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 2% of the full load energy to cover this loss, and large transformers less than 1%.

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% or better, which with good design and proper selection of materials will maintain this efficiency unimpaired.

It is only recently, however, that such transformers 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 tests 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 charge 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% efficiency. We have designed and built 60 cycle transformers of 60 k.w. capacity having a full load efficiency of 98%, which, with only the natural air circulation, have shown a rise of temperature, after 10 hours continuous run at full load, of less than 50 C. This same transformer operated at 125 cycles will run at a higher efficiency with a smaller rise in 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 thunderstorm 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 choaking effect, which follows with higher efficiency and reduced core loss, results in forcing the oscillatory high frequency lightning discharges to take some easier path to equilibrium of potentials. Notwithstanding this, do not neglect to install lightning arrestors, for though the improved transformers offer a more difficult path, yet if there are no lightning arrestors 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 inquiries as to whether the 60 cycle transformers will work on 125 or 133 cycles. A transformer suitable for 60 cycles or 7200 alternations will work better on 125 cycles or 15000 alternations than on the 60 cycles, as the core loss is reduced, though the regulation due to increased magnetic 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%, 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 managers to equip themselves with standard wattmeter, dynamometer and voltmeter, 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 switchboard instruments, recording meters, &c.

Central station practice has not yet settled down to uniform methods of installation, but the trend now seems to be in the direction of larger transformers with secondary networks, preferably on the thin wire system; the general introduction of meter basis of charge making it possible to safely connect double the rated transformer capacity in lamps to the secondary network—whereas with the older systems providing a separate transformer for each connection it was necessary to provide transformer capacity equal to the lamps connected.

With separate transformers of small sizes necessary for individual supply, the aggregate core losses become a serious drain upon the central station. We have frequently seen banks of small transformers serving a single customer or group of customers, this condition being brought about by the gradual growth of demand for light exceeding the capacity of the original transformer installed, a further growth exceeding the capacity of the second, and so on. In such cases the substitution of a single large transformer of modern design displacing the small ones would save its price in less than a year, if credited at the usual selling price, with the amount of current saved. Don't put a modern transformer of good regulation into a group of antiquated transformers of poor regulation; if you do you will lose your new transformer, which is likely to be unjustly condemned for trying to improve the regulation of its bad associates. Placed in such company the new transformer tries to maintain the good regulation for which it was designed, while the lazy, old shirks with which it is connected, steeped in the vice of bad regulation, throw their entire load onto the new comer, which good naturedly carries it all till it can no longer stand the strain and literally roasts out and breaks down under the load.

In most of the smaller stations and in many of the larger ones, money can be saved by remodelling the system of distribution, and at the same time improving the service by laying out a net work of secondary mains, starting first in the business portion of the town with the installation of a few large transformers, reserving the small transformers which these replace—if they are modern and worth keeping—for extensions in the more remote sections where for the time the secondary network is impractical. It may occur in some cases the secondary network will be practical in several different sections, and these separate sections will, in most cases, gradually grow together, allowing taps to be made for new customers at intermediate points. In most cases, where prices are based on meter rates, such an arrangement can be installed at no greater first cost than the individual transformer system, the saving in cost of transformers on account of their larger size and less total capacity required paying for the copper mains. Such an arrangement always results in more satisfactory service to the consumers, at the same time greatly reducing the leakage current necessary to magnetize the transformers or supply the waste in core losses.

A few figures may serve to impress the idea more firmly in your minds. Let us take the case of a station having an average load equivalent to 1000 lights, most of which average four hours burning per night, and, making due allowance for belting, dynamo, line, transformer and secondary wiring losses, we will allow that 10 lights are obtained per 1 h. p. at full load. In the first case we will suppose an individual transformer system is installed, using 10-10 light, 10-20 light, 10-30 light, 5-40 light, and 4-50 light transformers; even with modern transformers these would have an aggregate core loss of about 1200 watts.

If we substitute for this arrangement 6-150 light transformers, connected with secondary mains, retaining the 10 small transformers for isolated customers so scattered as to make it impractical to connect them to the secondary mains, our core losses will be reduced to 692 watts, or a saving of 448 watts for every hour the plant is run, which, for twenty-four hours a day, would amount to 3920 k. w. hours per year, which at 10c. per kilowatt hour would be $392.00, or 6% on more than $6500.00, a sufficient amount to more than pay for the change if no consideration is made of the transformers left on hand, which would be superseded by the new arrangement.

In the case just mentioned we have assumed the original arrangement to be modern transformers. Had we assumed them to be old types the saving would have been three or four times that shown, and would have allowed us to make a good or a better showing had we only charged 3c. per kilowatt hour, which would be less than the cost of production in a station of 1000 lights capacity.

Some of our friends may argue that these losses cost them nothing, as they are running on water power, but we would like to remind them that the capacity in their generators, water wheels, or whatever prime movers they use, represent capital invested, which add to the fixed charges their pro rata of interest and depreciation for which it makes no return; whereas, if the capacity used in overcoming these losses could be rented at the usual rates, a material difference in the capacity to pay dividends would be shown.