PRIME MOVERS.

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The growth of human industry depends on nothing more than the possession of cheap and convenient power. Labor is by far the largest factor in the cost of many manufactured articles, and cheap motive power tends to displace the strength of human hands in all manufacturing processes, and so reduce the labor cost, and to set free that labor for other and less purely machine-like purposes.

The first thing to be determined in planning a power station is the proper site, which should, if steam be the motive power, be settled by convenience with respect to the supply of coal and water. In using water power, the location depends upon the hydraulic development. It should be remembered that it is strictly a utilitarian structure, and for the best results, electrically, must be dry and clear of floods, conveniently arranged for all apparatus, with an easy entrance for transmission lines, and above all it must have solid foundations, capable of further extensions, and must meet all these requirements at a minimum cost. The best watchwords in power-house design are safety, operation, simplicity and accessibility.

With regard to outside arrangement in a water power plant, the units are most conveniently placed side by side, with their shafts parallel. This tends to concentrate and simplify the whole plant and bring it clearly under the eye of the operator. The fundamental question is the proper size of units. There is at present perhaps too strong a tendency to use direct coupled units at any cost. Direct driving is very simple and efficient when conditions are favorable, and for large units is necessary, but belt and rope drive gives little trouble when well engineered, and only wastes from 3 to 5 per cent. energy for a single drive. It is very easy to waste far more than this when using a dynamo designed for a speed unsuited for its output or with wheels under disadvantageous conditions.

(1) In deciding on the number of units to be employed several things must be taken into account. The number should not be so small that the temporary crippling of a single unit will interfere seriously with the work of the plant. This determines the maximum permissible size of the units. The nearer that one can come to this without involving difficulties in the way of proper speed or serious specialization the better. In a large plant it is seldom advisable to install less than three units, while in some cases, particularly in hydraulic plants, a larger number may have to be instaled to meet hydraulic conditions.

(2) In this case it is desirable to operate each dynamo by its own special wheels to avoid complication. Hence the consideration which determines the number of generators also determines the number of wheels in the hydraulic installation. Only on very rare occasions is it advisable to use more than a single wheel, or at most a pair of wheels, on one unit. If the plant is to feed several transmission lines it is sometimes best to assign separate generators to each line, and this may make it necessary to increase the total number. The requisite security from accident can in such cases be obtained by use of spare units or by shifting a generator from a lightly loaded line to a heavily loaded one.

(3) The first central station was put on a commercial basis about twenty years ago. Three years ago the steam power plant had settled down to a uniform arrangement, and everything seemed to indicate that it would only be necessary to buy a standard set of blue prints and make changes in size of units to have the station up to standard. From time to time gas engines were proposed, with improved economy of fuel, but, with a few exceptions, these were not generally favored. Then we have the steam turbine placed on the market after a long period of development, and during the last three years no other piece of apparatus has had such a stimulating effect upon the power plant. It has revived the superheater, which has been so developed and improved that a superheat of 200 per cent. or 300° F. can be economically obtained. With the general study of these conditions there has been brought about a general improvement of the furnace, and here there is apparently room for further improvement. It has also had a stimulating effect in the further development of condensing apparatus, so that it is now possible to obtain a vacuum within one inch of the simultaneous barometer reading.

Another change has been the adoption of high-speed generators, resulting in a decreased cost of generator and its foundations and a saving in floor space. The general high efficiency of the turbine and its claim for recognition is bound to make for a higher power plant efficiency.

In investigating the efficiency and economies of a power plant one must not confine himself to a study of prime movers, but must consider and analyze the entire plant from the coal to bus-bars; first, in regard to efficiency; secondly, in regard to the effect of load factor upon investment; and the effect of the first and second upon the total cost of producing the kilowatt-hour, which is the ultimate test.

The following table contains a complete analysis of the losses in a year's operation in one of the most difficult plants:—

Analysis of the average losses in the conversion of one pound of coal into electricity, B.t.u.:—

1. B.t.u. per pound coal	14150	100	....	....
supply	14150	100	....	....
2. Loss in ashes	....	....	340	2.4
3. Loss in slack	....	....	3212	22.7
4. Loss in boiler radiation	....	....	1131	8.0
5. Returned by feed-water	441	3.1	....	....
6. Ret'd by economizer	960	6.8	....	....
7. Loss in pipe radiation	....	....	28	.2
8. Delivered to circulator	....	....	223	1.6
9. Delivered to feed-pump	....	....	203	1.4
10. Loss in leakage drips	....	....	152	1.1
11. Delivered to small auxiliaries	....	....	51	.4
12. Heating	....	....	31	.2
13. Loss in engine friction	....	....	111	.8
14. Electrical losses	....	....	36	.3
15. Engine radiation losses	....	....	28	.2
16. Rejected to condenser	....	....	8524	60.1
17. To house auxiliaries	....	....	29	.2
	15551	109.9	14099	99.6
	14099	99.6		
Delivered to bus-bar	1452	10.3		

Coal should be bought by paying for B.t.u. only, with suitable restrictions on the maximum permissible amount of ash, etc. To test this coal a sample should be taken from each hopper so that we obtain a true average. This sample should be tested in a calorimeter. The loss in ashes mentioned above is probably as low as it is possible to bring it, and the extra cost of labor entailed in any reduction would offset any gain.

The loss to stack, we notice, is a very serious item, and recent investigation shows that this loss may be greatly reduced by the use of more scientific methods in the boiler-room. In nearly all cases it is found that the loss is due to admitting too much air into the combustion chamber, resulting in cooling the furnace. This result is usually due to carelessness and inexperience on the part of the fireman.

The loss in boiler radiation and leakage, amounting to 8 per cent., is largely due to inefficient boiler setting of brick casing, which, besides permitting radiation, admits

(1) "Electric Power Transmission." Bell. Page 427.

(2) "Electric Power Transmission." Bell. Page 430.

(3) "Power Plant Economics," by H. G Stott, A.I.E.E., January, 1906, page 1.

(4) "Power Plant Economics." Stott, A.I.E.E., January, 1906.