sion, the introduction of new applications, the perfecting of methods, designing and inventing, he resigns to others. With the man, however, who has devoted three or four years to a careful study of mathematics and the direct and related principles underlying the science of electricity, it is different, for though he may still have some difficulty in following electrical advancement, he is not wholly at sea. It is best, therefore, that the college student should pay special attention to those parts of his work that are usually classed under the head of theory. It is true that he may not do as well at first when he starts out in his profession as the graduate of a school where more attention is given to the practical side, but he will more than make it up in the long run. It is a case of slow, but sure.

Another objection to the class of practical work before mentioned—foundry, machine shop work, etc., is that, in college, it is usually under too artificial conditions, and is therefore not of as much value to the engineer as if he had obtained the experience in actual machine shops, etc., under normal conditions, and especially is this true in questions of the commercial value of the work done. Moreover, students may obtain this practical experience, or a large part of it, before graduating, for in most colleges there is a long summer vacation; in our own in this city they have five months, and the students are especially advised to and most of them do, obtain employment in various works, mechanical and electrical, and so supplement their course in a valuable way. An electrical student should, if possible, obtain his experience in an electrical machine shop for construction or repairs—the more general the work the better—and in this way he will be obtaining mechanical and electrical practice at the same time.

We have not the time now to go with more detail into the work of the college, or consider what subjects should or should not be included in the course and how they should be dealt with. The importance of the laboratory as an educational aid is generally recognized; a good library is also a great help, and in our day of such rapid advancement the electrical journal is indispensable; but a wide-awake staff and students that *mean business* are the chief factors in the success of any college.

## SOME OF THE CAUSES OF INTERRUPTION TO TELEGRAPH CIRCUITS.

A PAPER READ BEFORE THE CANADIAN ELECTRICAL ASSOCIATION, BY F. C. ROBERTSON.

A telegraph system, with its lines stretching over country in different directions, connecting cities, towns and villages, is to some extent at the mercy of the elements, with its batteries, instruments and wires, it is constantly subject to disturbance from various causes. The substance of this paper is a brief description of some of the common forms of interruption (usually called "troubles") which are experienced on telegraph circuits.

The troubles usually met with in the operation of telegraph circuits are of three kinds, and are known as "the break" (or open), "the ground," and "the cross." The circuit is said to be "open" when its continuity is broken and the current prevented from circulating, "grounded" when there is an abnormal electrical connection between the ground and the earth, and "crossed" when the line is in connection with another line upon which there is a current of electricity.

A circuit may be opened in various ways, for instance, by the breaking of the line, breaking of the magnet wire of a relay outside of bobbin, a loose connection at a binding post, displacement of plugs in switchboard, or by a key being accidentally left open. A break in the line wire generally occurs during very cold weather when the wire is contracted by the low temperature, causing a greater strain in it, and is often found at a point where the wire had been kinked, or at a joint which in making had been twisted so tightly as to cause the wire to be partially severed. Breaks are frequently caused by a tree falling on the line, which usually takes place during a violent wind storm, although sometimes through carelessness of woodmen in felling trees. Sleet storms are very destructive to the lines, owing to the excessive weight due to the ice adhering to the wires, which frequently causes them to break, or the alignment to become distorted. Poles carrying a large number of wires have frequently been known to break down under the extraordinary weight due to ice on the wires. Sleet storms general over a large area of country, of such severity as to damage lines, are fortunately of rare occurrence. The circuit is sometimes found to be open in an office, and might be traced to a broken connecting wire, broken relay wire, loose binding screw, but more frequently to a broken key, or a plug out of position in the switchboard. The circuit is sometimes found to be open in the battery, due to a jar breaking and allowing its solution to escape, a zinc falling from its hanger to the bottom of the jar, or the wire connected to the copper element becoming detached. There is a kind of trouble which takes the form of an extraordinary and variable resistance in circuit, which is sometimes met with on old lines, the source of which usually is a rusted joint, or a joint on a portion of the line in which there is no tensile strain. During dry weather these joints cause the resistance of the wire to be much increased, but during a rain the joints become wet, improving their conductivity.

Grounds on the wires are of more frequent occurrence than breaks or crosses. All ground faults contain more or less resistance; when the resistance of a fault is very small, the connection of the line with the earth caused thereby is comparatively perfect, practically dividing the line at that point into two circuits and preventing the current from the battery at either end of the line from passing further than the fault, but when the fault contains considerable resistance the connection with the earth caused thereby is not sufficient to prevent a portion of the current from either battery from passing the point of fault, the working margin of current being that which finds its way past the point of fault. The circuit in such case is not totally interrupted and signals may be exchanged between terminal offices on the circuit by properly adjusting the receiving instruments. Such a fault is called a "partial ground," or more commonly termed an "escape."

Although "single" (or simplex) circuits may be worked fairly well with a considerable and varying escape on the line (as the adjustment of receiving instruments can quickly be changed by the operator to correspond with the variations of the current), quadruplex circuits cannot be worked successfully under the same conditions, the varying escape causes the balance of the instruments to become disturbed, producing a mutilation of the signals on the receiving instruments.