'Hello Who's Calling?'

by J.K. Hearfield

How Telephones were Invented

In 1854 a paper was published by Charles Bourseul in which he described an experiment. "Suppose", he wrote, "a man speaks near a movable disc sufficiently pliable to lose none of the vibrations of the voice. If this disc alternately makes and breaks currents from a battery, you may have at a distance another disc, which will simultaneously execute the same vibrations . . . It is certain that, in the more or less distant future, speech will be transmitted by electricity". In 1876, Alexander Graham Bell's assistant, Mr. Watson, was the first man to have his work interrupted by a telephone call, and life has never been the same since.

Picture 1 shows Bell's first telephone of 1876. Bell's telephone consisted of a mobile iron diaphragm placed in the field of a polarised electromagnet, so arranged that any movement of the diaphragm produced a change in field. The same principle was used for both transmitting and receiving, so a conversation could be held between two identical instruments.

Bell was invited to demonstrate his wonderful machine to Queen Victoria at Osborne House in January 1878, and in 1879 the Telephone Company Limited was formed. The company was given a licence to use the Bell patents and opened its first telephone exchange in London the same year.

Picture 2 shows a fretwork fronted telephone, 1878 – one of the first used by the British Post Office. The user spoke into the microphone concealed behind the fretwork cover. Later in 1879, the Edison Telephone Company of London Limited opened a rival telephone exchange. Edison's design of microphone was more efficient and more practical than Bell's. It used the speech energy to compress a piece of carbon, thus varying its resistance. Two years later, the Reverend Hunnings built an even better microphone in which carbon granules replaced the single carbon block, and this design has formed the basis of most telephone microphones ever since. Picture 3 shows Edison's telephone of 1879 with its carbon transmitter and chalk receiver.

Why the Post Office Intervened

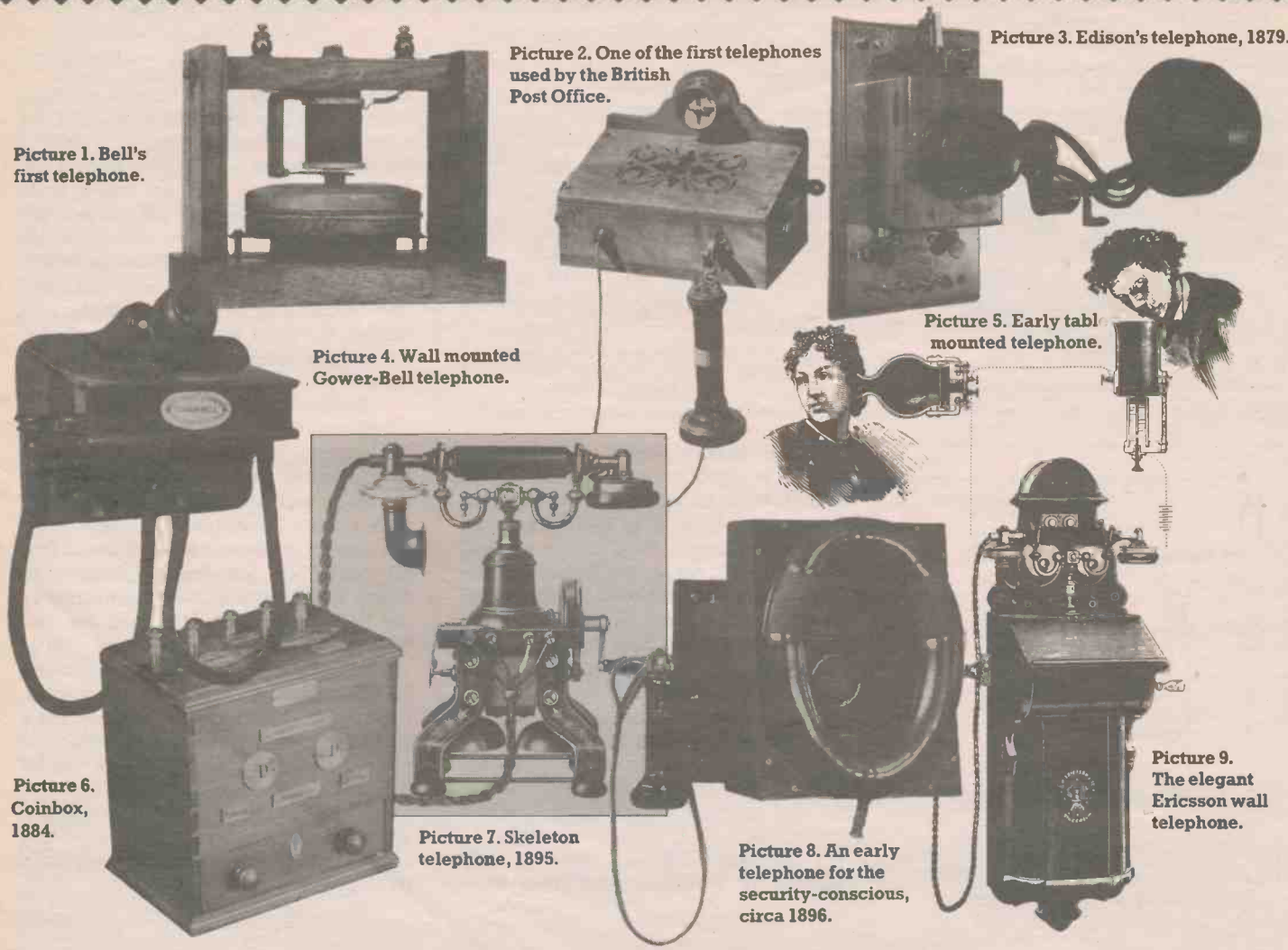
In 1880, the two telephone companies amalgamated to become the United Telephone Company, holding patents for both systems. This new telephone system threatened the then sole means of long-distance communication: the telegraph. Telegraphs were already under the control of the Post Office and, after successfully arguing that telephone calls were similar to telegrams, the Post Office was granted sole control of telephone systems by the High Court in 1880.

The Post Office then granted licences to such as the National Telephone Company to open and operate telephone exchanges. Usually the National Telephone Company operated within towns and cities, the Post Office providing the trunk lines and rural exchanges. London and Birmingham were linked in 1890, and London and Paris the following year.

The Post Office also opened a number of telephone exchanges in different cities and in 1899 an Act of Parliament enabled local authorities to operate their own exchanges. Of the few cities which took advantage of this, only the Hull system remains today as an independent telephone company.

Picture 4 is of the Gower-Bell telephone, circa 1881; the two flexible tubes were held to the ears. Elisha Gray's telephone of 1882 is shown in Picture 5 and Picture 6 shows the Smith and Sinclair coinbox.

The first public telephones were installed in shops as early as 1884. Only non-subscribers were required to use coins to pay for their calls – telephone company subscribers were issued with pass keys. The coinbox had separate



Picture 1. Bell's first telephone.

Picture 2. One of the first telephones used by the British Post Office.

Picture 3. Edison's telephone, 1879.

Picture 4. Wall mounted Gower-Bell telephone.

Picture 5. Early table mounted telephone.

Picture 6. Coinbox, 1884.

Picture 7. Skeleton telephone, 1895.

Picture 8. An early telephone for the security-conscious, circa 1896.

Picture 9. The elegant Ericsson wall telephone.

coin slots for local calls (2d) and trunk calls (6d).

The rather elegant Ericsson skeleton telephone of 1895, also known as the Telephone No. 16 (shown in Picture 7), is an example of good industrial design, since the induction coil for the speech circuits is hidden inside the bell shape which supports the cradle for the handset (then called the 'microtelephone'), and the curved legs form the magnets for the hand generator. The local battery is accommodated in a separate box, enabling the telephone to be used as a table rather than wall-hung model.

By contrast, the horse-collar telephone shown in Picture 8 was widely disliked. The idea was simple: a caller who did not wish to be overheard could press his face against the rubber collar, emerging presumably from time to time in order to breathe. Users thought it too unhygenic, and the design didn't last long.

Basic Telephony Principles

The simplest possible two-way telephone circuit is shown in Figure 1. It consists of a microphone, sometimes called a 'transmitter', and a receiver at each end of the line, with a battery somewhere in the circuit to provide the DC needed by the microphones. A microphone translates variations in sound pressure into variations of resistance, so that the current flowing around the circuit depends partly on the instantaneous sound pressure at each microphone. A receiver works rather like a loudspeaker, translating the small current variations into varying forces on a diaphragm and hence back into variations in sound pressure.

This circuit has several major disadvantages. First, and perhaps most important, it is very inefficient. The resistance of a microphone is quite small compared to the resistance of the whole circuit, so variations in this resistance can produce only minute variations in the circulating current. In energy terms, there is a very poor impedance match between the source (the microphone) and its load.

Second, the same current flows through both receivers, so the person speaking hears himself at the same sound level as does the person listening. This

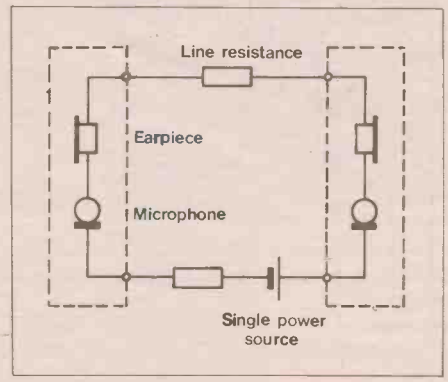


Figure 1. The simplest possible telephone connection.

local reproduction of outgoing speech is known as 'sidetone', and too much sidetone has the unfortunate psychological effect of causing the speaker to lower his voice, further degrading the effective performance of the circuit. The DC flowing through the receivers is not in itself a problem, since early receivers used it to power the electromagnets they used. Modern receivers are designed around permanent magnets however, and would not work well in this circuit.

Third, there is no means of signalling in either direction. The circuit consumes the same amount of power whether or not it is actually in use.

The Local Battery (LB) circuit, shown in Figure 2, was devised to overcome at least some of these shortcomings. The microphone now sees just the low (and constant) resistance of the induction coil primary, which also improves its impedance match to the line. The match will rarely be exact, of course, because each telephone will be connected to a different length of line. The induction coil is a special type of transformer in which the magnetic circuit is deliberately not closed. This avoids the problems of core saturation that would otherwise occur due to the large DC flowing through one or both windings.

The simple LB telephone still has no means of signalling either that the user wishes to make a call or that an incoming call has arrived. The first attempts to provide signalling involved the use of a trembler bell, as illustrated in Figure 3. This circuit also illustrates how the hooks-

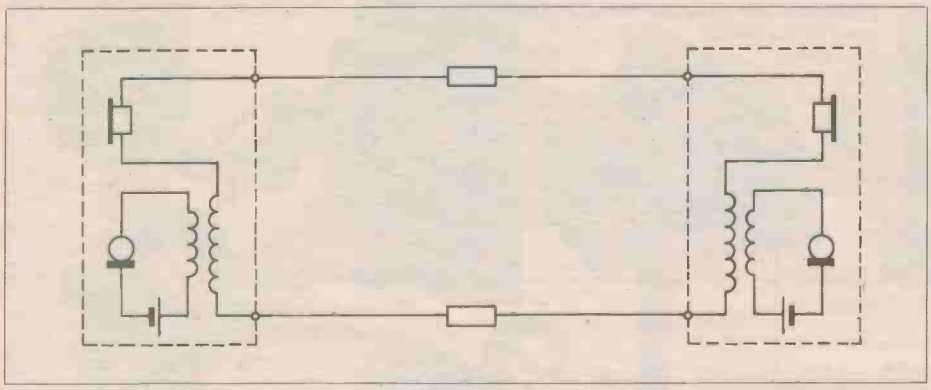


Figure 2. Local battery telephone principle.

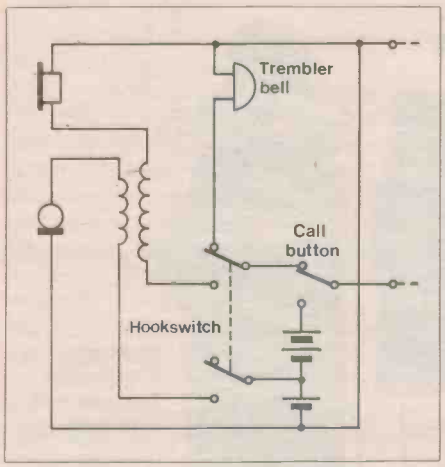


Figure 3. Local battery telephone with signalling.

witch (or 'gravity switch' as it was then called) is used to change the circuit configuration depending on whether or not the telephone is in use. In the idle state, the microphone circuit is broken, and the bell is connected across the line ready to detect an incoming ring signal (which in this case is just a battery applied across the line by the calling party). In use, the microphone is powered up and the receiver connected across the line in place of the bell. The user signals he wishes to make a call by pressing the CALL button, which connects the two batteries in series across the line in order to ring the bell at the distant end.

Trembler bells are however only suitable for signalling over quite short lines. For longer lines, a more efficient solution is to use high voltage AC, and the magneto – a hand-cranked alternator – quickly became a standard fitment on telephones. It was used not only to alert the operator that the user wished to make a call, but also to signal the end of the call by ('ringing off'). A magneto generally included some means of switching itself into circuit only when the handle was turned, as Figure 4 illustrates, to prevent its low resistance from affecting the speech performance of the telephone.

Picture 9 shows the Ericsson LB wall telephone, the ornate casing concealed the magneto generator (operated by the handle visible on the right hand side) and the large and sometimes messy battery cells mounted underneath.

One of the most popular designs was the so-called 'candlestick' telephone, which was known in its various forms as the Telephone No. 2, No. 4 and No. 150. The circuit diagram of the Type 150 is shown in Figure 5, and though it appears to differ only slightly from earlier circuits, it was in fact designed to work within a quite new system concept, known as Central Battery Signalling, which will be discussed in the next article.

Acknowledgement: All telephone illustrations are reproduced by courtesy of the archivist at The Telecom Technology Showcase.

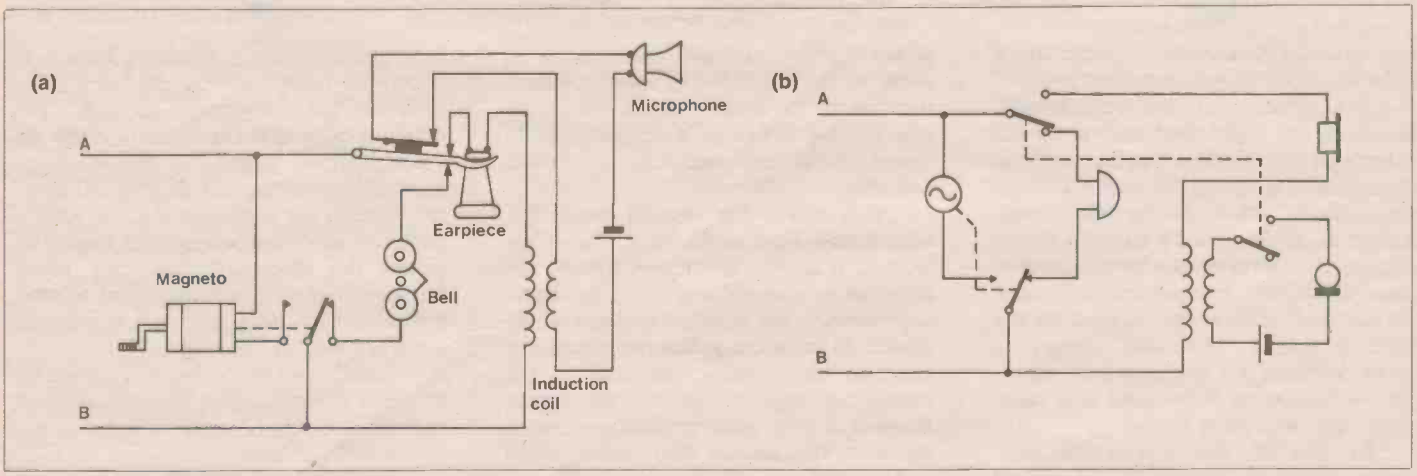


Figure 4. The Telephone No. 11 circuit (a) as it would have been drawn at the time, (b) redrawn with modern symbols.

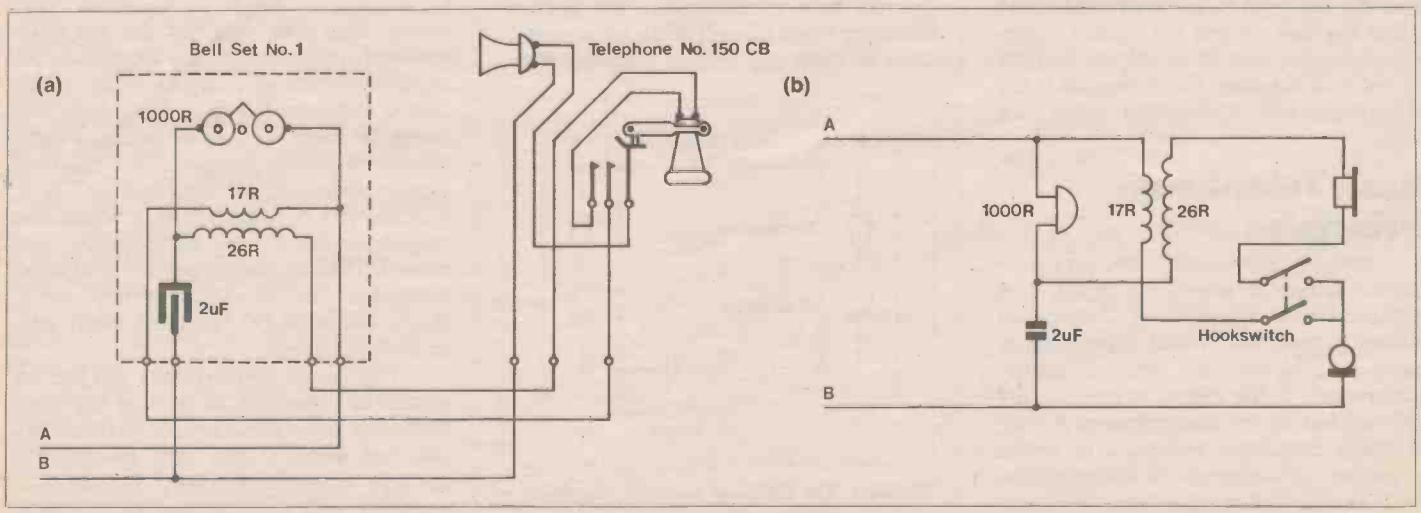


Figure 5. The 'candlestick' telephone circuit (a) in its original form, (b) redrawn with modern symbols.