Chapter Four

THE SEEDS OF RESEARCH ARE SOWN

Early days at O. T.D. and Erith - 33 and 66 kV Problems
Screening - Static Tensioning - Oval Conductors
Difficulties and Diversions at Ormond Yard

IT IS difficult to realise in this scientific age that in those days (the 1920's) industry generally was most definitely not "research minded". The vast sums spent nowadays on research and all it implies would not have been condoned by the shareholders, who were inclined to the short term view. Anything remotely savouring of the abstract, no matter what its practical potentialities, was anathema.

It is the more remarkable then that the seeds of research in the Company should germinate in this stony soil. That they did and came to fruition is largely due to the far-sightedness of Mr. Urmston and the backing he received at top level in the person of Mr. P. V. Hunter.

Mr. J. Urmston entertaining visitors at Wood Lane
Seated (front row): Mr. J. Urmston (4th from right);
Mr. K. S. Brazier (3rd from right); Mr. P. R. Hartshorn (end of row at right)

The majority of university graduates were Arts men, whose main outlet was the field of commerce. The few science graduates were mainly absorbed in the universities and in the teaching profession, and industry had little to offer them. However, Mr. Urmston appointed three scientists to the staff at Ormond Yard, namely Mr. F. S. Smith and Mr. K. S. Brazier (directly from London University) and Dr. L. G. Brazier (from the R.A.E., Farnborough). These three were among the first, if not the very first, graduates to be employed by Callender's and the year 1924 thus assumes some historical importance for the Company .

Initial work carried out by these three graduates was mainly centred on telecommunication instruments for measuring the properties of telephone cables in the field. For example, part of Mr. Smith's work involved the preparation of the jointing schedules for the "balancing" of telephone cables, referred to in the previous chapter.

The Technical Director at Erith Works at that time was Mr. J. F. Watson, or "Long John" Watson as he was better known, and in 1923-4 he started building up the Technical Department at the factory. He took into his employment Mr. S. W. Melsom who, in the course of his work at the E.R.A., had recently published, in conjunction with Mr. H. C. Booth, a now-famous paper on the current-carrying ratings of power cables (IS). Thus began the development parallel to that of O.T.D. at Ormond Yard, of a Research Department at Erith, which continued under Mr. Melsom's guidance for several years - in fact until the episode of the 66 kV failures, which will be discussed in more detail later. However, a close link never existed between the Research Department at the factory and O.T.D. at Ormond Yard, for the former was responsible direct to Sir Tom Callender, whilst the latter answered to the Contracts Manager, Mr. Green.

By 1925 serious trouble was being experienced with 33 kV belted cables which had been laid by the Company only a year or two previously. The problems associated with these failures were directly the concern of Mr. Hunter in his capacity as Chief Engineer. Work towards their solution, at his instigation, formed the first major research programme on power cables to be undertaken by the O. T. D. and so represents yet another milestone in the development of the Research Organization.

The failures of the 33 kV cables (9) should not have come as a surprise for during the development period preceding the First World War disturbing evidence had come to light of disruptive phenomena exhibited in cables for operation above the 25 kV range, which had not previously been encountered, or had been disregarded as of minor importance.

Unfortunately, so urgent was the demand for higher voltages following the war that substantial orders for three core cables designed to operate at 33 kV and at the hitherto accepted "safe" maximum stress of 26 kV /*cm*, were confidently accepted and carried out. Moreover, the arbitrary limit of 33 kV was viewed in some quarters as unnecessarily cautious, and a number of companies put in hand the manufacture of experimental three core 66 kV cables of the belted type. These were put into service in 1923-4, but after a few months proved to be far from reliable. In fact, it had now become evident that the warnings of inherent instability of this type of cable were only too well founded. A series of breakdowns drew attention to the need for a more conservative approach until the source of the trouble had been located and the danger eliminated. The cause of the deterioration, though it was eventually determined by a series of investigations extending over a number of years, was not at first apparent. The early theory as to the cause of these failures, and which was for a time widely accepted, was that breakdown was due to a component of the voltage which, as a result of the distorted field associated with three phase transmission acted intermittently in a direction tangential to the paper insulation layers. However, as time passed, it seemed likely that this was a secondary and not a primary effect, more particularly since breakdown almost invariably occurred between phases and not as a fault to earth, and was characterized by severe burning of the central filler.

These two facts, taken in conjunction with the curious relative immunity of lightly loaded cables of small section area, suggested that the problem was one of high current loading rather than excessive voltage; in other words, the source of the trouble lay not so much in tangential stresses as in the mechanical effects of thermal expansion.

Confirmatory tests showed that in the case of three core cable with small conductors, expansion of the copper, due to the load, was readily taken up by a minute radial expansion of the strand; whereas in the case of cables with conductors of relatively large section, these acted substantially as though they were solid bars and expansion due to heavy loading could only find relief through a widening of the coring-up helix, with the result that a partially vacuous space developed in the crutch between the three cores. Discharges initiated at this point caused rapid deterioration due to burning, and inadequate heat dissipation led to thermal instability, charring of the weaker portions of the insulation and early breakdown between phases.

It was abundantly clear that the predisposing cause was the lack of homogeneity in the dielectric. The core insulation and belt and the fillers all varied in construction, tension and dielectric strength; and of these, the relatively loose fillers, situated as they were within the electric field, constituted the gravest danger.

The remedy was found in core screening on the basis of the Hochstadter patent of 1914, as mentioned previously. Two types of cable were produced for 33 kV use; the H type with individual cores screened with a metallized paper or metal tape, and the H.S.L. type with each insulated core separately lead sheathed. The advantage obtained by this modification in structure was that the metal covering round each core was bonded to the lead sheath producing an earth potential, so that the stress lines instead of being intermittently tangential now became purely radial, and the general breakdown strength of the cable as a whole was greatly enhanced.

Moreover, Hochstadter, though his attention had primarily been directed towards the question of stress distribution, had accidentally found the solution of the second and perhaps even more important problem, that of separation of the cores on load; for, since the outer surfaces of all three cores were now at earth potential, the space between them - hitherto a danger area - was now free from stress and therefore innocuous.

The screening of individual cores, as mentioned, was the solution to the problem so far as new production was concerned. But what of the cables already in service? Replacement as a whole would have been an expensive undertaking, and attention was turned to finding a method of reducing the thermal expansion or of making it ineffective. Work began at Ormond Yard on a system of tensioning of the cable (6). Experiments demonstrated the great force which could be exerted due to heating of the cores under load, amounting to as much as 170 kg per core for a three core cable, for a temperature rise of 25^0C. Theoretical considerations gave a figure of 600 kg per core, however, and it was clear that a large part of the force was in fact being relieved in the cable construction. The magnitude of the remaining force was clearly such that its possible effect on the cable could not be ignored.

Further experiment showed that deformation of the cable under load gave rise to a large increase in power factor. Application of a temporary tension of suitable magnitude resulted in a large reduction.

In early work tension was applied by means of springs, but this method was not satisfactory as the springs tended to be released by the expansion of the conductor as the cable heated under load. This movement was inevitable in any arrangement using springs, and this led to the proposal by Dr. Brazier to use a constant stretch, or constant strain, system of tensioning. The method involved, known as "static tensioning", consisted of applying a force to the ends of the cable sufficient to extend it, within its elastic limit, by an amount equal to the extension which would normally occur in the free state over the given temperature rise, say 50^0C, and anchoring the cable in this position. Any subsequent expansion due to heating would merely serve to reduce the tension (up to the given temperature) and no disruptive forces would occur within the cable.

The practical difficulties of applying the method in the field were considerable, particularly in regard to the joints which had to be specially designed and were anchored to enormous concrete blocks. But this method was successfully applied in many cases and proved a complete answer to the problems arising in existing cables of the belted type. However, it was at best a palliative and the real solution lay with screened cables.

Attempts to make cables for use at still higher voltages (up to 66 kV) resulted in a different kind of problem (9). Failures in these high voltage single conductor cables were clearly distinct from the three core instability which had been largely cured by the introduction of core screening, and a disturbing feature was that though entirely satisfactory when tested before leaving the factory they tended to break down after a relatively short period in service. The breakdowns were characterized by extensive tracking and a waxy deposit associated with the track marks.

The mechanism of breakdown when eventually determined proved to derive from the behaviour of the cable under the influence of repeated heating cycles. Expansion of the compound forced it to migrate outwards through and past the paper layers, finding eventual relief in distension of the lead sheath beyond its elastic limit to accommodate the increased volume. On cooling the contracting compound, lacking any appreciable restoring force, was unable wholly to find its way back through the paper layers, and partly vacuous spaces were formed in the dielectric. Since the cable cooled from the outside inwards, these voids tended to form in the area of greater stress near the conductor, and breakdown of the vacuous spaces by disruptive discharge led to progressive deterioration, spreading further and further outwards until eventual failure occurred.

Two possibilities presented themselves: either a means could be provided of accommodating the increased volume of compound without permitting the irreversible migration which resulted in void formation, or a compensating mechanism could be provided which would enable the compound to flow freely with the heating and cooling fluctuations within the cable.

The first method was adopted by the Callender Company when, in 1930, and partly as a result of researches carried out at Ormond Yard, the oval conductor cable was introduced. In this type, while the lead sheath retained its circular shape, the conductor and insulation were in the form of an oval, so that the effect of expansion was to increase the minor and reduce the major axis, rendering the insulated core more nearly circular and thus accommodating the increased volume without any distension of the sheath. On cooling the core reverted substantially to its elliptical form and since no migration had taken place, the danger of void formation was largely eliminated.

The alternative method - that of compensation - had for some years been the subject of attention based as it was on a principle which had been tried out generation earlier (9). It led directly to the general adoption of the oil-filled cable and a rapid increase in permissible voltages up to 132 kV and in some cases 220 kV (see Chapter Five).

In the preceding pages several references have been made to "Ormond Yard" without actually describing the size and scope of the premises. Initially, when telephone work predominated, these premises consisted of No. 1 Ormond Yard, a corner house on two floors, in a mews which had originally housed Georgian stables. As more and more interest in high voltage work became apparent during the 1920's it became obvious that the existing premises were inadequate for the testing equipment required. In November 1927, therefore, negotiations were put in hand for the leasing of space in a furniture depository owned by G. Bailey and Sons on the other side of Ormond Yard. This was a four-floor rectangular building with brick walls and steel window frames and with concrete floors laid on steel joists. Callender's gradually took more and more space in this building and eventually occupied the whole of the 1st, 2nd and 3rd floors, each with an area of 4200 sq. ft. and also 1000 sq. ft. on the ground floor. The flat roof of this building was used for storage space and a goods lift 15 ft. square was available.

The building boasted stone stairs, unbalustraded, and there were no toilet facilities available except that in No. 1 Ormond Yard! In these surroundings worked about 25 staff and 15 to 20 hourly paid workers - the nucleus of today's research organization. Apart from testing equipment these entire premises contained offices for the senior staff, a general office, a telephone switchboard, a storeroom and a blueprint room. During this period (1928-3 1) various personalities who became well-known at Wood Lane joined Callender's at Ormond Yard. These were Messrs. J. C. Condon, N. E. Davis, G. H. Bradbery, H. C. Hall, P. R. Hartshorn and S. A. Tempest. The sometimes laborious task of compiling this History was frequently enlivened by their personal recollection (and not always printable anecdotes) about those early days.

Probably the highlight of this period was the troupe of "Power's Dancing Elephants" who used to play cricket in the yard! During the circus season the elephants were stabled on the ground floor of the depository, i.e. underneath the Research Department! One employee, whose name is apparently cloaked in secrecy, had an accident on his bicycle on his way to work one morning, damaging a wheel. He completed his journey to work carrying the bicycle. On arrival he parked it in its usual place. Later, and very indignantly, he complained to the elephant trainer that the elephants had damaged his bicycle. He claimed compensation - and got it!

Power's Dancing Elephants at Ormond Yard

There were still stables in Ormond Yard and an opportunist with a small cart and a ready market had contracted to remove the manure at weekly intervals. Imagine his chagrin when he turned up as usual with his little cart and found the result of a week's board and lodging by a troupe of elephants! The story has it, however, that he was held to his contract!

In addition to this form of diversion, correspondence of the following nature would sometimes flow between Callender's and its neighbours:

> ". . . to draw attention again to the very bad smells in the neighbourhood of our entrance door resulting from crates of fish and refuse that you keep at that point. We now have a large number of staff and employees continually using this entrance and these smells constitute an intolerable nuisance. I have previously written to you on this matter but have not had your reply. I must ask you to give this your serious attention",

If the fish and the elephants were there at the same time the atmosphere must have been "electric", to say the leas t!

Yet a further incident concerned a night watchman on his very first night's duty. He heard a strange noise coming from one of the rooms. Being a conscientious night watchman and not having the key on him he broke in with an axe! The cause of the noise is not recalled, but was quite inconsequential.

By 1930 it became obvious that the existing premises at Ormond Yard were too limited for the type of work in hand. Mr. Hunter, realising that an expansion of Research and O. T.D. was essential of the department was to continue its useful work, persuaded the Board of Directors that larger premises were imperative, and that such ideal premises actually existed in the then disused Wood Lane Power Station.

In these circumstances approaches were made to the London Power Company and the Wood Lane site was taken on a twenty-one years lease, effective as from October 1931. The first "resident" at Wood Lane in charge of the adaptation of the building'), etc., was Mr. A. S. Butler, who recalled in our interview with him that he first saw the establishment while negotiations were being commenced on (of all dates) the 5th November 1930. .