insulation, owing to the corresponding reduction of potentials between adjacent points, and also as regards regulation. With proper sandwiching and sub division of coils in both primary and secondary, the drop due to magnetic leakage may be reduced to a negligible quantity, so the drop in voltage, as the transformer loads up, may be practically confined to what is due to the ohmic resistance in the copper. This is essential, as the regulation of transformer plays a most important part in the quality of service to customers. Good regulation means from two per cent. in the small sizes to one per cent. or less in the larger sizes. No one has yet discovered a satisfactory method of compounding transformers so as to maintain the voltage as high at full load as at light load, and as line drop in the primaries, as well as in the secondary and inside wiring, tend to aggravate and magnify this condition, the importance of guarding against everything tending to drop the voltage will be appreciated, particularly when it is more clearly understood that a variation of one per cent. in voltage will make a difference of about five per cent. in the candle power of lamps.

Too much importance cannot be attached to hysteresis or the core loss of transformers, which calls upon the generators for a continuous supply of energy to overcome this loss as long as the transformer is in circuit regardless of the conditions of load, being the same when no current is drawn from the secondary as when full loaded, and if the power factor of transformers is low, the apparent flow of current on this score is greater at no load than at full load. Good transformers should, in the small sizes, not require more than two per cent. of the full load energy to cover this loss, and large transformers less than one per cent. While the copper loss of a transformer remains constant for any fixed load, throughout its life, the core loss—if proper precautions are not taken in the selection of iron and provisions made in the design to maintain it at a low temperature—may increase considerably, often doubling this source of loss in a very short period, and accordingly reducing the all-day efficiency, and this increased loss has to be supplied from the central station, for which it receives no income.

From the foregoing hints it will be seen that well designed, modern transformers, should give a full load efficiency depending upon their size, of from 95 to 98 per cent. or better, which, with good design and proper selection of materials, will maintain this efficiency unimpared. It is only recently, however, that such transformer could be obtained, and the matter of ageing of the core plates has but recently received attention. It is not more than three years ago that one of the largest electrical manufacturing companies in the United States sold, to a large central station, under guarantee of certain efficiencies for the various sizes of transformers, covered by the contract, and were obliged to take back every transformer before they had been in service four months, on account of the rapid increase in the core loss, which, in many cases, in the short space of time mentioned, had doubled the losses shown in the original factory tests. The iron was taken off the coils and a different quality of iron substituted, which, though not giving quite such good initial results, was able to maintain its efficiency unimpaired, exhibiting no apparent ageing after repeated tests extending over a period of eight or nine months.

By careful experiments with various samples of iron of known chemical composition, we have been able to determine which is the best for use in transformer cores, and samples of every lot of iron are submitted for test for hysteresis loss and for chemical composition. Without such precaution, no assurance of results of transformers in service can be secured. Even with the best of iron ageing will take place to a slight extent, unless precaution is taken to operate the iron at low inductions, and provide sufficient radiating surface to prevent the transformer becoming too much heated—it having been observed that iron will age much more rapidly when subjected to high temperatures. As the energy losses in transformers exhibit themselves in heat, precaution should be taken to get efficient transformers, which operate at a low temperature, obviating the tendency to char the insulation, at the same time saving the dynamo capacity necessary to overcome these losses, and avoiding the ageing of the iron and subsequent augmentation of losses.

Oil may, be used in small transformers, and where the losses are large the oil helps materially in radiating the heat. The life of a low efficiency transformer may be considerably increased by filling the case with oil, but this is unnecessary in small transformers of good design. In large transformers of 100 K.W. or more, it becomes necessary to use some method of dissipating the heat, as the proportion of radiating surface rapidly decreases as the transformer increases in size, and oil or an air blast becomes necessary even in transformers of over 98 per cent. efficiency. We have designed and built 60 cycle transformers of 60 K.W. capacity, having a full load efficiency of 98 per cent., which, with only the natural air circulation, have shown a rise of temperature, after 10 hours' continuous run at full load, of less then 50 C. This same transformer operated at 125 cycles will run at a higher efficiency with a smaller rise of temperature. Such transformers are rather expensive, however, and where slightly lower efficiency will suffice, an oil transformer can be used at a much lower cost of construction, which will give no greater rise of temperature.

Lightning discharges are less dreaded now by central station managers than they used to be. Formerly every thunder storm brought with it wreck to some of the transformers on the line, this has, however, come to be the exception rather than the rule, owing to the substitution of modern transformers, in which the better insulation, together with the greater choking effect, which follows, with higher efficiency and reduced core loss, result in forcing the oscillatory high frequency lighting discharges to take some easier path to equilibrium of potentials. Notwithstanding this do not neglect to install lightning arresters, for though the improved transformers offer a more difficult path, yet if there are no lightning arresters, through which these potentials can discharge, the best transformers are liable to be punctured. The suggestion has been made to ground the secondaries or the case of the transformers. Either method makes it safer for the consumer, but both result in greater strain on the insulation of the transformer.

We have had frequent enquiries as to whether the 60 cycle transformers will work on 125 or 133 cycles. A transformer, suitable for 60 cycles or 7,200 alternations, will work better on 125 cycles or 15,000 alternations than on the 60 cycles, as the core loss is reduced through the regulation due to increased megnetic leakage, is not quite so good. It is quite the opposite when a 125 cycle transformer is used on the 60 cycle circuit, as in this case the core loss is increased about 30 per cent., and the efficiency correspondingly decreased. If the transformer is not a very superior one at 125 cycles, it is quite likely to overheat, due to the increased core loss at 60 cycles, gradually charring the insulation until it finally breaks down, in the meantime probably showing an increasing core loss, followed by further development of heat, and bringing about the end at an earlier day. As the difference between two lots of iron from the same manufacturers may make a difference of ten or twenty per cent. in the core losses of transformers, otherwise identical, it is of the utmost importance for manufacturers to make careful tests of each shipment of iron, as it is received, and when this is not done the central station has no protection unless they possess the instruments to make proper tests on the transformers themselves as they are received.

For their own protection, we would urge central station men to equip themselves with standard watt meter, dynamometer and volt meter, with which it is a simple matter to determine whether they are getting what they pay for or not. The tests are quite simple, and any central station can equip for making them at very small expense, amounting to but little outside of the cost of the necessary instruments, which are almost a necessity for any central station in checking up switch board instruments, recording meters, etc.

(To be continued).