

## THE EVOLUTION OF THE TELEPHONE EXCHANGE.

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One of the most convincing arguments employed by telephone companies, in support of the high rates charged to subscribers in large cities, is to the effect that the cost of construction and operation of large telephone systems increases at a ratio far greater than that of direct proportion to the number of subscribers. To the mind of the average business man, whose experience teaches him that the greater the quantity produced, the cheaper the cost of production is, this argument seems to be totally opposed to reason; yet, the telephone manager fully realizes its truth from actual knowledge of the facts.

The cause of this increased cost is to be found in the central office equipment, where it is necessary to provide not only for the terminals of the subscribers' lines, but to so arrange the switchboard that each individual operator can, by a movement of the hand, connect the calling subscribers on her section with any one of the total number of lines on the exchange. For example; on an exchange of 5,000 telephones, an operator to whom is allotted the duty of attending to the calls of 80 subscribers, must have within arms' length 5,000 jacks or connecting springs, into which she can insert the plug attached to the cord connecting with the calling subscribers of her section of the switchboard. In order to accomplish this the switchboard is divided into sections, each of which comprises 200 answering jacks, and a number of connecting jacks equal to the total capacity of the exchange. Thus: on the switchboard of 5,000 lines there would be 25 sections, each containing 5,200 jacks, or a total of 130,000.

A 10,000 line switchboard would be divided into 50 sections, or 10,200 jacks each, or a total of 510,000, while an exchange into which all the subscribers' lines in New York were concentrated, namely, 100,000, would necessitate 50,000 jacks, a problem which would stagger the most sanguine telephone engineer.

In consequence of this unalterable law of multiplication in connection with the growth of a telephone exchange, it is generally conceded that when the capacity of a manual switchboard exceeds 5,000 lines, it becomes too expensive and too complicated to provide a good service at low rates.

In large cities the general practice has been to divide the city into sections, and to place in each section an exchange of 5,000 lines. For the purpose of connecting the subscribers throughout the whole system, trunk or junction wires have to be provided between the exchanges, and, in order to provide a prompt service, these trunk wires should be equal to 20 per cent. of the total number of lines on the system. This entails not only an increased cost of construction, but more complicated apparatus, and a large number of expert operators to handle the traffic over these trunk wires, in addition to the ordinary operating staff.

In view of the additional expense attached to all this, it may be said that the telephone charges of the independent companies in large cities in the United States have touched "rock-bottom" figures, and with respect to manual switchboards, these have reached the maximum of perfection as regards their ability to handle economically large numbers of subscribers.

Recognizing the fact that, if the use of the telephone was ever to become of universal benefit to the community, it would be necessary to eliminate the ever increasing expense which the manual operating of a large telephone exchange involves, inventors have been at work since 1879, endeavoring to devise a system which would connect telephone subscribers without the meditation of the "hello girl," or in other words, to produce a telephone-operating machine.

The development of automatic telephony has been necessarily slow, and although much has been done experimentally, in the past, it has remained for two natives of the birthplace of the "Bell" telephone, Messrs. J. H. and G. W. Lorimer, of Brantford, Ont., to produce a machine which, while costing less to manufacture than a manual switch-

board, will perform all the functions of a telephone exchange, with a promptness and decision not equalled in any manually-operated system in the world.

The operating machine comprises a number of sections each accommodating 100 subscribers. On each of these sections are five connecting divisions, any one of which automatically performs the same functions as a telephone operator handling a pair of connecting cords. In combination with each section is a "Decimal Indicator" and "Division Starter," which control the section to which they belong, and pilot each subscriber's call to an idle division, which completes the connection with the subscriber called.

A remarkable feature of this exchange is, that should the whole of these divisions be in use when a call is made, it is stored until the release of one of the divisions, when the waiting call is completed without any further effort on the part of the calling subscriber; hence, no call once made is lost nor neglected.

Each section is capable of handling 360 calls per hour, and inasmuch as the average calls per 100 subscribers, during the busiest hour of a large exchange, is computed to be 125, it will be seen that this machine can deal with traffic far in excess of known requirements.

The number of connecting divisions can, like the connecting cords of a manual switchboard, be arranged to meet the traffic requirements of an exchange. The percentage of cords of a manual exchange is usually ten per 100 subscribers, which enables 20 subscribers out of each hundred to converse at one time. In exchanges where the traffic is light, this number may be reduced, and where it is heavy the percentage is increased. This principle has been carefully followed in the "Lorimer" system, thereby enabling the maximum of service to be given at the minimum of cost.

The connecting divisions being for the common use of all subscribers it is only necessary to provide a sufficient number for each section to fulfil the demands of the service at the busiest hour of the day. The experience of manual exchanges proves that in the majority of cases ten, or even a less number of divisions in a section are sufficient. Hitherto it has been found necessary, in other automatic systems, to provide a set of individual connecting apparatus for each subscriber, with the result that at all times 90 per cent. of the apparatus of the exchange was always out of use. For this reason such systems are so costly and complex that they offer little inducement to the telephone companies to discard the manual system, but by the saving of the 90 per cent. of apparatus effected in the "Lorimer" exchange, the end of the manual switchboard is in sight.

Another point in this machine worthy of special mention is the fact that every line on the exchange is tested once in four seconds without intermission, and if a line becomes out of order, the fact is at once announced by the ringing of an alarm, when the attendant in charge can at once locate the faulty line, and isolate it until the defect is right.

Each section of the machine is completed at the factory, and is sent out fully wired and tested as an individual unit, thereby enabling the capacity of a telephone system to be increased or diminished by adding to or taking away any number of sections, without interfering with the working of the exchange. The wiring between each section is so simple that a youth with the merest elementary knowledge of wiring could complete the connections between any number of sections without assistance. This is an advantage absolutely unattainable by the builders of manual exchange equipments.

The subscriber's outfit consists of a long-distance central energy telephone set, in combination with which is an automatic device for transmitting the impulses necessary to operate the central machine. These impulses are controlled by four pointers, working on an indicator plate, arranged to be moved up or down four vertical rows of numerals, representing units, tens, hundreds and thousands. These pointers may be set to indicate any number from 0 to 9999. For instance, if 4567 is wanted, the pointers are set thus: in the thousands row, at 4; in the hundreds at 5; in the tens at 6; in the units at 7. The subscriber then pulls down a