A large percentage of the number of grounds which occur are found either on the lines in the towns through which they pass, or in the offices, only a small proportion being found on the lines in the country. The wire coming in contact with a foreign wire, such as a telephone, call bell, or guy wire, is a very frequent source of the trouble, though the circuit is very often grounded at the switchboard during a thunderstorm by lightning fusing the metal at the air gap of the lightning arrester in passing over to ground. Partial grounds, or escapes, are often due to the wire touching the branches of trees, and are more susceptible during wet than dry weather, the effect of the moisture being to magnify the escape. Highway lines are more subject to escapes of this kind than lines located on the right of way of a railroad, owing to the numerous shade trees which they encounter and the difficulty experienced in keeping them trimmed to clear the wires; owners of the trees as a rule object to any extensive cutting of limbs which would tend to disfigure the appearance of the trees, consequently to maintain a clearance the branches have to be frequently pruned. If this operation were neglected for a long time the effect would be manifested by the insulation of the line deteriorating. In cases where trimming cannot be done, in order to clear the line it becomes necessary either to replace the poles by higher ones, so that the wires will pass above the tops of the trees, or to divert the line by setting the poles out.

Crosses are not of such frequent occurrence as grounds, and in many cases occur through some material defect in the condition of the lines. Wires become crossed usually during the prevalence of a wind storm, which causes them to sway; at long stretches, especially where the wires happen to be slack, they more easily cross. Frequently crosses occur in consequence of a pin or tie wire breaking at an angle in the line, an insulator working loose and raising, or a pin being pulled out of cross-arm at a depression, allowing the wire to depart from its parallel position relative to the other wires. Crosses caused by a piece of small wire or other metallic object being thrown amongst the wires often occur, and on account of its obscurity the cross is with difficulty found by the lineman. I know of several instances where wires were found to be purposely connected with a piece of fine wire (evidently by persons bent on mischief), in such a manner that the fine wire could not be seen from the ground. Eventually in each case a galvanometer test was made and the cross approximately located; the lineman sent out to the supposed locality of the trouble was obliged to climb a number of poles before finding it.

When the nature of an interruption is such that the trouble does not remain on the wire constantly, but comes in and disappears again at intervals, it is called a "swing," and when the intervals are long and the length of time the trouble remains is short, the interruption, though of not so much consequence as regards impeding the working of the line, is more difficult and slow to locate than if the interruption were constant.

When two or more wires are crossed, one of them can be cleared by opening the others at stations on each side of the cross. In case a through and a way wire are crossed, it is customary to clear the through wire by opening the way wire at the stations between which the cross occurs in such a manner that said stations may have communication on the way with their respective terminals and intermediate offices. Such an arrangement is accomplished in the following manner: Suppose two wires, number 1 and 2, running west from terminal station A to terminal station D, are crossed between way stations B and C, of which B is east and C west of the cross. It is required to clear No. 2 (the through wire) and ground No. 1 (the way wire), so that B can work with A and C with D respectively. B opens the west end of No. 1 wire at the switchboard and grounds the east end with instrument in circuit east of the ground, C opens the east end of No. 1 at his switchboard and grounds the west end with instruments in circuit west of the ground, thus that part of No. 1 between stations B and C will be "dead," causing no interference with the working of No. 2. At the same time the circuit in the portions of No. 1 between A and B and between C and D, will be closed by means of the ground connections.

Lightning coursing the wires during a thunderstorm has a strong tendency to do damage to the instruments, and were it not for the presence of that valuable arrangement called the "lightning arrester" (which forms an adjunct to modern cut-outs and switchboards) many relays would be burned out. Before the lightning arrester was invented the custom was to cut out the instruments during a thunder storm, but now it is considered quite safe to leave the instruments cut in, regardless of the storm, where the switch-board is provided with this protection, and it rarely happens that a relay is found to be damaged by lightning. The tendency of lightning to do damage is not confined to the instruments alone, poles on the line in the country being shattered and cross-arms splintered. In this connection it may be apropos to remark that the custom of modern line builders to provide the poles at intervals along the line with ground wires may be regarded as commendable; the arrangement appears to give good results in the capacity of lightning-rod protection to the poles.

Office main wires, especially if insulated with paraffined cotton covering, where allowed to rest in contact with a gas pipe or grounded object, are liable to become grounded by lightning penetrating the insulation and carbonizing it in its path, producing a conducting medium and creating a permanent connection between the main wire and grounded object.

During the brilliant display of luminous streamers exhibited in the heavens occasionally, and known as the Aurora Borealis, the telegraph circuits throughout the continent are more or less affected by earth currents, which become so severe at times as to entirely interrupt communication. These earth currents constantly vary both in intensity and polarity, making it impossible to keep the instruments adjusted on circuits having an earth return. It may be of interest to mention that some tests were made by Mr. William Finn, of the Western Union Telegraph Company, on a No. 6 gauge iron wire 213 miles long, extending from New York to Boston, during the magnetic storm of July 16th, 1892, which showed that the abnormal current in the wire reached the strength of 133 milliamperes, and the maximum difference of potential of the earth at New York and Boston was 492 volts—such a high voltage had not been observed during any previous storm. A wire can be worked during a magnetic storm by disconnecting the ground at each end and substituting a wire return instead, thus forming a metallic circuit. I beg here to state that a quadruplex circuit