REMOVAL OF

BLOSSOM ROCK.

SAN FRANCISCO HARBOR.

REPORT

UPON THE

REMOVAL OF BLOSSOM ROCK,

IN

SAN FRANCISCO HARBOR, CALIFORNIA.

BY

R. S. WILLIAMSON,
MAJOR CORPS OF ENGINEERS, BREVET LIEUTENANT COLONEL U. S. A.,

AND

W. H. HEUER,
LIEUTENANT CORPS OF ENGINEERS.

1870.

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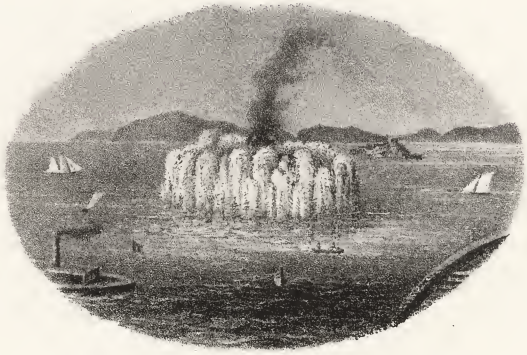


BY

R. S. WILLIAMSON,

MAJOR, CORPS OF ENGRS, BREVT LIEUT. COL. U.S.A.

AND

W. H. HEUER,

LIEUT. CORPS OF ENGINEERS.

1870

LETTER.

San Francisco, *April* 25, 1871.

General: I have the honor to submit to you the following detailed report upon the removal of Blossom Rock, in this harbor. It may properly be called a history of the work, as in it are described the preliminary steps taken, which resulted in a contract made between Mr. A. W. Von Schmidt and the United States, and a description of the operations under that contract. The contractor was not interfered with, and all deviations from the original plan which he thought necessary were consented to by me. My assistant, Lieutenant W. H. Heuer, United States Engineers, and myself, acted as supervising engineers from the day the contract was signed until the completion of the work, and this report is the result of our joint labors. With it are submitted eleven sheets of drawings to illustrate it, as without them it would be exceedingly difficult to give an intelligible description of the machinery used, and the operations conducted.

As the work was of a novel character, and of considerable magnitude, I think the description of it will prove of great interest to engineers in general. If so, I respectfully request that authority be obtained to have it, with the drawings, published, the form to be in quarto, uniform with No. 15 of the Professional Papers of the Corps of Engineers, so that none of the plates will require folding, except Plate I, which will require one fold.

I have the honor to be, very respectfully, your obedient servant,

R. S. WILLIAMSON,

Major U. S. Engineers, and Bvt. Lieut. Col. U. S. A.

Brig. Gen. A. A. Humphreys,

Chief of Engineers U. S. A., Washington, D. C.

REMOVAL OF BLOSSOM ROCK, IN SAN FRANCISCO HARBOR, CALIFORNIA.

This rock was situated in San Francisco Bay, directly east of the Golden Gate, or entrance to the bay, due north of the city, on a line between Alcatraz and Yerba Buena Islands, and nearly midway between them. It was distant from the city front about 1,500 yards. It was directly in the course vessels are often compelled to take in entering and leaving the harbor; was in the track of naval vessels passing to and from San Francisco and Mare Island navy-yard, and was also in the way of all passenger steamers and vessels plying between San Francisco and the Sacramento and San Joaquin Rivers. The rock was discovered and named in 1826 by Captain Beechey, Royal Navy, F. R. S., who entered San Francisco harbor in command of Her Britannic Majesty's ship The Blossom.

The top of the rock was about 5 feet below the surface of the water at mean low tide. Its greatest length at the depth of 24 feet was 195 feet, and its greatest breadth at the same depth was 105 feet. The quantity of rock to be removed to obtain a depth of 24 feet of water was 5,000 cubic yards. A portion of the top of the rock, about 34 by 22 feet in size, was comparatively level, but two of its opposite sides sloped off quite rapidly into deep water. The place is exposed to southeast gales which prevail here in the winter months, and the tide whirls over the rock at such a rapid rate that the buoy, which the Light-House Department placed there, has several times been swept away.

CHARACTER OF THE ROCK.

The rock was a metamorphic sandstone of a variable degree of hardness, of a brownish-yellow color, of irregular stratification, and in some places contained small beds of gravel cemented together with a bluish substance resembling clay. The specific gravity of the great mass of the rock was 2.64, a

cubic foot of it weighing 165 pounds, and was so soft as not to require blasting; but in some cases it had a bluish tinge, and was as hard as granite.

In August, 1866, my attention was called to Blossom Rock by the following orders:

"ENGINEER DEPARTMENT,
"*Washington, D. C., July* 21, 1866.

"COLONEL: In addition to your present duties, you are assigned to the charge of the following-named works: * * * * Survey or examination at San Francisco, California, with the view of the removal of Blossom and Rincon Rocks, by blasting. * * * *

"You will take measures for the commencement of these works with the least practicable delay, using your best judgment as to the most expeditious method of prosecuting the same.

"Respectfully, your obedient servant,

"RICHARD DELAFIELD,
"*Brevet Major General, and Chief Engineer U. S. A.*

"Bvt. Lieut. Col. R. S. WILLIAMSON, U. S. A.,
"*Major of Engineers, San Francisco, California.*"

"ENGINEER DEPARTMENT,
"*Washington, November* 27, 1866.

"COLONEL: * * * The Department will direct the insulated wire to be sent you from New York, in order that experiments may be made on Blossom Rock, similar to those made on Rincon Rock. This seems to be necessary in order to establish the character of the former, and to enable you to form an accurate estimate of the amount required for its removal. * * *

"Very respectfully, your obedient servant,

"A. A. HUMPHREYS,
"*Chief of Engineers, Brig. and Bvt. Maj. Gen. U. S. A.*

"Bvt. Lieut. Col. R. S. WILLIAMSON, U. S. A.,
"*Major of Engineers, San Francisco, California.*"

Accordingly, through the kindness of the Superintendent of the United States Coast Survey, the late Edward Cordell, assistant United States Coast Survey, who was in command of a surveying party on the Coast Survey schooner Marcy, was authorized to make a survey of Blossom Rock. Experiments in blasting were then made on the rock, by my assistant, Lieutenant W. H. Heuer, United States Engineers, under my direction, in February and March, 1867. The following is a copy of his report:

"SAN FRANCISCO, *March* 26, 1867.

"SIR: I have the honor to make the following report in regard to the late experiments on Blossom Rock:

"Blossom Rock is a sandstone, rather hard; is on a line with Alcatraz and Yerba Buena Islands, and about midway between them. When the tides are lowest the rock has about 5 feet of water over it. A horizontal section of the rock, 18 feet below the surface of the water at mean low tide, gives the greatest length of the rock 130 feet, by a width of 75 feet. To obtain a depth of 18 feet of water at mean low tide would require the removal of 1,000 cubic yards of stone.

"The experiments were made with gunpowder, with the view of estimating the cost of removal of the rock. The charges of powder used were of three sizes, viz: 75 pounds, 125 pounds, and 175 pounds, in order to enable us to ascertain which sized charge would prove most effectual, due regard being had to economy. Each charge was placed in a strong water-tight cask, in the head of which a small hole was bored to admit of the passage of the wire for exploding the charge. The cartridge was placed as near to the middle of the charge as possible. Each cask was inserted in a sack of sail-cloth, which fitted closely, and which was afterwards tarred. Two heavy pieces of iron were then tied to each cask (one on each side) to prevent the tide from washing the charge off the rock. Soundings were then made to enable us to find advantageous positions for the charge; a small scow was securely anchored over the spot; charge lowered to its place; scow hauled about 200 feet away; the two extremities of the insulated wire placed in contact with the poles of a 12-cup Grove's battery, and the charge immediately exploded; the scow was then hauled back to its first position, and soundings

were made, by which we ascertained approximately the effect of the blast. The blasts generally took place at high tide, as then we had the greatest pressure of water on each charge. On the succeeding low water the officers of the Coast Survey (Edward Cordell, assistant United States Coast Survey, and his assistants) would make an instrumental survey of the rock in the immediate vicinity of the blast, and thus we ascertained quite accurately the results. The officers of the Coast Survey, who made the soundings before and after the blasts, deserve great credit for the admirable manner in which their work was done, and to their persevering efforts much of the success of these experiments is due. Appended will be found the sketches furnished by Mr. Cordell relative to the experiments. [See Plates II and III.] Owing to the stormy weather, the experiments occupied nearly two months, although advantage was taken of every favorable day during that time; but frequently, after a blast had been made, the bay would be too rough for days and even weeks to make an accurate survey, all of which retarded our progress.

Before we commenced blasting, an examination of the Coast Survey chart indicated quite a crevice at or near one end of the rock. As it appeared favorable to place a charge there, instructions were given to place a charge of 75 pounds powder in the crevice. This was on the 29th of January. After they thought they had found the crevice, the charge was exploded in 16 feet of water. The rock was considerably shattered, but no large masses were broken off, and a subsequent examination proved that there was no crevice there.

The second experiment took place on January 30, when 175 pounds of powder was exploded on top of the rock, in 11 feet of water. The explosion shattered the rock, but did not materially increase the depth of water. It was then determined to have an examination of the rock made by a diver in armor. He reported that the rock was broken considerably where the two blasts had taken place; that no large fissures had been made; and that the rock was quite jagged in many places. He brought up an armful of specimens of the rock which we had broken up.

"*Third experiment, February* 9.—One hundred and seventy-five pounds of powder was placed near the west end of the rock, in 14 feet of water, and exploded. Water was thrown to the height of 40 feet, and the survey indicated that about 11 cubic yards of stone had been removed.

"*Fourth experiment, February* 19.—Two blasts of 125 pounds each were exploded in succession in 20 feet of water. About 15 cubic yards of material were removed.

"*Fifth experiment, February* 20.—Two charges of 125 pounds each were exploded in succession, one in 18 feet, the other in 21 feet of water. Only about 3 cubic yards of stone were removed. It is believed that these charges were placed on loose rock that had accumulated from previous explosions, which these two blasts broke into smaller fragments, and did much less damage than would have resulted had they been placed on solid rock.

"*Sixth experiment, March* 4 *and* 5.—Two charges of 75 pounds each were exploded in 21 feet of water. Very little damage done.

"*Seventh experiment, March* 6.—Two charges of 125 pounds each were exploded in 16 feet of water. Twelve cubic yards of stone were removed.

"*Eighth experiment, March* 7.—The remaining charge of 175 pounds of powder was exploded in 13 feet of water. A large volume of water, probably 50 feet in height and nearly as much in diameter, was thrown up. The survey showed that 8.5 cubic yards of stone had been removed.

"The experiments just made show that the charges of 175 pounds of powder produced the best results, averaging about 6.17 cubic yards per blast. The 125-pound charges averaged about 5 cubic yards per blast, while the 75-pound charges produced but little effect. It is thought that much loose rock remained where the blasting occurred, which, had it been removed, would have increased the average somewhat, probably 30 per cent. I am also inclined to think that much better results would have been obtained had we used strong iron vessels to contain the powder, instead of wooden casks.

"Number of charges of powder used	12
"Number of experiments	8
"Number of cubic yards of stone removed	49.5
"Total expense incurred, including use of surveying vessel Marcy, officers, and crew	$3,417 42
"Average cost of removal per cubic yard	$69 05
"Cost of removing Blossom Rock, at this rate, to a depth of 18 feet of water, (mean low tide)	$69,050 00

"The above amount would be the cost of removing the rock to this depth if we could continually average a pressure of 18 feet of water on each charge; but when the pressure is less, which necessarily follows as we approach the top of the rock, the expense per cubic yard increases rapidly, and, judging from experiments one and two, I think that twice the above amount, or $138,100, would not be too large an estimate. To obtain a depth of 25 feet of water (mean low tide) would require the removal of 3,345 additional cubic yards of stone, which, at an average cost of $69 05 per cubic yard, would make the cost of the additional 7 feet of depth $230,972 25, or, for the removal of the whole rock to a depth of 25 feet, (mean low tide,) a cost of $300,022 25.

"A few suggestions might not be out of place here. If Blossom Rock must be removed, I think it can be done more economically by drilling, and afterwards by surface-blasting, than by surface-blasting alone. But, as the tide is very strong over the rock, drilling might at first be considered rather a difficult matter. This can easily be overcome by building a frame-work of timber and iron, setting it on the rock where we wish to drill, placing a portable 4-inch cylinder engine on top of the frame, drilling with the engine to the required depth, inserting the charge, (nitro-glycerine or powder,) removing the frame, and exploding the charge by means of a battery. After sufficient rock has been removed in this way to enable us to have a depth of 18 feet of water at high tide, then surface-blasting can be advantageously used.

"*Estimated cost of removal of Blossom Rock in this manner to a depth of 25 feet of water, (low tide.)*

"Cost of engine, sliding-boxes, pipe, &c.	$2,173 50
"Schooner for powder and quarters for men, (one year)	3,000 00
"Scow	1,500 00
"Engineer, (one year)	3,600 00
"Four laborers, at $150 per month, (one year)	7,200 00
"Overseer	3,600 00
"Powder, 90,000 pounds, at $229 50 per 1,000 pounds	20,655 00
"Canisters for containing same	6,000 00
"Coal for engine	4,000 00

"Rope and tackle	$3,000 00
"Battery	500 00
"Repairs for the year	1,000 00
Total	56,228 50

"Respectfully submitted.

"W. H. HEUER,
"*Lieutenant of Engineers.*

"Bvt. Lieut. Col. R. S. WILLIAMSON, U. S. A.,
"*Major of Engineers.*"

In 1868 an allotment of $50,000, from the general appropriation for improvements of rivers and harbors, was made for this work. In October 1868, Brevet Brigadier General B. S. Alexander, United States Engineers, sent in the following project for the removal of the rock, with letter of transmission:

"SAN FRANCISCO, CALIFORNIA,
"*October* 3, 1868.

"COLONEL: Since the passage of an appropriation by Congress for the removal of Blossom Rock, in this harbor, I have been thinking, from time to time, as to the most practical way of getting rid of that rock; and having arrived at a conclusion on the subject, which is satisfactory to my own mind, I venture, inasmuch as it differs from the process usually followed, to communicate it to you for your information.

"I understand that you are charged with the execution of this work, but, when I assure you that I have no desire to interfere in any manner with your duties, I feel confident that the assurance taken, in connection with our personal relations, will relieve me, in your mind, from any other wish in the matter than to see this work prosecuted to completion in the cheapest and speediest manner. I therefore send you, without apology, a sketch which will explain my ideas on the subject, together with a description of the proposed operations.

"Having had considerable experience in such matters, particularly in building a coffer-dam around the site of Fort Richmond, Staten Island, when that fort was commenced, I will add that I have no doubt of the entire practicability of putting the proposed dam on Blossom Rock in the manner proposed, nor have I any doubt but that it may easily be made practically water-tight.

"It then becomes a question of sinking a shaft and tunnelling under the rock. There will be no trouble in the operation, if the rock itself will keep out the water. On this point it is impossible to pronounce judgment before investigation. If the rock is like that at Lime Point, or at Angel Island, or at Alcatraz, Yerba Buena, or Point San José, the leakage into the tunnels will be small, and but little pumping will be required. There can be no doubt, if these tunnels can be made without lining, that this will be the cheapest and most expeditious way of removing the rock.

"Should it be found, however, (of which I have little fear,) that the tunnels cannot be made as I have designed them, I think you would find such a dam as that proposed of great assistance, whatever plan of operations you might then be forced to adopt. It would give you a *fixed point* on the rock, which will be the first requisite in enabling holes to be drilled into the rock. If you undertake to drill for blasting, I think you will find a fixed point for your drills absolutely necessary.

"Again, the coffer-dam would enable you to build a barrack and blacksmith shop upon it, where the workmen could live and be always on hand to take advantage of good weather and favorable tides; saving thereby, to a great extent, the expense of vessels for the transportation of workmen and tools.

"I have not attempted to make the sketch, or the description, in such minute detail as will be necessary before commencing such operations. All I proposed to do was to present a plan in outline, to show the practicability of such an undertaking, with such hints as would serve as an indication of the course to be followed.

"I do not propose for you to adopt the plan I have suggested on my responsibility. In an undertaking of this sort, where there is a possibility of failure, it is proper that the mode of proceeding should receive full investiga-

tion, and then the Engineer Department should assume the responsibility for whatever plan may be finally adopted.

"While, therefore, I do not hesitate to say that if I were charged with the removal of Blossom Rock, I would urge the department to sanction the plan I have prepared for that purpose, all I can ask of you is that you will forward this plan, with the written description, and a copy of this letter, to the Chief of Engineers, for his information.

"Very respectfully, your obedient servant,

"B. S. ALEXANDER,

"*Lieut. Col. of Engineers, Bvt. Brig. Gen. U. S. A.*

"Colonel R. S. WILLIAMSON,

"*Corps of Engineers, U. S. A., San Francisco, California.*"

The following is the project of General Alexander:

"BLOSSOM ROCK.

"This is a sunken rock in the harbor of San Francisco, with about 5 feet of water upon it at low water.

"It is situated a little over three quarters of a mile from the city front and is in the track of vessels approaching the city from the ocean, or in going to sea; and is directly in the way of vessels, running to and from the Sacramento and San Joaquin rivers.

"The length of the rock above the level which would give 24 feet of water over it at low water is about 180 feet. Its breadth above this level is about 100 feet.

"The removal of so large a rock by surface blasting will, I fear, be a long, as well as an expensive undertaking. After a good deal of reflection on the subject, I have arrived at the conclusion that it may be done in a single season, and at greatly reduced cost, by undermining the rock, making a number of powder chambers under it, and blowing the whole rock to pieces at a single operation.

"To do this, I propose to enclose a small surface of the rock by a water-tight coffer-dam; in this space to sink a rectangular shaft about 4

feet by 9 feet, which is the size I have seen in coal mines; from the bottom of this shaft to run tunnels and make powder chambers in such positions that, when exploded, the whole rock, down to the level of 24 feet below the level of low water, will be lifted in the air and shivered to pieces.

"DESCRIPTION OF THE PROPOSED OPERATIONS.

"I propose, in the first place, to blast off a small portion of the top of the rock, by what we call surface blasting, down to about the reference of—10′, or 10 feet below low water. This is for the purpose of furnishing a comparatively level surface upon which to build a coffer-dam. This blasting operation will consist in lowering down charges of from 100 to 300 pounds of gunpowder to the surface of the rock, over the part to be removed, in water-tight vessels, and exploding them by means of Beardslee's magneto electric machine, and afterwards removing the shattered portions of the rock by men in armor.

"It will not be necessary to try to get a smooth surface. All that is necessary is to get a surface upon which the coffer-dam will stand. (See Figs. 1, 2, and 3, Plate IV.)

"This operation will be a little tedious, but will not be very expensive, as the quantity of rock to be removed is small, and but few men will be employed in it.

"There is no doubt of its entire practicability. In fact, it is believed that the whole rock, to any required depth, might be removed by this process, the only objection being the great cost.

"It is probable that nitro-glycerine or giant powder, owing to their powerful local effects in shattering, would prove a more efficient agent for this surface blasting than gunpowder.

"This being done, I propose to frame a strong coffer-dam of 12-inch square timber, as shown in Figs. 1, 2, and 3, Plate V.

"This may be built on shore, and made water-tight. It should be built up so as to be 13 feet high before launching.

"It will then, if built of Oregon pine, draw about 10 feet of water, and may be easily towed out and anchored over the spot where it is to be placed.

"It will then just ground on the rock at low water, and by the aid of

ballast, say bags of sand placed upon platforms, or otherwise fastened to the dam, be prevented from floating as the tide rises.

"If it does not ground in exactly the right place at the first trial the bags of sand may be removed, when it will float again, and its position may then be altered at the next low water. A sufficient number of mooring buoys will have to be placed around the rock, during this operation, to enable the coffer-dam to be drawn exactly into the required position.

"When it has been finally placed, it may be loaded with sand-bags or other ballast spiked to the sides, or piled on temporary platforms so arranged as to be easily removed afterwards, and the construction completed by carrying it up to the required height, say to the reference 10 feet, or 5 feet above high water.

"Having got it built, I would next plank it over, and load it down securely with ballast, taking care to leave man-holes in each of its ten compartments. I would then put down sheeting piles both outside and inside of the dam. I have supposed them to be 3 inches thick and rather narrow; say 9 inches wide. It is not supposed that these sheet piles can be driven *into* the rock, but by cutting the lower ends to a feather edge thus:  they may be driven down until the lower ends crush into the crevices of the rock, stopping, to a great extent, the flow of water under the dam.

"I have supposed that there are two rows of these sheeting piles both outside and inside. The second row may or may not be necessary.

"These piles should be bored beforehand to receive several 6-inch spikes, and after each pile has been securely placed against the dam, and against the sheet pile last driven, a man in armor should go down and drive the spikes so as to hold it in position.

"This being completed, the next operation will be to fill up the inside of the dam so as to make it water-tight.

"I have supposed that we will use concrete placed in bags to fill it up to the low-water level, though it is altogether likely some cheaper material may be found to answer.

"If bags of concrete are used, they should be about half filled, and of such a size as not to weigh more than 50 or 75 pounds when immersed in the water. When ready to be put in place, a man in armor would go down into one of

the compartments of the dam and place them in the crevices of the rock, taking care to fill up solidly the spaces under the timbers, particularly below the timbers which connect the inside with the outside walls of the dam, under which there would otherwise be leakage.

"To give room for this operation, it might be better to frame these lower timbers, say 6 inches above the bottom of the outer and inner timbers, though they are not so represented in the drawing.

"Having these spaces under the timbers securely filled, all the man down there would have to do would be to keep the concrete bags into place, and walk over them as they were lowered down, until the compartment was filled.

"The concrete, if made of good cement, would soon harden, and the cement would come through the bags so as to unite them and make a water-tight mass.

"I would recommend that this concrete be placed in layers of about 2 feet in thickness, carrying it up a layer of about that thickness each day.

"The concrete being all in position, the upper portion of the dam is to be filled up with clay or some other water-tight material.

"The middle compartment of the dam is to be kept open, and it is supposed when the dam has been finished in the manner described that this compartment will be practically water-tight. All that is necessary, therefore, to reach the surface of the rock within this space will be to pump the water out of it.

"If the dam is found now not to be entirely water-tight, it may easily be made so by caulking between the inside sheeting piles, and between their lower ends and the surface of the rock.

"We are now prepared to sink into the rock. I have supposed it to be 4 feet by 9 feet in the clear, leaving a ledge of 12 inches between its edges and the face of the sheeting piles on the inside.

"I suppose that this shaft will be sunk so that its bottom will be in the reference of —36′, and at this level small tunnels will be run under the rock, as shown in plan in Fig. 1, and in Figs. 2 and 3 of Plate IV.

"At the ends of, and in these tunnels, 55 separate chambers for powder will be placed, as shown in plan, and connected by insulated wires with the

battery or machine for exploding them. Water will then be admitted through the sluice for tamping, and the whole space filled, pumping water into the middle compartment until it is filled to the top or reference of 10′.

"The mines may be fired simultaneously by the use of about three of Beardslee's machines.

"In consequence of the great depth of the charges, I would recommend that the explosion take place at low water. I propose so to adjust the charges in the chambers that all the rock above the reference of—24′ will be blown up, shattered, and broken to pieces.

"Much of it will fall back again, but the currents will rapidly remove a great part of it, and the remainder may then be scraped off into deep water, sending down men in armor when necessary to fasten to pieces that may prove too heavy to be scraped off.

"The quantity of powder that would be necessary to lift the rock and the water above the mines would be about 13,000 pounds; but as it will be desirable not only to lift the rock, but to break it up into small pieces, and blow it away as much as possible, I would recommend that about double this quantity of powder be used—say 26,000 pounds—the quantity of powder in each chamber being proportioned to the weight it will have to lift, or to the work it will have to do.

"ESTIMATED COST.

"Blasting off and removing top of rock to receive the coffer-dam, 150 cubic yards, at $40	$6,000
"Building coffer-dam, 61,500 feet of timber, at $40 per M, including workmanship and materials	2,460
"Cost of placing frame-work in position, say	1,000
"Cost of sheeting piles, 20,300 feet board measure, at $40, including spikes	812
"Cost of placing the same, say $1 per piece	452
"Cost of concrete, 200 cubic yards, at $15	3,000
"Cost of clay filling, 200 cubic yards, at $3	600
"Cost of planking over the dam, joints, and covering, 5,000 feet, at $40 per M.	200
"Cost of shaft, with enlargement at bottom, 40 cubic yards, at $10	400
"Cost of tunnels and powder chambers, 778 running feet, at $15	11,670
"Cost of powder, say 26,000 pounds, at 10 cents	2,600
"Cost of 55 packages and placing the same, at $20	1,100

"Cost of engine for pumping and hoisting	$2,000
"Cost of pump and fixtures	1,000
"Cost of derrick and rigging	1,000
"Add for contingencies, including barrack and smiths' shop over the dam, use of boats, superintendence, and unforeseen expenses, say 20 per cent	6,838
Total, (in coin)	41,132

"I do not make any estimate of the cost of removing the broken rock after it has been blown to pieces, because it is impossible beforehand to tell what operations will be necessary in order to accomplish this object. If the rock is anything like that at Lime Point, and if it is shattered like the blasts there have shattered that rock, the currents in the course of a year would remove the greater portion of it. But if it should be a stronger rock and come out in larger masses, it would have to be removed by mechanical operations, and at considerable cost, which, however, would be far less by having the whole rock broken to pieces down to the required depth, than would be the case if the rock had to be blown up by piecemeal, involving a removal of the *débris* after each successive series of blasts.

"B. S. ALEXANDER,
"*Lieut. Col. of Engineers, Bvt. Brig. Gen. U. S. A.*

"San Francisco, California, *October* 3, 1868."

In November following Mr. A. W. Von Schmidt sent in a project, as follows:

"San Francisco, California,
"*November* 20, 1868.

"Sir: I have the honor to submit herewith a plan for the removal of Blossom Rock, together with a description of doing the work.

"I will remove the said rock in accordance with the plan as proposed by me, in the space of eighteen months from the time of signing the con-

tract, for the sum of $75,000, currency of the United States, giving such bonds as shall be required for the faithful performance of the work.

"Yours, respectfully,

"A. W. VON SCHMIDT.

"Lieut. Col. R. S. WILLIAMSON, *U. S. A.*,
"*Major of Engineers.*"

The following is the project of Mr. Von Schmidt:

"SAN FRANCISCO, *November* 20, 1868.

"SIR: I have the honor to submit to you a plan and descriptive specifications for the removal of Blossom Rock, in the harbor of San Francisco, California.

"Blossom Rock, so called, is a sunken rock so well known that I consider a description of its locality unnecessary for these specifications, and shall therefore proceed with explaining my plan for removing the same, reference being made to the annexed plan, in which Plate VI represents the mode and manner of constructing the necessary machinery for working out the interior of the rock. Fig. 1 represents a longitudinal section of the rock. Fig. 2 represents transverse sections of the rock, as shown on the plat of survey made by Edward Cordell, assistant United States Coast Survey, February, 1867.

"The first object in view is a thorough removal of the rock, so that vessels drawing 24 feet of water will be able to pass over the same at low tide. To accomplish this the mere blasting and breaking up of the rock would not, in my estimation, accomplish the desired object, as the rock in broken masses would still form an obstruction to the navigation of the harbor. I have therefore matured a plan by which the entire rock itself shall be excavated in chambers, as shown by Plate VI, Figs. 1 and 2.

"The rock taken out of the interior compartments will be removed through a shaft and discharged into deep water alongside the rock. When the whole inside of the rock shall have been removed, I propose, finally, to blast the crust over the chambers and drop the same to the bottom of the excavation.

"To accomplish this the following mechanical operations will be necessary: I make my lodgment on the highest part of the rock, which is nearly or quite level at this point, being 5 feet under the low-water line, and having a sufficient area for the works necessary to be constructed. I moor a scow, for working purposes, in the position required. I then place a boiler-iron case 9 feet in diameter and 13 feet high, with flanges on the lower end, on top of the rock. This flange has a canvas apron, 3 feet wide, running entirely around it, and lying on the rock. I then place a lot of sand-bags on top of the canvas apron and around the case. To secure the case I use 1½-inch round iron rods, the ends of which are firmly secured into the rock by 'Lewis holes.' Turnbuckles are also placed on each rod, for the purpose of tightening them up from all sides. After this has been done, I pump out all the water there is in this case and make an excavation into the rock, downwards, for the purpose of erecting the main case, which is of boiler-iron, 6 feet in diameter and 17 feet in height. This is set within the outside casing, and also firmly set into the rock, and secured with anchor-bolts, in the same manner as the first case. After this is done I fill all the cracks between the casing and the rock with Roman cement, excluding the water from the interior iron casing.

"When it is found that the leakage has been thoroughly stopped, and the platform erected as shown in the plan, I commence sinking a shaft down through and into the main body of the rock to the depth required, at which point I place a pump for removing such water as may be encountered in carrying on the work. From the bottom of the shaft I commence tunnelling the rock in all directions. As fast as the rock is worked, it is brought to the centre shaft through the different tunnels and placed in a tub, when it is hoisted by steam and discharged alongside the rock into deep water by means of a swinging derrick.

"The rock that will remain between the excavation and the water will be about 6 feet in thickness, supported by pillars 4 feet square and 10 feet apart from centre to centre. It is proposed to remove most of these pillars when the rock shall have been tunnelled, and to set up in their place wooden supports as often as may be required to sustain the weight overhead.

"When the entire mass of rock shall have been excavated, the work

will be in readiness to receive the several packages of powder, in such quantities as shall be thought necessary, the wires being laid to the several torpedoes, and connecting with a magnetic battery placed in a vessel near by. The chamber is to be filled with water, and the torpedoes fired by the battery simultaneously, when it is supposed that the entire shell of rock will be broken into small pieces and precipitated to the bottom, the timber supports floating out, and the work completed in all its details.

"All of which is most respectfully submitted.

"A. W. VON SCHMIDT,
"*Civil Engineer.*

"Lieut. Col. R. S. WILLIAMSON, U. S. A.,
"*Major of Engineers.*"

These projects, together with their drawings, were sent to the Chief of Engineers at Washington, and $30,000 additional money was asked for to secure the removal of the rock. In February, 1869, I was directed to advertise for proposals for removing the rock, although at the time there was but $50,000 available for its removal. The following advertisement was therefore inserted in several prominent newspapers:

"PROPOSALS FOR REMOVING BLOSSOM ROCK.

"Sealed proposals in duplicate will be received by the undersigned at his office, 509 Kearny street, San Francisco, California, until 12 o'clock noon, April 15, 1869, when they will be opened, and bidders are invited to be present, for the removal of Blossom Rock, in San Francisco Harbor, California, to a depth of twenty-four (24) feet at mean low tide, which is the zero of the Coast Survey map of this harbor. In case any of the bids should exceed forty-five thousand ($45,000) dollars in currency, bidders must state to what depth they will remove the rock for forty-five thousand ($45,000) dollars currency.

"All bids are to be made in United States currency, and the payment to be made on the satisfactory completion of the work, after examination by the undersigned, or other authorized agent of the Government.

"Each bidder will be required, before the time fixed for the opening

of the bids, to file in this office a bond, with sufficient sureties, in the sum of five thousand ($5,000) dollars, conditioned that if his bid is accepted he will execute a written agreement for the faithful performance of his contract, and give such further bond for the faithful performance of his written agreement as may be required; said agreement to be made subject to the approval of the Chief of Engineers, United States Army.

"The contract will be awarded to the lowest responsible bidder, but the right to reject any or all of the bids is reserved.

"A copy of this advertisement must be attached to each bid.

"Bids that do not comply with the above requirements will not be entertained.

"Plans and sections of the rock, copied from the Coast Survey chart, may be seen at my office.

"Persons who wish to bid for the work, and who reside at a distance, can be furnished with copies of said plans and sections by applying at this office.

"R. S. WILLIAMSON,
"*Bvt. Lieut. Col. U. S. A., Major of Engineers.*"

In reply to the advertisement only one bid was received, which was from Mr. George W. Townsend, of Boston, Massachusetts, who offered to remove 900 cubic yards of rock from Blossom Rock for $45,000, which he estimated would leave the upper surface of the rock level and 15 feet below mean low water. We estimated that the removal of 900 cubic yards would only bring the level of the rock down to 13½ feet below mean low water. Mr. Townsend's bid was declined. In May, 1869, Mr. Townsend made another proposal, in which he offered to furnish all the materials, vessel, &c., except the powder, electric fuse, and cartridges, for $125 per day.

"This proposal was also forwarded to the Chief of Engineers at Washington, in June, 1869, and it was there decided to accept the offer of Mr. A. W. Von Schmidt, and $25,000, and subsequently $5,000, were allotted for the work, making in all $80,000 to pay for the contract price of the work, and such other work as would be necessary under it. A contract was therefore made with him on the 16th day of June, 1869, in which he agreed to remove the

rock to the depth of 24 feet of water, in accordance with the plans which he had previously submitted, for $75,000 in currency. The following is a copy of the contract:

"Articles of agreement entered into this 16th day of June, A. D. 1869, between Brevet Lieutenant Colonel R. S. Williamson, an officer in the Corps of Engineers, United States Army, for and on behalf of the United States of America, of the one part, and Allexey W. Von Schmidt, civil engineer, of the city of San Francisco, State of California, of the other part.

"This agreement witnesseth, that the said Brevet Lieutenant Colonel R. S. Williamson, for and on behalf of the United States of America, and the said Allexey W. Von Schmidt, his executors and administrators, have mutually agreed, and by these presents do mutually agree to and with each other in the manner following, namely: that the said Allexey W. Von Schmidt will remove the obstruction in the bay and harbor of San Francisco, commonly designated and known as 'Blossom Rock,' to the extent and depth of twenty-four (24) feet below the water surface, by measurement to be made and taken at mean low-water mark, which is the zero of the Coast Survey chart of said bay; and in the execution of the said work of removal he will adopt and follow the plan and specifications heretofore, on the 20th day of November, A. D. 1868, submitted in writing by him and accompanying his proposal to the said Brevet Lieutenant Colonel R. S. Williamson, United States Army, acting for and on behalf of the United States, for the removal of the before-mentioned obstruction, and which proposal and specifications are on file in the office of the Chief of Engineers at Washington, District of Columbia, and to which reference is hereby made; unless and until a practical trial of the mode and means set forth in said specifications shall prove it to be impracticable to effect the removal of said obstruction in the way and by the means proposed therein. In which case the said Allexey W. Von Schmidt shall be at full liberty to adopt and follow such other and further and different plan and means of removal as will enable him to fully execute the said undertaking to remove said obstruction. The plan to be approved by the engineer in charge of the work.

"And the said Allexey W. Von Schmidt hereby undertakes and agrees, without qualification, and without reference to the success of his said proposed plan and specifications, and at all hazard, to effect and fully complete the removal of the said obstruction, to the extent hereinbefore provided, within the period of eighteen (18) months next after the execution and delivery of these presents, hereby giving and granting unto the said 'The United States of America,' by its officers and agents thereunto duly authorized, full license and permission, at any and all times during the progress of the work, to inspect his plans and operations in the doing of said work, and for that purpose to enter into and upon any vessels, boats, rafts, floats, and erections engaged, employed, and used in and for the same.

"In consideration of the said agreement and undertaking by and on the part of the said Allexey W. Von Schmidt, so to be performed by him, and upon the full and complete performance thereof by him, his heirs, executors, and administrators, the said first-named party undertakes and agrees to pay to him, the said Allexey W. Von Schmidt, his heirs, administrators, and executors, the just and full sum of seventy-five thousand ($75,000) dollars in currency of the United States as the value of and in satisfaction for the said work.

"No member of Congress, officer or agent of the Government, or any person employed in the public service, shall be admitted to any share herein, or any benefit which may arise herefrom.

"In witness whereof the undersigned have hereunto placed their hands and seals the day and date first above written. Executed in quintuplicate.

[SEAL.] "R. S. WILLIAMSON,

"*Bvt. Lieut. Col. U. S. A., Major of Engineers.*

[SEAL.] "ALLEXEY W. VON SCHMIDT."

"STATE OF CALIFORNIA,

"*City and County of San Francisco:*

"I do solemnly swear that the copy of contract hereto annexed is an exact copy of a contract made by me personally with Allexey W. Von Schmidt; that I made the same fairly, without any benefit or advantage corruptly to

the said Allexey W. Von Schmidt, or any other person; and that the papers accompanying include all those relating to the said contract, as required by statute in such case made and provided.

"R. S. WILLIAMSON,
"*Bvt. Lieut. Col. U. S. A., Major of Engineers.*

"Sworn to before me this 17th day of June, A. D. 1869.
"F. J. THIBAULT,
"*Notary Public.*"

Attached to the contract was a bond for $10,000, with sufficient sureties.

EXCAVATING OPERATIONS UNDER THE CONTRACT.

In October, 1869, Mr. Von Schmidt commenced operations. In order to place his boiler-iron cases in position, he desired to remove a portion of the top of the rock, to have a comparatively smooth surface on which they were to rest. He therefore constructed a scow 80 feet long by 30 feet wide, and having near its middle part a well about 10 feet square. Immediately over the well was constructed a frame-work of timber about 30 feet high, from which he could work the drills to be used in cutting off and smoothing the surface for the iron cases; but the scow was found to have so much motion that he was obliged to abandon the idea of getting the iron cylinders in position by that means. He therefore commenced the construction of a crib-work of timber, which was launched and floated over to the rock in November.

"The details of this crib are shown in Plate VIII. In its centre is a double tank or coffer-dam, about 10 feet square, built of plank, caulked and pitched; between the outer and inner portions of the coffer-dam was a space of 2 feet, which was filled with bags of tough clay. (*b*, Fig. 2, Plate VIII) The portion between the outer side of the dam and the outer edges of the crib was boarded up 6 feet high, forming a box around the dam. As soon as the crib was towed to its place, this box was filled with ballast, (about 200 tons of loose rock,) which caused the crib to rest on the rock.

Anchors were then carried out from the crib, and the chains connecting them with its angles were drawn taught. Steel-pointed piles were next driven around its outer edges, and the rock being soft, they soon held it perfectly firm. On its top a floor was now laid, at a height of 20 feet from the rock, and on this a shed was placed containing sleeping and cooking arrangements for about fifteen men.

"The water was then pumped from the dam, and the surface of the rock within it laid bare. It was found that considerable leakage occurred from beneath. This was partially remedied, when water was again allowed in the dam, and cement and sand were thrown in, which soon hardened. On this cement bed a boiler-iron cylinder, 6 feet in diameter and 14 feet high, was placed, and between it and the wooden dam more cement was thrown in, which was allowed to harden. The water was then pumped out of the cylinder, and the leakage was found to be small.

The sinking of the shaft was then immediately commenced, (December 7th.) Only one man could work in it at a time. The hoisting of the débris was at first done by manual labor. After the excavation had been made to the depth of about 10 feet, it was found that the water came through the rock at an inconvenient rate, and a second boiler-iron tube of a slightly less diameter was telescoped into the first one, and cement was run in between it and the rocky surface of the shaft. This was repeated in the progress of the excavation, a third cylinder, slightly less in diameter than the second, being found necessary. The lower portion of this lowest iron cylinder was $14\frac{1}{2}$ feet below the upper surface of the rock.

At the end of December, 1869, the bottom of the shaft was 22 feet below low water, and early in January, 1870, the depth was increased to 30 feet. The leakage into the shaft was now nearly checked. Drifts were then run in the direction of the longer and shorter axes of the rock. Steam was now used for hoisting, and a swinging derrick (like the one shown in Fig. 1, Plate VI) was constructed, which hoisted the tub containing half a cubic yard of the excavated fragments and dumped the contents on the eastern slope of the rock. Much of this débris was carried away by the tides. The work progressed so favorably during January that eight miners found space to work in the drifts, which had been run for a lineal distance of 130 feet. The rock

had easily been picked off, and but 10 pounds of powder (giant) were used in excavating the whole of the interior portion of it.

During February there was space enough in the various drifts to work sixteen miners. The drifts were enlarged and connected, and the interior of the excavation now had the appearance of a large chamber, having an arched roof supported by a dozen columns of rock. The average thickness of the roof of this chamber was about 14½ feet.

During March the chamber had increased in size so that its greatest height was 12 feet, greatest length 135 feet, and greatest width 55 feet. The rock columns which previously supported its roof were then all removed with the exception of four near the shaft, and their places were supplied by timbers from 8 to 10 inches square, on top of each of which a sill was placed, and between the roof and sill wooden wedges were driven. (Fig. 2, Plate VII.) Water percolated through the rock in small quantities, but a small steam-pump placed in the chamber near the shaft kept the floor of the excavation quite dry. With sixteen men at work in the interior of the chamber, the average day's work was about 50 cubic yards of stone.

The only tools used to loosen the stone were the ordinary steel-pointed pick, gad, and sledge. In a few instances, in the early part of the progress of the work, small blasts of giant powder were used, which did good service. During the early part of the month of April quite a heavy earthquake shock occurred, though it did not damage the rock in the least.

"The inner excavation was almost completed, when some of the miners, in trimming down its edges, struck gravel, which had been rounded by the action of water, and which appeared to be cemented together in a bluish clay. This circumstance frightened them, and many of them left. The crust of the rock when the gravel was struck was about 15 feet thick, through which some streamlets of water entered, though not enough to impede the work, as the pump was sufficient to check the water. This place was propped up, and excavating in that direction ceased.

PREPARATIONS FOR THE BLAST.

On the 20th of April the contractor ceased excavating. The size of the chamber was then 140 feet long, by 60 feet broad, with a maximum height

of 12 feet, and preparations were at once made for putting in the powder. The position of the charges and the detailed arrangements of the torpedoes are shown on Plate IX. The kind of powder used was a nitrate of soda powder, as it was less expensive than ordinary gunpowder. A quantity amounting to 43,000 pounds was used in the various charges. The vessels for containing it were thirty-eight ale-barrels, of an average capacity of 60 gallons each, and seven old tanks made of boiler-iron, securely riveted. The iron tanks varied in size from 5 to 7 feet in length, and from 2 to $3\frac{1}{2}$ feet in diameter, and contained from 80 to 175 kegs of powder of 25 pounds each. The inside of the barrels was coated with asphaltum. It was run in while hot; the barrels were then rolled over, and afterward placed first on one head then on the other, until the inner surfaces were covered. The outside of the casks was coated with the same preparation.

In the centre of one of the heads of each cask a hole was bored, into which an iron gas-pipe tube, $1\frac{1}{2}$ inches in diameter and about 3 feet in length, was tightly screwed, and so placed that the lower end, which was plugged up, was within 6 inches of the bottom of the barrel. That end of the tube which is outside of the barrel had another tube of the same diameter screwed on to it, which terminated with a right angle to the right and left, (the whole like the letter T,) the length being, in all, 5 or 6 inches. The two ends were cut with screw-threads, the object of which was to receive couplings to which air-tight India-rubber tubes were fastened. These rubber tubes were made of sufficient length to be fastened, in a similar way, to the barrels to the right and left; and in fact all the barrels and tanks were connected in that way, and finally a piece of rubber tube passed from the last torpedo, through the shaft, to the crib above.

Nothing has, as yet, been said about the arrangement of the wires, and the charging of the barrels and tanks. Two long wires, one insulated, pass through the whole system of rubber tubes and their intermediate connections, and are eventually led up to the crib. An Abel cartridge is now placed about the middle of the gas-pipe tube, which is in each barrel, and from the cartridge lead two wires, each about 22 inches long, one of which is fastened to the long insulated wire, and the other to the other long wire, as shown in Fig. 3 of Plate IX.

That portion of the gas-pipe tube which was within the barrel was perforated with holes $\frac{1}{8}$ of an inch in diameter, and about 4 inches apart. This tube was filled with rifle-powder. The barrels were filled through the bung with the nitrate of soda powder. By this arrangement it was supposed that when a cartridge was ignited, the quickly-acting rifle-powder would ignite the more slowly-acting soda powder in many places, thus insuring the burning of all of it. When filled the barrels were securely plugged, and an iron hoop was driven around each of them over the bung, to prevent it from being driven into the cask from the pressure of the water tamping when the chamber and shaft were filled with water.

The wooden-cask torpedoes were placed against the edges of the excavation and about 8 feet apart. The iron-tank torpedoes were distributed in the interior near the rock columns. When all were in position it appeared as though each torpedo was connected with the adjoining ones by an India-rubber hose. Each torpedo was braced and fastened in position by means of timber, so that when the chamber became filled with water they would not float about.

"It was feared that when the water was introduced into the chamber its pressure would crush some of the barrels, unless some counteracting force prevented. An air-pump was, therefore, brought into requisition. In order to see that there was no leakage, air was forced through the hose to the various packages of powder. The test was satisfactory.

All the arrangements having been completed, it was publicly announced that at noon of April 23d, the explosion would take place, and immense crowds collected on Telegraph Hill, and other prominent places in the city, to witness the novel sight. On the morning of that day a hole about 5 inches in diameter was cut in the iron case about 2 feet above low-water mark. As the tide rose the water flowed through the hole, and at noon of that day the chamber was two-thirds full of water. The indicator of the air-pump at that time indicated a pressure of 5 pounds to the square inch.

"At 2 p. m., everything being ready, an insulated wire was connected with the one brought up through the hose (the end of the other wire being in the water) and a boat containing the Beardslee's magneto-electric battery

and the coil of insulated wire pushed off from the crib, paying out the wire as we proceeded. When about 800 feet from the crib the wire was cut and the end connected with one of the poles of the battery, the circuit being completed by a wire connected with the other pole dragging in the water. One turn of the battery-crank and the explosion instantly follows. A column of water, variously estimated at from 200 to 300 feet high, rose majestically in the air. The diameter of the body of water thus thrown up was probably 200 feet. Around the base of this column was another simultaneous outburst of water, probably 70 feet high, whose flood seemed to roll outward. High above the mass of water could be seen rocks and pieces of timber. The highest jet of water was that which came through the shaft, and appeared as black as ink.

An examination made shortly after the blast showed that the shoalest part of the water over the rock was but 14 feet deep at mean low tide. As this shoal place was but of small area it was thought to be the old dump pile, as a pole could be thrust for several feet into the mass of broken rock of which it was composed. It was also thought that the tides would carry off a considerable portion of this broken mass; but, after waiting several days and again examining the locality, it was found to be in nearly the same condition as immediately after the blast.

"It was therefore necessary that the contractor should take some active steps toward removing the débris. For that purpose he constructed a rake. (See Plate X.) It was made of heavy wrought iron, weighing $2\frac{1}{2}$ tons, and its general appearance was that of an ordinary garden-rake, except that all its parts were very much heavier. It was 8 feet wide. Each tooth was about 28 inches long, and slightly curved, with a width of 3 inches, and an average thickness of about 5 inches. The space between two teeth was 2 inches. Its handle was of heavy iron and about 8 feet in length. When ready for use it was lowered through the well, which was in the middle of the scow, by means of three ropes, two of which passed over a windlass at the rear part of the well and were fastened to the two sides of the rake, while the third rope, coming from a point on the front part of the top of the well, was attached to the handle of the rake. While in position the handle of the rake was horizontal and its teeth nearly vertical

To prevent its sagging to the rear when the scow was moved forward, a chain was attached to each side of it, and the two led forward to the bow of the scow, where they were fastened.

When a steam-tug attached to the scow was moved back and forth over the rock, the rake generally scraped the débris into deep water, and the depth of water over the rock was increased a few feet. Occasionally pieces of timber would float to the surface, and as they all proved to have been part of the crib-work, packages of powder were placed on the surface of the rock and exploded, with the hope of breaking up the remainder of the crib. The result was that numerous other pieces, varying from a few inches to 12 fee, in length, were disengaged from the mass of the débris, and came up to the surface. This led to the conclusion that, at the time of the explosion the lower part of the crib-work, which consisted of a box filled with 200 tons of rock, must have broken in two, and fallen down bodily into the crater which the blast had produced. In raking over the rock, the small, loose pieces of stone would be dragged along until the rake came in contact with the interlaced timbers of the crib-work. This would temporarily check the progress of the tug, and it was supposed that it caused the rake to jump over the obstacle and form a new dump. A diver was several times sent down on the rock. He stated that it was broken to pieces, the largest of which would not measure more than half a cubic yard, and that their average size was about that of a hen's egg. He moreover reported that at his last descent he could find no timber. Charges of powder, varying from 25 to 75 pounds, were occasionally lowered to the spot and exploded, with results similar to those of previous blasts. At last, on the 25th of May, the contractor informed us that he thought he had obtained the requisite depth of water.

An experiment was made a few days afterwards by passing the rake over the surface of the rock, noting the depth of water at the time, and then ascertaining the height of the tide at the time of the experiment from the self-registering tide-gauge at Fort Point. It was found that the surface of the rock was uneven, and that many of the lumps did not have 24 feet of water over them at mean low tide. The contractor therefore resumed work as before.

It was found very inconvenient to go to Fort Point, about four miles

distant, to examine the readings of the tide-gauge there, and consequently the contractor placed a floating gauge at Cozzen's Wharf in the city, a place directly opposite the rock. The zero of this gauge was determined from the observations taken during a few days, and this zero at that time was supposed to be mean low tide. From time to time, during a few months after the blast, the contractor requested that an experiment be made, which was done, resulting in determining that the necessary depth of water had not been obtained. In the mean time the method of testing the depth of water by means of the rake was not satisfactory to all the parties interested, and Lieutenant Heuer devised what he called a boom. (See Plate X.)

Two pieces of timber, each about 25 feet long and 12 inches square, were nailed to two cross-pieces of timber in such way that the space between the two long pieces was about 2 feet. These cross-pieces were secured at points about 5 feet from the end of the logs, and the whole constituted the floating or buoyant part of the apparatus. On the cross-pieces, and midway between the logs, holes were bored, corresponding with those in two cast-iron cylinders, standing on flat rectangular bases, which were screwed to the cross-pieces. The cylinders were 7 inches high with an interior diameter of $2\frac{1}{16}$ inches, the thickness of the iron being $\frac{1}{2}$ inch. Through the cylinders and the holes through the cross-pieces, gas-pipes, 2 inches in diameter and 30 feet long, passed. The gas-pipes hung vertically, and could be fastened at any desired depth by set screws attached to the cylinders. The lower end of each pipe terminated in a T, through which a bar of iron, 30 feet long by 2 inches in diameter, passed and was fastened. The gas-pipes were graduated, and when both were lowered the same distance, the iron bar was horizontal. Experiments were made with this apparatus, referring the soundings to the contractor's gauge.

As the rock was gradually removed and the required 24 feet of water at mean low tide was nearly attained, it became a question whether the contractor's gauge, the zero of which had been determined from observations taken during a few days only, was correct or not; and also whether the water-level, at low tide, at the gauges at Fort Point wharf and Cozzen's wharf, four miles apart, were practically on the same horizontal plane. Lieutenant Heuer, therefore, ran a line of levels between the two points,

thereby, in fact, carrying the mean low tide mark at Fort Point to Cozzen's Wharf. The contractor ran a similar line of levels to test the accuracy of Lieutenant Heuer's work, and the results by the two differed by less than an inch.

With these data, a United States gauge was established at Cozzen's Wharf, the zero of which corresponded, as nearly as possible, with the zero of the gauge at Fort Point. On comparing the two gauges at Cozzen's Wharf, it was found that they differed over a foot, the United States gauge giving the highest reading. The latter gauge was not a floating one, but was merely a graduated rod fastened to a pile, and it was difficult to read it with accuracy in ordinary conditions of the bay, and almost impossible to do so when the bay was rough; still it was impossible to conceal the fact that this discrepancy existed between the two gauges, and although the experiment made on the 20th of August showed that there was 24 feet of water over the rock at mean low tide by the contractor's gauge, it was necessary to inform him that he had not yet fulfilled his contract.

Other official duties required us to visit Oregon. We sailed on the 2d of September and returned on the 14th of October, and during this interval tidal observations were taken at all low tides by an observer employed by the United States. On our return it was ascertained that the work had been suspended by the contractor, who insisted that he had complied with the terms of his contract. A careful examination was made of the observations taken in the interval, which were compared with corresponding ones at Fort Point, and the result was a full confirmation of the fact that the contractor was mistaken. Upon being convinced of this he acknowledged his mistake, and resumed the work of removing the rock.

The discussion of the subject was quite interesting, bringing out several points of importance not thought of in the beginning of the work, and therefore it is thought best to insert here the following extract of the official letters written to the contractor, and on the strength of which he resumed work on the rock:

"SAN FRANCISCO, *October* 20, 1870.

"SIR: * * * * * * *

"The first matter of investigation was the error in the position of the tin pointer of your gauge, which you supposed to read zero when at mean low water, (defined by the Coast Survey to be 'the level of average lowest low water.') From the discussion of the observations taken with your gauge at Cozzen's Wharf, from September 5 to October 14, inclusive, I find the mean low-water line to be —0.357; that is, the tin pointer must be moved down 0.357 of a foot in order to correspond with the mean low-water line deduced from the above-mentioned observations. A mean of the twenty-five observations from September 5 to September 30, inclusive, gives the number —0.377 instead of —0.357.

"The mean low-water level deduced from this short series of observations is different from that deduced from a series of many years, duration. I, therefore, have compared the observations taken at the Fort Point gauge with the mean low-water line of the Coast Survey, determined from a mean of fourteen years' observations, and I find that during the twenty-five days commencing on the 5th of September (the Coast Survey observations for October cannot be obtained until the end of the month) the mean of the lowest low water was +0.694; that is, the average height of the lowest low waters during that period was 0.694 feet above the Coast Survey mean low-water line. Therefore the difference between your tin pointer and the mean low-water line of the Coast Survey is 0.694—(—0.377)=1.071.

"In the following table will be found a copy of the low-tide observations taken in September, at Fort Point, and at your gauge on Cozzen's Wharf:

Low-tide observations taken at Fort Point and Cozzen's Wharf.

Fort Point.			Cozzen's Wharf.		
Height of low tides above mean low water.			Height of tides by Von Schmidt's gauge.		
Date.	Tide.	Time.	Date.	Tide.	Time.
Sept. 5..	0.29	2.10 A. M.	Sept. 5..	— 0.78	2.25 A. M.
6..	0.19	2.52 A. M.	6..	— 0.89	3.20 A. M.
7..	0.13	3.14 A. M.	7..	— 0.93	4.10 A. M.
8..	0.04	4.20 A. M.	8..	— 1.00	5.00 A. M.
9..	0.11	4.18 A. M.	9..	— 0.95	5.25 A. M.
10..	0.59	5.30 A. M.	10..	— 0.48	5.50 A. M.
11..	0.79	6.00 A. M.	11..	— 0.26	6.30 A. M.
12..	1.04	6.37 A. M.	12..	— 0.00	7.10 A. M.
13..	1.69	7.03 A. M.	13..	+ 0.57	7.20 A. M.
14..	1.71	8.37 P. M.	14..	+ 0.65	8.30 P. M.
15..	1.64	9.32 P. M.	15..	+ 0.54	10.05 P. M.
16..	1.49	10.40 P. M.	16..	+ 0.39	10.55 P. M.
17..	1.17	11.47 P. M.	17..	+ 0.09	11.50 P. M.
18..	.....	.....	18..	.....	.....
19..	0.87	12.48 A. M.	19..	— 0.22	12.55 A. M.
20..	0.67	1.37 A. M.	20..	— 0.46	1.55 A. M.
21..	0.49	2.30 A. M.	21..	— 0.62	2.50 A. M.
22..	0.42	3.03 A. M.	22..	— 0.65	3.20 A. M.
23..	0.29	3.50 A. M.	23..	— 0.72	4.15 A. M.
24..	0.34	4.20 A. M.	24..	— 0.80	5.00 A. M.
25..	0.51	5.00 A. M.	25..	— 0.55	5.10 A. M.
26..	0.69	6.15 P. M.	26..	— 0.33	6.45 P. M.
27..	0.53	7.07 P. M.	27..	— 0.52	7.25 P. M.
28..	0.59	8.05 P. M.	28..	— 0.45	8.35 P. M.
29..	0.69	9.14 P. M.	29..	— 0.35	9.20 P. M.
30..	0.39	10.17 P. M.	30..	— 0.70	10.43 P. M.
$25)17.36$			$25)-9.42$		
$+.6944$			$-.377$		
= Average above mean low water.			=Average value of mean low water at Cozzen's Wharf below the contractor's zero.		

"The number 1.071 represents the distance your tin pointer must be moved down in order that your gauge reading corresponds to that of the Coast Survey at mean low tide at Fort Point. The scale reading of the United States gauge at Cozzen's Wharf and the Fort Point gauge would be the same, if the water between the two places at low tide were on the same horizontal plane, and they would be, at mean low water, 3.411, that being the reading of the Fort Point scale at mean low water. The mean of the low tide readings at Fort Point, from September 5 to September 30, inclusive, is 3.411+0.694=4.105. The corresponding reading of the United States

gauge is 4.435. The difference is 0.330. If the lower ends of the two gauges are on the same horizontal plane, as is believed to be the case, and if the observations were correctly taken, then this difference can only be accounted for by a slope of the waters between the two places. I must state, however, that the observations at the United States gauge were quite difficult in rough weather, and could not be relied upon within a tenth of a foot.

"Supposing that this 0.33 of a foot in your favor were allowed by the Chief of Engineers, you have still to remove 0.741 of a foot before the required 24 feet of water over the rock is obtained. The number 0.741=1.071—0.330.

"I state, for your information, that I have learned officially from the Coast Survey Office in Washington that the mean rise and fall of the tide at Fort Point is 3.76 feet, and at Meigg's Wharf, near Cozzen's Wharf, it is 3.86 feet.

"A copy of this letter will be forwarded to the Chief of Engineers.

"Very respectfully,

"R. S. WILLIAMSON,
"*Major United States Engineers.*

"Mr. A. W. Von Schmidt, C. E.,
"*Contractor for Removing Blossom Rock.*"

It is difficult to conceive that in an open bay like that of San Francisco there should be a perceptible difference of level between Cozzen's Wharf and the wharf at Fort Point, but being confident that the lines of level run by the contractor, and Lieutenant Heuer on the part of the United States, gave essentially the same results, and being unable to conceive of any other cause for the difference of 0.33 of a foot, except an actual difference of level of the waters at low tide between the two points, this 0.33 of a foot has been given in favor of the contractor, as, in fact, have all doubtful points been given to him.

Being convinced of the truth of the facts contained in the above letter, the contractor resumed his work with the view of removing $\frac{3}{4}$ of a foot of the rock at such parts of it as the removal was necessary. On December 6, 1870, I received from him the following letter:

"SAN FRANCISCO, *December* 6, 1870.

"SIR: I have the honor to state that I have removed from the surface of Blossom Rock, since your last survey, 700 cubic yards of stone. So far as I am able to ascertain, I have 24 feet of water over the rock at mean low water.

"I most respectfully ask you to order a survey to be made for your own information, and hope that you will be pleased to accept the work. I would propose that at 10 o'clock to-morrow would be a good time for the survey, on account of the tide.

"Very respectfully,

"A. W. VON SCHMIDT,

"*Civil Engineer, &c., Contractor for Removing Blossom Rock.*

"Major R. S. WILLIAMSON,

"*United States Engineers.*"

In consequence of this letter we were at the wharf at the time appointed, where we found the tug, the scow, and the boom ready for us. The boom was set to the proper depth of water, on it stood Lieutenant Heuer with a lead line in hand, and the apparatus was very slowly and frequently towed over the rock, until every portion of it must have been passed over by the boom. The boom did not strike the rock, and every sounding indicated 24 or more feet of water over it at mean low tide. On the following day the work was accepted, and the contract-money paid to the contractor.

The officer of the Coast Survey in charge on this coast, Assistant Geo. Davidson, had intimated that, as soon as our operations were over, he would make a survey and chart of the portion of the bay where the rock formerly stood. The survey was made, but before the chart was finished the subordinate officer of the Coast Survey, who made the hydrographic survey, became sick, and the work was delayed until he should recover. An examination of the soundings taken by the United States Coast Survey showed that there were four lumps on the rock which had not quite 24 feet of water over them. I therefore directed Lieutenant Heuer to make the survey of the rock.

METHOD OF MAKING THE FINAL SURVEY OF BLOSSOM ROCK.

A scow, 46 feet by 28 feet, was moored on the rock by means of four anchors and lines. Two observers on shore, and distant about one mile from the scow and from each other, took angles simultaneously, with theodolites, on a flag-staff erected on the scow. The direction of its axis at the same instant was determined by compass on board. As soon as the theodolite men had observed its position, two men with lead lines (one on each side and end) would sound all around it. When these sets of soundings were completed, its position would be slightly changed, the theodolite men would again be signaled, would observe its new position, and soundings would be made as before. This operation was repeated many times until the whole surface of the rock was covered with soundings. We obtained over 1,800 soundings, about 1,300 of which were plotted.

After the soundings were reduced to mean low-water level and plotted, it was found that there were seven places where there was less than 24 feet of water. At these places there appeared to be small masses of loose rock, about the size of a cubic foot or less, rising above its general level. They were so small that it was often difficult to find them a second time. In previous examinations which had been made by us, by means of the sounding float or "boom," we had found no place where there was too little water, and therefore the money had been paid to the contractor. As soon as the detailed survey, above described, was completed, the contractor was informed that these seven lumps still existed on the rock; he therefore at his own expense and with as little delay as possible, sent down a diver in armor, who found the lumps. He reported that the surface of the rock was uneven, like furrows, and was covered with small stones, usually quite small, and seldom as large as a cubic foot. All the lumps on these ridges were scraped off into deeper water. He went down twice, remaining nearly an hour each time. He could only go down about slack water.

We made a re-survey of that portion of the rock which had contained the lumps, and found over each of them 24 feet or more of water. Some of these lumps may have existed when that survey was made which resulted in the money being paid to the contractor, because they were so small; and

being detached masses, were not detected. Some of them, however, were made during the recent survey, when several times rocks, used as sinkers to buoys, had been lowered on the rock, and left there by the parting of the lines to which the buoys had been attached. The survey could only be made when the bay was smooth, and only fourteen days suitable for the purpose were found during three months. The soundings over the rock at the final survey are shown on Plate XI.

CONCLUDING REMARKS.

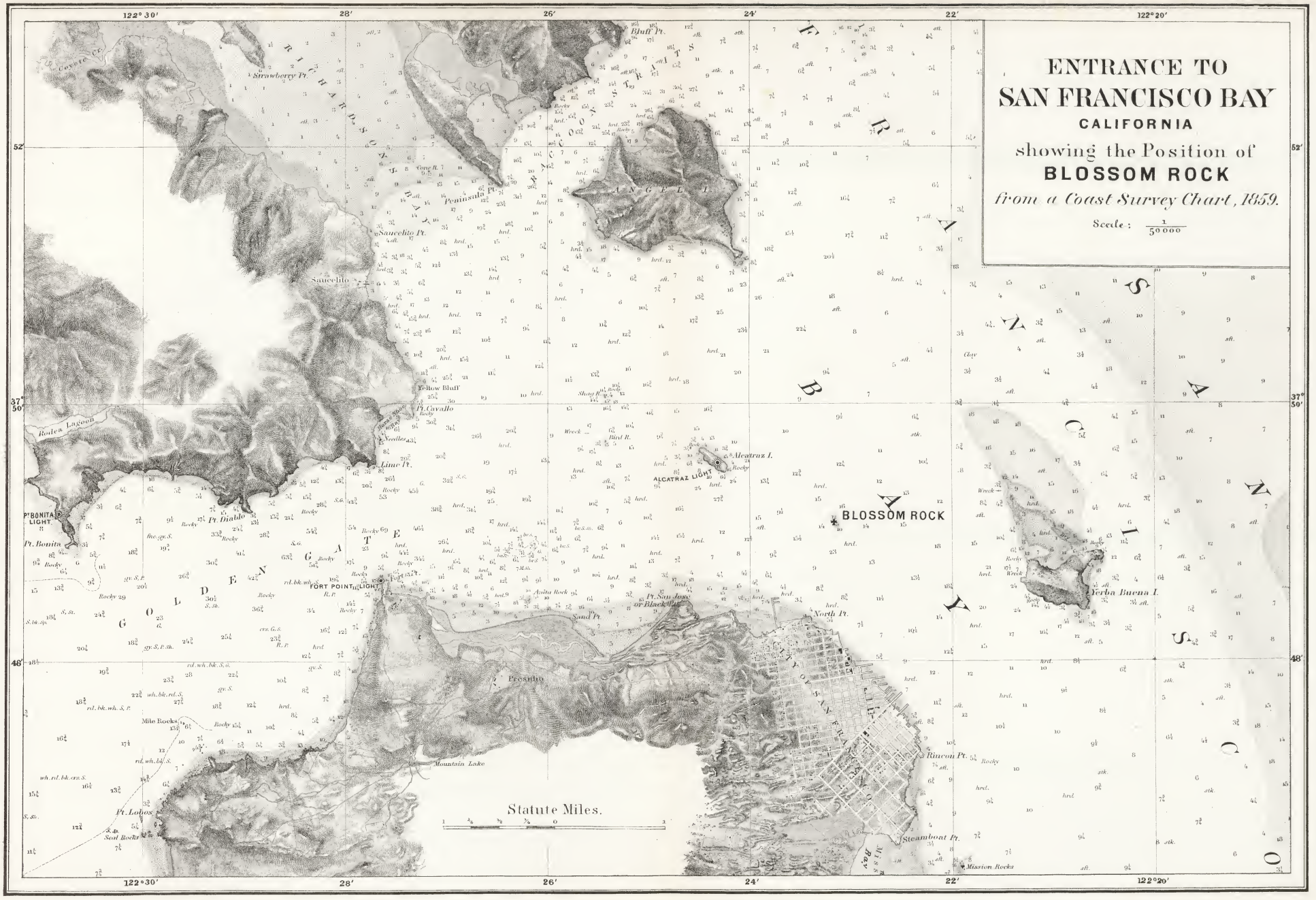
In concluding this report, a few words with regard to the manner of conducting the work, the defects in it, &c., may be of value, though they are the natural deductions from the operations already detailed. The main defect was in firing the charges of powder before a sufficient amount of excavation had been made. A glance at the original plan as partly shown on Plate VI (the stone pillars were to be replaced by wooden ones) and the plan actually followed out as shown on Plate VII shows at once that, in the former case, the amount of excavated rock was so great that when the shell of the rock was broken, and lifted up by the force of the explosion, the greater portion of the débris would fall into the excavation, and there would be at least the required 24 feet of water over the rock or débris; and in the latter case, the amount excavated was not half as much as the amount of rock remaining above the line of 24 feet at mean low water. Consequently, just after the blast there were only 14 feet of water over the débris. In order that the mass of rock over the 24-foot line should equal the mass excavated, about 10 feet more of excavation should have been made.

The contractor and many others supposed that the tide would sweep away the loose débris, but this idea proved fallacious.

It was supposed that a crust of only 6 feet thick, supported by the pillars of rock or wood, would be admissible; but, in fact, a thickness of from 14 to 18 feet was required to prevent the water from entering the chamber in quantities greater than could be easily controlled; but there was no practical difficulty in excavating more in the central part of the rock, though towards the edges suspicious leaks had developed themselves. The removal of the débris probably cost more than the amount expended up to and including the

time of the blast. Had he made this 10 feet of additional excavation, it is probable he would have been perfectly successful. Again, the chamber containing the powder being only about two-thirds full of water at the time of the blast made the resistance very much less than it would have been had the chamber, as well as the shaft, been filled, so that the water would have stood on the same level in the shaft as on the outside. To that fact may be attributed some of the contractor's want of perfect success.

Mr. Von Schmidt deserves a great deal of credit for the work he has achieved. His daring character is shown by his accepting a contract in which he was to receive no money until the completion of an experiment, the success of which could only be decided by the United States as the sole arbiter. The energy with which he pushed forward the work until the explosion took place, and the renewed energy with which he pursued his labor under such discouraging circumstances, deserves the success he attained.


ENTRANCE TO
SAN FRANCISCO BAY
CALIFORNIA
showing the Position of
BLOSSOM ROCK
from a Coast Survey Chart, 1859.
Scale: 1/50000
BLOSSOM ROCK
ALCATRAZ LIGHT
FORT POINT LIGHT
PT BONITA LIGHT
Alcatraz I.
Yerba Buena I.
Angel I.
Saucelito
Sausalito Pt.
Strawberry Pt.
Bluff Pt.
Peninsula Pt.
Yellow Bluff
Pt. Cavallo
Lime Pt.
Needles
Pt. Bonita
Pt. Diablo
Anita Rock
Pt. San Jose or Black Pt.
Sand Pt.
North Pt.
Presidio
Mountain Lake
Mile Rocks
Pt. Lobos
Seal Rocks
Rincon Pt.
Steamboat Pt.
Mission Rocks
Statute Miles.
122° 30′
28′
26′
24′
22′
122° 20′
52′
37° 50′
48′

SKETCH

showing the Positions and Results of the

Experimental Blasts on BLOSSOM ROCK

SHEET I

under the Direction of

Br.t Lieut. Col. R.S. Williamson U.S.A. Maj of Engineers

assisted by Lieut. W.H. Heuer, U.S. Eng.rs

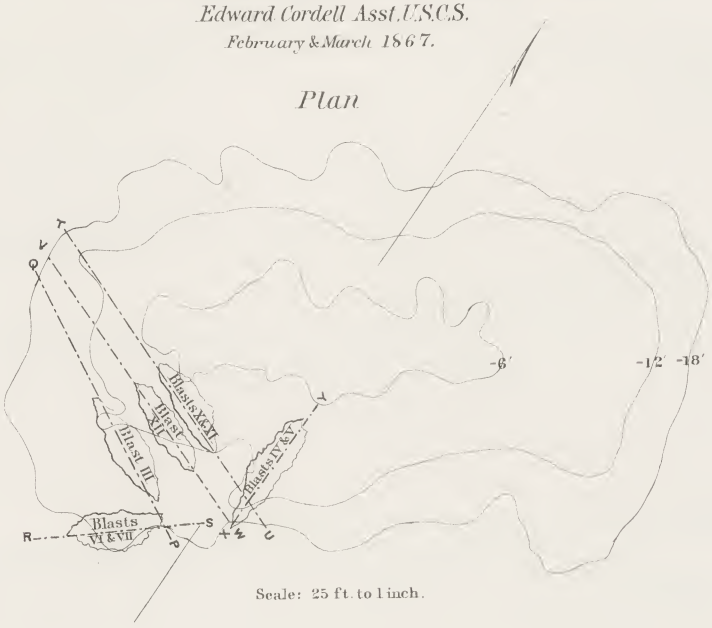
from soundings taken before and after the blasts

by the Hydrographic Party in charge of

Edward Cordell Asst. U.S.C.S.

February & March 1867.

Plan



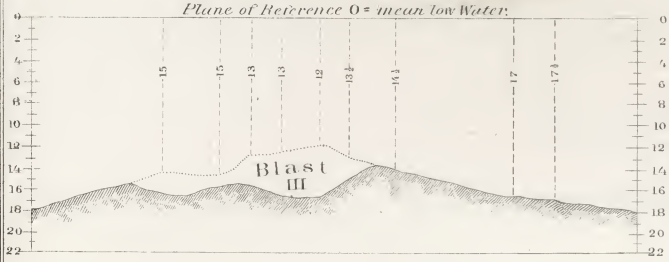
Scale: 25 ft. to 1 inch.

No of Blast	Date	Charge	Result
I	*January* 30th	75 *lbs. Powder*	*No perceptible effect*
II	" 31st	175 " "	*Rock shattered, depth not increased*
III	*February* 9th	125 " "	*About* 11 *Cubic Yards removed*
IV & V	" 19th	125 " "	" 15 " " "
VI & VII	" 25	125 " "	" 3 " " "
VIII	*March* 4th	75 " "	*No perceptible effect*
IX	" 5th	75 " "	" " "
X & XI	" 6th	125 " "	*About* 12 *Cubic Yards removed*
XII	" 7th	175 " "	" 8½ " " "

TOTAL

8 effective Blasts, 1050 *lbs. Powder, about* 49½ *Cubic Yards of Rock rem.d*

Fig. 1 Section on P Q



SKETCH
showing the
Positions and Results
of the
Experimental Blasts
on
BLOSSOM ROCK
SHEET 2

Fig. 2 Section on X Y

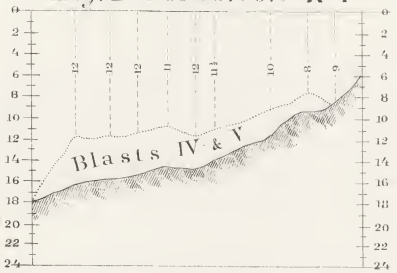
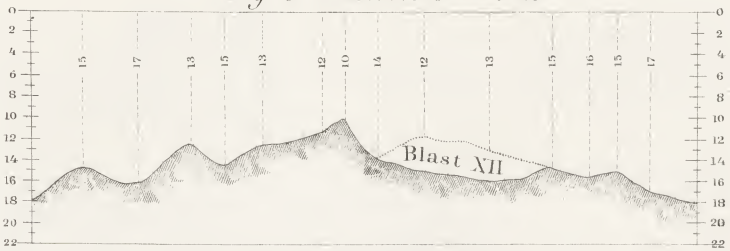


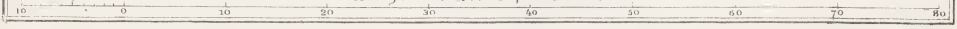
Fig. 3 Section on R S

Fig. 4 Section on T U

Fig. 5 Section on V W

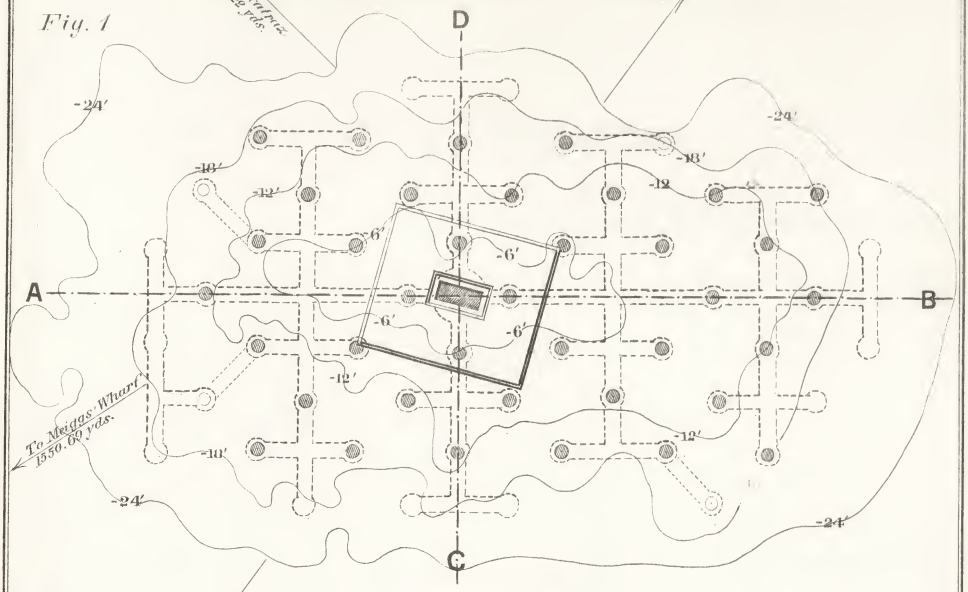


Horizontal Scale for Section.



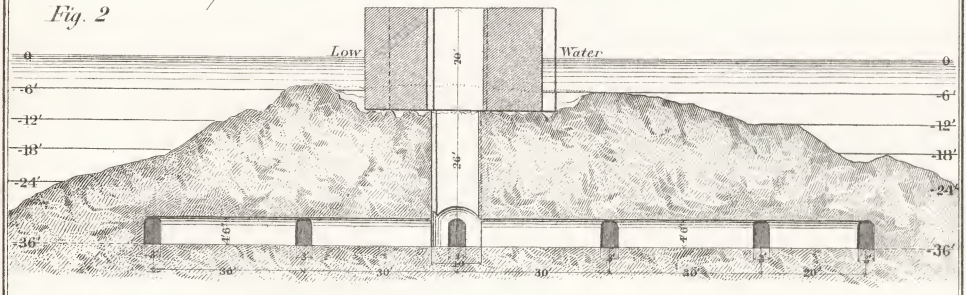
Plan of the Rock
showing the proposed Tunnels for blasting.

Fig. 1



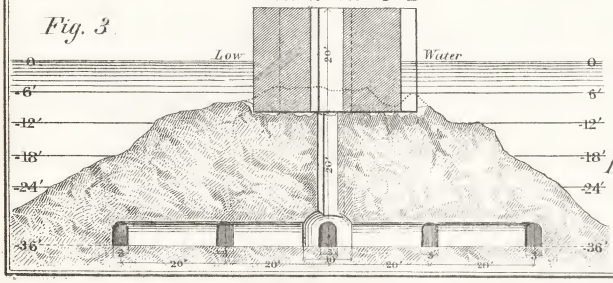
Section on **A B**

Fig. 2



Section on **C D**

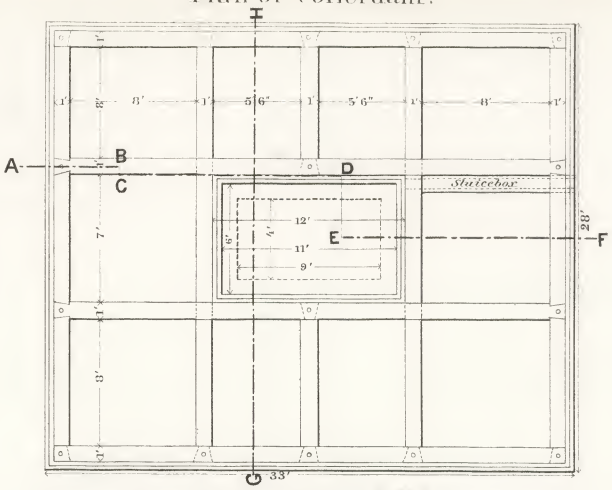
Fig. 3



Project for blowing up
BLOSSOM ROCK
San Francisco Harbor
SHEET I
by
Br.t Brig. Gen. B.S. Alexander U.S.A.
Lieut. Col. of Engrs
Submitted October 3rd 1868.
Scale: 25 ft. to 1 inch.

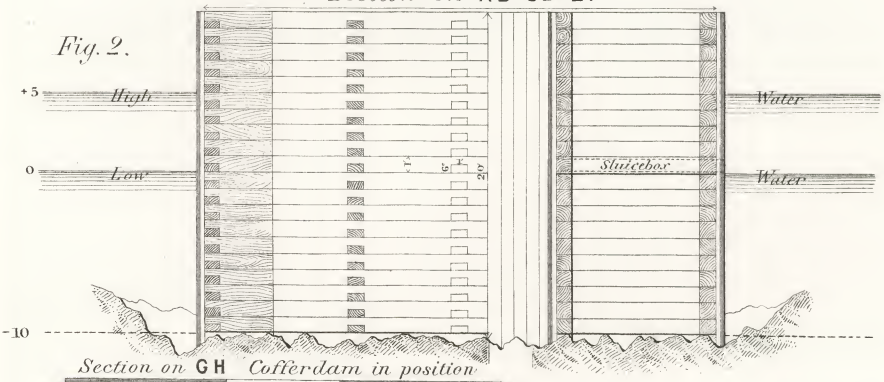
Plan of Cofferdam.

Fig. 1.



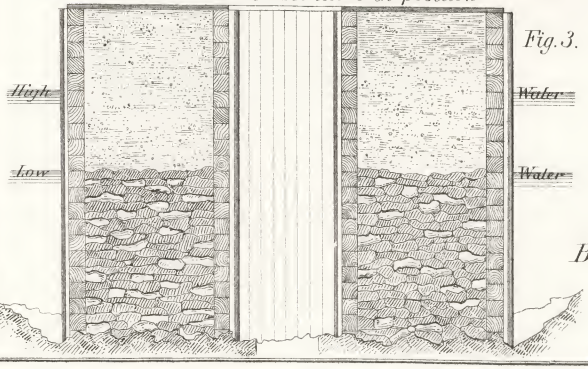
Section on AB-CD-EF

Fig. 2.



Section on GH *Cofferdam in position*

Fig. 3.



Project for blowing up

BLOSSOM ROCK

San Francisco Harbor

SHEET 2

by

Br.t Brig. Gen. B.S. Alexander U.S.A.

Lieut. Col. of Engr.s

Scale 8 ft to 1 inch.

Project for removing
BLOSSOM ROCK
San Francisco Harbor
by
A.W.von Schmidt
Civil Engineer
Submitted November 20th 1868.

Fig. 1
Longitudinal Section

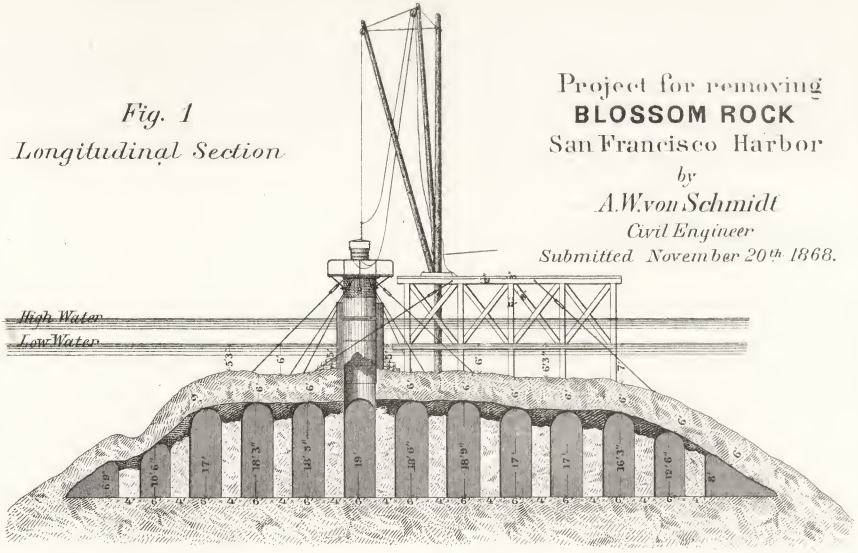


Fig. 2
Transverse Section.

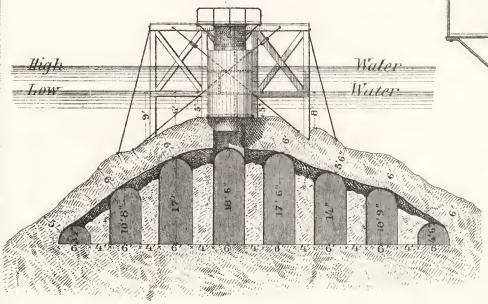
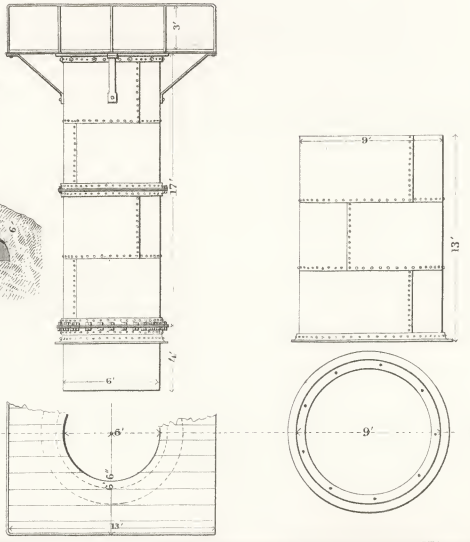


Fig. 3.
Boiler-Iron Shaft.



Scales:

Figs 1 & 2 — 25 ft to 1 inch

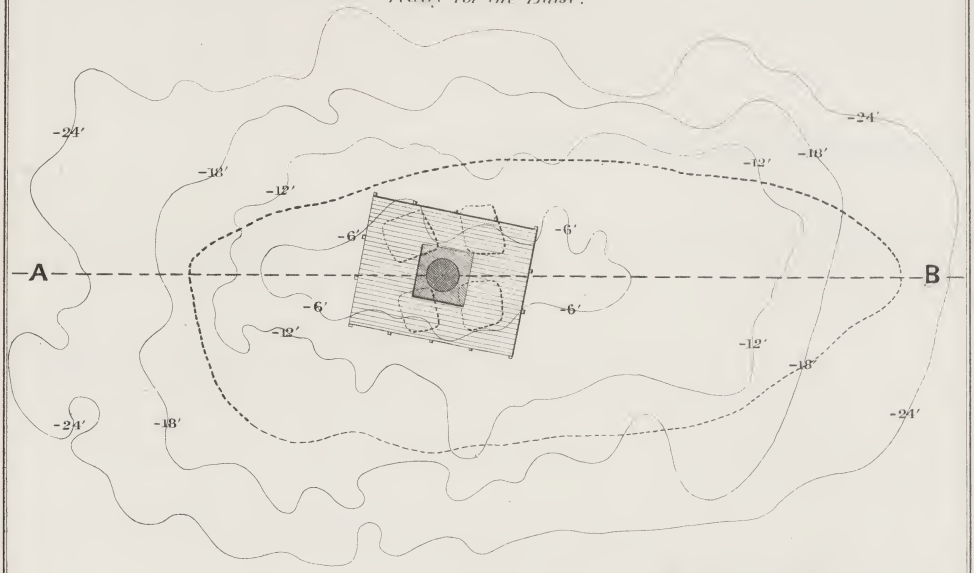
Fig. 3 ——— 8 ft to 1 inch

Fig. 1

Plan of the Rock

showing the excavated Chamber;

ready for the Blast.



Removal of

BLOSSOM ROCK

San Francisco Harbor

SHEET 1

by the Contractor

A. Wrom Schmidt

Civil Engineer

1869 & 1870.

Scale 25 ft to 1 inch

Fig. 2 Section on A B

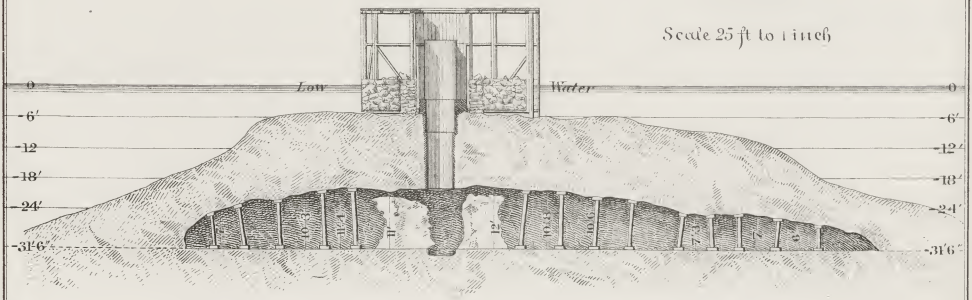
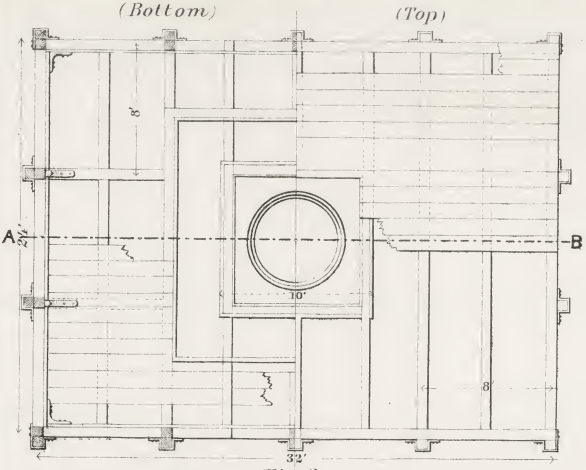


Fig. 1.

Plan of Cribwork and Boiler-Iron Shaft.



Removal of
BLOSSOM ROCK
San Francisco Harbor
SHEET 2
by the Contractor
A. W. von Schmidt
Civil Engineer
Scale 8 ft. to 1 inch.

Fig. 2.

Front Elevation *Section on* **A B**

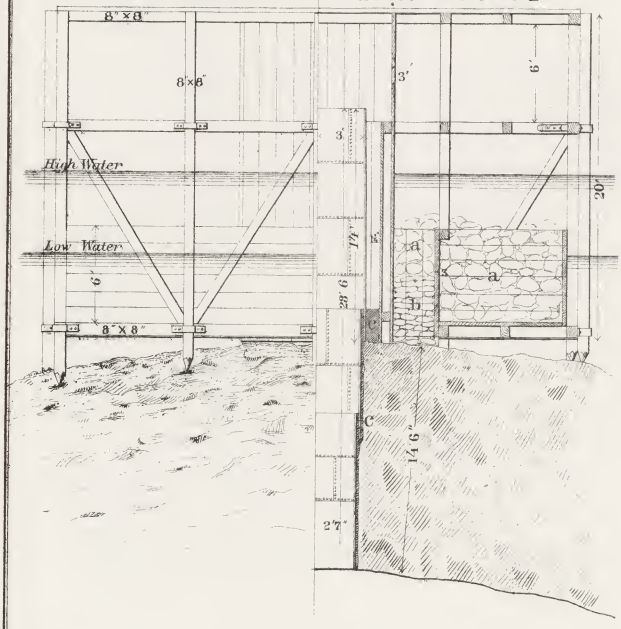
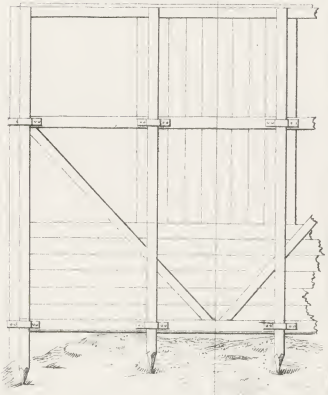


Fig. 3.
Side Elevation



Explanation

a — *Stone Ballast.*

b — *Claybags.*

c — *Cement.*

Fig. 1. Plan of Chamber
showing the distribution of Powder-packages.
Scale 25 ft. to 1 inch.

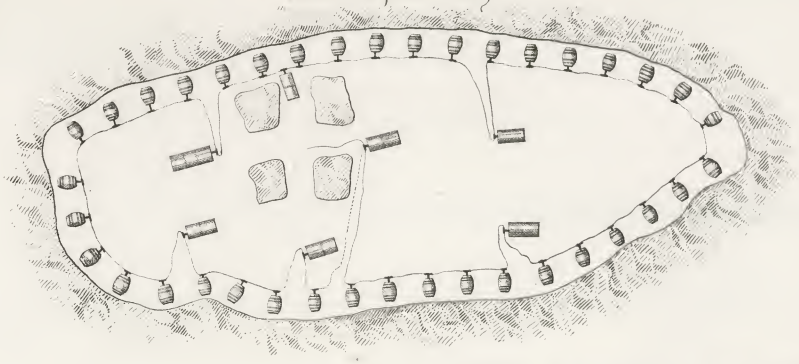
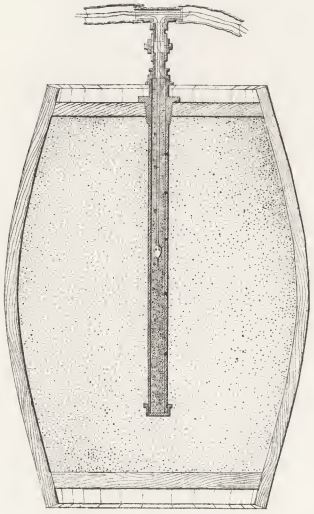


Fig. 2
Section of Powder-barrel
showing fuse-arrangement
Scale 1 ft. to 1 inch.



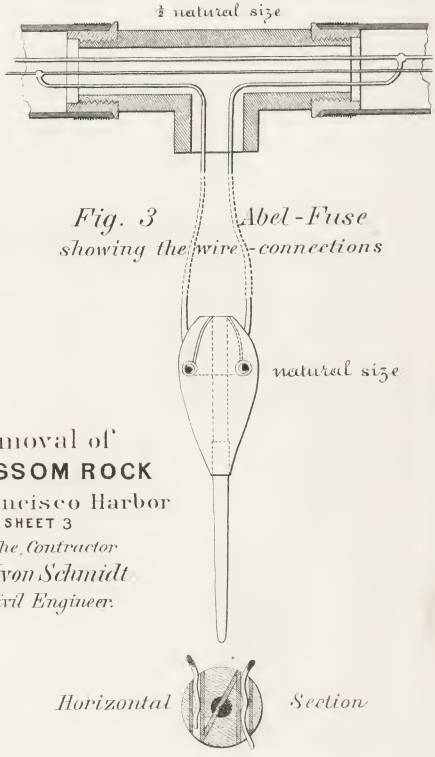


Fig. 3 Abel-Fuse
showing the wire-connections

Horizontal Section

Removal of
BLOSSOM ROCK
San Francisco Harbor
SHEET 3
by the Contractor
A. W. von Schmidt
Civil Engineer.

Removal of BLOSSOM ROCK
San Francisco Harbor
SHEET 4

by the Contractor A.W. von Schmidt, Civil Engineer.

Fig. 1 View of Scow and Rake
Scale 16 ft. to 1 inch.

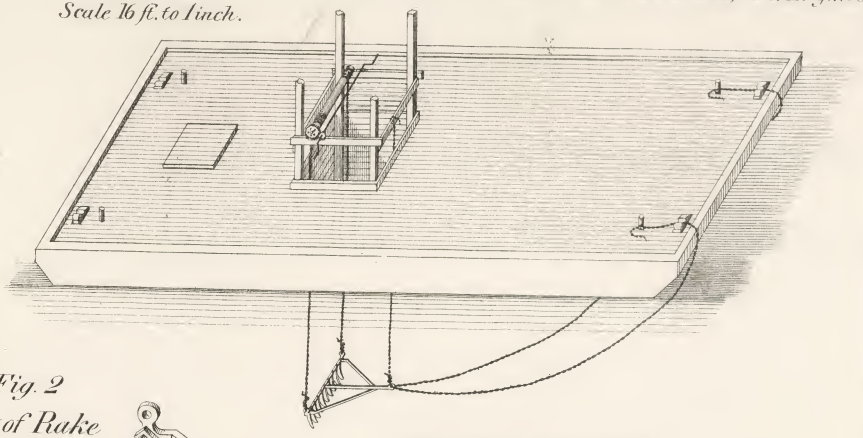


Fig. 2
View of Rake
Scale 4 ft. to 1 inch.

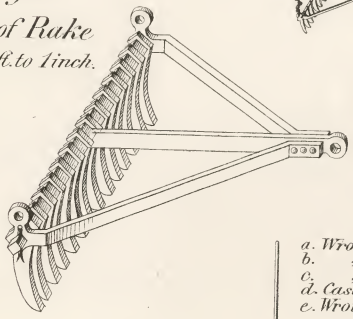


Fig. 3. Elevation of Rake
Scale 2 ft. to 1 inch

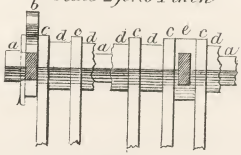


Fig. 4
Scoop-Attachment to Rake
Scale 4 ft. to 1 inch.

a. Wrought Iron Shaft
b. " " Brace
c. " " Teeth
d. Cast " Washers
e. Wrought " Tongue

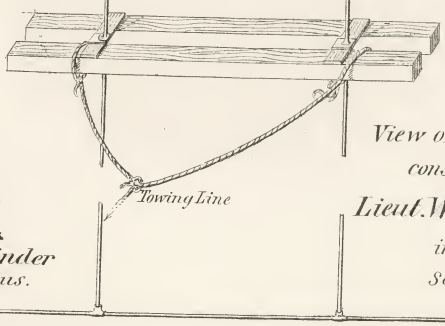


Fig. 5
View of Sounding-Float constructed and used by
Lieut. W. H. Heuer, U.S. Engrs
in final Survey
Scale 8 ft. to 1 inch.

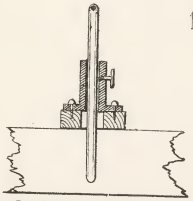


Fig. 6. Adjusting Cylinder to sounding Apparatus.
Scale 2 ft. to 1 inch.

Removal of BLOSSOM ROCK

San Francisco Harbor

SHEET 5.

by the Contractor, A. W. von Schmidt, Civil Engineer.

MAP

showing the Depth of Water on

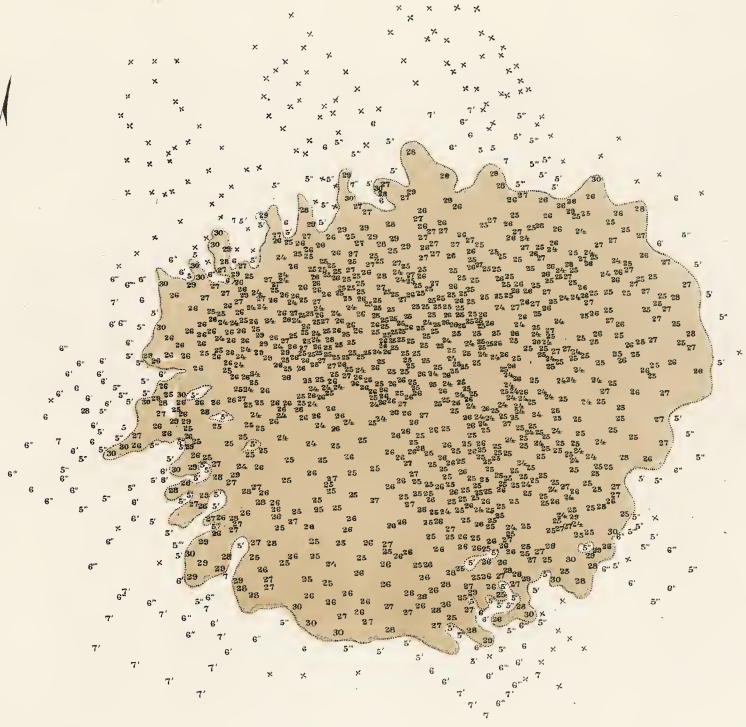
BLOSSOM ROCK

as established by Survey of
April 1871.

made by

Lieut. W. H. Heuer, U. S. Engrs

Scale 50 ft. to 1 inch.



Note: *Within shaded Area, and up to 30 feet, Soundings are expressed in feet. beyond, in fathoms and quarters of fathoms; at places indicated thus: × no bottom was reached at 6 fathoms. The Soundings refer to mean low water.*