THE RESEARCH LABORATORIES OF THE POSTMASTER-GENERAL'S DEPARTMENT

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INTRODUCTION

In spite of the large resources of scientific manpower and facilities that are devoted to telecommunications research in overseas countries, the Postmaster-General's Department has found it advantageous to maintain its own independent research and development group so that it is in a position to contribute to its own technical advancement in those areas where overseas research and development or local industrial development does not adequately meet the needs of the Administration. The Laboratories must of course be geared to the resources available on the one hand, and to the unsatisfied needs of the Department on the other. This means that the Laboratories do not attempt to carry out research that can be done more effectively elsewhere, nor attempt to develop systems or apparatus if suitable items are available for purchase from commercial sources at economic rates. It does mean however, as experience has shown, that there are many areas where research and development effort is necessary by the Department, and its Research Laboratories have the responsibility to provide this effort.

* See page 169.

GENERAL RESPONSIBILITIES

Briefly the functions of the Laboratories are as follows:

(i) To conduct research and development work with the aim of developing telecommunications theory and practice, as applying in particular to Australian conditions.

(ii) To develop and design forms of telecommunication or mail-handling plant suitable for use in Australia, in collaboration with user groups.

(iii) To collaborate with planning and design groups in Engineering and other Divisions in appraising world-wide developments, and in keeping abreast of prospective developments; adaptation and introduction of Laboratories developments into service, including field trials.

(iv) To provide other groups with services calling for a scientific approach or laboratory back-up or specialised testing facilities; to provide the Departmental reference standards, and a scientific and engineering consultative service, including patent, information and library services.

(v) To participate in the work of national or international organisations or committees associated with telecommunications research.

Broadly speaking these functions have not been changed in principle since the Laboratories were founded in 1923 as part of the Headquarters Engineering Division, and mean that the Laboratories have the responsibility to maintain a position at the forefront of knowledge in communication techniques and, from this position, to advise and assist the Department on advances in communications technology. Naturally, over the years, there have been radical changes in emphasis of their activities; for example, two of the early responsibilities of the Laboratories were to provide the scientific and engineering background necessary for the successful introduction of voice frequency

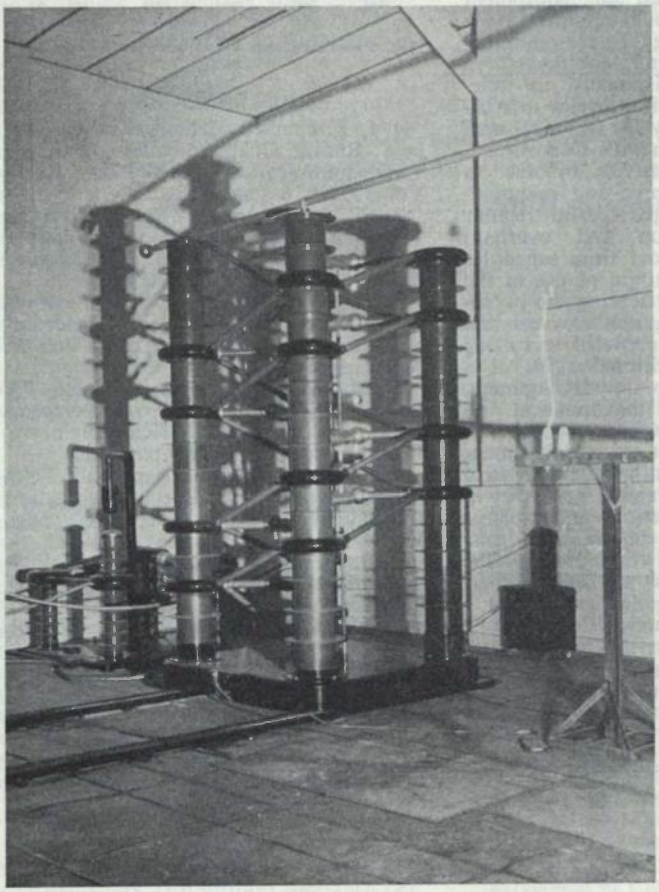

Fig. 1.—1 M.V. Impulse Generator used in Studies of Lightning Protection.

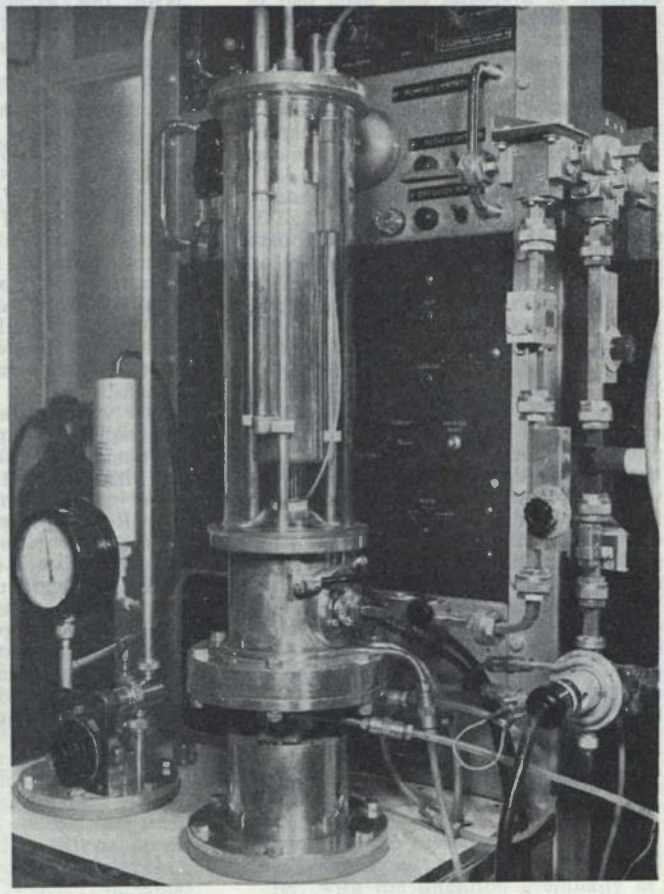

Fig. 2.—Ammonia Gas Maser. A precision oscillator with high order of short-term stability used with the primary frequency standard at the Postmaster-General's Department Research Laboratories. Frequency—23,870 Mc/s approximately.

repeaters and carrier telephony. These were followed by responsibilities in the field of radio broadcasting and radio communications, and during the war years a major interest in Radar for the armed services. At the present time satellite communications and electronic switching are among the activities occupying the attention of the Laboratories.

ORGANISATION OF LABORATORIES

In recent years it has become increasingly evident that the old break-up of activities into separate areas of Radio and Line Communications was outmoded by modern developments which cut across the distinctions between these areas. Furthermore the increasing complexity of the science of telecommunications increased the demands being made on the Laboratories, particularly in regard to the level and range of talents necessary in the staff, and necessitated conditions that would attract outstanding young research workers to the Laboratories and would provide them with satisfaction and adequate reward in their activities. During 1961-62 a thorough examination was made of the Laboratories' organisation and activities in relation to other Departmental activities and requirements and, as a result of this examination, a new organisation has been adopted.

The basic objectives in planning this organisation were:

(1) To raise the level of attention that can be given to projects by providing an environment which will attract and retain men with the necessary intellectual attainments and abilities. More levels were introduced into the organisation, so that a total of four levels of professional staff now actively participate in research work, with two further levels for supervision and direction.

(2) To provide a classification structure within the Laboratories that will offer adequate advancement opportunities for men with the necessary talent, and will provide positions to which outstanding specialists from outside the Laboratories can be attracted if no suitable men are available from within.

(3) To provide for adequate attention being given at an appropriate level to matters of research policy, and its development and implementation within the framework of the Department.

(4) To provide a flexible organisation that can be modified to take account of the experience and specialist ability of individuals.

(5) To provide a grouping of activities and functions that will facilitate specialist knowledge in one area being made available in another area. With the old type organisation it was not unknown for two groups concerned with development for two different applications to spend a good deal of effort independently on technical problems common to both projects.

(6) To retain sufficient flexibility in the control of projects to facilitate collaboration between various groups at the specialist level without the necessity to observe the formality of a rigid pyramidal structure.

The activities of the Laboratories are divided into 22 Divisions with functions ranging from the theoretical and mathematical concepts that form the basis of telecommunications, to intensely practical matters of design and application. The titles of these Divisions are Circuit Theory, Probability, Telephone Standards, Frequency Standards, Electrical Standards, Radio Systems, Pulse Systems, Multi-Channel Systems, Electronic Switching, Physics, Chemistry, Metallurgy, Mechanical and Electrical Design, Radio Equipment, Telephonometry, General Laboratory Services, Laboratory Equipment, Information, Microwave Techniques, Pulse Techniques, Radio Propagation, and Transmission Lines.

Further expansion of activities in the near future is contemplated, Divisions working on Field Physics, Semi-conductor Circuitry, Materials Evaluation, Mail Handling, and Polymer Applications being possible additions. The existing Divisions are organised in seven groups, and these in turn are arranged in three Sections, namely the Systems Principles and Standards Section, Apparatus and Services Section, and Advanced Techniques Section.

As in most other research establishments, it is realised in the Research Laboratories that their greatest asset is in the special abilities and personal talents of the research workers. For this reason the theoretical organisation of activities can be departed from if by doing so better use can be made of the specialists actually occupying the various key positions.

ACTIVITIES

Systems Principles and Standards

The Principles and Standards Group has the responsibility to ensure that its communications research and development is based on sound mathematical and theoretical concepts, and that it is supported by adequate standards of measurement. The Circuit Theory Division and the Probability Division are located in this group, as will be the Field Physics Division when created. By its very nature this group is very much of a specialist nature and here is found one of the classical problems of industrial research laboratory organisations, namely to provide adequate opportunities for growth, recognition and advancement by specialist mathematicians. Telephone traffic engineering positions in the State and Headquarters organisations provide possible areas where men with mathematical ability can obtain wider experience of the Department's activities before coming to the Research Laboratories, and also offer avenues of advancement.

Standards activity covers electrical measurements from DC up to UHF frequencies, as well as transmission standards for telephone instruments and networks. In addition, the Departmental Primary Frequency Standard is maintained by the Research Laboratories as an essential Post Office standard.

Advances in engineering technology necessitate advances in standardisation techniques and methods. This group is working to extend the Laboratories' standards of measurement into the higher radio frequency regions, to supplement the frequency standards by molecular and atomic oscillator techniques, and to extend telephone and network standards to take account of the modern under-

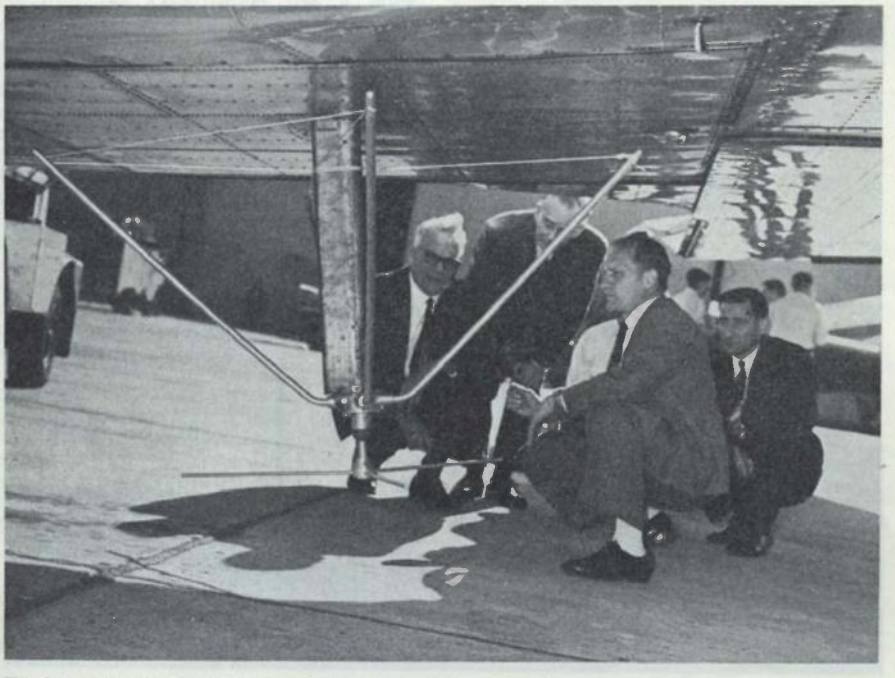

Fig. 3.—Transmitting Aerial for TV Relay Project. An airborne repeater was used circling at 10,000 to 14,000 feet to relay TV over a distance of 500 miles. The aerial is shown in the retracted position under the belly of the DC3 aircraft.

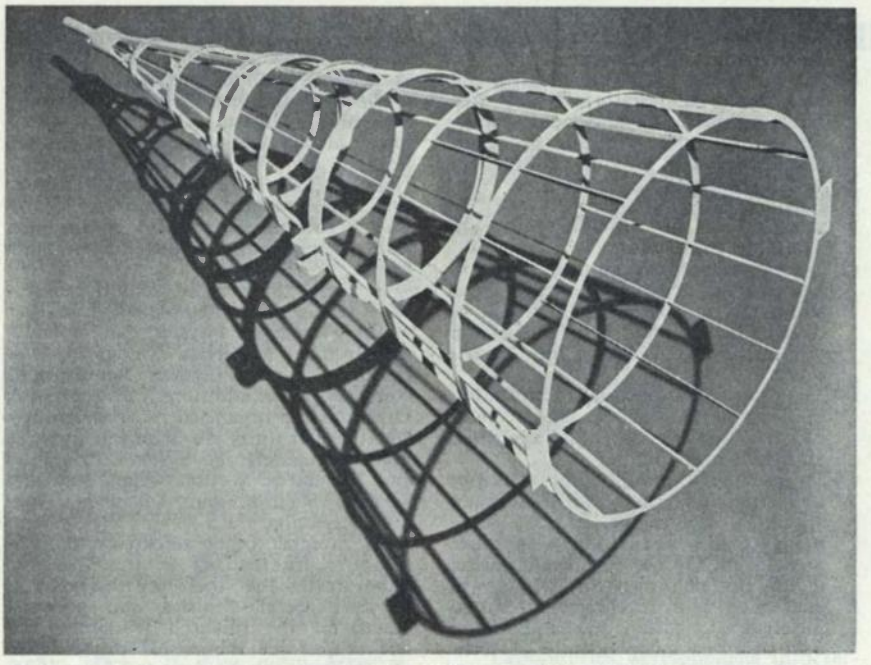

Fig. 4.—Launching Horn used in Experiments with Surface Wave Transmission Line. Length is approximately seven feet, for broadband operation centred on 300 Mc/s.

standing of speech and intelligibility.

Systems Development occupies a very important place in the programme of the Laboratories. Communications from one point in the network to another is by means of a system or combination of systems, and in this Group the objective is to keep abreast of modern developments in systems and, in special cases, to develop systems that are found desirable in the Australian network but which have not been developed commercially. A typical project is to improve the service offered to subscribers living in sparsely populated inland areas. In some instances these subscribers are connected by earth return circuits one hundred miles or more in length, and very poor performance is obtained from conventional equipment. The Laboratories have developed a transistorised voice frequency amplifier for use on these circuits. Another example of application in outback areas is the development of a special repeater for use with a 12-channel open wire carrier system between Alice Springs and Darwin. This route traverses 1,000 miles of sparsely populated territory and because of the high cost of providing buildings, power supplies and adequately trained staff, it was decided to reduce the number of conventional repeater stations by developing a pole mounted transistorised repeater. Every third repeater is a conventional 12-channel repeater station and power is supplied over the lines to the two adjacent pole mounted repeaters. Replaceable "plug-in" units keep on-site maintenance to a minimum.

Many new advances in devices, apparatus and systems are taking place overseas and the Department has found it necessary to conduct its own research into modern system developments in order to acquire technical competence so that it is continually in a position to evaluate and if necessary to engineer the introduction of new types of systems into Australia. For example, it is probable that solid state electronic exchanges will be available in the future. If the Department is to take advantage of such an advance it must have staff with experience in the concepts involved. It must have engineers who know the problems and are able to set the standards to be observed and see the pitfalls to be avoided. In the Research Laboratories, research is being conducted on transistorised switching systems and on semiconductor circuitry, not because the Department expects to manufacture solid state telephone exchanges but to gain experience, so that when such exchanges are available the Laboratories will be in a position to assess them and give advice that is based on practical experience and knowledge. Digital methods of communication is another area of work of this Group.

Apparatus and Services

Even in the largest of research organisations major advances in communications are comparatively rare. Many advances are of a marginal nature—an improved material, a faster assembly technique, or a modified design. Although small in themselves, in the aggregate substantial advantages accrue from these improvements, and there is a great deal to be gained by ensuring that the best materials and the latest techniques are incorporated into equipment, and the resources of modern scientific or engineering knowledge are brought to bear on existing equipment problems as well as on future developments. This is an important function of the Section of the Laboratories which deals with Apparatus and Services.

The Physical Sciences Group is staffed with physicists, chemists and metallurgists whose responsibility is to bring the knowledge of their respective disciplines to bear on the material and equipment problems of the Department. The Materials Evaluation Division and the Polymer Applications Division, when created, will be located in this group. These scientists cannot operate without the tools of their profession and

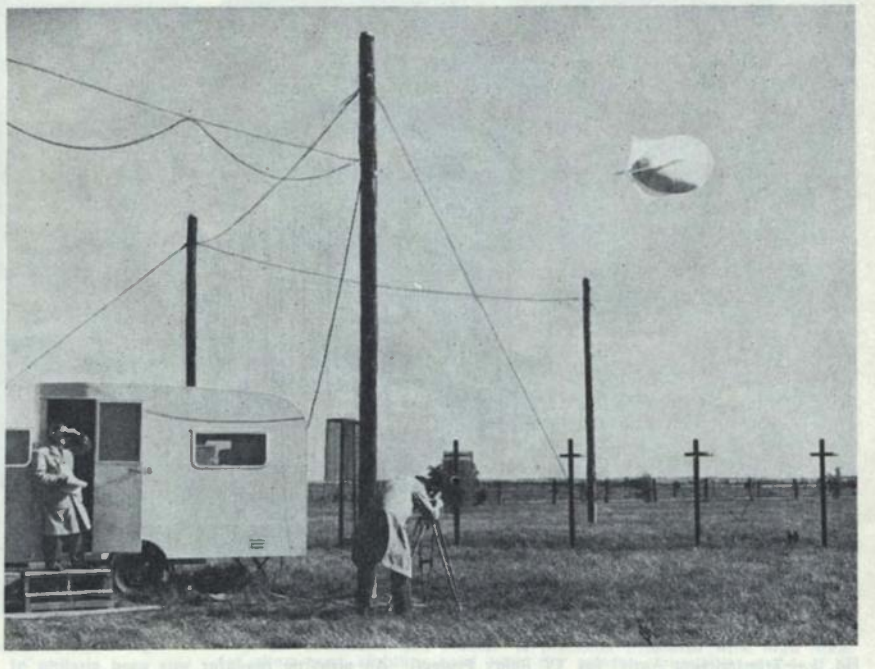

Fig. 5.—Polar Diagrams of Aerials being Measured at a Field Site using a Kytoon to Position a Signal Source in the Vertical Plane.

the Sub-Section is equipped with a wide range of physical, chemical and metallurgical equipment including facilities for Gas Chromatography, Infra-Red Spectrography, and X-ray Fluorescence Analysis. Whilst not always spectacular, the efforts of this group have made a big contribution in identifying points of weakness in materials and equipment and in the application of physical and chemical methods to plant problems. The introduction of epoxy resins for component encapsulation and for cable jointing techniques, as covered in more detail in another article in this issue, is a typical project by this group, and has been of considerable importance to the work of the Engineering Division.

The Equipment Development Group has responsibility for mechanical and electrical design, for radio equipment development and for development and assessment of subscribers' apparatus. In this group the emphasis is on items of equipment and apparatus rather than on integrated systems. In conjunction with the Physical Sciences Group these Divisions are responsible to see that the very latest advances in material and techniques are incorporated in the items of equipment which go to make up the communications systems. A further aspect of this responsibility is the very practical task of assisting local manufacturers with problems arising in the manufacture of equipment in Australia. A typical project is the development, in association with Broken Hill Pty. Ltd., of a grade of soft magnetic iron that will be a suitable substitute for iron that is otherwise only available from Sweden. Another is the development of an Australian design of telephone dial for local manufacture.

Although the interest of the Engineering Division is primarily in telecommunications, the Laboratories are mindful that the Department has a huge responsibility for mails and that mechanisation and automation, although of long standing in Australia, are being introduced in this area to an increasing extent. Considerable advances in mechanisation have already been made by the Postal Services Division and the Laboratories have assisted in several of these projects. In future developments it can be expected that there will be an increasingly complex component concerned with address coding, reading devices and memory techniques, and the projected Mail Handling Division will deal with these problems in collaboration with the Postal Services Division.

Essential requirements in any laboratory are well organised Library and Information Services, efficient equipment control and maintenance, and a competent Model Shop. These functions are the responsibilities of the Laboratories Services Group and the Library. In recognition of the increasing importance of library services the Library has been completely re-organised and the staff strengthened. The Library works in close association with the Information and Patents Service to provide the latest technical information when and where it is needed. The Model Shop is equipped to carry out precision machine work as well as the more routine fabrication tasks. It is expected also to be up to date with the latest of manufacturing and assembly techniques and to carry out experimentation and trials in this area. Printed circuits, solderless wrapped connections, and epoxy encapsulation are typical projects appropriate to the Model Shop and its controlling engineers.

The whole Laboratories depend on an efficient system of equipment maintenance and calibration and, this together with a specialist instrumentation service, is provided by the Laboratory Equipment Division which also has overall responsibility for the purchase and control of equipment.

Advanced Techniques

The activities dealt with so far in this paper have been activities that can be defined, for the most part, as applied research and development or the application of effort to achieve practical goals that can be fairly precisely defined. There is also an area of activity in the Laboratories which can be described as objective basic research as defined in the Zuckerman Report*, that is, research in a field of recognised potential but where the final application is a little less clear. Activities of this type are found in the Advanced Techniques Section, intermingled with activities of a more practical nature.

Thin film and laser phenomena receive attention in this Section together with microwave and pulse techniques. Bandwidth compression for TV signals is the basis of a fundamental study of the psycho-physics of human perception. Satellite communication systems and surface wave transmission lines are other projects in this Section, as well as more practical investigations concerning radio propagation, lightning protection, and microwave switching.

The Laboratories C.D.C. 160A Computer is under the control of this Section and is available on the "open shop" principle to other engineers of the Laboratories, many of whom are being trained in programming techniques.

CONCLUSION

The Research Laboratories are not restricted to research and development only, but are also called on to fulfil pressing needs of a working Department. Included in their activities are functions covering almost the full spectrum of research and investigation, from objective basic research through applied research to development, design and testing and, in some special instances, to maintenance trouble shooting. They are responsible also to use influence to foster the study of telecommunications problems in Universities and Colleges, and to collaborate with other government and industrial research and development laboratories working in similar fields.

The normal method of publication of the results of work is through Australian Post Office Research Laboratory Reports, which in many cases are circulated to interested bodies throughout Australia and overseas. It is recognised however that such publication reaches only a limited audience, and staff are encouraged to publish their work through papers delivered to the appropriate learned societies and published in the technical press.

As examples, the following references illustrate types of papers by staff of the Research Laboratories which have been published in this *Journal* during the past few years.

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14. A. W. Thies, "Transistor Amplifier with Heavy Feedback for 12-channel Open-wire Carrier System"; Vol. 12, No. 3, page 187.

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16. H. S. Wragge, "Design of Transistor Circuits"; Vol. 12, No. 3, page 151.

17. H. S. Wragge, "Electronic Telephone Exchanges"; Vol. 13, No. 1, page 14.

*Report to Minister for Science by Committee on the Management and Control of Research and Development—Her Majesty's Stationery Office, 1961.