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ISAMBARD K. BRUNEL, Vice-President,  
in the Chair.

No. 935.—“On Improvements in Diving Dresses, and other Apparatus for Working under Water.”<sup>1</sup> By JOHN WILLIAM HEINKE.

FROM the earliest times, divers have been in requisition for various purposes,—in raising goods from wrecks,—in recovering anchors, or lost treasure,—as well as in pearl, sponge, and other fishing,—and they, most probably, received no artificial aid; but practice, as in all pursuits, rendered some more daring, or greater adepts at the employment, than others, until, for the sake of ease and comfort, and greater security in following their avocation, different contrivances were resorted to, of which no accounts have been recorded.

Alexander the Great, at the siege of Tyre, employed divers to impede, or destroy the works of the besieged, as they erected them. The Syracusans, also, trained persons for the same purpose, and for getting beneath and injuring the enemy's vessels. The Rhodians had a law, by which all divers were allowed a proportionate share of recovered treasure, according to the depth from which it was brought, or the risk incurred. If the divers raised it from the depth of 8 cubits, or 2 fathoms, they received one-third;—if from 15 fathoms, one-half;—but for goods cast near the shore, and found at 1 cubit, or 18 inches from the surface, only one-tenth was paid.

Among the pearl fishers, one method of prolonging operations under water, was by retaining in the mouth, while below, a piece of sponge soaked in oil, and replenishing it at each plunge; this is said to have enabled some of the most hardy, to remain at least six, or seven minutes under water, which length of time is considered by physiologists, to be the limit of submarine endurance.

The divers of Astracan used to step from a warm bath into the water, where they would continue six, or seven minutes; they then returned to the warm bath, from which they again plunged into the water. This was repeated about five times during the day, after which they became exhausted and senseless; blood flowing from the nose and ears.

There are, however, many accounts of long continued immersion, which, if true, certainly show, that other than natural means were resorted to, for enabling men to work under water. The Dutch were originally celebrated as divers, and some are said to have re-

<sup>1</sup> The discussion upon this Paper extended over portions of three evenings, but an abstract of the whole is given consecutively.

mained below, more than an hour. Mersennius, in his work published at Amsterdam, in 1671, mentions a man, named John Barrinas, who could remain six hours under water ; which, it is evident, could only have been accomplished by the aid of mechanical apparatus. Many instances of intrepidity and dexterity in diving, may be found in "Jans Kraft, Sitten der Wilden, Kopenhagen, 1766 ;" but perhaps the most remarkable, is that recorded by Father Kircher, of the Sicilian diver Nicolò Pesce ; his skill was amazing, and it was said, that he carried letters for the King from Sicily to Calabria. His fame being wide spread, the King offered him a golden cup, to explore the terrible gulf of Charybdis, and he remained three quarters of an hour amidst the foaming abyss ; on his return, he described all the horrors of the place and so astonished the monarch, that he requested him to dive once more, further to ascertain its form and contents. He hesitated, but upon the promise of a still larger cup and a purse of gold, he was tempted to plunge again into the gulf, whence he never more emerged.

As, in the earlier stages of commerce, vessels, whether freighted, or not, never ventured far from the shore, there were numerous opportunities for the diver, and as the chief considerations were time and safety, an apparatus that would supply fresh air for a comparatively long period, was a great desideratum ; for without such an instrument, frequent visits must be made to the surface, causing an evident loss of time, and the mere act of holding the breath almost precluded the exertion of any physical force.

Although the invention of the Diving Bell has been generally assigned to the sixteenth century, yet there are evidences of other, although rude modes, having been adopted, long anterior to that era. Beckmann, in 1770, quoted a passage from Aristotle, (Problem xxxii,) to show, that the divers of his time, used a sort of kettle, to enable them to remain longer under water ; but the inference drawn, does not seem very clear. The renowned friar, Roger Bacon, who flourished about 1250, has been considered by some to be the originator of the diving bell, or of some machine to facilitate working under water ; but little credit can be attached to the tradition. The earliest mention of anything of the kind, that can be depended upon, is by John Taisner, who says he saw the experiment made by two Greeks at Toledo, in Spain, in 1538, before the Emperor Charles V. and ten thousand spectators. Gaspar Schott, (Nürnberg, 1664,) repeats the story, and calls the vessel an 'aquatic kettle,' but prefers another apparatus, which he designates 'aquatic armour,' that enabled those covered with it, to walk under water. The Plate, accompanying the description, represents a man walking in the water, with something like a small diving bell over his head. In an edition of Vezetius on "The Art of War," published in 1511, there is an engraving, which represents a diver with a cap

on his head, from which rises a long leather pipe, with an open end floating on the surface of the water.

Lorini, in his work on Fortification, published at Venice in 1609, gives a Plate and a description of a diving apparatus, or chest, which he describes, as "a square box bound round with iron, furnished with windows, and has a stool affixed to it for the diver;" but he does not lay claim to the discovery, and seems to consider it as a machine already known.

Francis Kessler, of Oppenheim, in 1617, gave a description of a suit of water armour, which, however, Beckmann<sup>1</sup> and others declared, could not be used with safety.

About 1620, Cornelius Debrell contrived a submarine vessel, or boat, to be rowed and used under water. This was tried upon the Thames by order of James I., and is said to have succeeded admirably; it carried twelve rowers, besides passengers. This vessel is mentioned by Robert Boyle, in his "New Experiments Physico-Mechanical," wherein he professes to give Debrell's secret, from authority; he says:—"the composition was a liquid, that would speedily restore to the troubled air, such a proportion of vital parts, as would make it again, for a good while, fit for respiration." This novelty induced "His Most Serene Highness, Charles Landgrave of Hessen Cassel," to have a diving vessel constructed for the same purpose; some years afterwards, it was described, (with a diagram,) in the '*Gentleman's Magazine*.'<sup>2</sup>

The celebrated Lord Bacon, in his "*Novum Organum*," 1645, suggested a machine, where the diver "stood upon a stool of three feet as a tripod, which were in length somewhat less than a man, so that the diver, when no longer able to contain his breath, could put his head into the vessel, and having breathed again, returned to his work."

Bishop Wilkins, in his "*Mathematical Magic*," 1648, proposes a machine "whose benefits shall be incalculable: 1st,—Privacy, as a man may go to any part of the world invisible, without being discovered, or prevented. 2ndly,—Safety from the uncertainty of tides and tempests, that vex the surface, from pirates, robbers, and ice, which so much endanger other voyages towards the poles. 3rdly,—It may be used to undermine and blow up a navy of enemies, or to relieve a blockaded place." His plans were, however, wholly theoretical.

In 1663, the Marquis of Worcester published the heads of his "Century of Inventions," the necessary directions for carrying out these projects having been lost, as it is stated in his observations on the title-page. Proposal 9 is—"A ship-destroying engine, port-

<sup>1</sup> *Vide* Beckmann, translated by William Johnson, 8vo. London, 1797 and 1814.

<sup>2</sup> *Vide* Gentleman's Magazine, December, 1747.

able in one's pocket, which may be carried and fastened on the inside of the greatest ship, and at any appointed minute, though a week after, either of day, or night, it shall irrecoverably sink that ship." Proposal 10,—“Away from a mile off, to dive and fasten a like engine to any ship, so as it may punctually work the same effect, either for time, or execution.” Proposal 11,—“How to prevent both.—How to prevent and safeguard any ship, from such an attempt by day, or night.”

In 1669, Borelli contrived a ‘vesica,’ or bladder, which was, in fact, a copper vessel, 2 feet in diameter, with glass fixed before the face of the wearer. This contained the diver's head, and was fixed to a goat-skin habit, exactly fitted to the shape of the body. He carried an air-pump by his side, by means of which he condensed, or rarified the air in the vessel, and thus made himself heavier, or lighter, on the same principle as fishes. Within this ‘vesica’ there were pipes, by means of which a circulation of air was contrived; thus equipped, and with artificial webbing to the feet, to enable him to tread the water, the inventor supposed, that he had overcome all difficulties hitherto known, or objections to which such machines were liable. Hooke, in 1681, in his “Philosophical Collections,”<sup>1</sup> speaks of Borelli's apparatus, of which he gives a Plate, as also of one which he claims to have himself constructed. This he describes, as “another way of swimming under water, and breathing, by the help of a leather pipe, kept open by wreathed wires, and extending from the diver's head to the top of the water.” In 1678, a German, named Sturm, was enabled to make some further improvements in Borelli's apparatus, but neither seem to have answered the intention, or ever to have been used.<sup>2</sup>

Mersennius, in his publication at Amsterdam, in 1671, proposed a submarine boat, by which persons might pass from place to place under water, move it to and fro, and make it rise, or sink in a river, or sea: this project failed, however, like all its predecessors. Another proposal for a diving machine appears, also, in the same place and in the same year, from Nicolas Witsen; he describes his invention very explicitly, and gives instructions to the divers, as to its proper use and management, but there is not any account of its real utility, or success.

About this time, a spirit of enterprise seems to have sprung up, and more attention was directed to the best means of securely searching for treasures hidden in wrecks, &c.; and both in Holland and in Great Britain, great efforts were made, for that purpose. As might be expected, many of the schemes failed, either from want of proper machinery, or lack of means; companies were formed in haste, for the purposes of exploration, and as quickly

<sup>1</sup> *Vide* No. 2, p. 36.

<sup>2</sup> *Vide* Collegium Curiosum.

abandoned. The Duke of Argyle, among others, joined in the mania, and determined upon examining the wreck of a vessel sunk off the Isle of Mull, in 1588, being, in fact, one of the Spanish Armada, and supposed to be richly laden. He engaged for the task, a man named Colquhoun, of Glasgow, who went down several times, but merely surveyed the wreck as well as he could. The apparatus he employed, seems to have been made after that suggested by Hooke, and consisted of a long pipe of leather, by which the air was communicated, his head being covered with some sort of bell. In 1688, Sinclair, a Professor in the University of Glasgow, published his *Principles of Navigation*, in which, in a postscript, he gives directions how to buoy up any ship of burthen, from the ground to the surface of the sea; and he speaks of the apparatus employed in searching the vessel, as being similar to that which Colquhoun had previously used.

The most successful adventure of the period, was undertaken by one Phipps, a ship-carpenter, the son of a blacksmith, at Boston, in America. He began to operate, in 1687, with an apparatus, the character of which is now unknown, upon the wreck of a Spanish galleon, lying off the coast of Hispaniola; but what he then recovered, did not repay the outlay. Nothing daunted, he determined upon trying again, and assisted with money, (though most usurious,) by the Earl of Albemarle, son of the well-known General Monk, he eventually, but with much difficulty, rescued property of the value of nearly £300,000, of which sum he received about £20,000 for his own share. In other ventures, he was equally successful; he was afterwards knighted, became Sheriff of New England, and founded the present noble family, represented by the Marquis of Normanby.

With the publication of a work by Pasch, at Leipsig, in 1700, the century closes. His plan was merely an alteration of others that had preceded, and was never, probably, tried with success.

The celebrated Dr. Edmund Halley, Secretary of the Royal Society, paid great attention to the subject for some years, and from his continued experiments, and the very different structure of his machine, he was considered as the inventor of the diving bell; that notion has, however, long been exploded.

In 1716, he read his Paper, entitled "The Art of Living under Water,"<sup>1</sup> before the Royal Society; and the following extract conveys his views. He says:—"when there has been occasion to continue long at the bottom, some have contrived double flexible pipes to circulate air down into a cavity, enclosing the diver with armour, to bear off this pressure of the water, and give leave to his breast to dilate upon inspiration, the fresh air being forced down

<sup>1</sup> *Vide Phil. Trans.*, No. 349, vol. xxix., p. 492.

by one of the pipes, with bellows, or otherwise, and returning by the other of them, not unlike an artery, or vein. This has been found sufficient for small depths not exceeding 12, or 15 feet, but when the depth surpasses 3 fathoms, experience teaches us, that this method becomes impracticable; for though the pipes and the rest of the apparatus, may be contrived to perform their office duly, yet the water, its weight being now become considerable, does so closely embrace and clasp the limbs that are bare, or covered with flexible covering, that it obstructs the circulation of the blood, and presses with so much force on all the junctures, where the armour is made tight, with leather skins, or such like, that if there be the least defect in any of them, the whole engine will instantly fill with water, endangering the life of the man below. . . . To remedy these inconveniences, the diving bell was next thought of."

He then describes his contrivance, which was a truncate cone of wood, containing 60 cubic feet in its concavity, the diameter at the top being 3 feet, and at the bottom, 5 feet. In the top, was placed a strong clear glass to give light, and a cock, to let out the air that had been breathed. The machine was coated with lead and otherwise weighted, that it might sink steadily; when below, it was supplied with air by two barrels of 36 gallons each, which were alternately lowered, and raised, full, and empty. In this instrument, he says, that he remained without inconvenience, wholly dressed, with all his clothes on, for one hour and a half, at a depth of 10 fathoms. He subsequently conceived a method, by which the diver could leave, and walk about some distance. This he also described to the Royal Society, in 1721.<sup>1</sup> He says:—"I bethought myself how to enable the diver to go out of the bell, to a considerable distance, and to stay a sufficient time without it, with full freedom to act as occasion served. . . . I procured pipes to be made, which answered all that was hoped from them. They were secured against the pressure of the water, by a spiral brass wire, which kept them open from end to end." This appears to have been an adaptation of Hooke's apparatus, or of that used by Colquhoun. These wires, of which the diameter of the cavity was about one-sixth of an inch, "were coated with thin glove leather curiously sewed on, and then we dipt the leather into a mixture of oil and bees-wax hot. Then we drew several folds of sheep's-guts over them, which when dry, we painted with a good coat of paint, and then secured the whole with another coat of leather, to keep them from fretting. The pipes, of which we made several, were about 40 feet long, the size of half an inch rope; the one end thereof being fixt in the bell, and the other fastened to a cock, which opened in the cap. . . . The diver, therefore, putting on

<sup>1</sup> *Vide* Phil. Trans., No. 368, vol. xxxi., p. 177.

his cap, and coiling his pipe on his arm, like a rope, as soon as he is discharged from the bell, opens a cock and marches on the bottom of the sea, seeing that the coils of his pipe, which serves as a clew, to direct him back again, &c. &c. . . . The leaden caps were made to weigh half a hundredweight, to which I added a girdle of large weights of leads, of about the same weight, in the whole, to be worn about the waist, and two clogs of lead for the feet, of about 12lbs. each.”<sup>1</sup>

About the same time that Dr. Halley read his first Paper to the Royal Society, in 1716, a person named John Lethbridge, of Newton Abbott, near Exeter, invented a machine, which was made under his directions, by a cooper in Stanhope Street, Clare Market, the particulars of which he published about thirty-three years afterwards, in the ‘Gentleman’s Magazine.’<sup>2</sup> He thus describes it:—“It is made of wainscot, perfectly round, about 6 feet in length, about 2½ feet in diameter at the head, and about 18 inches diameter at the foot, and contains about 30 gallons. It is hooped with iron hoops without and within, to guard against pressure; there are two holes for the arms, and a glass about 4 inches diameter and 1¼ inch thick, to look through, which is fixed in the bottom part, so as to be in a direct line with the eye; there are two air-holes upon the upper part, into one of which air is conveyed by a pair of bellows, both of which are stopped with plugs, immediately before going down to the bottom. At the foot, there is a hole to let out water; sometimes there is a large rope fixed to the back, or upper part, by which it is let down, and there is a line called the signal-line, by which the people above, are directed what to do, and under, is fixed a piece of timber, as a guard for the glass. I go in with my feet foremost, and when my arms are got through the holes, then the head is put on, which is fastened with screws. It requires 5 hundredweight to sink it, and taking 15 lbs. from it, it will buoy upon the surface of the water. I lie straight upon my breast, all the time I am in the engine, which hath many times been more than six hours, being frequently refreshed upon the surface, by a pair of bellows. I can move it, about 12 feet square at the bottom, where I have stayed many times, 34 minutes. I have been 10 fathoms deep, many hundred times, and have been 12 fathoms, but with great difficulty.”

Another claimant appeared, nearly at the same time, in the person of Nathaniel Symonds, of Harburton, near Totness. He produced a diving machine, in the shape of a boat, in which, before many hundreds of persons, he sank himself in the River Dart, where he remained three-quarters of an hour, and then re-appeared. He

<sup>1</sup> Vide Plate 2 in Vol. III. of Plates, Rees’ Cyclopædia.

<sup>2</sup> Vide Gentleman’s Magazine, Oct. 1749.

complains with evident disappointment, that "though a great number of gentlemen of worth were present, he received but one crown piece from them all."

In 1724, Jacob Leupold, of Leipzig,<sup>2</sup> describes an apparatus, then in vogue, but of which he does not claim the invention. Later still, Martin Triewald, Military Architect to Frederick, King of Sweden, greatly improved upon Halley's invention, by making a machine, both lighter and less expensive. In the head of his apparatus, which was of tinned copper, and which was managed by two men, he used in lieu of plain glass, convex lenses, to admit the light. He published the particulars at Stockholm, in 1732, and the description was subsequently read before the Royal Society.<sup>3</sup>

About 1750, a Mr. Rowe invented a 'diving engine' for searching wrecks, which consisted of a hollow copper vessel, of sufficient dimensions to contain the body of a man, with holes at the sides, through which his arms protruded. At the end of the 'engine,' glasses were placed, through which he could see the objects of his search. The diver was lowered by a rope, and could remain below, for half an hour, without any difficulty.<sup>4</sup>

A daring, but unfortunate, attempt to use a submarine vessel was made, in 1774, by Mr. Day, in Plymouth Sound. So confident was he of success, that he had a small ordinary vessel, prepared for the purpose, according to his directions, and at the time appointed for making the experiment, all being ready, he sank the vessel and himself, in the presence of a great many spectators: but he never rose again.

In 1775, Mr. Spalding brought out an improvement upon both Dr. Halley's and Triewald's apparatus, and was rewarded by the Society of Arts,<sup>5</sup> with twenty guineas; he was followed by Farey, who rendered it still more complete and more applicable to the required purposes.

About the same time, (1775,) a Mr. Bushnell, of Connecticut, endeavoured to realize the project of Bishop Wilkins, and with the apparatus he constructed, he offered the newly-formed Republican Government of America, to destroy the British shipping, then lying in their different harbours and rivers; but although he found it quite practicable to travel under water, he did not succeed in the rest of the design. His machine had a resemblance to two upper tortoise shells, of equal size, joined together, and it was capable of holding the operator, with sufficient air to support him for thirty

<sup>1</sup> *Vide Gentleman's Magazine*, July, 1749.

<sup>2</sup> *Vide Theatrum Machinarum Hydraulicarum*, Leipzig, 1724-5.

<sup>3</sup> *Vide Phil. Trans.*, vol. xxxix., p. 377.

<sup>4</sup> *Vide Universal Magazine*, Sept. 1753.

<sup>5</sup> *Vide Transactions of Society instituted at London for the Encouragement of Arts, &c.*, vol. i., p. 220.



minutes. He could swim so close to the surface of the water, as to approach, unperceived, very near any ship during the night. He could sink quickly, keep at any depth he pleased, could rise to the surface for fresh air, and descend again at pleasure, as described in his publication of 1787.<sup>1</sup>

This scheme was resuscitated in 1822, by Mr. Samuel Colt,<sup>2</sup> who proposed to the Government of the United States, to construct a machine, which would effectually realize all that Bushnell had suggested. In order to test its utility, the Secretary of the Navy was instructed to render Mr. Colt every assistance and facility, and to appropriate 15,000 dollars for the purpose.<sup>3</sup> A vessel was actually destroyed at some distance from the shore, but the means employed, were not made public.

Benjamin Martin, originally a plough-boy in Surrey; but afterwards a celebrated optician and globe manufacturer in Fleet Street, published in 1778, a description of his diving apparatus.<sup>4</sup> It consisted of strong leather, so prepared, that no air could pass through: it fitted his arms and legs, and had a glass window in the front part. This apparatus held half a hogshead of air, and when dressed in it, he could walk on the ground, at the bottom of the sea, or enter the cabin of a submerged ship, and take out any valuables. He appears to have used this apparatus rather successfully. In his work, he speaks of a machine for the same purpose, by a gentleman of Devonshire; it is presumed, that he alludes to Lethbridge's apparatus, previously described.

Smeaton, in 1779, first employed the diving bell for Civil Engineering operations; it was used in repairing the Bridge at Hexham, in Northumberland.<sup>5</sup> The apparatus was an oblong wooden box, 4 feet high, 2 feet wide, and 3 feet 6 inches long. It was supplied with air by a pump fixed on the top. He afterwards constructed an improved apparatus, of which he made use in the construction of Ramsgate Harbour, in 1788. Mr. Rennie subsequently made great improvements in it, adapted it to local circumstances, and extensively used it at the works of Howth Harbour, near Dublin.

The apparatus, designed by Mr. Kleingert of Breslau, was first described in a pamphlet, published in 1798. The harness, or armour, was made of strong tin plate, in the form of a cylinder, which enclosed the diver's head and body; it consisted of two parts, that he might easily get it on. Besides this, he had a jacket with short sleeves, and a pair of drawers of strong leather,

<sup>1</sup> *Vide* Brewster's Edinburgh Cyclopædia, vol. viii., art. Diving.

<sup>2</sup> Now Colonel Samuel Colt, Assoc. Inst. C.E.

<sup>3</sup> *Vide* Nautical Magazine, vol. viii., New Series, 1844, p. 74.

<sup>4</sup> *Vide* Philosophia Britannica, 1778.

<sup>5</sup> *Vide* Smeaton's Life.

all water-tight and joined by brass hoops round the metal on the outside, so that he was relieved from pressure on all parts, except the legs and arms. With this apparatus, on the 24th of June 1798, a man named Joachim, under his direction and before many spectators, dived and sawed through the trunk of a large tree at the bottom of the River Oder, near Breslau.

At this time, there were many projects of analogous character, but none particularly worth notice, except that by Robert Fulton, who first introduced steam navigation on the rivers of America. At the close of the last century, he made a submarine boat, or chest, which he exhibited, under the patronage and at the expense of the French Government, on the Seine at Havre and Rouen; and afterwards at New York, and other places in America.

In the year 1786, Messrs. John and William Braithwaite were engaged in recovering the guns from the floating batteries, which were sunk off Gibraltar; and they presented eight pieces of fine Spanish ordnance to the Emperor of Morocco. In the years 1789 and 1790, they successfully searched for and recovered all the dollars, and a large quantity of tin and lead, from on board the 'Hartwell' East Indiaman, lost off Bonavista, Cape de Verd Islands. This was accomplished in depths varying from 5 to 7 fathoms, by means of Mr. John Braithwaite's diving machine. On their return from Bonavista, they negotiated with the Government to commence operations on the 'Royal George,' and they made all the necessary preparations. But although the ship ostensibly belonged to the Admiralty, its guns were claimed by the Ordnance: hence difficulties arose between the Government Departments, which induced Messrs. Braithwaite to relinquish their design. From the wreck of the ship 'Earl of Abergavenny,' outward-bound East Indiaman, of 1,300 tons burthen, they succeeded in recovering nearly all the cargo, and £75,000 in dollars. This vessel was lost in 1805, and after having laid under 10 fathoms water for sixteen months, during which time many unsuccessful experiments were made by Mr. Tucker, Mr. John Braithwaite, by means of his peculiar diving machine, (but which was not a diving bell,) succeeded in raising the ship and cargo, amounting in value to many thousands of pounds. By this apparatus, he was enabled to remain under water, eight, or ten hours at a time, and to conduct the various operations, which were effected by machinery exclusively his own, and by the aid of gunpowder. The diving machine which he employed, is now the property of his Son, Mr. John Braithwaite, (M. Inst. C.E.) who, with his Brother, was present, on several occasions, to witness the operations.

The Plymouth Breakwater, for which many plans had been suggested, was commenced on the 12th of August 1812, the first stones being deposited with much ceremony. In the progress of a work

of such magnitude, extending over many years, and which, in fact, is scarcely yet completed, this mode of working below, has been found of essential service, and has been adopted, wherever it has been necessary to have firm and substantial masonry constructed under water. At the works for the Harbours of Refuge at Dover and at Alderney, it is extensively used by Mr. Walker.

But, perhaps, one of the most striking uses to which it has ever been applied, was in the demolition of the wreck of the ill-fated 'Royal George,' sunk off Spithead, in August 1782. In less than a month after the accident, several proposals were made for weighing her, and the proposition of Mr. Tracey was selected from those of one hundred and eighteen candidates. It was no easy undertaking, considering that the weight of the guns, stores, &c. on board, amounted to 1,031 tons, and that she had sunk 13 feet into a bed of silt, or blue clay. After a trial of three seasons, and an expense of £12,000, borne between the Government and Mr. Tracey, the project was abandoned. Thus matters rested, until June 1817, when Mr. Ancell, of the Portsmouth Dockyard, went down in a diving bell and surveyed the wreck, as far as was practicable, in a depth of water of 10 fathoms. Another respite of seventeen years then took place. In the mean time, Mr. Deane, with an apparatus which was originally intended for the recovery of property from houses, or factories while on fire, but which, having failed to obtain the patronage of the insurance offices, he applied to diving purposes, succeeded, in 1828, in clearing the wreck of the 'Carnbrae Castle' Indiaman, lost at the back of the Isle of Wight; he also operated upon the wreck of H. M. S. 'Boyne,' burnt, at the latter part of the last century, off South Sea Castle. He then offered to remove the wreck of the 'Royal George,' and after some delay, received permission to make the attempt. In 1834-5-6, having had more perfect apparatus made under his directions by Siebe, he was enabled to bring up twenty-eight guns, (of which twenty-one were of brass and in good preservation,) and also some other portions of the wreck.

His task being so far complete, he attempted, with success, to bring up the guns of the 'Mary Rose,' which was lying not far from the other wreck. This vessel had been submerged for nearly three hundred years, as she went down in July 1545, and its situation was only discovered in 1836, by some fishermen, whose nets had sustained injury from something protruding from the bottom of the sea. In 1836, he succeeded in raising twenty-five guns, five of which were of brass, and the other twenty, of wrought-iron. The brass guns bore date, 1535, and the makers' names were "Robert and John Owyn." The other guns were of peculiar construction, being manufactured of wrought-iron bars, secured by thirty-three hoops; besides these, he brought up some iron and many

granite shot, eight ancient bows, a number of miscellaneous articles, and part of the oak mainmast; the latter still in good preservation.

In 1839, the operations upon the 'Royal George' were resumed, under the direction of Colonel, (now Lieutenant-General Sir C. W.,) Pasley. It was determined, if possible, to clear the roadstead, although, at one time, doubts were entertained of the propriety of attempting it, unless it could be done so effectually, as to entirely free the bank from all debris. The destruction of the remains by gunpowder having been resolved upon, cylinders were prepared, and being heavily charged, the first explosion was reserved for and took place on the 29th of August, 1839, that being the fifty-seventh anniversary of the melancholy event. On the 20th of September, a charge of 260 lbs. of powder was fired by the voltaic battery; and this is supposed to have been the first public practical adaptation of such means, although the applicability of the voltaic battery for such purposes, had been previously demonstrated by Mr. J. Bethell, (Assoc. Inst. C.E.,) on the 24th of April, 1838, at the Institution of Civil Engineers. The effect was instantaneous, highly satisfactory, and grand beyond description. The surface of the water was immediately covered with dead fish and with fragments of all descriptions, curiously covered with sea-weeds, and of richly tinted colours. During the season, they recovered, among other things, five brass guns weighing 26,072 lbs., (the value of which, as old metal, was estimated at £1,000,) and seven iron guns.

In 1840, the Colonel again resumed operations, and with the same success; having an able assistant, as a diver, in Mr. George Hall, of Whitstable, with about eighty men, including Sappers and Miners. The apparatus employed was manufactured by Siebe, by whom several alterations, at Deane's suggestion, had been made in that previously used.

By the end of 1841, much valuable timber was rescued; indeed, between the months of May and November, in that year, not less than 18,600 feet, or 372 loads of timber were brought up, and being afterwards sold by public auction, great quantities were preserved as relics.

The season of 1842 was quite as satisfactory as those preceding, and in that of 1843, the harbour was finally cleared of all obstruction. The consumption of gunpowder during the operations, was 52,963 lbs., and there were recovered, no less than 581 cwt. 2 qrs. 14 lbs. of various sorts of metal, (exclusive of eighty-six guns,) and 59,000 cubic feet of timber.

It may be remarked, as somewhat curious, that of all the money which must have been on board at the time of the catastrophe, when twelve hundred persons went down, only two guineas were found. It is, moreover, satisfactory to know, that during the works,

no accident occurred, attended with loss of life, or limb, although there were three, or four narrow escapes. But, perhaps, the most singular incident is, that an actual fight took place below, between two divers, for the possession of some portion of the wreck claimed by both; in the scuffle, the glasses of one helmet were broken, and the diver was nearly drowned before he could be rescued. Such an accident is now, in Heinke's apparatus, effectually provided against, by helmet slides.

The operations against the wreck in question, also resulted in great benefit to the practice of diving, the applicability of the apparatus having been tested in every possible manner. Many of the Sappers and Miners, both of the regular army and of the East India Company, were fully initiated in the use of diving apparatus, and sailors from different vessels, were also trained so as to be useful in cases of emergency.

In France, there had been many efforts towards establishing the practicability of submarine boats, but the great difficulty was, how to supply air to the men employed. Dr. Payerne,<sup>1</sup> however, felt convinced, that it was practicable by chemical means, to restore the purity of the air under water, without communication with the atmosphere. This experiment was first tried, in England, at the Polytechnic Institution, and was then repeated with success at Spithead.

On the latter occasion, the bell was accompanied by four cylinders, each 4 feet long and 12 inches in diameter, containing condensed air, which was forced into them by an air-pump, and allowed, when required, to flow into the bell, by turning a cock. Another experiment was made without cylinders; the end of one of the diver's air-pipes, was conducted into the bell, and air was forced through it by one of the small pumps, ordinarily used for supplying air to a helmet diver. The water was kept out of the bell as well as under the ordinary system, and the respired air was renewed in a perfectly satisfactory manner. The result was approved by Lieutenant-General Sir C. W. Pasley and other scientific men, the air for respiration being perfectly good, and the whole apparatus for purifying it so compact and simple, that it could be contained in a case not larger than a common portable desk, and it could be used without any trouble.

The helmet diving apparatus has now become of comparatively common use, for the repair of lock-gates and other works under water. In the building of almost all docks, bridges, &c., of any extent, it is in constant use; and in examining accidents occurring to vessels, and more especially, to the shafts of screw-propellers, to rudders, &c., it has been very useful. It has been so constantly

<sup>1</sup> Vide "Description of a Diving Machine, employed in the Government Works at Cherbourg, by Dr. Payerne," by Captain H. Tyler, R.E. Published in the Prof. Papers of the Corps of Royal Engineers, vol. v., New Series, p. 35.

exhibited at the Polytechnic Institution and at the Panopticon; that it has become familiar to all.

Besides the various alterations and improvements already mentioned, there have been many others, that deserve notice.

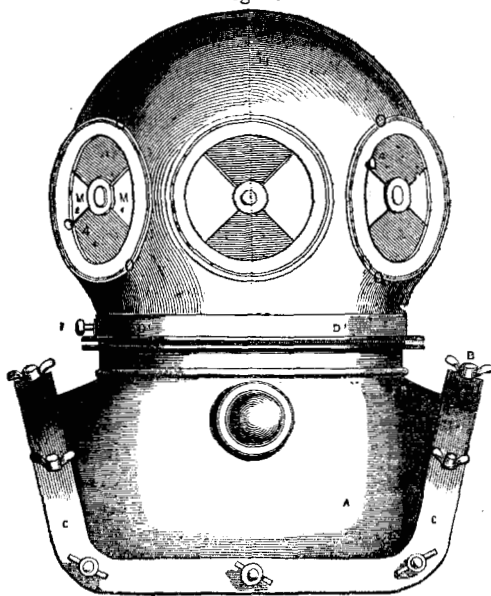
In 1835, Mr. J. Bethell introduced several important improvements in the form and use of diving apparatus.

In 1836, Mr. William Bush, of Bishopsgate, claimed the introduction of air-pumps into diving bells, instead of pumping air down from above;—the application of a pump to diving dresses, whereby the diver might supply himself with air from above;—and the use of an air-belt, combined with a diving dress, to facilitate the diver in rising and sinking. He also applied a compass to the helmet of the dress, in order that the diver might ascertain his position, when below the water.

In 1836, Mr. Frazer made an improved escape-valve, and other additions to the dress.

In 1838, Mr. Thornthwaite, of Hoxton, produced a diving-belt, for which he was rewarded with a Silver Medal, by the Society of Arts, and his invention was ordered to be placed in their Repository. His instrument consisted of a belt of india-rubber

Fig. 1.



Heintke's Helmet.

cloth, to which was attached a small strong copper vessel; into this, air was forced by a condensing pump, until it had a pressure of between thirty and forty atmospheres. The belt, being put on in a collapsed state, did not give any buoyancy, nor impede the diver in his descent. If he desired to rise, he opened a valve, by which the condensed air escaped from the metal vessel into the belt, and by its expansion, enabled him to rise to the surface.<sup>1</sup>

In the ordinary apparatus, and helmet,

<sup>1</sup> Vide Transactions of Society instituted at London for the Encouragement of Arts, &c., 1838-9-40, vol. lii., p. 243.

great alterations have been effected from time to time, by the various makers. The improvements introduced by Mr. E. Heinke and the Author, some of which are shown in Figs. 1, 2 & 3,<sup>1</sup> are based upon long experience of the defects complained of in ordinary apparatus. The submarine dress, as manufactured at that period, was exhibited at the Great Exhibition, in Hyde Park, in 1851, and obtained the award of a medal; since that time, several additional improvements have been made, and so nearly perfect may the apparatus be now considered, that there are few persons who would hesitate to go down in the dress, after once seeing it used.

Among the most prominent of the improvements, is that of the eye-frame, to which is affixed a brass slide, so contrived, that in case of accident to the glass, the diver can immediately close it, and thus save himself from drowning.<sup>2</sup> A double valve fixed in the front of the gorget, enables the diver to descend and rise at pleasure, with the whole of his gear, which weighs upwards of 200 lbs.; in fact, it places the whole apparatus completely under his control, and protects him in case of anything happening to the air-

Fig. 2.

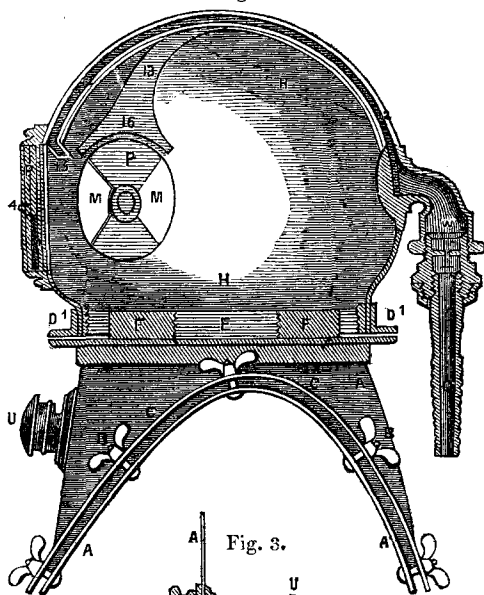
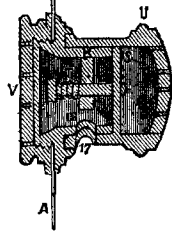


Fig. 3.



Side View and Sections of Heinke's Helmet.

<sup>1</sup> The Institution is indebted for the loan of these woodcuts, to the Editor of the 'Engineer.'—Ed.

<sup>2</sup> Since this Paper was written, a diver of the name of Batt, lost his life at Margate, in April 1856, in consequence of the breaking of the glass. If the slides here alluded to, had been affixed to the helmet, the accident, in all probability, would not have happened.—W. H.

hose, as by its means, a sufficient quantity of air, to support respiration for ten minutes, can be contained in the helmet and dress, thus giving time to ascend, even from a very great depth. The connecting joints are now so manufactured, that they can scarcely be broken, as they will resist the most powerful pressure, in consequence of having a double safety-cap affixed. The new vulcanized band completely excludes the water from the dress, and enables it to fit more easily and with greater comfort to the wearer. The signal-dial makes the wants of the diver known to those above, instantly and correctly, and in fact, renders the apparatus nearly complete for the most difficult undertakings.

In 1855, a number of interesting trials took place in various places. The experiments which were conducted at Portsmouth, in the month of June, in the presence of the Admiral-Superintendent and Dock-yard Officers, gave great satisfaction; the diver remaining below, half an hour at a time, in a depth of water of  $3\frac{1}{2}$  fathoms. At Chatham Dock-yard, in October, a similar trial took place, in the presence of the Captain-Superintendent, and several gentlemen connected with the establishment, as well as many Officers of the Corps of Royal Engineers and others, who all expressed their gratification at the result of the experiment.

At Paris, it was tested on the Seine, by command of the French Government, and in the presence of Prince Napoleon, a large number of military and other Engineers, the Commissioner-in-chief, the Secretary of the Exhibition, and the Members of the International Jury.<sup>1</sup> On that occasion, five kinds of diving dresses were tried, (of which three were English and two were French,) in every variety of situation. The apparatus which was attended with the most successful results, and which, it was decided, possessed the greatest facilities, was that exhibited by Mr. Heinke. The diver, without any assistance, raised himself to the surface, by partly closing the valve in the breast-plate of the helmet; the compressed air thus filled the waterproof dress and brought him up. When he wished to descend, he had only to turn on the air-valve.

In order to test the alertness of the divers, twelve small rings were thrown into the river; of these, Heinke's diver picked up ten, and the other two were not found by any of the divers. Again, at the request of Prince Napoleon, he went down with a helmet, the glass of which had been accidentally broken at the Westminster Bridge works, and which, of course, admitted water; he immediately closed the safety-valve as directed, and remained under water half an hour, before coming to the surface. The under-clothing was then examined, and was found to be perfectly dry. The divers, representing the other makers, were then requested to

<sup>1</sup> *Vide Morning Post*, Oct. 1st, 1855.



submit their apparatus to the same test, but they all declined. The French exhibitor, M. Ernoux, at once and in the most handsome manner, acknowledged the superiority of Messrs. Heinke's apparatus, stating, that he considered it really perfect.

At the close of the Paris Industrial Exhibition, a First Class Medal was awarded for the apparatus, which was transferred to the Crystal Palace, at Sydenham.

The Paper is illustrated by views of the helmet and apparatus.