although a stream of water was continually running over the surface in contact. Various expedients have since then been proposed for remedying this inconvenience. One of these was to let the end of the shaft enter a tight cylinder of oil in the manner of a piston, so that it would press against a liquid instead of a solid. Another was to place a large collar upon the shaft, which should press against a number of balls or small rollers like those of a swivel bridge. Neither of these plans, however, appears to have been so successful as to get into general use, and one or other of the following expedients is now generally adopted. The thrust of the screw-shaft is received either upon a number of collars or a series of discs placed at the end of the shaft and resting on a cistern of oil, which is usually cast upon the base plate or some solid part of the engine, and its end is sufficiently strong to bear the thrust of the screw. Interposed, however, between the end of the cistern and that of the shaft are two, three, or more discs of metal, generally two inches thick, and having diameters equal to that of the shaft. A bolt passes through their centre to keep them in lines, but they are each free to revolve in the bolt, and where the shaft passes out of the cistern a collar of leather is applied to prevent the oil from escaping. It will be obvious from such an arrangement that if the end of the shaft where it presses upon the discs begins to heat from undue friction, it will revolve with more difficulty, and will consequently carry the first disc with it. The rubbing surfaces are therefore no longer at the end of the shaft, but at the first disc and the second disc. In fact the rubbing surfaces, instead of being limited to a single disc, are distributed over several. Those surfaces which begin to heat, and consequently to stick, will cease to rub, whereby they will speedily become cool again, and their efficiency consequently be retained.

According to Mr. Borne, the best practical proportion and form of screw-propellers for mercantile vessels are as follows (those of three blades are on the whole preferable). The diameter should be as large as possible. When the area of the circle described by the extremity of the arms of the screw has one square foot for every two-and-a-half

square feet in the area of the midship section immersed, a very efficient performance is obtained. The pitch of the screw should be equal to its diameter, or perhaps a little exceed it, and the length measured parallel to its shaft should be about one-sixth of a convolution.

For example, in the case of a screw twelve feet in diameter the pitch would be from twelve to fourteen feet, and the length about two feet. Screws are generally made with one uniform pitch, and their blades are set at right angles to the shaft; a gradual increase of pitch towards the leading end of the screw is, however, recommended. Thus the pitch of the centre should be about ten per cent. less than at the circumference, for the centre should merely screw through the water, without producing any reaction or propelling force. The effecting part being near the circumference, it is also recommended that the blades, instead of being precisely perpendicular to the shaft, should be inclined a little sternwards, so as to produce a tendency in the water which they drive backwards to converge to a point. It is assumed that this convergent tendency may balance the divergent tendency due to the centrifugal force attending the revolution; so the two forces being in equilibrium will cause the water to be projected backwards from the screw in a cylindrical column. In the case of the ordinary screw with blades at right angles to the shaft, the water projected backwards assumes the figure of a frustrum of a cone, and a certain proportion of the power is thereby lost.

The relative advantages of the screw and paddle propellers depend in a great degree upon the immersion. It appeared by experiments made on a considerable scale with the steamers of the Royal Barge, that in deep immersion the screw has an advantage over the paddle wheel of one-and-a-half per cent., but that with medium immersion the paddle-wheel had an advantage of one-and-three-quarters per cent., an advantage which was augmented to four-and-three-quarters per cent. for light immersion.

It appears, therefore, that the screw-propeller has a certain advantage over the paddle when the vessel is deep in the water, and that on the other hand the paddle gains

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