THE LURAY CAVERNS BY ELECTRIC LIGHT.

BY H. C. HOVEY.

The facilities now furnished by the Shenandoah Valley Railroad have drawn twelve thousand visitors to the Caverns of Luray since last June. The majority of these have had to grope their way by candles, with occasional flashes of red lights or magnesium tape; and, on special days, the galleries have been illuminated by fixed chandeliers, ten thousand candles having been thus consumed on a single occasion. The unavoidable result has been the dropping of a great amount of melted tallow among the crystals and into the springs and pools, the smoking of some of the more delicate stalactites, and the change of those bright colors that attracted the admiring gaze of visitors who saw, as the writer did, the cave in its unsullied purity, just after its discovery, in 1878, by Messrs. Campbell and Stebbins. It may be added, in self-defense, that some of the beautiful objects, described by me in articles then written for the SCIENTIFIC AMERICAN, have been thus transformed beyond recognition —a remark especially true of the alabaster grotto known as "The Bridal Chamber," and the scale-covered column called "The Mermaid."

There are, however, attractions enough remaining to justify the boast of the proprietors that they have the most beautiful cave ever found; and new rooms are being frequently opened, so that the local residents in the vicinity imagine that these are discovered to order, whenever the curiosity of the public begins to flag. Whatever may be true as to this, it is well that the law is most stringently enforced against mutilating the formations or taking specimens; because, famous as the cave has become, its proportions are limited, and it might quickly be spoiled of charms that centuries were required to produce.

In order to the better preservation of the cave, and also that its wonders might be seen to the best advantage, the company have lately had electric lights introduced with admirable success; and as this is the first attempt of the kind, the particulars may be of general interest.

When I say that thirteen electric lights are kept burning in Luray Cave, the statement may not seem extraordinary, now that lights of this description are common in every city. But a moment's reflection will show that it is quite different to run wires along poles or over house-tops, and to run them underground, under perilous masses of dripstone, through nearly inaccessible galleries and across profound chasms. The hard carbonates into which holes had to be bored for the insulators proved to be so very hard as repeatedly to snap the drills. There were also unusual magnetic disturbances, and the difficulties of perfect insulation were such that some of the workmen received severe shocks while testing the wires.

The engine is more than a mile from the cave, being the same that is used to supply water for the Luray Inn, and for the tank at the railroad station. The power required for each light is three-fourths of one horse power, and the expense of putting in the works, aside from the engine, was about $3,500. The length of the single wire used is three and a half miles, which, with the return current through the earth, makes an entire circuit of *seven miles*, and is supposed to be the longest current yet attempted with one engine. Automatic regulation is of importance in managing so extended a circuit; and this was secured by using the Thomson and Houston system, the special advantage of which, in this case, as explained to me by the electrician, Mr. T. H. McCollin, is that it allows any number of lamps to be turned on or switched off, without any change in the running of the engine. The current regulator is actually an electric governor. By rocking the brushes on the commutator the current is increased or decreased automatically. Otherwise, when some of the lights were extinguished, the same amount of electricity would continue to be generated as if all were burning, unless specially checked by hand; and consequently the machinery would become heated unless slowed down or else a proper means of wastage provided. But here the excess above the quantity of electricity generated for actual use is provided for, without diminishing the number of revolutions of the generator or the speed of the engine itself. The decrease of resistance, however, in case lights are extinguished, is immediately felt by the engine, and results in less consumption of fuel and steam.

The lamps, with a single exception, are used without shades, there being little draught except near the entrance, and the shades only serving to intercept the rays. From 2,000 to 2,500 nominal candle power is claimed for each lamp, which ought to give for each about 1,000 for available use in illumination. But I observed that the amount of light actually obtained was much less than what would be expected in the ordinary atmosphere. I found the explanation of this in the fact that the cave atmosphere, being *optically pure*, does not carry the rays as effectually as would be done by air in which motes were floating. This theory was verified by me last summer, in other caverns, by burning blue lights and magnesium tape. Returning to the same localities about an hour later, the increased light from our torches was very perceptible, and was accounted for by the fact that particles had thus been set afloat in the air that served as vehicles for spreading the rays.

The lamps in Luray Cave are in a measure movable, that is, they may upon occasion be swung from one point to another. But as they are at present placed they throw light on points of most interest to the visitor. The first is in the Vestibule, and finely lights up Washington's Pillar and the entrances to Stebbins' and Specimen Avenues. The next is in the Fish Market, making the long strings of bass and mackerel glisten as if they were real fish instead of stone.

Two lamps cast their beams into Pluto's Chasm, a pit said to be 500 feet long and 70 feet deep. Another is amid the alabaster scarfs and brilliant stalactites that embellish Hovey's Hall. Others light up to advantage Oberon's Grotto and the diversified and curiously beautiful bronze, pink, blue, and white formations in the Cathedral, the Giant's Hall, and the Ball Room. The most remote points reached by the lights are Collins' Grotto and Campbell's Hall. The last object of interest usually exhibited, and which the visitor carries away as something to be cherished in memory as long as memory shall endure, is the Imperial Spring and Brand's Cascade. The "Spring" is not properly a spring, but a limpid pool, overarched by a grotto 25 feet across, and so thickly studded with bronze stalactites from three inches to three feet in length, that after several trials at counting the number on a square foot, we estimated the entire number in the vault to be about fifty thousand, each tip gleaming with a crystal drop. The light is so placed as to cause all these sparkling pendants to be reflected from the face of the pool.

Brand's Cascade, it should also be understood, is not a real one of water, but a mass of alabaster, seeming to gush from the side of the Imperial Spring, and to have been frozen in the act of falling down into the ravine below. Imagine a cataract of milk suddenly caught in mid air and polished to a wax-like luster, and beyond it another as yellow and golden as amber, and the whole mass flooded by electric light, and you will see that the scene could not be painted by pencil or pen.

During my last visit to Luray, a few days ago, a photographer from Philadelphia, Mr. C. H. James, was trying to fix on paper some of these indescribable visions. The experience of those who have hitherto attempted underground photography has not been very encouraging, but this gentleman has overcome many of the difficulties in the way, and hopes to get good pictures. Those he has already secured certainly surpass any taken by calcium or magnesium light, both in sharpness of outline and distinctness of detail.

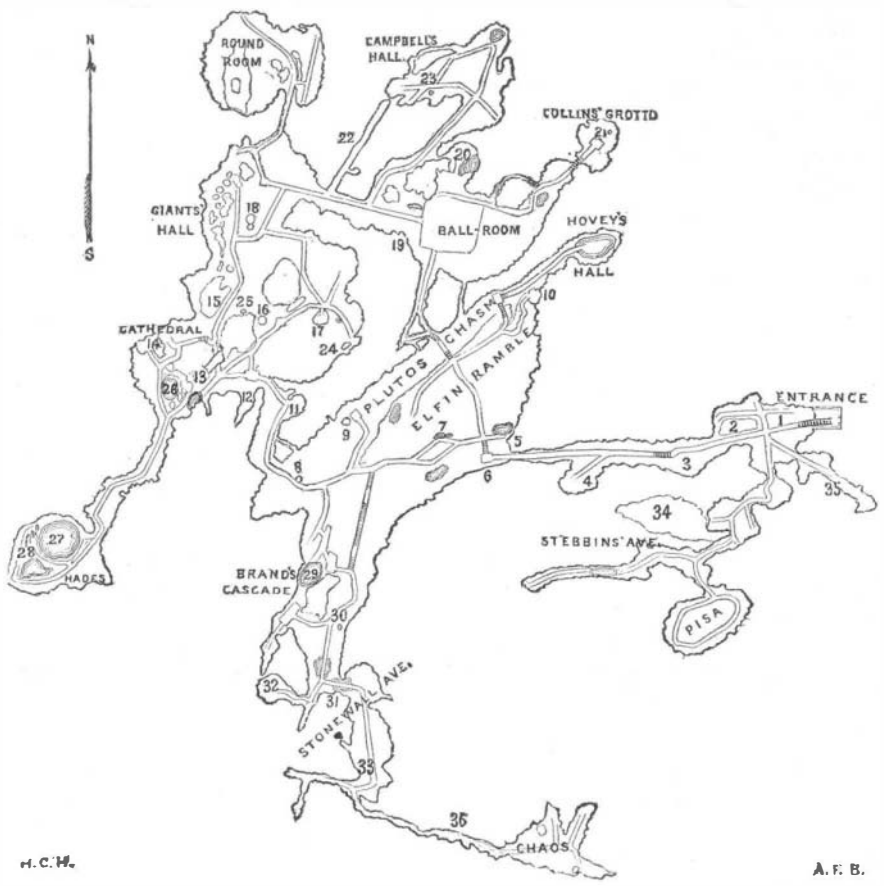
Wisely the guides show to visitors only those parts of the cave that have been made easily accessible by concrete pavements, plank walks, bridges, and stairways. Places that can only be reached by creeping and wading are not open to any but explorers who cannot rest until they have seen all that can be seen. Work is constantly in progress to facilitate the examination of the entire cavern without one's being obliged to retrace his steps, but emerging from his underground journey at an exit to be made about five hundred feet south of the entrance.

The pick and crowbar are the main reliance for enlarging narrow passages, but an occasional charge of dynamite has been fired in places where other galleries were not endangered by the explosion. Among the huge blocks thus dislodged I noticed some that were remarkable for size and also for fineness of texture. Experimenting on a few fragments given me for the purpose, I find that, on being cut into slabs and polished, they are quite equal to the celebrated Mexican onyx, from which they differ mainly in vividness of color.

A correct map of Luray Cave has long been wanted by persons interested in subterranean regions. A sketch was prepared by Mr. A. Y. Lee, for the *Herald*, in 1878; and another, embodying certain improvements, was made in 1880, by Mr. S. Z. Ammen. It is no disparagement to these gentlemen to say that their maps were imperfect, for they could hardly have been otherwise under the circumstances.

Since the electric lights have been put in a new survey has been made with the greatest care, resulting in the accurate map that accompanies this communication. It is published by the consent and approval of the company, and can be depended on as to its details. It was found impossible to indicate every object of interest; but a list of the more important ones serves to explain the map. Nearly all the points indicated are now exhibited to visitors; and others will be opened to the public during the next season.

Should the reader desire more full particulars concerning this wonderful series of caverns, he will find them in the files of the SCIENTIFIC AMERICAN for 1879, in the reports of the Smithsonian Institution, and in various magazines.



1. The Vestibule.—2. Washington's Pillar.—3. The Flower Garden.—4. The Amphitheater.—5. Natural Bridge over Muddy Lake. 6. The Fish Market.—7. The Crystal Spring.—8. Proserpine's Pillar. 9. The Spectral Column.—10. Hovey's Balcony and Scarfs.—11. Oberon's Grotto. 12. Titania's Vail. 13. Saracen's Tent, and Fallen Column.—14. The Organ and Throne.—15. The Tower of Babel.—16. The Empress Column.—17. The Hollow Column.—18. Henry Baird (or Double) Column.—19. Chalcedony Cascade.—20. The Coral Spring.—21. The Dragon of Luray.—22. Bootjack Alley.—23. The Mermaid, or Scaly Column.—24. The Lost Blanket.—25. Helen's Scarf.—26. Chapman's Lake.—27. Broaddus Lake.—28. The Castles on the Rhine.—29. The Imperial Spring.—30. The Skeleton.—31. The Twin Lakes.—32. The Engine Room.—33. Miller's Room.—34. Hawes' Cabinet.—35. Specimen Avenue.—36. Proposed Exit Avenue.

MAP OF LURAY CAVERN.

The Expanding Power of Ice.

In a recent number of *Naturen*, Hr. Bergh has drawn attention to the powerful agency exerted by ice in severing rocks, of which he gives a striking instance occurring on the Aalesund in West Norway, where a low ledge rising out of the fjord is all that remains of a once extensive fjæld promontory, which, in the year 1717, was suddenly blown up and precipitated into the water by the force of the ice within the interstices of the stone. The winter had been mild, and during a rapid thaw a considerable stream had welled up from the ice covered summit of the fjæld, and carried its waters into every crevice of the rock, when a sudden change of wind brought about a sharp frost, which turned the descending waters of the newly formed stream into ice, arresting their course within the interstices of the rock. The result was the explosion of the entire mass of the fjæld below the outbreak of the stream, and its projection from a height of more than 1,500 feet into the neighboring fjord, which ingulfed the whole of the promontory, with its cultivated fields and farmstead. Simultaneously with the disappearance of the land below the surface of the fjord, a huge mass of waters was propelled against the opposite shore, carrying with it rusty anchors, boat rafters, and numerous other objects which had long lain at the bottom. The disturbance extended a mile beyond the point at which the land was submerged, and the waters in retreating carried with them a wooden church which had stood fifty feet above the fjord, besides sweeping away all the fishing boats for a distance of two and a half miles. Before this occurrence, which was attended by loss of life to about a score of persons, the headland had been much resorted to on account of the halibut which abounded in the neighborhood, but since that period the fish has never returned, a circumstance which, according to local popular belief, is due to the covering up by the infallen rock of certain submarine cavities and springs frequented by the fish.

MISCELLANEOUS INVENTIONS.

An improved dentist's broach has recently been patented by Mr. Olof Johanson, of New York city. The object of this invention is to improve the construction of the ordinary dental broach for cleaning hollow teeth and extracting nerves by rendering it equally flexible in all directions, so as to reach every part of a hollow tooth, and making it stronger, so that when revolved it shall be less liable to break than the ordinary broach.

Mr. Charles Royle, of New York city, has patented an improvement in that class of lamps in which the oil chamber is surrounded by, supported upon, and connected with the pedestal by a body made of ornamented porcelain. The invention consists of the body made of cement moulded into shape and covered with a shell of ornamented sheet metal or paper.

An improvement in desks has been patented by Mr. Joseph H. Burrows, of Boise City, Idaho. The invention consists in combining with a main section and writing board two hinged bars pivoted to the lower ends of two slide rods and a block.

An improved method of embroidering and apparatus therefor has been patented by Mr. Joseph Halter, of Rebstein, Switzerland. The object of this invention is to make different kinds of lace, guipures, and other varieties of machine embroidery that can be made on ordinary embroidery machines with cotton, flax, wool, silk, or other thread upon a ground of paper or other material that can be easily washed away or removed when the lace or other open work is completed; also to provide apparatus to support the paper when it would by itself be torn by the embroidery needles and thread; and to connect the embroidery figures by strong thread passed through each figure, so that they are suspended to each other; and to wash away or remove the paper or other easily destructible ground on which the embroidery has been made.

A new apparatus for facilitating adding numbers, and to enable persons not acquainted with the addition table to add numbers, has been patented by Messrs. David M. Fulwiler and James A. Fulwiler, of Lexington, Ill. The invention consists in a board divided into longitudinal columns, each provided with an index letter and containing rows of numbers, the board sliding in a frame attached to a base, and provided with a transverse rule or strip above the board, and having subdivisions corresponding with and indexed the same as the columns on the board, with which they coincide, this frame being also provided with a longitudinal casing at one end, containing a slide with numerals on the upper surface, showing through a slot in this casing, and with ratchet teeth on the lower side, in which teeth a spring pawl in the sliding board catches.

An improved basket for gathering or holding cotton has been patented by Mr. George W. Starr, of Vicksburg, Miss. This basket can be folded very compactly, so as to occupy very little space while being transported or stored. It is formed of an upper metal ring with loops, in which rods are pivoted, having their lower ends bent over, so that they will catch under the bottom, which is attached to the sides, made of canvas.

An improved device for holding drawers in such a manner that they will not be inconvenient to the wearer, and can be fastened or unfastened easily and quickly, has been patented by Mr. William W. Beach, of New York city, assignor to himself and Charles V. Goddard, of same place.

An improved wagon has been patented by Mr. Silas Van Patten, of Duanesburg, N. Y. This wagon is constructed in such a manner that it can be loaded and unloaded by the action of the team while attached to the wagon.

FAILURE OF MATS AS A PROTECTION TO THE RIVER FRONT OF NEW ORLEANS.—SOMETHING NEW WANTED.

The board of engineer officers appointed last fall to examine the work in progress for the protection of the river front of New Orleans have reported against the continuance of the present plan of operation. This work, it will be remembered, has been going on for several years to stop the more or less rapid erosion of the river front of the city, by carpeting the slope of the river bed with mats of brush and cane.

The course of the Mississippi at New Orleans is such as to throw its powerful current directly against certain portions of its bank. Issuing from the straight reach above Nine Mile Point, it makes a sharp bend to the right at Carrollton, then gradually curves to the left to the foot of Canal street, and then makes another sharp bend to the right, after which it follows a nearly straight line until beyond the city limits. The width at Carrollton is about 2,250 feet, and the channel depth about 140 feet, and these dimensions remain nearly uniform to about the middle of the gentle leftward curvature, when the width is gradually reduced and the depth increased. The former finally becomes about 1,900 feet and the latter reaches a maximum of over 200 feet, and it is in this shape that the river enters the sharp bend below Canal street, called in New Orleans the third district. The entire Mississippi River, concentrated to a degree nowhere else to be found along its course, and possessing therefore its maximum power of excavation, is here turned about an angle of 90° upon a radius of about 3,000 feet. The concave bank—meaning by that term the entire slope from the top to the bottom of the river—which can resist such a force for even a brief period must possess great stability. Rapid excavations and deep incursions are to be expected.

It was ascertained by the Board of Engineers convened by the Mayor of New Orleans, in 1877, that the bank at Carrollton Bend had receded about 500 feet in twenty years. While this has resulted in the loss of considerable valuable property and should be checked, the locality is of altogether secondary importance when compared with the third district. At the latter place vast commercial interests are concentrated; the bank is crowded with wharves, and every inch of the adjoining ground has a value. Here the bank is practically where it has been for a century and a half, or rather there has been no recession. At the extreme upper end of the bend, in the immediate vicinity of Canal street, there have been large accretions, several blocks of the city having been added and built upon outside of what was formerly the shore line. This is due to the natural movement of the bend down stream. In the bend itself considerable batture formations have occurred at intervals and then disappeared. This cannot be accounted for without a knowledge of the various obstacles, such as wharves, wrecks, etc., that may have been placed in the river at various periods—information not now attainable.

The explanation of the fact that the main bank as a whole maintains its position is found in the multitude of wrecked wharves and bulkheads which here line the river front. There is no record of how many wharves and bulkheads have gone in at any one place, but the number is known to be large. In some cases a wharf has lasted but a single year. Divers report that the remains of these structures are to be found all the way to the bottom of the river.

The piles, beams, and planks, though more or less held together, are twisted into irregular shapes, making excellent silt-catching devices. But this is a very expensive protection; and the repeated destruction of the wharves has rendered high wharf rates a necessity, so that the entire commerce of the port is interested in having the evil removed.

The plan proposed in 1878 was to cover the upper section of the river slope at Carrollton with a layer of brush ballasted with stone. For the section from Morgan's Wharf to the foot of Congress street, including the sharp bend below Canal street, it was proposed to form a bulkhead in line with the outer row of wharf piles, by driving piles in pairs three feet apart, the distance between the pairs to be six feet; these piles to be bolted together at low water and at the top, and a wall of brush fascines set up between the piles, up and down stream, to low water mark; the rest of the space to high water to be planked. From the foot of the row of piles it was planned to lay upon the slope mats of brush ballasted with stone as far out as might be necessary to cover all defective strata.

Operations have been carried on during the low water seasons of 1878, 1879, 1880, and 1881, the work for the first three years being confined to the third district, while the greater portion of the work done the next year was in Carrollton Bend. The following method of construction was adopted for the former district:

The mat was first made in small sections, 24 feet by 25 feet, the material used being cane. In the finished section the canes lay in a single layer, side by side, with sufficient interval between them to allow for the stitching, say one inch. It was sewed from one end to the other by seven continuous pairs of wires or pieces of marline, the latter being used to the exclusion of wire after the first few mats were placed. The stitch was the shoemaker's stitch; that is, one marline passing under one cane, passed over the next, under the third, over the fourth, and so on, while the other marline of the same pair alternated in the same manner, but passing on the opposite sides of the canes. The marlines thus crossed each other at each interval between the canes. In crossing they were not caught together. They were secured only to the middle and end canes of the section. The breaking of a marline at one point destroyed its efficiency throughout its length. An opening was made in each joint of each cane to destroy its buoyancy and admit sediment from the river after sinking. Eight of these small sections were sewed together, end to end, making a mat 200 feet by 24 feet, and it was in this shape that the mats were put down during the seasons of 1878 and 1879. For placing them a row of guide piles 6 feet apart were driven upon the line of the front wharf piles. These were heavy piles of pine 65 feet long, and were intended to subsequently form part of the brush wall described in the plan. An iron ring was slipped over each pile, fitting loosely, to which the end of the mat, the 24 foot side, was secured by a piece of light rope. The barge upon which the mat was spread was then moved out into the stream by a tug boat, the mat was launched and placed upon the bottom, with its longer side as nearly as possible perpendicular to the shore. The ballast used with the first few mats was old boiler tubes, and afterward sand bags. Buoys were attached to each mat before sinking, by means of which its location upon the bottom could afterward be approximately ascertained.

Care was taken to sink a new mat at any place which seemed to have been left uncovered, but notwithstanding this precaution, it is probable that some portions of the slope within a distance of 200 feet were left uncovered. The presence of ships at the wharves was a serious inconvenience to the work, causing frequent interruptions. It could not be made continuous. The work done in 1878 and 1879 was begun just below Picayune Pier and extended to the foot of Mandeville street, covering a length of 1,116 feet measured along the bank. It consisted entirely of matting of the above description, nothing being done toward the brush wall except the piling.

In resuming operations in 1880 it was found impossible to begin at Mandeville street, where the work of 1879 terminated, because of the number of ships moored below, as many as twenty sometimes lying between Mandeville and Montegut streets. These the wharf master refused to move. Work was accordingly begun at Montegut street, leaving a gap of 2,262 feet between that and the work of 1879. The general construction of the mats was the same as before, except that they were made larger. Forty sections, each 14 feet by 25 feet, were sewn together, making a mat 200 feet by 70 feet, instead of 200 feet by 24 feet, as before. Floating ways, having the direction of their slope parallel to the shore instead of perpendicular to it, as before, were moored to the guide piles. The mat, being secured to the latter in the same manner as before, was launched up and down stream instead of across stream, as before. Ten such mats, covering a length of 560½ feet of bank between Montegut and Louisa streets, were laid in 1880.

The ballast used was sand bags. Very little work was done at this place last season.

The wharves in front of which the work of 1878 and 1879 was done fell into the river in 1880. They were rebuilt and were wrecked again in 1881. The wharves in front of which the work of 1880 was done were destroyed in 1881.

The decision of the board of engineers is that the plan of improvement as executed, so far at least as the third district is concerned, is a failure.

"The impossibility of doing continuous work, and the flimsy character of the matting put down, would perhaps account for this. Under any plan a remedy for the first evil consists in withdrawing the portion of the river front under improvement from wharf service while the work is going on, and this requires the co-operation of the city authorities. The cane is not, in the opinion of the board, a good material for the protection of the banks of the Mississippi. Its straightness and smoothness deprive it, to a large degree, of the silt-catching quality which is of so great importance in the revetment of the banks of this river. A mattress made of cane receives little if any re-enforcement from the deposits of the river. If this material be used the mattress should be fabricated with great care, all its fastenings should be made substantial, and if it be found impracticable by any disposition of the material to procure an artificial roughness, it should be prepared to resist by its own strength all the forces which may be brought to bear against it. This has not been done, and in the opinion of the board the mats, as constructed, do not form a protection as efficient as the one contemplated in the plan.

"While the method of construction has been defective, and the circumstances of carrying on the work have been singularly difficult, it is the opinion of the board that no better results would have been attained in the third district if both these causes of failure had been wanting. The problem here seems to be one of wharf protection rather than of bank protection, though the latter question appears in the background.

"The root of the principal evil—the repeated destruction of the wharves—seems to lie in the construction of the wharves themselves. The bearing piles, fender piles, and mooring piles alone obstruct the flow of the water and cause deposits. When to these are added the remains of old wharves, old broken and settled piles, and old bulkheads, a collection of obstacles is found near the top of the bank which, for efficiency in causing silt deposits, could hardly be excelled if designed for that purpose. Heavy deposits are made among them and between the wharves during the higher stages of the river when it is charged with sediment. This mass of soft material acquires in time a bulk and weight which the steep slope below cannot support, even while it remains submerged. When the river falls the new deposits are often uncovered, and the tendency to rupture is increased by the withdrawal of the support furnished by the water. The difficulty is aggravated by the presence of vessels.

"Vessels lying at the ends of the wharves deflect the current downward toward the bottom, and while preventing deposits at that place cause a scour upon the material below. The deeper the draught of the vessel the deeper will this action extend. A vessel drawing 25 feet will, if left long enough at one spot in a rapid current, deepen the water by an amount nearly equal to its draught. Here are all the conditions necessary to explain the various phenomena which accompany the destruction of the wharves. The slope of the bank being too steep to bear the great additional weight at the top of it yields, and may yield in a variety of ways. The new material may slide out, carrying the upper parts of the piles with it, and leaving the toes undisturbed; in this case the piles will be inclined outward. Or it may settle down vertically, pushing out a layer of similar material from beneath it. If the latter layer is within the range of the piles it will carry their toes out, and in this case the piles will be inclined inward; if it is beyond the range of the piles these will simply sink and not be inclined either way. In the disintegration attending these disruptions a crack may be formed into which a pile will sink of its own weight, and, tearing loose from its cap, will settle down with greater rapidity than the balance of the wharf. A combination of the two movements above described, or unequal loading of the wharf, or an eddy about its extremity, or the unequal stability of different portions of the soil underlying the fresh deposits, will account for the irregularities which sometimes appear in the wreck of a single wharf. The yielding of the bank may occur at any stage of water, though it is most usual immediately after the fall from a high stage, and is rare immediately after a prolonged low stage. The increased draught of the sea-going ships now visiting New Orleans would cause more rapid wrecking of their wharves than formerly. While the presence of vessels at the ends of the wharves aids and hastens their destruction, it is, as before stated, not essential to it.

"How far down this sloughing of the bank extends is not now known, and it can be ascertained only by careful and prolonged observation. It would seem probable that the depth is not great, not exceeding perhaps a depth of 40 or 50 feet. But whatever the depth, a preliminary to any efficient protection must be the removal of the primary cause of the sloughing, viz., the overloading of the top of the bank by silt deposits. The brush wall proposed in the plan under discussion would have the contrary effect. It would increase the amount of this overloading and would aggravate the evil.

"The board is, therefore, forced to the conclusion that the present plan of improvement, whether viewed in outline, as to its general merits, or in detail, as to its method of execution, should not be continued."

The board does not offer any substitute for the plan of operation which it condemns.