

conditions. It has been found necessary to have good insulation when wires of such low conductivity are being treated in this way. It therefore became necessary to remove all the glass insulators that were formerly used and replace them by specially designed double-petticoated porcelain insulators. The insertion of Pupin coils in circuits is called "loading." There are two loaded No. 8 circuits between New York and Chicago; also two between Omaha and Denver. The length Chicago to Omaha is a single pair of No. 8 circuits. A phantom is arranged over the top of the two circuits, New York-Chicago and Omaha-Denver. These phantoms are also loaded. The best circuit for speech over the whole distance is that got by using the phantoms. It would lead to a long discussion to pursue this matter. It should, however, be stated that each of those circuits can have the telegraph superimposed upon each wire, that these telegraph circuits can be terminated at any point desired, and that they can be used right through by suitably arranging repeaters. The whole advantage may be summed up by saying that, while a conversation was proceeding between New York and Denver, nine other conversations could be going on on the same wires between intermediate places, and twenty-eight separate telegraph communications might also be conducted simultaneously. This narration illustrates forcibly the wonderful engineering skill and ability that are at the command of the American Telephone and Telegraph Company, and how their exercise enables largely increased facilities to be afforded with comparatively little cost.

This company has also, from a consideration of the results obtained on aerial and underground circuits by "loading," decided to have complete underground talking circuits from Boston to Washington, a distance of 475 miles. Between New York and Washington the underground conduit was complete, and it was expected to have the other side complete during 1911. Blizzards sometimes so affect aerial lines as to prevent service entirely, and it is to meet such contingencies that these works have been undertaken. The cable will be made up of No. 13 and of No. 10 B. and S. gauge copper pairs. They will be loaded and phantomed. The phantoms will also be loaded. Great care will be necessary in keeping capacity-balances along the route, but it is anticipated that all will result satisfactorily. So satisfied are the engineers of the correctness of their theories that, although actual tests have not been made to confirm them, orders have been placed for 150 miles of cables at a cost, including loading, of about £200,000. The phantomed No. 10 New York to Washington, 235 miles, will have a speech efficiency equivalent to 13 miles of standard cable, the physical No. 10 of 16 miles, the phantom No. 13 of 21½ miles, and the physical No. 13 of 28½ miles. Good commercial speech can be obtained over about 35 miles of standard cable.

Between Boston and Washington, 475 miles, the speech between test-boards over the phantomed No. 10 will be equal to twenty-six miles of standard cable. It is not intended to use these for continuous talk Boston to Washington. Aerial wires will be associated with them over portions of the distance. When, however, stressful conditions of weather mar the aerial circuits the underground is always there to help out in the hour of difficulty.

On several of the long-distance aerial unloaded circuits in the States the American Telephone and Telegraph Company introduce a "repeater relay." This is found to improve speech about 30 per cent. It is, however, not entirely reliable, and is not standard. Sometimes the results are good; at other times frying noises are introduced into the circuit. Arrangements are provided for reversing the terminals and cutting out resistance, and these are often productive of improved conditions.

The insulation of lines in America is generally more easily maintained, and is much higher than can be got in this country even with the best porcelain insulators. Single-shed glass insulators are freely used in the States, and the normal insulation of overhead lines is about 10 megohms per mile.

For leased telegraph circuits the annual rental is usually £4 a mile. Telephone circuits are sometimes leased for £8 a mile. This applies to circuits between cities. Arrangements are often made by which a lessee can obtain a loop telephone circuit before 9 a.m. or after 4 p.m., the wires being used as Morse during those busy hours. Contracts are sometimes made for the lease of telegraph and telephone circuits for an hour or two a day with a minimum of half an hour. The leasing of circuits cannot apply in this country, all telegraph and telephone facilities being in the hands of the Government.

The combining of telegraph and telephone work on the same wires degrades both services somewhat if the circuits are fairly long. The effect on the telegraph for hand speed may be disregarded; that on the telephone is to reduce the distance over which speech can be got, and to introduce slight Morse noises into the receiver. When, however, what has been accomplished over the circuits from New York to Denver, already referred to, is considered, there need be no hesitation in accepting the entire practicability of such arrangements, as there are few circuits with such complicated requirements. The highly efficient transformers now designed are most suitable for that class of work. Although the telegraphs can be worked duplex they are usually worked as simplex, though fitted up as duplex, that being found to be most satisfactory. It is said that a revenue results to telephone companies in America from the leasing of telephone lines for telegraph purposes aggregating about £750,000 per annum.

The care taken to meet fire is noticeable in nearly all exchanges. Water-hose, sand-buckets, asbestos sheeting, and chemicals are usually provided and kept in a convenient place. Switchboards are not yet made of wholly fireproof material. The backs are closed with wooden roller shutters which fold up, and wood is largely used in other parts of the boards. In some cases a waterproofing is placed on the top of the board and arranged so as to be easily spread over the back and front so as to completely cover it and maintain it dry in the event of water having to be used to arrest a fire-outbreak. There are sliding partitions of uralite or of iron, and in some cases bulkhead divisions to limit fire as far as possible. The switchboards, being owned by companies, are usually insured, and insurance companies stipulate certain conditions to be observed.