ANOTHER "MYSTERIOUS" BOILER EXPLOSION.

BY JOSHUA ROSE, M.E.

James McCreery & Co., whose well known dry-goods store is situated at the N.W. corner of Broadway and 11th street, in this city, have beneath the sidewalk in West 11th street a pair of cylindrical multitubular boilers, exactly alike, and by the same builder. They are used to heat the store and drive the elevators. On Saturday night, January 15, the engineer in charge banked the fires as usual and left them, returning on Sunday at 12:30 P. M. to see that all was right. He cleaned the fires, banked them again, and says he examined the dampers and saw that they were closed; examined the pressure gauges and found them to indicate 3 lb of steam; saw that there was plenty of water in the boiler, and left, leaving all so safe that, as he states, he would willingly have slept on top of the boiler. In all this he is corroborated by the fireman, who was present at the time. The watchman reports that he is positive the dampers were closed, because he noticed the presence of coal gas in the building, the smell being so offensive that he notified the burglar alarm office, at 4:30 P.M., that he was about to open the windows to let it out, which he then did. Shortly afterward, however, a terrific boiler explosion occurred, tearing away the massive girders overhead, blowing up the sidewalk above them, but fortunately, being Sunday, when that part of the city is deserted, nobody was hurt. The boiler was ten years old, and was tested in August last by hydrostatic test at 105 lb., and licensed for 70 lb It was usually worked at about 50 lb.

The daily papers have called this a "mysterious explosion," and so it is to the superficial observer, but close examination dispels the mystery.

On visiting the scene of the explosion I found that the crown sheet of the dome of one of the two boilers (which were connected by a steam pipe) had blown off completely, leaving a ragged fibrous edge right in the flanging bend, as shown at A, Fig. 2, which is taken from the dome on the uninjured boiler, and is a sectional side elevation. An inspection of one half of the exploded dome head, one half of which is at police headquarters and the other half (shown in Fig. 6) in the engine house, showed that the dome crown, in addition to tearing around the edge, at A, had torn across at B, being in two completely severed pieces. The iron at the fractures was in all cases of excellent and fibrous appearance. Two things, however, attracted attention: First, that the plate showed lamination in places varying from an inch to two inches in length, and running around the bend of the flange, at A. Second, the crack around A was too rusty to warrant the conclusion that it had been of recent formation. The greater part of this fracture was clean enough to admit of inspection, but some parts were not, and the dirt was so embedded in the fibers of the iron as to preclude its inspection. The edges of the two halves, however, appeared to have been fractured recently, probably at the time of the explosion.

The six stays, three of which are shown in place at C, Fig. 2 (drawn to a scale of one eleventh full size), were all in position in the dome, and it was observable that their surfaces having contact with the dome were covered where they fitted with a black polish, evidencing movement and some slight abrasion. These marks, however, did not, except in one case, extend all around the hole. During a visit to the boiler works the ring, A, of the crown sheet was bent and doubled, showing strength and ductility. I then chipped a piece along the edge, and the iron showed toughness and strength as far as such a test would determine, leaving no doubt in my mind, from all the appearances, that the iron was good.

During the inspection of the half crown sheet at police headquarters, I expressed to Inspector Horton the opinion that the crack around the edge, A, was decidedly not of recent origin, in which opinion he entirely concurred.

In considering what could have caused this fracture, the following points suggest themselves:

The stays, C, joined the cylinder of the dome 11 inches from the top (as marked in Fig. 2), and the crown sheet 7½ inches from the dome cylinder edge. Now, as the temperature of these stays increased they would expand and lengthen, exerting a pressure on the crown sheet in the direction of H. The steam pressure acting on the under surface of the crown sheet would also be in a direction to lift it; hence, as the pressure and temperature increased and decreased the crown sheet would lift and fall, bending it on A as a center of motion. The stays being at so great an angle would not be in a good position to resist this movement of the sheet; thus taking I as a center, the movement of the other end of C would be in the direction of F, while at D the direction of motion would be toward J, hence the direction of motion of the two would to a great extent coincide. That this view is accepted is proven by the fact that ten stays are now to be used instead of six, and that they are to be longer and more nearly in the line of strain, being as shown at G.

The old stays had a single rivet; the new ones have two rivets, the foot, G, one, being a crow foot, as in Fig. 3. The exploded dome shows an indentation at I, due to the motion of the foot of the stay, but this the two rivets will prevent.

If G′ be taken as a fulcrum the motion of the other end of that stay would be as denoted by E, offering a greater resistance to motion in the direction of K, and this increase of resistance would augment in proportion as the body of the stay stood more nearly vertical or more nearly in the line of the strain.

Now let it be noted that if a stay stands at an angle it will, under any increase of temperature above that at which it was riveted up, tend to push the two plates it connects apart (instead of holding them together) until the weakest plate has moved a certain amount. Thus, if the old stay, C, measures 15 inches, it will expand a certain amount per inch through a length of 15 inches; but the shell of the dome will expand through a distance of its vertical height from the hole at I, or in this case 11 inches only; hence to the amount that C would expand in 4 inches in length it would push against the crown sheet and help the steam to lift the crown sheet, and not until the crown sheet endeavored to move still further would C begin to act as a stay. The same effect will be produced in proportion as the line of the stay varies from a right angle to the surface it is to stay, hence the stays, C or G, should be as near vertical as possible.

Another error in the design of this boiler is that the diameter of the dome shell is 34 inches, and a circle of iron about 28 inches in diameter is punched out of the shell at D. This opening is required only to admit an inspector or workman to the interior of the boiler, hence it is several inches wider than it should be, which unnecessarily weakens the boiler. Yet another defect is that the shell of the dome has the wide side of the punched holes on the inside, as shown in Fig. 4, in which S represents a section of the shell and C of the crown sheet, the wide side of the hole being at P. As a result, the rivet has less hold upon the shell, and to whatever extent the rivet fills and binds against the walls of the shell it tends to force the two plates apart instead of binding them together. The extent to which the body of a rivet swells under even hand riveting is shown in Fig. 4, which is drawn from one of the only two rivets (that held the crown sheet to the shell) of the stays that have been found. The holes for these rivets were, as they should be, punched from the inside, and are therefore widest on the outside, the swell of the rivet at X showing how it expanded under the riveting blows and filled the hole. In this case the taper of the hole helps the rivet to bind the plates together. Here it is well to call attention to another fact, which is that in hand riveting pointed rivets are usually made, and these rivets do not present so strong a form of head as rivets riveted by machine, which have a button-head, as denoted by the dotted line in Fig. 5.

Now, while this explains why the crack at A, Fig. 1, was induced, and therefore one of the elements causing the explosion, it does not explain how it should happen that a boiler tested in August last at 105 pounds, and used daily during the week before the accident at pressures varying at from 40 to 50 pounds, should explode under a lesser pressure, or even under a pressure of 60 pounds, especially as it had a safety valve set to blow off at 60 pounds.

On questioning this part of the subject the engineer was questioned a second time, giving me the following information:

On his last visit previous to the explosion he "cleaned the dirt out of the fire and put fresh coal on, leaving the fire covering the bars," which was his usual method of banking, and the method practiced before he took charge.

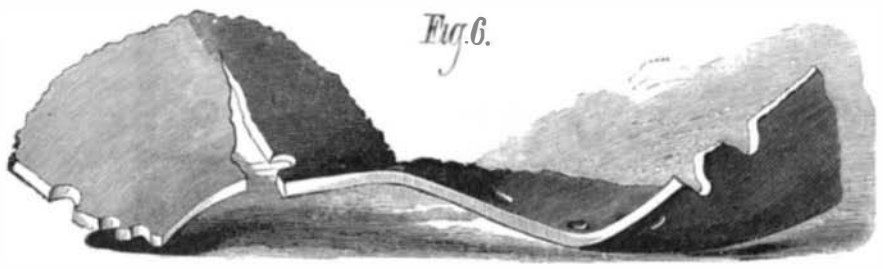
He usually left from 3 to 5 lb. of steam after banking at night, and found from 20 to 25 lb. when he arrived in the morning.

This method of *banking*, under which a steam pressure is slowly raised, is a decidedly dangerous one, because a little extra cleaning of the fire, the use of larger coal than usual, or leaving a rather better fire than usual, would simply cause a more rapid production of steam, whereas it appears that it was not uncommon to find the boiler in the morning with a pressure of within 15 lb. of that under which it was daily used.

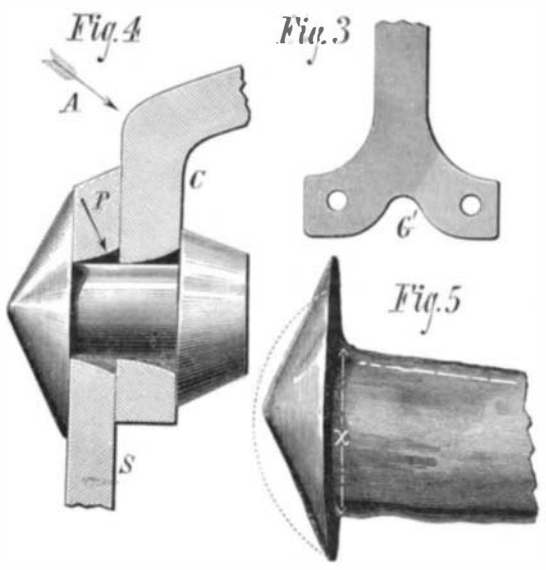
The proper way to bank a fire is to pile it at one end of the grate bars, leaving nearly two-thirds of them bare, so that cold air would pass in freely if the fire burned up, and check any undue combustion, even if the dampers were left open. The practice of smothering a fire by leaving it spread over the bars and simply giving it a fresh covering of coal and closing the dampers, is a common and unsafe practice that ought to be prohibited. But one more point remains to be explained, which is; how did it happen that the test made in August did not develop the weakness of the crown sheet?

The New York *Sun* credits Inspector Horton with saying as follows: "Possibly the expansion and contraction of the drum (shell) as the volume of steam was increased or diminished, had weakened the edges at the point of contact of the crown plate. This weakness, he stated, might not be developed by the hydrostatic test. Possibly the hydrostatic test might have weakened the iron to the point of breaking, leaving the first accumulation of high pressure to cause an explosion. But if the engineer's statement is true, the safety valve ought to have prevented an explosion, even if the fires were not banked and the steam ran up by the unexpected starting of the fires."

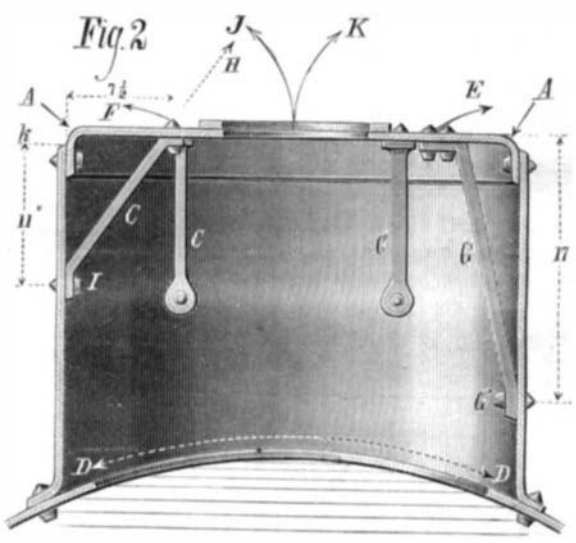
There has been for years a discussion carried on as to



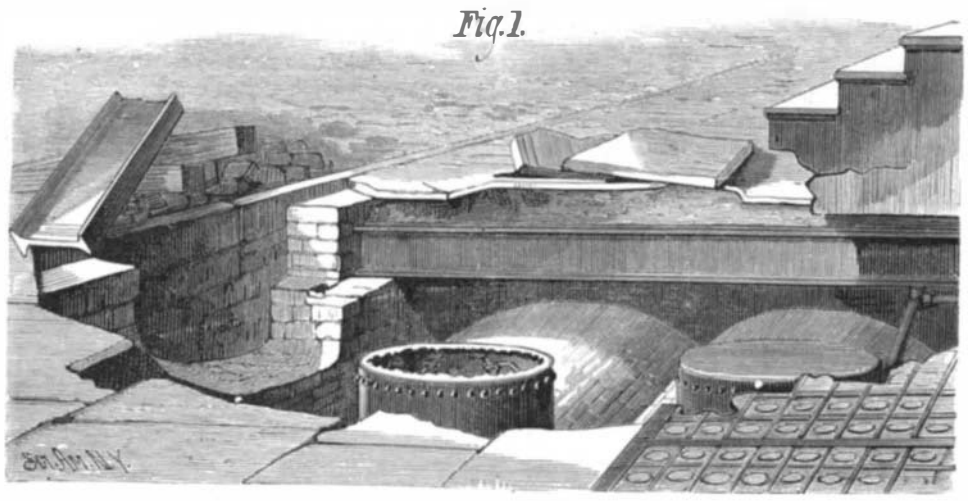
HALF OF THE CROWN OF THE DOME.



RIVET, JOINT, AND BRACE-END.



VERTICAL SECTION OF DOME.

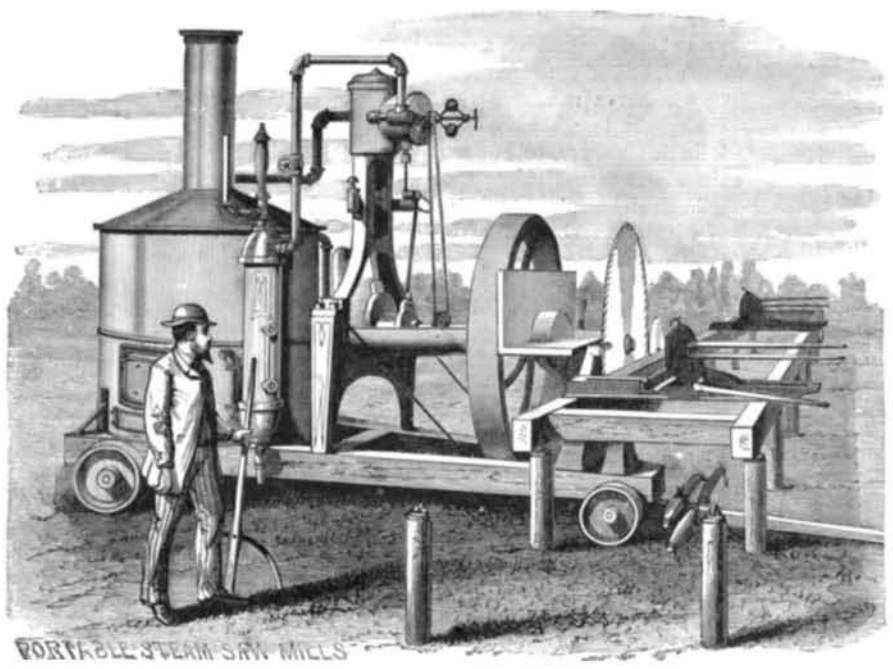


EXPLODED BOILER SHOWING THE UPHEAVED SIDEWALK AND BROKEN IRON GIRDERS.

whether the hydrostatic test was sufficient alone, or whether the hammer test was not a necessary adjunct to the hydrostatic one, some indeed claiming that the hammer test alone is more reliable than the hydrostatic test. In this city the hydrostatic test alone is employed, and since so high an authority as Inspector Horton says that it may not discover an existing defect, but may induce a dangerous one, it is about time that it was supplemented with the hammer test. There is no doubt that the hammer test would have disclosed the defect in this boiler, and that Mr. Horton's views are entirely correct.

The writer endeavored to ascertain what amount of coal and refuse was found on the fire bars after the explosion, and how much was left on at 4:30 P.M. on Sunday, so as to see how much fuel consumption had taken place, but the bars had been cleaned.

Finally, as the safety valve was set to blow off at 60 lb., and the boiler was daily used at from 40 to 50 only, there is nothing to indicate that the boiler was, at the time of the explosion, capable of carrying, say, 55 lb., hence the explosion might occur when this pressure was reached without being relieved by the safety valve. This would leave the pressure to run up, under unusually favorable conditions, probably to but 30 lb. more than it sometimes was found at in the morning, which would easily be accomplished with no consumption or circulation of steam through the building taking place. The thoroughness of the crown sheet fracture is shown in the one-half of it presented in Fig. 6. The iron is what is termed three pile, that is to say, the mass from which it was originally made was composed of three thicknesses welded together, and it was defects in this welding, from the presence of dirt or other foreign material, which, when rolled out, formed these laminations. Now, in an unbent sheet the laminations would not form such serious defects, but in flanging or bending the edge, the laminations would tend to separate, and undoubtedly to some extent did so, weakening the plate at A, where the bend and the fracture took place.



PORTABLE STEAM SAW-MILL WITH HERRESHOFF BOILER AND ENGINE.

AMERICAN INDUSTRIES.—No. 65.

THE HERRESHOFF LAUNCH.

The remarkable little steam vessels turned out by the Herreshoff Manufacturing Company, of Bristol, R. I., have attracted world-wide attention, and in a very few years have earned a reputation which is truly enviable. These boats have not only been indorsed by the Bureau of Steam Engineering of the United States Navy, but their merits have been acknowledged by European engineers, and the English government has given its opinion in an emphatic way, by ordering a number of the boats to be used in the English navy.

The works of the Herreshoff Manufacturing Company were established in 1864, and consist of several machine and constructing shops, in which are employed about one hundred men. The works are on the shore of the Narragansett Bay, whose waters present a ready field for experiments in naval engineering, and afford facilities for developing, by actual trial, the best models for steam and sailing craft.

The Herreshoff Brothers possess, by inheritance, great talent for mechanical construction, especially as applied to marine engineering, and this talent has been developed by practical experiment supervised by these indefatigable inventors. From first to last success has followed their efforts, and, judging from the present showing, a prosperous future is before them.

During the first years of the operations of this company the business was chiefly confined to the construction of sailing craft of various descriptions, principally yachts and smaller pleasure boats, which were known all over the Atlantic coast for the fineness of their models, and their yachts became famous for their fast sailing, the beauty of their lines, and excellence of workmanship and material. Among the best known of the yachts built by the Herreshoff Company are the Clytie, Kelpie, Quivive, Sadie, Orion, Shadow, Triton, Faustine. These, together with a number of smaller yachts, are all noted for their speed, and have taken many prizes in our club and open regattas. About five years since the demand for steam launches and steam yachts sprang up, and this company, ever on the alert to meet the wants of the people, turned its attention to perfecting and constructing this class of vessel. In this their success has been remarkable, and to-day they turn out the fastest, safest, and handsomest vessels that ply either in our own waters or those of any other country. The distinguishing feature of the Herreshoff system of marine steam machinery, is the safety coil boiler, which has been brought to great perfection and patented by the Herreshoff Brothers, and which is shown in two forms in our first page illustration. The boiler consists of a spiral coil made of iron tube arranged with proper spaces between the coils for the escape of the products of combustion. The coil is made of conical form and surrounds the combustion chamber, presenting an effective heating surface to the fire. The heated gases proceeding from this chamber are made to pass through the spaces of a flat coil at the top, which heats the feed water before its entrance to the boiler proper. The feed water is forced in at the cooler end of the flat coil, through which it passes to the top of the main coil, and descending, is finally discharged into a vertical cylinder, which is called the separator, and in which the steam and water discharged from the coil are divided, the water falling to the bottom, the steam being taken from the top and passed through a superheating coil located above the main coil, which completely dries and superheats the steam. Generally a single coil is used as the steam generator; but when the greatest economy is the main consideration, a double coil, in which one is placed within the other, is employed. Both forms of boiler are shown in the engraving.

The advantages possessed by the coil over the shell boiler in any of its forms are marked and are apparent almost at first sight. The coil is absolutely safe from destructive explosion, and weighs less than one-half as much as other boilers of the same capacity, and in point of economy its superiority is undoubted. It is capable of raising steam from cold water in from five to seven minutes. This is an important feature, especially in steam launches and torpedo boats, where time is an all-important matter.

The engines used in the Herreshoff system for marine purposes are of the compound condensing type, having feed and air pumps attached. The machinery of this system is especially noteworthy for its extreme lightness and for the judicious distribution of material, all of the parts having ample strength, and no portion being loaded with useless metal, which would rather detract than add to the efficiency of the machine. These engines use the steam with the highest economy, actual and prolonged tests having proved the efficiency to be at least 40 per cent greater than that of the non-expanding type. As to mechanical details of construction, finish, proportion, and general design these engines leave nothing to be desired.

Of the several steamers shown in our engraving, the one hundred foot size—of which a number have been built—is considered by yacht men as the most advantageous size for coastwise cruising. It can be handled by a few men, consumes a minimum of fuel, and, what is more important than anything else, the interest on first cost is small in comparison with that of the large iron steamers recently added to our fleet of pleasure vessels. The plan view in the front page engraving shows the arrangement of the interior of one of these yachts so accurately that no further description is required.

The maximum speed of the 100-foot yacht is 18 miles per hour, and in that time it burns only 200 pounds of coal. Three men manage the vessel easily. The 60-foot yachts are planned with a view to river, bay, or lake navigation, and are arranged to accommodate a number of persons for short excursions. Yachts of this size will steam 15 miles an hour, and in that time will consume about 90 pounds of coal.

The Herreshoff torpedo boats have features peculiar to themselves, which distinguish them from everything else of the same class, and have earned for them a well deserved reputation. They are at least three tons lighter than those of foreign make; they will go astern as fast as ahead, and can stop in half their length from full speed. They are capable of turning in a circle whose diameter is three times the length of the boat. All these desirable qualities are due to the lightness of the entire structure, including the boiler and machinery, and to the position of the screw, it being located under the hull at about one-third of the distance from the stern to the bow. The quickness with which steam can be raised is of inestimable strategic importance in naval warfare, as it admits of repelling sudden attacks of an enemy, the boat being always ready and capable of being put under full steam by the time its keel touches the water. These boats are fitted for the use of either spar or Whitehead torpedoes, and are supplied with four spars, two at each end, when the spar torpedoes are employed. By this means the efficiency of the boat is immensely increased, their remarkable quality of backing as readily as going ahead rendering the use of stern spars perfectly practicable.

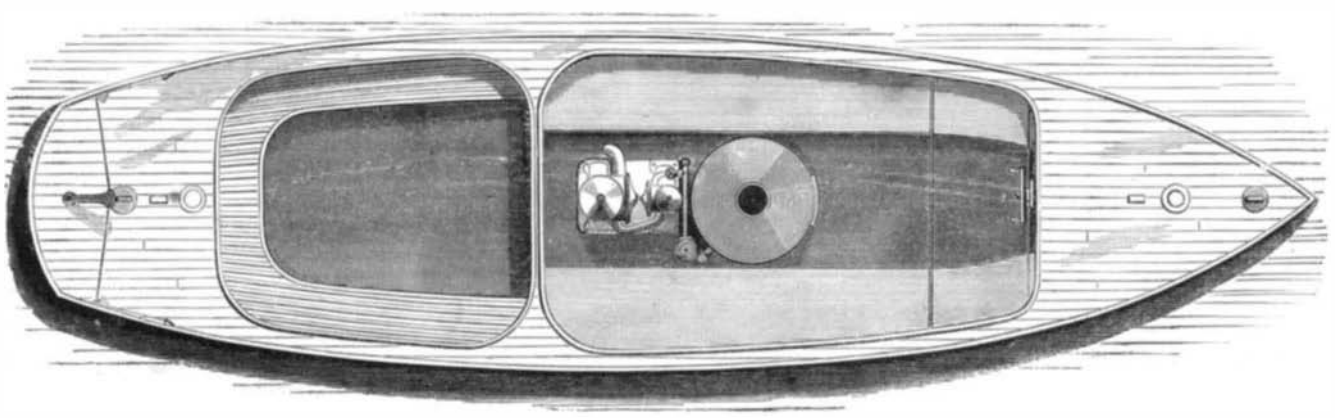
The length of the torpedo boat is 60 feet; width, 7 feet; depth, 5 feet 6 inches. Their weight when ready for service is 6 tons, and they are capable of steaming 23 miles an hour, developing 150 horse power.

In the whole range of the manufactures of this company, perhaps the most successful craft is the navy or government launch, shown in the engraving. It is 33 feet in length, 8 feet 6 inches in width, and is furnished with a folding tent or awning over the standing room, either or both sides of which may be raised to protect passengers from rain, spray, or wind. When not in use the tent folds down snugly on either side of the boat outside the rising. Either or both sides of the tent may be elevated, thus making an awning proper.

The general advantages of the Herreshoff launch are summed up in the preliminary report of Chief-Engineers Isherwood, Zeller, and Carpenter, from which we make the following extracts:

"The following general opinions, arrived at by close observation during long and exhaustive experiments, can be depended on.

"1. As regards the hulls of the launches. The models of the Herreshoff launches and the distribution of their weights have been so perfected by long and intelligent experience and experimenting, as to scarcely leave room for improvement, the Herreshoff Manufacturing Company having for many years made a specialty of designing, constructing, and testing steam launches, steam yachts, steam torpedo boats, and similar vessels. The material is of the best quality, well seasoned, and carefully selected. It is so distributed in the construction of the hulls that the required strength is obtained, with the least weight; the thoroughness and perfection of the fastenings being depended on, instead of masses of material poorly secured. The workmanship cannot be excelled in neatness, finish, and skill. These hulls combine the maximum of strength with the minimum of weight, which is the end to be attained in this class of vessels where lightness is of the first consequence for stowage on board ship, carrying capability, small draught of water, and speed. In all these particulars of model, construction, combination, strength, finish, lightness, quality of materials and workmanship, the Herreshoff steam launches are incomparably superior to the navy launches, a superiority resulting from the fact that the latter are only occasionally designed and built at the navy yards, and then by persons whose skill and experience lies in the designing and constructing of large vessels, and who devote little or no attention to what is considered as comparatively a small matter, but which, if the highest excellence is to be attained, requires much special training and experience.



PLAN OF 33-FOOT LAUNCH.

"2. As regards the machinery. The system of machinery employed in the Herreshoff launches is quite original in most of its details. It is diametrically opposite to that which is used in the navy launches and is in every particular greatly superior to the latter. In the navy launches a single cylinder is employed, and the starting and stopping are consequently uncertain and slow, with the risk of damage and accident from running into wharves and vessels, and also loss of time.

"In the navy launches steam of high pressure (80 to 100 lb. per square inch above the atmosphere) is used almost without expansion, and it is generated in a type of boiler whose strength is only moderately in excess of the pressure. This steam is not condensed, but is exhausted direct into the chimney of the boiler to cause sufficient draught for generating the disproportionately large quantity of steam required with this system.