der that the original strength of the bridge, even if the iron had been good, was not sufficient for ensuring stability.

"3. That the widening appears to have been injudicious, and made without sufficient reference to the original strength of the bridge and the weight which it had to support; and therefore, that it operated as an aggravation of the evil.

"4. That in the original construction of the bridge the casualty of a great load, all on one side, does not appear to have been contemplated. If it had been, I think that the chain on that side would have consisted of more than two bars, any one of which, taken separately, was unequal to the load which the bridge was likely to carry.

"The whole weight of the bridge had, before my arrival, been calculated with great accuracy by Mr. Scoles and was checked by me. The addition to the width, as far as its own weight is concerned, is comparatively small and unimportant. The weight of the bridge before the addition, including the suspension chains, was 17 tons, 14 cwt. 3 qrs. 25 lbs.; with the additional width and the railing, its weight was 20 tons, 8 cwt. 9 lbs., making an addition of only 2 tons, 13 cwt. The evil arose from the footway being outside the chains, and therefore throwing the whole load upon the two bars of the south suspending chain, without any part being thrown on the north chain.

"I beg to add, that during my investigation I received every assistance from Mr. Cory with reference to all the documents which were in his possession, which enabled me to arrive at my conclusions in less time, and with, I trust, a greater approximation to accuracy than I could otherwise have done.

"I have the honour to be, Sir,

"Your most obedient servant,

(Signed) "JAMES WALKER.

"To the Right Hon. Sir James Graham, Bart.,
Secretary of State."

No. 719. "Description of the 'Vanguard' Iron Steam Vessel, after being ashore on the rocks in the Cove of Cork." By John Grantham, Assoc. Inst. C. E.

The Author having been called upon by the owners and underwriters of the 'Vanguard' to survey her, and to give directions for the repairs, had an opportunity of making a minute examination of the injuries she had received, from running ashore. From these observations, and from the accounts he had received of the accident, he was induced to think, that it formed the most remarkable and satisfactory instance of the strength of an iron vessel, which had yet occurred, and that it deserved to be recorded. There are many other striking

cases, in which iron vessels have given proof of great strength; but the size of the vessel, the severity of the trial, her ultimate preservation, and the opportunity afforded of observing the effects, all unite to render this case more than ordinarily interesting.

The 'Vanguard' is a fine iron steamer of about 670 tons burthen, and 300 H.P., built by Mr. R. Napier for the Dublin and Glasgow Steam Company. The engines are on the side-lever plan, with large flue boilers, about 26 feet in length. The keel is an iron bar, about 6 inches deep by $2\frac{1}{2}$ inches thick; the garboard streak is made of plates $\frac{5}{8}$ inch thick, and the remainder of the bottom averages $\frac{7}{8}$ inch in thickness. The floorings are composed of single bars of angle iron, $3\frac{1}{2}$ inches deep by $2\frac{1}{2}$ inches wide, riveted to the shell, with iron plates $\frac{3}{8}$ inch thick to stiffen them, and another piece of angle iron on the top of these. The depths of these plates vary very much; being so formed as to allow the engine beds and the boilers to go down below the general level of the frames.

The floorings under the centre boiler, and over the keel, are 12 inches deep; those under the cylinders are 11 inches deep; but under the condensers they are only $3\frac{1}{2}$ inches in depth. Between the engines the floors are 2 feet deep, the parts that are reduced under the engines, being strengthened by longitudinal plates riveted to the floorings.

Instead of keelsons, longitudinal rows of bridging pieces, composed of angle iron and of short plates $\frac{3}{8}$ inch thick, are riveted between each flooring.

The plates of the bottom are clencher fastened, and are double riveted.

It is stated by those connected with the vessel, that on the 14th of December, 1844, in rounding the lighthouse, at the entrance of the Cove of Cork, the helm being put rather too hard over, and the curl of a very heavy sea setting in at the same time through the channel, she approached too near a reef of rocks, and struck so heavily upon them, as to carry away her rudder, the heel of her stern-post, and part of the keel; injuring, also, the lower part of the after partition, which was only 5 feet from the stern-post, and thus causing the after hold to fill with water.

After receiving the blow, and before the way could be checked, she ran fairly in upon the rocks, where she continued to beat for about $2\frac{1}{2}$ hours, till the tide left her seated upon two ridges. The fore foot resting on a rock, which raised her head considerably, and prevented her from floating off when the water was pumped out of her.

The keel lay between two ridges, and the bottom principally

rested on four points, two on each side. The stern also occasionally struck on another point. The stem was nearly uninjured; the fore hold was entirely so, and it remained to the last perfectly watertight. Under both engines, at the after ends of the boilers, and at the fore part of the after hold, the plates were very much indented. These injuries clearly indicated where the vessel had been most severely tried.

The vessel continued to strike for $2\frac{1}{2}$ hours, after she first ran on the rocks; during all this time the engines were kept at work, but as the tide fell, all hopes of immediately getting her off were relinquished. The water had risen above the cabin floor, and a plate was cracked in the engine room, so that as the tide rose, the after hold and the engine compartment continued to fill.

As the after end of the vessel was never dry, even at low water, a diver was employed to ascertain the extent of the damage. A curious circumstance was thus discovered. At the time the keel of the vessel was knocked off, the plates were torn away higher up on one side than on the other, and the plate which was left lower than the rest, was, by the subsequent striking of the ship, bent upwards across the opening, which had been left by tearing away part of the keel. This circumstance proved, afterwards, a means by which the water was kept out of the vessel, as upon this projection old sacks and other materials were rammed down, and caused a temporary stoppage of the leak. Excepting this injury at the stern, only one hole was made in the plates, and this was so small, that by injecting from the bilge, into the condenser of one engine, the water was easily kept down.

Whenever the vessel floated, the lurches and the striking on the rocks, are described as being so severe, as to sound as if the hull was being crushed to pieces. It was therefore generally reported that she must become a total wreck.

The mode of getting her off was very simple. At low water, during a spring tide, the sea so far receded from the engine room, as to leave the furnace bars dry; this enabled the men to light the fires, and although the other ends of the boilers were immersed nearly 3 feet in the water, the steam was raised, and the engines started, and in 4 hours all was clear in the engine room; in this state they were kept at work for two days. The after hold was then partially cleared, by the means before described, and the rock having been cut away under the stern, she at length slipped off into deep water, and was kept afloat by the pumps, just long enough to beach her in a safe place, at Spyke Island. She was there sufficiently repaired to enable her to be taken to Dublin. The engines were taken out, and

she was hauled up on the patent slip where the Author surveyed her.

It was found, that the vessel had not received the slightest injury, except in the parts where she struck upon the rocks; the engines, although in one place raised a little, worked as well as before the accident; and the general form of the hull had not been, in the least degree, disturbed.

The plates of the hull, although much bent, were not in any part indented more than $2\frac{1}{2}$ inches, and this in only about four places; the other indentions did not much exceed an inch in depth. Only one hole, and two or three cracks, could be discovered, except at the stern, as before described. Not more than three broken rivets were found. All the bent plates were fit to be restored, with the exception of about thirty, which would have been so much stretched when straightened, that the rivet-holes would not have accorded.

The keel was driven up to the extent of about an inch, under the main-mast, but no mark could be discovered to indicate the exact point on which it had struck.

The angle bars of the floorings were broken in a few places, at the rivet-holes, and a few of the stiffening plates were bent; but the leve of the engine beds and the boiler seats were only disturbed in one place, and even there not so much as to injure the working of the engines. This last circumstance is very remarkable. A timber built vessel, with only half the amount of straining sustained by this vessel, would probably have entirely broken and dislocated the engines. In similar cases, when timber-built vessels have been wrecked, even if they were ultimately saved, the whole frame has been disturbed, and the shape of the hull much altered; the upper works were generally opened, the bolts drawn, and the beams broken; but in the 'Vanguard' nothing of the kind, after the most careful search, could be discovered, the injuries being wholly confined to the part in actual contact with the rocks; so that when the damaged plates and ribs were replaced, the hull was as good as at first, and did not require a single additional fastening.

The paper is illustrated by sketches showing the state of the vessel on the rocks.

Mr. J. MILLER instanced as a proof of the extraordinary strength of iron vessels, the case of the 'Prince of Wales,' which, when being launched from Messrs. Miller and Ravenhill's building yard at Blackwall, hung by the fore foot upon the wharf wall, leaving 110 feet of her length unsupported. The whole of the deck, in the centre of the vessel, was not laid, on account of the reception of the ma-
[1845.]