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GEORGE PARKER BIDDER, President,
in the Chair.

No. 997.—“On the Construction of Floating Beacons.” By
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FLOATING Beacons may be divided into two classes, according to the service for which they are designed:—

1°. Beacon Buoys, which are placed in exposed situations, to mark the position of sunken rocks, sand banks, wrecks, or similar matters dangerous to navigation.

2°. Channel Buoys, which are used for defining the navigable channels of rivers.

It is of essential importance, that all buoys, but more especially those used for sea marks, should be conspicuous in all states of the weather; and for this purpose, they should fulfil the following conditions:—

1°. The superstructure should be erect, well raised above the surrounding water, and presenting a considerable breadth of surface, so as to be conspicuous at a distance. Hence, stability is an essential quality.

2°. The buoy should present a steady object to the view, and be as free as possible, from rolling, and more especially, from abrupt pitching, which not only tends to snap the mooring chain, but also prevents the seaman from deciphering any name, or characteristic mark which may distinguish the buoy, and define its position on the chart.

These qualities of stability and steadiness, in connection with others of great importance, such as simplicity of construction and consequent cheapness of manufacture, are combined in that form of beacon buoy, a description of which the Author now submits to the Institution, and which, from the peculiarity of its construction, has been called the ‘Keel Buoy.’ Before describing it, however, it may be desirable to notice the various forms of floating beacons hitherto adopted.

BUOYS WHOSE AXIS OF SYMMETRY IS HORIZONTAL, OR OBLIQUE.
—The earliest buoys were, probably, barrels, or large casks, and

this form is still retained in channel buoys. When the barrel buoy is made of iron, the ends, instead of being square, are slightly rounded, so that the buoy resembles a woolpack, rather than a cask. The barrel buoy is strong, and it is simple in construction, but from its low elevation above the surrounding water, it does not fulfil the most important requirement of a good sea mark.

The Can Buoy has, until within the last few years, been a favourite shape; formerly, it was always constructed of timber staves like a cask, but latterly, of iron plate also. When a can buoy has the name of the sand bank, or rock, which it marks, painted upon it, it is necessary to ballast one side with a small cast-iron keel, so as to insure the name remaining uppermost. The can buoy is not of a conspicuous form, nor does it possess any characteristic good quality, which merits its being longer retained as a beacon; it will, therefore, doubtless, soon be superseded by other forms of greater merit.

BUOYS WHOSE AXIS OF SYMMETRY IS VERTICAL.—The next class of beacon buoys is characterised by a lofty superstructure, of which the cone may be considered the typical form, the body of the buoy being symmetrically disposed around a vertical axis. When the necessity for large floating beacons first arose, it may readily be conceived, that a boat with a cask, or other conspicuous mark fastened to the mast, suggested itself. The Bell Beacon of Liverpool¹ is an example of this class, in an improved form. Wooden spars, springing from the gunwale of the boat, meet together at an apex on the mast, and present the outline of a limpet shell. A globe and bell are attached to the mast. This form of beacon is now being superseded by others specially adapted for the purpose.

Another form of beacon, still sometimes used, consists of a spar, passing through a float, or raft of solid timber, called a deadman. The spar is moored near its lower end, so that it floats vertically, and a globe, or barrel, may be attached to its summit.

Of beacons specially adapted for the purpose, the Nun Buoy first claims attention. In its original form, it presented the appearance of two cones attached by their bases. The Egg-bottomed Buoy is an improved modification of the nun buoy. Its superstructure, which is conical, like a church spire, is formed of sheet iron, riveted to a malleable, or cast-iron bottom of a hemispherical form. This buoy possesses some good qualities. It is simple in construction, and so long as the sea is calm, it is tolerably conspicuous, having a lofty, though narrow superstructure, well raised above the plane of flotation, and held in an upright position, by the combined weight

¹ Vide "Sailing Directions from Port Lynas to Liverpool, with Tidal Courses and Tide-gauge Table for navigating the Dee and the Mersey," &c. By Commander H. M. Denham. 8vo. Liverpool, 1840. Plate 5, facing page x.

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of the metal bottom and the mooring chain. But in a tideway, or under the influence of wind, it inclines over at a considerable angle from the perpendicular, and when the waves rise, it rolls and pitches violently, so as to become an indifferent sea mark.

One great defect of the nun, or egg-bottomed buoy is its want of rigidity, arising from the shape of the bottom. This defect is remedied in the buoy represented in Fig. 1, which is made of iron.

Fig. 1.

Channel Buoy; River Liffey.

It is very buoyant, and presents a far more conspicuous object than the barrel buoy, which it has superseded in the River Liffey. The bottom is either flat, or slightly coned. Another modification of the same form is represented in Fig. 2, (page 303,) which is an elevation of a channel buoy moored near the entrance of the River Liffey, and within the shelter of the walls which protect the harbour. The lower portion is a wrought-iron tub, 12 feet in diameter at the widest part, and 9 feet across the bottom. The conical superstructure is formed of wooden spars, arranged somewhat similar to those on the Liverpool Bell-boat. Flat-bottomed buoys are, however, ill-adapted for the open sea, as they are only slightly

immersed, and are, consequently, easily 'boxed' about by the waves, which make them roll violently in rough weather; but this, perhaps, is of little consequence in the inner waters of a harbour.

Fig. 2.

Channel Buoy; River Liffey.

Want of conspicuousness and instability, one, or other of which defects characterise the buoys already described, have, in some measure, been remedied in Mr. Herbert's Cone-bottomed Buoy (Fig. 3, p. 304), a description of which has already been presented to the Institution.¹ It is well known, that the higher the centre of gravity of a free floating body is placed, the more sluggish will be the rolling motion, though its amount may be considerable. This was exemplified in the cruise of the 'Agamemnon,' with the Atlantic cable on board. The coil of cable on the upper deck raised the centre of gravity, and thus diminished the abruptness of her rolling, the angle of which is said to have exceeded 45° , in the terrible

¹ Vide Minutes of Proceedings Inst. C.E., vol. xv., p. 1.

storm which she encountered. When vessels with a sharp rise of floor roll rapidly, the defect is said to be sometimes remedied

Fig. 3.

Cone-bottomed Buoy.

by stowing the ballast higher up. The adoption of this principle seems to have been the aim of the inventor of the Cone-bottomed Buoy. "The mooring chain," he states, "should be attached near to the centre of gravity and to the centre of the plane of flotation, which points should be nearly identical; and it was considered, that the easiest mode of attaining this, was by raising up and hollowing out the bottom of the buoy, to about the surface of the water, and near to the apex of the hollow cone thus formed, to attach the mooring cable."¹ Whatever advantage the inventor may have proposed by this arrangement, it has not been realised in practice, for the mooring chain is not attached either to the centre of gravity, or to the centre of the plane of flotation, but to a point nearly half-way between the plane of flotation and the lower edge

¹ *Vide Minutes of Proceedings Inst. C.E.*, vol. xv., pp. 1, 2.

of the buoy, and considerably below the centre of gravity. If it were fastened, as originally proposed, to the centre of the plane of flotation, the buoy would, under the influence of currents, incline strongly in the opposite direction, from the lateral pressure being below the centre of mooring, in place of being above it, as is usually the case.

In practical inquiries, the first step is to profit by the experience of others, and to ascertain what has been already done, under similar circumstances, to attain the desired result. In the case of a floating body, a ship obviously suggests itself for consideration. Now every sailor is aware, that additional keels, or bilge boards, tend to prevent ships of certain forms from rolling; and advantage has been taken of this in some of the lightships stationed round the coast, which have two keels on each side of the central keel, five in all, and their efficacy in steadying the vessel is due, doubtless, to the mass of water constrained to move along with the ship when she rolls, and which resists by its inertia any sudden movement of the vessel. A similar arrangement may be applied to a floating beacon, and the result is the Keel Buoy, represented in section, in Fig. 4; (page 306.) The superstructure may be of any of the ordinary forms, but the dome shape is preferred, as being the most conspicuous. It will be observed, that the sides are prolonged below the bottom, so as to form a circular keel, within which a large body of water is retained. Thus, a buoy 6 feet in diameter, with a keel of 18 inches, contains within the latter, a body of water exceeding a ton in weight, or a mass of water of nearly the same weight as the buoy. A buoy 8 feet in diameter, with a keel of 20 inches, contains upwards of 2 tons of water within the keel. A few air-holes are pierced in the keel, just underneath the bottom, for the purpose of letting the air escape on first floating the buoy. Thus, by a very simple arrangement, the floating mass is virtually doubled, or even further increased, if desirable; and the buoy is, consequently, less liable to be tossed about like a cork on the waves. Again, the bolt of the mooring chain, where it passes through the mooring ring, divides the surface exposed to lateral pressure, into equal, or nearly equal portions. Hence, the Keel Buoy floats erect in tideways, or rivers, however rapid; for equal pressure is exerted both above and below the centre of mooring. The keel also gives this buoy a much greater hold in the water, than is the case with other buoys. A sudden blow of a wave is resisted, as has been shown, by the inertia of the enclosed mass; but it is also resisted by the reaction of the water against the outside of the keel, especially when the buoy receives a sudden blow above the plane of flotation, a frequent occurrence in a chopping sea. Hence, the tendency to pitch is diminished.

Fig. 4.

There is another advantage connected with the adoption of a keel. It acts as ballast placed in the best possible position for stability; and this is an important consideration, for it will be readily perceived, that the value of a beacon depends upon its having a lofty and conspicuous superstructure, which cannot be attained to the same extent in other buoys without the addition of ballast. Egg-bottomed buoys, for instance, do not float erect, unless either ballast or a heavy mooring chain be attached; and when the conical superstructure is replaced by a more conspicuous one, dome-shaped, the amount of ballast required has proved so serious a drawback, as to prevent this form being adopted. Even with ballast, the egg-bottomed buoy is easily inclined, owing to its shape under water. The Keel Buoy, in consequence of its peculiar form, may have a very lofty superstructure without endangering its stability. A buoy, 9 feet in height, (not including the keel,) and 6 feet in diameter, projects 7 feet 6 inches above the water; and in general, a Keel Buoy may have a superstructure 25 per cent. higher than that of other buoys of equal diameter, with the same configuration above water. A Keel Buoy of the size mentioned weighs $23\frac{1}{2}$ cwt., while an egg-bottomed buoy of the same diameter weighs about 2 tons. The former will, however, even before the mooring chain is attached, support the weight of an ordinary man on the summit with only a slight inclination from the perpendicular; whereas the latter will, under similar circumstances, lie with the apex close to the water. The steadiness of the Keel Buoy is equally remarkable; for when in an experiment it was made to oscillate violently, by repeated synchronous pulls of a rope attached to the apex it ceased to roll after four or five oscillations.

The mooring ring adopted has been found to be simple and efficient. It is a button-shaped casting, which with the shank projects through an aperture in the wrought-iron bottom. As it is riveted to the inside of the bottom by a double row of rivets, the straining of the chain, however severe, can neither tear it away from the bottom, nor loosen the rivets. The ordinary form of mooring ring is a cross of wrought iron, riveted to the outside of the bottom; and it seems probable, that the disappearance of buoys may, occasionally, be attributed to the loosening of the rivets, under the ceaseless strain of the chain, which tends to produce leakage below the water line.

Turning from the arts of peace to those of war, another application of the keel suggests itself; namely, to floating batteries, whether revolving, or fixed. Here, stability, combined with freedom from rolling motion, is an essential quality, which may, it is believed, be attained by arrangements similar to those above described. In beacons of unusual size, or floating batteries, it may be found desirable to employ more than one keel, so as to

divide the enclosed space into cells, whereby the water may be more surely made a part, as it were, of the floating mass.

The Author does not pretend to claim for floating bodies, constructed with keels as proposed, a total freedom from rolling. This is not to be expected, for there are certain waves which will cause any floating body to roll. What is claimed for, and has, it is believed, been attained in the Keel Buoy, is a greater freedom from abrupt motion than is possessed by other floating bodies having the same amount of displacement. A Keel Buoy will pitch less abruptly than any other buoy of the same diameter and weight, and it is only when these are equal, that a fair comparison can be instituted. If, for instance, a buoy is made very wide in proportion to its height, and with slight immersion, it will float upright, because it floats like a board on the surface of the water; but the stability thus gained is at the expense of facility in management. If, on the other hand, stability is sought for, not by breadth of beam but by ballasting the bottom, the buoy will not only be unwieldy, but expensive. Now the Keel Buoy is, as has been already stated, light, and therefore, easily handled; and moreover, it occupies no greater amount of space on deck, than is sufficient for it to stand on end; thus contrasting favourably with the can and the egg-bottomed buoys.

The Paper is illustrated by a series of diagrams, from which the woodcuts, (Figs. 1 to 4,) have been compiled.

[Mr. JOHN MURRAY