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“Dry-Dock Equipment, and Ship-Repairs.”

By JOSEPH FELL REDMAN.

THE increase in size and in value of merchant steamers has rendered their rapid and efficient repair in a dry-dock of great importance, especially in the case of mail-steamers. The mechanical appliances of a dry-dock are frequently in so primitive a state that, if possible, repairs are sent to the workshop, as better results are thus obtained both as regards time, quality, and cost.

The draught of some of the largest steamships built within the last twenty years, in average dry-docking state, ranges between 17 feet and 23 feet, so that a depth of water of 25 feet on the sill is required to allow a margin for varying tides. However, even 25 feet of water would not meet all emergencies, as an ordinary load-draught of mail-steamers is 26 feet; and, as in taking a ship out of dock a propeller-blade may be broken, time and money would be saved by partially drying such a ship down to the top of the boss, extra shores being placed round the vessel, and, as a further precaution, the rise of floor being known, an extra line of blocks on each side of the keel along the flat portion of the bottom. The Author once docked a loaded steamer, drying her from the mean draught of 19 feet 2½ inches, with 7,300 tons displacement, to 12 feet with 4,060 tons, so that the weight on the blocks was 3,240 tons. The displacement of this steamer, at 11½ feet mean draught, with clean-swept holds and no coal or water-ballast, is 3,850 tons, so that less strain was imposed upon the hull than by an ordinary docking. Two new propeller-blades were fitted; and the vessel proceeded to sea in thirteen hours from the time of entering the dry-dock. On the other hand, the Author has seen a vessel delayed many days by the discharge and replacement of 1,800 tons of cargo. The vessel was tipped 29 feet 5 inches fore and 11 feet 4 inches aft, and one blade was fitted. When a dry-dock is available, the tipping of a loaded steamer is inadvisable, as it is dangerous and expensive, according to the nature of

the cargo. The Huskisson Lock in Liverpool was often used as a dry-dock some years ago; and it has consequently occurred to the Author that at docks, having more water on the sills of their entrance-locks than dry-docks, some low blocks might be fitted with great advantage. A timber rubbing-fender, 12 inches by 12 inches, at each side of the lock, would suffice to support the shore-ends.

Docking a Ship.—The vessel having been towed to the dry-dock entrance, is hauled into position by ropes, and steadied over the line of blocks. For hauling the vessel upright, masthead tackles of 5-inch wire-rope, coupled by wire strops and shackles, and led to a secure anchorage, are useful but objectionable. It is better to present the vessel plumb for docking. Free bilge-water, which the pumps cannot clear, often causes a vessel to lean to one side; and after being dried out, and all wear and tear of cement-work made good, the vessel comes out quite stiff. With pumping-power capable of emptying a dock in about $2\frac{1}{2}$ hours, it is desirable to have four rafts on which the men can scrub and scrape the vessel's hull as the water descends; and when a ship is very foul, the pumps have to be eased or stopped. Rotary wire-brushes, and jets of water, under a pressure of at least 100 lbs. per square inch, may be useful. Ashes, ground-clinker, or sand, with either steam or water from an annular jet, would enable a vessel to be scoured bright.

The fixing of the shores as the water leaves seems a simple operation on a calm day; but four hydraulic shores, on each side of a ship, placed in position in pairs, would be useful in a high wind or with a quickly-falling tide, *Fig. 1*, p. 186. The hydraulic cylinders could be built into the side-wall, at about the level of the upper altar; and the ordinary shores would rest in a rebate forming the ram-head.

A large steamer approaching an entrance in a strong wind or tideway, is controlled by a 7-inch manilla head-rope, with a breaking-strength of about 25 tons, and a similar rope at the stern. If either rope breaks, there is not time to pass another to the tug or to the shore before the vessel swings round heavily against a pier-head or boom. With a floating hydraulic-buffer in rear of the boom, to project and meet the approaching vessel, it might be eased up and brought alongside quietly, when a fresh rope could be made fast and the vessel warped in. This appliance would be most useful for twin-screw steamers, or single-screw steamers of fine lines aft, with counters running too high above the quay-walls of the entrance for the use of ordinary fenders.

Blocks and Blocking.—In most dry-docks, when a vessel dries, the whole of her weight rests upon the keel-blocks, until a row of shores can be fitted between her bilge and the dock-bottom. Sliding bilge-blocks, as at present fitted, involve too much rigging for drawing them into position; and they hinder the painting and examination of a ship's bottom. The sliding bilge-chocks in the dry-dock of the North German Lloyd Co., at Bremerhaven, moved upon balks of timber 10 feet apart, so that it was necessary to pass round the ends, or climb over them. In the Erie Basin dry-dock, Brooklyn, New York, the dry-dock bottom is left flush, as the chocks draw back over metal races, into recesses at the sides of the dock. To avoid undue crushing of "caps" under the engines or any local weight, extra blocks can be laid at such points. At some ports the dry-dock is pumped out between the turning out of one vessel and the docking of another, for the purpose of laying fresh fir-caps. This seriously reduces the working capacity of the dry-dock; but any irregularity in the keel will readily adjust itself on the fresh soft caps. With good English-elm caps, when bringing in another vessel on the same tide, no great risk is run, as before lifting the first vessel the state of the blocks can be ascertained by inspection.

Good blocks for the heaviest class of work are shown in *Fig. 3*. Other blocks, which have stood hard work for many years at the Thames Ironworks, and are readily removed, are illustrated in *Fig. 4*. The block under the cap is strengthened by bolts passing through it with three plates on each side, to resist crushing strains. These blocks are not bolted to the dock-bottom, but are braced together in groups of three and loaded with double-headed rails. The blocks wear most quickly at the springing of the fore-foot from the straight line of the keel, corresponding to the position of the foremast in many modern vessels, as no shores can be fitted under the stem until the vessel is dried out. With single-screw steamers, floating considerably by the stern, and not having much rise toward the heel of the stern-frame, it is better to leave the caps off the last two blocks, and subsequently make up a bearing by folding wedges. With a tender vessel, no weights should be shifted, either vertically or athwartship, without due provision being made by shores; and such weights should be replaced before the vessel is refloated.

Some vessels need water-ballast for dry-docking, and while in the dock the tanks may be emptied for cleaning, examination, and cement-washing. For undocking, there is considerable risk and delay if the water is let in to about the 8-foot water-line and

stopped until the tanks are filled. Sometimes the filling of a small tank, holding about 100 tons of sweet water, directly the vessel was cleaned, has saved a day's dock rent; but it would be a convenience to have a large supply of coarse water available from a 6-inch hose. This water would be good enough for washing out limbers, and also for washing the cables as they are lowered and ranged on the dock-bottom for examination and overhauling the shackle-pins.

Dry-Dock Bottom.—A flat bottom for a dry-dock, cambered slightly towards the gutter water-ways on each side, with a raised pathway round, as in *Fig. 1*, gives space for passing round a vessel before the dock is quite dry; and a reflected light enables any defect to be quickly observed. All ring-bolts, &c., should be flush on the dock-bottom. Ring-bolts, of $1\frac{1}{2}$ -inch round iron, are convenient for fastening tackle-blocks to for work near a ship's stern, when placed 10 feet on each side of the keel-blocks, and about 10 feet apart. For checking draft-marks and truth of keels, datum-points of granite on the middle line of the dock, about 25 feet apart, would be useful; or small bronze castings could be fitted in any existing dock, and proved by sights from time to time. A tramway on each side of the dock, with a trolley spanning the water-ways, would render one slide at the head of the dock sufficient, coupled with a hydraulic hoist, as shown in *Fig. 1*; and these tramways would save wear and tear of the dock-bottom and altars.

Staging and Painting.—In London, the staging for painting and propeller work, charged at 23s. per 100-foot run, making and breaking, forms a costly item. Upper stages are carried by tiers of shores, and must be two planks in width; lower stages are carried efficiently on iron horses. If no extensive repairs are necessary, the largest vessels are dry-docked and turned out after receiving two coats of paint, one priming and one composition, or two coats of some anti-corrosive material, within twenty-four hours, saving a second day's rent. In some states of the weather the bottom has to be dried artificially by portable fires; but without care these give trouble. Gas fires, with atmospheric burners, could be readily passed under the bottom, and, if of good size, should dry it quickly. They should be kept at least 3 feet from the plating, and be moved continually to avoid local heating of the plates. Owing to the speed of painting required, much paint is wasted. The Author has suggested that it should be applied with a squirt, the feasibility of which has since been confirmed by the spraying nozzle used in the Priestman petroleum

engine, and also by the statement that the Exhibition buildings at Chicago were coated by the use of nozzles.¹ Boiled linseed-oil, or red-lead paint applied by this method, would probably dry quickly; and these are the best for a priming coat for either the inside or outside of a ship.

Rudder Work.—As most rudders are now fitted with loose pintles, and loose bushes in the braces on the rudder-post, the up-keep is simple. On docking a 4,000-ton steamer, the Author once found the rudder-frame broken in two places near the bottom. In hauling the rudder clear of its trunk at the ship's counter there was only 6 inches clearance, so that a rudder-pit would have saved anxiety. No crane being available, derricks had to be rigged and the rudder floated over to a barge, sent to the forge, and repaired. The bushes on the rudder-post were made good and proved, the ship floated and towed to the loading-berth, and the rudder shipped afloat. A coupling with carefully-fitted bolts is frequently fitted some distance below the counter, which further facilitates repairs; the latest form of frame has long projecting tails across the whole breadth of the single plate forming the rudder proper, on alternate sides, as shown by the dotted and full lines in *Fig. 7*.

Propeller Work.—In a propeller with loose blades, any found broken or seriously decayed can be easily replaced by new ones, as the weight is comparatively small, and the nuts on the studs holding them to the boss are readily unscrewed. When the boss appears to be amiss or does not fit well on the shaft, the nut is at once slackened back, and the boss is then struck with a ram or tup, conveniently hung by tackling. If a few blows will not start it the heat from a wood fire may be resorted to; and a steam-jet has been suggested for this purpose. But if the boss was originally well bored and fitted to its shaft it should be readily started or driven into position by hydraulic power, the nut being simply screwed up. The tup or battering-ram should be discarded as dangerous, and has split many bosses. An annular ram, about 6 inches long over all, for driving a boss home, could be placed between the boss and the nut, the latter being made sufficiently deep to avoid distorting the threads on the shaft, *Fig. 5*. For drawing a boss off a shaft the ram would be in rear of the nut,

¹ "The air-compressor used in the mechanical process of painting the Exhibition buildings at Chicago, is a rotary one, which, when driven by an electric motor, compresses air from 15 lbs. to 18 lbs. to the square inch. The air is then mixed with calcimine; and both are impelled, through a hose, upon the surface being painted or calcimined, from the nozzle in the hands of two men on the scaffolding."—*Engineering*, Feb. 3, 1893, vol. lv. p. 145.

which would be slackened back about $\frac{1}{2}$ inch, the power being transmitted by a pair of large bolts with shields or plates of ample strength. The boss must be taken off periodically in a single-screw steamer to allow an examination of the part of that propeller-shaft which works within the stern-tube, and to line up the lignum-

Scale to Figs. 7 & 9, $\frac{1}{240}$

vitæ strips forming the bushing of most tubes. Sometimes these strips are cut to a template by revolving cutters, which give better results than can be obtained by fitting them by hand in place.

Some years ago the whole of the propeller-shaft between the boss and the inside of the stuffing-box gland in the tunnel was covered with brass liners, cast in two or more lengths, bored, heated, shrunk

on, and pinned. Gradually, however, the springing of the shaft produced a deep groove at the butt-joint, nicking the shaft in some cases $\frac{3}{4}$ inch deep all round. Subsequently, the central part of the shaft was left bare, and the ends bevelled, so as to avoid its "catching" against the neck-bush when drawn in towards the tunnel; but bushes are still shrunk on and pinned. As gun-metal is treacherous when hot, it is better to make an allowance by gauge, and draw the liner on cold, all in one piece, and by hydraulic power. The end of the liner may fit 2 inches or 3 inches into the boss; or the latter can be fitted to within $\frac{1}{2}$ inch of the liner, in which space an india-rubber ring, $\frac{3}{4}$ inch thick, can be inserted, which will check the galvanic action and keep water out of the boss, *Fig. 5*.

For twin-screw propellers the same kind of annular hydraulic plant as described for the single-screw steamer would serve, not only for drawing off and forcing home the bosses, but also for drawing the bushes out of the brackets or A frames when they require relining with lignum-vitæ or white-metal, which could then be done in the factory. The shafts could then remain in place, if they have not to be removed for any other purpose. Ordinary screws are slow, and often become distorted at critical times.

Two methods of fitting propeller-shafting, shown in *Fig. 9*, indicate the needless work and expense avoided by being able to push out the bracket-bushes for refitting. In the one case, a box or sleeve coupling, which has been shrunk together with feathers, and cross-keys through it, would have to be taken adrift; and in the other, the tunnel-shafting would have to be disturbed by one length being removed, and the propeller-shaft length drawn in clear of the bracket. In dealing with interchangeable propellers, the Author prefers to use complete cone-gauges of sound cast-iron, male and female, instead of the ordinary plate-gauges, *Fig. 6*. Lugs or eyes cast on the top of the gauge representing the propeller, are for lifting purposes and trying it freely upon the propeller-shaft. By marking these cone-gauges, the true position of keyways can be set off, and much heavy work saved. The metal should be about 1 inch thick, with three circular ribs to assist in maintaining the shape truly circular. For the manipulation of twin-screw propellers and their shafts, the Author considers that hawse-pipes might be fitted with advantage in the counter or stern of the vessel, directly over the centre of the boss, *Fig. 1*, which would give a better lead for all necessary gear for dealing with the great weight, than the usual threading of chains over a ship's upper works. The shackles fitted by builders are usually only

suitable for dealing with single blades ; but it is often convenient to take a propeller off bodily without disturbing the blades.

Stern-Frames.—A frequent accident to a single-screw steamship is the fracture of the stern-frame, either by grounding upon the heel, or by the continued striking of seas upon the rudder, reacting upon the bottom of the sweep near the inner post ; and if a scarf occurs at that part and is not quite sound, rupture takes place, and in heavy weather probably the rudder is carried away with the after part of the frame, *Fig. 7*. The cutting out of a large stern-frame is a serious matter, as so much work is disturbed, including the clearing away of cement-work between the fine floor-plates forming the counter of the vessel, and drawing the shafting and stern-tube out of the way. The large rivets passing through both thicknesses of shell-plating and the body of the frame, are cut across the points with cross-cuts or diamond-points, and drifted out. As both sides of the ship are available, and several stages can be erected one over the other, this is the most simple part of the work. While the frame is at the forge being repaired and drilled to template, the vessel can generally be floated out if the dry-dock is needed for another vessel, or to save rent, and re-docked for finishing.

The stern-frames of two large first-class mail-steamers have recently been skilfully scarfed at the Thames Ironworks, in the centre of the lower part of the frame, and about half-way up the rudder-post. The scarfs were all worked out to template, no propeller work was disturbed, and both time and money were saved. Some later vessels have had the stern-frame scarfed when new. Many stern-frames are now made of mild cast-steel, and when fractured by an accident, are cut out bodily and replaced. The inner stern-post is frequently carried up and secured to a plated deck by angle-bar collars and a deep floor-plate, giving great strength, carrying the weight well, and avoiding straining at the counter.

The Author once fitted a solid bulkhead of $\frac{5}{8}$ -inch iron plate, from the point of the foreside of the top or arch of an ordinary frame, to the deck above, of a 5,000-ton steamer. The bulkhead was stiffened on the one side with two horizontal angle-irons, 6 inches by 4 inches by $\frac{5}{8}$ inch, and on the other side with similar vertical angle-bars. All unsound rivets in the neighbourhood were cut out, the holes being rimered and carefully re-countersunk, and served with Lowmoor rivets ; and the whole stern was braced together, and gave no more trouble, *Fig. 7*.

Bottom Repairs.—For detaching the plates from the bottom of a

ship when the rivets are of iron, the usual plan is to cut the rivet-heads off in the holds, or any other clear space, after the ceiling and cement have been removed; but in a steel ship with steel rivets, the Author's experience is in favour of drilling from the outside, about the depth of the countersinking, with drills of nearly the size of the rivets, which can then be punched or drifted out. This operation also breaks up the cement, and the clearance of the remainder is much simplified, *Fig. 8*. Most ordinary indentions in good iron, or mild steel, if heated to redness, will roll out flat; but with deep and abrupt impressions, although the plate may stand fairing, it stretches so much as to throw the holes out of truth, and a new plate must be fitted. All steel plates should be annealed after fairing, preferably by a wood fire; and when cold, all the countersinking of the holes should be cleaned out afresh, as sound riveting cannot be made in a hole covered with scale.

When bottom plates are damaged the frames and floors become more or less bent and buckled; and their resetting in place, or their cutting out, scarfing, renewal, or giving compensation, requires careful consideration. A hydraulic rail-bender would often straighten a frame or buckled edge of a plate better than the ordinary bars and screws, and hammers generally used at gentle heats.

A most interesting instance of damage with which the Author had to deal, was that of a loaded twin-screw steamer, with a flat-plate keel of two thicknesses of steel, grating over a sharp-pointed rock amidships. The principal indentation was under a bulkhead, which relieved itself by a sharp local buckle; and the vessel touched the rock with her keel again some 50 feet further aft, and scraped upon it from that point to the stern-post. For further examination and repairs, the ship had to be "hung" from amidships to the stern. The vessel's weight was carried by three rows of shores on each side, with solid timber blocking under both sets of engines. The vessel was 420 feet long between perpendiculars, and 47 feet beam, and its weight as dry-docked was 4,050 tons, of which 3,000 tons were hung clear of the middle-line blocks, by shipwrights driving wedges in unison under each of the shores, and long folding wedges at the solid blocking. The weight being duly taken, the middle-line keel-blocks were readily cleared away, resembling the "setting-up" of a vessel previous to a launch. Cement-work, to an average width of 8 feet, was cut out fore and aft from the commencement of the damaged portion. At the fine part of the vessel aft, where through rivets could not be served, $\frac{7}{8}$ -inch turned and tapped rivets of Lowmoor iron were employed, screwed in to

make a good fit; and they have stood perfectly for the last five years. The repairs occupied fourteen days working continuously; nearly all the bottom plates, which were of mild steel, were replaced; and the ship did not move, nor was anything strained or thrown out of line.

Double-bottomed ships are particularly troublesome to repair. If the damaged area is large the bracket floors, &c., are rendered more accessible by taking off many of the plates; and in closing up it can be arranged to finish within a short distance of a manhole, either in a hold or in the machinery space. The disturbance rarely reaches as far as the tank-top. The Author has seen many instances of damage of this nature, but only once heard of serious disturbance of the inner bottom or tank-top; and in that case it evidently saved the ship. Tank-tops under the boilers are subjected to great wear and tear, owing to more or less heated salt-water washing about, laden with ashes, *Fig. 1*. Occasionally the boilers have been hung from the upper part of the vessel, and shored from the keelsons for repairs. With long double-ended boilers, it is sometimes practicable to remove one set of bearers at a time, replacing them as the work of replating and caulking is completed. There should be a space of 12 inches to 18 inches left between the boiler-bottom and tank-top for cleaning and repairs. For renewing boilers in either a man-of-war or a mail-steamer, which cannot pass through the funnel-hatch combing-space, it is best to cut the necessary opening through the ship's side. A single-ended boiler, averaging 15 feet in diameter and 12 feet long, and double-ended boilers, could be drilled round and taken out in halves, saving much disturbance of the upper works and decks.

Double Bulkheads.—When water leaks into a compartment of a steamer carrying breadstuffs, peas, or seed, their swelling causes great strain and distortion, often far exceeding the injury caused by the accident; and unless this happens near a port, the bulkheads will probably be wrecked in rotation, and the vessel lost. In vessels carrying such cargoes, the Author strongly recommends the fitting of at least two double bulkheads, with two distinct sets of plating between double frames, from 24 inches to 30 inches apart, one at the after end of No. 1 hold, and one just abaft the engine-room, as least interfering with the working of the ship. Vertical plates could be fitted in line with the centre and side keelsons, so as to bind the two bulkheads together, as well as to the decks. With deep lower holds, two extra flats should be “worked in,” like the decks of a caisson; and the bulkheads could be flush next to the cargo holds, avoiding the chafe of gussets, deep stiffen

ing bars, and broken stowage; and they must be provided with manholes for examination and repairs. The space between the bulk-heads, not being available for cargo, should be excluded from the measurement of the ship's tonnage. The space being so small, the workmanship could be readily proved by water up to the upper deck; and being fitted with steam-pumps, it could be used as a ballast-tank, a chamber to check rolling, or a screen against fire.

Stem- and Bow-Damage.—When a laden steamer has been damaged at the stem or the bow, the cutting away of the damaged parts can follow down stage by stage as the cargo is discharged, so that the time in dry-dock is often very short, especially where a vessel is easily tipped. To avoid a group of short lengths of frame, as many as possible should be taken out down to the sweep of the stem, and all scarfs well separated, reversed frames being treated similarly. If a stem is but slightly twisted it can be heated in place and set fair; but it is generally necessary to take the rivets out to the top to give freedom for the expansion. Where the damage does not extend far down it is sometimes convenient to cut a fresh scarf, keeping the points clear of the plate landing-edges.

Lifting-Appliances.—For a pair of dry-docks, a 50-ton (or upwards) steam jib-crane, travelling on a good broad track, capable of serving either dock, and lifting pieces of machinery into or out of craft in the wet-dock, or railway trucks, would be very useful. Rolling cranes, similar to those at the Sandon Dock, Liverpool, serving the ship at right angles, avoid fouling the rigging and stays. Floating cranes are too uncertain in keeping to time to be depended upon for serving dry-docks, throwing work into confusion, and causing extra expenses. Moreover, it is unsafe to bring a craft against the caisson of a dry-dock for dragging at great weights.

Hydraulic Hoist.—A direct hoist might be readily arranged in one wing of a dry-dock, and would prove a great convenience, *Fig. 1*, as no ordinary crane will reach under a ship's counter, heavy weights being first lowered into the dock-bottom by the ship's own tackle. Any piece could be readily transported to the lift platform by a trolley on a metal traverse across the dock-bottom, where, after being cramped, it could be promptly raised to the truck-level. A single ram of 12 inches diameter, worked at 750 lbs. pressure per square inch, with a good cross-head and a pair of metal slipper-guides, should work well.

Hydraulic Capstans.—Three capstans should serve a dry-dock, one at the head, and one at each side of the entrance; and their

maximum load of, say, 10 tons should be plainly stated in cast figures on the head.

Hydraulic Drilling.—Water under pressure, available at convenient distances along the dry-dock, could be charged for, either by meter, or per machine in use by the hour. The Berrier-Fontaine drill, driven by a three-cylinder engine made of phosphor-bronze, is in use in most, if not all, of the French Government shipyards. Sir W. G. Armstrong, Mitchell, & Co. carried out some intricate drilling for bolts for the armour of H.M.S. "Victoria," in confined spaces, by this plant, with a pressure of 750 lbs. per square inch. They were manufactured on the Tweddell system, and are advantageous for drilling holes of 1 inch and upwards. The machine can be either placed against the work direct, or clamped down at some distance on planks; and by employing a "Stow" flexible shaft, a large area can be served without shifting. By using a worm-wheel and bar with cutters, side-light holes and other boring operations can be readily performed.¹

Steam from Shore.—If a steam-ship is to be in dry-dock more than twenty-four hours it will probably be desirable to submit the donkey-boiler to the annual Board of Trade survey, and not worth while to work one of the main boilers. Steam of the required pressure could be supplied from the shore, through a flexible metallic pipe, for all the deck machinery, and for the turning gear for the main engines, and in winter time for heating purposes. Care would be necessary in plugging deck-scuppers, &c., to avoid interference with painting the ship's top-sides and bottom.

Filtered Water.—This is generally available by meter, but is costly, leaving room for a fair sliding-scale of prices according to quantity.

Gas-Mains.—A 4-inch or 6-inch gas-main round the dry-dock, with well-placed branches, would be appreciated, not only for lighting, but also for heating and motive power. A gas-hammer, placed on timber in the dock-bottom, might do good work. Gas fires for heating rivets should also be available.

Electrical Apparatus.—Although a vessel may carry electrical generating plant, it may be preferable to take the current from the shore, not only for lighting during repairs outside or inside the vessel, but also as a source of power, and for driving various tools or winches. Messrs. Denny & Brothers, of Dumbarton, have laid a

¹ Minutes of Proceedings Inst. C.E., vol. lxxiii. p. 64

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large cable $1\frac{1}{2}$ inch diameter, capable of transmitting 30 E.H.P. at 100 volts, with 1-inch branches, throughout their shipyard. The Rowan drilling machines, on the current being made, magnetically attach themselves with a force of 2,800 lbs. wherever required, dispensing with drilling-posts and angle-plates, *Fig. 2*. Various forms of stirrup-irons are used for hanging the machines conveniently for their work. One form of the Rowan drill will bore a hole within $1\frac{1}{2}$ inch of a corner; and another serves for radial work, such as drilling holes for boiler-furnaces in position, and counter-sinking them. Messrs. R. Napier & Sons have used some of these drills on H.M.S. "Gibraltar," for drilling 20,000 holes, $\frac{1}{16}$ inch diameter, for the sheathing, and a similar number for the protective deck; and about 200 holes were enlarged to $2\frac{3}{8}$ inches diameter, through $2\frac{1}{2}$ inches thickness of metal, for heavy bolts. It is consequently very desirable to make such tools, and also the hydraulic system, available for repairs.

The Paper is accompanied by ten photographs and a tracing, from the latter of which the *Figs.* in the text have been prepared.