119. *Balance of Longitudinal Forces\*. Dummies.—*Since the pressure of the steam falls progressively from left to right there is a resultant longitudinal thrust on the drum forcing it to the right, which is balanced by means of "dummy ” rings C' C'' C'". These correspond in diameter with the several portions of the bladed drum and are connected with them by steam passages which secure that each dummy shall have the same pressure forcing it to the left as tends on the corresponding part of the drum to force it to the right. No steam-tight fit is practicable at the dummies, but leakage of the steam past them is minimized by the device of furnishing the circumference of each dummy with a series of rings which revolve between a corresponding series of fixed rings projecting inwards from the case. The dummy rings do not touch but the clearance spaces are made as fine as possible and the whole forms a labyrinth which offers great resistance to the escape of steam. Sub­stantially the same device is employed to guard against leakage in the glands DD where the shaft leaves the turbine case. There is a “ thrust block ” E at one end of the shaft which maintains the exact longitudinal position of the revolving part and allows the fine clearances between fixed and moving dummy rings to be adjusted.

120. *Lubrication.—*The main bearings LL are supplied with oil under pressure kept in circulation by a rotary pump F which draws the oil from the tank G. The pump shaft H, which also carries a spring governor to control the speed of the turbine, is driven by a worm on the main shaft. The same oil is cir­culated over and over again and very little of it is consumed. No oil mixes with the steam, and in this point the turbine has a marked advantage over piston and cylinder engines, which is especially important in marine use. In small fast-running turbines each bearing consists of a bush on which three con­centric sleeves are slipped, fitting loosely over one another with a film of oil between. The whole acts as a cushion which damps out any vibration due to want of balance or alignment. In large turbines this device is dispensed with and a solid brass bearing lined with white metal is employed.

121. *Blades.—*The blades are generally of drawn brass, but copper is used for the first few rows in turbines intended for use with superheated steam. In the most usual method of construction they are put one by one into the grooves, along with distance pieces which hold them at the proper angle and proper distance apart, and the distance pieces are caulked to fix them. The length of the blades ranges from a fraction of an inch upwards. In the longest blades of the largest marine steam turbines it is as much as 22 in. When over an inch or so long they are strengthened by a ring of stout wire let into a notch near the tip and extending round the whole circumference. Each blade is “ laced ” to this by a fine copper binding wire, and the lacing is brazed. For long blades two and even three such rings of supporting wire are introduced at various dis­tances between root and tip. The tips are fined down nearly to a knife-edge so that in the event of contact taking place at the tips between the "rotor ” or revolving part, and the “ stator ” or case, they may grind without being stripped off. The possible causes of such contact are wear of bearings and unequal expansion in heating up. With a proper circulation of oil the former should not take place, and the clearances are made large enough to provide for the latter. Various plans have been devised to facilitate the placing and fixing of the blades. In one method they are slung on a wire which passes through holes in the roots and in the distance pieces and are assembled before­hand in a curved chuck so as to form a sector of the required ring, and are brazed together along with the supporting wires before the segment is put in place. In another method the roots are fixed in a brass rod in which cuts have been machined to receive them; in another the rod in which the roots are secured has holes of the right shape formed in it to receive the blades by being cast round a series of steel cores of the same shape as the blades: the cores are then removed and the blades fixed in the holes.

122. *Drums.—*In small turbines the drums carrying the **re­**volving blades are solid forgings; in large turbines they are also of forged steel but in the form of hollow cylinders turned true inside as well as out. These are supported on the shafts by means of wheel-shaped steel castings near the ends, over which they are shrunk and to which they are fastened by screws the heads of which are riveted over. The case is of cast iron with a longitudinal joint which allows the upper half to be lifted off.

123. *Governing.—*The governor regulates the turbine by causing the steam to be admitted in a series of blasts, the dura­tion of which is automatically adjusted to suit the demand for power. When working at full power the admission is practically continuous; at lower powers the steam valve is opened and closed at rapidly recurring intervals. Each revolution of the governor shaft causes a cam, attached to the governor, to open and close a relay Valve which admits steam to a cylinder controlling the position of the main steam valve, which accordingly opens and closes in unison with the relay. The position of the governor determines how long the relay will admit steam to the con­trolling cylinder, and consequently how long the main valve will be held open in each period. In turbines driving electric generators the control of the relay-valve is sometimes made to depend on variations of the electric pressure produced instead of variations in the speed. In either case the arrangement secures control in a manner remarkably free from frictional inter­ference, and therefore secures a high degree of uniformity in speed or in electric pressure, as the case may be.

To admit of overloading, that is, of working at powers con­siderably in excess of the full power for which the turbine is designed, provision is often made to allow steam to enter at the full admission pressure beyond the first set of rows of blades: this increases the quantity admitted, and, though the action is somewhat less efficient, more power is developed. An orifice will be seen in fig. 60 a little to the right of the main steam admission orifice, the purpose of which is to allow steam to enter direct to the second set of blades, missing the first seven stages, so that the turbine may cope with overloads.

124. *Absence of Wear.—*Owing to its low steam velocities the Parsons turbine enjoys complete immunity from wear of the blades by the action of the steam. A jet of steam, especially when wet, impinging at very high velocity against a metal surface, has considerable cutting effect, but this is absent at velocities such as are found in these turbines, and it is found that even after prolonged use the blades show no signs of wear and the efficiency of the turbine is unimpaired.

125. *Blade Velocity.—*Experience has shown that the most economical results are obtained when the velocity of the steam through the blades is about twice the velocity of the blades them­selves, and the Parsons turbine is accordingly designed with, as far as possible, a constant velocity ratio of about this value. As already explained, it is convenient in practice to divide the expansion into a comparatively small number of steps (about twelve steps is a usual number), giving a constant area of steam passage to the first few rows, a larger area to the next few, and so on. An effect of this is that the velocity ratio varies slightly above and below the value of two to one, but if the steps are not too great this variation is not sufficient materially to affect the efficiency.

If the spindle or drum carrying the moving blades were of the same diameter throughout, the blades at the exhaust end would have to be exceedingly long in order to give passage to the rarefied steam. By increasing the diameter towards the exhaust end the peripheral velocity is increased, and hence the proper velocity for the steam is also increased. The amount of heat drop per ring is consequently greater towards the low-pressure end: in other words, the number of rings for a given drop is reduced. Taking the turbine as a whole, the number of rings will depend on the blade velocity at each step, the relation being such that Σ*n*Vb2=constant for a given total drop from admission to exhaust, *n* being the number of rings whose blade velocity is V*b* It appears that a usual value of this constant is about 1,500,000@@1 for the whole range from an admission pressure which may be nearly 200 lb per sq. in. down to condenser pressure.

@@@1 Speakman, "The Determination of the Principal Dimensions of the Steam Turbine with special reference to Marine Work,” *Proc. Inst. Engineers* *&* *Shipbuilders in Scotland* (October 1905). On this subject see also Reed, “ The Design of Marine Steam Turbines,” *Proc. Inst. Civ. Eng.* (February 1909).