THE NEW HARBOR WORKS AT DOVER.*

By HAROLD J. SHEPSTONE.

THE new national harbor, which the British Admiralty are building at Dover, on the English south coast, is progressing rapidly, and has now reached a stage when a description of the great undertaking cannot fail to be of more than passing interest. In addition to the work of the British government, the Dover

yard, the desired revolutions have been performed during the period of traveling, so no time whatever is lost. The concrete blocks of course are composed of cement, shingle, and sand, mixed in certain quantities with water. The ballast is brought to the scene of operations by rail to the top of the cliffs, and then lowered by the cliff railroad on to the elevated platform.

When a mold is filled, it is left to set for eight days,

"grabs," operated from the Goliaths and capable of holding three tons each. The grabs are opened when lowered, and on being raised the teeth are drawn together and into the sea bed, thus excavating the material, which is then brought to the surface, deposited in barges, and taken out to sea for discharge in deep water. The final leveling of the foundation is carried out by means of the diving bells. Altogether, the diving staff number eighty men; that is, dress and bell divers. The former, of course, work in ordinary divers' costumes from boats, and the latter in the big diving bells, of which there are seven. The writer took a trip down in one of these. The men were working in fifty feet of water at high tide. The foundation is being carried down to the solid chalk flint of which the bed of the Channel is composed off Dover. The task of securing the foundation has not been found very difficult, as the strong ocean currents which prevail in the neighborhood keep the bed of the Channel swept fairly clean of debris and mud. Four men work in a bell and stay under water for a period of three hours. The bells are about 17 feet long, 10 feet wide, and weigh about 35 tons apiece; they are lighted by electric light.

The foundation having been secured, the huge blocks are lowered into position by the powerful cranes. The dress divers superintend the laying of these blocks. To prevent the possibility of any slight lateral movement under the shock of heavy storm-waves, the blocks are "joggled." Cylindrical cavities are left between the blocks, and these are filled in with concrete in bags.

As will be seen by our plan, the national harbor will boast of two entrances. The western entrance, at the end of the Admiralty pier extension, will have a width of 800 feet. At low water there will be a depth here of 42 feet, and 60 feet at spring tides. The eastern entrance will have a width of 600 feet, while the depth will be the same as that at the other entrance. Of the 685 acres of water thus inclosed, no less than 315 acres are situated beyond the five-fathom line. The cost of the work is put down at \$20,000,000.

In addition to the above scheme, the Dover Harbor Board have decided to spend \$5,625,000 in improving the present commercial harbor. A new pier is to be built. It will be 1,100 feet long and 320 feet wide. It will be constructed so as to hold four platforms, two 50 feet and two 30 feet wide. It will also contain eleven lines of railway, and will be provided with four landings for steamboats, which will disembark their passengers under cover at the same time, without causing any inconvenience to one another. The existing outer harbor is to be deepened and converted into a deep-water floating dock, approached through lock gates, which will enable vessels to enter it at any state of the tide. There are two or three other items, mainly of local interest.

The national harbor, of course, is purely a government enterprise, whereas the proposed improvements by the Dover Harbor Board is a private undertaking. To enable this body to carry out the work, they have obtained sanction from Parliament to levy a poll-tax of fifty-five cents on every passenger embarking at Dover. Not only do the Board anticipate a great extension of their already very large Continental traffic, which now averages from 1,000 to 1,500 passengers daily, but they also hope to induce the liners to make it their port of call. Dover is so near the regular track of the many lines of steamers running between London, Hamburg, Bremen, Rotterdam, and New York that it will only require a very slight detour from their ordinary course to pick up at Dover passengers from England, France, Germany, and Belgium,

PLAN OF DOVER HARBOR, SHOWING IN HEAVY BLACK LINES AND SHADING THE NEW PIERS AND BREAKWATERS.

Harbor Board has also obtained Parliamentary sanction and prepared plans for the erection of a new commercial harbor, the building of a pier, the reclaiming of a large piece of ground, etc. It will be seen, therefore, that very extensive operations are now in progress at Dover.

Before describing either undertaking, it is interesting to note that the necessity for the erection of the national harbor has arisen through the introduction of the torpedo-boat and destroyer in modern warfare, which makes the Downs, in the English Channel, no longer a safe anchorage for a fleet in time of war. The British Admiralty have been aware of that fact for many years past, and in 1897 the English Parliament sanctioned the construction of a harbor of refuge at Dover for ships of war. In like manner, the body responsible for the commercial facilities of the harbor, fully alive to the importance of Dover as a port of call for the many lines of steamers running between London, Hamburg, Bremen, Rotterdam, and New York, have very rightly decided to improve existing accommodations, with a view to catching additional Continental traffic and inducing the Atlantic liners to call there.

The national harbor, which first demands our attention, is being made by extending the present Admiralty pier 2,000 feet, forming the westward arm of the harbor, and building out from the base of the cliffs, immediately below the old convict prison, a wall, 3,320 feet in length, which will form the east arm of the harbor. A breakwater, 4,200 feet long, will form the southern wall, and will be erected some three-quarters of a mile from the shore and almost parallel with it. These three walls will inclose a water area at low tide of 685 acres. This will afford ample accommodations for a fleet of twenty-five first-class battleships with all the attendant smaller craft, such as gunboats, torpedo-boats, etc. When completed it will be the largest artificial harbor ever built.

The plans for this gigantic undertaking were drawn up by Messrs. Cooke, Son & Matthews, consulting engineers to the British Admiralty, while the work of carrying out the project was placed in the hands of Messrs. S. Pearson & Son. Work was actively commenced at Dover in the summer of 1898. At the time of writing, the extension to the Admiralty pier and also the east arm wall of the harbor are nearing completion. Work will be commenced on the breakwater during the summer.

A reference to our plan will give an idea of the extent of the work. One of the first things the contractors accomplished at Dover was the reclaiming of twenty-one acres of ground at the base of the cliffs, extending from the Castle jetty to the root of the east arm of the harbor. To do this a sea wall thirty feet high had to be built, the space between this and the shore being filled in with chalk rubble obtained on the spot by blasting away the tall cliffs. Some 600,000 cubic yards of excavation was required to fill the huge gap. The land having been reclaimed, it was at once turned into a blockyard, where the giant concrete blocks of which the harbor walls are being built are made.

The blocks of which the harbor proper is being built are made in this yard for the erection of the eastern arm. The blocks for the Admiralty extension are fashioned in another blockyard on the seashore to the west of that pier. The eastern blockyard, by far the largest, is the one that calls for a description. Up and down the yard run six sets of elevated rails. Upon these travel six electric mixers. They receive the cement and ballast, mix it as they go, and after the requisite revolutions have been recorded, namely sixteen, drop it into the large wooden molds beneath. In the case of the molds at the farther end of the

when the sides are removed. In three weeks it is ready for use, and is as hard as stone. All blocks above the low water mark are faced with granite masonry. The larger blocks are 14 feet long, about 6 feet high, and weigh 42 tons. The smallest weigh 24 tons.

The construction of the harbor wall is carried on from temporary staging of a very massive kind. At every fifty feet, two sets of six piles are driven firmly into the ocean bed opposite one another, across which heavy iron girders are placed, and in this way the staging is carried out seaward. The majority of the huge piles are 100 feet long and 20 inches square. At first Oregon pine was used, but it has now been supplanted by Tasmanian bluegum. There are two reasons why this wood is preferred. In the first place, it was necessary to weight the Oregon wood, so that in case of accident it would sink and not be a menace to shipping. On the other hand, the Tasmanian bluegum is so dense that it will sink like a stone. It is also immune from the attacks of sea insects. Some idea of its density may be gaged when we say that a pile 100 feet long and 20 inches square turns the scale

MOLDS IN WEST BLOCKYARD. THE MOLDS IN THIS YARD ARE NOT MADE BY THE ELECTRIC MIXERS.

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at nearly 10 tons. It is so heavy that it has to be towed into position between empty barrels. This timber was specially selected and imported by Messrs. Pearson & Son.

Upon this staging large overhead Goliath cranes have been erected, each having a movable steam winch or grab. Some of the cranes weigh 350 tons each. The larger ones have a lifting power of 60 tons on a 100-foot span. Any loose material lying on the sea bed is removed by large mechanical diggers or

and thus save the time and expense of putting in at Southampton for English passengers and then crossing over to Cherbourg for passengers from the Continent, Dover being as convenient a point for the rendezvous of passengers from all directions as it is for the liners to make it a port of call. In conclusion, it may be added that the scheme has met with the warm approval of the German Emperor and his ministers as well as those of France, Belgium, and Holland. The Hamburg-American Line have already made

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

arrangements to call at Dover, and will do so on May 1 next. The proposed berths for the Atlantic liners will not then, of course, be finally completed, and in the meantime passengers will be landed by tender.

HIGH SEA AT DOVER DURING THE CONSTRUCTION OF THE SEA WALL ALONG THE EAST ARM BLOCKYARD.

Several of the English steamship companies are negotiating with the Dover Board for landing their passengers at Dover, and the Atlantic Transport Company have expressed their desire to make Dover their stopping place as soon as the necessary work has been carried out.

Correspondence.

PROF. ALEXANDER GRAHAM BELL ON KITE CONSTRUCTION.

To the Editor of SCIENTIFIC AMERICAN SUPPLEMENT:
In the issues of the SUPPLEMENT, vol. iv., page 22947, of June 13, 1903, and the National Geographical Magazine (vol. xiv., No. 6, June, 1903) are interesting articles by Prof. Alexander Graham Bell on "The Tetrahedral Principle of Kite Construction." Prof. Bell takes as his point of departure the cellular kite shown in Fig. 1, which he says is now universally known as "the Hargrave box kite." Now it happens that the kite represented by Prof. Bell is exactly the one covered by a patent granted to me by the United States Patent Office after a year of full consideration and a vigorous contest with other inventors, which brought letters to the Patent Office from most of the leading kite experts in this country and one from Mr. Hargrave himself. Recognizing Mr. Hargrave as an inventor of the principle of the cellular kite, I did not attempt to attach my name to the improved kite; and this kite, as Prof. Bell says, has become universally known as the Hargrave kite; while kites embodying the principle covered by my patent, but differing in detail, are coming to be known by the names of their designers. Yet, oddly enough, Mr. Hargrave himself disowns my style of cellular kite. He said in a paper before the Aeronautical Society of Great Britain on May 26, 1899: "The American copies of my cellular kite have no diagonal struts, the corners being pushed out by horizontal and vertical pieces of wood. In addition they require to be guyed in every direction by steel wires. This style appears to me barbaric." (The Aeronautical Journal, vol. iii., page 50.)

Mr. Hargrave made many forms of cellular kite, but in all there is a central spine of one or more sticks with braces extending or radiating outward. In other words, the skeleton is on the inside of the kite. My improvement consists in removing the skeleton to the outside of the kite, and particularly in removing the longitudinal braces to the corners of the kite.

Notwithstanding Mr. Hargrave's condemnation, I think this results in great advantage, for several reasons: (1) The kite skeleton serves to hold the cloth covering of the kite taut and prevent the vibration and wave motion which occur without the stiffened edges. (2) The posts placed at the corners of the kite give the maximum of resistance to torsion, and hence great rigidity when guyed. (3) The absence of any projecting corners, particularly between the cells, is a great advantage in tandem flying, because secondary kites with projecting corners are very liable to catch on the flying line of the primary kite and dive to the ground. (4) Placing the longitudinal braces in the corners of the kite permits of very simple forms of construction, and hence the general use of the kite for recreation.

The importance of this change is proven by the fact that this style of construction has come into almost universal use. The kites used for scientific work at Blue Hill, by Teisserenc de Bort in France, by the German and Russian governments, and by the United States Weather Bureau, as well as the kites sent out on the various Arctic expeditions, were all of this type.

But the main object of this letter is to point out certain additional reasons to that given by Prof. Bell as to why a large kite cannot be built up of many small ones without increasing the weight per unit area. Prof. Bell quotes a statement of Prof. Newcomb concerning the difficulty of building a large flying structure, because of the law that weight increases as the cube of the dimensions, while surface increases only as the square of the dimensions, so that a structure of double size should weigh eight times as much as the smaller one, but have only four times the lifting surface. This conclusion Prof. Bell thinks is true for models exactly alike, only differing in the scale of their dimensions, but is not true if the large structure

is built up of small units. In such a case the weight per unit area of the large structure need be no greater than the individual units. He finds but one difficulty, and that is, as the structure grows large the parts re-

quire to be farther apart to maintain stability, and there exists a necessity for empty framework in the central spaces.

A statement by Prof. Le Conte in the Popular Science Monthly several years ago, similar to that made by Prof. Newcomb, led me to a line of experiments similar to that of Prof. Bell in the effort to build up a large structure out of a number of small units. But I found two other difficulties besides that mentioned by Prof. Bell which led me to abandon the effort, and it seems to me that these would apply also to Prof. Bell's structures.

I secured eight small kites such as are used for toys and business advertising and are called the Blue Hill naval kites. A structure built of these flew very well and was very steady, but I found there were serious difficulties in keeping the large structure of the same specific weight as the unit. The chief difficulties were the two following: (1) Each kite was not an independent flying unit, but pulled or pressed against its fellow, and tended to concentrate strain on points which had to be strengthened, and that meant increased weight. For example, if the flying line was attached to one or two points, the total pull of all the units was concentrated on the points of attachment, and these parts had to be strengthened. In such a case the upper units are pulling against the lower and tending to crush them. This effect may be partly obviated by tying a flying line to each unit, and bringing these leading lines to a single line at a distance from the kite; but in that case there is a crushing strain on the central parts, due to the inward pressure of the outer units, so that the central parts must be made heavier. (2) When a structure of many units touches the ground, the unit which first touches the earth has above it the weight of all

increasing the relative weight, by tying a number of small surfaces in tandem very close behind each other but without any rigid connection. Such a scheme has drawbacks, but is useful for certain purposes.

Prof. Bell does not mention these difficulties in building up a large structure of small units. Perhaps he has overcome them by his principle of tetrahedral construction. It would have been a help to other experimenters if Prof. Bell had given the weights per unit area of his kites. He speaks of lifting one of his kites by means of a galloping horse. This means a speed of 10 to 15 miles an hour. The kites used at Blue Hill, containing 75 square feet of lifting surface in two rectangular cells, have repeatedly floated in a wind of 10 to 11 miles an hour, recorded at the kite, and sustained a Fergusson meteorograph weighing three pounds besides two or three pounds of wire. In June, 1897, I saw a kite built by C. H. Lamson, consisting of two cells with 600 square feet of lifting surface. This kite flew beautifully in a breeze of 15 to 20 miles an hour, and later aided by several men running with it against the breeze, the kite lifted a man inside of it from the ground, where the wind must have been lighter and carried him to a height of about 50 feet, which was considered the limit of safety. This flight was witnessed by Mr. Lamson, Mr. Rotch, Mr. Fergusson, and myself.

In increasing the size of kites of exactly similar models, the weight undoubtedly increases somewhat more rapidly than the surface, but does not approximate the cube of the dimensions. The reason is that only the sticks increase in size, the surfaces exposed to the wind remain of the same thickness through wide limits. I do not know the law of increase of weight to surface, but our experiences at Blue Hill are that if a kite 4 feet high and sufficiently strong for practical work weighs 1.5 ounces per square foot, then a similar one 8 feet high and sufficiently strong for practical work will weigh 2 ounces per square foot. Mr. Lamson's kite, which was 30 feet high and contained 600 square feet of surface, weighed I think 4 ounces per square foot.

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WESTINGHOUSE STEAM TURBINE AND ELECTRICAL POWER MACHINERY FOR PHILADELPHIA SUBWAY.

ONE of the largest contracts for steam turbine and electrical power machinery recorded in America has just been closed by Westinghouse, Church, Kerr & Co., covering 15,000 kilowatts of steam turbine and approximately 50,000 kilowatts of electrical generating and converting machinery, for equipping the new rapid transit subway and elevated system, now under construction in Philadelphia. The most interesting feature of the equipment to be installed is that steam turbines are to be used exclusively for power generation in the new central station now under construction. There will be three turbines installed, each of 5,000 kilowatts normal capacity, which will be of the type now being built by the Westinghouse Machine Company for large powers. The turbines will be direct connected to Westinghouse three-phase, 25-cycle generators, and all units will run at 750 revolutions per minute with 175 pounds of steam, 27½-inch vacuum, and possibly 100 to 150 degrees of superheat. The three units will operate in multiple upon a common bus bar, and power will be distributed at a nominal potential of 13,000 volts directly from the station without the use of any intermediate transformers;

LOWERING A BLOCK INTO THE SEA.

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of the superposed units, and in consequence is crushed, while if it had come to the ground with only its own weight, it would not have sustained the slightest injury. This was so serious a drawback that I gave up trying to build a large kite out of small units without increasing the specific weight.

I did find, however, that one can build up a large flying surface out of small units without materially

for this purpose the generators are wound for high potential.

The new power station will be located upon the Delaware River near the foot of Green street, and is laid out for an ultimate capacity of 50,000 kilowatts, it being the idea of its designers to concentrate at this point the entire generating equipment at present distributed among a number of smaller stations. The

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PART OF THE EAST ARM BLOCKYARD AND VIEW OF THE EAST ARM. THE BLOCKYARD STANDS ON TWENTY-ONE ACRES OF RECLAIMED LAND.

TEMPORARY WOODEN STAGING, RUN OUT ON EACH SIDE OF THE SEA WALL, FROM WHICH ALL OPERATIONS ARE CONDUCTED.
THE NEW HARBOR WORKS AT DOVER.