

Beginnings of the telephone service



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After the invention of the telephone in 1876, telephony developed rapidly, more rapidly in the USA than elsewhere. Telephone exchanges were introduced from 1878, interurban links coming into use as the density of exchanges grew. Technical difficulties, commercial rivalries, and, outside the USA, governmental policies, held back the development of long-distance or trunk lines until the middle 1880s. In 1891 Britain scored a notable success in providing telephony between London and Paris, although there was no effective internal long-distance system until 1896

Commercial development of the telephone began quite soon after the initial inventions of Bell and Gray in 1876. Bell's company started in 1877, changing its form rapidly at first, and became well established in the USA, with subsidiary companies in Britain and elsewhere, by 1879. The Western Union Telegraph Co., a large and long-established organisation, having unwisely turned down an opportunity to obtain Bell's patents in 1876, started a competing telephone company on the basis of Gray's patent and further commissioned inventions by Thomas Edison. This company was successful, so Bell started an infringement action against it. At the end of 1879 Western Union decided to settle out of court, on the basis that it would withdraw from the telephone field in return for royalties for 17 years.

Independent telephone companies that Edison had set up in London and elsewhere amalgamated within a further year or two with the Bell or other suitable companies in their locality. Nevertheless, there were numerous inventions of new or modified forms of telephone transmitter and receiver, and numerous companies set up to exploit them.

The concept of the telephone providing a public service on a basis rather different from that provided by the telegraph sprang up quickly. Individual telephone renters, or 'subscribers', would require to be connected to another subscriber on demand, and to provide this service, telephone 'exchanges' were introduced; by Bell from 1878 and by Edison from 1879. At first, of course, the service was entirely local, but as exchanges became more numerous, the need for interconnecting them became apparent.

Thus an interurban telephone network started to grow; its growth and usefulness were considerably restricted by the fact that in many areas each exchange, or small group of exchanges, belonged to a separate company using different technical and commercial methods. Since also many governments actively discouraged the development of interurban links from fear of competition with state-owned telegraphs, it is not surprising that it was only in the USA that a significant telephone network had

developed by 1884. Statistics published in 1885 showed¹ the USA to have 140 000 subscribers with 800 exchanges, while for the rest of the world, the list was topped by Britain with a mere 10 000 telephones; interurban lines in the USA numbered over 800, while there were only about 80 in Britain.² It is probable that the USA had more than twice as many telephones and interurban lines as the rest of the world put together.

Inevitably, as interurban telephony developed, a demand for interregional or long-distance telephony arose; but the technical difficulties were such, and the performance of the few lines that were provided was so poor, that the demand grew only slowly at first, and it was the middle 1880s before any serious programme of provision of long-distance lines emerged—and then Europe (except Britain) was well to the fore, for reasons which will be discussed later.

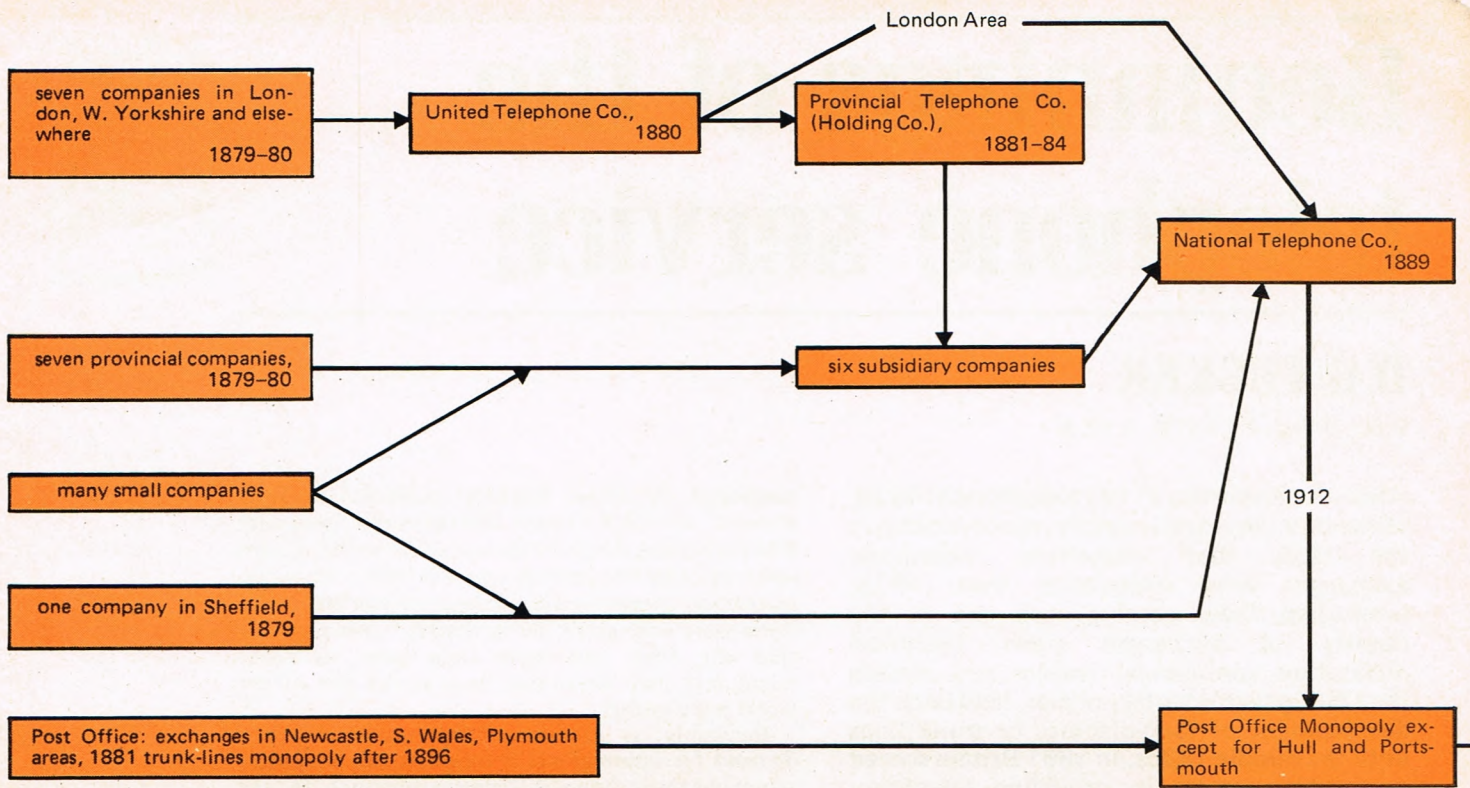
In spite of disparities in telephone densities in different countries, proportional growth rates represented by a doubling of numbers and wire mileages every two or three years were maintained almost everywhere.

Telephone exchanges: The idea of connecting one subscriber, on request, to another by means of a flexible switching system had, on a very small scale, been applied to local telegraph subscribers in the USA before 1877. During 1877 one or two very small private telephone exchanges had been tried, also in the USA, but the first commercial telephone exchange was that at New Haven, Conn., opened on the 28th January 1878. In this, eight lines (with 21 telephones connected) could be connected in pairs by means of a direct cord with a plug at each end; calling 'annunciators' were provided, operated by direct current from the subscriber's battery. A 20-line exchange was fitted six months later at Bridgeport, Conn.

During the same year, the American District Telegraph Co. opened an Edison exchange in Chicago, which also used direct interconnection by a single cord. Calling for subscribers who already had a telegraph instrument was by telegraph; for others, calling relays were used. This switchboard grew rapidly and several boards were needed, with interboard connections and two operators involved in most calls. It was here that the 'jack-knife' switch, forerunner of the well known 'jack', was introduced

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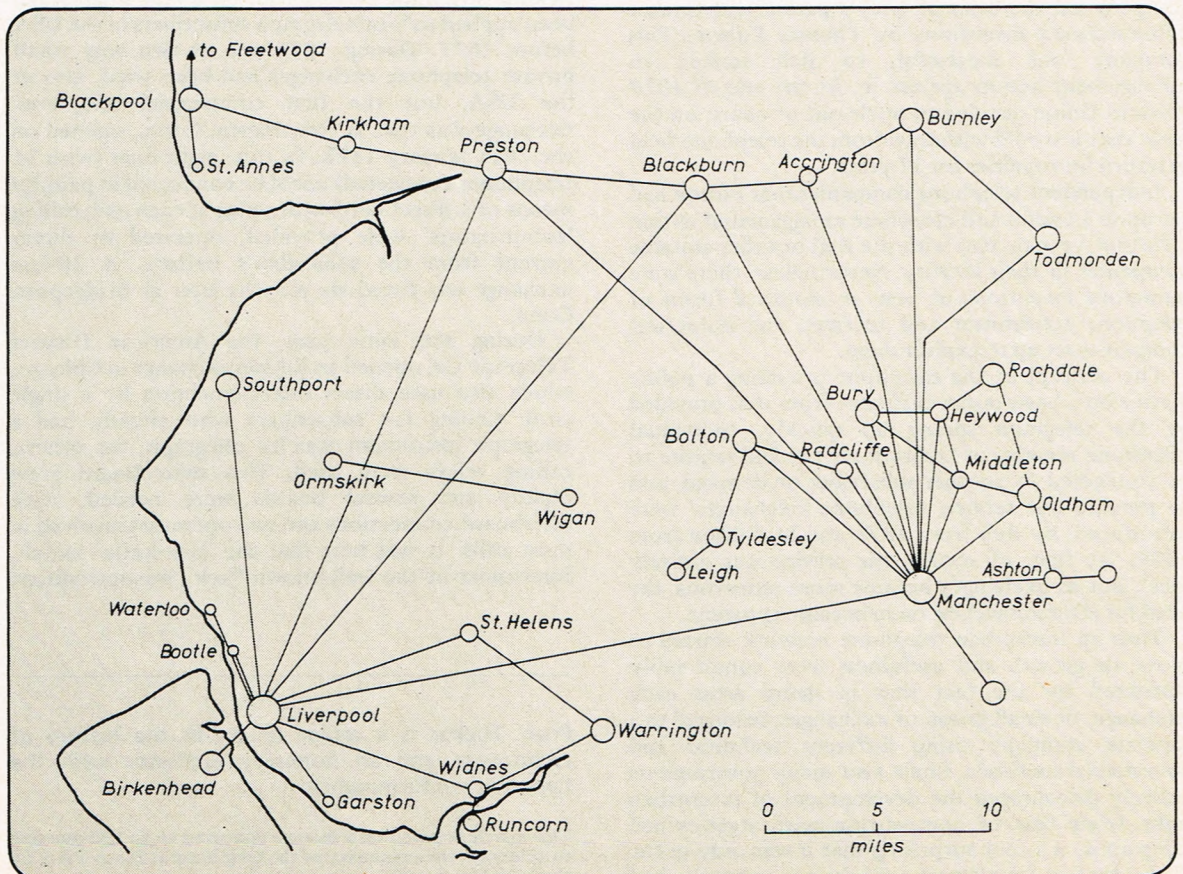


1 Changing relationship between the telephone companies and the British Post Office from 1878 to 1912. By 1889, the National Telephone Co. had almost a monopoly of the telephone business, there were just a few minor companies outside their organisation

2 Interurban network of about 3000 km of lines belonging to the Lancashire & Cheshire Telephonic Exchange Co., 1886. Two years earlier, the Post Office had removed the restrictions that it had imposed on telephone companies when granting licences to limit the company's operations to an area of radius 4.5 miles

by C. E. Scribner, engineer of the Western Electric Manufacturing Co.³

1879 might well be regarded as the year of the telephone exchange, for it saw the introduction of double-cord interconnection via intermediate connecting bars, which could run the length of a whole suite of 25-line boards; of the 'multiple', whereby outgoing access to subscribers' lines was repeated throughout the suite, so that each operator had direct access to every subscriber; of several line-engaged



testing arrangements, and of the first exchange in Britain. This last innovation was opened by the (Bell) Telephone Co. in August 1879 at Coleman Street, London, and had calling indicators, jacks, cords and connecting bars.^{4,5}

It could fairly be said that the manual telephone exchange of the form that became so ubiquitous in the first half of the present century arose directly out of the developments just described. Many technical and operating improvements were introduced, of course; e.g. making the engaged signal a click when the operator touched the tip of her calling plug on the outer ring of the jack, the use of small lamps as calling and supervisory signals etc.

But this type of switchboard was not the only one. The National Bell Telephone Co. in the USA in 1880 introduced a board using an array of horizontal and vertical bars, one of each for each line, so that interconnections could be made by inserting a plug at the crossing of two lines. In Britain, the Edison Telephone Co. used a similar arrangement. It was, however, not suitable for expansion by the 'multiple' method, and so it died out.

The reliance on batteries at each subscriber's premises was obviously undesirable. Common battery signalling, with a central battery at the exchange, was introduced by J. J. Carty at Boston as early as 1880, and the use of a central battery for both speaking and signalling, patented by C. A. Bell in 1886, was further developed by H. V. Hayes of the American Bell Telephone Co. (and later chief engineer of the American Telegraph & Telephone Co.), and first came into commercial service at Lexington, Mass., in 1893.³

Incentive

For many decades there was no economic incentive to try to use automatic exchanges, for operators were cheap and equipment was expensive. Nevertheless, A. B. Strowger of Kansas City began the development of his automatic switching system in 1889; the first commercial automatic exchange was working by 1897, and by 1898 the USA had 22 such exchanges. The first one in Britain was at Epsom in 1912.⁴

Telephone companies, competition, and the state: The manner in which the telephone service developed in different countries was influenced very largely by the attitudes of the governments concerned. The beginning of telephony in nearly all countries was due to commercial companies, the only important exception being Germany, where the state took control from the start. In the USA the companies were, and are still, left to organise themselves according to the ordinary rules of competitive enterprise; the stronger companies became stronger and took over the weaker ones, thus enabling an effective public telephone service to be established with full interconnection facilities as the interurban network grew.

The dominant company became the Bell organisation, working through regional subsidiaries. In Europe, however, the companies came under government influence at a very early stage, and in several countries, notably France, Belgium and Switzerland, there was complete state monopoly before 1890.⁶

The initial formation of a company was usually based on the possession of rights in some patent for a new design of transmitter or receiver which was thought not to infringe the Bell patents.⁷ Litigation over these patents was the most usual cause of failure of these companies and their consequent absorption by the Bell companies. This happened in Britain, but the position here was complicated by legal action taken by the British Government in 1880 against the United Telephone Co., which had just been formed



by the amalgamation of the Bell and Edison companies. The Government's contention that the telephone was a telegraph within the meaning of the Telegraph Act of 1868 was upheld by the court, and thus the Post Office acquired control over all telephone activity in Britain.^{5,8} This it exercised by giving licences to companies in return for a 10% royalty on their business; but it also began to set up telephone exchanges itself, notably at Newcastle on Tyne.

The pattern of company formation, amalgamation, reformation, and the setting up of subsidiaries, not to mention the Post Office's activities, was very complicated, but may be followed in as much detail as we can here afford by reference to Fig. 1, which is based on data given by Baldwin.⁹ By 1889 the National Telephone Co. had almost a monopoly of company telephone business; there were just a few minor companies outside their organisation. The number of subscribers on the Post Office exchanges was very small in relation to the number connected to the National Telephone Co., but the technical standard of the Post Office was high, with metallic-loop lines instead of the single-wire lines of the company. Around the turn of the century, there was a small third group of telephone undertakings, the municipal exchange systems.⁶ These were, in general, unsuccessful, and at the time of the takeover

3 Interurban telephone system in Britain in 1887. The local networks were not linked, and, in modern terminology, there were junctions but not trunks



4 Trunk telephone network in Britain, 1896, distinguishing between the lines taken over from the National Telephone Co. and those built by the Post Office

of the National Telephone Co. by the Post Office in 1912, only two had survived.

Detailed accounts of the telephone systems in the other countries of Europe in the 1890s are given by Bennett.¹⁰

Growth of interurban telephone networks: As the number of telephone exchanges grew, so did the demand for links between the exchanges in neighbouring places. Subscribers' lines were usually of the single-wire type with earth return, so that there was no difficulty in linking them by means of single-wire interexchange lines. In the USA, there was no obstacle other than transmission and commercial considerations to the growth of interexchange networks. In Britain, however, there were legal difficulties imposed by the licencing system.

In granting a licence to a company, the Post Office restricted the area to be served under the licence to a radius of four or five miles. It was thus impossible for a company to develop a network that could be classed as interurban. This disability was removed in 1884,¹¹ and thereafter there were a few notable interurban networks built up, an outstanding example being that of the Lancashire & Cheshire Co., which by 1886 had about 3000 km of interurban lines as shown in Fig. 2.¹²

The position of interurban telephony in Britain as a whole is shown in Fig. 3, the data for which has been

obtained from 24 separate reports in *The Electrician* between 1881 and 1887. It will be seen that the various local networks are not linked; in modern terminology, there were junctions but not trunks. Although there were technical difficulties in providing good enough long-distance lines, they were overcome in other countries that had the will to go ahead. Britain, almost alone, took the line—at least, its Government did, for I quote the Postmaster General¹³—that 'having regard to the cheap and swift means of communication which at present exist by means of the telegraph between the principal towns in the UK, . . . it is extremely doubtful whether there would be much public advantage in establishing telephonic communication generally between those towns'.

At this time, 1887, continental Europe had about 17 000 km of long-distance telephone lines. The technical problems of long-distance telephony during this period, and the way in which they and also the economic problems were overcome in Europe by the van Rysseberghe system of simultaneous telephony and telegraphy on the same wires, have been discussed in a previous article.¹⁴

Long-distance telephony in Britain: I have previously referred to Government attitudes in Britain that effectively led to a great retardation of growth of long-distance telephone services compared with the rapid development taking place elsewhere. Obviously, however, this unsatisfactory position could not continue indefinitely.

A curious situation had arisen in 1889 when two London-Paris telephone circuits were planned, with a new cable between St. Margaret's Bay (Dover) and Sangatte (Calais),¹⁵ since at that time it was not possible to telephone from London to any other town in Britain except Brighton. The Anglo-French lines, opened in 1891, were a great success, and by then London had also been linked to Birmingham and Merseyside. Nevertheless, it is hardly surprising that agitation arose in Parliament for the provision of a proper trunk network.

After widespread discussion and debate, it was agreed in 1892 that the Post Office should purchase the companies' trunk lines, improve them where possible, and construct a complete trunk network of high standard, to which all telephone subscribers should have access. This was rapidly put into effect, the transfer taking place in 1895, and the new Post Office network being substantially completed by 1896.¹⁶ Fig. 4 shows the position then reached; the data for this map have been collected from over 70 individual reports in the technical press for the years 1888-96. By the time of the transfer, all company lines were in the hands of the National Telephone Co., from which about 46 000 km of line were purchased; to this the Post Office added nearly 33 000 km.¹⁷

New trunk exchanges were provided by the Post Office, on which all these lines terminated, and which had local links to the companies' exchanges with agreed operating procedures. It could fairly be claimed that Britain had at last a reasonable trunk network. Nevertheless, it remained a long way behind many other countries of Europe in its general telephone development, especially in rural areas.¹⁸

Long-distance telephony in Europe: By the time the trunk network had been developed in Britain as just described, the network in Europe had also grown into a largely interconnected system as shown in Fig. 5. Only the southernmost parts were left without international links. This map has been compiled from data scattered over more than 60 separate reports in the contemporary technical journals, and consequently may well be incomplete.

Long-distance telephony in the USA: Interest in the use of the telephone over long distances arose in the USA very soon after the commercial introduction

of the telephone. Long telegraph routes were available for trials of the telephone, and, as early as 1879-80, claims were being made for successful telephone communication over vast and unlikely distances.¹⁹

The Southern New England Telephone Co. opened in 1884, for public service, a metallic-loop circuit (claimed to be the first metallic long-distance telephone line ever built) between New York and Boston, approximately 450 km in length.²⁰ It proved very satisfactory.

In 1886 the newly-formed American Telephone & Telegraph Co. (generally referred to as the 'Long Distance Telephone Co.' and a subsidiary of the Bell Co.) embarked on a programme of long-distance lines, several routes being opened in 1887-89 over distances up to about 700 km.^{21,22} The success of these led to the construction in 1892 of a through metallic-loop circuit from New York to Chicago²² with copper conductors of number 8 gauge (435 lb/mile or 121 kg/km), a substantial increase in conductor size over the previously-used number 12 gauge (172 lb/mile or 48 kg/km).

The lines could be extended at each end to give through speaking between Boston and Milwaukee, about 2100 km, but this was considered rather beyond the limit of satisfactory transmission. Normally, special soundproof booths were used at New York and Chicago. The plan of the main-line development is shown in Fig.6.

In addition to the American Telephone & Telegraph Co.'s network, there were also other interurban lines constructed by local companies, some of considerable length, and some much further west, as instanced by the line from Kansas City to Wichita, Kans., of about 300 km, built in 1889-90 by the Missouri & Kansas Telephone Co.²⁴

By the early years of the 20th century, the American Telephone & Telegraph Co.'s network had linked all major towns in the eastern half of the USA. The first transcontinental line, from New York to San Francisco, was opened in 1915. This, however, depended for its operation on the use of coil loading, phantom working, and, most important of all, telephone repeaters or amplifiers.²⁵

References

1 *Electr. Rev.* (New York), 1885, 6, pp.6-7

2 *Ibid.*, 1888, 12, p.6

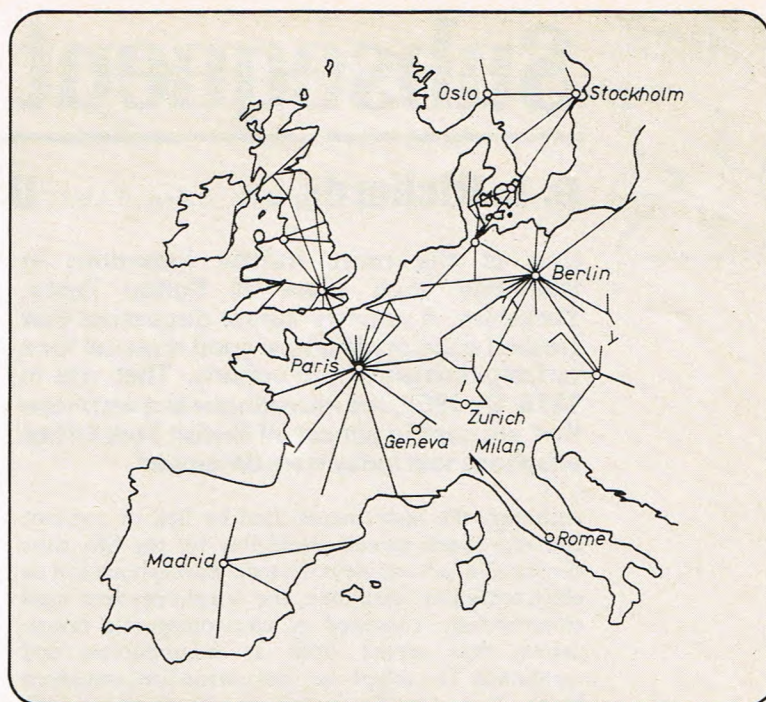
3 RHODES, F. L.: 'Beginnings of telephony' (Harper, 1929)

4 DUNSHEATH, P.: 'A history of electrical engineering' (Faber, 1962)

5 RAPHAEL, F. C.: 'The telephone system of the United Kingdom', *Electrician*, 1897, 39, pp.307-9 and 334-335

6 WEBB, H. L.: 'The development of the telephone in Europe' (Electrical Press, 1911)

7 'The rise and progress of telephony in the United Kingdom', *Electrician*, 1887, 19, pp.288-9, 338-9, 412-3; 1888, 20, pp.230-231 and 338



5 European telephone network in 1896, main lines only. Just the southernmost parts were left without international links

8 *Ibid.*, 1887, 19, p.310

9 BALDWIN, F. G. C.: 'The history of the telephone in the United Kingdom' (Chapman & Hall, 1938)

10 BENNETT, A. R.: 'The telephone systems of the continent of Europe', (Longman Green, 1895)

11 'The rise and progress of telephony in the United Kingdom', *Electrician*, 1888, 20, pp.437-438

12 Post Office Records Office (Preece Collection). Data in memoranda from Lancashire & Cheshire Telephonic Exchange Co., 6th and 7th March 1886

13 *Hansard*, 319, report for 16 Aug. 1887, pp.664-5

14 TUCKER, D. G.: 'Beginnings of long-distance telephony, 1882-87', *Electron. & Pwr.*, 1974, 20, pp.825-827

15 TUCKER, D. G.: 'The first cross-Channel telephone cable: the London-Paris telephone links of 1891', *Trans. Newcomen Soc.* (to be published)

16 BALDWIN, F. G. C.: 'The history of the telephone in the United Kingdom' (Chapman & Hall, 1938), p.486

17 GAVEY, J.: 'The telephone trunk line system in Great Britain', *J.IEE*, 1896, 25, pp.624-656

18 BENNETT, A. R.: 'Some lessons in telephony', *Elect. Eng.*, 1895, 16, pp.319-321 and 365

19 BRAULT, J.: 'Histoire de la Téléphonie' (Masson, 1888), pp.97-100

20 'Long-distance telephony', *Electr. Rev.* (New York), 20th Nov. 1886, 9, p.6

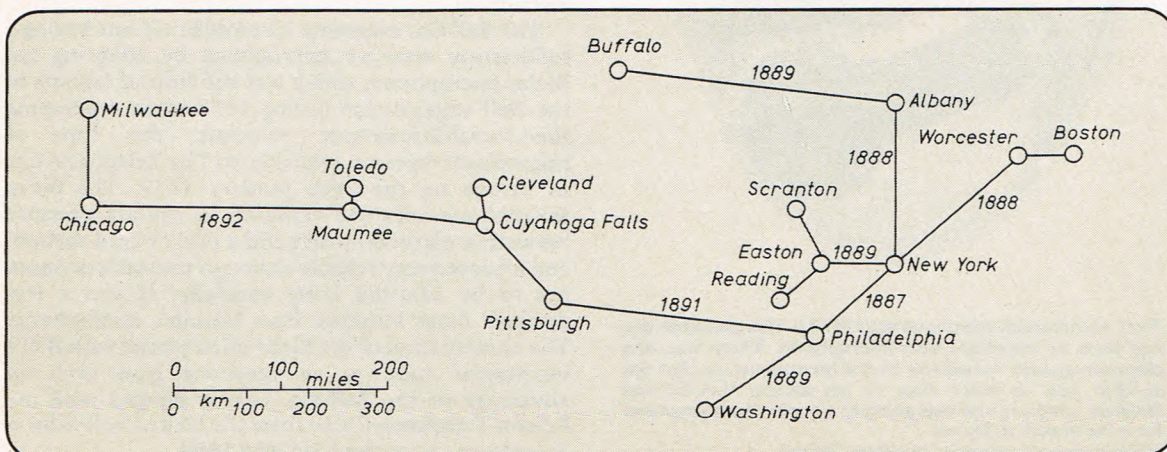
21 'Long-distance telephoning', *ibid.*, 17th Mar. 1888, 12, pp.1-2

22 'From an admirer of the telephone', *ibid.*, 23rd Nov. 1889, 15, p.6

23 'One thousand miles by telephone', *ibid.*, 1892, 21, pp.109-110

24 *Ibid.*, 31st Aug. 1889, 15, p.6

25 SHAW, T.: 'The conquest of distance by wire telephony', *Bell Syst. Tech. J.*, 1944, 23, pp.337-421



6 Development of the long-distance telephone network in the USA 1888-92 (American Telephone & Telegraph Co.). By 1892, commercial telephony over a distance of 1625 km between New York and Chicago was established. The American Telephone & Telegraph Co. was referred to generally as the Long Distance Telephone Co. It was a subsidiary of the Bell Co.



Subsequent developments

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One of the most fruitful inventions in telephony took place at Bolton Percy, Yorkshire. A country curate discovered that crushed coke made a very good material for a variable-resistance microphone. That was in 1878. By 1957, the microphone and earphone that are used in almost all British Post Office telephone sets today were developed

Although the instruments used by Bell to transmit and reproduce speech intelligibly for the first time consisted of a 'variable-resistance' microphone and an electromagnetic earphone, the telephones first used commercially consisted of electromagnetic instruments that served both as microphones and earphones. The telephone instrument first employed by the Telephone Co., which was set up on the 14th June 1878 to exploit Bell's patents in Britain, was as shown in Fig. 1. The customer did not have to have a set with two instruments, he could make do with one by adopting 'semiduplex', i.e. making clear to his partner that he had finished speaking and was going to transfer the instrument from his mouth to his ear. The methods of use are illustrated in the Figure.



1 First commercial telephone set (1877). The customer did not have an earphone and microphone. There was one electromagnetic transducer in the instrument, so that the speaker had to make clear to his partner that he had finished speaking and was going to transfer the instrument from his mouth to his ear

[Illustration: Courtesy of the Post Office]

Although Bell and Watson had made great improvements in the electromagnetic instrument, and these enabled it to be used as a microphone and as an earphone, the arrangement, being entirely 'sound powered', could not be expected to be very sensitive as a complete telephone connection. In fact, it could not be used with more than a few decibels of transmission loss between instruments. It was therefore inevitable that use would be made of the discovery in 1856 by Count Th du Moncel that the contact resistance between two poorly conducting solids is dependent on the pressure between them. This fact can be used to produce a more sensitive microphone because the relatively weak power of the voice can be arranged to modulate much greater power from a battery, so providing amplification.

With great energy, Thomas Alva Edison and his assistants tried some 2000 different substances before settling for carbon in the form of a cake of compressed lampblack as the active element in a variable-resistance microphone. Edison secured a patent on this arrangement on the 15th June 1878.

When it was manufactured, the increased sensitivity of the Edison microphone provided a strong challenge to the Bell companies' operations, especially when the Edison Telephone Co. was set up in Britain on the 2nd August 1879. However, the Edison Co. found itself in a difficult position because it could not match its sensitive microphone with an earphone as sensitive as Bell's and patent protection prevented them from using that itself. With characteristic ingenuity, Edison produced a rival receiving device based on his discovery in 1873 that the friction between a metal contact and a moving strip of paper moistened with an electrolyte, such as a solution of potassium iodide, was varied by the passage of an electric current between the point of contact and the paper.

Loud reproduction

The Edison chalk receiver uses a cylinder of chalk rotated by a handle and a diaphragm of mica to which is fitted a brass spring carrying at its extremity a platinum contact, which presses on the surface of the chalk. The chalk is moistened with the solution and the speech currents passing between the contact and the chalk surface vary the friction and cause the diaphragm to vibrate in sympathy and so reproduce the speech sounds. Very loud reproduction was claimed, but the device lacked the simplicity of Bell's instrument.

The Bell Co. overcame its problem of not having a sufficiently sensitive microphone by adopting the Blake microphone, which was the fruit of labours in the Bell organisation during 1878 when developing the variable-resistance principle; this type of microphone became available to The Telephone Co. in Britain on the 20th January 1879. The Blake microphone uses the variation in contact pressure between a platinum pellet and a disc of hard carbon, and it proved very reliable although the static pressure has to be adjusted fairly carefully. It was a few decibels more sensitive than Edison's microphone. The combination of the Blake microphone with Bell's instrument used as an earphone gave such an advantage to the Bell Co. that it merged with the Edison Telephone Co. to form the United Bell-Edison Telephone Co. on the 13th May 1880.