

XXX.—THE DEVELOPMENT OF THE TELEPHONE EXCHANGE

IN the previous article in this series we described the development of the telephone in America from a crude apparatus, faintly

conveying the sound of the human voice into a practical instrument enabling two people to talk to one another from a distance when they had the necessary instruments connected together by wires. The next problem was that of devising some means of enabling all the owners of instruments in a certain area to be placed in communication with one another as required, and it was solved by the introduction of the telephone exchange. In the exchange system the wires from all the telephones in a certain area are extended to a central building, where they terminate at a switchboard in charge of an operator, usually a girl, whose duty it is to put any subscriber of that area in touch with any other subscriber he desires to speak to, by connecting the wires from his telephone to those leading to the telephone of the called subscriber.

The first telephone exchange was established in Boston, America, in 1877, and was a small and crude affair. It had no facilities for placing telephone users in direct communication with each other, and one subscriber wishing to get into touch with another had to call up the operator, who received the message and repeated it to the desired person. As the number of subscribers increased it became impossible for the operator to keep pace with the calls, and it was obvious that some means must be devised of enabling the operator to put telephone users in direct communication with each other easily and quickly.

The invention of the "Williams" switchboard made this possible. This switchboard consisted of two vertical panels carrying the indicating mechanism, and immediately in front of these were two operator's tables each provided with a transmitter and receiver, and connecting, earthing and battery keys. Numerous horizontal brass strips grouped in pairs and containing holes for the reception of circular pegs extended across the upper portion of each panel. The lower portion contained three rows of indicators or "drops," the front portion of each drop consisting of a small metal door hinged at the bottom. Immediately beneath each drop was a "slipper," which consisted of a small flat brass spring that made contact with a brass plate connected to earth through the indicator. In addition there was a set of flexible cords each terminating at one end in a circular brass peg and at the other end in a plug called a "flat jack," a small brass plate secured to a piece of insulating material.

When a subscriber wished to get into touch with the exchange he pressed a "calling button" on his instrument, and this action caused a battery current to be transmitted over his line to the slipper associated with his telephone number on the exchange switchboard, where the opening of the door of the indicator notified the exchange of his call. F. G. C. Baldwin in his book "The History of the Telephone in the United Kingdom" relates that "the connecting operator then inserted the flat jack at the end of one of the loose cords into the slipper associated with the indicator of the calling subscriber, which had the

effect of connecting the cord to the subscriber's line, and disconnecting the subscriber's indicator and earth connection. The circular peg at the other end of the connecting cord was then inserted into one of the holes in a brass strip which was not in use and the indicator shutter restored."

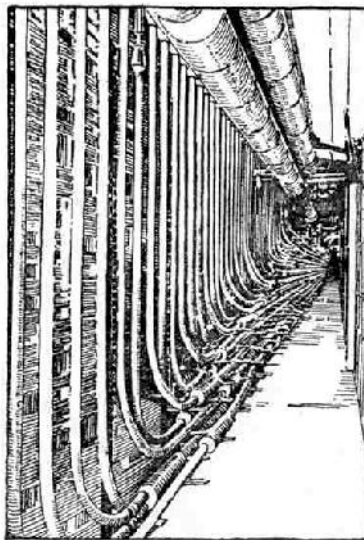
This operation connected the subscriber's line to keys controlled by the second or "answering" operator who, by depressing appropriate keys, established connection with the particular horizontal strip to which the calling subscriber was connected, and asked for the telephone number required. "The connecting operator," says Baldwin, "was then instructed to connect the wanted subscriber's line to the horizontal bar which formed a pair with the first one, a second connecting cord being used for the purpose. The required subscriber was then called by means of a key associated with the answering operator's instrument and, when his attention had been secured, he was informed of the pending conversation and the two subscribers left connected through the two connecting cords."

A switchboard of this type was imported from America and installed in the first telephone exchange in England. This exchange was established in 1879 at 36, Coleman Street, E.C., and started with only seven or eight subscribers. A steady increase in subscribers soon resulted in two more telephone exchanges being started in London, one at Leadenhall House, in Leadenhall Street, and the other at 3, Palace Chambers, Westminster. The switchboard at Leadenhall House was made in this country and though similar to the others in being of the "slipper jack" type it had some novel features, one being that it had numerous brass contacts instead of the horizontal strips of the Williams switchboard. Another innovation was that when a subscriber replaced his receiver at the close of a conversation the descending switch hook of his telephone caused a "clearance signal" to be automatically transmitted to a galvanometer at the exchange.

These early exchanges, and others installed in various provincial cities, placed subscribers in touch with one another, but the method by which this was done entailed much manipulating by the operator and consequent delay to the caller.

For many years telephone users called up the operator at an exchange by turning a handle situated at the side of their instrument. The handle worked a small dynamo and the current produced caused the door of the drop on the exchange switchboard to fall open, revealing the caller's telephone number.

Immediately the operator switched on her telephone to the caller this door automatically resumed its closed position. The operator then ascertained the telephone number required and called up the subscriber concerned. Some of these handle-operated telephones are still in use, but they are being replaced gradually by instruments that do not entail the turning of a handle or the opening and closing of drops at the exchange.



In the cable vault of a telephone exchange. The many wires in the lead-covered cables lead from the subscribers' instruments to the exchange switchboard.



A modern telephone instrument equipped with dial for automatic operation.

The user of the improved telephone needs only to lift the receiver from its rest and immediately a small electric bulb near his indicator and jack on the exchange switchboard lights up.

At the exchange numerous flexible cords terminating in plugs, and grouped and electrically connected in pairs, rest on a long shelf in front of the operator. The cords pass through the shelf and hang below it, being kept taut by lead weights on pulleys. When a plug is lifted the cord comes up through the shelf, and when the operator later releases it from the switchboard it is drawn back into its hole by the weight on the cord. A small lamp is fixed close to each cord, and as mentioned earlier each jack also has a lamp of its own. Normally the two lamps near each pair of cords are lighted, but when a subscriber lifts his receiver to call the exchange, the lamp associated with the first cord goes out, and the lamp near his jack immediately glows. This lamp goes out when the operator inserts one plug of a pair into the jack indicated by the light. She switches on her telephone to the caller and says "Number, please," and on receiving this information she inserts the other plug of the pair into the jack associated with the required number. This causes the lamp of the second cord to glow. The operator then presses a button that causes the bell of the wanted subscriber's telephone to ring. Immediately that subscriber lifts his receiver to answer the summons the lamp of the second cord goes out, thus silently informing the operator that he has responded and that the two subscribers are in communication with each other. At the close of their conversation the speakers replace their instruments and immediately the two lamps concerned at the exchange light up, and the operator knows that she can disconnect the plugs.

As the telephone became more and more popular and the number of subscribers increased, additional switchboards had to be installed in all important exchanges. Each switchboard was in charge of one operator and the telephone numbers ran consecutively, the first switchboard dealing perhaps with 200 lines, numbered 1 to 199; the second switchboard with lines numbered 200 to 399, and so on. By this means a very large number of subscribers could be dealt with by a single exchange, but a serious defect of the system was that a subscriber belonging to the first section could not easily be connected to a subscriber in the other sections owing to the distance the first operator had to stretch across to the other operators. It was of the utmost importance that each operator should be able to quickly connect any one of her subscribers to any other subscriber in the exchange, and the problem of accomplishing this was solved by the adoption of the "multiple" switchboard.

The first switchboard of this kind was fitted in the Central Trunk Exchange in Oxford Court, Cannon Street, London, in 1883, and since that time thousands of multiple switchboards have been installed in exchanges throughout this country and abroad.

A modern multiple switchboard is divided into sections each provided with as many jacks as there are lines in the exchange. Suppose the exchange has 1,800 lines, and that these are divided into groups of 200 lines. Above the 200 indicators in front of each operator there are 600 jacks which, together with 600 on her left and 600 on her right, cover the whole of the lines of the exchange, so that each operator can reach any number unassisted. It will be seen that all the sections are multiples of each other, and the

duplicate jacks are known as "multiple jacks." These jacks are connected in parallel with one another. The lamps are not multiplied, for only one operator is required to answer any particular line at once, although all must be able to call it.

The multiple system made necessary a further addition to the switchboard circuit, for if a certain subscriber is engaging in a conversation put through by the operator covering his number, he must not be interrupted by being called by another operator further down the switchboard who cannot see that he is engaged by the operator of his section. In order to enable operators to

ascertain quickly whether the line is free or not, an electrical test is incorporated in the system. When two lines are connected, all the multiple jacks belonging to each line become charged with electricity, and any operator who touches one of these jacks with the tip of a plug hears a clicking sound in her receiver, by which she knows that the line is engaged elsewhere.

It is essential that the operator should have both her hands free to manipulate the plugs, and for this reason her telephone receiver is fixed over one ear by means of a clamp over her head, and a peculiarly shaped transmitter is suspended from her shoulder so that it is always close to her mouth.

Trunk calls, when a subscriber from one exchange wishes to speak to a subscriber belonging to another, are put through in different

ways at different exchanges, according to the method of working. The common system is for each operator to have before her a number of jacks that are connected to the neighbouring exchanges in the same way as the other jacks on her switchboard are connected to subscribers. The called exchange answers and is informed of the number required, and the call is put through in the usual way.

The manual system just described is employed at the present time in thousands of exchanges throughout the world. Although it entails the employment of a fairly large staff of operators, it represents an enormous advance on the system used in the early days of telephony, particularly in the employment of various automatic devices to assist and speed up the service.

Rapidly as the telephone system advanced, telephone engineers were not satisfied, for they had visions of automatic systems in which the exchanges would require no operators, subscribers making their own connections by means of simple switching arrangements in their own homes.

Three American inventors patented an automatic switching device as long ago as 1879, and instruments incorporating their invention were shown at the Paris Exhibition held two years later. The defects of the system were so numerous, however, that it did not come into general use.

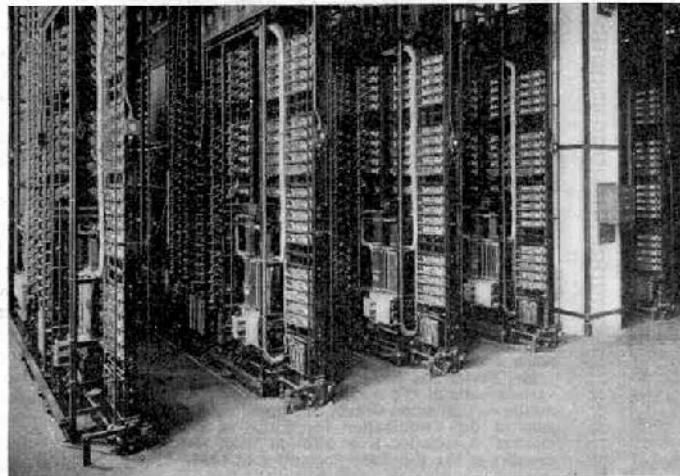
In 1883 a British engineer named Sinclair took out a patent for a semi-automatic switching device for use at branch telephone exchanges. This instrument incorporated a system of remote control by which telephone calls were controlled from the distant control exchange, where operators were in attendance, thus dispensing with the need of an operator at the branch exchange. An instrument of this kind was installed at Coatbridge, near Glasgow, in 1886, six years before automatic exchanges came into use in America.

Sinclair's line selector, as the invention was known, was far from perfect, but a more efficient system was not invented until 1889. In that year A. B. Strowger, a Kansas

(Continued on page 150)



Interior of a large manual operated telephone exchange, showing the extensive switchboard.



Some of the complicated mechanism at an automatic telephone exchange.