and then either to earth or back to the induction coil by a return line of wire.

Another type of microphone which was used in Europe much more than in the United States was the multiple-contact instru­ment. In this several microphonic joints were employed.

Thus, in the Crossley transmitter four hard carbon pencils were arranged in a lozenge-shaped figure, the ends of each pencil resting loosely in a small carbon block. These blocks were fastened to a diaphragm of wood. The circuit connexions were such that two adjacent sides of the lozenge were in parallel and two in series. In the Ader transmitter as many as twelve carbon pencils were employed, arranged in a scries of two groups with six pencils in parallel in each group. These were supported at their ends in parallel carbon bars, which were carried by a nearly horizontal wooden diaphragm. Such multiple-electrode transmitters give a loud although somewhat harsh sound, and will bear being spoken to very strongly without breaking the circuit.

A type of transmitter which has come to be invaluable in connexion with long-distance telephony, and which has prac­tically superseded all other forms, is the granular carbon trans­mitter. The earliest instrument of this kind was the Hunnings transmitter, patented in 1878. This was constructed of a shallow box placed in a vertical position, with metallic front and back and insulating sides. The front face was of thin metal, and served as a diaphragm. The box was filled nearly, but not quite full, of granulated hard carbon. The current from the battery used passed from the diaphragm through the granulated carbon to the metallic back of the box. When spoken to the diaphragm vibrated, and thus set the carbon granules into vigorous vibration. The vast number of microphonic contacts present give rise to very strong electrical un­dulations, and hence to a loud sound.

The chief difficulty with this transmitter, and with various others of later date based upon it, has been the frequent pack­ing of the carbon granules, which renders the instrument in­operative. The difficulty was first satisfactorily overcome in the long-distance transmitter, invented by A. C. White in the laboratory of the American Bell Telephone Company, and commonly known as the “ solid back transmitter ” (fig. 6).

The microphonic portion of the transmitter is contained in a thin cylindrical box or case of brass A, the inner curved surface of which is covered with an insulating layer of paper. The case is firmly fixed to a “ bridge ” B with its back or bottom in a vertical position. To the brass bottom of the case is attached a thin disk of polished hard carbon C, which is slightly less in diameter than the brass bottom, so that the carbon disk almost entirely covers this brass back, leaving only a slight annular space around its edge. The front or cover of the case is a similar button of hard polished carbon D, also slightly smaller in diameter than the cylin­drical wall of the box. It is attached to a brass disk E, which is fastened to the centre of the diaphragm F by means of a rivet, and is capable of moving to and fro like a plunger when the dia­phragm vibrates. A washer of thin flexible mica G concentric with the carbon button is carried by the brass disk, and projecting over the edge of this is held firmly against the rim of the cylin­drical wall of the case by an annular brass collar H, which is screwed upon the outer curved surface of this wall. The box is thus entirely closed at the front, while the front carbon disk, which constitutes an electrode, is perfectly free to follow the motions of the diaphragm.

The space enclosed between the front and rear faces of the box is filled about three-quarters full of finely granulated hard carbon, which therefore lies in contact with the front and rear carbon disks of the apparatus, and also fills up the space lying between the lower edge of these disks and the curved surface of the case. The current from the battery passes from one of the carbon disks to the other through the particles of granulated carbon which fill the space between them.

The disks and granules constitute a very powerful microphone. The motions impressed upon the carbon granules are very vigorous, and this together with the particular arrangement of the parts of the instrument is effectual in obviating the difficulty from packing which attended the use of earlier forms of granulated carbon trans­mitters. This instrument has almost entirely displaced all other forms of transmitter.

*Subscribers’ Organization.—*The employment of the telephone as one of the great means of communication requires a definite organization of the subscribers. It is not practicable to connect each subscriber directly to all the others, hence a system of exchanges has been adopted. The territory in which a tele­phone administration operates is usually divided into a number of local areas, in each of which one or more exchanges are placed. An exchange is a central station to which wires are brought from the various subscribers in its neighbourhood, any two of whom can be put in telephonic communication with each other when the proper pairs of wires are joined together in the exchange.

When the subscribers in a local area exceed a certain number,. or when for some other reason it is not convenient or economical to connect all the subscribers in the area to one exchange, it is usual to divide the area into a number of districts in each of which an exchange is placed, and to connect these district exchanges together by means of “ junction circuits.” In some cases the exchanges are connected together directly; but when the volume of traffic is not sufficient to warrant the adoption of such a course connexions between two exchanges are made through junction centres to which both are connected.

A system of wires, similar to that which connects the district exchanges in an area, links together the various local areas in the territory, and sometimes the territory of one administration with that of another. These inter-area or long-distance lines, called trunk circuits in England, terminate at one exchange in each local area, and between that exchange and the various