Telegraphy

By 1906, 70 years had already elapsed since the opening of the first operational telegraph circuit, and a major preoccupation was the transfer of the main overhead telegraph circuits to underground cables. Methods of operating the long-distance circuits included the Wheatstone, Murray, Baudot, Hughes and quadruplex Morse systems, and Wheatstone speeds of 400 words/min were commonplace. The development of the telegraph service is traced from that time to the present day, when the page-printing teleprinter has supplanted other instruments in the inland network and connexions are established via automatic telegraph exchanges. The growth of the telex service and the development of facsimile telegraphy are also described..

EARLY TELEGRAPH HISTORY

In 1908, Sir John Gavey, the first President of the Institution of Post Office Electrical Engineers, wrote In his "Words of Welcome," to the first issue of the journal:

> " ... even as recently as 40 years ago, telegraphy was the only existing branch of electrical engineering, and when the present Institution of Electrical Engineers was founded in 1871, with the title of The Society, of Telegraph Engineers, it fully represented the whole of our interests."

The idea of the "sympathetic needle" for communicating intelligence over great distances is very old indeed. It is fascinating to read[1,2] of the practical attempts that were made to establish alphabetic electric telegraphy (often using one wire per symbol), even before the work of Volta made possible a continuous source of electric power and so prepared the way for Oersted and Ampere to demonstrate the magnetic effect of the current.

Early in the 19th century, Cooke in this country produced improved instruments, using various numbers of line wires and magnetic needles from one to five, and in 1837 he collaborated with Wheatstone to provide the first operational telegraph circuit in the United Kingdom, for the railway between Euston and Camden Town. In the same year the electromagnetic relay was invented by Davy. Attempts to lay lines underground were unsuccessful because of poor insulation resistance, and for a long time development in this direction ceased in favour of overhead lines. In the public eye, interest was quickly awakened to the potentialities of the telegraph by the dramatic arrest of a murderer in 1845 as a result of a message sent over a circuit between Slough and Paddington. Single-needle and double-needle instruments in association with some form of code soon, became established in this country, the double-needle being favoured by the railways, but with the gradual improvements in line insulation, constancy of battery performance, and instrument production, the sounder slowly superseded the single-needle instrument on Post Office circuits. The double-plate sounder, which enjoyed a long period of popularity until about 1880, consisted of a polarized relay and a pair of sounders, fitted with sounding plates of brass and steel, respectively, to denote dot and dash signals by different notes. Wheatstone's more expensive ABC instrument, which appeared in 1840, remained in use until long after 1900.

Apart from attempts at duplexing, two outstanding inventions between 1850 and 1875 were the printing system introduced by David Hughes, of Kentucky, in 1855, and Wheatstone's automatic system, which was patented in 1858, and when first brought into use in 1867 operated at 70 words/minute (w.p.m.) The Hughes system (Fig. 1) was an improvement on House's system of some seven years earlier; it used a piano-type keyboard and printed at 60 w.p.m. Hughes printers were in use longer than any other type-printing instrument, their supremacy declining only as the result of demand for greater speed; in fact, three such circuits were still in operation at the Central Telegraph Office (C.T.O.) up to 1939.

A time-division system had been proposed by Wheatstone in 1841, and successful experiments with such a system were carried out by Farmer ten years later. Meyer, in 1871, devised a four-channel system, using keyboards having eight keys and printing Morse characters on paper tape. Baudot combined a printing instrument with the multiplex principle and, most important of all, used a code with five units of equal length, and in 1877 the French Administration decided to adopt Baudot's system. A keyboard perforator (which punched square holes in a paper tape) and a synchronous automatic tape transmitter were designed by Carpentier in 1887, but these instruments were not used in the telegraph services until much later.

Meanwhile, after taking over the private telegraph systems in the United Kingdom in 1870, the Post Office began to adopt duplex working extensively many years before it was used by other Administrations, although poor insulation resistance of lines and difficulty-in obtaining accurately differential instruments presented a number of problems. Quadruplex circuits also came into use at this time (1872), and the first mobile telegraph office, complete with batteries and half a mile of three-wire iron-sheathed cable, was brought into service in 1873. In 1886, the American Delaney multiplex system appeared: despite many admirable devices such as the vibrating reed and phonic-wheel control, its use was abandoned in this country in 1903 after three years' trial, on account of the inherent mutilation of the signals. It used the Morse alphabet, fundamentally unsuited to multiplex systems, and was worked by key and sounder at 25 w.p.m.

The Post Office were slow in adopting the Hughes instrument

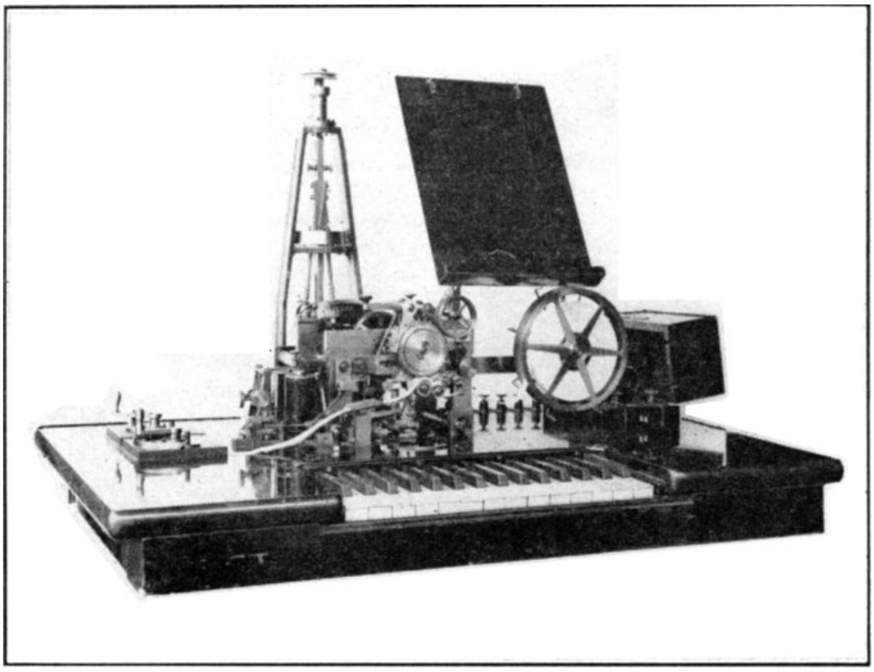

FIG. 1 - THE HUGHES INSTRUMENT

FIG. 2 - THE METROPOLITAN GALLERY, TELEGRAPH ST. (1871)

because of its cost and the special training needed, although it was used widely on the Continent, but, with the acquisition of the Submarine Telegraph Company by the Post Office in 1889, the Hughes instrument came to be used extensively on Anglo-Continental circuits, the Post Office Factory making its own instruments from 1890, which used an electric motor in place of the original pedal-wound weight drive.

A 12-channel v.f. system was introduced by Mercadier in 1895 employing frequencies in the range 480 c/s to 900 c/s, tuned headgear receivers being used for reception, but this system caused interference with telephone circuits, and so did not progress beyond the trial stage.

In 1901 the Murray high-speed automatic type-printing system was introduced, only to be abandoned after more than ten years of trials on London-Edinburgh, LondonDublin and London-Berlin circuits. The equipment comprised a keyboard perforator (40 w.p.m.), automatic transmitter (120 w.p.m.), reperforator and column printer (100 w.p.m.), and incorporated such novel features as phonic-wheel drive and speed correction from the intelligence signals themselves; in the tape all perforations appeared longitudinally on one side only of the centre holes. Murray later focused the attention of telegraph engineers upon start-stop working and the five-unit alphabet.

It is interesting to note that in the early trials of keyboard perforators each perforator was associated with an automatic transmitter, which was automatically switched to the line, under the control of perforations inserted in the tape by the perforator operator after a given batch of messages. The line was shared by two automatic transmitters.

THE TELEGRAPH SCENE BETWEEN 1906 AND 1908

By 1906-1908; 70 years had elapsed since the opening of the first operational telegraph circuit, and the International Telegraph Union - the oldest inter-governmental organization - had passed its 40th anniversary. In February, 1908, at the annual dinner of the Engineering Department, the Engineer-in-Chief, Major O'Meara, claimed that the British telegraph service was acknowledged throughout the world to occupy the premier position. Competition from the telephone system had, however, already caused a considerable reduction in the number of messages circulating from one part of London to another.

A major preoccupation was the transfer of the main telegraph circuits to underground cables to afford greater security from storms, and the Northern and Western Underground telegraph cables were well on the way to completion. The standard method of working inland circuits was by some form of duplex system using sounders: a side-stable polarized sounder had just been introduced which responded to double-current signals produced from a single-current battery at the central office, by the charge and discharge currents of a capacitor. The non-polarized sounder had had its day as a line instrument, because of its heavy power consumption, the troubles due to unskilled adjustment of the associated polarized relay, and the sounder-chattering caused by the response of this sensitive relay to voltages induced into underground circuits. At central offices where secondary cells were not available, groups of bichromate cells were installed.

At the C.T.O., which had been opened in 1871 and replaced Telegraph St. (“TS”), Moorgate (Fig. 2) as the chief telegraph office of the Post Office, Metropolitan sounder circuits, as well as certain provincial circuits, were operated via new switching equipment (Fig. 3). The equipment used lamp calling and clearing, and by saving nearly 4,000 transactions a day, reduced the average cross-London delay from 18 minutes to five. To accommodate some 150 short provincial omnibus lines, each serving two or more offices, a two position central-battery concentrator with lamp calling and clearing was installed in the C.T.O. Coincident with the new installations in the C.T.O., a task of considerable magnitude was completed-the conversion of all the London offices to central-battery (C. B.) work-

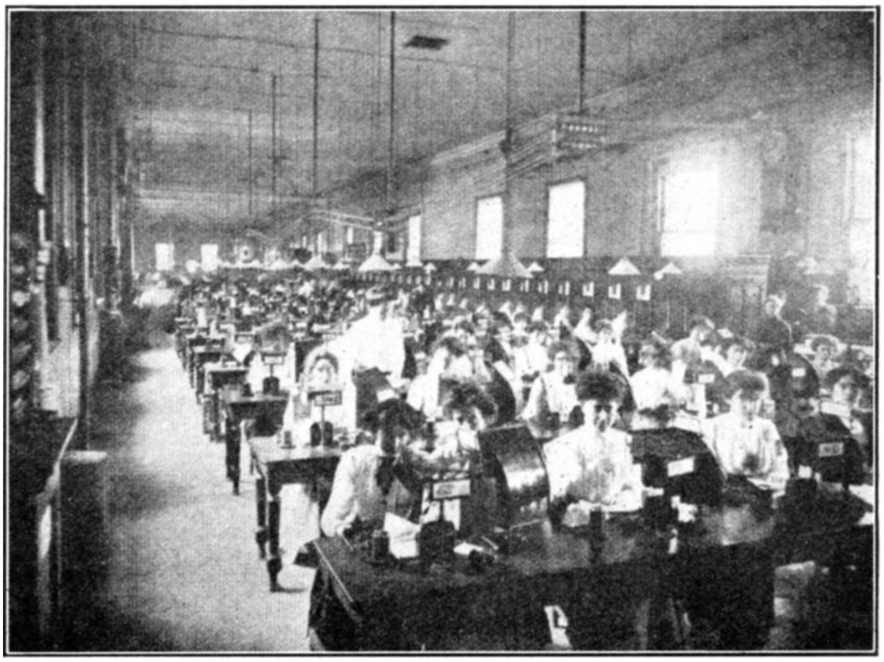

FIG. 3 - THE METROPOLITAN GALLERY, C.T.O. (1911)

ing- - and great economies were achieved from the abolition of well over 1,000 scattered groups of primary batteries.

Many miles of pneumatic tube had already been laid between branch and head offices; on the longest tube circuit, connecting the House of Commons to the C.T.O. (3,992 yd), the transit time was just under eight minutes.

Long-distance overhead circuits within the British Isles could be operated commercially by Wheatstone apparatus at speeds up to 300 w.p.m. duplex and 400 w.p.m. or more simplex; some quadruplex circuits were also in use. The Wheatstone system,had changed very little since its introduction many years earlier. Trials were being made with electric-motor-driven transmitters, the main problem being the achievement of constant speed. Perforated tape was prepared by the three-punch "stick" perforator, but operation of this device for long periods was very tiring. To increase the speed of punching tape, trials were being made with early designs of alphabetic keyboard perforator, but they were not entirely successful. At the receiving end the process of transcribing messages from the Morse signals recorded by an inker upon a paper tape, often under artificial light, caused considerable eye-strain. As a result this system tended to fall into disuse.

Circuits to the European capitals were operated by printing telegraph systems, using the Hughes apparatus except for a single Baudot system to Paris. The Post Office operated five repeater stations, at Nevin, Llanfair and Haverfordwest on the Irish cables; at Lowestoft and N. Walsham on the Continental cables. Nevin, for example, had nine Wheatstone duplex and two quadruplex repeaters, the latter carrying Wheatstone and key signals. The Post Office standard B relay was firmly established. At repeater stations, sounders repeating all signals were the cause of great inconvenience, and silencers were being provided which could be rendered inoperative from the distant station when it was necessary to call the repeater staff. Repeater stations were being converted to secondary cell working, to replace the many groups of line and local batteries whose maintenance occupied the full time of one man.

At this time an investigation was being carried out into the speeds and relative economics of various methods of operating long-distance circuits, including Wheatstone, Murray, Baudot, Hughes and quadruplex Morse. Although the quadruplex system worked for many years on London-Dublin and other long circuits, with Wheatstone on the "A" (polarized) side and key at 25 w.p.m. on the "B" (incrementing) side, there was a tendency to split the keyed signals, and the repeater with its 12 relays and 15 separate batteries (368 bichromate cells) was troublesome to adjust; hence it cannot have been a very stable system.

In the large offices secondary batteries were installed to provide ±40V, ±80V and ±120V. The 80V and 120V sections were used only on the longer circuits and the loads at these voltages were lower than at 40V. A novel form of no-break rotary switch was therefore used to enable four sets of 40V cells to be cyclically switched, every two or three days as required, to occupy progressively different positions in the battery; each set in turn becoming available for charging, after which it carried the heaviest load (40V).

A PERIOD OF TRANSITION (1908-1928)

From 1908 onwards the effect of the growth of the telephone service on the shorter-distance telegraph services became more pronounced. In the provinces, as well as in London, short-distance telegraph traffic decreased rapidly, and phonogram and telephone-telegram working were introduced. As fast as exchanges were installed in rural areas, Wheatstone ABC, Morse sounder and single-needle instruments, which had hitherto served small offices, were replaced by telephones used jointly for a public calloffice and as a means of disposing of telegrams, and by 1915 one-half of the 14,000 telegraph offices were operated by telephone. This process continued steadily until 1932, when the last inland Morse circuit in the C.T.O. was closed, quietly and without ceremony, and Morse working was only retained in the inland system for a few circuits.

This period saw the rationalization of power `supplies in telegraph offices. In the first place, conversions to central-battery working obviated the need for large numbers of scattered groups of primary cells, and the standardization of an improved Leclanche cell in 1911 led to the gradual abandonment of Daniell and bichromate cells. Secondly, as the spread of electric power mains brought charging facilities, conversions to secondary cells were steadily made, with considerable reduction in battery maintenance costs. Secondary cells in the C.T.O. replaced 5,000 "Z" cells used on underground loop circuits up to 1919; at the same time a ring-main was run to Fleet Street, so replacing 3,000 primary cells in newspaper offices by power supplies fed from the C.T.O. As secondary-cell batteries became universal the trend towards C.B, working was halted to obtain the improved transmission performance of double-current working.

During this period an extensive program of installing concentrator switchboards (including also some for phonograms) was completed at offices in all large towns. To dispense with the need for switchboard operators, this phase of evolution culminated in the installation of small automatic concentrators for trial at C.T.O. and Leicester (1923), and ancillary concentrators (for lines from "forwarding only" offices) which enabled the switching to be done by the receiving telegraphist. At this stage (1925) the London Intercommunication Switchboard, which had been a conspicuous feature of the London telegraph system for over 20 years, was finally closed down.

The important changes of this period, however, were in the methods of long-distance operation, though they were in fact destined to revolutionize all forms of telegraph working. Development proceeded along three lines, automatic high-speed transmission, multiplex systems, and direct keyboard transmission. For a long time competition was between the first two, typified by the Wheatstone and Baudot system; the former, after initial success, yielded to the latter, but both finally gave way to the third.

Against the high transmission speed of the Wheatstone automatic system must be set the disadvantages of operating methods which, being slow, needed a team of sending and receiving telegraphists to feed the line and handle the output. Indeed, these very disadvantages had, over a long period of years, brought about a tendency to revert to key and sounder except for special arrangements, breakdowns and press work. To speed up the rate of tape perforation, trials had been carried out for many years with keyboard perforators whose punches derived their power from a pneumatic source, from electromagnets or from an electric motor: the successful keyboard perforator solved the Wheatstone sending problem. At the receiver, the dot and dash slip from the inker was transcribed - whether for delivery or for re-transmission - by one or more operators; and delays were frequent. A revised operating procedure, known as "Systematic Wheatstone Working"[3] was introduced in 1908, in which all Morse slip was gummed on message forms, that for delivery being transcribed direct, using typewriters, and through messages being re-transmitted without transcription, so reducing the error-rate as well as the delay. Such was the improvement that at Edinburgh, for example, it enabled four out of six London-Edinburgh circuits to be closed down, as well as the direct London-Inverness and London-Leith circuits. In London this procedure could not be carried out owing to the size and dispersion of the instrument room, but trials

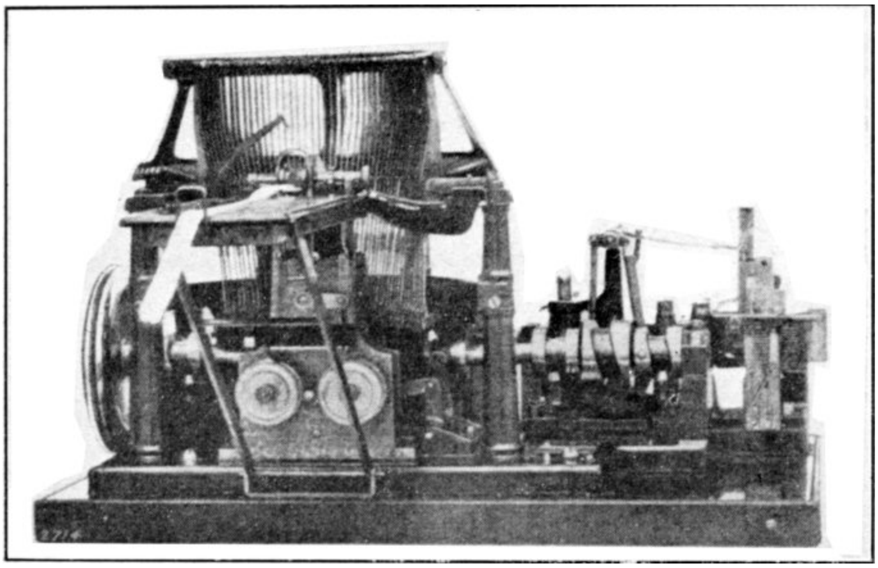

FIG. 4 - EARLY CREED PRINTER

were in hand with a Creed reperforator and a Creed printer (Fig. 4) ; the reperforator automatically reproduced a perforated tape, at 150 w.p.m., which could be used direct for re-transmitting telegrams, or fed into the printer for producing a tape printed in Roman characters at 100 w.p.m., ready for gumming up. The subsequent improvement and adoption of keyboard perforators, reperforators and printers together with the provision of automatic transmitters, all electrically driven, put the Wheatstone automatic system on a firm basis in a form which is still in use for some radio circuits. .

In Britain, multiplex systems were not looked upon with favour, largely due to the unsatisfactory results of the trials of the Delaney system and to some reluctance to embark upon large-scale adoption of any one system while other promising systems were under trial. True, a London-Paris Baudot system, working two channels simplex, had been operating satisfactorily since 1897, but in that form its output was no better than Morse-quadruplex and inferior to Wheatstone. In 1910, quadruple-duplex equipment was available for trials on a loop circuit in the London-Birmingham cable, and double-duplex trials were also made on a London-Berlin circuit. The French had long abandoned their only attempt to duplex the Baudot, on a Paris-Nantes single-channel circuit in 1887, on account of balance troubles coupled with the lack of any real justification for duplex working on that particular route. The protagonist of the Baudot duplex system,[4] against those who doubted its practicability, was A. C. Booth of the Post Office Engineering Department, and it was largely due to his efforts that the duplex Baudot was adopted, not only for the inland service, but also to displace the slower Hughes system on many Anglo-Continental circuits. Indeed, the British Post Office supplied apparatus and engineers to some of the foreign capitals to collaborate in setting-up Baudot circuits, and later supplied duplex repeaters to the French Administration for use on the LondonParis triple-duplex circuits. A lot of work was done to determine the relative efficiency of double, triple, quadruple, quintuple or sextuple Baudot, simplex or duplex, on any particular circuit whose Wheatstone speed was known. At 30 w.p.m./channel, the sextuple duplex was capable of maintaining 180 w.p.m. in two directions and provided formidable competition with the Wheatstone system at its best. As the result of consistently good performance the Baudot duplex system became firmly established technically in this country, so much so that in January 1914 the Postmaster-General appointed a Committee to inquire into high-speed telegraph systems. Telegraph engineers were rapidly coming to the opinion that the most promising line of telegraph progress was in type-printing multiplex systems.

A disadvantage of the Baudot system (Fig. 5) was the method of sending, which required the operator to memorize the 5-unit code in order to manipulate the five piano-type keys and to keep in exact cadence with the distributor. In the Murray and Western Electric multiplex systems, which the Post Office put on trial, the sending process was simplified by the incorporation of keyboard perforators coupled with automatic transmitters; other innovations were the use of phonic motors controlled from vibrating reeds to drive the distributors at a speed of 40 w.p.m./ channel, and the introduction of page printers.

With the First World War telegraph traffic increased - 91 million messages were handled in the United Kingdom in 1915. As a consequence the number of Wheatstone and Baudot systems had increased appreciably by the time the report of the High-Speed Telegraph Committee[5] was published in January 1916. The main conclusions of this committee endorsed the definite superiority of multiplex systems over high-speed automatic transmission for inland commercial traffic, and advised the gradual supersession of systematic Wheatstone by multiplex working. Other recommendations were that automatic transmitters be added to the Baudot equipment; that the 5-unit code was superior to Morse (excluding news traffic and submarine cable working) ; and that the application of printing telegraphy to less important circuits should be kept in mind. The committee also thought that page receivers were preferable to tape receivers.

After the committee's report, and particularly after the war, when apparatus was more easily obtainable, the use of duplex Baudot sys-

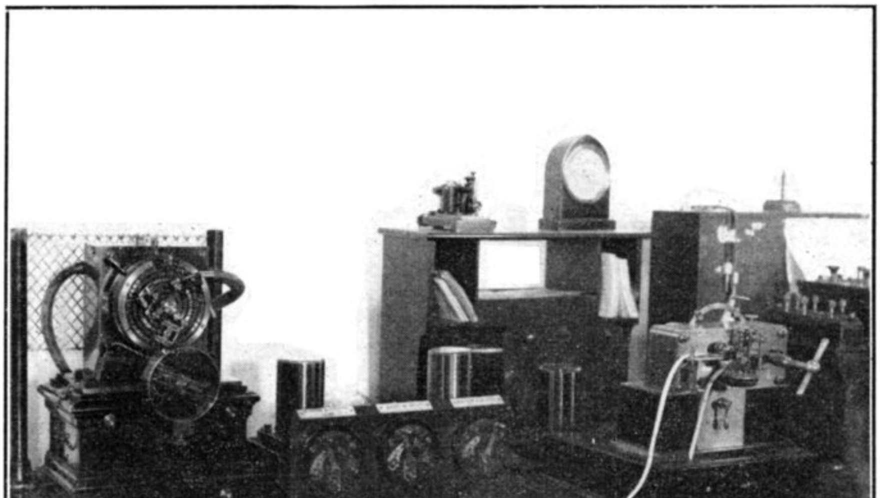

FIG. 5 - BAUDOT DISTRIBUTOR AND RECEIVER

tems (mostly quadruple) extended rapidly both for the inland service, at the expense of CreedWheatstone and Hughes systems, and on Anglo-Continental circuits, where it superseded the Hughes system and doubled the output. The Baudot receiver was fitted with a mains-driven motor, the improvements already mentioned were incorporated in the later Baudot apparatus, and the speed was increased to 35 w.p.m./channel. By 1922 the number of Baudot channels had reached 700. The re-transmitter, a simple device which allowed channels to be coupled together and regenerated the signals, gave a certain amount of flexibility m utilization, though not without some complexity in connexion with speed control. This program of expansion was only halted by the decline in telegraph traffic which,set in during the second half of the 'twenties. In all this program, and particularly on cable circuits, a most important part was played by the vibrating relay, invented by Gulstad in 1898, by means of which the performance and speed of operation of the circuits were appreciably improved.

In the early 1920s came the first of the radical changes to be made in telegraph technique and operation. In 1912 the first start-stop instrument had appeared in America, having been developed over a period of 12 years and more by Krum, a cold-storage engineer, financed by a Chicago millionaire named Morton: Far ahead of its time, this instrument used a typewriter keyboard in conjunction with a 5-unit code, and printed on a page. Some years later Morkrum instruments printing from a typewheel at 40 w.p.m., and known to the Post Office as the Teleprinter No. 1A, were giving satisfactory service in trials on two circuits in London. This was followed by other trials on longer circuits, and a Morkrum type-bar instrument working at 60 w.p.m. (Teleprinter No. 2A) was tried in 1925, one such instrument being used for booking calls over the new London-New York radio-telephone circuit. Other teleprinters[6] were also tried and by 1928 it was possible to standardize on the Creed No. 3A model with tape printing at 65 w.p.m. for the inland service.

The general adoption in the early 1920s of loaded and repeatered underground cables for long-distance telephony raised fundamental problems in the transmission of telegraph signals through telephone cables. Investigations of d.c. transmission covered composited and superposed, working, balanced circuits, and the design of new relays, such as the standard H relay, of increased sensitivity to work over long distances at reduced voltage and current. The solution to this problem of operating telegraph circuits in telephone cables clearly lay in voice-frequency telegraphy[7] and, following the development of filters, the first trials in this country were made in 1925 with Siemens-Halske 6-circuit v. f. telegraph equipment working over 40-lb loaded London-Derby and London-Manchester loops; then, in the following year, trials were made with a General Electric Company's 6-circuit v.f. equipment working over a London-Leeds, and later a London-Glasgow, circuit. In both equipments valves were used as oscillators (the G.E.C. equipment with tuning-fork control), amplifiers and detectors. The circuits used in the trial were equipped with Teleprinters No. 3A, of which several hundred were then in operation, some having already superseded Baudot apparatus. For some time the need for standardization of alphabets and keyboards had been urgent. The Baudot system itself had variants for inland and international working, while the Murray system differed from both. The Baudot alphabet was designed primarily for ease in memorizing and manipulation on five keys, with the result that in keyboard working the numerals became scattered over the keyboard. The Murray alphabet was designed to take account of frequency of occurrence of letters in the English language, and so maintain the strength of perforated tape by punching the least number of holes in it; also, figures appeared in numerical order on a single row of key`s.

The International Telegraph Union had never extended its activities far into the technical field, but in 1926 an organization was established to deal with technical matters, the International Consultative Telegraph Committee (C.C.I.T.). At its inaugural meeting in Berlin, in 1926, the C.C.I.T. decided to study the standardization of a single international 5-unit code based on the Baudot alphabet. A sub-committee was given the task of studying the problems of co-existence of telephone and telegraph circuits in the same cable. Until 1926 the only means of assessing the transmission efficiency of a circuit was in terms of its possible Wheatstone speed, or less precisely in its message-carrying capacity. At its first meeting the C.C.I.T. defined and recommended the baud as the unit of modulation rate, to honour the memory of Emile Baudot. At its second reunion (1929), held also in Berlin, the C.C.I.T. recommended the adoption of two codes: the International Alphabet No. 1 for multiplex systems; and the International Alphabet No. 2 for start-stop systems. Both were basically Baudot codes but the latter had the secondary symbols - re-arranged to suit keyboard layout, made provision for page teleprinters and included a change in the erasure signal to cover the use of perforated tape. This form of the Alphabet No. 2 was not, in fact, adopted; it was changed by a C.C.I.T. sub-committee, which met in Berlin in July, 1931, and was replaced by what was practically the Murray alphabet, differing extensively from the Baudot alphabet. The other more important recommendations of the 1929 reunion were a 50-baud standard for start-stop apparatus (the Creed No. 3A teleprinter worked at 49 bauds); the choice of negative polarity for the start signal and positive for the stop signal (this recommendation was not, however, adopted in this country, where the opposite conditions already prevailed); and the use of 7-unit start-stop receivers. The maximum permissible power (5 mW) for v.f. multicircuit systems was also established and a sub-committee was appointed to study the question of frequency division for v.f. multi-channel systems.

THE TELEPRINTER AND V.F. ERA

With the introduction of the teleprinter and the development of a network of v.f. telegraph circuits, telegraphy changed its character completely.[8]

The v.f. network introduced complete flexibility as well as great economy in the provision and utilization of telegraph circuits, all with identical characteristics; it also removed the distinction between telegraph and telephone plant so far as cables and transmission equipment were concerned.

The teleprinter provided direct working to line at an adequate speed, and with the introduction of the page model (No. 7) in 1932 a telegraph instrument was available which, from its essential similarity to a typewriter, could be put into ordinary commercial offices.

As a result of these changes the techniques of testing and maintenance, for the first time, acquired precision in measurement. At its Third Reunion (Berne, 1931) the C.C.I.T. began to make recommendations for the measurement of distortion and margin, in addition to standardizing the carrier frequencies for multi-circuit operation. In the same year a 12-circuit system to the new 120 c/s spacing was in operation between London and Dundee.[9] Apart from superseding the polarized sending relay by a static modulator which appreciably reduced distortion, the design of this equipment was not changed until 1951 when a new detector of improved performance was introduced and the physical design changed. It has not yet proved practicable to displace the polarized telegraph receive relay.

In 1932 development in superposing had reached the stage where it was possible to offer by-product point-topoint teleprinter circuitsphantoms and double-phantoms on main cable routes at rates that were attractive to the renter and remunerative to the Post Office. An extensive private-wire teleprinter service was built up on this basis, until circumstances forced abandonment of this method of providing teleprinter circuits, by which time the v.f. network had grown sufficiently to cater for, the growing private-wire service.

For a long time telegraph engineers had advocated the introduction of a telegraph exchange service, but, in the absence of a universal telegraph instrument and sufficient relatively inexpensive similar circuits, those systems that had been tried, such as the sounder intercommunication switch, the Wheatstone ABC exchange, and the telewriter exchange, catered only for local services. In 1932 the Post Office was a pioneer in introducing a telex service which, with only a limited v.f. network and demand for service, was based on the use of telephone exchanges and the telephone network; transmission was on a 300-c/s (later 1,500 c/s) carrier, and page teleprinters were used. A "printergram" service was introduced for the direct handling of telegrams between business houses using the service and telegraph offices. In 1936 a limited service with the Continent was opened, using 1,500 c/s transmission.

In the public telegraph service the introduction of the tape teleprinter (No. 3), in association with v.f. circuits for the greater distances, quickly became universal. Instrument rooms acquired a new appearance with the introduction of double-tables and conveyor belts; the auxiliary apparatus which had hitherto encumbered operating positions was removed and mounted on apparatus racks. In the new conditions it became possible to envisage an automatically switched telegraph system, thus directly attacking the age-old problem of reducing the number of times that telegrams were re-transmitted. A Re-transmissions Committee set up to study the problem reported in favour of a national teleprinter automatic switching system. Switching equipment was designed and successful large-scale field trials were held, but plans for the introduction of a pilot stage of the network were suspended on the outbreak of the Second World War.

One result of the war was the decentralization of telegraph operating from zone to` area centres, a step which involved an increase in re-transmissions and in staff. To reduce this extra work, it was decided to introduce a switching system with manual switchboards at six zone centres, the first two being brought into service early in' 1944.[10] The completed program required the use of more than 1,500 circuits at 134 multiple switchboard positions, some 75 per cent of the total public traffic being handled in this way. Manually switched teleprinter networks were also set up for the Services,[11] for various Ministries, and for other important users, with the result that the v.f. network expanded considerably.

Radio teleprinter circuits were also brought into use, employing two-tone and frequency-diversity transmission.[12] After the war the resumption of telex working with the Continent became urgent; it was at once decided that this service should be on the basis of a network of exclusively telegraph circuits using standard v.f. multi-circuit working.

Temporary switchboards, which were quickly built, enabled service with Holland to be re-opened early in 1947; this was followed by considerable expansion until at the present time the international telex switchboard in the C.T.O. (Fig. 6) has more than 70 positions giving access to practically every European country; as well as to the whole of the United States and to parts of Africa. It is notable that since 1948 connexions with European subscribers served by automatic telex networks have been established by direct dialling from the C.T.O. switchboards. For some time it had been apparent that operation of the inland telex service on the telephone network suffered from certain disadvantages, and a Committee set up in 1947 to study this question recommended the establishment of a new inland telex service using a network of exclusively telegraph circuits, to be started temporarily by using manually operated switchboards. The final stage in this conversion program was completed in 1954,

FIG. 6 - THE INTERNATIONAL TELEX SWITCHBOARD, C.T.O.

giving complete flexibility between the inland and international - telex services. At the present time there are just over 100 inland switchboard positions and approximately 3,000 subscribers.

The period of post-war activity included the conversion of the whole of the inland public -network from manual to fully automatic working. The deferment of the pre-war switching scheme was not without advantage, since it gave the opportunity for further thought on signalling methods and resulted in the adoption of principles that were laid down for the telex service at the Sixth Reunion of the C.C.I.T. (Brussels, 1948). The conversion of the public service to automatic switching,[13] involving the opening of 22 telegraph exchanges serving 2,200 lines and the introduction of a new teleprinter (No. 11) conforming to international standards, was completed early in 1954 and has been very successful (Fig. 7).

Concurrently with the adoption of the principle of random selection of v.f. circuits to form switched connexions, much work has been done in the design and utilization of electronic equipment for measuring and analysing distortion and investigating its cumulative effect in tandem-connected circuits.

FACSIMILE TELEGRAPHY

Facsimile telegraphy is almost as old as electrical telegraphy itself, having been introduced by Bain in 1842, using a receiver which recorded from five electrodes in contact with a moving tape of chemically treated paper, so reproducing letters that had been set up in metal type and scanned by five metallic feelers at the transmitter. The following year Bain patented an instrument in which scanning and synchronizing were based on his electromagnetically-maintained pendulum; the swinging pendulum carried a scanning stylus and also controlled a traversing mechanism.

Bakewell, in 1848, patented a "copying telegraph" which laid the foundations for the design of orthodox present-day facsimile equipment. His instrument embodied a drum around which was wrapped the message form to be scanned, and an electrical contact device, traversing by means of a lead screw, scanned the message form. The message could be written in insulating varnish upon metal foil, or alternatively written upon a varnish-coated foil with a sharp point to

Fig. 7 - Modern Instrument Room, Equipped with Teleprinters No 11

expose the metal; recording, which could now include drawings, was again on chemically treated paper.

Various forms of non-facsimile chemical telegraphy were also in vogue for some years, and around 1910 the Siemens Photoprinter and similar machines used photographic paper for reception of printed characters: both these methods of telegraphy were capable of recording at speeds far in excess of existing electromagnetic means.

With improvements in electromagnetic telegraph instruments, facsimile telegraphy declined for some time until interest was revived following the development of photography. Some early work was carried out by Korn, who transmitted pictures by radio from Berlin to Paris in 1913. Ten years later a system was in use for transmitting pictures with limited tonal gradations by the use of ordinary five-unit perforated tape in conjunction with an automatic transmitter and reperforator: though special equipment was needed to prepare the tapes and record from it, the transmission itself was entirely by conventional telegraphic means.[14]

By the late 1920s the developments in photo-emissive cells, electronics, valve-maintained tuning forks and quartz crystals, and the availability of channels of suitable characteristics enabled picture transmission of reasonable quality to be realized. In 1928 the Post Office provided four-wire circuits into newspaper offices equipped with Bell or Belin photo-telegraph apparatus, and in the following year a public photo-telegraph service with Continental stations was opened with the installation in the C.T.O. of a Siemens-Karolus equipment.[15] At its Second Reunion (Berlin, 1929) the C.C.I.T. made recommendations for standardization of photo-telegraph apparatus and circuits.

The original picture-telegraph equipment was destroyed during the Second World War when the C.T.O. was very severely damaged, but in 1948 the service was re-opened using a new Muirhead equipment, and today the photo-telegraph service is world wide, using sub-carrier-frequency modulation for extra-European radio transmission.

TOWARDS THE FUTURE

It is difficult to foresee any radical changes in telegraph technique in the near future. From various causes, during recent years the inland traffic of the general telegraph service has fallen sharply. The future rests more with the telex service,[16] which is rapidly growing and has, no doubt, a remarkable development before it. Plans are well advanced for converting the inland telex service to automatic working within the next few years, and the ultimate aim is for full subscriber-to-subscriber dialling within Europe. A project is also being examined for the establishment of a European switched teleprinter-network for the general telegraph service.

The expansion of the international telex service has been aided by the recent introduction in this country of electronic regenerative repeaters, and of error-correcting equipment for use on radio circuits. To provide telegraph circuits over the transatlantic telephone cable, the first installation in this country of narrow-band frequency-modulated v.f. telegraph equipment has been made.

Switching methods that involve the use of reperforators and automatic transmitters, interconnected automatically under the control of perforations forming the prefix in a tape, may, for special requirements, have. advantages over more orthodox step-by-step systems. Equipment for this purpose has been developed and some systems of this type are already in operation. Magnetic storage methods may also have some influence on switching applications.

During recent years, trials have been in progress for the local transmission of telegrams by direct-recording facsimile telegraphy. It is difficult to foresee a wide application of this service, but the same technique is being applied in the reception of meteorological charts, and the C.C.I.T. is at the present time studying the question of design standards for such services.

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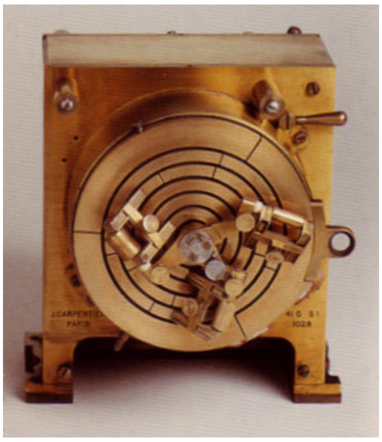
ADDENDA IN 2009

This document has been on display on Sam Hallas' web sitefrom February 2009. In May of that year, Fons VandenBerghen, the noted collector of early telegraph instruments, spotted that the caption to Fig 5 is incorrect.

He points out that the left hand equipment is, indeed a Baudot distributor, like this:



However the right hand equipment is in fact a Wheatstone Morse receiver like this, which marks dots and dashes on paper tape fed from the drawer below.

It should be a Baudot receiver like this which prints characters on paper tape. Note the typewheel in the centre.

All the pictures on the left were kindly supplied by Fons Vanden Berghen of items in his extensive collection.

More of Fons'collection can be seen at:

http://www.faradic.net/~gsraven/fons_images/fons_museum.html

More Pictures

Here's a picture of the Hughes printing telepgraph (Fig 1) which is now in the Amberley Working Museum as part of BT's Connected Earth Project. Picture: Sam Hallas 2006.

And a better image of an early teleprinter (Fig 4), the Teleprinter No 1 from the BT Archive.