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NIL SINE LABORE

The Story of Dollis Hill

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With the opening of the new British Post Office (BPO) Research Centre at Martlesham, the long era of BPO Research at Dollis Hill comes to an end.

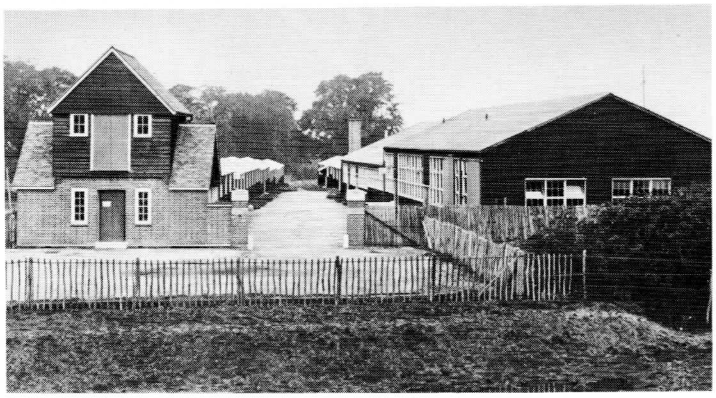

FIG. 1—The main entrance of Dollis Hill in 1922 and 1971 from the same viewpoint

EARLY HISTORY OF BRITISH POST OFFICE RESEARCH

Dollis Hill in north-west London has been the home of British Post Office (BPO) research for more than 50 years, for, although the official opening of the Research Station did not take place until 1933, research had been going on in temporary accommodation on the site from as early as 1921. Fig. 1 shows the main entrance in 1922 and 1971 from the same viewpoint. However, the true history of research in the BPO goes back much further than this. The records show that early experimental work in connexion with telegraphy and telephony was carried out from 1878 onwards. But it was not until 1904 that a few members of the Engineering Department were relieved of their executive duties to pursue investigations of a purely experimental nature, in a room specially allocated to them in the Central Telegraph Office in London. It is recorded that the use of thermionic tubes for telephone amplifiers was being experimented with as early as 1908.

At about the same time, the National Telephone Company installed in Telephone House on the Victoria Embankment, London, a laboratory entirely devoted to telephonic research. Some of its early work on telephone transmission was described in 1907.[1] The length of life of the National Telephone Company had been fixed by Parliament in 1905, and so the 2 administrations were beginning to work together in anticipation of the eventual merger. Combined telephonic speaking tests were carried out and, in 1906, a telephone Standard of Reference was set up. An experimental laboratory in the south-east corner of GPO West, in London, was made generally available for such work.

In 1909, the BPO Research Section was given official recognition as a separate entity and, in 1912, when the BPO took over the National Telephone Company, the Section was augmented by amalgamation with the Company's Investigation Department. The laboratories of the National Telephone Company in Telephone House were transferred to the top floor of King Edward Building, London; the combined staffs were redistributed to deal with the various problems of telephone lines and apparatus, loading coils, and telegraph apparatus, involved in the rapid development of the communication services provided by the BPO. By the end of 1913, the total accommodation occupied by the Research Section in GPO West and King Edward Building amounted to more than 450 m^2 of floor area.

THE NEED FOR A PERMANENT RESEARCH STATION

In 1914, the then Postmaster General, Mr. Hobhouse, inspected the laboratories of the Research Section, and agreed that the BPO needed improved facilities for research, and that a permanent Engineering Research Station should be established. Even at that time, the high cost of land in cities made the purchase of a site in central London prohibitive, but it was felt that the proposed new Station should be within easy reach of BPO Headquarters. It was also desired that the site should be in a locality as free as possible from the noise and vibration of traffic and its consequent dirt, and from electrical interference from tramways and railways; these were important considerations in those days, when the

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measurement of small electric currents depended upon sensitive mirror-type galvanometers.

Eventually, a site of 32 000 m^2, which appeared to fit the requirements, was found at Dollis Hill in north-west London, about 13 km from BPO Headquarters, in what was then farmland just north of Cricklewood and Willesden. The site consisted of fields and 2 small ponds, and occupied a commanding position on the summit of the hill, about 76 m above sea level. Away to the west lay the Neasden golf course and, beyond that, the small village of Neasden. On the other sides were fields, leading down on the north to the waters of the canal reservoir known as the *Welsh Harp*, and on the south to the slopes of Gladstone Park.

Authority to purchase the site and to erect on it a permanent building of 2600 m^2 floor area was sought from the Treasury in July 1914. The site purchase was sanctioned, but the Treasury demurred at the cost of the building scheme, and suggested that less ambitious proposals should be framed. Then came the outbreak of war, and the project was deferred.

During the 1914–18 War period, the greater part of the staff of the Research Section was allocated to research connected with the war effort, one example being the development of an apparatus by which the location of an enemy gun could be pin-pointed. During this period, the perfecting of the thermionic tube made the telephone repeater practicable, and thus opened up a boundless vista of possibilities in the development of long-distance telephonic communication. With demobilization, the arrears of work in the Engineering Department which had accumulated during the war years were taken in hand, and the development of telegraph and telephone services pushed forward. Underground schemes, both main and local distribution, were evolved, repeater stations were designed and installed, automatic switching made rapid headway, and telephone charges were revised and put on a paying basis.

By 1919, the Research Section had grown to such an extent that it was occupying parts of GPO West, King Edward Building, Newgate Street Building, Denman Street Building, Toll Exchange, New Barnet Exchange and Threadneedle Street Telegraph Office. The need for the new Research Station had become pressing.

THE MOVE TO DOLLIS HILL

In August 1919, the Treasury authorized the purchase of the Dollis Hill site—at a higher figure than the 1914 offer—and possession was taken in July 1920. The conveyance contains the information that Dollis Hill was formerly known as *Dolleys Hill.*

Experimental work on radio transmission had not, at that time, been considered to be proper to the Research Section, and was the province of the Wireless Laboratory at GPO West. Here also expansion was being considered, and authority had been obtained for 2 small experimental wireless stations to be set up, one at Dollis Hill and the other on the site of an ex-War Office wireless direction-finding station at Peterborough. In 1920, 2 small huts for the Dollis Hill wireless station were erected on the west side of the larger pond (see Fig. 2), and constituted the first use of the site by the BPO.

Meanwhile, the needs of the growing Research Section were becoming so pressing that it was decided not to wait for the construction of permanent buildings, but to accommodate the staff temporarily on the Dollis Hill site in ex-army wooden huts. The first huts erected thereon were occupied in December 1920, and the transfer of the whole of the research work involved was completed by October 1921; the total floor area of these huts was then 3300 m^2. In 1923, the Wireless Laboratory was also moved to Dollis Hill, into another hut of 110 m^2 area.

These wooden huts were heated by coke stoves in winter, and made unbearably hot by the sun in summer, but it does not appear that the staff were unduly dissatisfied with the working conditions. The remoteness of the site from tramways and railways also had its drawbacks, since car ownership was then a rarity and most of the staff had to face an uphill walk of 2 km every morning from the Metropolitan Railway station at Neasden. It is evident that the accepted standards of accommodation in the early 1920s were much lower than those of today.

FIG. 2—The beginning of Dollis Hill in 1920

RESEARCH IN THE 1920s

The nature of the experimental work being carried out in this complex of huts was described in detail in 1924[2]. The Research Station staff then totalled about 100, of whom 38 were qualified engineers. They were divided into 6 groups, covering the following fields.

(*a*) *Trunk Telephones* Research was carried out on underground and submarine cables and open-wire trunk lines, and repeater stations and loading coils.

(*b*) *Telephone Transmission* Studies were conducted in: standards of telephonic speech, and the production and maintenance of "standard" telephone transmitters and receivers; new methods of measuring transmission efficiency of telephone apparatus; new telephone apparatus.

(*c*) *Telephone Exchange Signalling* This group was concerned with the d.c. and a.c. measurements involved in exchange signalling, electromechanical tests of such items as relays, and special circuit problems.

(*d*) *Telegraphs* All research problems in telegraphy were dealt with by this group.

(*e*) *Physical and Chemical Group* This group handled all physical and chemical problems, and electrical problems not specially applicable to any other group; for example, studies of corrosion, primary and secondary batteries, insulating materials, materials used in thermionic tubes, carbon granules, alloys for electrical contacts and production of special magnetic alloys.

(*f*) *Construction* This group provided workshop and drawing office facilities; it was responsible for the design and construction of all apparatus required for research purposes by any group, and for the maintenance of laboratory services.

In the article in reference 2, the author, B. S. Cohen, notes that:

"The main difficulty in the organization of technical research is to obtain researchers combining both the requisite technical experience and the necessary aptitude for research which is to a great extent inborn."

Capt. Cohen was subsequently to become Staff Engineer in charge of the Research Station, and to devote himself, in the

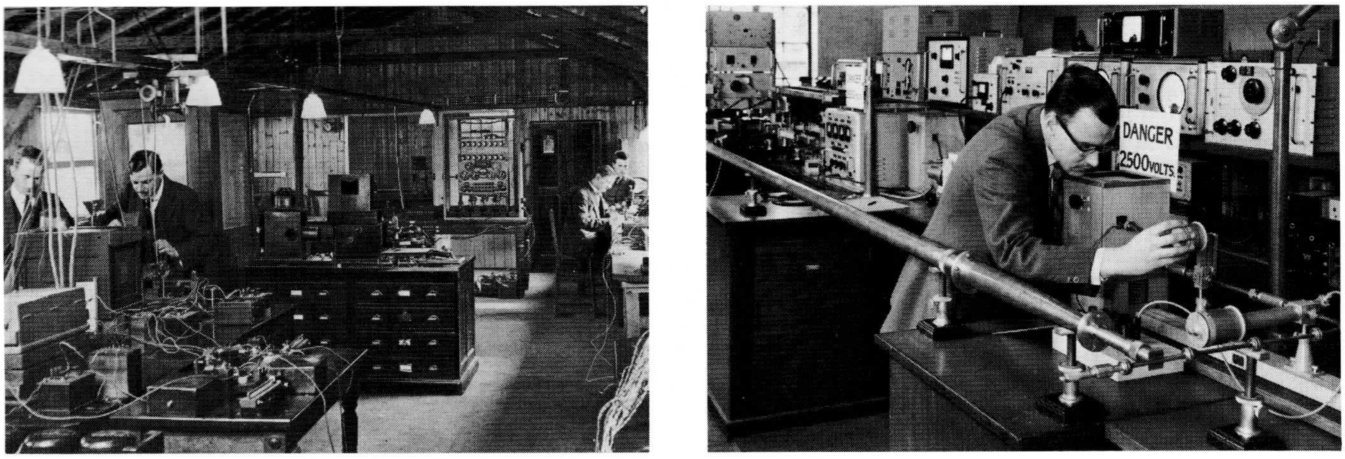

FIG. 3—The transmission laboratory in 1924 and the millimetric waveguide laboratory in 1960

1930s, to building up the Section with a well-chosen body of young graduate engineers and scientists.

Thus, in the 1920s, the work of the Research Section and the Wireless Laboratory centred mainly on the transmission of telephony and telegraphy by cable and by radio. Although by modern standards much of the laboratory equipment may seem primitive (see Fig. 3), many noteworthy contributions to the technology of communications were made during those years. Notable examples are the design of the radio transmitters for the long-wave radio station at Rugby and, in 1926, the historic measurements by W. West of the acoustical impedance of human ears[3]; this led to the design of the first artificial ear to provide a realistic acoustic load for measuring the performance of telephone receivers. Another urgent problem in those years was the protection of BPO cables from corrosion by the electrolytic action of stray currents (for example, from tramways), and much skilled effort was devoted to the development of accurate methods of measuring such currents.

In 1924, construction of the permanent buildings of the new Research Station in substantial red brick was commenced. Meanwhile, the hutments were proving inadequate to house the growing Research Section and, as a temporary measure, some groups were accommodated at Marshalsea Road, just over Southwark Bridge, and also in premises near the trunk exchange in Carter Lane. The first of the new blocks to be ready for occupation was that designed to serve as garage and life-testing laboratory. Other buildings followed one by one, and were occupied as they were completed: the chemistry laboratory in 1926, the carpenters' and millwrights' shops in 1928, the radio laboratory in 1929, the central block (containing power and battery rooms, canteen and lecture hall) in 1930, and training school blocks, workshops and radio assembly shop in 1932. Last to be completed was the imposing main administration block, commanding a fine view across London to the Surrey hills and visible from many miles around. Inscribed in the stone lintels over the front porch are the words *RESEARCH IS THE DOOR TO TOMORROW* and *TO STRIVE, TO SEEK, TO FIND.* The Research Station was formally opened on 23 October 1933 by the Prime Minister, the Rt. Hon. J. Ramsay MacDonald.

Meanwhile, suburban London had been spreading rapidly, and the Dollis Hill site was no longer surrounded by green fields (see Fig. 4). The golf course on the west side of the site had been sold in 1929, a plot of 36 000 m^2 immediately adjacent had been bought by Middlesex County Council for the eventual provision of a new secondary school (though this was not built until 1959), and the remainder, together with all the fields on the north side of the site leading down to the Welsh Harp, had been covered with rows of semi-detached houses and new roads. Gladstone Park, on the southern slope of Dollis Hill, had been preserved for all time as a public open space, but the surrounding woods and fields had gone for ever—and so too had any prospects of future large-scale expansion of the Research Station. The only available land remaining was a small plot of 10 000 m^2 on the south side of the site, all that was left of the old Dollis Hill Farm. This was purchased by the BPO in 1939, and used for additional laboratories after the war.

MONETARY RETURN FROM RESEARCH

There will always be argument about the proportion of its resources that an organization such as the BPO should invest in its research, and about the monetary return that can be expected from such investment. In 1930[4], Capt. Cohen, pursuing his aim of strengthening the research effort, claimed that:

"An analysis in 1927 of the more important researches carried out (by the Research Section) during the preceding years indicated that they could be divided into two groups. In the first group, consisting of approximately one third, it was found fairly easy to allot a monetary value to the research, either by virtue of a definite saving in maintenance or by the introduction of a new service or channel and so forth. With respect to this group of researches, an estimated annual saving to the Department exceeding £150 000 was indicated. The remaining two-thirds researches, whilst more difficult to define in terms of pounds, shillings and pence, included many investigations the results of which it had been found necessary or advisable to incorporate into the Department's service, and also work which would have had to be done elsewhere if not done by Research staff. As the overall annual cost of the Research Station plant and staff does not exceed £75 000 per annum, it will be realized that the Research Section may be regarded as a highly successful business organization, paying a handsome profit."

Of the work done in 1929, Capt. Cohen claimed, on the same basis:

"The work done showed a direct saving of £128 000 per annum, while important research and development work now in hand gives promise of very considerable reductions both in capital expenditure and in annual maintenance charges."

RESEARCH IN THE 1930s

The total staff of the Research Section (which at that time did not include those working on radio) had grown by the time of the official opening in 1933 to 290, of whom 110 were qualified engineers or scientists, under the direction of a Staff Engineer. Also housed on the Dollis Hill site were the Radio Experimental and Development Branch (under an Assistant Staff Engineer) and a section of the Engineering Training School.

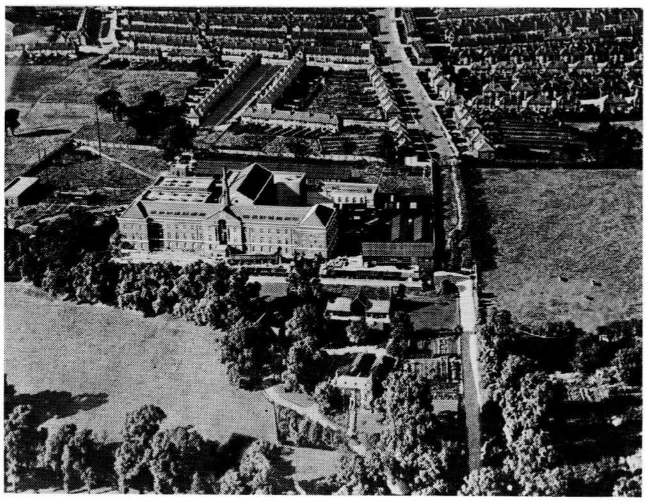

FIG. 4—The main block nearing completion, and suburban housing creeping up all around

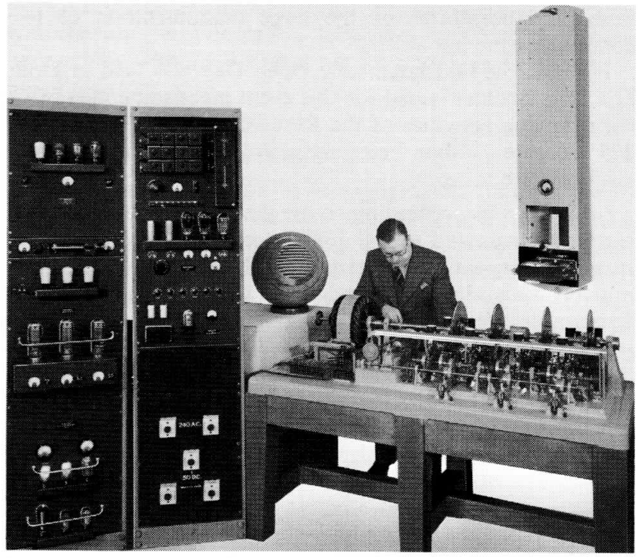

FIG. 5—The first speaking clock in 1936 (with its principal designer, Dr. E. A. Speight)

This was a time of recession in industry, and qualified engineers and scientists could not find jobs easily. The BPO, with foresight, went ahead with the recruitment of a strong force of able young graduates, of whom many of the most highly qualified were posted to the Research Section. The wisdom of this policy of building up a strong research staff was to become evident in the years to come.

The 1930s were years of rapid development and expansion in the telecommunication field, and the research teams at Dollis Hill played a leading part in most of these advances. This was the era of innovations such as the first speaking clock[5], using photographic sound recordings on glass discs and controlled to a guaranteed accuracy of one-tenth of a second by a master pendulum (see Fig. 5), and the first loud-speaking telephone set for subscribers' use.[6] These were the years that saw the pioneering work on quartz crystals for the frequency control of oscillators and radio transmitters, the work on frequency standards, and the development of voice-frequency signalling for the telephone network. Wideband transmission systems for frequency-division-multiplex telephony and for television were developed using coaxial cables, and first installed between London and Birmingham.[7] In the development of television broadcasting, Dollis Hill engineers played a large part in providing the links for outside broadcasts, such as the first direct televising of the Cenotaph Remembrance-Day service in 1937.

Again on the subject of financial returns, Capt. Cohen wrote[8] in 1933 that:

"It may be taken as axiomatic that it is generally impracticable to estimate the value of pure research in terms of pounds, shillings and pence; but in the case of a research station such as that of the Post Office, which deals mainly with *applied* research, this does not necessarily hold. Experience has shown that it is possible to produce an annual balance sheet showing expenditure and revenue accruing from a selected number of the cases dealt with.

The number of investigations increased from 370 in 1927–28 to 511 in 1932–33. During the latter year, 14 of the more important cases dealt with were of the type for which the revenue accruing could be accurately assessed, and these 14 cases result in either increased annual revenues or savings to the Department, amounting to a sum more than double the total annual expenditure on research."

The 14 cases referred to above ranged from the introduction of a new voice-frequency signalling system[9] to methods of localizing submarine cable faults by means of electrodes towed from a cable ship.[10]

The financial aspects of research were continually being kept to the fore, and the Research Section was required to forecast annually its general expenditure on staff, plant and materials. Special authority had to be obtained for excess expenditure on any individual case, and schedules of running costs were maintained. In 1933, the overall value of the Research Station's plant (excluding consumable stores and materials) was put at £100 000.

In passing, it may be noted that in 1933 the American Telephone and Telegraph Company was spending on research about one dollar per annum per subscriber's station, equivalent then to about 5 shillings (25p), compared with the BPO figure of approximately 9$\frac{1}{2}$d (4p).

The system that evolved to ensure co-ordination at all stages of the work between the research group and the other sections of the Engineering Department concerned required regular progress reports on each case. In addition, overall supervision was exercised by a co-ordinating committee for Research and Development that had representatives of all the headquarters sections of the Engineering Department and met at approximately 3-weekly intervals. The Department as a whole was thus able to maintain close touch with any new developments within the functions of research.

Finally, a report (bearing the original case number) would normally be prepared on completion of an investigation, and copies circulated throughout the Department and also to various Service Departments and overseas administrations. Printing and publishing the reports in this form has ensured that they have remained permanently available and, to this day, it is still possible to request a copy of Research Report Number x, even though it may have been published 50 years or more ago.

Co-operation was always maintained with other research organizations, and it was never the practice to carry out research at Dollis Hill that might be better carried out elsewhere. For example, investigations into the acoustic properties of building materials were delegated to the National Physical Laboratory, and a purely chemical investigation which did not specifically involve electrical communication would be referred to the Government Chemical Laboratory. Use was also made of the work of organizations such as the British Non-Ferrous Metals Research Association, the British Electrical and Allied Industries Research Association, the Forestry Products Research Laboratory and the Building Research Station. Close touch was also maintained with the research laboratories of the large manufacturers of telecommunication apparatus.

In 1937, the first large-scale Open Day was held at Dollis Hill. The booklet issued for this event gives some idea of the wide-ranging activities of the Research Section, no less than 275 separate exhibits being listed from which the following examples are taken.

(*a*) Work was proceeding on the development of 12-channel carrier systems and group modulators, and the special measuring equipment being designed included a main-line transmission measuring set intended for use in repeater stations, a portable transmission measuring set, and an objective sound-level meter.

(*b*) Methods of measuring the transmission efficiency of telephone sets were being developed using articulation and other forms of speech tests, and standards were being laid down in co-operation with the telephone Administrations of other countries; in particular, with France, Germany and the USA.

(*c*) A conference amplifier had been designed which allowed up to 8 lines to be coupled together for a telephone conference.

(*d*) The external-plant group was studying methods of locating faults in submarine cables, and of measuring attenuation and crosstalk on land and sea cables; cable creepage inside ducts was also being investigated.

(*e*) Research had been commenced on mechanization of the postal services, and experimental devices had been made for removing parcels and small packets from mixed mail, and for the detection and recognition of the stamp by a photoelectric scanning system.

FIG. 6—Dollis Hill engineers (Messrs. V. G. Welsby, E. F. S. Clarke and R. A. Brockbank) on the deck of cable ship *Monarch* during submarine repeater laying trials in 1954

THE 1939–45 WAR

In 1939, came the Second World War, and the handsome red-brick facade disappeared under a camouflage network of wire mesh and painted hessian—as one wag put it, well and truly "tarred and feathered". The depleted staff soon found themselves involved in top-priority work for the fighting and defence services, and two 55 m lattice radio masts were erected on the site by the Admiralty; these were very useful in post-war years for radio propagation studies. Dollis Hill had already achieved international reputation as a communication research centre, and it was expected to be a wartime bombing target, but the Research Station escaped significant damage, whereas the surrounding residential areas all suffered some devastation.

In 1942, H.M. King George VI paid a surprise visit to Dollis Hill, and spent some time examining the work in the laboratories. Staff to whom he talked were impressed by the depth of his technical understanding of the projects.

As in all other establishments, able-bodied staff were required to undertake defence duties, either as firewatchers, firemen or Home Guards, on a rota of every ninth night. The firemen and the guards put in a good deal of practice, but fortunately none of them had to deal with any major incident.

POST-WAR DEVELOPMENTS

After the war, the Research Section reverted to its proper job of furthering the development of communication technology. The camouflage netting quickly came down, most of it through being accidentally set on fire; fortunately, during the daytime when the building was staffed and there were plenty of willing hands available to beat out the flames that entered the windows. The tempo of expansion increased, more staff were recruited, and new buildings erected to meet the specialized requirements of new techniques. The Training Branch had already moved away from Dollis Hill, and the next logical step was the integration of the Radio Experimental Branch and the Research Section under a Controller of Research. The Controller in those critically formative years was Dr. W. G. Radley—destined subsequently, as Sir Gordon Radley, to become Director-General of the BPO.

One important development which was to have far-reaching effects on world communications was the submerged repeater; an amplifier in a watertight case laid on the bed of the ocean. In 1943, the first such repeater ever to be installed in a working cable[11], designed and made at Dollis Hill, had been laid in a telephone cable crossing the Irish Sea. This was a vital step forward in the utilization of long under-sea coaxial cables; it opened up the possibility of installing repeaters at regular intervals along the sea bed and thus greatly widening the usable frequency bandwidth. A new BPO cable ship, *Monarch*[12], launched in 1945, was specially equipped to lay submerged repeaters, and research engineers from Dollis Hill sailed in her to see their precious repeaters lowered into the depths (see Fig. 6). Some of these laying trials, in rough weather, tried the Dollis Hill engineers, not all of whom were good sailors, more severely than did the repeaters.

With the ultimate target of a transatlantic telephone cable[13], a deep-sea repeater was developed. This required not only a construction that would remain watertight under pressures up to 100 MPa, but also, because of the difficulty of recovering such a repeater from the deep sea-bed, a high degree of reliability and long life expectancy from the components of the amplifiers. A high-pressure hydraulics laboratory was set up at Dollis Hill, and studies were undertaken of long-term component reliability. By his work on oxide-coated cathodes in thermionic tubes, Dr. G. H. Metson showed that it was possible, by the adoption of special techniques, to make tubes which had a working-life expectancy in excess of 20 years

Other major contributions made by Dollis Hill to submarine cable technology were the lightweight cable[14], having its tensile strength in a central steel core instead of in conventional outer armouring, and the linear cable engine, which speeded up the laying of cable with in-line repeaters.

Meanwhile, other teams were making progress in different

FIG. 7—Speech tests on a prototype 700-type telephone in 1958

fields. Working on the analysis of speech, E. W. Ayers produced an electronic speech machine known as *ESME*. New surveys were made of the acoustic characteristics of human ears and mouths, and greatly improved artificial ears and mouths were constructed for use in telephone measurements. Research on trunk signalling systems formed the basis of the national trunk-mechanization scheme, and electronic techniques were applied to the development of new switching systems. With the expansion of the telephone network, the need arose for a new telephone set of higher sensitivity than hitherto for use on longer local lines, and in 1958 the 700-type telephone was developed[15] (see Fig. 7). This incorporated F. A. Wilson's automatic regulator, an ingenious device that reduces the sensitivity of the telephone when connected to a short line.

INTO THE 1960s

The 1960s saw the field of research in telecommunications becoming even wider. In the radio field, great advances were made in microwave propagation, and Dollis Hill played a major part in the design and testing of the satellite earth station at Goonhilly. In the semiconductor field, studies were made of the utilization of transistors and the newer microelectronic circuits to improve communications. In the field of exchange switching, studies were concentrated on the switching of pulse-code-modulated telephone signals in digital form. Subjective studies were made of human visual requirements in broadcast and closed-circuit television, and related to transmission distortion. A human factors research group was set up to study the interface between the public and the telephone system. Work was proceeding on the evolution of new digital systems for the future, on new customer services like data transmission and Viewphone, and the development of Confravision, providing 2-way sound and vision links between distant conference rooms. New wideband transmission systems were being evolved, using microwaves in waveguides and using light beams in optical fibres.

In postal mechanization, extensive studies were being made of the possibilities of applying to postal sorting automatic recognition of typed and hand-printed characters on envelopes with the aim that one day all letter sorting would be possible by machine without the need for the addresses to be read by human sorters.

THE END OF THE LINE

With so much expansion in so many fields, the pressure for more laboratory space was ever increasing, and it was evident that the time was approaching when a move from Dollis Hill would be inevitable. By 1966, the total staff complement of the Research Branch had reached 1400, of whom 480 were qualified engineers or scientists, with about 700 engineering and scientific supporting staff, plus clerical, drawing office and other grades. The original site of 32 000 m^2 had been enlarged by the acquisition of the adjoining farm site of 10 000 m^2, and more laboratories erected thereon. But the local planning authorities had put a limit on the density of building they would permit on the site, this being now in a residential area, and there were no possibilities of further expansion. Already some research groups were housed in outlying stations, such as the radio laboratories at Backwell in Somerset and at Castleton in Monmouthshire.

After much deliberation, it was decided that the best plan would be to abandon Dollis Hill and to build an entirely new Research Centre well away from London, where there would be room to bring together all the scattered research groups on one large site, with ample room for field work and for further expansion. Thus, the Martlesham Heath site was chosen and now, in 1976, the final move from Dollis Hill is taking place. It is a sad day for Dollis Hill, so widely known for so long as the centre of BPO research, but the beginning of a great new era for the Martlesham Research Centre.

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