Electrical Transmission of Energy.

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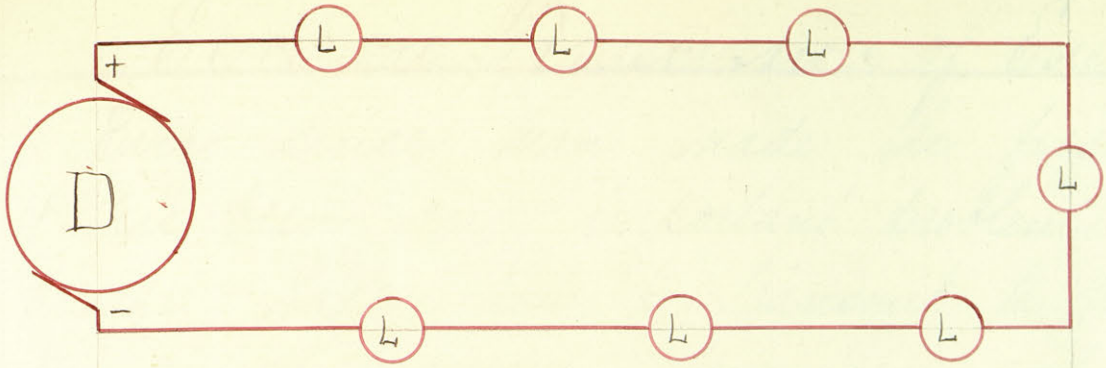
Outline.

1. Historical.
   - (a) Early crude forms.
   - (b) Wire ropes.
   - (c) Electrical transmission.
2. Evolution of Dynamo.
   - (a) Developement.
   - (b) Motor vs. Engine.
3. Efficiency.
   - (a) Dynamo. { earlier. later.
   - (b) Motor.
   - (c) Lamps. { earlier. later.
   - (d) Conductor, high vs. low potential.
4. Systems of Wiring.
   - (a) Series.
   - (b) 3-wire.
   - (c) Parallel.
5. Trolleys.
6. Storage Batteries.

1.



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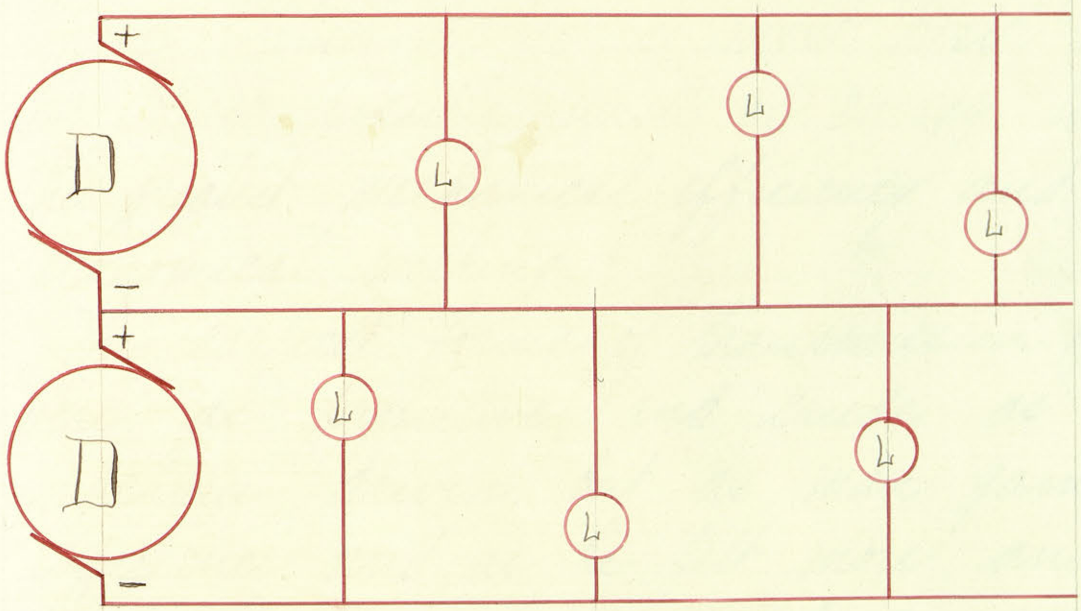
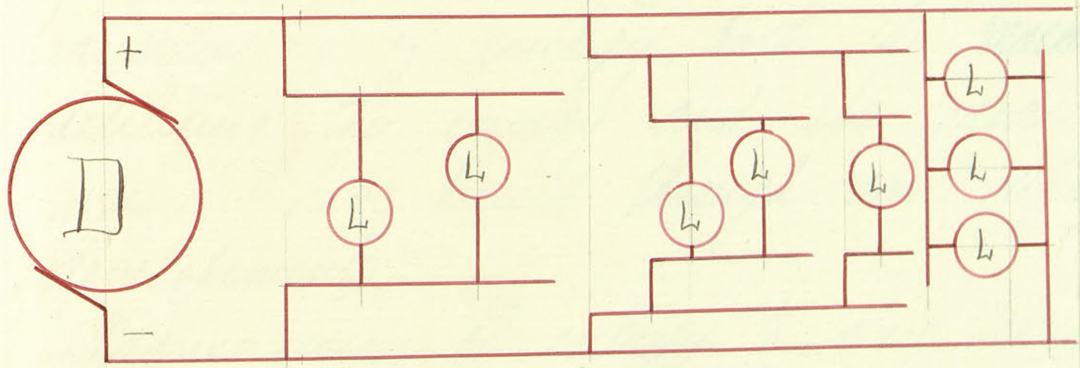


3.



D = Dynamo. L = Lamp.

method very Expensive

In later years the invention of the dynamo and motor led to their experimental use for this purpose. They proved to be satisfactory, with one serious exception, their efficiency was too low, there was too great a waste of power. Of the original power from the engine, only one fourth, or even less, was obtained from the motor, and in such a cases it was too expensive, unless for very small amounts of power, or for short periods of use.

But later dynamos were constructed having an efficiency of 90% to 95%, and motors practically the same, and by using large conductors, from 75% to 90% of the power generated by the engine could be obtained from the motor.

With an ultimate efficiency of 90%, or even 75%, power in small amounts, or for limited periods, becomes more economical than the use of an engine for such power for the following reasons:

First, the cost of labor and fuel represented by the energy lost in firing up and cooling of the boiler is far less in one large boiler kept in use all day than for many small boilers fired up once or twice a day and for only a few hours.

Second, a large engine is much more efficient than a small one; we get a greater return, proportionately, in relation to the cost of fuel and care.

Third, the motor does not require an experienced attendant, as does the engine; the engineer at the central station may answer for fifty or a hundred motors.

Fourth, cleanliness is often of much importance, as is also convenience and economy of space, which is often quite valuable.

These points show very clearly the greater cheapness and desirability of central stations and motors for power in small amounts as compared with small separate engines. Today no city of any considerable size in the United States can be found where the successful electrical transmission of power is not in use.

In the consideration of this topic we see very plainly the law of the conservation of energy, which holds equally as good here as in all other branches of mechanics.

Of the power delivered from the engine to the dynamo, that which can not be found in the motor or lamps must be accounted for in one of three places, first, the dynamo wastes energy in two ways, mechanically, by friction, inertia, et cetera, and, electrically, as in resistance of conductors and so forth. Thus a dynamo may have an electrical efficiency as high as 98%, yet the mechanical causes will reduce its ultimate efficiency to 95%. Second, the wires leading from the dynamo to the motor have an appreciable resistance and hence absorb some energy, varying with the length and cross area of the wire. Third, the motor wastes energy precisely as does the dynamo.

The great desideratum in the manufacture of dynamos and motors is to increase their efficiency, and to this inventors and experimenters have turned their attention almost wholly.

Dynamos, motors and arc and incandescent lamps were known to the scientists years before they came into general use, and this was due only to their lack of efficiency. Such a small portion of the energy put into those machines was given back in power or light as to render them too expensive to be of any practical application.

Ever since lamps and motors, and the dynamos necessary to generate the electricity needful to drive them came into general use, the inventors have been working to improve their efficiency, and have succeeded to a wonderful extent.

In the earlier days the dynamos had only an efficiency of 60% to 70% and were often as low as 40% to 50%; so that if we put, say, 100 H.P. into a dynamo we received from it perhaps only half that amount.

At the present, a dynamo is considered below the average if its efficiency is less than 95% and machines have been made having as high an efficiency as 98%. So that heretofore, we were obliged to give 100 H.P. to get 50 H.P. in the form of electricity; now we get 95 H.P. for the same expenditure, or if we only want 50 H.P., it costs us but 53 H.P., as opposed to 100 H.P., formerly.

Just in the same proportion have

we reduced the cost of the necessary fuel required to give us a certain amount of electrical energy, by increasing the efficiency of our machines.

Much has also been done in securing greater compactness and fine appearance, but these are minor items, and if the machines lack a fair efficiency they are of little or no value.

Motors have about the same efficiency as dynamos, so if we have a dynamo and motor, both having an efficiency of 95%, the motor would give us 90.25% of the original energy. This is on the assumption that the resistance of the conductor be practically nothing. If its resistance be taken into account, as in all ordinary cases it must, it may reduce the ultimate efficieny 5% to 10%.

Atkinson says that all these transforma-tions need not exceed a consumption of to exceed 15% of our original energy, in all ordinary cases.

Nor have lamps been behind hand in this improvement. In the earlier days about eight 16 C.P. lamps required one electrical horse power, or 746 watts, which is equivalent to 128 C.P. per H.P., or a watt efficiency 5.8 watts per C.P. At present the Packard lamp claims an efficiency of 2.5 watts per C.P., or 298.4 C.P. per H.P. In the earlier days then, a 100 H.P. engine gave 37,300 watts, or 50 electrical H.P.; this gave 5,760 C.P., or 360 ordinary incandescent lamps, allowing 10% to be absorbed by conductors. Now a 100 H.P. engine gives 95 electrical H.P., 70,870 watts or 26,938 C.P., equal to 1683 lamps, allowing 5% for resistance of conductors. I have assumed 10% as waste before and 5% now; this is because better conductors are used now; larger and therefore of less resistance and better insulated and hence less leakage. We have, then, 1683 lamps at present as opposed to 360 formerly for the same consumption of fuel and cost of attendance, assuming the efficiency of the engines to be the same in both cases, but they, as well as the boilers, have advanced in the same line as they dynamos, of which we get the advantage, and consequently, we get a greater comparitive return for;

but this is foreign to the present topic, though, closely associated with it, and much of the success of the former has been due to the latter.

The resistance of conductors, spoken of above, often becomes a serious obstacle to long distance transmission of energy. In the earlier history of they dynamo its efficiency was so low that by the time the energy had been transmitted a distance of 5 to 10 miles, there was not much left; now, the increased efficiency of the dynamo makes it possible to afford a considerable waste; besides the conductors used now are more economical than formerly. In long distance transmission either an immediate expense for extra large wire must be incurred or else the continual expense of current absorbed by a smaller conductor must be borne. Here comes in the use of the transformer. It is a well established fact that a current of high potential will be transmitted by a smaller wire than will a current of low potential; and hence a high potential plant will require a smaller cash outlay for conductors.

But a current of high potential is unsuitable for many purposes and, to get over this difficulty, a high potential current is taken from the dynamo, carried through the mains to transformers, where it is transformed, by an induction coil, from a high potential to a low potential current. Such is the system used for the incandescent lights in Manhattan.

Closely connected with the resistance of conductors, are the systems of wiring. The simplest, and a common method for, arc lamps, is the series system, shown in figure 1, page 1a. In this system, a wire leads from one brush of the dynamo to lamps in regular series and back to the other brush. The objection to this system is that an accident to one lamp, or wire, disables then entire circuit.

In case two similar dynamos are to be used for the same purpose, a three-wire system is sometimes used (Fig. 2, page 1a). This saves the cost of one wire. An objection is that if the center wire be broken both dynamos are disabled, while if they were separate, an injury to any one wire could disable but one dynamo.

A very common method, and that used in Manhattan on the incandescent circuit, is the parallel, or multiple system (Fig. 3, page 1a). An injury to one light or wire disables but one lamp, or group of lamps. In all electric cars not operated by storage batteries carried on the car, some kind of traveling contact must be used. The trolley, or overhead wire, is most common. There are many objections to this plan. The trolley wheel is liable to get off the wire. The wire and poles are liable to injury of various sorts and leakage of current occurs in damp weather. If the wire be placed underground, as in Washington, many of these disadvantages are overcome. If we can have an elevated road, we can do better yet by having a third insulated rail to carry the current, as was done on the "Intramural Railway" at the Columbian Exposition, which demonstrated very thoroughly the feasibility of elevated electric roads. For use in mines, tunnels, etc., I see no other plan except the trolley system or else a storage system.

There remains yet one other important system in the electrical transmission of energy and that is the storage system. Until very recently storage batteries have been of little practical value, but in the last few years they have come into use to a quite limited extent, and their practicability was well shown at the Columbian Exposition. The electric launces there were nominally of 4 H.P., and carried 66 cells. They were used from 12 to 14 hours daily and almost always proved successful, and not only that but economical. The cost of charging never exceeded 36 cents per day and on this charge 6 boats averaged 50 miles and 20 of them averaged 40 miles, or less than 1 cent per mile. The efficiency of a central station storage battery plant recently established is 86%. The Waddell-Entz battery has a resistance of but .001 ohm, requires .94 volts to charge and gives .89 volts at discharge, with a capacity of 240 ampere hours, and therefore is capable of giving .38 H.P. for one hour, or 144 cells give 50 H.P.

With such a record of the past what we not expect of the future!

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Manhattan, Kans.

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