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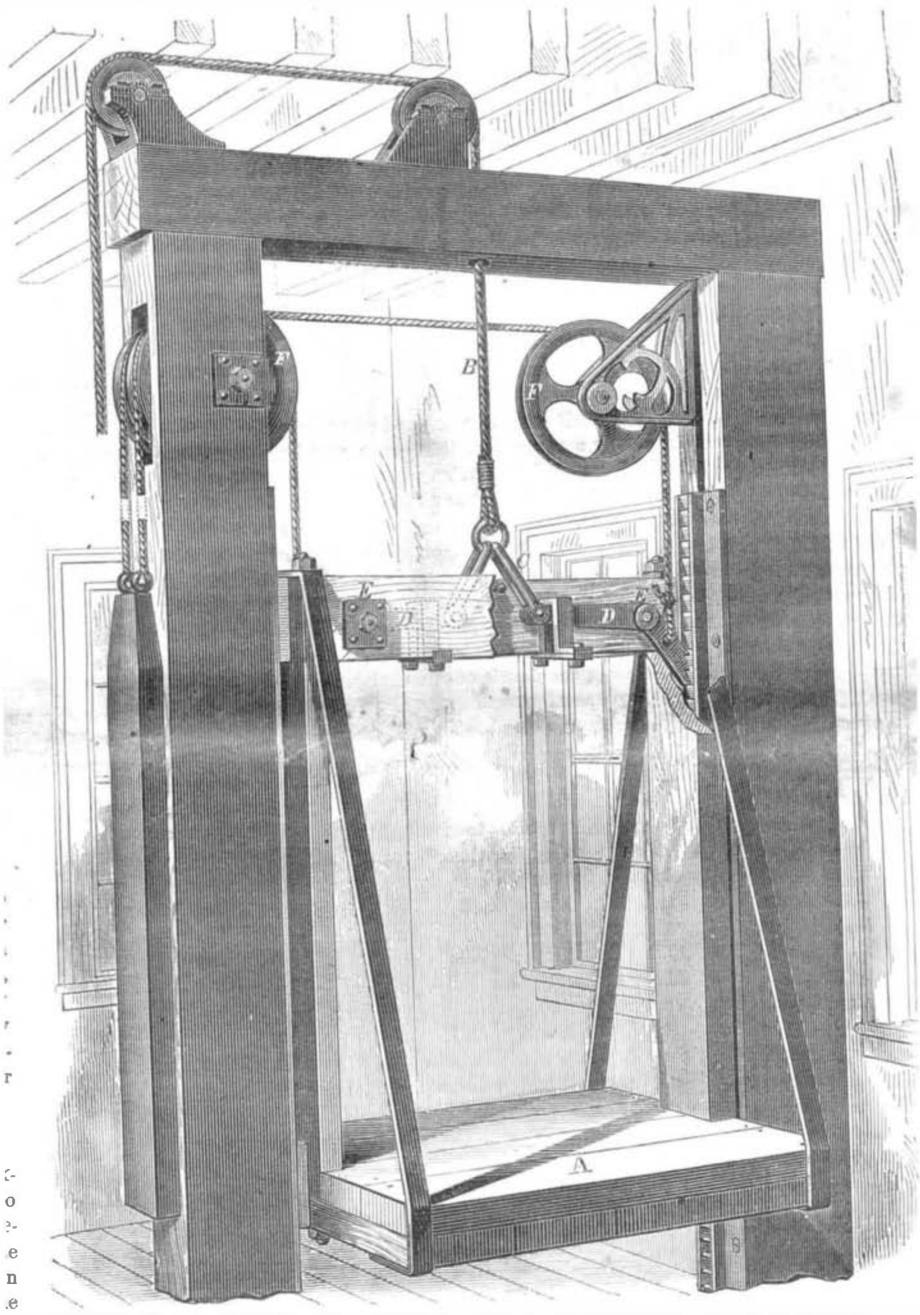
### Improvement in Safety Hoisting Apparatus.

The use of cams and levers and of springs and levers for preventing the fall of the cage of a hoist, on the breaking of the hoisting rope, is not new; but, unfortunately, neither cams nor springs are wholly reliable, the latter, especially, are unreliable transmitters of power, losing elasticity when kept long compressed, and breaking when subjected to sudden strain. The object of the improvement, of which the accompanying engraving is an illustration, is to provide a certain means for preventing the fall of the cage in consequence of accident to the hoisting rope or chain. In this device the operation of the arresting levers is assured, as they are engaged with the rack instantly, in case of the breakage of the hoisting rope, by means of a counterbalance or weight, which, when the cage or platform is ascending, is moving in a contrary direction, thus giving the additional advantage of reducing the weight of the cage. Whenever the hoisting rope or chain ceases to act, the counterbalance rope comes into action and prevents disaster.

In the engraving, A, is the hoisting cage or platform, B, the lifting chain, attached by means of links, C, to the bell crank levers, D, having their fulcrums at E, and provided at their outer ends with teeth cut to fit the racks in the uprights of the framing. The ropes suspending the counterbalance weights are attached to the levers, D, at points outside their fulcrums, and pass over grooved pulleys, F.

The operation of the machine and its arrangements is apparent from an examination of the illustration. So long as the hoisting rope is held "taut," the levers, to which it is attached, are drawn away from the racks, and the machine operates freely; but the instant the hoisting rope breaks, or is slackened suddenly from any cause, the weight of the cage and its load comes upon the counterbalance ropes, the levers instantly engage with the racks, and the descent of the cage is prevented. There is no possibility of the device getting out of order, and ceasing to operate, except by the breaking of both the levers or one of the ropes; and the former may be made of the toughest wrought iron, and the latter may be wire ropes. A large machine is in operation at the works of Merrick & Sons, Philadelphia, Pa., and a working model may be seen at their office, 62 Broadway, New York city. Further information may be obtained by addressing the patentees at either place.



MERRICK & SONS' PATENT SAFETY HOISTING APPARATUS.

### THE PARKHEAD FORGE.

The Parkhead Forge, Glasgow, is an extensive establishment, giving employment to seven hundred men and boys, but in consequence of the heavy nature of the work, the proportion of boys to men is smaller than in other branches of iron manufacture. The buildings cover several acres of ground, and are built in a most substantial style. On approaching the entrance to the Forge, the visitor is startled by the vibration of the ground under his feet, caused by the incessant blows of the steam hammers; and a peep inside reveals a scene of extraordinary activity. We shall briefly describe what came under our observation as we were shown through the work by one of the proprietors, and thus endeavor to convey some idea of what goes on in the place. The first department we entered was the rolling-mill, which is three hundred feet in length, and one hundred and fifty feet in breadth. At one end of the mill are arranged twenty-two puddling furnaces, and half a dozen reheating furnaces. The rolling and other machines are driven by a pair of horizontal engines of three hundred horse-power. The fly-wheel of the engines is eighteen tuns in weight, and it makes one hundred revolutions in a minute. The steam is supplied by fourteen vertical boilers, heated from the puddling furnaces. The iron is first rolled into bars, then cut up, re-heated, and either rolled into ship and boiler plates or wrought into pieces suitable for the forge. At one time the firm devoted attention to the making of armor plates, and their specimens stood the test of competition with those of English makers most creditably; and but for the want of convenience for carrying the plates—the nearest railway being a mile distant—Messrs. Rigby and Beardmore would have obtained a fair share of patronage from our own and other governments. The machines are capable of producing plates eight inches thick, and some of the plates made of that thickness have weighed twelve tuns each. At some of the puddling furnaces a new invention was being tested, and we were told that the most satisfactory results were being produced by it. Its object is to hasten and render more perfect the puddling process, by injecting a current of air at high pressure into the furnace. This is done by making the puddling bar hollow, and affixing to the outer end of it an india-rubber tube communicating with a powerful air pump. The patentee is Mr. Richardson, of Glasgow; and the advantages gained by the contrivance are that a charge of the furnace can be puddled in fifteen minutes less than the time required by the usual process, and that the iron produced is purer and tougher.

The forge or smithy is nearly as large as the rolling-mill, and its fittings are of the most gigantic kind. There are two steam cranes, capable of lifting fifty tuns each; four, forty tuns each; and four, twelve tuns each; and these are so arranged that a shaft or other piece of work may be passed from one to the other all over the shop. There are fifteen steam hammers, varying in weight, from seven tuns to two. Finished shafts—that is, finished so far as the hammering was concerned—were lying about in all directions, and so delicately had these been operated upon by the hammers that the surfaces were so smooth that turning would seem to be almost superfluous. Yet they were destined before leaving the place to be fitted into a lathe and turned with the greatest exactness. In the heating furnaces, and under the hammers, were a dozen more heavy jobs in the shape of crank shafts, rudder frames, and such like; and as these were in all stages of progress, a glance at them made plain the whole process of forging. In making a crank shaft, for instance, a piece of iron, eight feet or ten feet long, and of suitable diameter, is used as a "haft" or handle. At one extremity it is fitted with cross bars or levers, by which it may be turned on its axis; and the other end is shaped conveniently for having smaller pieces of iron welded to it. The welding end is placed in a furnace, and in about an hour and a half raised to a welding heat. The crane by which the iron is moved about is fitted with a chain collar or sling, in the loop of which the iron rests. The collar works in a pulley attached to the chain of the crane, and moves easily, so that the shaft may be readily turned on the anvil. When the proper degree of heat is attained, the stopping of the furnace is removed, the steam crane put in motion, and the gigantic bolt is swung on to the anvil of the steam hammer. Several large slabs of iron, similarly heated in another furnace, are then brought out and laid on the "face" of the "haft." A signal from the head forgeman, and the hammer drops upon the glowing mass, and a dazzling shower of sparks fly off in all directions. Again and again the hammer descends, the iron meantime being carefully moved about, so as to have the whole wrought into a homogeneous mass. Gradually the iron assumes a dull color, but not before the desired end is obtained. It then goes back to the furnace, comes forth glowing, has another addition made to its bulk; and so on. The most difficult part of the work is the formation of the crank-piece, which is forged solid, and forms a huge square projection on one side of the shaft. When the shaft has acquired the proper dimensions it is allowed to cool, and the haft-piece is cut off to be used again. As the shafts are turned down until a good surface is obtained, an extra inch or so is allowed in the forging. The heaviest work on hand, at the time of our visit, were the shafts for two iron-clad rams which are being built by Messrs. R. Napier & Sons for the British Government. These shafts were upwards of fourteen inches in diameter. All shafts are made in lengths of about twenty feet, and these are made with flanged ends so that they may be firmly united.

For dressing and finishing such huge pieces of iron as we have described, special and costly appliances are necessary. These are located in the machine shop, an apartment one hundred and fifty feet in length and fifty feet in breadth, both sides of which are lined with turning lathes, slotting and boring machines, and such like, of extraordinary size. One of the turning lathes is said to be the largest in the world; and some idea of its dimensions and form may be obtained from the fact that the crank shaft of the *Monarch*, though weighing thirty-two tuns, was turned in it without taxing its capabilities to the utmost. Some of the iron shavings lying about the vast machine were fully one inch broad and one eighth inch thick; yet these were turned off with apparently as little effort as if the material had been wood instead of iron. One of the boring machines is sufficiently powerful to drill a hole ten inches in diameter through a solid block of iron; and the largest slotting machine can send off chips a pound or two in weight. When the work leaves this department, it is generally quite ready for being fitted into its place. This firm pay nearly £40,000 a year in wages; and in all departments of the establishment, 15,000 tuns of iron, and 60,000 tuns of coal are annually used.—*The Ironmonger.*

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### THE LIFE OF IRON BRIDGES.

*The Engineer* says: "It may be assumed that a wrought iron girder bridge, subjected at intervals to a dynamical load not exceeding the fourth part of its powers of ultimate resistance, will be safe for traffic for a period of 328 years. This assumption is based upon the proviso, that the successive alternations of strain and repose should not be repeated more than 100 times during the same day. With the exception of some country lines and rural branch railways, the number of trains of every description passing over bridges in twenty four hours, considerably surpasses the limited number one hundred. Taking the traffic during the night to be only one third of that during the day, we may conclude that, as a low average, 200 trains pass daily over the majority of our metropolitan and suburban railway bridges, and as a maximum, the hardest worked member of the bridge tribe possibly undergoes as many as 300 alternate changes of active and passive conditions from sunrise to sunset. Adapting this calculation to our theory, we may estimate the life of the hardest worked railway girder to extend over a period, in round numbers, of 100 years, under ordinary circumstances.

"Similarly to all theories, conditions are here supposed to exist, which, in numerous instances, are probably wanting. In the experiments upon a wrought iron beam, from which these results have been deduced, the dynamical load was accurately proportioned to the ultimate power of resistance; but there is no question, that in some of the earlier built iron girders no such proportion obtains. Certainly the majority of wrought iron girders are in excess, so far as their strength is concerned, of the quarter ratio between their working and breaking load; but, if we may judge from failures that have taken place, some are comparatively weaker than they ought to be. Unfortunately, in these experiments, with the exception of those confined cast iron bars, in which the load applied was of a static and not dynamical character, the element time does not enter into the calculation, and the inevitable deterioration it produces upon everything exposed to its influence, is altogether disregarded. It is one thing to rivet up a beam, and then subject it immediately in the plentitude of its strength to so many alterations of state, before the corroding action of wind and weather has the least chance of exerting its destructive power; but it is a very different affair to allow a beam, which is yearly becoming weaker, to be submitted to the passage of heavy rolling weight. In the one case the strength of the girder, so far as extraneous causes are concerned, is constant; in the other it is variable.

"A difference will obviously present itself respecting the ultimate durability of cast and wrought iron girders individually. When the former fail they fail completely; there is no repairing a fractured cast iron beam, whatever shape it may possess; it is only fit for the cupola or the puddling furnace. The same circumstances do not attend the dissolution of wrought iron girders provided they are well watched and the 'first symptoms' attended to. The Menai Bridge, for example, might be replaced piecemeal, accordingly as every plate, angle iron, or other portion of it becomes deteriorated to an extent sufficient to imperil the safety of the structure. In this sense a wrought iron bridge is practically indestructible, since it admits of any and every degree of partial repair, and after the lapse of its first hundred years of life, may be completely rejuvenated and commence a fresh career. Lattice bridges—those constructed upon the open web system—in general afford special facilities for this process of gradual reconstruction, since a bar can be taken out and replaced without in any manner jeopardizing the safety of the remainder. The external effects, or visible appearance of the influence of time, must not be confounded with that invisible and inexplicable action that is incessantly in progress in connection with the molecular composition of the material. For similar reasons that the wrought iron girder, as a structure, can be preserved by successive reparation from the results of visible corrosion and decay, so is it also independent, in some degree, of any atomic alteration, unless we imagine the whole girder to be equally affected, and to fracture precipitately like one of cast iron. It has always been a puzzle to engineers to satisfactorily account for the sudden fracture of cast iron, whether in the form of girders, axles, or engine beams, under a much smaller strain, than what they had previously borne with impunity for a long period of time. A ready and apparent, though by no means necessarily a true, explanation of the fact is that it is owing to 'a change having taken place in the internal structure of the material.' This is equivalent to the specious and clever manner in which members of the faculty extricate themselves from their professional dilemmas by ascribing the fatal termination of any unknown complaint to 'disease of the heart.' The experiments made by Mr. Fairbairn upon cast iron bars, although interesting and valuable so far as a mere static load is regarded, present no analogy to the case of a cast iron bridge undergoing the transit of some couple of hundred trains per diem. Whatever the exact nature of the change may be, or the rate at which it progresses, until the cohesive power of the material is injured, it is impossible to assert; but we are nevertheless certain that the continual repetition of severe strains on a girder, must ultimately impair its powers of resistance. In a word, then, upon this hypothesis, every cast iron girder is doomed to break at some time or another, and what is worst, break suddenly, the precipitation of the passing load into the gulf beneath being the first sign of danger. This is not a very consoling reflection to a people who travel so much by rail as ourselves; but immunity from accident begets indifference, and although the contingency is possible, yet it is of an occurrence so rare that it is out of the sphere of probabilities.

"One is apt to regard the breaking down of a railway bridge in the light of a possible, but very remote contingency; to believe in such an occurrence in a vague, uncertain manner as an event that might or perhaps would take place 'some day,' but which, at present, is not worth thinking about. There is a little of the Mahometan doctrine of fatalism in all this, and although we do not exactly sit down, fold our hands, and cry 'Bishmillah,' as the sole preparation and defence against a coming danger, yet we require it to be brought pretty well home to us before we are thoroughly aroused to action From the experiments we have quoted, it was ascertained that the strength of cast iron to resist repeated alterations of strain was much greater than what has usually been accorded to it. At the same time we have no data upon which to base the life of a cast iron girder, unless we assume it to be equal to that of a wrought iron one. It has already been shown that the facilities offered by structures of the latter description, for gradual repair and actual reconstruction, leave no cause for anxiety on their behalf. We are in possession of the true elixir vitæ as regards them, and all that is required is to watch the time for making use of it. On the other hand, the 'first symptoms' of approaching rupture in the case of a cast iron girder cannot be perceived, and it is questionable whether the most careful and minute 'surveillance' which can be exercised over every cast iron bridge upon a line, would be able to detect the 'internal change of structure,'—that invisible dissolution which precedes the visible downfall. Taking for granted, therefore, that the natural life of a cast iron railway bridge is, for a minimum, one hundred years, some of our oldest examples have about sixty years to run, supposing that they die literally of old age, and their demise is not accelerated by accidental injury."

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## THE SHOEBURYNESS EXPERIMENTS.

During the months of June and July, a series of experiments in artillery practice have been made at Shoeburyness, England, to test the modern improved artillery, and its effect upon iron plating. The tests were of the most severe character, the plates being of a great thickness and of a superior quality of iron One of the targets had a porthole in its center, and its condition at the end of the experiments, as illustrated in the English journals, gives evidence of the enormous efficiency of the guns used in the experiments. The most formidable shot at this target was from a 10-inch gun, at a range of 1000 yards. The effect of this shot was to carry away, for a considerable area, the whole of the plating above and to the left of the port-hole, driving with it masses of iron, converted by the projectile into missiles more deadly than the shot they were designed to resist. We have waited for the conclusion of these important experiments, which have extended through a much longer period than was at first anticipated, that we might lay their results before our readers. We shall only refer to the most important of them, as described in the *Mechanics' Magazine.*

The first experiment we shall notice was a 12-inch shell, with full charge, aimed at the upper part of an extra plate, placed on the front of the shield, and which it broke into several pieces. It penetrated 16 inches, and exploded backward, doing no damage at the rear of the shield, beyond fracturing another horizontal plank. The Rodman gun, with a full charge, was then brought to bear on the upper part of the shield. It struck the curved plate at the left hand top corner, a portion of which was already knocked off, and it broke in two, doing no further damage. A shell from the 12-inch gun was fired with a charge equivalent to 1,000 yards range. The shell struck the second plate from the left hand, carrying away a piece from the corner, and bursting; the explosion lifting up a large triangular fragment of the adjoining plate previously broken, and hurling it on the roof of the building. This mass of iron was about 6 feet base by 5 feet sides, and remained pivoted on one of the large roof bolts, which held it without breaking. Inside the casemate at the rear, the ironwork in connection with the roof was much distorted, and a great cavity, admitting daylight, was formed through the plates, the head and point of the shot remaining jammed among the debris of the cavity.

The firing was afterward directed against the granite base on which the target stood. This forms a plinth about 4 feet high, projecting about as much from the surface of the shield, the step being rounded off. The shot—a 450-pounder, from the Rodman gun, with full powder charge—struck the granite toward the right hand, plowing a furrow some 5 feet wide and 3 feet deep, smashing the granite to powder, and scattering a cloud of fragments and dust around. After this shot, two rounds were fired at Sir John Brown's solid rolled 15-inch plate, which merely stood against some iron standards and a few balks of timber. This target had already had three rounds fired at it, with a result highly creditable to the plate, considering the conditions under which it was tested. The first was a 12-inch shell, with 76 pounds of powder, and which struck the shell about 2 feet from the end, which it broke off and hurled about 6 feet to the rear. The second shot, which was from the Rodman gun, with full powder charge, struck the plate near the center of the original length, and close to where it was hit by the two shots of the previous day. The plate at this point was already severely cracked, and the result of the last shot was to complete its destruction, the plate separating into four pieces. The fractures showed a splendid quality of iron, although here and there symptoms of bad welding were visible, and this was all the most adverse criticism could pronounce against it. In its favor there was everything to be said. Considering its unsupported position, and the widely different conditions under which it was fired at to those of a fort where it would be fixed as a defence, it stands out at once as a great success. Although the Plymouth fort stood a good amount of battering, it is to be remembered that it has been improved upon by replacing some of the bars by plates. These were just the points that withstood the firing the best, and this strengthens the conclusion that a mighty strength of resistance would result from the use of a single solid plate, instead of a compound laminated plating.

This was the conclusion of the third day's experiments, and at this point we may pause to notice the recorded details of the practice, as regards the force and velocities of the shots fired, and which are as follows: The Woolwich 12-inch rifled 600-pounder, with 76 pounds of pellet powder, 5,588 foot-tuns, 1,159 feet per second velocity. The 10 inch rifled 400-pounder, with 60 pounds 1 gr. powder, 4,431 foot-tuns, 1,264 feet velocity. The 15-inch smooth-bore Rodman, with 50 pounds English powder, equal to 60 pounds American, 4,215 foot-tuns, 1,161 feet striking velocity. In the same gun, with 83¼ pounds charge—equal to 100 pounds American powder—the velocity was above 1,400 feet, and the total energy about 4,000 foot-tuns.

The "War Office Casemate," was next made the object of attack. This casemate was manufactured at the Millwall Iron Company's works, and was designed with the view of testing the resistance offered by a given weight of iron plate, disposed in various thicknesses and positions. It is divided into six sections, each one of which represents a different system. The first section consists of an 8 inch solid plate, placed direct upon the 2-inch skin, which is common to all the series The second is of 4½-inch plate upon a backing 7 inches deep, formed of channel-iron placed back to back. The third is a 6-inch plate, with backing 7 inches deep of Hughes' hollow stringers. The fourth is a 4-inch plate, with 7 inch backing of channel-iron; the fifth is a 4½ inch plate resting partly upon 7-inch backing of channel-iron, and partly, with only the interstices between itself and the inner 2-inch skin, filled up with 7 inches of concrete, forming the sixth section. The structure was roofed in with brick arches and concrete, as in ordinary casemates. The firing was from the 7-inch, 9-inch, and 10-inch rifled guns, and the Rodman 15-inch smooth-bore gun, with battering charges, and at the same range as the Plymouth shield, viz., 200 yards. Only Palliser shells were used, these having established their superior penetrative power over the Palliser shot.

Twenty rounds were fired in all at this target, the first being a 7-inch shell, which struck the 8-inch plate, penetrating about 8½ inches, but doing no damage to the rear. The second round, a 7-inch shell, struck the 4½-inch plate supported by 7-inch channel-iron backing. It penetrated 14 inches into the target, but caused no damage to the rear. The third shell struck on the vertical junction of the last plate fired at, with the 6-inch plate backed by hollow stringers. The result was a penetration of 8¾ inches, the head of the shell remaining in the hole, and the rear remaining undamaged. The above three portions are marked A, B, and C, respectively, and they are backed with a massive tapering concrete pier. The fourth shell struck the last named section (C) where it has behind it 2 feet 6 inches of concrete, strengthened by iron girders. The penetration was 10½ inches, with half a dozen nuts stripped off in the rear. The fifth shell struck that portion of the target covered by 4-inch plates upon 7-inch channel iron. The plate buckled ¼ inch for about two feet around the shothole, and the total penetration was 13¾ inches, the head of the shell remaining in the hole. Seven more nuts in the rear were stripped off the bolts. The sixth shell struck the 4½ inch plate on concrete backing, penetrating 14 inches into the structure.

The practice now commenced with 9-inch shells, the first round striking section A of the target, penetrating 13 inches. The second shell struck the B section, penetrating 21¼ inches, the plate buckling considerably, and seven nuts twisted askew in the rear. The third shell struck on a bolt in section C, causing a buckle of ½ inch at the top edge of the plate, the penetration being 18¾ inches. The fourth shell struck the same section, penetrating 14½ inches, and clearing off five small nuts in the rear. The fifth shell hit on section D, the penetration being 9 feet 8 inches. At the rear the ⅝ inch iron skin mantlet was driven back 3 inches, and twenty small nut heads were stripped off. This portion was driven back by a bolt, and the mantlet skin was turned up also beside the port, the whole forming a considerable smash. The sixth round struck upon the E section, penetrating 22¼ inches, and causing no damage in the rear. The 10-inch gun was then brought into play, the first shell from which struck the A section, buckling the plate, and penetrating 32 inches. The second round struck the B section, causing a buckle, and penetrating 4 feet 9¼ inches. The shell was supposed to have burst in the concrete backing. One of the vertical channel irons lifted up a few inches through the concrete roof. The ⅝ inch skin at the back of the pier opened slightly at the joints. The third shell struck the section C, penetrating 6 feet, and passing into the concrete pier. At rear, the covering slip at the angle of the pier, ripped open over a length of 5 feet 8 inches, with ten rivets sheared, and a bulge of 5 inches in the ⅝-inch skin on the back of the pier.

The next shell struck the C section in another place, and completely penetrated the structure, clearing everything before it, the point of the shell being carried 200 feet to the rear. Some pieces of the ⅜-inch skin were thrown 20 feet away. The point struck was a weak one, being near a joint which was not covered by the backing. This points out the necessity of placing the stringers so that the joints of the plates should be supported by them, instead of having them at right angles to the line of the plates, as at present. The fifth round, with the 10-inch shell practice, struck the D section, making a clean penetration. One of the ⅜-inch mantlet plates in the rear was blown 20 feet away, and the timber screen was smashed up. There was an opening in the back of the target 4 feet in hight and of considerable width. The angle iron of a vertical girder on the left of the shot-hole was curved 3 inches out of the straight, a 2-inch bolt was broken off, and the concrete was blown out. The sixth and last 10-inch shell also struck upon the D section, and drove the whole side of the target back from its brick-work setting about half an inch. It penetrated 4 feet 11 inches, lodging in the concrete backing, and bulged the cover plate in the rear, stripping some more small nuts, and cracking the roof slightly all round. After this shot the Rodman gun was fired, a round shot striking the junction of the 6-inch plates above the porthole. It caused an indent 7 inches deep, and sheared off a bolt head 6 inches from the face of the target. At the rear the angle iron supporting the ⅜-inch skin over the port bent three inches, thirty small screw nuts were knocked off, and the whole skin ⅜-inch plate, was knocked out a distance of 9 inches. One rivet was knocked out from the top of each port jamb. The second round from the Rodman gun struck the A section of the target, making an indent of 4¼ inches, but doing no further injury.

From the above the nature of the subsequent experiments may be sufficiently inferred, as well as their general results. *Engineering* says that the protective points of the Plymouth Breakwater Fort have been well tested in this trial, and found