district exchanges junction circuits are provided for the purpose of connecting subscribers to the trunk lines.

*Circuit and Working Arrangements.—*The method first em­ployed for working a telephone line was extremely simple. A single fine of wire, like an ordinary telegraph line, had a Bell telephone included in it at each end, and the ends were put to earth. Words spoken to the telephone at one end could be heard by holding the telephone to the ear at the other. To obviate the inconvenience of placing the telephone to the mouth and the ear alternately, two telephones were commonly used at each end, joined either parallel to each other or in series. The contrivance most generally adopted for calling attention was a call-bell rung either by a small magneto-electric machine (magneto-generator) or by a battery. The telephone was switched out of circuit when not in use and the bell put in its place, a key being used for throwing the battery into circuit to make the signal. This arrangement is still employed, a hook being attached to the switch lever so that the mere hanging up of the telephone puts the bell in circuit. In some cases when a magneto-generator is employed for calling purposes the coil of the machine is automatically cut out of circuit when it is not in action, and is brought into circuit when the handle is turned by the operation of a centri­fugal or other arrangement.

At first it was usual to join the microphone transmitter in the direct circuit. It was soon found that it could only be used to advantage in this way when the total resistance of the circuit, exclusive of the microphone, was small compared with the resist­ance of the microphone—that is, on very short lines worked with low resistance telephones. The transmitter on long and high- resistance lines worked better by joining, in the manner shown in fig. ", the microphone, a battery and the primary of an induction coil in a local circuit, and putting the line in circuit with the secon­dary of the induction coil, which acted as the transmitter. The resistance of the microphone can thus be made a large fraction of the total resistance of the circuit in which it is placed; hence by using considerable currents, small variations in its resistance can be made to induce somewhat powerful currents in the line wire. The requisite energy is derived from the battery.

In the earliest telephone switchboards the lines were connected to vertical conducting strips, across which were placed a series of similar horizontal strips in such a manner that any horizontal could be connected to any line strip by the insertion of a plug into holes provided in the strips for the purpose. Any two lines could be connected together by connecting both to the same horizontal strip.

The next step of importance was the introduction of what was termed the “Standard board.” This board was equipped with spring-jacks and annunciators (calling-drops) for the subscribers’ lines, and with flexible cords terminating in plugs for connecting purposes. The spring-jack used was a form of switch with two contact springs which pressed against each other, one being con­nected to the subscriber’s line wire and the other to the annun­ciator, which was also earthed. When a plug was inserted in the spring-jack the connexion between the springs was opened, dis­connecting the calling-drop from the line. Each connecting-cord circuit had associated with it a clearing-out drop connected between the cord and earth and a key by means of which the operator’s speaking and ringing apparatus could be brought into circuit. When a subscriber called (by turning the handle of his magneto­generator), the shutter of the annunciator associated with his line dropped. This attracted the attention of the attendant, who in response to the call inserted a plug into the spring-jack and con­nected the speaking apparatus to the circuit by means of the key. Then, having obtained particulars of the subscriber’s requirement, the operator connected the second plug to the spring-jack of the wanted subscriber, whom she rang up. When the conversation was finished either of the subscribers could release the shutter of the clearing-out drop by turning his generator handle, and the operator thus notified of the fact removed the plugs and discon­tinued the connexion.

The single-wire earthed circuits used in the early days of tele­phony were subject to serious disturbances from the induction caused by currents in neighbouring telegraph and electric light wires, and from the varying potential of the earth due to natural or artificial causes. The introduction of electric tramways caused an enormous increase in disturbances of this class. It was early recognized that a complete metallic circuit would obviate troubles from varying earth potentials, and that if the outgoing and in­coming branches of the circuit were parallel and kept, by trans­position spiralling, or otherwise, at equal average distances from the disturbing wire, induction effects would likewise be removed. These advantages led to the gradual supersession of the single-wire system until at the present day the all-metallic system is employed almost universally. Since the time when the system first became prominent all switchboards have been arranged for metallic circuits.

Though many types of manually operated switchboards have been brought into use, differing from each other in respect of cir­cuit and working arrangements, yet each of them may be placed in one or other of three main classes according as the system of working is magneto, call-wire, or common battery. The funda­mental principle of the magneto system has been described in con­nexion with the "Standard board."

In a large exchange a number of operators are necessary to attend to calls. Several single switchboards like that described may be employed, each devoted to a certain section of the sub­scribers, and placed in care of an operator. In these circumstances, when, as frequently will be the case, the person calling desires to be put in communication with a subscriber who belongs to another section, connexions must be established in the office between the two sections; this necessitates additional switchboard arrange­ments, and also increases the time required to put subscribers in communication with one another. The difficulty was obviated by the introduction of the “ multiple switchboard.” This board is built up in sections of one or more operators’ positions each. All the subscribers’ lines are connected in order to jacks on the first two or three or four operators’ positions, and these connexions are repeated or “ multipled ” upon each succeeding similar group of positions. Each subscriber's circuit is further connected to another spring-jack directly associated with the calling-drop. These spring­jacks, known as answering jacks, are distributed along the switch­board, a certain number being terminated upon each position and placed in the care of the operator assigned to that position. Hence this operator, when signalled in the ordinary way, can put any one of these subscribers in connexion with any subscriber whatever, without the necessity of calling upon another operator to make connexions.

Two methods of “ multipling ” have been much used. In the arrangement first introduced the line wire is connected in series through the various spring-jacks, the circuit finally passing through the answering jack to the calling-drop. This arrangement is liable to give trouble, as disconnexions may arise in the spring-jacks in consequence of the failures of the springs to make contact. Operat­ing mistakes also cause interruptions to conversations, as it is possible, by the insertion of a plug in a multiple jack, to disconnect the circuit between two talking subscribers. To overcome these difficulties the “branching multiple” was introduced. In this arrangement, instead of the circuit being made through the jacks in series, each jack is connected to an independent branch from the main circuit. With the “ branching multiple ” the "self-restoring drop ” was introduced. This apparatus has two coils, one of which, connected across the line, is provided for the purpose of projecting the shutter, while the other is intended for its restora­tion and is joined in a local circuit arranged to be closed when a plug is inserted in any one of the associated jacks.

It is necessary that the operators working at a multiple board shall be able to ascertain without entering a subscriber's circuit whether the circuit be disengaged. This requirement is usually met by connecting a third or “ test ” wire to each of the jacks associated with a subscriber’s line, and by making the circuit arrangements such that this wire is either disconnected or at earth potential when the line is not in use, and at some potential above or below that of the earth, when the circuit is engaged. With a proper arrangement of the operator’s speaking set it is possible, by touching the socket of a jack with the tip of a peg or a special “ test ” thimble, to determine whether the circuit connected to the jack is in use.

Both the series and the branching methods of multipling are recognized at the present time as standard methods, although the former is only employed in comparatively small exchanges. The magneto system itself is dying out. There are still many magneto exchanges in existence, but when new exchanges are erected only the very smallest are equipped for magneto working, that system having succumbed to the common battery one in the case of all equipments of moderate and large dimensions.

The “ call-wire ” system has been used to some extent, but it is now obsolete. The feature of the system was the provision of special service circuits, termed call-wires, for purposes of communication