bridge, in Muskoka, and to Wiarton and Kincardine; conversation can also be carried on with Detroit and Buffalo on the American side, and to New York by repeating at Buffalo.

The places noted on the sketch above mark the present range of the Bell Telephone Co.'s long-distance lines, but the system will be extended as required in the future. The wire used for this service between Montreal and Toronto is a No. 10 copper wire, that between Chicago and New York being a No. 6.

OPERATING ENGINES WITHOUT A NATURAL SUPPLY OF CONDENSING WATER, OR THE CONTINUOUS USE OF INJECTION WATER.*

BY E. J. PHILIP.

The subject is somewhat new, and information on it must be taken from the few plants that are now operated upon this principle. Like all other new departures in steam engineering, there is very much to be learned and studied before everything in connection with it is properly understood. In a paper of this kind we can only go into the leading points about it, as the subject is so large that a whole volume might be written on it to cover fully the whole ground. From observation throughout the country it is evident that the principle of running condensing engines is not as thoroughly understood as it should be, for we have many cases where there is a sufficient supply of water within reach, and still the engines are exhausting into the atmosphere. This, perhaps, because many think the expense of putting in and maintaining a condenser is greater than the saving would warrant. As an illustration, take an ordinary high-pressure engine of, say, 100 h.p., using, say, 4 lbs of coal per h.p. per hour and running 10 hours per day, the coal consumption would amount to two tons per day. The water consumption per h.p. in that case would be represented by 30 lbs. per h.p. hour. If a condenser is added, the same power would only require, say, 22 lbs. of water, making a saving of 26 per cent. The total coal consumption for the year, running 365 days, would be 730 tons. If the coal can be put in for $3.00 per ton, the year's consumption would amount to $2,190. The cost of adding a condenser to such a plant, including the necessary piping, should not exceed $300. The cost of operating the condenser will be about 6 per cent. of the power of the engine, and is equal to $131. The interest on the condenser investment at 6 per cent. is $18, making a total cost of $149 per year to maintain and operate it. Twenty-six per cent. of the coal account would be $569, from which deduct $149, the cost of operation, leaving a net gain of $420. This in many cases would make a dividend for the owners where there is none at present. In cases where the water for condensation is not procurable except at considerable expense, it can be used over and over again, and be cooled by air. The idea of cooling water in this way originated in Germany, and was applied for the purpose of cooling beer. The first cooling tower was filled by the branches or trees, or brush. The air used was only the natural current due to the warm water. This, of course, required a very large tower to get an amount of cooling surface to be effective, as the air current was necessarily very slow. The air is the cooling medium, and is indirectly the condensing medium. If you wet your hand and hold it in a current of air, you will feel a cold sensation, because the water is being evaporated and is taking up the latent heat of evaporation from your hand and the surrounding air. The specific heat of air is .2375, while that of water is unity.

If we depended upon the direct absorption of heat by a rise in temperature of the air, we would have to raise about 4 pounds, or 55 cubic feet, one degree to absorb a heat unit. Consequently we would have to raise 1,000 cubic feet of air 55 degrees to condense one pound of steam at atmospheric pressure. But when air is brought into direct contact with water, there is a cooling action due to evaporation much greater than is due to the elevation of temperature. When a pound of water is evaporated in this way, five times as much heat disappears as when a pound of water is raised from the freezing to the boiling point, and every pound of water so evaporated absorbs heat enough to condense one pound of steam. Now, by having an arrangement whereby we can pass a strong current of air over a quantity of water, favorably disposed to be acted on by the air current, we can by evaporation of a quantity reduce the temperature, and that is what takes place in a cooling tower, which is an apparatus designed to distribute the water so as to expose a large surface to be acted on by the air. Now, for every pound of water evaporated there is a reduction of temperature which will allow of a pound of steam being condensed, and just bring the remainder to the original temperature. It will be plain, therefore, that in operating a cooling tower there can be no more water used than when running non-condensing. In fact, there is not as much, because there is not as much water evaporated in the tower as there is condensed, as the surface of the tower and pipes have a cooling effect; also, the direct rise in temperature of the air takes away a quantity of heat without evaporating any water.

The engine will require less steam, consequently there is a smaller quantity of feed-water used than when running non-condensing. The system, therefore, allows a plant which has to buy even its feed-water, to run condensing at a less expense for water than when running non-condensing. The details of the system are, at the start, like an ordinary condensing plant. The steam leaves the engine, passing through the condenser, is here condensed by water taken from a small reservoir instead of some natural supply. The water passes to the air pump and is pumped out, forming a vacuum as in an ordinary condensing plant; but now, instead of letting it run to waste, it is elevated to the top of a tower, either by the air pump itself, if the tower be low, or by an auxiliary pump if the tower be high. This is preferable in any case. The water is distributed over the surface of the filling tower, falling to the bottom through the up-coming current of air, and the temperature is thereby reduced sufficiently to be discharged into the small reservoir from which the condenser takes its water, and is used over and over again. The details of the tower are: At the top of the tower is an arrangement to distribute the water over the whole surface of the interior. This distributor has taken many forms, some of which are quite ingenious. Some of the latest are the revolving distributors, illustrated in *Power* for March, and other mechanical papers. This distributor is mounted in the centre of the tank on ball bearings, and the water issues from the cross pipes like the ordinary lawn sprinkler, and distributes the water evenly. Another distributor which is used in towers with what might be termed partition filling, is made with a little trough across the top of each parti-

*A paper read before the Canadian Electrical Association.