in elevating back water, and only a small portion in carrying forward the ship. But this is the case of a vessel at rest or not in rapid motion. Now it is argued from this view of the case, that the only way in which a paddle-wheel could be made efficiently to perform its propelling duty, would be, by giving the paddle-boards such a motion upon themselves as to keep them always in a vertical position, both on entering the water and on emerging from it. This was effected about the com­mencement of steam navigation by Mr Buchanan of Glasgow, in what may be designated the parallel paddle-wheel.

The parallel wheel, fig. 33 is constructed on this principle, “ that if two equal circles be equally divided, and so placed, that the dis­tance between two of the points of division is equal to the distance between the centres of the circles, then will all the other points of division be also equidistant, and all the straight lines joining them be pa­rallel.’’ By giving to each paddle-board re­volution on an axis, and placing an arm at right angles to it, connected by a junction-bar with an eccentric strap around the axis, the geometrical problem is mechanically constructed, and we have Buchanan's parallel paddle-wheel. This wheel, with and without alterations in me­chanical structure, has been invented and reproduced over and over again. It has always failed, being radi­cally bad.

In truth, the phenomena of a paddle-wheel revolving on a steam-boat, when the vessel is in motion, differ es­sentially in their form and effects from the phenomena of a wheel revolving around a centre which stands still. When the vessel is only starting, or as yet moving very slowly, all the evils here mentioned do in some degree take place ; but by the motion of the vessel forwards, which is the result of the revolution of the paddles, the evils complained of are at once remedied, and the pad­dle of a common wheel in a quick vessel is actually “ fea­thered,” according to the most dexterous toss of the practised rower. A little study of the geometrical con­ditions of a paddle moving forwards and in a circle at the same time, will make this plain. Let us trace for this purpose the motion of a single paddle. At the point *o,* the paddle-board O' being in the position O', the wheel, turning on a stationary axle, would bring the board *o* successively into the positions *a*', *b'*, *c'*, *d', e', f', g',* &c. ; but the axle being advanced by the motion of the boat into the places *a, b, c, d, e, f, g, h, i, k,l, m, n, o, p, q,* in the same intervals of time, and these motions being simultaneous, the paddle-board describes a path in reference to the water which is the result of both, and the successive positions of the paddle-board are *a*A, *b*B, *c*C, *d*D, *e*E, F, *g*G, &c. The paths described by the boards are trachoidal curves, being of the family of the cy­cloid. Now, from the study of the actual motion thus performed by the paddle-board of the common wheel, it is plain, first of all, that the paddle is inserted into the water in an angular position resembling closely the entrance of an oar into the water ; that it is then made to act horizontally on the water during a short interval ; after which it is withdrawn from the water, edgeways, in an easy and elegant manner, which the dexterous rower might envy and try to equal, but which he could hardly excel.

All this, however, takes for granted that the paddle and the boat are well proportioned and placed ; other­wise all this perfection may be impaired or lost. To this exposition of the subject, it may be added that the com­mon paddle-wheel is in practice, as it ought to be in theory, exempt from the faults generally attributed to it ; and that experiment has shown that its action presents as much perfection in operation, as its simple form and mechanical arrangements do in enabling the artist to give it durability and strength.

When the paddle-wheel is badly proportioned, badly placed, attached to a very slow or full boat, or immersed too deep in the water, its action becomes impaired or impeded. Hence much attention has been devoted to the construction of a paddle that should be more effec­tive in these unfavourable circumstances than the com­mon wheel ; in short, to construct a paddle-wheel that should be an effective propeller, even when immersed to its axis, or wholly placed under water. This may be properly enough called the radiating paddle, as distin­guished from the parallel paddle.

The radiating paddle is not constructed on the falla­cious view of the subject which gave rise to the inven­tion of the parallel paddle-wheel. On the contrary, it proceeds on the hypothesis, that the actual motion of a paddle-wheel on a moving ship is cycloidal ; and its in­tention is to adapt the wheel with greater perfection to that cycloidal motion. The theorem on which it is founded is as follows. Let the circle in the following diagrams, figs. 35, 36, represent that circle in a paddle-wheel which is described by a point moving in the com­mon cycloid, that is, where velocity in the circle is equal to the velocity of the vessel, *o* being the centre of the paddle-wheel,

then, by the property of the cycloid, all lines drawn from the point M at the superior extremity of the vertical diameter of that circle to A, B, C, D, E, F, &c., points in its circumference, will be parallel to the cycloid of progression, or rather to its tangents, at the points of its periphery which correspond to A, B, C, D, E, &c., when in motion. If it were possible to construct this