DESIGN AND CONSTRUCTIONAL FEATURES OF TURBINE PUMPS

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(Continued from last week's issue.)

AS is well known, the internal design of a multi-stage turbine-pump involves a rotor comprising a number of impellers keyed on to a shaft, the shoulders or bosses of which abut on each other and are secured and maintained together by double nuts or the like at, or near, the ends of the shaft. Such portions of the shaft as are not covered by the impellers, but are subject to the action of the pumped liquid, are protected by sleeves which fit up to the impeller bosses and thus make a complete sheath outside the shaft itself, Fig. 1 (b), and Fig. 2 (a and b), etc.

This rotor revolves within the guide-chamber and housing, each impeller running at some points in the closest proximity to the partitions dividing the pressure-stages and return-guides.

These so-called running joints or neck-rings must be so maintained by design and construction as to secure in continued service the smallest possible hydraulic leakage-back from stage to stage, or mechanical loss by rubbing friction, both of which affect the efficiency and wear and tear of the pump. As a question of practical importance, the design of this combination probably follows next to that of the successful automatic hydraulic balancing of the axial end-thrust. We have in it the question of the deflection of the pump-shaft; the reinforcing effect of the surrounding impellers; the support afforded by the bushes, if any, between each stage, and the loss by bush friction (wear); the form of neck ring to reduce leakage; and the effect of keyways and keys, etc., all independent of each other and affecting the whole.

The ideal condition is that of a rotor supported in lubricated bearings with a shaft of such sufficient stiffness between supports that the deflection, under all possible running conditions, is less than the clearance allowed at the neck rings and intermediate bushes, so that no contact takes place between the rotating and the fixed members, this clearance at the neck-rings and intermediate bushes being kept down to the smallest possible limit. It will be seen that it is impossible to present mathematically, the exact conditions with such a number of incalculable factors to take into account.

For instance, it may be thought that a not inconsiderable reinforcing effect is obtained by the combination of the impellers outside the shaft as a whole. In practice, however, it is not advisable to lock up the impellers together shoulder to shoulder against each other by the end-nuts in order to get the advantage of the reinforcing effect; because, due to amongst other things, the slight inaccuracies of manufacture in squaring the shoulders of the impellers, sleeves, etc., the result would be to throw the combination out of truth, that is, to distort the shaft.

It might be contended that this need not be so, but even then provision must be made for dismantling in a mine or similar place, with its obvious attendant disadvantages, and the possibility of rough treatment taking place; furthermore, as a safeguard against heating up and consequent expansion of the outside combination (bronze) against the internal (steel) shaft due to accidental contact with the intermediate bushes, running, perhaps, when the pump is empty, suitable expansion should be allowed for, and the impellers, to ensure this, must not be locked tight against each other.

The supporting effect of the bushes on the shaft, in passing through the diaphragm intermediate between the impellers, is very difficult to exactly allow for; it may be that the bushes will decrease the deflection of the shaft by a material amount, but it must not be assumed for one moment that they are bearings of such a nature as lubricated bearings. Intermediate bushes can only, in some cases, be considered as water-lubricated supports which will act as such so long as a certain low surface pressure on them is not exceeded; if too great pressure comes on, heating takes place on account of the high speed of rotation. The effect of wear has also to be taken into account for the hydraulic pressures at the two ends of these bushes are different and there is, therefore, always a flow taking place through them, carrying with it any sedimentary or foreign cutting matter which may be in the water. This state of things causes the supports to wear more or less rapidly so as to become almost useless, the pump eventually arriving at a condition worse than if a suitable clearance had been allowed at the first.

The author believes that too much use is made of these intermediate supports in turbine-pump design. It was found in practice that an internal bearing to be successful must have the same water pressure at both ends, and must be properly lubricated with good grease, it then gives excellent results. We are thus left with the fact that we are practically dependent on the shaft itself for the necessary strength and stiffness to allow of fine internal clearance, and the importance of a good design which will economically give the minimum deflection of

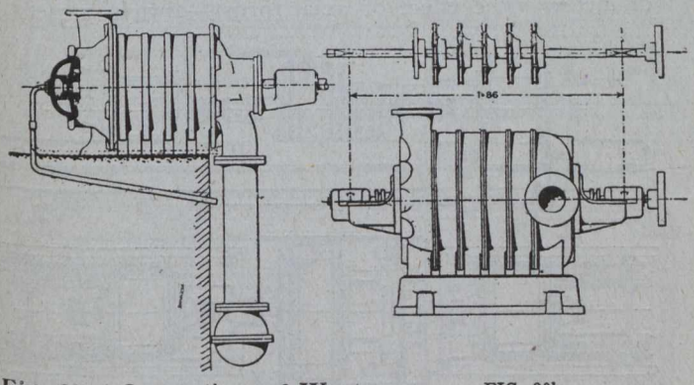

Fig. 29.—Connections of Waste Water from Balancer

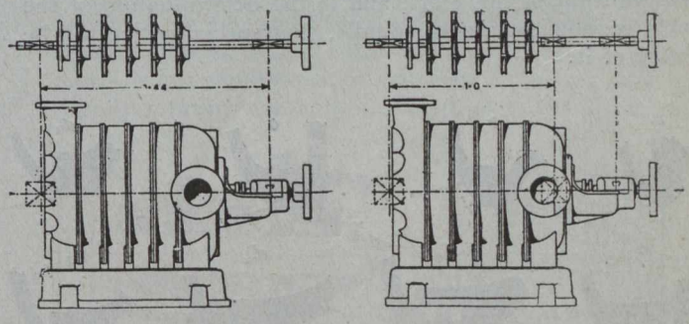

FIG. 30b. FIG. 30a. FIG. 30c.

Fig. 30.—Span of Bearings—Three Arrangements