

How research into medical ultrasound began in Australia

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ABSTRACT

In 1955, the National Health and Medical Research Council set up an Ultrasonics Committee to inquire into the control and use of ultrasound physiotherapy equipment. The Director of the Commonwealth Acoustic Laboratories (CAL) was appointed Chairman of this Committee. In 1958 the Chairman recommended that, in view of developments internationally in medical ultrasound, the Commonwealth Acoustic laboratories should undertake research into this field in Australia. An Ultrasonic Research Section was established in the Laboratories in March 1959, and research into medical ultrasound began at that time. This review describes the events leading to the establishment of the Ultrasonics Committee, the activity of the Committee between 1955 and 1958, and the research undertaken by the Ultrasonic Research Section of the Commonwealth Acoustic Laboratories until 1963 when the Ultrasonics Committee of the NHMRC was discontinued and the control of the research transferred to the Commonwealth Acoustic Laboratories.

INTRODUCTION

Research into medical ultrasound in Australia began in 1959, nine years after the first publication on "the use of ultrasonic pulses to detect soft tissue density changes (1)". Much of the credit for the early entry by Australia into this field belongs to Mr. Norman Murray, the Director of the Commonwealth Acoustic Laboratories (CAL). Murray recognised the contributions that medical ultrasound could make to clinical practice. Using his position as Chairman of the Ultrasonics Committee of the National Health and Medical Research Council (NHMRC) he established that year an Ultrasonic Research Section in the Laboratories to undertake research into this application. He also recognised that the Laboratories would benefit by having the research into ultrasound technology guided by input from the medical profession. He therefore set up a structure, similar to one already in place in audiology research within the Laboratories, whereby scientists had the primary responsibility for the research and clinicians were appointed as medical consultants to the Laboratories. In this way the research was conducted in an interdisciplinary manner with no restrictions on areas in which participants could make contributions. He also adopted the policy that the developed equipment was to be evaluated in hospitals to determine the clinical usefulness of the new technology.

This review describes the events that led to the establishment of CAL and of the Ultrasonics Committee of the NHMRC, the work of this Committee between 1955 and 1958, and the research undertaken by the Ultrasonics Research Section of CAL from 1959 to 1963. The Ultrasonics Committee of the NHMRC was disbanded that year and control over the research transferred to CAL.

Events leading to the establishment of the Commonwealth Acoustic Laboratories (CAL)

Two of the main problems in acoustics facing the Armed Services during World War II were communication between personnel under conditions of loud noise and the harmful effect of noise from guns. The Services turned to the NHMRC for assistance with a request to fund research and to recruit civilian scientists to do it.

At that time the National Standards Laboratories (now the CSIRO) had no laboratory facilities for acoustic research. Because much of the work was to be of physiological nature, Dr John C Eccles, then Director of the Kanematsu Memorial Institute of Pathology, Sydney Hospital, recommended in 1943 that the NHMRC establish an Acoustic Testing Laboratory to undertake this research in that hospital (2). Mr Norman Murray, shown in Figure 1, was seconded from the Post Master General's Department to be the engineer in charge of the project. The following year the Laboratory was renamed the Acoustic Research Laboratory and transferred to the Medical School, Sydney University.



Figure 1 Norman Murray, Foundation Director of the Commonwealth Acoustic Laboratories, 1947-1967.

Following the War the Laboratory began to undertake research into civilian problems in acoustics, in particular the rehabilitation of deafened ex-servicemen through the design and provision of a standard hearing aid. Attention was also given to the problems of a large group of children with congenital deafness resulting from an epidemic of maternal rubella in 1940/41.

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In 1946, the NHMRC decided that it was no longer justified in financing these civilian activities and recommended that the Laboratory be taken over by the Commonwealth Department of Health. Cabinet agreed to this proposal and the transfer was effected on the 1st of January 1947, the name of the Laboratory being changed to the Commonwealth Acoustic Laboratories (CAL).

The functions of the Laboratories were significantly expanded in the establishment process. The rehabilitation program was enlarged with the Laboratories given responsibility to provide hearing services to all deafened ex-servicemen and to all school children in Australia. Its service activities were also extended to permit investigations of effects of noise in industry.

Early investigations into ultrasound by CAL

In the early fifties, with the rapid expansion in use of jet and propjet aircraft, the Royal Australian Air Force requested CAL to undertake investigations into possible effects on its personnel by noise generated by these airplanes and to recommend appropriate hearing protection procedures. Although it was appreciated that the main energy in this noise was in the audible frequency range, concern was also expressed about possible effects from energy in the ultrasound frequency ranges *ie* above 20 kHz.

The energy and frequency distribution of noise from jet and propeller aircraft was determined using high frequency microphones capable of measuring air-borne acoustic energy at frequencies up to 60 kHz. It was found that the ultrasound component of the noise was small and for personnel to suffer a hearing loss from ultrasound they would have to stand so close to the engines that they would be hurt either by the exhaust or by the propeller. A precedent had been however established that the Laboratories were the appropriate authority to request assistance on matters relating into effects of ultrasound on personnel.

Ultrasonics Committee of the NHMRC 1955-1958

The Ultrasonics Committee was established at the meeting of the NHMRC held on 19th and 20th of May 1955. The brief of the Committee, as specified in the letter from Dr AJ Metcalfe, the Chairman of the NHMRC, to Norman Murray, was "to inquire into the control of the sale and use of ultrasonic therapy apparatus". The membership of the Committee consisted of Dr. Gordon Smith and Dr BG Wade, both specialists in physical medicine, and of Norman Murray as Chairman.

The initial meeting of the Ultrasonic Committee was held shortly after at the Acoustic Laboratories. The general field of work was surveyed and the minutes state that the Committee considered that its brief was "to oversee the use of ultrasonic apparatus for diagnosis and therapy and of industrial equipment". Consideration was also to be given to possible misuse of this equipment. The Committee considered the control of sale of this equipment and concluded that it would only be possible in relation to specific physical characteristics of the equipment. The common factor was the need to establish standards for

measurement of acoustic output of the equipment. The Chairman was requested to investigate this aspect to be discussed at the next meeting.

The second meeting of the Committee was held in October 1955. The Committee discussed the ultrasonic therapy paper presented at the Australian Medical Congress, BMA, held in Sydney in August of that year, in particular "the possible misuse in regard to the gravid uterus such as to procure abortion". Standards for measurement of acoustic output from physiotherapy equipment were again discussed, and the Committee recommended that the Acoustic Laboratories be asked to set up appropriate measurement facilities. The NHMRC accepted this recommendation in December 1955 and requested the Acoustic Laboratories undertake "the setting up of apparatus for determination of standards and methods of measurement and dosage". Norman Murray accepted this task in February 1956 as "an extension of our present work in ultrasonic measurements in air and our use of ultrasonic therapy in investigating its benefits in otological use".

The Committee next reported to the NHMRC in May 1958. The report states that the Acoustic Laboratories had purchased calibration equipment to measure the acoustic power output from physiotherapy equipment and that the Laboratories were following the activities of the International Electricity Commission (IEC) regarding the adoption of an international standard for measurement of dosage. The report also states that the Laboratories intended to commence research into "the use of ultrasonics in the alleviation and reduction of deafness and hearing defects". This was reference to the development in the use of ultrasound for treatment of Meniere's disease, whereby ultrasonic irradiation of the vestibular system was claimed to alleviate attacks of vertigo while preserving hearing.

Norman Murray was also keeping a close watch on developments in medical ultrasound. In the report he also refers to two new major applications, the use of strongly focused ultrasound for "destruction of nerve centres for treatment of Parkinson's disease" and the diagnostic use of "reflected ultrasound to detect and determine nature of breast tumours". The report concludes with the recommendation "that the work has developed to such an extent that it justifies the full-time attention of a first class research physicist on the Acoustic Laboratories staff".

The Committee issued a relatively short report to the NHMRC in November 1958. The report describes a change in the membership of the Committee with Dr TW Burgess, President of the NSW Physiotherapists Registration Board, replacing Dr BG Wade who resigned due to ill-health. The report discusses the concern by the Physiotherapists Registration Board regarding the use of ultrasound physiotherapy equipment by unqualified people and the action by the NSW Minister of Health to prevent this misuse. The report concludes by mentioning the work of "two British doctors and a research engineer who had developed a device, using ultrasound reflection methods, to avoid unborn children from being exposed to possible danger from X-ray radiation".

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Establishment of the Ultrasonic Research Section of CAL

At its Council meeting in November 1958 the NHMRC endorsed Norman Murray's recommendation that CAL should have a full-time scientist undertake research into medical ultrasound. Having obtained this endorsement, he approached the Commonwealth Department of Health in December 1958 for funding to allow CAL to establish a small Ultrasonic Research Section. To his delight he obtained approval for this action the last week in February 1959. He immediately contacted the Head of the Faculty of Electrical Engineering at the University of Sydney for names of undergraduates enrolled in the Honours degree. He wanted to identify from this list suitable applicants for the position, the urgency of his action being prompted by the fact that the results of the graduations were to be announced the following week.

The results of the graduations were announced the first week in March, and Norman Murray approached me that week inviting me to set up and head the Ultrasonics Research Section. I had at that time considered taking up an offer of appointment as a nuclear scientist at the Atomic Energy Commission. Norm Murray persuaded me to accept his invitation on the basis of his description of Medical Ultrasound as a field in the early stages of development when it would be easier to make a meaningful contribution. As there was no one in the Laboratories with experience in ultrasound I was to report directly to him as a Section Head. In recognition of this responsibility my appointment would be at a grade higher than that normally offered to a raw graduate. In other words he made me an offer which I just could not refuse, and I commenced duties with the Commonwealth Acoustic Laboratories on the 10th of March 1959.

My brief was

- a) to establish calibration facilities to measure the acoustic output from physiotherapy equipment,
- b) to initiate research into the ultrasonic treatment of Meniere's disease in collaboration with the ENT consultants to the Laboratories, and
- c) to identify key areas of expertise in technology required for diagnostic applications.

I was allocated a reasonable budget to allow purchase and construction of equipment to undertake measurements at ultrasonic frequencies, a technical officer to assist in the construction of the equipment, and the generous use of library facilities. The annual salary and operating budget for the Section the first year was four thousand pounds.

Investigations by the Ultrasonics Research Section of CAL 1959-1963

Calibration Facilities for Measurement of Acoustic Output

The first task that I undertook on my appointment was to evaluate existing international standards for measurement of acoustic output at ultrasonic frequencies. The International Electrotechnical Commission (IEC) had just released a draft of a proposed standard that I adopted for

measurement of total acoustic power output. The technique used a Cartesian float method which has proven to be remarkably age resistant and is still used occasionally by the Laboratory for quick, first cut assessment of power output in the 1-10 Watt range. The intensity distribution was measured by a densitometric evaluation of the degree of starch-iodine reaction on starch coated plastic film which I developed for the application (3). The method was accepted as an Australian standard for measurement of output from physiotherapy equipment and we used it over the years to measure the output from a number of physiotherapy equipment installations in public hospitals and in private practices. Not surprisingly we found that most units were out of calibration and the acoustic output indicated by the meter on the machine bore little relationship to the emitted power.

The experience we acquired in this project proved to be highly useful when we began to measure the acoustic output from diagnostic equipment. We were probably the first laboratory in the world to do so and as a result were able to influence the development of existing international standards in this application.

Ultrasonic Treatment of Meniere's Disease

The audiologists at the Commonwealth Acoustic Laboratories had several on-going research projects with the ENT consultants to the Laboratories. It was natural therefore that Murray also wanted the Ultrasonic Research Section to investigate with them the ultrasonic treatment of Meniere's disease, particularly as the technique was said to be able to alleviate the attacks of vertigo while preserving patients' hearing.

The major proponents of the techniques were otologists in Europe and particularly in Italy. Murray visited some of these otologists and proceeded to purchase the main Italian unit developed for this application. A program was set up between the Laboratories and Dr Home Eizenberg, a senior otologist at St. Vincent's Hospital, Sydney, who had recently observed this operation being performed in Italy. Dr Albert Khan, a consultant otologist to the Laboratories was to assist with the first procedures and participate in the program. In the Ultrasonics Committee Report of October 1960 to the NHMRC Murray recommended that, because the work in otology had become a major project, Dr Albert Khan be appointed to the Ultrasonics Committee.

The Italian equipment was awkward to use and frequently drifted out of calibration. I was therefore invited to attend the operations to assist with technical matters and to bring expertise in ultrasound should that prove to be necessary. The irradiation alleviated the attacks of vertigo in the two patients treated with the equipment. Unfortunately the treatment also caused medium-term facial paralysis which we attributed to the heating of the ultrasonic probe reaching the facial nerve which lies in close proximity to the irradiated semi-circular canal.

We proceeded to design new equipment for the application which was first used clinically in March 1962. The ultrasonic probe was miniaturised while the use of a more efficient coupling approach avoided the issue of selfheating. The

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equipment was transistorised and reduced to the size of a standard telephone. The safety and efficiency of the instrument encouraged otologists to use the technique on patients with less severe symptoms and quickly we were able to obtain results on a large number of patients (4). Our publications attracted international attention and requests for purchase of equipment locally and from overseas. The Commonwealth Department of Health gave free the rights for the manufacture of the ultrasonic Meniere's generator and the instrument we developed for the measurement of nystagmus to the Watson Victor Co. The company proceeded to sell, primarily overseas, over one hundred units of each type in the next several years.

Research into Diagnostic Ultrasound

The CAL/RHW Obstetric Program

In July 1959 the NHMRC, at its meeting in Canberra, discussed the use of X-rays in general and in particular their use in pregnancy. The meeting was attended by Professor Bruce Mayes, Professor of Obstetrics at the University of Sydney, and Norman Murray, who attended as an observer. After the meeting Murray suggested to Mayes that they should hold a meeting in Sydney to discuss the possible use of ultrasound as a replacement for some obstetric examinations. The proposed meeting was held on 7th September 1959 at the Queen Elizabeth II Research Institute for Mothers and Infants at the University of Sydney. Norman Murray brought me along while Bruce Mayes invited Dr. William Garrett to attend. Murray brought with him the original 1958 publication by Ian Donald (5) and a reprint of the 1955 Douglas Howry classical paper (6) of B-mode water delay studies that clearly showed fascial and bony interfaces in cross-sectional views of limbs and the neck. The conclusion of the meeting was that if that could be done for limbs and the neck, it should be possible to do the same for the larger late-term uterus. Accordingly, a research liaison was established between the respective institutions. It was agreed that the Commonwealth Acoustic Laboratories would fund the research. I was given the responsibility for the budget and the technology developments while Bill Garrett was to be responsible for the medical aspects. This was in keeping with the structure that existed in the audiology research program in the Laboratories, where scientists had the responsibility for the research and the ENT clinicians were appointed as medical consultants to the Laboratories. In keeping with this policy Norman Murray appointed Bill Garrett as consultant to the Laboratories to the Ultrasonics program and we established weekly meetings at CAL to maintain close contact. These meetings were later extended to all those working in association with the Ultrasonics Research Section and were a source of first class feedback and education to all present.

Bill Garrett had returned twelve months earlier to Sydney to take up a research and teaching post at the newly opened QEII Institute as a part-time lecturer and, in December 1958, he was appointed to the Honorary Staff of the Royal Hospital for Women then in Paddington. Norman Murray also held the policy that any equipment developed by the Laboratories had to undergo thorough testing on patients in a hospital environment to determine the clinical

usefulness. It was agreed therefore that the equipment would be installed and evaluated at the Royal Hospital for Women.

The images obtained by Howry were clearly superior to those published by Donald. We attributed this partially to the water delay method of coupling used by Howry. For this reason we opted to use the water delay method in our investigations.

Because not much was known about the safety of ultrasound in obstetrics we also agreed that it would be appropriate for us to undertake a pilot study on safety. As we did not have access to diagnostic ultrasound equipment, we used the physiotherapy machine purchased by CAL for its calibration work to irradiate pregnant mice. The research was conducted using the animal house facilities at the QEII Institute. We irradiated about one hundred mice and compared the number of deliveries in the exposed versus a similar control group. The study, which was completed by mid 1960, showed that there was no statistical difference in the number of progenies in the two groups and we were happy to proceed with the research. It was also becoming obvious that the obstetrics program was a major undertaking. In recognition Murray recommended, in his report to the Council in May 1960, that Dr William Garrett be added to the NHMRC Ultrasonic Committee .

In September 1960 Murray obtained approval from the Commonwealth Department of Health to employ a second scientist in the Ultrasonic Research Section. Dave Robinson was at that time working for the Postmaster General's Department (the precursor to Telstra) and was dispatched by his Divisional Engineer to the Commonwealth Acoustic Laboratories to measure the performance of microphones. To Dave's surprise he was summoned to Norm Murray's office and was told that there were two jobs available at the Laboratories, one in electroacoustics and the other in ultrasonics. Dave Robinson elected to accept the position in ultrasonics for the same reasons I had done eighteen months previously. He had never heard of ultrasound and reasoned that not many others had either, and therefore it was a field where you could make your own possibilities.

Upon Dave's commencement we split the work into two areas of responsibility. I continued my involvement in the transducer design and also had time to pursue my other briefs into standards and research into the surgical treatment of Meniere's disease. Dave's responsibility was to finish the development of the prototype echoscope completing the design and construction of the electronics and the mechanical scanner. The equipment was completed and installed at the Royal Hospital for Women in May 1962. I was away at that time attending my first international meeting on medical ultrasound in the United States. Fortunately Dave was able to send images to me in time for my presentation (7). To our surprise and delight, they were as good as, if not better than any other shown at the meeting. The prototype scanner installed at the Royal Hospital for Women and an example of one of the echograms that I presented at the meeting are shown in Figures 2 and 3.

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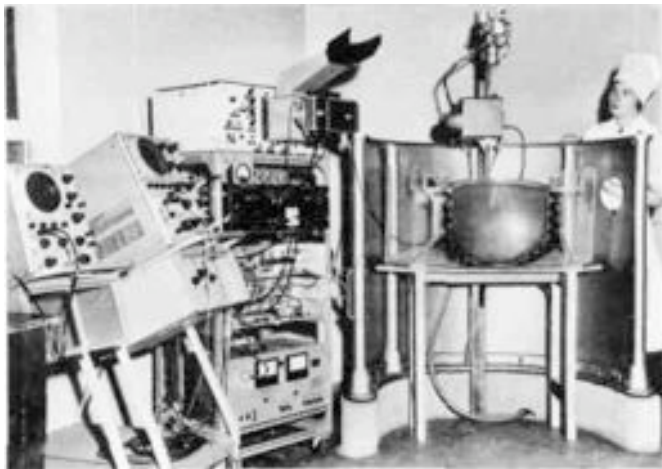


Figure 2 The CAL Mark I Obstetric Echoscope installed at the Royal Hospital for Women, Paddington in 1962.

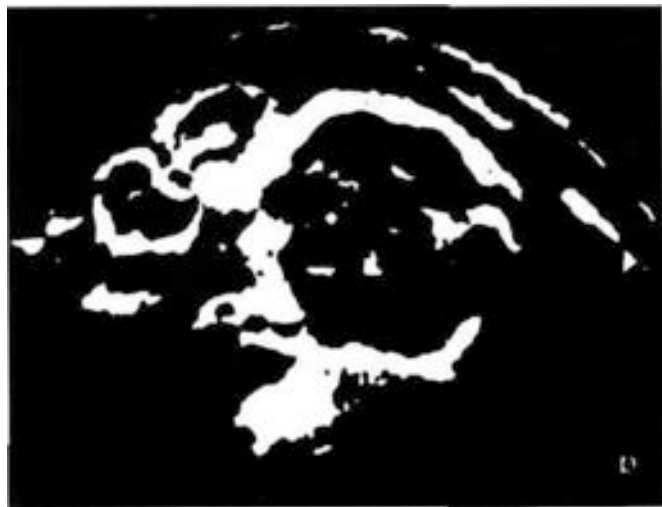


Figure 3 An obstetric echogram obtained in May 1962 showing the fetal spine and limbs.

The CAL/RPA Ophthalmology Program

The October 1960 Report from the Ultrasonic Committee to the NHMRC informed the Council that, following discussions with the President and the Vice-President of the Ophthalmological Society of Australia, investigations would begin to develop an ophthalmic echoscope for intra and retrobulbar investigations in conjunction with Dr Herbert Hughes, an ophthalmic surgeon at the Royal Prince Alfred Hospital. As this program was to be a major project, the report recommended that Dr Herbert Hughes be added to the Ultrasonics Committee.

The first ophthalmic echograms were obtained in 1963 and a limited number of patients were examined initially at the Laboratories and subsequently at the Royal Prince Alfred Hospital. It was not however until 1966, when Mike Dadd joined the Ultrasonic Research Section, that this program achieved appropriate momentum leading to the setting up of regularly scheduled clinical examinations in 1968 (8).

The CAL/RNS Breast Program

Being aware of the work by Wild on the ultrasonic examination of the breast, Murray held a series of meetings with the NSW State Cancer Council and hospitals in Sydney regarding the setting up of a program for the ultrasonic examination of the breast.

In a letter to Dr R Richards in December 1961, the Secretary of the NHMRC, he referred to discussions with Drs Freeborn and Ingram of the Royal North Shore and the intent by the Laboratories to carry out research into this application at that hospital. The March 1963 Report from the Committee advised the Council that an echoscope to undertake breast examinations had been designed and was being built with intent to be installed at the Royal North Shore Hospital. Professor Tom Reeve was appointed clinical consultant to the project later that year.

Jack Jellins joined the Ultrasonic Research Section in 1965 as scientist responsible for the technology in this program. The equipment was installed at that hospital in 1966 but it was not until 1969 after the implementation of grey scale on this equipment that we began to issue clinical reports on the results of the examinations (9).

CAL Takes Responsibility for Research into Medical Ultrasound

By 1963 the Ultrasonic Research Section of CAL was no longer involved in any research into physiotherapy applications and the active members of the Ultrasonic Committee of the NHMRC were the clinical consultants to CAL on the Meniere's and the diagnostic ultrasound projects. Murray felt that the NHMRC Committee had successfully completed its task in assisting the setting up of investigations into medical ultrasound and its overseeing role was no longer necessary.

The Report sent by the Ultrasonic Committee to the NHMRC in March 1963 which described the activities in physical therapy, industrial ultrasonics, otology, obstetrics, ophthalmology and breast cancer had the following conclusion-

" It will be seen that the number of areas opened up and which we consider we need to make contributions is becoming very great. The Ultrasonics Committee is not so much a committee of experts in ultrasonics as a committee of medical specialists who are co-operating with CAL in ultrasound research. If the committee extended in similar way it would become very large, causing difficulty bringing it together.

The Ultrasonic Research Section consists of three scientists and several technicians. We propose to add another scientist and a physiologist to the group. The Section is a permanent one under the Department of Health. We are now in a position to undertake any investigation that might be referred to me in my capacity as Director of CAL.

It seems, therefore, that the Committee has carried out its function of investigating the use of ultrasonics in medicine generally, and in initiating for the Council the setting up of investigations that might be useful.

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It was considered, therefore, that the Committee might well terminate these activities as a Committee under the NHMRC. This aspect was discussed at the meeting and all members were unanimous in this view. It is therefore recommended that the Ultrasonics Committee be discontinued."

The NHMRC accepted the recommendation to close the Ultrasonics Committee and from that date CAL took full responsibility for the management of research into medical ultrasound.

CONCLUSION

Research into medical ultrasound in Australia began because of the vision of Norman Murray who recognised from the outset the contributions that this technology could make to patient care. He was responsible for setting up the research projects undertaken by the Ultrasonic Research Section and all of us mentioned in this review are most grateful to him for introducing us to medical ultrasound.

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