but publication did not start until 1960.

3. Problems in Relativity Theory.

4. Solid-Earth Geophysics, including the forecasting of earthquakes and geomagnetism.

We shall first discuss previously established research activities.

Ionospheric Physics

Reference was made in Chapter V to the rotating array, set up under the Research Contract with the U.S. Air Foce. In all, three sounders were used in this research, the second being a 55 MHz sounder, made by modifying the antennas etc. of the original sounder, and the third, a swept-frequency system with a fixed rhombic antenna directing a beam towards the north. (The use of a rotating log-periodic antenna gave inadequate sensitivity.)

The primary aim of the research was the detection of irregularities, in the F-layer, aligned along the geomagnetic field. During 16 months of operation at 16 MHz, patches of echoes, identified as field-aligned, were regularly observed. They could be separated into two groups, one corresponding to direct reflections, at right angles to the geomagnetic field, the other corresponding to reflections via an intervening F-hop and ground reflection. On some occasions the reflecting irregularities appeared to be present over a region at least 3000 km long in an EW direction, and at least 100–200 km in a north-south direction. (The latter is constrained by the vertical thickness of the F-layer). On other occasions, the irregularities covered a considerably smaller area; there being evidence that the average patch size increases with increasing latitude. The near type of patches frequently show northwards or southwards movement, northwards on magnetically-disturbed days; southwards, on quiet. Typically, the vertical extent of irregularities is 300 km and for one selected series of observations the mean height was 450 km. The behaviour of the second class of patches was uncertain, because of changes in effective height of the intermediate F reflection.

Comparing the occurrence of the near-type patches, with Geiger counter counts of electrons in Explorer VI, showed a good positive correlation. This strengthens the hypothesis that the irregularities are caused by dumping of electrons from the outer Van Allen Belt. Abnormal phenomena were noted on 6 May 1960, which appear to have been due to an unusual impact on the outer magnetosphere (i.e. near where the geomagnetic field has about the same strength as the interplanetary).

Parallel work in the Department on the amplitude scintillations of 20 MHz transmissions from Explorer VII showed an enhanced effect when the path between satellite and receiver lay along a geomagnetic field line, confirming the existence of field-aligned columns of abnormal electron densities and suggesting that their diameters were of the order of 1 km. Scintillations also tend to appear more often when frequency-spreading in the F-layer is indicated in vertical-incidence ionograms, but rarely with range-spreading. Although individual columns may have a size as small as 1 km, they seem to be present in patches never less than 100 km in diameter.

The later modifications of the equipment and the swept-frequency equipment were set up to check a claim by Gallet and Utlaut to have detected, in the United States, transequatorial propagation via whistler ducts in the mesosphere (i.e. extending to several thousand kilometers height). The Brisbane conclusions were negative, and set a lower limit for the attenuation (one-way) on such a path, to Brisbane, at 100 dB for 16 MHz and 83 dB at 55 MHz.

The results quoted above were due to Thomas, McNicol, McInnes, Singleton, Goodwin and Crouchley, with graduate students E.W. Dearden, Evelyn M. Matthew (now Swenson), G.H.C. Lynch and J.G. Steele.

As well as F-region field-aligned columns, evidence was found of columns within the E-layer at times when Esc reflections were recorded. They appeared more frequently when there was range-spreading of Esc. It was found that their lengths were probably quite short (50–600 m) and were shorter when range-spreading was present. They showed some off-normal scattering but no refraction. A greater electron content tends to coincide with greater vertical thickness of the layer.

As the rotating arm covered the full 360°, the system for a considerable sector looked in a generally northerly direction. At that stage, echoes could be observed, ascribed to backscatter, from the ground to the north, of pulses reflected from the F-region. This process appeared to occur also as a result of several reflections, alternating between ionosphere and ground. It was found that, additionally to the echoes explicable in this fashion, other echoes appeared on the records, which had to be accredited to some anomalous form of propagation to the northern side of the Equator and return after backscatter. These anomalous echoes were not phase-coherent and showed complex fading patterns. They appeared almost exclusively between 1400 and 2400 local time, usually appearing first somewhat to the east of north and spreading, or moving, later, towards the west. On rare occasions, the echoes covered the whole azimuth sector ± 70° with a minimum range (at 0°) 6500 km and maximum 10,000 km. Using ray-path analysis, it was found possible to develop a theory of the phenomenon, taking account of the F-region equatorial anomaly. The analysis predicted a focussing effect which gave the right order of magnitude for the returning signal strength.

It should be mentioned, at this stage, that Steele, when a Ph.D. student, used the 16 MHz system to measure ground backscatter coefficients as a function of angle of incidence. He later made similar measurements at 32.8 MHz at Stanford University.

The anomalous trans-equatorial echoes showed some dependence on the phase of the moon. A careful study of lunar semi-diurnal tides in the height of the F-layer as measured at 19 ionosonde stations, extending from +51° dip to −57° dip, showed significant tides only near the magnetic Equator and at local solar time between 1900 and 2300. This was found to be consistent with the dependence mentioned above.

The investigation of whistling atmospherics, while undertaken as a part of a world-wide network, enabled some conclusions to be drawn concerning the limited range of latitudes covered by the Department's experiments, viz: from Macquarie Is. (54°S) to Brisbane (28°S). Thus a systematic diurnal variation in occurrence, with a minimum in daylight, and a seasonal variation with a maximum in winter, were found. With one station (Adelaide) there appeared to be some association between occurrence rate and sunspot numbers, and, in all cases, there were signs of recurrent tendencies (as deduced from auto-correlation plots).

Further work, using four stations separated by only about 100 km, indicated that these observed the same dispersion (defined by $D = {}^1/_{f^{1/2}t}$) for the whistler excited by a particular lightning flash, over a distance around 300 km, though the intensity was not usually the same. From the studies of "diffuseness" (the spreading of the f, t curves, resembling the spread-F ionograms), it appeared that the energy received at the station spread out from a region of diameter between 10 and 200 km at the base of the ionosphere, which Crouchley named the "ionospheric source". Such sources appeared to be most prevalent at around 51°S geomagnetic latitude in summer and 45°S geomagnetic latitude in winter. Since whistlers are more frequent in winter than in summer, it was not surprising that the Hobart station (45°S) received the most whistlers.

Consistent with this picture, it was found that a given lightning strike could produce different dispersions at stations separated by around 1000 km. (It was unusual for more widely separated stations to receive a whistler simultaneously.) Dispersion at each station covered a wide range of values, there being some systematic diurnal and seasonal variations. It appeared that there was a dependence on the latitude of the ionospheric source, and indications of influence of the F critical frequency and magnetic disturbance.

The diffuseness referred to above was greater, the greater the number of traverses between hemispheres between excitation and reception, and was linearly related to geomagnetic latitude and whistler dispersion. Diffuseness is probably due to the transmission of energy over several distinct, but adjacent, propagation paths.

The whistler equipment also detected other natural very-low-frequency noise of natural origin, variously called "dawn chorus", "chorus", "ionospherics" etc. The Brisbane whistler equipment was exceptional in giving no record of these. However, Brown (as a graduate student) and G.G. Cairns obtained evidence of a broad-band component in the 5 kHz region, but at a 10 dB lower level than the similar noise at Camden, about 750 km to the south. At all other whistler stations, ionospherics were recorded, peaking before local noon and showing some dependence on magnetic K index.

Singleton suggested that the frequency-spreading of F traces on ionograms could arise from reflections from the end of whistler ducts. A comparison of the proportionate width of the spreading (Δ f/f) at different latitudes suggested that changes in electron density adequate for ducting occurred more rarely at sub-tropical latitudes, consistent with the lower occurrence rate of whistlers at such latitudes. Frequency-spreading tends to be most prevalent at auroral latitudes and close to the Equator and lower at the poles and mid-latitudes.

Although the researches on field-aligned irregularities and whistlers were the chief achievement in Ionospheric Physics during this decade, other advances were made, some of which will now be mentioned.

Further work on travelling ionospheric disturbances in F-region confirmed the existence of wide fronts in such disturbances and indicated that most originate at high latitudes. Similary, Es clouds tend to have the shape of horizontal cylinders. More extensive statistics on high-multiple reflections from the night-time F-layer in Brisbane indicated a strong maximum just before sunrise at 90 km and while confirming the tilted ionosphere picture, suggest that they occur when non-deviative absorption is reduced to near zero, which is consistent with the systematic measurements of reflection coefficients mentioned previously.

It became evident, during the decade, that a complete clarification of the shape of the surfaces of equal electron density in the ionosphere demanded a high-resolution probing system (analogous to the high-resolution radar systems), which would require a pencil-beam quality. This could be incorporated in either the transmitting or receiving system, but it appeared that the most economical system was a combination of both; in effect, using the principle of the Mills cross. The beams produced by transmitting and receiving antenna systems would thus each be fan-shaped, with the two fans being at right angles. Horizontal scanning could be effected by phase-changes between the individual antennas used, and vertical scanning by the use of several frequencies.

Construction of a system based on this principle, using an array 1 km long for both transmitting and receiving beams, was commenced during this decade, but the phasing system, as designed, was found to be unsatisfactory and the difficulties were not overcome until the next decade.

Following the termination of the whistler studies, an investigation was inaugurated, in 1965, for which equipment was lent (for an indefinite period) by the United States Government. The project consisted of the recording of phase and amplitude change of signals emanating from U.S. stations, operating in the range 10–25 kHz, with their frequency and phase exactly controlled by caesium standards. It was part of a world-wide network, all data from which being collected, and collated, at Deal, New Jersey. In general, the results obtained at the Bribie Island station were consistent with those obtained at other receiving stations. An interesting phase anomaly was observed when the path from transmitter to receiver crossed the Equator near the sunset line. Such anomalies had previously been observed by a former student, Kenneth Lynn, in South Australia. (Lynn afterwards enrolled for a Ph.D. at this University and extended his analyses to Bribie data.) Of particular interest, in other students' work, were the phase changes in the signals from a station in Japan, which indicated considerable scatter from first order to second order (waveguide) mode near the intersection of the sunrise, or sunset, line with the Equator. An independent search was also made for lateral deviations, from great circle paths, of the signals from Japan at these times, but the results were negative. On certain days, the sunrise/sunset line is nearly parallel to the great circle path, but these also showed negative results. These results have some bearing on the accuracy of the Omega system for navigation near Australia.

Some work was also done at considerably lower frequencies (5–25 Hz) on peaks in the spectrum of atmospherics due to (Schumann) resonances in the earth-ionosphere cavity. General agreement was found between temporal changes in level, and results anticipated from the known world-wide distribution of thunderstorms, together with the theory of the Schumann resonances.

Frequency analyses of micropulsations (from about 1 millihertz to 2 Hz) using both magnetic and electric sensors, revealed the occasional occurrence of spectral lines of systematically changing frequency in the range 0.1–1.5 Hz. These were discovered simultaneously in several institutions and have been satisfactorily explained in terms of hydromagnetic waves originating in the outer magnetosphere. On one occasion, an even higher frequency was recorded near Brisbane. At frequencies below 100 millihertz, band spectra were obtained, usually more prominent in day-time. They correlated with the magnetic disturbance index K_p.

Among the theoretical projects was Catchpoole's examination of the effect of electric fields on electron motions in the magnetosphere and the resultant dumping of electrons from the Van Allen belt. Possible contributions of low-energy electrons by photoelectric processes in the upper ionosphere were also assessed. Another was Stening's calculations of ionospheric currents, based on a highly simplified model of ionospheric winds, conductivities, etc; fair agreement with observation was obtained.

Whitehead was the author of a wind-shear theory of sporadic-E and has developed his theories further, since rocket data indicated the presence of metallic and other unexpected ions. In order that theories of sporadic-E (especially the enigmatic night-time appearances of the layer) should be fully explained (and, indeed, also the normal E-layer) it is necessary that more precise information should be available on the relationship between electron density and altitude, as a function of time and place. Shortly before coming to Brisbane, Whitehead, with Malek, had developed, in principle, a much more accurate ionosonde than those currently available. During the 1960–1970 decade a group of workers developed equipment based on this principle. The technical problems proved to be much greater than appeared at first sight, and it was not until near the end of the decade that a unit was completed, which permitted an accurate measurement to be made. Unfortunately, this suffered from the severe disability that the analysis of a single ionogram required many hours of work and thus the use of the system to determine diurnal changes was quite impracticable, and the incorporation of a computer essential. This was achieved during the next decade.

Radiation Biophysics

Two major projects were in operation during this decade, viz:–

1. The measurement of solar ultraviolet radiation, by Robertson.

2. The measurements of the radon content of the ambient atmosphere at St. Lucia, by Taylor.

Robertson devised a measuring instrument which recorded, at short intervals, the solar ultraviolet radiation falling on a horizontal surface, the sensitivity of the instrument being adjusted to change with frequency in very nearly the same manner as the sensitivity of skin to sunburn. This peculiar spectral sensitivity was chosen since there is evidence, from other work, that the production of skin cancers follows the same dependence on frequency. Instruments were set up in Brisbane, Townsville and Cloncurry and operated for a number of years, and later at Melbourne, and at several sites in the United States (in cooperation with Temple University, Philadelphia). There was found to be a rough correspondence between the integrated results of the instruments and the incidence of skin cancer as determined by epidemiologists, but the detailed situation is more complex. The results were used in an assessment of the possible increase of skin cancer arising from general use of supersonic aircraft for commercial flights.

Taylor used much the same method of measurement as previously used by Junge and others, involving freezing out the radon from a large volume of air. The results indicated wide variations in radon content, depending on meteorological conditions such as strength and direction of winds, presence of rain and temperature inversions. The maximum content recorded was 6.29 becquerels per cubic metre, the minimum, 0.037 becquerel per cubic metre, and the average, 1.04 becquerels per cubic metre. Under conditions of maritime wind, the average content was 0.6 becquerel per cubic metre, and with a wind from the land mass, 1.50 becquerels per cubic metre. Rain tended to reduce the radon content.

It may be appropriate to mention here that, during this decade, Macky made a study of the effect of wind on the accuracy of standard rain gauges.

Theoretical Astrophysics

The appointment of Mugglestone as Senior Lecturer in Theoretical Physics in May 1958 has already been mentioned in Chapter V. His first work concerned the formation of the H_γ line of hydrogen in the solar atmosphere, which, in 1960, resulted in a paper describing how the profile of H_γ could be used as a device for testing existing solar model atmospheres. The important principle of using the H_γ profile as a crucial test of a solar model atmosphere remains valid, but the conclusions reached in the paper may no longer be valid, as the description of the broadening of the H_γ line used in the paper is now known to be inadequate.

The basic method of determining the solar abundance of an element is to construct a synthetic line profile for a particular spectral line of the element, using a physical model of line formation, in conjunction with a model of the solar atmosphere, and then to adjust the abundance of the element so as to obtain agreement between the observed and synthetic profiles. Such a program can only be realistically carried through with the aid of an electronic digital computer. When Mugglestone was working on his thesis, digital computers were not available, so it was necessary to develop methods of abundance determination amenable to hand calculation. This was achieved by matching the computed equivalent width of spectral lines to observed equivalent widths; the equivalent width being defined as the area of the spectral line divided by the local continuum intensity. In his thesis, Mugglestone developed a procedure for determining solar abundances in this manner, which he called the Planckian Gradient Method, and which was, at that time, restricted to weak Fraunhofer lines. At the University of Queensland, this method was extended to strong Fraunhofer lines by Mugglestone and D.J. Faulkner. The method was applied to a determination of the abundance of oxygen and the results were published in 1962.

At that time it was already apparent that digital computers would play a major role in astrophysical calculations. M. Andrews was the first person in the Department to develop an expertise in the use of computers, in particular, the SILLIAC at the University of Sydney. His first efforts were concerned with the development of statistical analysis programs for the ionospheric group. The method of determining solar abundances developed by Faulkner and Mugglestone was programmed for the SILLIAC by M. Andrews. The program was then used to determine the solar abundance of carbon and the results and certain related material were published in 1963.

At much the same time, B. Horton was working with Mugglestone on the adaptation of these methods to the determination of abundances in stars other than the sun, but unfortunately this work was never completed. B.J. O'Mara joined the group as a fourth-year student in 1960 and worked on the development of computer programs for calculating Stark broadening parameters required by the solar abundance program of M. Andrews. The results were used in the carbon abundance determination referred to previously.

In 1966 O'Mara and G.D. Finn enrolled as Ph.D. students. O'Mara's project involved a systematic determination of the solar abundance of all of the elements for which lines had been identified in the sun, with particular attention to the influence of spectral-line-broadening mechanisms. This involved the recoding of the programs prepared for the SILLIAC to suit the GE225 at the University of Queensland. In the middle of 1967, O'Mara went to the U.S. but two papers were published on his work. One, on the solar abundance of nitrogen, was written in reply to criticism of an earlier paper by Mugglestone. The other dealt with the solar abundance of sodium, and the particular importance of Stark broadening in the determination of the abundance. Previously, it had been widely believed that the broadening of metallic lines in the sun was dominated by broadening due to collisions with atomic hydrogen, and the Stark broadening was of little consequence.

Since the GE225 was sufficiently fast to permit direct computation of solar spectral line profiles, Finn's project was to have included solar abundance determinations using line profiles rather than equivalent widths, but it soon became apparent that a simple model of line formation based on the assumption of local thermodynamic equilibrium was not capable of accounting for the deep cores of certain strong lines, such as the sodium D-lines. This changed the course of his work to an analysis of physical processes of importance in solar spectral line formation. The work resulted in three papers, two on the formation of the sodium D-lines in the sun and the other on the computation of the so-called Voigt profile, which incorporates the effects of collisional and Doppler broadening. Finn was the first astrophysics student to receive a Ph.D., which was awarded in 1965.

In 1964, R.L. Young enrolled as an M.Sc. student. Young completed his thesis on the solar abundance of ten elements up to calcium in the Periodic Table. In the case of oxygen, data was employed from several positions on the solar disc. Unfortunately this work was not published in any Journal.

In September 1964, Mugglestone took up a Visiting Fellowship at the Joint Institute of Laboratory Astrophysics in Boulder, Colorado. There he worked with Dr. R.N. Thomas and Dr. J.T. Jefferies who were at that time working on what is now known as *non-L.T.E. theory.* Up to that time it was assumed that, in spite of the fact that the colour distribution and angular distribution of radiation at a given point in the solar atmosphere does not conform to Planck's law, the population of atomic energy levels and the ionization equilibrium is given by the Boltzmann and Saha equations at the local kinetic temperature. This is known as the assumption of local thermodynamic equilibrium or L.T.E. Thomas and Jefferies pointed out that arguments previously presented in favour of L.T.E. were based on the erroneous supposition that photons absorbed at a given frequency within a spectral line are re-emitted at the same frequency. There was, in fact, strong evidence that the re-emitted radiation is completely redistributed in frequency. With this as the true situation, they showed that it may be necessary to replace the assumption of L.T.E. by the assumption of statistical equilibrium in which it is supposed that the populations of atomic energy levels and ionization equilibrium remain constant in time but not necessarily in L.T.E. With this new assumption it is necessary simultaneously to solve the equations of statistical equilibrium and the equations of radiative transfer to determine spectral line profiles. The technique for doing this became known as *non-L.T.E. theory.* This experience changed the course of Mugglestone's work after his return (to take up the Chair) and his later work was mainly in the field of non-L.T.E. theory.

In 1965, L. McNamara and J.D. Argyros enrolled as Ph.D. students. McNamara worked on the formation of the sodium D-lines and certain lines of ionized calcium in non-L.T.E. Argyros worked on the fundamental problem of the redistribution of line radiation, a problem of considerable importance in the transfer of line radiation in stellar atmospheres. A number of preliminary reports appeared in the Proceedings of the Astronomical Society of Australia, but there were no major publications.

In 1968 O'Mara began the supervision of the I.R. Shortt (M.Sc. student) and R.J. Dyne and R.W. Simpson (Ph.D. students). Shortt worked on the problem of light scattering in reflection nebulae. In previous work, it had been assumed that light reaching the observer from the nebula is a result of a single scattering of light from the central star by dust in the nebula. Shortt showed that for certain reflection nebulae, multiple scattering of the radiation must be taken into account. R.W. Simpson worked on the helium abundance in 33 main-sequence B-type stars and certain non-L.T.E. effects in the formation of helium lines. R.J. Dyne worked on spectral-line-broadening mechanisms of astrophysical interest. Reports on all this work appeared in major papers after 1970. G.D. Finn completed several papers in collaboration with J.T. Jefferies, of the University of Hawaii, and initiated his work on the probabilistic theory of radiative transfer, (an area in which he is now the acknowledged expert) during his term in the Department, 1968 and 1969. In 1969, J.N. Holt enrolled as a Ph.D. student and began working on the analysis of solar spectral line profiles, obtained at high spatial and spectral resolution, which led to a number of papers after 1970.

Dr. N. Weinstein, Senior Lecturer in Theoretical Physics, arrived in July 1963. In 1964, D.T. Pegg enrolled as a Ph.D. student under his supervision. Pegg worked on radiation theories as crucial tests for cosmological models. (This idea was first suggested by J. Hogarth. Later F. Hoyle and J. Narlikar worked on the relation between the *absorber theory of radiation* of J.A. Wheeler and R.P. Feynman and cosmological models.) Pegg's admirable thesis reviews and considerably extends much of this work, particularly with regard to physical insight. As far as I am aware, Pegg did not publish any papers on this material while in the Department but the work in his thesis formed the basis for an exchange of letters with Hoyle and Narlikar in Nature. More recently, he has written a review article on the absorber theory of radiation in Reports on Progress in Physics. In 1965, P. Tulloch enrolled as an M.Sc. student, and worked on the conjecture of F. Zwicky that clustering of galaxies is due to the gravitational field having a finite range (which requires the *graviton* to have a non-zero mass). In his thesis, Tulloch assumed a graviton mass of 10^{-64} gm and investigated the effects of this assumption on the classical Jeans's criterion for gravitational instability. This material has not been published. As already mentioned, Pegg and Tulloch completed their work without adequate assistance, due to Weinstein's departure.

Microwave Spectroscopy

The microwave work of the Department was initiated by Parsons, Noon and C.H. Burton (a final Honours student) in 1960. For the first few years, studies were made of gases at x-band frequencies and cavity techniques were used. The real part of the refractive index of methyl chloride was measured at 10 GHz and at pressures up to 2 bars, and deviations from linearity in the relation between refractive index and the number of molecules per unit volume were interpreted in terms of the contribution of non-resonant transitions to the refractive index. This was followed by an extensive study of absorption of 10 GHz radiation by pure methyl chloride and by binary mixtures of methyl chloride with H_2, He, A, N_2, and CO_2 at pressures up to 4 bars, and this in turn was followed by measurements on dilute binary mixtures of methyl chloride with H_2 and A at pressures to 100 bars. The results were interpreted in terms of collision-broadening theory; agreement with experiment was reasonable of both a distribution of line widths and also the possibility of other than binary collisions were admitted. Burton joined the CSIRO in 1965 and has remained there; he submitted his thesis shortly after taking up his appointment and graduated with the degree of Ph.D. in 1966.

E.C. Morris continued work in this field during 1966–70. He also used a cavity technique and made measurements on mixtures of polar molecules in a predominantly non-polar atmosphere. For mixtures of CH_3Cl or NH_3 with H_2 or H_1, Morris extended his measurements to 700 atmospheres, using a mercury piston compressor which he designed himself and which was in turn operated by a commercially available hydraulic band pump. The transition to non-resonant behaviour of the NH_3 inversion spectrum was studied, and collision diameters were deduced – some evidence was also found for a partial transition to non-resonance of the rotational spectra of CH_3Cl and OCS. Morris graduated with the Ph.D. in 1970 and since that date has been doing high pressure equation-of-state work with the CSIRO. The work of Morris was extended by J.C. Andrews in 1970. He measured absorption at 9.75 GHz by N_2O at pressures up to 54 bars and by CO at pressures up to 670 bars. In both cases, there was a transition from a resonant rotational spectrum to non-resonance. The interpretation of Andrews results involved the possibility of collision-induced absorption. Andrews graduated with the M.Sc. in 1971 and joined the Department of Supply.

In 1966, I.C. Story enrolled as a Ph.D. candidate and embarked on the construction of a waveguide cell spectrometer for use in the frequency range 20–40 GHz. His original plan was to make measurements of pressure broadening in the millitorr region of certain methyl halide rotational lines. However, in 1968 he modified his apparatus and constructed a multicell spectrometer with which he observed pressure induced line-shifts in the NH_3 inversion spectrum. Simultaneously, R.P. Netterfield constructed a spectrometer for investigating spectral line shapes; a klystron source of radiation was frequency modulated and, after transmission through a cell containing the gas under study, harmonics of the modulation frequency were observed and measured. Netterfield concluded that the Voigt shape gave a good representation of the line shape for inversion and rotational spectra at pressures up to 100 mτ. Netterfield graduated with the Ph.D. in 1972 and joined the CSIRO where he worked on optical problems associated with astronomical telescopes; Story took his Ph.D. in 1971 and then went to Harvard where he subsequently took a Masters degree in Business Administration. During this time, advice on theoretical problems relating to molecular interactions was given by B.S. Frost, an Honours B.Sc. graduate of Queensland and a Ph.D. of Sydney who had joined the staff as a lecturer in 1966; Frost was to make a more substantial contribution, however, during the following decade.

Geophysics Research

Research in Solid-Earth Geophysics began with the appointment of F.D. Stacey, late in 1964, and was quickly established by enthusiastic participation of graduate students. Three main lines were pursued: rock magnetism, earth strain and theoretical studies of global scale processes.

In the mid-1960's the origin of remanent magnetism in rocks was poorly understood. The rival theories of single-domained and multidomained magnetic grains both failed to explain thermo-remanent magnetism as observed in the magnetically stable igneous rocks, which were used extensively in paleomagnetic studies. It had become apparent that grains in the most important size range, 0.1 μm to 20 μm, were in some way intermediate in properties between the smaller single domains and larger multidomains and Stacey had introduced the term 'pseudo-single domained grains' which is now in general use. A series of experiments aimed at solving the problem resulted in theses on the dependence of magnetic susceptibility on magnetic history and grain alignment (R.S. Bhathal) and the comparison of thermoremanent magnetization with anhysteretic magnetization (induced by a small steady field in the presence of a stronger alternating field) (D.E.W. Gillingham), with supporting Honours projects on magnetic anisotropy and the role of crystal dislocations in the coercivity of magnetite (W.F. Leong, A.S. Cheam, K.N. Wise, W. Smith). A more general theory of thermoremanence evolved as the relevant parameters were clarified in a series of experimental papers. Toward the end of the decade, it was becoming apparent that the important fundamental problems in rock magnetism were being solved and that the validity of paleomagnetism was securely established. The sense of excitement and urgency in the subject was fading and this line of research was being phased out by 1970. A monographic review of the whole field was begun by Stacey, in collaboration with S.K. Banerjee of Minnesota, and has subsequently (1974) been published by Elsevier (The physical principles of rock magnetism).

Rock magnetism studies had led to recognition of a possible magnetic effect associated with earthquakes and volcanic eruptions, the seismomagnetic and volcanomagnetic effects, which were the subjects of theoretical papers by Stacey before arriving in Queensland. In common with the familiar ferromagnetic metals, magnetite is magnetostrictive and the thermodynamic converse of magnetostriction is piezomagnetism, the change in magnetization with stress. Magnetic anomalies to be expected for historical earthquakes with well-documented patterns of stress release were calculated by Sabiha Shamsi and a differential proton magnetometer, recording directly the difference in magnetic field intensity at sensors connected by several kilometres of cable or by radio links, was constructed by M.J.S. Johnston. Johnston's equipment was taken to New Zealand and set up on the volcanoes Ruapehu and Ngauruhoe with the active collaboration of the New Zealand, D.S.I.R., whose Volcano Observatory facilities were used. Eruptions of both Ruapehu and Ngauruhoe in 1968 yielded remarkable magnetic signatures, in the case of the Ngauruhoe eruptions reaching a maximum excursion of 40 nT, more than 20 times the effect on the difference field record of magnetospheric disturbances seen on recordings of two years of volcanically quiet time. In both cases, the magnetic changes preceded eruptions by periods of several hours to several days. This experiment proved to be a most encouraging step toward a system of earthquake prediction, and attracted the interest of authorities in seismically active countries, including the U.S. Geological Survey, which engaged Johnston to set up an extensive magnetometer array in California. In Queensland, construction of a new magnetometer array was begun by P.M. Davis, who also started a programme of magnetic surveys in the area of Talbingo Dam in the Snowy Mountains, to seek evidence of the piezomagnetic effect of ground loading by an artificial lake.

A particular merit of the piezomagnetic method of seeking seismic stresses is that it is sensitive to crustal stresses down to the Curie point isotherm (normally about 20 km) and so integrates stress over a depth range inaccessible to other methods. Even the simple fact that it is sensitive to stress is important, because most instruments record strain, which is necessarily ambiguous. A crustal strain may be a result of creep and not an elastic deformation storing seismic energy. However, it is unlikely that any one method will ever suffice to give an adequate indication of an impending earthquake and three other novel techniques were investigated in a comprehensive study of potential prediction methods.

S.K. Shamsi used a Michelson interferometer with two metre arms to obtain a two-year record of shear strain in the University's mine in Indooroopilly. J.M.W. Rynn recorded N-S and E-W tilt variations in the seismological vault at Mt. Nebo, using capacitance bridges and mercury level tiltmeters of novel design and M.T. Gladwin recorded times of flight of ultrasonic pulses through walls of the T2 power station in the Snowy Mountains for similar periods. The capacitance bridge and ultrasonic techniques have both proved to be valuable instrumental developments, having wider applications. The tiltmeter was patented by the University and is being manufactured by the Auckland Nuclear Accessory Co. in New Zealand. At the time of writing this is still the only University patent to have yielded a profit. These instrumental developments, which were supported by ARGC grants, became the basis of the experimental programme in the following decade.

Apart from theoretical papers related directly to the experimental programme, members of the Geophysics group investigated several global scale problems, viz: the electrical resistivity and thermal balance of the Earth's core (R.B. Gardiner), the interpretation of global gravity anomalies (J.W. Higbie), tectonic stresses and the energy balance and the dynamic coupling of the core and mantle. There was a strong relationship between these studies and the writing of a graduate level text 'Physics of the Earth' by F.D. Stacey, which was published by Wiley in 1969, and quickly adopted for Geophysics classes, both overseas and in Australia.

In 1967, G.J. Tuck began a search for the piezoelectric effect in quartz-bearing rocks. The existence of this effect, reported by Parkhomenko and co-authors in Russia, has never been confirmed in western literature. If it exists it could become the basis for a dramatic new branch of Geophysics, 'paleoelectricity', with the practical implication that it may indicate sites of electrochemically active ore deposits. However, by 1970, no rock had been found with a piezoelectric effect exceeding that expected statistically in rocks specimens with finite numbers of grains. It appeared possible that the Russian reports are misleading.

CHAPTER VIII. Concluding Remarks

In previous Chapters, reference has been made to the salaries paid to Professors, Lecturers and other academic staff. Properly to appreciate the changes over the years, one should make allowances for variations in the cost of living. The Commonwealth Statistician's Labour Report*, 1973, gives cost-of-living indices back for several decades. I have used these figures to compute what may be called "purchase pounds", by dividing the salary, when expressed in pounds, by the cost-of-living index, taken as *unity* for 1911, and when in dollars, by *twice* the cost-of-living index. The results are given in the Table below. Minimum and maximum salaries are quoted when there was a range of salaries for a particular office.

Year	C of L Index	Prof.	A/Prof. Reader	S/Lect.	Lect. I	Assist L Lect. II	S/Dem.	Dem. (f.t.)
1910	0.97	?	(a)	(a)	-			
		930			365	?	?	(a)
1920	1.93	390	(a)	(a)	206			
		465			285	?	?	(a)
1930	1.62	495	(a)?	(a)	309	216	216	(a)
		616	(a)?	(a)	402	279	279	(a)
1932	1.38	495	(a)?	(a)	312	225	225	(a)
		615	(a)?	(a)	406	301	301	(a)
1940	1.59	531	(a)?	(a)	358	252	(a)	126
		685	(a)?	(a)	469	326	(a)	189
1946	1.90	545	439	359	306	254	(a)	201
		675	541	451	386	319	(a)	221
1950	2.62	531	400	341	295	247	(a)	184
		631	476	400	344	294	(a)	209
1955	3.94	762	560	469	330	(b)	255	216
		-	610	548	443	(b)	292	231
1960	4.59	868	642	550	400	(b)	316	276
		-	698	627	510	(b)	348	298
1970	5.86	1230	940	767	539	(b)	426	337
		-	1015	796	747	(b)	480	380

(a) Position non-existent (or in abeyance) at this stage.
(b) Position abolished. Lecturer grades merged into one.

These figures still fail to give a complete picture, since the rate of Income Tax increased, from an almost negligible amount, in 1910, to as much as 35% in 1970. The situation is, however, confused by concessions, and University assistance, during Study Leave, the improved Superannuation privileges, etc. Overall, professorial salaries are probably effectively lower than for 1910, but there has been a substantial improvement at lecturer level.

The table reveals a harsh reduction in real salaries following the end of World War I. It is not generally realized that World War I produced such substantial inflation. The cut in salaries in 1932 appeared harsh, but, in fact, was compensated for by an equal proportional fall in the cost of living.

In the preceding Chapters one vitally important component of the Physics Department has scarcely been mentioned, viz: the Parnell Library. It is, I think, better to describe its history separately, rather than in relation to the several decades. In the early years of the Department, the Physics Library was very small and the recording and checking of books and periodicals was one of the many chores undertaken by Lusby. It operated on the "honour" system, and up to the end of World War II, this worked effectively. Unfortunately, with the general deterioration of morals which followed

* I thank Professor Gates for this information.

World War II, stealing became a serious menace and when I took over the headship of the department I found that the value of books stolen per annum was about equal to the annual grants, then £70 ($140). I therefore asked for a full-time Library Assistant to be provided, to control the issue and return of books, etc. Miss Margaret Quin was appointed to this position; although not possessing the full Librarianship qualifications, she had preliminary qualifications. In 1955, she married R.G.S. Taylor, and resigned. She was replaced by Miss Millicent Hooper, who had completed part of the Dentistry Degree course, and was thus familiar with the terminology of Physics. Miss Hooper resigned upon her marriage to A.C.N. Marsden.

By this time, the Library had grown considerably and, when transferred to St. Lucia, the bookstacks and Librarian's office occupied an area about three times that available at George Street, and there was in addition, a Reading Room of about the same size as the bookstack room.

Miss Hooper was succeeded by Miss Claire Gunnis, B.A., who had preliminary Librarianship qualifications on appointment, and completed qualifications during her appointment in the Physics Library. In July 1964, upon her marriage, she resigned and was succeeded by Miss Denise Mulhern (now Mrs Dryburgh), who completed her Librarianship qualifications in 1966, and transferred to the Main Library at the end of that year. In 1964, in order to permit the opening of the Library for one evening a week, a half-time Library Assistant was appointed. In 1965, this post was held by Miss Janine Hogg. In 1966, she was replaced by Miss Ann Clarkson, who was appointed as a Library Clerk, and in the same year Miss Mulhern obtained her full Library qualifications, and at the end of the year transferred to the Main Library.

In common with other Libraries, the space available for the Physics Library soon became inadequate, and it was necessary to incorporate a new, and larger, Library in the Annexe which, as mentioned earlier, was occupied in 1965.

In 1967, Miss Roslyn Gresham was appointed as Graduate Library Assistant, with Miss Clarkson continuing as Library Clerk. In 1968, Miss Clarkson was replaced by Miss Margaret O'Moore, and in that year Miss Gresham completed her Library qualifications.

In 1969, Miss Gresham was Librarian, with Miss Mary Pirotta, as Graduate Library Assistant. Miss Pirotta was replaced by Miss Patricia Lainson in November 1969 (as Library Assistant) and in December 1970 the latter post was reduced to half-time Library Assistant. Miss Gresham resigned in 1971. Mr. K.S. Sheekey was appointed Graduate Library assistant and became Librarian in 1973.

The selection of books to be purchased each year, and the introduction of new periodicals, subject to the usual financial restrictions, was the duty of the Head of the Department, but in the latter part of the 1969–70 decade, I found it desirable to delegate this responsibility to another member of the academic staff. All members of the academic and technical staff were invited to make suggestions.

For several decades, the existence of a separate Library for Physics has been a bone of contention between the Departmental staff, and the University Librarian. The staff values the easy access to the books and periodicals often needed in a hurry, while the Librarian claims that a better service could be provided by grouping together several Departmental Libraries.

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