DISCUSSION ON "HEAT-TESTS ON ALTERNATORS" AT
MILWAUKEE, WIS., MAY 28, 1906.

C. P. Steinmetz: This paper is very interesting, as it deals with a problem of machine testing and manufacture that is becoming more and more serious, and will probably in the future be a proper subject of investigation by our standardizing committee. The investigation and measurement of the temperature-rise of a machine under load have been made by loading the machine to full load, and then running it a sufficiently long time to reach stationary temperature. The size and number of machines has increased so fast that even by relegating these heat-tests to the night time, when not much power is used for operating the factory, the amount of power required to make the tests exceeds that available. With the development of hugh alternators in the last few years, the amount of power required by a single alternator has risen beyond the available power of most manufacturing plants; it is not very uncommon now to find two or three alternators in a factory, of sizes varying from 5 000 to 8 000 kw., waiting to be tested. With such hugh machines, the time required to reach stationary temperature is from 20 to 24 hours, or more. Few facilities are available now really to make a full-load heat-test of these machines; therefore it has become necessary to determine the heating at full load without being required to put full load on the machine.

A number of methods have been produced and recommended, none of them being really quite satisfactory. The split-field method, the split-armature method, and the method so ably discussed in the paper—all are steps in this direction. A simple compromise method has been used for a number of years. This consists in making a no-load open-circuit test, and a no-load short-circuit test; that is, running the machine at open circuit at over normal voltage a certain length of time, whereby the core losses and no-load losses are more than normal; and then running the machine at short-circuit on overload current for a certain number of hours, whereby the load losses are more than normal, and from the heating observed under these two conditions, estimate the actual rise of temperature at full load. These tests are very satisfactory as check tests; that is, to determine whether the rise of temperature of the machine is what it was expected to be. But they really beg the question; because they do not show how much overload in voltage and overload in current is required to represent full load in both applied simultaneously. This means that a machine must be tested first at regular full load, observing the temperature rise; and then by experiment find out how much excess voltage, how much excess current, successively applied, give the same rise of temperature. Then by exercising judgment all the other machines of the same size, type, and character can be

tested by comparing the open-circuit and the short-circuit tests. But the first machine must still be tested at full load, and that is not feasible; it is one of the difficulties met with in attempting to make full-load tests with large machines.

The other difficulty is that even if there were unlimited power at ones disposal, if one were able to run a 5 000- or 8 000-kw. alternator in the factory at full load for 24 to 36 hours, the full-load temperature rise would not be got, because so long a time has elapsed before the machine temperature has become constant, that it is practically impossible to maintain constant air temperature; and the variation of air temperature must be reckoned with. If the air temperature changes during the test, it is not right to call the temperature rise the difference between the machine temperature and the air temperature at the moment of shutting down; nor is it right to compare it with the air temperature in starting up, nor with any intermediate temperature. The problem is not merely to be able to run the machine at constant full load for a considerable time, but to keep the air temperature in a room large enough to accommodate a 5 000- or 8 000-kw. alternator constant within a degree or two during the whole length of time. The problem is so formidable that the solution is rather difficult. Theoretically one may say it could be done by running the machine at full load for some weeks, and recording continuously by registering instruments the temperature of all parts of the machine and of the air; then, after discarding the records of the first 24 or 48 hours, compare the average temperature of the machine with the average temperature of the air, averaging over a considerable period so as to offset the daily fluctuations of temperature. This method is not practicable in the factory.

Hence it is a very difficult problem to determine the temperature rise of a very large machine under full load and service conditions. Even if by some compromise we should be able to run the machine without power expenditure with such internal losses as would represent the full-load losses—still the other problem would have to be solved, to correct for the variations of the air temperature. Not only must the load on the machine be kept constant, but constant, too, must be kept the air temperature of the surrounding space; this is almost impossible