method, with small economizer, realizes 940,800 B.T.U., while the fan method, with large economizer, realizes 2,170,-000; less power to fan 280,000 = 1,890,000 B.T.U., or about double. Thermodynamically, therefore, under the assumed conditions, there is a gain of over 3½ per cent., really due to the use of the large economizer which is made possible by mechanical draft.

Next, as to the relative cost of the arrangements. This will vary in every case, and no two opinions on the matter will be the same. On the basis of an evaporation of 60,000 lbs. steam per hour, or a combustion rate of 3.84 tons of coal per hour, the capital cost of a fan installation with economizer of 9.6 pipes per 1,000 lbs. evaporated per hour, and short chimney, will be found to be, roughly, the same as for a natural-draft installation with 220 feet chimney and economizer of four pipes per 1,000 lbs., viz., £1,800. Capital charges can, therefore, be left out of a comparison, which might take the following form:—

	Per 60,000 lbs. Steam per Hour. Mechanical Draft. £	Natural Draft. £
Saving of heat expressed as coal at 8s. per ton, 12,000 B.T.U. per lb., and 80% efficiency of evaporation........	774	336
Maintenance	180	108
Power reckoned for 5,000 hours at 0.25d..	255	16
	435	124
	£339	£212

showing an advantage, in the case of mechanical draft, of £127 per annum. To this saving, which will obviously be greater still with greater load factors and in districts where coal is dear, must be added, for whatever it is worth, the convenience of being able to control draft independently of atmospheric conditions, and to force it to a degree unattainable with any chimney. It may be argued that this proposition depends entirely upon the manner in which the capital expenditure is made up. In the example cited above, variation of 25 per cent. in calculating the capital cost made, so as to swell the mechanical cost and reduce the other, would just about make the final results equal. But even in that case there would remain the practical advantages indicated.

Cost of Auxiliary Power.

Of more importance is the objection that an increase of the cost of power from 0.25d. to 0.38d. would extinguish the saving altogether. And this leads us to enquire what is the cost of power for auxiliary purposes. For most calculations it may be taken as the cost at generator terminals, plus some addition for transformation if necessary; less wages, as these are practically unaffected by the small proportion of output used on the station. The cost thus resolves itself into coal repairs and capital charges on generating and transforming plant. Many stations can now produce energy at 3 lbs. of coal per unit—some, of course, for much less—but at that figure and 8s. per ton the coal cost is 0.13d. Capital charges, at 15 per cent. on £15 per kw. with load factor 40 per cent., amount to 0.154d., repairs to 0.02d., making a total charge, for auxiliary power, of 0.304d. The figures adopted here are liberal with respect to good modern practice, and the price of 0.25d. assumed in former calculations, if low, is not by any means unattainable. On the whole, it would seem that the deciding factor in settling the matter of draft is the nature of the load. In isolated cases such a question as ability of the ground to carry a high chimney might be important—or again, the quality of ease in removal might recommend a short chimney and fan.

Feed Pumps.

It is only by elasticity of definition that feed pumps can be regarded as apparatus to render a thermodynamic principle advantageous. Yet they do not fall naturally into any other subdivision, being rather one of the main organs for carrying out the cycle. The power station designer has here a wide choice, between steam and electrical drive, and between reciprocating and rotating pumps. The latter possess many of the advantages of rotary air pumps already discussed, and practicable forms have been evolved. Such pumps, in respect of minimum wear, absence of valves, elimination of shocks to feed pipes and check valves, inseparable from reciprocating pumps, are almost ideal for power station work.

If a rotary pump can be combined with the circulating auxiliaries already described, and the whole be driven by a turbine on one shaft, a peculiarly compact and economical piece of apparatus results. There are naturally drawbacks in giving effect to this idea: one is that it may be difficult to find one speed suited to four different rotating objects; to a circulating pump, which may possibly have to deal with seventy times as much water as the feed pump, or to an impeller drawing against 29 inches vacuum and one delivering against 250 lbs. pressure.

Though not necessarily dependent upon rotary feed pumps, the closed-cycle system, whereby the feed water is at no stage exposed to the atmosphere, is rendered so much more attractive by their use that it may be noticed here. The idea underlying its application is that by reducing or altogether eliminating the aeration of the feed much trouble with economizers, feed pipes and boiler shells may be prevented. Since the feed is at no stage exposed to view as a current, it cannot be measured by the ordinary methods, and where anything more accurate than a Venturi tube test is required, an alternative arrangement of pipes must be installed for diverting the feed to the test tanks or recorders. For this reason it cannot be heated at atmospheric pressure, and surface heaters are, therefore, necessary. Then some elasticity is required between the discharge of the extraction pump and the suction of the feed pump to meet the case of boilers not requiring, minute by minute, exactly the same quantity as the steam condensed. And again, make-up feed for wastage has to be provided for. There are two or three methods of meeting these points. The simplest, but also the crudest is to provide a relief valve on the feed discharge, and regulate the admission of make-up feed to the condenser by hand. A more elegant suggestion, due to Mr. Sargent, and shown in Fig. 1, is to provide a tank into which the extraction pump delivers, and from which the feed pump draws. The tank is furnished with an overflow to a main reserve tank below, and a float mechanism controlling a make-up feed valve from reserve tank to condenser. When there is a surplus of water discharged from the condenser it overflows to the reserve tank, and when there is a shortage the float valve opens the connection from reserve tank to condenser. In this manner the system is rendered absolutely automatic, while the external make-up for wastage can be introduced by a float-controlled valve in the reserve tank fixed at a suitable level. By introducing the external make-up at this stage it becomes completely de-aerated before reaching the feed pump. Some stand-by pumping plant might be required for the case of banked fires.

In Fig. 2 is shown an alternative suggestion, proposed by Mr. Fullagar, with a tank floating, as it were, between the two pumps, but no provision is made here for de-aerating the make-up feed.

(To be continued.)