struments for the high potential receiving and lower potential distributing circuits, completes the distributing station equipment.

The line is usually the weakest link in the chain, being exposed to the weather, and not under that careful supervision which is given to the rest of the plant. The pole line as a supporting structure must of course be of the solidest to stand the strains imposed, not only by the weight of copper, but in these latitudes by a great weight of ice also, which if assisted by a gale will try the best work to the utmost. Poles of cedar, pine, or chestnut of very heavy section are necessary for this work. They should be set in concrete or broken stone and heavily guyed on curves, or in certain positions double poles with heavy cross arms between should be used. The insulators for high potential work are universally made of porcelain, as that material weathers better than glass and is not so hygroscopic. This porcelain should be so vitrified as to exhibit a fracture like glass when broken, otherwise it will absorb moisture and break down. To minimize surface leakage, which, if severe, may burn off the pins, the surface over which it has to take place is made as long and of as small surface as possible. To assist in reducing this leakage, insulators with oil in grooves, over the surface of which the leakage must take place, have been tried and found to work well when the oil surface is clean, but in operation dirt accumulates and troubles ensue so that the plain porcelain insulator of large insulating surface and high resistance to piercing is now the standard.

The copper circuits are of bare copper, as weather-proof insulation at high voltages is perfectly useless. The cross section of the copper being of course so proportioned as to give the loss determined upon as suitable for the conditions existing. These conditions depend upon the cost of the power, the amount available and the demands. The loss may be reduced to any extent by the use of more copper, but unless there is a demand for the power saved, which will pay interest and depreciation on the additional cost of circuits, no economy results. On the other hand, the copper may be reduced and the losses increased, but only within the bounds set by the demands of good regulation. In practice a loss of 15% is seldom exceeded, and a very common allowance is from 7% to 10%.

Several effects manifest themselves in alternating lines which do not exist on those of direct current systems, and they deserve the closest attention in planning the system. While the actual losses in direct and alternating work are about the same under the same conditions, the drop in voltage in the former is a measure of that loss, while in the latter it may be no indication. In fact, it is possible to so arrange the circuits in some cases of alternating work as to have a greater voltage at the end of the circuit than is generated at the station, but this does not indicate that the line generates power of itself; it simply means that, while the self-induction and capacity of the line and load raises the voltage, much as a water ram in a pipe line raises the pressure, it at the same time throws the current out of phase with that voltage, and the real power is that obtained by the multiplication of the apparent volt-amperes by the cosine of the angle of lag introduced It is therefore only possible to read the power indications of a Watt-meter, which instrument takes account of this angle while the volt and ampere meter readings which are used to determine direct current power are not reliable for the alternating This increase of voltage may under certain conditions become so serious as to endanger the insulation of line and apparatus. In most cases it is advisable to reduce the induction as much as possible, and to effect this the wires on opposite sides of the circuit are strung as closely together as is consistent with safety, and several wires of equivalent cross section used rather than a smaller number of larger area. To do away with unbalancing of the phases of the system, the circuits should be strung symmetrically, which is effected in the case of two phase lines by placing the going and returning wires of each phase on the opposite ends of the diagonal of a square, and in three phase lines by stringing the three conductors at the corners of an equilateral triangle. As lightning may cause trouble, not only by direct stroke, but by the accumulation of static electricity upon the lines, means must be provided for getting rid of it safely. To this end, guard lines of barbed wire are strung above the circuits, and these are grounded at frequent intervals.

The apparatus in the generating section of the plant consists of the water wheels, generator, raising transformers and switchboard apparatus. Regarding the latter two, the same remarks apply as were made regarding similar apparatus in the distributing station. As to the generators, their size is usually limited by the power of the water wheel units, and their speed by the wheel speed unless gearing be used. The usual method of attacking the question with direct connected units is to arrange for as powerful wheels as is possible consistent with having the proper size units to handle the load properly, and designing the generators properly to suit the wheels as regards size and speed Vertical turbines with the rotating part of the generator revolving in a horizontal plane are usual, but, in several recent plants, horizontal turbines are used direct connected to the generators, which in that case are below the crest of the dam and above the tail-race by an amount determined by the height of the draft tube. The first system introduces footstep bearings, which are always more or less objectionable, but removes the delicate armature windings from chance of damage by water. The second places the generator at the mercy of water-tight bulkheads and stuffing-boxes. As to the voltage to be generated upon the machines, if raising transformers are used, this is of little consequence unless from a machine designer's point of view, as the transformers will have equal efficiency at any ratio of transformation. When the transmission voltage is not dangerously high, it is of course preferable to do away with these transformers, and generate directly on the machine. In deciding this point it must be kept in mind that the failure of a transformer through the breaking down of insulation is a much less serious matter than that of a generator, which is less likely to occur when that apparatus is of low voltage. Owing, however, to improved types of generators, we may expect to see raising transformers dispensed with in many cases where they would have been deemed indispensable with older types.

In specifications drawn up for the generating apparatus, the following points are strongly insisted upon: (1) That the heating of any part shall not exceed a certain specified temperature after a certain length of run at full load and an additional time at a certain specified overload. (2) That the efficiency at full load, three quarters, one half, and one quarter loads, shall be guaranteed by the tenderer and proved by test. (3) That the regulation of the generator shall be within a certain per cent. at full non-inductive load (4) That the insulation of any part of the machine shall not break down under a specified voltage which is high enough to allow of a good factor of safety over the normal pressure. Although it is impossible to specify limits for these requirements which will suit every case, it may be said generally that the allowable increase of temperatures for large generators ranges from thirty to forty degrees centigrade. The full load efficiency from ninety-four to ninety-six per cent. The regulation depends upon whether the machine is compound wound or not. In the former case the regulation may be anything for which the compounding is set, and in the latter from three to ten per cent. The test voltage applied ranges from three to ten times the operative, the former factor for high voltage machines, the latter for lower voltages. The modern generator being either of the inductor, or revolving field type, in which the high potential armature windings are stationary, lends itself to high voltage generation as the insulation spaces may be increased largely without rendering the machines unwieldy, for the reason that the armature wires are distributed over the outside ring where space is more abundant, and the vibration of running, which abrades, and finally breaks down the insulation on the older revolving armature types is largely absent in the newer machines.

(To be continued.)