

IMPROVEMENT OF MISSISSIPPI RIVER BETWEEN THE MOUTHS OF THE
ILLINOIS AND OHIO RIVERS.

Officer in charge, Col. J. H. Simpson, having under his immediate orders Capt. C. J. Allen, Corps of Engineers.

1. *Improvement of Mississippi River.*

A. *Piasa and Alton Dams.*—The funds available for these works are:

Balance July 1, 1876.....	\$3,682 76
Appropriated August 14, 1876.....	15,000 00
	<hr/> 18,682 76

Which were to be applied to the construction of Piasa Dam and such repairs and extensions as were needed at Alton Dam. There has been expended during the fiscal year:

Piasa Dam	\$7,525 64
Alton Dam.....	696 40
	<hr/> 8,222 04

The balance will be applied during the coming year. Further appropriation to the amount of \$15,000 will be required to complete the works already begun.

B. *Sawyer Bend and Venice Dike.*—No work has been done at Sawyer Bend nor at Venice for want of funds. The completion of the estimated work at these points will require \$53,929.10.

C. *Improvement of channel opposite Saint Louis, (closing Cahokia Chute.)*—The work done under the appropriation of \$29,600 has been confined to the revetment of Arsenal Island and the construction of the abutments of the dam. The officer in charge submits a suggestion in connection with this work which is worthy of consideration; the essence of the suggestion being that since the closing of the chute will seriously increase the risk of damage to boats in the harbor by ice, as was conclusively demonstrated by the experience of the last winter, it would be advisable to make the dam a high one instead of low, as now authorized, so as to form a protected pool which may be made a secure and permanent winter harbor. The data for a full estimate of cost not being available, it is recommended that a survey and estimate be ordered.

D. *Horse-tail Bar.*—The condition of navigation at Horse-tail Bar was very unfavorable much of the season of 1876. Owing to the delay of appropriation, nothing could be done until September. Relief quickly followed the resumption of work, and it is hoped that the works are now in such state of advance that the channel will remain under their influence throughout the year. The locality has been brought to that stage of progress when protective work becomes necessary, which in this case takes the form of a longitudinal dike, an estimate for which is submitted by the officer in charge.

E. *Fort Chartres and Turkey Island.*—No work was done or contemplated at Fort Chartres until further appropriation.

A small amount of work was done at Turkey Island, which put the work in safe condition until further means are provided.

F. *Kaskaskia Bend.*—No work has as yet been done at this locality, the funds being withheld in 1876. The progress of erosion is rapid, and further appropriation is urgently needed.

G. *Liberty Island.*—Protection near Liberty Island has been extended 2,700 feet during the year; the protected part is now 6,474 feet, and benefit is being derived from the greater permanence of channel and absence of the snags from the caving banks.

H. *Devil's Island*.—The favorable results previously reported continue. The dams are still unfinished, the work of the past year being mostly limited to extending the revetments.

I. *Dickey Island to mouth of Ohio*.—Protective work to check the erosion in rear of the city of Cairo was begun in 1876. The principal effort was to secure the series of spur-dikes from destruction, and to extend the protection by continuous revetment. The work done remains perfect, and promises to be efficient. Work will be resumed to full extent of funds this season.

The officer in charge recommends that, in case Congress is not disposed to grant larger appropriations than heretofore, no new works be undertaken until those now in hand be complete. Works now begun will require \$555,425.49 to provide for their completion, of which nearly two-thirds is for work begun by direct or implied order of Congress.

The officer in charge submits an estimate of \$500,000 for the fiscal year ending June 30, 1879. This sum would secure the completion of the works that are now in advanced state, and also allow some new work to be begun. The appropriation of the above sum is recommended.

July 1, 1876, amount available.....	\$15,724 68	
Amount appropriated by act approved August 14, 1876.....	229,600 00	
		\$245,324 68
July 1, 1877, amount expended during fiscal year.....	138,920 54	
July 1, 1877, outstanding liabilities.....	5,803 69	
		144,724 23
July 1, 1877, amount available		100,600 45
Amount (estimated) required for completion of existing project.....	6,729,600 00	
Amount that can be profitably expended in fiscal year ending June 30, 1879.	500,000 00	
(See Appendix N.)		

IMPROVEMENT OF MISSOURI RIVER ABOVE THE MOUTH OF THE YELLOWSTONE.

Officer in charge, First Lieut. Edward Maguire, Corps of Engineers.

The party organized for this work left Saint Paul, Minn., on June 11.

The length of time required to reach the scene of operations permitted the accomplishment before the 30th of June of nothing more than a detailed survey of the locality.

During the present season it is proposed to commence operations at Dauphin's Rapids, and thence proceed to Cow Island, Two Calf Island, and such other points as the length of the season will permit. The work will consist in the removal of bowlders, reefs, and bars, and in the construction of wing-dams.

Amount appropriated by act approved August 14, 1876.....	\$20,000 00	
July 1, 1877, amount expended during fiscal year.....	\$4,589 33	
July 1, 1877, outstanding liabilities.....	951 04	
		5,540 37
July 1, 1877, amount available.....		14,459 63
Amount that can be profitably expended in fiscal year ending June 30, 1879.	30,000 00	
(See Appendix O.)		

APPENDIX N.

ANNUAL REPORT OF COLONEL J. H. SIMPSON, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1877.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., August 1, 1877.

GENERAL: I have the honor to submit herewith my annual report for the fiscal year ending June 30, 1877.

In addition to the duties connected with the works of river and harbor improvement under my charge, I have also served as a member of the Board of Engineers constituted by Special Orders No. 52, Headquarters Corps of Engineers, dated June 22, 1876, to inquire into the expediency of causing sheer-booms to be placed above bridge-piers on the Mississippi River.

I was also detailed by Special Orders No. 99, Headquarters of the Army, Adjutant-General's Office, May 19, 1876, as president of a board to retire disabled officers, to convene at Saint Louis on the 29th of that month, which board was dissolved by Special Orders No. 108, dated June 1, 1876, without performing any duty for which it was constituted.

In forwarding my report, I cheerfully acknowledge the valuable aid of my assistants and clerks, who have never failed to perform their duty assiduously and completely, and without whose assistance the Government could not have accomplished the favorable results which I believe have attended the engineering operations of this district. These gentlemen are Capt. Charles J. Allen, Corps of Engineers; Assistant Engineer Robert E. McMath; and S. S. Hutchins, chief clerk, with S. G. Clark, his assistant, in the office; and Assistant Engineers D. M. Currie, Charles S. True, and W. S. Simpson, in the field, and William Popp, assistant engineer and draughtsman, both in field and office.

Very respectfully, your obedient servant,

J. H. SIMPSON,

Colonel of Engineers, and Brevet Brig. Gen. U. S. A.

Brig. Gen. A. A. HUMPHREYS,

Chief of Engineers, U. S. A.

IMPROVEMENT OF THE MISSISSIPPI RIVER BETWEEN THE MOUTHS OF THE ILLINOIS AND OHIO RIVERS.

BETWEEN THE ILLINOIS AND MISSOURI RIVERS.

The funds available for the continuation of the works in this section were:

Balance July 1, 1876.....	\$3,682 76
Provided in act approved August 14, 1876	15,000 00
	<hr/>
	18 682 76

It was proposed to continue the construction of the dam at Piasa Island, and to make such repairs and extensions as were needed to the abutment of the dam at Alton Slough.

DAM AT PIASA ISLAND.

Work was commenced in October under arrangements made for purchase of material in open market, riprap being delivered on barges near the dam at 70 cents a cubic yard. The material was unloaded and placed in the dam by hired labor. Work was continued until the end of November, when it was suspended for the season.

The expenditures were:

30 mooring-piles	\$156 31
5,474.92 cubic yards riprap	5,097 80
Engineering and contingencies	2,271 53
	<hr/>
	7,525 64

The foundation of the dam was completed, and the base of dam widened throughout its length. The revetments below the dam were extended to a length of 150 feet on both banks. The dam is now considered secure, though incomplete. The available balance will be applied toward the completion of the prism of the dam. It will probably be necessary torevet the head of the island, as it is being cut away to some extent. The channel has continued good in this vicinity.

ALTON DAM.

Owing to the early setting in of winter less work was done toward extending the revetments below the dam than was intended. The west abutment now extends 235 and the east 220 feet below the center line of the dam. These lengths will probably be sufficient, but the revetments are incomplete in height. When last reported the height of the dam was stated to be 10 feet above low water. The height was materially reduced by the ice this spring, by very heavy fields passing over the dam when the river broke up.

The expenditures on the dam were:

569.68 cubic yards riprap	\$652 17
Engineering and contingencies	44 23
	<hr/>
	596 40

It is proposed to complete the revetments this fall. No complaint has reached this office of any failure of the dam in practical results. Local interests frequently urge that the dam be raised so as to be a high-water dike, available for a roadway, to which proposition no engineering objections can be raised.

PROTECTION OF SAWYER BEND.

No work was done at this locality for want of means. The old revetment has been somewhat injured where the ice has cut through the rock facing. The damage is not serious, but it is hoped that means will be provided at the coming session of Congress for the continuation of this work.

LONG DIKE, NEAR VENICE.

For reasons given in my last year's report nothing has been done at this locality.

The work remains in the same condition as at the date of last report.

A survey and estimate of damages, if any, done or to be done to riparian owners, by reason of the Government improvements, has been ordered, and will be made as soon as practicable, when a report will be submitted.

CLOSING CAHOKIA CHUTE.

This work was authorized by special clause in the appropriation bill of August 14, 1876, providing \$20,000 toward the construction of a low dam and the revetment of Arsenal Island. The island was being cut away by the river so rapidly that it was necessary to devote the whole appropriation to securing the remnant of the island and the site of the proposed dam. A low revetment was made of part of the west side of the island for a distance of 600 feet, in two sections of 450 and 150 feet, respectively, being separated by a projecting clay point, which, protruding beyond the line adopted for the final eastern limit of the river, was left unprotected in order that it might be cut away. On the east side of the island the immediate vicinity of the dam was protected by a revetment 750 feet in length, extending 450 feet below the line of the dam. This revetment was carried to the top of the bank. The eastern or Illinois shore was also revetted for a distance of 500 feet.

The expenditures were—

2,478.2 cubic yards riprap, west shore of Arsenal Island.....	\$2,832 61
8,092.3 cubic yards riprap, east shore of Arsenal Island.....	9,268 04
5,542.7 cubic yards riprap, Illinois shore.....	6,192 12
Engineering and contingencies.....	2,665 84
Total	20,958 61

Nearly all the work on the Illinois shore, and nearly one-half of that on the east side of the Island, was done in February and April of the present year. All this work is in good condition. But little more can be done until further appropriation is made. The estimate for the dam is, as stated in last report, \$75,000 for a low dam.

The projected closing of this chute compels a consideration of the consequences which will result therefrom to the harbor and commerce of Saint Louis. Heretofore the expansion of the waterway at the island into two channels, either capable of passing the whole volume of the river at ordinary stages, has relieved that portion of the harbor below the bridge from dangerous pressure when ice was running, and the west bank in the vicinity of the island has for many years been considered one of the safest winter-harbors on the river. On December 3, 1876, the ice gorged in the Cahokia Chute, compelling the whole body to pass down the Arsenal Channel. The immediate consequence was the total loss of several steamers and barges, and material injury to many others.

The losses were at first estimated at nearly \$200,000; but as the river was wholly blocked in a few days, and remained firmly closed for two months, some of the sunken boats were raised, and others endangered were secured, lessening the final loss. Much apprehension was felt lest, when the ice broke up, all the remaining boats should be destroyed. Fortunately the gorge in Cahokia Chute ran out February 1, the other chute remaining closed until the 8th; consequently the hard ice of the harbor found an open passage on the opposite side of the river to the exposed property, and little damage was done. The experience of the last winter from natural causes affords an illustration of what will be the yearly experience when the chute is closed by a dam. There will then be no place within convenient distance of Saint Louis where boats can lie during the winter with reasonable safety. The tonnage employed on the upper rivers will be compelled to retire to

Alton Slough betimes, and that of the lower river, of which a considerable part cannot pass under the bridge, will have no refuge, and must remain away from Saint Louis, or incur the risk of being lost should a sudden intense cold find them there. As the inevitable result of closing the chute will be to deprive the tonnage of Saint Louis of its only ice-harbor, it seems necessary to call attention to the danger, and to suggest a remedy; for the interests of commerce demand that there should be a winter harbor of refuge in the immediate vicinity of Saint Louis. The proposed dam is a necessary improvement, and, in my opinion, can readily be so designed as to afford a much better winter-harbor than has ever existed.

If the proposed dam be made a high one, the pool below it will afford a perfectly secure and easily-accessible harbor, provided it can be kept from filling up with sand. With a high dam and the side-protection of the island there would be little danger of the pool itself filling; the only problem would be to keep a sufficient entrance to it open.

I am confident that this can be done by extending the point of the island artificially to within a short distance of either the railroad embankment and incline opposite Carondelet, or within like distance of a dike, which might be constructed near the Bessemer Iron Works, and near the proposed location of the Saint Clair and Carondelet Bridge.

Having made no special surveys for the purpose, I am not able to submit any estimate of the cost of modifying the project as suggested. The fact that a part of the working-equipment belonging to the United States shared in the danger of last winter mentioned above, and to a small extent in the damage, compelled me to share in the anxiety felt by all interested in the exposed property, and justifies this proposition to extend the projected works with a view to obviate such risks hereafter.

The sudden and unexpected formation of ice at so early a date rendered it impracticable to remove the Government property from the locality, which the results showed to be a dangerous one, though judging from former experience, no one could have selected a place less likely to be dangerous.

From comments made last winter, it would seem that comparatively few comprehend the nature of ice-risks in the Mississippi, which are much more serious than would naturally be expected, considering only the latitude and mean climate at Saint Louis.

Ice forms along the margin of the river at a temperature of about $+20^{\circ}$ F. and below. Owing to the rapid current it is continually being detached, and as the temperature falls, the quantity becomes very great. By attrition between the masses it is reduced to the form of mush-ice, which in extreme cold becomes more compact, and when the river is full, heavy masses are cemented together under pressure by "regelation." While moving, the mass is often several feet in thickness and capable of crushing vessels by pressure, when its soft condition and very slow movement scarcely suggest the thought of almost resistless power. In this state it arrives at some part of the river exceptionally narrow or shoal; in the former case the mass is compacted together on the surface and solidifies very quickly under pressure; other ice following, piles upon its surface and is drawn under until a complete dam is formed and the ice is said to be gorged. This dam arrests both ice and water until the accumulated head furnishes energy either to break through the dam, cut around it, or to lift the dam high enough to detach it from the sides; when the first or last contingency occurs the movement is rapid, and no human device can avail to save whatever is exposed. During the last winter the gorge in Arsenal Chute was found by actual measurement to be 22 feet in depth, and the water-level, at one time, 8 feet higher at the

Arsenal than at Elwood street, Carondelet, 3 miles below. With these facts in mind, it is easy to understand why such serious disasters sometimes occur; indeed the wonder is that anything escapes.

The losses from ice at Saint Louis since 1865 must aggregate over \$500,000. Should the opportunity now available at Arsenal Island not be improved, and the chute be allowed to silt up, as would naturally result from a low dam, there would then be no opportunity to secure a harbor of refuge within 30 miles of the city. I therefore recommend the matter to the consideration of Congress, and those interested, as worthy a close examination.

HORSETAIL BAR.

As stated in the last annual report, the navigation at this locality was extremely bad during a great part of the season of 1876, furnishing occasion for much complaint, and criticism of the work which had been done for its improvement. The facts concerning which there could be no dispute were, that after an unusually long high-water period, attended with very active erosions in the vicinity of Arsenal Island, (Horsetail being the natural place of deposit for this eroded material,) the bed of the river was filled with sand to the height of about 10 feet above low-water mark; the dikes at that time were none of them higher than 8 feet above low-water; it is therefore plain, that with a depth of channel of only 6 feet and a stage of water above 14 feet, the dikes could have been exerting no influence either beneficial or injurious; they, therefore, did not cause the difficulty, and are only chargeable with the failure to prevent it.

The work done in the years 1873 and 1874 was chiefly designed to relieve the difficulty at the then bar opposite Jefferson Barracks. The difficulty now referred to was located nearly 2 miles farther up stream, a locality where previous to 1875 there had been no trouble since 1870. When this bar made its reappearance in 1875, works were commenced with a view to its removal; this work, begun in October, 1875, had not progressed far enough to exert any appreciable influence when suspended in December for want of funds. No additional means were provided until the latter part of September, 1876. As soon as practicable, after that date, work was resumed and vigorously pushed. Owing to the raising the dikes, and the fall of the river, a channel was scoured out which became available October 23, one month and two days after the work was begun.

This channel gradually deepened until the close of the navigation, affording from 6½ to 9 feet, which latter depth was maintained through the early spring of 1877, at stages varying from 8 to 12 feet. The dikes, therefore, acted promptly and satisfactorily, as soon as the stage of water brought the channel within their influence, and continued to do so until the water rose to a stage which prevented further observation or inquiry concerning them.

As a result of the year's operations, dikes 1, 2, and 3 are raised to a height that will bring them into action when the river falls below an 18-foot stage, and we may, therefore, anticipate that the difficulties which were experienced in 1875 and 1876, while the river was falling from 15 to 9 feet above low-water, will not be repeated in the same locality. There is, however, a possibility that there may be trouble farther down stream, owing to the insufficient height of dike 4 and incomplete state of dike 5. With the means now on hand it is the intention to resume work with the expectation of being able to prevent serious trouble, if there should be a tendency of the mean-stage channel to run across dike 4, which is the only danger anticipated.

Dike 5, as has been stated in previous reports, crossed a small tow-head, which last year proved a weak point, the tow-head being cut in two just below the dike, and producing a break in its continuity, which it will be necessary to fill. When this dike is restored and dike 4 raised, (which last need not be done unless the tendency of the channel demands it,) the system of dikes perpendicular to the current will be practically complete to an extent justifying the commencement of a training wall to connect the outer ends.

In European river improvements these training walls have been found necessary to success, and this improvement has often been sharply criticised because all the work hitherto done has been upon a series of perpendicular dikes or wing-dams, which, of themselves have been always found unsatisfactory, and the question is often asked, why the longitudinal dike has not been built. The reason is, that in all cases the longitudinal dike must be connected with the bank by cross-dikes, and the order of construction must be governed by circumstances. In a narrow stream, where the longitudinal dike can in no place be more than a few hundred feet from the bank, the construction of the cross dikes is a matter so easy that they may well be made numerous, and be built as the longitudinal dike progresses, or even after it. But in a wide river, where the improvement contemplates narrowing the bed nearly one-third, or even one-half of its width, it would not be prudent to follow the precedent of smaller streams too closely. With unlimited supplies of means it might be possible to carry on both kinds of work with equal steps; but, (as is the case with all Government works in the United States,) when appropriations bear no fixed relation to estimates, it is necessary to conduct the work so as to secure results, although the conductor may be well aware that under other conditions the work could be better done another way.

If, then, but one kind of work can be done at a time, which is the better: to build cross-dikes first, which will have a certain effect in pushing the channel toward its desired position, though not as complete as desired, and await the opportunity to construct the training-wall; or to build the wall first, which for great part of its length must be far out from the bank, and incur the probability of the channel getting upon the wrong side of it, a danger only to be averted by making the longitudinal dike high and massive?

The contemplated training-wall in this case must eventually extend from the ferry dike, opposite Carondelet, to the western side of Carroll's Island, opposite quarantine, a distance of 21,000 feet. Consideration of its cost per running foot will sufficiently answer the question of order of construction, for a low training-wall will cost \$5 or \$6 a foot, and the higher near \$20. This answer was and is deemed conclusive. The cost of this training-wall has never distinctly appeared in the estimates, being classed with protective works, estimated in the aggregate at \$4,000,000, (see Report of Chief of Engineers, 1875, volume 2, Appendix C C, page 492;) this particular estimate is \$126,000. The wall, as estimated, is designed to restrict the channel within the lines at low-water, but not to be high enough to be itself exposed to injury by ice.

The expenditures during the year were—

Dike No. 1:	
28 mooring-piles	\$188 11
11,268.6 cubic yards riprap, raising the dike from 6 feet to 15 feet above low-water	12,996 68
Engineering and contingencies	490 90
	<hr/>
	13,675 69

Dike No. 2:	
21 mooring-piles	\$141 10
5,357.3 cubic yards riprap, raising the dike to 14 feet above low-water for a distance of 1,060 feet	5,983 04
Engineering and contingencies	223 41
	<hr/> 6,347 55
Dike No. 3:	
24 mooring-piles	\$161 24
19,832.5 cubic yards riprap, raising the dike to 13½ feet above low-water for a distance of 1,335 feet	22,554 70
Engineering and contingencies	842 87
	<hr/> 23,558 81
Dike No. 4:	
2,306 cubic yards riprap at shore end revetments and stem of dike	\$2,548 14
Engineering and contingencies	93 80
	<hr/> 2,641 94
Dike No. 5:	
5,626 cubic yards riprap placed in breach made by washing away of tow-head.	\$6,437 77
Engineering and contingencies	242 79
	<hr/> 6,680 56

All work was done by hired labor with material purchased in open market.

It is proposed to continue the repairs of dike 5, to raise dike 4, and to commence a section of longitudinal dike the present season, with funds now available.

FORT CHARTRES DAM.

No work has been done at this dam, which is in good condition, though incomplete. In order to preserve the favorable condition of channel in this vicinity the revetment of a portion of Fish Bend will be necessary, and also part of the Illinois shore opposite the island. Length of protection necessary, 18,000 feet, at an estimated cost of \$234,000.

TURKEY ISLAND DAM.

A small amount of work was done at this dam in October, 1876, toward filling the prism. The site is inaccessible when the river is low; consequently work can only be done on it at intervals. The work already done is in fair condition. No work is contemplated here the present season.

The expenditures were—

1,865.75 cubic yards riprap	\$2,559 18
Engineering and contingencies	414 21
Total	<hr/> 2,973 39

KASKASKIA BEND.

The specific sum set apart in the act of August 14, 1876, having been withheld until April 19, 1877, no work has been done. The caving has progressed rapidly since the special report was made. The least distance between the two rivers March 18, 1876, was 2,080 feet; on May 16, 1877, it was reduced to 1,504 feet, since which time it is reported that the caving continues. The caving during low stages was located nearer the head of the bend than was anticipated when the report was written.

The amount available will, therefore, be applied to that part of the bend the coming fall. It will be necessary to continue the work until the whole distance estimated is protected, requiring further appropriations to amount of \$37,000.

REVTMENT NEAR LIBERTY ISLAND.

This revetment, commenced in 1875, has been extended during the year 2,700 feet, making the length of bank now partially protected to the height of about 12 feet above low-water, 6,474 feet, which covers the most important part of the caving. It would be desirable to carry the revetment higher up the bank, but no funds are now available for the purpose. An allotment of \$15,000 is desired to continue the work.

The expenditures during the year were—

11,607.82 cubic yards riprap	\$17,254 17
Engineering and contingencies.....	1,215 12
Total	18,469 29

DEVIL'S ISLAND.

Work at Devil's Island was resumed March 7, 1877, and continued until the 15th of April, when it was suspended on account of the quarry being flooded. An erosion occurring at the east end of dam No. 2 during the latter part of April and first of May, endangering its connection with the shore, caused the necessity of procuring stone at the stages then prevailing. In order to do this a berme was raised at the quarry to 27 feet above low-water, thereby rendering it available at that and lower stages.

Following the order in which the work here was done, the work of March and April was on revetment above and below dike No. 1. That above was extended to the length originally contemplated, say 1,000 feet, and was raised to about 15 feet above low-water. Its height is not very regular, however, as the stage of water changed frequently while the work was being done, and was above the height contemplated for the revetment part of the time. Therefore this revetment may need some labor to trim it when the stage of water renders it practicable.

Below the dike 250 feet was revetted to the top of the bank, covering the space originally protected by spur-dikes. The spurs had been damaged to such extent as to seriously impair their usefulness. Scouring had reached such depths that repairing the dikes, so as to restore their usefulness, would have been very expensive. It was considered better to cover the space to be protected with a continuous revetment, and to use the available stone from the dikes in the revetment.

Expenditures were as follows:

5,308.91 cubic yards riprap	\$7,591 74
Engineering and contingencies.....	459 75
Total	8,051 49

The next work in order of time was repairing and raising dam No. 2, which was done in the latter part of May and first of June. The east bank was revetted 400 feet above and 250 feet below the dam, and rising from low-water level at either end to the top of bank at the dam. The east end of the dam was extended well back into shore; the west end strengthened, and the dam slightly raised. It may be desirable to raise it more at a lower stage of water, when the work can be economi

cally done. The stage of water was not unfavorable when work was suspended there, but we changed to dam No. 1 in order to secure its east end while it was accessible, and since then the river has risen so much that it is unfavorable for work at both dams.

The expenditures appear as follows :

3,615.79 cubic yards riprap	\$5,170 58
Engineering and contingencies.....	596 26

Total..... 5,766 84

Work was commenced on dam No. 1 June 21, and continued to the close of the month. The east end was strengthened so as to be considered secure, unless a radical change in the direction and velocity of currents should take place. Work of filling the gap was well advanced towards completion, but as the gap is widening slowly it is difficult to estimate how much stone will be required to complete it. It commences at a point about 400 feet from the east end of the dam and extends 250 feet westerly, and was a dry bar when the dam was built, in 1875, the bar extending at that time 650 feet from the east shore. This is not the gap left at close of the working season of 1875 near the west end of the dam, which was filled with sand during the high-water of 1876, the top of the sand being now about 24 feet above low-water.

Expenditures were—

2,917.95 cubic yards riprap.....	\$2,885 67
Engineering and contingencies.....	299 23

Total..... 3,184 90

The work remaining to be done on the works commenced in this vicinity will probably be filling a gap near shore in dike No. 1; filling the gap in dam No. 1, and raising dam No. 2 to 14 feet above low-water; and among works for preservation, the protection of Minton's Point should receive favorable consideration when other allotments are made

DICKEY ISLAND TO MOUTH OF THE OHIO.

Under the provision of the act of August 14, 1876, requiring \$30,000. to be expended within the limits above specified, work was begun in October last and continued until the close of the season. The plan described in the special report dated February 5, 1876, was followed with successful results. The eddies between the old spur-dikes which were being enlarged and threatening to break through the main levee in the rear of Cairo were stopped, and about 500 feet of bank above them partially protected, the total length of bank protected being 1,500 feet. Owing to the sudden closing of navigation the revetment was not made as high as intended, but the condition of the work when last visited was unchanged. A considerable balance of the allotment remains available, which will be applied this fall to raising and extending the protection. It is very important that the work so begun should be extended as soon as possible to the full extent estimated, requiring further appropriations to the amount of \$142,000.

The expenditures were—

156 piles.....	\$400 79
2,234.78 cords brush	6,468 22
5,162.21 cubic yards riprap.....	8,861 80
Engineering and contingencies	2,548 57

Total..... 18,679 38

Reviewing the results of the efforts to improve this section of the river since their beginning in 1872, we have to admit that some expectations have not been realized, because too much was expected by ourselves as well as by the public. Many contingencies have arisen which have increased the cost of individual works beyond what was hoped; still it can be said that as yet it has not been necessary to exceed the estimated sum at any locality. Looking forward to future work it is suggested that unless Congress is disposed to grant more liberal appropriations than have been given hitherto, it will be advisable to modify the plans and limit each year's work to one or at most two localities, and take up new undertakings only as those now begun are completed. In 1874, in confidence that the report of the select committee of the Senate would result in the prosecution of improvements on a liberal scale, the field of operations was considerably enlarged. Since then the act of March 3, 1875, led to the commencement of work at Piasa and Liberty Islands, and that of August 14, 1876, ordered further expansion of the field by works at Cahokia Chute, Kaskaskia, and near Cairo. As a consequence of these congressional orders, some of the works previously begun have remained untouched for the want of the funds diverted to new works which were ordered, while the whole appropriation remained at the uniform figure of \$200,000 annually, except in the case of Cahokia Chute, for which special provision was made.

By commencing works the Government has committed itself at a number of points, and awakened expectation that something useful will be done at each; if these works stop or progress slowly, these expectations are disappointed and complaints are made against the administrative bureau, which, if justified at all, should rest upon the legislative branch of the Government. So far as the matter is left to the discretion of the engineer in charge the policy hereafter must be to devote all available means to the prosecution of works already begun, to the entire exclusion of all new undertakings until these are complete.

It cannot be disputed that there are new works needed at several points as urgently as those now in hand, but the financial limit is absolute and the engineers not at fault.

The estimated amounts required to complete works already begun are—

Piasa Island Dam, begun in 1872, virtually ordered by Congress	\$17,474 36
Alton Dam, begun in 1872, virtually ordered by Congress	7,935 15
Sawyer Bend protection, begun in 1872, virtually ordered by Congress	50,270 95
Venice Dikes, begun in 1872, virtually ordered by Congress	3,658 15
Closing Cahokia Chute, begun in 1876, virtually ordered by Congress	83,641 39
Horsetail Bar, begun in 1873, not ordered, but most important work on whole section	19,606 41
Horsetail Bar protective work, not begun, but essential	126,000 00
Fort Chartres, begun in 1874, not by order	9,750 00
Turkey Island, begun in 1874, not by order	8,101 61
Kaskaskia, ordered in 1876, not yet begun	37,000 00
Liberty Island, ordered in 1875, virtually by provision	8,140 71
Devil's Island, not by order, 1874, very necessary	30,026 14
Cairo protection, ordered in 1876	153,820 62
Appropriations required to finish	555,425 49

It will be seen that the works undertaken under the discretionary authority of the Bureau of Engineers in 1873 and 1874 require to complete them \$193,484.16, and that the balance of the estimate, \$361,941.33, is for works ordered directly or by implication by Congress. Of these latter,

Sawyer Bend	\$50,270 95
Kaskaskia	37,000 00
Liberty Island	8,140 71
Cairo	153,820 62
	<hr/> 249,232 28

are protective works for which the principal influence toward obtaining the order came from local interests. In order that the proper committees may have before them the full extent of the possible field for such applications, a list of localities is given where the banks are caving to a greater or less degree, covering the river from the Missouri to the Ohio:

Opposite mouth of Missouri	36,000 feet caving moderately.
Sawyer Bend	27,000 feet caving moderately.
Above Widow Beard's Island	14,000 feet caving slowly.
Near Smith's Landing	17,000 feet caving fast.
Near Harrisonville	5,000 feet caving slowly.
Near Harlow's or Perry's Towhead	17,000 feet caving slowly.
Fish Bend	20,000 feet caving very fast.
Fort Chartres Landing	15,000 feet caving slowly.
Big Fields below Saint Genevieve	17,000 feet caving slowly.
Kaskaskia and vicinity	21,000 feet caving very fast in part.
Bois Brule, below Saint Mary's	27,000 feet caving slowly.
Liberty Island	26,000 feet caving slowly.
Above Big Eddy	14,000 feet caving rapidly.
Grand Tower Island	21,000 feet caving slowly.
Near Poe's Landing	9,000 feet caving slowly.
Minton's Point	4,000 feet caving rapidly of late.
Cape Girardeau Bend	19,000 feet caving very slow.
Dog Tooth Bend	20,000 feet caving moderately.
Thompson's	6,000 feet caving moderately.
Greenleaf's Bend	25,000 feet caving rapidly.
Dickey Island to Ohio	17,000 feet caving rapidly.
Bird's Bend	30,000 feet caving rapidly.

407,000 feet.

In addition to these, which are all confined to the main bank, there would be engineering reasons for the protection of islands at various points in direct connection with improvements of the channel, amounting in the aggregate to 80,000 feet, to which may be added the work of defining the eastern limit of the river in front of Saint Louis, and extending to Carroll's Island, 63,000 feet, making a total length of 550,000 feet, the cost of which will vary from \$6 to \$20 per foot. Taking the mean at \$13, there is a total estimate of \$7,150,000. Of this aggregate, (by shortening the measurements to what would probably be necessary to protect,) 327,000 feet remains as the estimate of necessary protections, which, at \$13 per foot, as above, would cost \$4,251,000, which is reasonably near the approximate estimate of \$4,000,000 given in the report on transportation routes, Report of Chief of Engineers, 1875, Part II, page 492.

SURVEYS.

No surveys were made except such as were required for the final location of new works at Cahokia Chute and near Cairo, and a partial resurvey at Horsetail Bar, in connection with the work at that locality.

EQUIPMENT.

No additions have been made to equipment during the year. Two of the barges first purchased having become worthless for further service were sunk to form part of foundations; the remainder of property is on hand and most of it is in good condition for further service; but three more of the old barges will have to go out of service the coming year, being too old for repairs. As this will reduce the number of serviceable

barges below the requirements of the work, it is hoped that appropriations will allow the purchase or construction of four new barges, at an estimated cost of \$13,000, the ensuing year.

The prosecution of the works the last season by purchase of material in open market and by hired labor has been very satisfactory, material having cost fully one-fifth less than it was ever obtained for by contract, and in quantities so large as to materially reduce the cost of transportation. The competition in open market is very sharp, and successful competitors are much more closely bound by the consideration that others would gladly take their place, than by a nominal bond which all experience shows will not be enforced; besides, payments monthly in full make it easier to carry on the furnishing of material than if a percentage is retained, an advantage which enables material to be procured at more favorable rates.

STATISTICS.

In obedience to the requirements of the circular from the Chief of Engineers, dated March 9, 1877, a special effort was made to obtain statistics of the commerce of this portion of the Mississippi River. In addition to the general movements in the direction of the river, information was also obtained concerning the movements of freight across the Mississippi by ferry and transfer of cars by water in order to show the importance of the harbor facilities at Saint Louis in relation to the business of the railroads, a relation which has heretofore received little attention, although, as will be seen by reference to the statistics, this transfer business is in proportion to the river freightage proper as eight to ten nearly. The labor of obtaining and compiling the statistics, which has been very considerable, was done by my chief clerk, S. S. Hutchins, whose report is appended hereto, and to which I respectfully refer.

The work is located in the collection-district of New Orleans.

The amount of revenue collected at the port of Saint Louis for the fiscal year ending June 30, 1877, was \$1,422,642.93.

Construction account.

Name of work.	Amount expended previous to July 1, 1876.	Amount expended during year ending June 30, 1877.	Total cost to June 30, 1877.	Amount required to complete.	Total estimated.
Piasa Island Dam	\$16,210 73	\$7,525 64	\$23,736 37	\$17,474 36	\$41,210 73
Aiton Dam	31,368 45	606 40	32,084 85	7,935 15	40,000 00
Sawyer Bend protection	91,940 67		91,940 67	50,270 95	142,211 62
Venice Dikes	36,341 85		36,341 85	3,658 15	40,000 00
Closing Cahokia Chute		20,958 61	20,958 61	83,641 39	104,600 00
Horsetail Bar, dike 1	26,873 84	13,675 69	40,549 53		
Horsetail Bar, dike 2	15,564 03	6,347 55	21,911 58		
Horsetail Bar, dike 3	47,506 81	23,558 81	71,065 62	19,606 41	221,502 86
Horsetail Bar, dike 4	34,648 17	2,641 94	41,290 11		
Horsetail Bar, dike 5	20,399 05	6,680 56	27,079 61		
Fort Chartres Dam	36,812 86		36,812 86	9,750 00	46,562 86
Turkey Island Dam	21,490 46	8,973 39	24,463 85	8,101 61	32,565 46
Liberty Island Dam	5,053 91		5,053 91		5,053 91
Liberty Island protection	16,647 68	18,469 29	35,116 97	8,140 71	43,257 68
Devil's Island, dike 1	50,416 89	8,051 49	58,468 38		
Devil's Island, dam 1	43,064 06	3,184 90	46,248 96	30,028 14	150,000 00
Devil's Island, dam 2	9,479 18	5,766 84	15,246 02		
Cairo protection		18,679 38	18,679 38	153,890 62	172,500 00
Totals	507,838 64	139,210 49	647,049 13	392,425 49	1,039,465 12

NOTE.—The changes made in first column from amounts shown in report for previous year consist of unimportant errors then made, and are due to that statement being hastily prepared in advance of the records being fully written up.

Property and material account.

Class of property.	Balance July 1, 1876.	Dr.	Cr.	Balance July 1, 1877.
Office furniture	\$500 55		\$120 00	\$380 55
Instruments and survey material	250 00	23 00	3 00	250 00
Five pile-drivers	10,071 39	392 12	259 00	10,210 51
Sixteen barges and one quarter-boat	49,339 46	3,129 38	13,499 22	29,969 60
Two tow-boats, one small tug and expenses	56,402 24	21,729 55	30,870 02	47,262 37
Small boats	166 22	104 17	175 00	95 99
General expenses of property	13,495 49	4,555 59		12,051 08
Material and quarry privileges	1,961 70	110,671 27	109,824 99	2,807 98
Tools	1,915 00	2,516 10	3,437 28	993 82
Quarters for workmen, shops, &c.	2,177 79	2,161 91	759 00	3,580 70
Totals	127,221 04	145,269 07	158,947 51	114,202 60

Engineer Office, United States Army, in account with United States.

Dr.			Cr.
To allotments for surveys and examinations at various dates prior to July 1, 1876	\$48,008 77	By expenses of office.....	\$39,353 64
To appropriations for improvement of the Mississippi River between the Illinois and Ohio Rivers prior to July 1, 1876	725,000 00	By general engineering	25,271 38
To appropriation for improvement of channel of Mississippi River opposite Saint Louis, (closing Cahokia Chute,) approved August 14, 1876	29,600 00	By surveys	75,531 58
To appropriation for improvement of Mississippi River between Illinois and Ohio Rivers, approved August 14, 1876	200,000 00	By constructions	647,049 13
To unpaid percentage on annulled contracts	900 17	By balance on account of property ..	114,202 60
To liability for labor, (non-payment account)	4,781 85	By cash on hand and in Treasury ..	106,404 14
To liability for material	112 67		
To liability for office supplies	9 00		
Total.....	1,008,412 47	Total.....	1,008,412 47

Money statement.

July 1, 1876, amount available	\$15,724 68	
Amount appropriated by act approved August 14, 1876	229,600 00	
		\$245,324 68
July 1, 1877, amount expended during fiscal year	138,920 54	
July 1, 1877, outstanding liabilities	5,803 69	
		144,724 23
July 1, 1877, amount available	100,600 45	
Amount (estimated) required for completion of existing project	6,729,600 00	
Amount that can be profitably expended in fiscal year ending June 30, 1879 ..	500,000 00	

COMMERCIAL STATISTICS.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., July 24, 1877.

GENERAL: To comply with instructions from the Chief of Engineers, requiring a statement of statistics of commerce of the Mississippi River between the mouths of the Illinois and Ohio Rivers, you issued, April 2, 1877, a circular requesting information upon the subject. This circular was forwarded to persons engaged in business at all points along the river within those limits except Saint Louis, and requested each to fill up and return a blank form sent with it, showing their receipts and shipments by river of all articles in alphabetical order, with estimated value of each, during the year 1876.

The number of circulars distributed and responses received appears as follows:

Locality.	Circulars sent.	Responses received.
Grafton, Ill.....	10	4
Portage des Sioux, Ill.....	3	1
Alton, Ill.....	77	39
Harrisonville, Ill.....	2	1
Prairie du Rocher, Ill.....	1	1
Saint Genevieve, Mo.....	22	15
Saint Mary's, Mo.....	13	4
Kaskaskia, Ill.....	3	1
Chester, Ill.....	25	10
Rockwood, Ill.....	4	2
Wittsburg, Mo.....	7	2
Grand Tower, Ill.....	9	9
Cape Girardeau, Mo.....	41	41
Commerce, Mo.....	7	3
Rush Power, Ill.....	1	1
Cairo, Ill.....	1	1
Total.....	232	133

From the information thus received, and from that contained in the published report of Mr. George H. Morgan, secretary of the Merchants' Exchange of Saint Louis, with additional data obtained from him and other sources, the accompanying statement has been compiled, and is submitted with the following explanatory remarks:

This statement shows approximately for all points between the Illinois and Ohio Rivers.

Receipts, tons.....	1,222,631	\$38,000,716 40
Shipments, tons.....	874,099	60,761,262 84
Total, tons.....	2,096,730	98,761,979 24

The above total, however, is evidently less than the true amount, since of the 232 persons called upon 99 failed to respond, though full returns are included of Saint Louis, Grand Tower, Cape Girardeau, and Cairo, which cover over 95 per cent. of the whole.

It may be stated, too, that the destination of shipments from the several points is unknown; hence, in summing up the receipts, some items are necessarily repeated; yet as Saint Louis, which represents the greater tonnage and value, is doubtless the destination of nearly all these items, the result would not be disturbed to any appreciable extent.

Some replies to the circular contained no weights, but gave quantities of certain items in the most convenient unit with value, while others specified quantities or weights, and omitted value. The difficulty in determining deficient weight and value in some of these cases was overcome by assuming the unit of weight or value supplied by other returns, and applying the same to like items where not given. The report of the secretary of the Merchants' Exchange of Saint Louis and the files of the Saint Louis Market Reporter aided also very materially in fixing average prices and weights per unit of many of the leading articles.

Special requests were made for information showing the tonnage and value of the ferry and harbor business of Saint Louis, of which full returns were furnished, but a portion of them were deficient in detail, presenting the information in a manner too general to admit of its use without aid from other sources. That given, however, with the weights and values per unit of many articles of merchandise transported, already ascertained, furnished the data from which the inclosed estimated statement was prepared.

The aggregate of this statement shows 1,627,083 tons, with a value of \$79,695,922, which, added to the receipts and shipments for all points on the Mississippi River between the Illinois and Ohio Rivers, as shown above, gives a grand total of 3,723,813 tons, with a value of \$178,457,907.24.

Of course, as has been demonstrated, absolute accuracy is not claimed for this result; but, considering the character of the information, and the method of putting the same in shape, it is hoped it will aid in conveying an approximation to the extent and value of the tonnage of the river within the limits stated.

Very respectfully, your obedient servant,

S. S. HUTCHINS.

Gen. J. H. SIMPSON,
Colonel of Engineers, U. S. A.

Statement showing approximately the extent and value of commerce of the Mississippi River between the mouths of the Illinois and Ohio rivers for the year ending December 31, 1876.

Locality.	Receipts.		Shipments.	
	Tons.	Estimated value.	Tons.	Estimated value.
Grafton, Ill.....	3,038	\$157,159 00	39,445	\$226,825 00
Portage des Sioux, Ill. *				
Alton, Ill.....	43,700	1,104,687 26	13,468	943,227 94
Saint Louis, Mo.....	1,143,866	34,478,175 17	607,769	55,745,837 55
Harrisonville, Ill.....	635	40,884 15	5,684	95,439 45
Prairie du Rocher, Ill.....	535	7,091 00	2,431	141,551 00
Saint Genevieve, Mo.....	3,934	228,653 47	46,570	541,224 52
Saint Mary's, Mo.....	3,109	8,918 00	3,894	199,505 00
Kaskaskia, Ill. *				
Chester, Ill.....	5,838	123,043 30	5,544	275,012 70
Rockwood, Ill.....	360	16,525 00	1,229	65,392 50
Wittenburg, Mo.....	296	153,516 75	3,928	225,622 00
Grand Tower, Ill.....	1,047	356,240 84	41,508	339,109 85
Cape Girardeau, Mo.....	2,003	395,331 46	16,138	1,015,408 41
Commerce, Mo.....	111	36,135 00	838	28,469 00
Rush Tower, Ill.....	4,124	116,500 00		
Cairo, Ill.....	10,085	777,856 00	85,653	918,577 92
Total.....	1,222,631	38,000,716 40	874,099	60,761,262 24

* No returns received.

Statement showing approximately the extent and value of ferry and harbor transportation at Saint Louis, Mo., during the year ending December 31, 1876.

	Tons.	Estimated value.
General merchandise transported by ferries both ways across the Mississippi River at Saint Louis.....	1,437,470	\$79,255,596 40
Coal moved in harbor of Saint Louis.....	148,188	371,263 04
Stone moved in harbor of Saint Louis.....	41,425	38,626 31
Towing in harbor of Saint Louis.....		30,442 25
Total.....	1,627,083	79,695,928 00

Empty cars, empty wagons, carriages, and buggies with teams and passengers, not included.

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

An allotment was made from the appropriation of August 14, 1876, for Mississippi, Missouri, and Arkansas Rivers, for *surveys and examinations for improvements on the Missouri River at Omaha and Council Bluffs, and at Plattsmouth, Brownville, Atchison, and Sioux City.*

Major Suter was charged with the execution of these surveys, and his reports thereon, with the exception of the last named, were transmitted to Congress at its last session, and printed in Senate Ex. Doc. No. 30. They will all be found in Appendixes M 11 and M 12 of this report.

To comply with provisions of the river and harbor act of June 18, 1878, Major Suter has been charged with and is now engaged upon examinations and surveys at the following localities, the results of which will be duly submitted when received:

1. *The Missouri River at Cedar City, in Callaway County, Missouri.*
2. *Missouri River at the City of Saint Charles, Missouri.*
3. *The Arkansas River from Fort Smith, Arkansas, to the mouth of Little Arkansas.*
4. *The Missouri and Kansas Rivers at and near their junction.*
5. *The Kansas River from its mouth to Junction City, Kansas.*

IMPROVEMENT OF MISSISSIPPI RIVER BETWEEN THE MOUTHS OF THE ILLINOIS AND OHIO RIVERS—IMPROVEMENT OF OSAGE RIVER.

Officer in charge, Col. J. H. Simpson, Corps of Engineers, having under his immediate orders Capt. Chas. J. Allen, Corps of Engineers.

1. *Improvement of Mississippi River—Piasa and Alton Dams.*—The funds available for these works were—

Balance July 1, 1877.....	\$10,561 72
which was applied to the construction of Piasa Dam and the revetment of the head of Piasa Island, and repairs and extension of the abutments of Alton Dam, as follows:	
Piasa Dam and revetment of Piasa Island.....	\$8,596 93
Alton Dam.....	1,559 07
	<hr/>
	10,156 00

Owing to favorable conditions, these dams are now virtually complete, leaving the \$20,000 required by the terms of the act approved June 18, 1878, to be expended between the Illinois and Missouri, available for any new work which may be thought advisable after examination of the river at a lower stage than prevailed at the time this report was made.

Sawyer and Venice Bends.—A small amount of work was done at Sawyer Bend, rendered necessary to preserve the work; but no extension of the protection has been possible since 1875, for want of funds. It is intended to resume work the present season to a limited extent.

No work was done near Venice, and none is contemplated.

Closing Cahokia Chute.—At the beginning of the fiscal year a balance of \$8,641.39 remained applicable to this work. The revetments were extended and repaired, to preserve the site of the proposed dam, but no work has yet been done upon the dam itself.

The act approved June 18, 1878, having provided the full amount of the estimate for the dam, \$75,000, it is hoped that during the year it will be well advanced toward completion.

Horsetail Bar.—The results of the work at this locality of previous years were on the whole satisfactory during the past season. For a

few days a serious difficulty in navigation existed, due, in a great measure, to changes resulting from the work, then in progress, of restoring one of the dikes which had settled. After this temporary disturbance was removed, the channel opened and gradually improved; a result which it is hoped to maintain hereafter.

As the training-wall, commenced last season, progresses, the permanence of the improvement will be secured. After maintaining the dikes, the work of the coming season will be the extension of this training-wall.

Port Chartres and Turkey Island.—No work was done on these dams during the past year, and none is contemplated the present fiscal year.

The protection of Fish Bend is essential to the permanent realization of the benefits expected to result from these dams.

Kaskaskia Bend.—The results of the work last year are unsatisfactory. The small amount set apart for the work by the terms of the appropriation did not allow the work to progress far enough to be secure, and it is feared that it is destroyed.

The appropriation of June 18, 1878, sets apart \$10,000, which it has been deemed advisable to supplement by an additional allotment of \$10,000 from the funds left to be distributed by the department. With this amount the work can be secured.

Further appropriations will be much needed to continue the work.

Liberty Island.—This work was untouched during the past fiscal year, and, as a consequence, the upper part of the partially-completed revetment has received material injury. The caving has extended up stream, rendering extension and restoration necessary.

An allotment of \$20,000 has been made for the present fiscal year.

Devil's Island.—The dams at this island are reported to be practically complete, and it is not intended to commence additional works.

The channel during the year remained in good condition, affording no difficulty to skillful and capable navigation.

Dickey Island to Cairo.—The results of the previous year's work have been maintained and secured by such extension of the protection as the means allowed to be made. These results are gratifying, as the locality afforded a severe test of the proposed plan.

Work will be continued to the full extent the means recently provided will allow, and it is hoped further appropriations will be made, that the work may progress until complete.

The officer in charge submits an estimate of \$500,000 for the fiscal year ending June 30, 1880. This sum would complete all the works now in progress and allow some new ones to be begun.

The appropriation of the above sum is recommended.

July 1, 1877, amount available	\$106,404 14	
Amount appropriated by act approved June 18, 1878.....	240,000 00	
		\$346,404 14
July 1, 1878, amount expended during fiscal year.....	90,006 52	
July 1, 1878, outstanding liabilities.....	1,274 48	
		91,371 00
July 1, 1878, amount available.....	255,033 14	
Amount (estimated) required for completion of existing project	6,489,600 00	
Amount that can be profitably expended in fiscal year ending June 30, 1880.	500,000 00	
(See Appendix N 1.)		

2. *Improvement of Osage River.*—Work upon this river has been suspended during three years just past; but the act approved June 18, 1878,

having provided the sum of \$20,000 for its further improvement, work will be resumed during the coming season.

There being no definite project in progress, no statement of estimated amount to complete existing project can be given, and no sum recommended for the fiscal year ending June 30, 1880.

Amount appropriated by act approved June 18, 1878.	\$20,000 00
July 1, 1878, amount available	20,000 00

(See Appendix N 2.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with provisions of the river and harbor act of June 18, 1878, Colonel Simpson has been charged with and is now engaged upon examinations and surveys at the following localities, the results of which will be duly submitted when received.

1. *The Mississippi River, to ascertain the practicability, cost, and utility of a dike from Bloody Island, opposite the city of Saint Louis, Mo., north to the dike or dam opposite Brooklyn, on the Illinois shore.*

2. *A survey and estimate of the damages, if any, done, or to be done, to riparian owners of lands and improvements thereon, at or in front of the town of Venice, Ill., near Saint Louis, Mo., by reason of government improvements made, or to be made, at or near said town of Venice.*

IMPROVEMENT OF MISSOURI RIVER ABOVE MOUTH OF THE YELLOWSTONE.

Officer in charge, Lieut. Edward Maguire, Corps of Engineers.

At Dauphin's Rapids a channel 100 feet wide and 1,800 feet long has been cleared of rocks.

A dam 130 feet in length containing 200 cubic yards of stone, and three short dams containing about 60 cubic yards of stone, have been built.

At Cow Island all of the rocks were removed from the channel, and a dam built 419 feet long, containing 710 cubic yards of stone.

The results of last season's work are apparently favorable.

During the coming season the work at Dauphin's Rapids will be continued by one party. Another party will complete the projected improvement at Cow Island, and thence proceed to Grand Island and Two Calf Island.

July 1, 1877, amount available	\$14,459 63	
Amount appropriated by act approved June 18, 1878	30,000 00	
		\$44,459 63
July 1, 1878, amount expended during fiscal year	10,838 50	
July 1, 1878, outstanding liabilities	23 50	
		10,862 00
July 1, 1878, amount available	33,597 63	
Amount that can be profitably expended in fiscal year ending June 30, 1880.		55,000 00

(See Appendix O.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with provisions of the river and harbor act of June 18, 1878, Lieutenant Maguire has been charged with and is now engaged upon an examination and survey of the *Yellowstone River*, the result of which will be duly submitted when received.

APPENDIX N.

ANNUAL REPORT OF COLONEL J. H. SIMPSON, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1878.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., July 16, 1878.

GENERAL: I have the honor to submit herewith my annual report upon the river and harbor improvements under my charge, for the fiscal year ending June 30, 1878.

Additional duties have been performed by me during the year as follows:

President of Board of Engineers constituted by Special Orders No. 141, Headquarters of the Army, Adjutant-General's Office, dated June 28, 1877, to examine and report upon the most advisable means of preserving the water-front of Vicksburg, and of arresting the danger which appears to be apprehended from the cut-off opposite that city. Report of Board submitted under date of January 22, 1878.

President of Board of Engineers constituted by Special Orders No. 88, Headquarters Corps of Engineers, dated August 1, 1877, to consider and report upon the project for a bridge across the Ohio River at Beaver, Pa. Report submitted August 15, 1877.

President of Board of Survey constituted by Special Orders No. 41, Headquarters of the Army, Adjutant-General's Office, dated February 26, 1878, to examine and report fully upon the facts connected with the loss of the dredge-boat McAlester. Report submitted from New Orleans, March 23, 1878.

President of Board of Engineers constituted by Special Orders No. 40, Headquarters Corps of Engineers, dated April 9, 1878, to consider and report upon the plan and location of the bridge proposed to be erected over the Missouri River at or near Glasgow, under an act of Congress approved March 13, 1878. Report submitted April 20, 1878.

Very respectfully, your obedient servant,

J. H. SIMPSON,
Colonel of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

N 1.

IMPROVEMENT OF THE MISSISSIPPI RIVER BETWEEN THE MOUTHS OF THE ILLINOIS AND OHIO RIVERS.

BETWEEN THE ILLINOIS AND MISSOURI RIVERS.

The balance of appropriation applicable to work within these limits July 1, 1877, was \$10,561.72, with which it was proposed to continue the

construction of the dam at Piassa Island, and to make such repairs and extension of the shore connections of Alton Dam as were needed.

DAM AT PIASSA ISLAND.

By the operations of the year the prism of the dam has been filled to a height of 6 feet above low water, except for a distance of 400 feet near its eastern end, which remains incomplete. The head of the island has also been revetted to prevent its further erosion. Both dam and revetment are now practically complete, at a cost of \$32,333.30, against an estimated cost of \$41,210.73; the saving arising from the unexpected stability of a sand-bar, which is crossed by the dam and which has not washed away as anticipated.

The expenditures were—

22 piles	\$66 00
5,857.03 cubic yards riprap	7,463 45
Grading	168 49
Engineering and contingencies	898 99
	<hr/>
	8,596 93

ALTON DAM.

The revetments have been repaired and extended to an extent deemed sufficient to secure the work.

The expenditures were—

998.37 cubic yards riprap	\$1,185 60
Grading	27 07
Engineering and contingencies	346 40
	<hr/>
	1,559 07

The completion of these dams renders it proper to commence a new work under the recent appropriation of \$20,000, the location of which will be made when the stage of water permits.

SAWYER BEND.

The work at this locality having been suspended since 1875 for want of funds, the upper end of the protection was in danger of being detached from the shore, rendering it necessary to revet in part the space between the two upper spur-dikes, and also to repair a number of the spurs.

The expenditures were—

1,192.62 cubic yards riprap	\$1,514 80
Engineering and contingencies	360 10
	<hr/>
	1,874 90

Further repairs will be necessary during the coming season, and it is proposed also to devote a part of the appropriation of June 18, 1878, to the prolongation of the protection.

VENICE.

No work was done at this locality except a survey to ascertain the damages, if any, resulting to riparian owners from the government work actual and proposed. The report of this survey was made April 10, 1878.

No work is proposed the coming season.

CAHOKIA CHUTE.

The balance available was not sufficient to warrant any attempt at the construction of the dam. The revetments at the site of the proposed dam were strengthened and the revetment of the west side of the island completed for a length of 685 feet.

The expenditures were—

4,083.47 cubic yards riprap	\$4,574 75
Grading	332 05
Engineering and contingencies	537 85
	<hr/>
	5,444 65

In consequence probably of the suggestion made in my last annual report that this chute would afford a favorable opportunity for the construction of an ice-harbor, a special report and estimate was called for, which was made in my absence by Capt. Charles J. Allen, Corps of Engineers. The plan proposed I deem practicable, and the object is certainly an important one. I therefore recommend the matter to the consideration of Congress.

In the appropriation act approved June 18, 1878, provision was made for the construction of the dam across the chute to the full amount of the estimate. It is hoped this will suffice to complete the low dam, and any further estimate or appropriation would be applicable to the construction of the ice-harbor. The two channels at Arsenal Island have continued to divide the water, either being navigable, but the larger and deeper boats have mostly used the Cahokia Chute.

A recent examination of the site of the dam develops a regular bottom with comparatively slight variations of depth, except along the Illinois shore, where the depth at a 22-foot stage was 37 feet. This, however, is in a blind pocket behind a sand-bar, the greatest depth in the true channel being 24.8 feet. The conditions are favorable to the construction of the dam if no serious change takes place when the river falls.

As an illustration of the influence the change of the bottom has upon the navigation of the Mississippi and all questions of its improvement, the following comparison of cross-sections is made:

First section made December, 1874.

Area of Cahokia Chute sounded at 6-foot stage:		
Reduced to 8-foot stage	= 12,411	and to 0 stage = 6,526
Area of Arsenal Chute sounded at 6-foot stage:		
Reduced to 8-foot stage	= 19,775	and to 0 stage = 8,023
Total area, square feet	32,186	14,549

Second section made November 25, 1876.

Area of Cahokia Chute sounded at 10½-foot stage:		
Reduced to 8-foot stage	= 20,700	and to 0 stage = 11,332
Area of Arsenal Chute sounded at 10½-foot stage:		
Reduced to 8-foot stage	= 16,800	and to 0 stage = 4,078
Total area, square feet	37,500	15,410

Third section made July, 1878.

Area of Cahokia Chute sounded at 22-foot stage:		
Reduced to 8-foot stage	= 16,036	and to 0 stage = 4,593
Area of Arsenal Chute sounded at 22 foot stage:		
Reduced to 8-foot stage	= 12,300	and to 0 stage = 3,875
Total area, square feet	28,336	8,473

Of the 4,598 square feet found at Cahokia Chute after reducing to 0 stage, 3,112 square feet are cut off from the main river, leaving 1,476 square feet to be added to 3,875 to give the low-water area of 5,351 square feet obtained by reducing the soundings taken at 22-foot stage. Comparing this with areas obtained by reduction from soundings at lower stages, the fact of enlargement of section attending fall of surface is evident, and affords another link in the chain of evidence that the channel-filling at high water is general and not limited to bars or shoals.

HORSETAIL BAR.

The difficulties encountered at this locality in previous years were not repeated the past season. For a time the depth in the channel was reduced to $4\frac{1}{2}$ feet, and much apprehension was felt on the part of river-men that the previous experience would be repeated. As there was a disturbing cause at work producing a local movement of sand, the hope was indulged that the obstruction would be but temporary. This hope was realized in a few days, a continual decline of stage brought the scattered waters together, and a fair channel was maintained for the balance of the season, at no time affording less water than existed elsewhere in the river, and gradually deepening to $8\frac{1}{2}$ and 9 feet, at which depth the channel maintained itself during the winter, by which I mean that during the minor rises and falls of the late fall and winter the channel maintained a nearly constant depth.

It has been repeatedly said in the reports upon these works that the improvement of the low-water river would not secure a good channel at all stages. It is still necessary to repeat the statement, for it is a fundamental proposition consequent upon the fact that the bed of the river fills at flood and clears itself at low stages. Failure to recognize this fact with its logical consequences must always lead to failure and disappointment in practical works, and vitiate all theoretic reasoning about the river. The period of worst navigation last year was during the time of decline from a stage of 10 to 7 feet; previous years it was at a higher stage. The cause of last year's trouble arose from the peculiar course of the channel around the head of one of the dikes, the outer end of which had settled during the summer rise. A sand-bar was deposited in mid-river above and quite near the dike. When the water fell the channel lay between the end of the dike and this bar. Under these conditions, when the dike was restored, the end having settled some 28 feet, the channel was crowded against the bar, which yielded (but only after the depth of water became over 70 feet). This scouring of the bed and erosion of the bar set in motion a volume of sand which exceeded the ability of the current in the section of river below to dispose of, and, of consequence, a reef was developed. The spill-way over this reef being three-fourths of a mile or more in length, allowed the water to pass in a thin sheet without any defined channel. Early in October the dike was restored to its full length, and so soon as its reconstruction ceased the cutting at the dike stopped, the reef was cut through, and a defined channel, permanent for the season, was developed.

The training-wall mentioned in my last annual report as necessary to complete the improvement was commenced last season, and 2,550 feet of it built to a height of 12 feet above low water, at a cost of \$8 per linear foot.

The only work on the perpendicular dikes during the year was the restoration of the outer end of dike No. 3, and the closure of one of the breaches in dike No. 5.

The expenditures were—

Dike No. 3:	
10,256.20 cubic yards riprap.....	\$10,842 49
Engineering and contingencies.....	784 43
	<hr/> 11,626 92 <hr/>
Dike No. 5:	
4,290.57 cubic yards riprap.....	\$4,415 82
Engineering and contingencies.....	258 30
	<hr/> 4,674 12 <hr/>
Training-wall:	
357 piles.....	\$1,129 69
976.34 cords brush.....	1,686 30
Old barge-hull.....	350 00
15,346.09 cubic yards riprap.....	16,246 72
Engineering and contingencies.....	985 39
	<hr/> 20,398 16 <hr/>

During the coming season it is proposed to close the remaining breach in dike No. 5; to repair dike No. 3, and to continue the construction of the training-wall.

FORT CHARTRES DAM.

No work was done at this dam during the year, and none is contemplated during the coming season. Continued changes in the bend above may eventually bring about the necessity of allowing the channel to go through the dam, but it is hoped that an appropriation may be made applicable to the protection of Fish Bend in time to prevent this change. This bend is caving rapidly and needs protection. The length is very considerable—20,000 feet—and its protection will cost about \$10 per foot.

TURKEY ISLAND DAM.

Remains as last reported; no work done or contemplated.

PROTECTION OF BANK NEAR KASKASKIA.

After long hesitation the attempt was made to check the caving of this bend. Brush and stone footing was placed along 1,100 feet of the bank near the head of the active caving, and with a view to guard against a possible cutting of the Mississippi through into the Kaskaskia immediately above the point of nearest approach of the two rivers. The severe weather of the latter part of November rendered it necessary to close operations when the height of the protection was 13 feet above low water. The small balance available did not warrant resumption of work.

The spring rise of the river commenced an active erosion about one-half mile above the revetment, which in a short time worked down to it and to some unknown extent behind it. The high stage of water when the locality was last visited was unfavorable to an accurate determination of the condition of the work placed last fall; but there are serious grounds to apprehend that it is nearly if not wholly lost. Had the amount available been greater so that the work could have been resumed early this spring, the loss would not have occurred.

The changes at this locality during the winter and spring have been very great, the caving progressing more rapidly than ever before, reu-

dering it probable that the portion of river between Kaskaskia and Saint Mary's will be very troublesome to navigation the coming fall from the vast quantities of sand which have been moved out of Kaskaskia Bend.

The act of June 18, 1878, set apart \$10,000 for the improvement of this bend, but the condition is such that, in the light of last year's experience, it has been deemed advisable to allot \$10,000 additional from the part of the general appropriation not allotted by Congress.

The expenditures during the year were—

28 piles.....	\$56 00
149.53 cords brush.....	391 12
2,267.30 cubic yards riprap.....	3, 174 35
Grading.....	66 40
Engineering and contingencies.....	826 44
	<hr/>
	4, 514 31

LIBERTY ISLAND.

No work was done in this vicinity last year owing to lack of means. The incomplete revetments have, in consequence, suffered material injury. The bank for nearly a mile above the revetment is now caving, and at the upper end of the revetment the bank has retreated from 20 to 50 feet from the position it had a year ago. So far as can be determined at the present stage, it is probable that a flat bench extends from the top of the revetment in to the foot of the new bank. If neglected, this bench will be washed out and a destructive current run inside of the revetment. It is therefore designed to apply \$20,000 of the recent appropriation to the strengthening and extending of the revetment.

Interruptions of work for want of funds are costly. A year ago the bank was in excellent shape for raising the revetment; now, some 2,000 feet of the upper end will require much additional work to restore it to the condition attained a year ago.

To illustrate the value of the protection of caving bends as an improvement of the navigation, I insert from the files of my office copies of letters received from J. P. Keiser, superintendent of Memphis and Saint Louis Packet Company, premising that at the time these letters were written it was considered a hopeless task to clear the Missouri Chute of snags. Since the revetment of the bank no very great amount of work has been done by snag-boats, and no boat has received injury at the locality. What the condition was may be learned from the following:

LETTER FROM CAPT. JOHN P. KEISER, SUPERINTENDENT OF MEMPHIS AND SAINT LOUIS PACKET COMPANY.

OFFICE OF MEMPHIS AND SAINT LOUIS PACKET COMPANY,
Saint Louis, December 30, 1874.

DEAR SIR: The inclosed letter shows the condition of the river at Liberty Island. You will excuse the liberty I take in sending it to you, when you know the importance it is to us as a packet company, and knowing also that you would, in your official capacity, like to know of the important places to operate when the season comes to operate your work. I have telegraphed to the captain of the *De Runy* of the importance of her coming there, and this morning received a telegram that he would start up to-day, but am afraid the cold weather will prevent her doing any good.

We have ordered our boats to double-trip their freight over the bar on the Illinois side in preference to going down the Missouri side. Five years ago the channel was down the Missouri side, and it cost this company between \$60,000 and \$70,000 repairs to *Marble City*, *Belle Saint Louis*, and *Adam Jacobs*, and the *Oliver Branch* and *W. J. Lewis* both sunk on that side; the last two did not belong to us. Our pilots report that it is impossible for a boat to go through that side without striking.

When the water gets very low the channel goes down on that side in consequence of the gravel on head of Liberty Island. I believe that the boatmen all, without an

exception, agree with me that it is more important now to close up the Missouri side of Liberty Island with a dike than any other point on the river.

Hoping you will give the matter due consideration,

I am, yours respectfully,

JNO. P. KEISER,
Superintendent.

J. H. SIMPSON,
Colonel of Engineers, U. S. A.

LETTER OF A. S. LIGHTNER, STEAMER E. C. ELLIOTT, TO SUPERINTENDENT OF MEMPHIS AND SAINT LOUIS PACKET COMPANY.

GRAND TOWER, ILL.,
December 27, 1874.

DEAR SIR: On our down trip I only find 4 feet of water at Sheep Island, on Illinois side of Liberty Island, the way we have been running. The iron steamer tow-boat, Alex. Swift, has just sounded the Missouri side of Liberty Island and reports 6 feet of water, but impossible for any boat to run on account of the logs, as it is a perfect mass of logs from the head to the foot of the island. The water is drawing off very fast down the Missouri side of the island, and I do not think there will be over 3 feet water down the Illinois side of Liberty Island in three days from this time if there is not something done with the Missouri side. Either the logs removed or a dike built across the Missouri side to throw the water back to the Illinois side would be the most advisable plan if it could be done at once. There is one thing certain, if there is not something done you can consider Liberty Island about the foot of navigation for the present.

Yours, respectfully,

A. S. LIGHTNER,
Steamer E. C. Elliott.

Capt. J. P. KEISER,
Superintendent Memphis Packet Company.

LETTER FROM CAPT. JOHN P. KEISER, SUPERINTENDENT OF MEMPHIS AND SAINT LOUIS PACKET COMPANY.

OFFICE OF MEMPHIS AND SAINT LOUIS PACKET COMPANY,
Saint Louis, June 17, 1875.

DEAR SIR: My attention has been called to the fact that the channel at the head of Liberty Island is now very close on to the head of the island, and the probability is that the channel will go down the Missouri side if the water should fall much more. This is the bad place I wrote you about last fall, when we had concluded to lay our boats up rather than run down that side until something was done with it. I got Major Suter to send a snag-boat up to try to take the logs out, but the weather turned so cold that the snag-boat had to turn back on account of the ice, and the river closed, so we have not had to run it yet. The only boat that tried to run it last fall was lost, the tow-boat Babbage; the *Lewis* sunk there the fall before. We have never had one of our own boats to go through there in low-water without striking a break.

We consider the closing of this channel more important than others between this and Cairo.

Very respectfully, your obedient servant,

JOHN P. KEISER,
Superintendent.

General SIMPSON,
Colonel Engineer Corps, U. S. A.

A revetment of the Missouri shore was substituted for the proposed closing of the Missouri chute, and no complaint of difficulty or loss has been made for two seasons.

DEVIL'S ISLAND.

At the date of the last annual report work was in progress on dams Nos. 1 and 2. The gap then mentioned as existing near the east end of dam No. 1 was filled and dam No. 2 raised to a height of 14 feet above

low-water. Both dams are completed except a gap near the west end of No. 1, which has been buried in sand for the past two years, and is liable to be washed away at any time.

Dike No. 1 in the main or Missouri Channel was repaired, and the revetments strengthened.

The expenditures were—

Dam No. 1:	
2,026.64 cubic yards riprap.....	\$3,040 02
Engineering and contingencies.....	539 60
	<hr/> 3,579 62 <hr/>
Dam No. 2:	
817.36 cubic yards riprap.....	\$1,226 04
Engineering and contingencies.....	206 24
	<hr/> 1,432 28 <hr/>
Dike No. 1:	
4,153.98 cubic yards riprap.....	\$6,230 97
Grading.....	63 91
Engineering and contingencies.....	1,107 91
	<hr/> 7,402 79 <hr/>

As the works are apparently in good condition, it is not intended to expend any part of the appropriation recently made, at this locality.

DICKEY ISLAND TO MOUTH OF THE OHIO.

The work done in the fall season of 1876 not only passed through the winter and spring without injury, but also proved effectual to stop the cutting away of the bank. The upper 500 feet which was above the old spur-dikes assumed a moderate slope as had been anticipated, which slope was revetted during the fall of 1877 to a height of 25 and 30 feet above low-water. The footing was also extended 1,000 feet upstream, and the bank revetted to the top of the defined slope, or about 13 feet above low-water.

A recent inspection showed that no caving had occurred along the protected front, and that the bank whose foot was revetted last fall had assumed a slope ready to receive revetment to a height of 25 feet or thereabouts.

It is proposed to apply the \$40,000 recently provided in perfecting the protection between the old spur-dikes, and in extending the regular revetment as far as the means will allow. It will be possible to prepare a considerable extent of foundation, and it is hoped that the means will be provided to complete the revetment to the full extent of the foundation next season.

The expenditures during the year were—

21 piles.....	\$106 96
Grading.....	255 07
421.63 cords brush.....	819 08
4,973.49 cubic yards riprap.....	8,703 61
Engineering and contingencies.....	1,528 75
	<hr/> 11,413 57 <hr/>

Recurring to the suggestions made last year that no new works be undertaken upon this section of river until those now in hand are completed, according to the estimate then submitted of the cost of completing works then commenced, there remains \$315,425.49 to be appropriated

before it would be wise to commence works at any new localities. As said last year, it is not to be disputed that there are many points where works are as urgently needed as at those where they have been commenced; but it is not good policy to attempt more than there is reasonable prospect of being able to complete. To carry on the work on a scale commensurate with its importance, and in the interests of a wise economy would require an annual appropriation of not less than \$500,000. With this amount the coming year it would be possible to complete the list of unfinished work given above, and to commence new work at some one or two new points.

SURVEYS.

The only survey was that made to ascertain the damage, if any, done or to be done to riparian owners, at and near Venice, Ill., by reason of works done or to be done by the United States for the improvement of the Mississippi River, the map and report of which were transmitted to the Chief of Engineers under date of April 10, 1878.

EQUIPMENT.

No additions were made during the year. One hull of quarter-boat, being too rotten for further use, was sunk in the foundation of the training-wall at Horsetail Bar, and the quarters were transferred to another barge which had become too weak to carry stone. One good barge was totally wrecked in a storm last fall, being carried by the wind and waves upon the dike at which it was about to be unloaded. This loss and the natural deterioration of the earlier purchases rendered it necessary to make provision for building four new barges, as recommended in the report of last year. Proposals have been advertised for, and will be opened July 20.

All work during the year has been done by hired labor and the purchase of material in open market with highly satisfactory results. Material has been procured in quantities needed at very moderate rates. One chief article of use being riprap stone, the system of purchase in open market enables all quarries located along the river to compete, and affords opportunity for most of them to dispose of rough stone, which, except for riprap, would be of little value. It is intended to continue the system the present year.

The work is located in the collection-district of New Orleans.

Amount of revenue collected at the port of Saint Louis for the fiscal year ending June 30, 1878, was \$1,552,723.93.

REPORT OF THE CHIEF OF ENGINEERS.

Construction account.

Name of work.	Amount expended previous to July 1, 1877.	Amount expended during year end- ing June 30, 1878.	Total cost to June 30, 1878.	Amount required to complete.	Total estimated.
Piassa Island Dam.....	\$23,736 37	\$8,506 83	\$32,333 30	\$8,877 43	\$41,210 73
Alton Dam.....	32,064 85	1,550 07	33,623 92	6,376 08	40,000 00
Sawyer Bend protection.....	91,940 67	1,874 90	93,815 57	48,396 05	142,211 62
Venice Dikes.....	36,341 85		36,341 85	3,658 15	40,000 00
Closing Cahokia Chute.....	20,958 61	5,444 05	26,403 26	78,196 74	104,600 00
Horsetail Bar, dike 1.....	40,549 53		40,549 53		
Horsetail Bar, dike 2.....	21,911 58		21,911 58		
Horsetail Bar, dike 3.....	71,065 62	11,626 92	82,692 54	3,305 37	221,502 86
Horsetail Bar, dike 4.....	41,290 11		41,290 11		
Horsetail Bar, dike 5.....	27,079 61	4,674 12	31,753 73		
Horsetail Bar, training-wall.....		20,308 16	20,308 16	105,601 84	126,000 00
Fort Chartres Dam.....	36,812 86		36,812 86	9,750 00	46,562 86
Turkey Island.....	24,463 85		24,463 85	8,101 61	32,565 46
Kaskaskia protection.....		4,514 31	4,514 31	37,485 60	42,000 00
Liberty Island Dam.....	5,053 91		5,053 91		5,053 91
Liberty Island protection.....	35,116 97		35,116 97	8,140 71	43,257 68
Devil's Island, dike 1.....	58,468 38	7,402 79	65,871 17		
Devil's Island, dam 1.....	46,268 96	3,579 62	49,848 58	17,601 95	150,000 00
Devil's Island, dam 2.....	15,246 02	1,432 28	16,678 30		
Cairo protection.....	18,670 38	11,413 57	30,083 95	142,407 05	172,500 00
Totals.....	647,049 13	82,517 32	729,566 45	477,898 67	1,207,465 12

Property and material account.

Class of property.	Balance July 1, 1877.	Dr.	Cr.	Balance July 1, 1878.
Office furniture.....	\$380 55	\$3 50	\$120 00	\$264 05
Instruments and survey material.....	850 00			850 00
Five pile-drivers.....	10,210 51	132 46	428 00	9,914 97
Barges and quarter-boat.....	29,969 60	2,103 14	7,714 14	24,356 60
Two tow-boats, one small tug, and expenses.....	47,262 37	18,761 06	24,254 87	41,760 16
Small-boats.....	95 99	87 20	125 00	58 19
General expenses of property.....	18,051 08	1,600 86		19,660 94
Material and quarry privileges.....	2,807 98	58,000 88	59,389 53	2,079 33
Tools.....	993 82	463 90	1,190 11	258 61
Quarters for workmen, shops, &c.....	3,580 70	1,229 97	675 00	4,135 67
Totals.....	114,202 60	83,052 57	93,905 65	103,349 52

Engineer Office, United States Army, in account with United States.

DR.		CR.	
To allotments for surveys and exam- inations at various dates prior to July 1, 1877.....	\$48,008 77	By expenses of office.....	\$47,273 24
To appropriations for improvement of Mississippi River, between the Illinois and Ohio rivers, prior to July 1, 1877.....	954,600 00	By general engineering.....	30,316 62
To appropriation for improvement of Mississippi River, between the Illinois and Ohio rivers, approved June 18, 1878.....	240,000 00	By surveys.....	77,000 80
To unpaid percentage on annulled contracts.....	900 17	By constructions.....	729,566 45
To liability for labor, &c.....	374 31	By balance on account of property.....	103,349 52
	1,243,883 25	By cash on hand and in Treasury.....	256,307 62
			1,243,883 25

Money statement.

July 1, 1877, amount available	\$106,404 14	
Amount appropriated by act approved June 13, 1878	240,000 00	
		\$346,404 14
July 1, 1878, amount expended during fiscal year	90,006 52	
July 1, 1878, outstanding liabilities	1,274 48	
		91,371 00
July 1, 1878, amount available		255,033 14
Amount (estimated) required for completion of existing project		6,489,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1880.		500,000 00

N 2.

IMPROVEMENT OF OSAGE RIVER.

Work upon this river has been suspended during three years just past, but the act of Congress approved June 18, 1878, having provided the sum of \$20,000 for its further improvement, work will be resumed during the coming season.

There being no definite project in progress, no statement of estimated amount to complete existing project can be given and no sum recommended for the fiscal year ending June 30, 1880.

Money statement.

Amount appropriated by act approved June 18, 1878	\$20,000 00
July 1, 1878, amount available	20,000 00

2. *Tallahatchie River, Mississippi.* (See Appendix L 18.)
 3. *Coldwater River, Mississippi.* (See Appendix L 18.)
 4. *Upper Red River, from the raft up to the Missouri, Kansas and Texas Railroad bridge.* (See Appendix L 19.)
 5. *Little River, Arkansas.* (See Appendix L 20.)
 6. *Fourche la P  r  , Arkansas.* (See Appendix L 14.)
- The results of the above-named examinations were transmitted to Congress and printed as Senate Ex. Doc. No. 42, Forty-fifth Congress, third session.
7. *Tone's Bayou, Louisiana.* (See Appendix L 21.)
 8. *Bayou Pierre, Louisiana.* (See Appendix L 21.)
 9. *Bayou Winny, Louisiana.* (See Appendix L 21.)
 10. *Lake Bayou Pierre, Louisiana.* (See Appendix L 21.)
 11. *Lake Cannasanier, Louisiana.* (See Appendix L 21.)
 12. *Bayou Bartholomew, Arkansas.* (See Appendix L 22.)

The results of the above-named examinations were transmitted to Congress and printed as House Ex. Doc. No. 61, Forty-fifth Congress, third session.

13. *Sabine River, Arkansas.* (See Appendix L 23.)
14. *Falls on Red River, near Alexandria, Louisiana.*—The result of which will be duly transmitted when received.

And to comply with provisions of the river and harbor act of March 3, 1879, has been charged with and is now engaged upon the following, the results of which will be duly submitted when received:

1. *Yallahusha River, Mississippi.*
2. *Tehula Lake, Mississippi.*
3. *Black River, Arkansas.*

And also, to comply with joint resolution of June 28, 1879:

4. *Mississippi River, near Lake Concordia, Louisiana, and of Cowpen Bend, Mississippi, looking to the protection of the harbor of Natchez and Vidalia, by restraining the river from cutting into Lake Concordia.*

IMPROVEMENT OF MISSISSIPPI RIVER BETWEEN THE MOUTHS OF THE ILLINOIS AND OHIO RIVERS—IMPROVEMENT OF OSAGE RIVER IN MISSOURI AND KANSAS.

Officer in charge, Col. J. H. Simpson, Corps of Engineers, having under his immediate orders Capt. O. H. Ernst, Corps of Engineers.

1. *Improvement of the Mississippi River between the mouths of the Illinois and Ohio Rivers.—Piasa and Alton Dams.*—No work has been done at these places during the fiscal year, the dams at Piasa and Ellis Islands being virtually completed.

Pending the execution of the survey of Alton Harbor, recently ordered by Congress, it is deemed advisable to retain the \$35,000, now available, for any work which may be found necessary. The general interests of navigation would be best served by the improvement of the channel at Maple Island, a work closely related to the desired improvement at Alton.

Sawyer and Venice Bends.—A small amount of work was done at Sawyer Bend to repair and secure the old work; no work is contemplated except such as may be necessary for preservation.

Closing Cahokia Chute.—The dam to close this chute was successfully constructed during this fiscal year to a height of 9 feet above low-water.

No further work is contemplated unless Congress should favor the construction of a winter harbor at the locality, for which it is well adapted.

Revetment of west side of Arsenal Island.—This has been rendered necessary by the increased current since the closure of Cahokia Chute. The work will require extension from time to time. For the present year the necessary funds will be allotted from the undistributed balance of the appropriation of March 3, 1879.

Horsetail Bar.—The results of work at this locality have been favorable. The channel has remained within the intended limits, and has assumed a position and direction entirely satisfactory.

Further work will be necessary to perpetuate the results and permanently narrow the river. An allotment of \$70,000 was made to this locality from the appropriation of March 3, 1879.

Fort Chartres and Turkey Island.—No work done or contemplated.

Kaskaskia Bend.—The peculiarly unstable soil at this locality has rendered it necessary to expend more money than Congress specifically set apart for the work, and there is urgent necessity for further allotment from the undistributed part of the recent appropriation.

Protection near Liberty Island.—Was repaired and extended during the year. Work the coming year will be limited to repair and preservation.

Devil's Island.—No work done or contemplated.

Protection between Dicky Island and mouth of the Ohio.—This protection has been materially extended during the year, and with satisfactory success. The work of former years stands well. A portion of the appropriation of \$30,000, of March 3, 1879, was expended during the fiscal year.

The officer in charge submits an estimate of \$500,000 for the fiscal year ending June 30, 1881. The appropriation of this sum is recommended, which will enable the works hitherto commenced to be completed, and several new ones begun.

July 1, 1878, amount available.....	\$256,307 62	
Miscellaneous receipts.....	56 92	
Amount appropriated by act approved March 3, 1879.....	200,000 00	
		\$456,364 54
July 1, 1879, amount expended during fiscal year.....	256,119 27	
July 1, 1879, outstanding liabilities.....	8,889 91	
		265,009 18
July 1, 1879, amount available.....	191,355 36	
Amount (estimated) required for completion of existing project.....	6,289,600 00	
Amount that can be profitably expended in fiscal year ending June 30, 1881.	500,000 00	

(See Appendix N 1.)

2. *Improvement of Osage River in Missouri and Kansas.*—The act of Congress approved June 18, 1878, appropriated \$20,000 for the improvement of the Osage River in Missouri and Kansas. To supply needed information concerning that part of the river above Osceola, Mo., a survey was made from Ottawa, Kans., to Osceola, Mo., a distance by the river of 196 miles.

The work of improving the navigation of the Osage River has been continued by an extension of the improved channel over a distance of 16 miles, making a total improved navigation for a distance of 45 miles from the mouth. The appropriation of March 3, 1879, will be applied to the extension of the improvement to Tuscumbia, Mo., a distance of 15 miles farther.

The amount which can be profitably expended during the fiscal year ending June 30, 1881, is \$50,000.

July 1, 1878, amount available.....	\$20,000 00	
Miscellaneous receipts	15 75	
Amount appropriated by act approved March 3, 1879	20,000 00	
		\$40,015 75
July 1, 1879, amount expended during fiscal year.....	19,224 65	
July 1, 1879, amount available		\$20,791 10
Amount that can be profitably expended in fiscal year ending June 30, 1881.	50,000 00	
(See Appendix N 2.)		

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with provisions of the river and harbor act of June 18th 1878, Colonel Simpson was charged with and has completed the following examinations and surveys:

1. *The Mississippi River, to ascertain the practicability, cost, and utility of a dike from Bloody Island, opposite the city of Saint Louis, Missouri, north of the dike or dam opposite Brooklyn, on the Illinois shore.* (See Appendix N 3.)

2. *A survey and estimate of the damages, if any, done or to be done to riparian owners of lands, and improvements thereon, at or in front of the town of Venice, Illinois, near Saint Louis, Missouri, by reason of government improvements made or to be made at or near said town of Venice.*—This report will be submitted for transmission to Congress at the next session.

And to comply with the provisions of the river and harbor act of March 3, 1879, has been charged with and is now engaged upon the following, the result of which will be duly submitted when received:

1. *Alton Harbor, Illinois, and the Mississippi River opposite the mouth of the Missouri.*

REMOVING SNAGS AND WRECKS FROM MISSISSIPPI, MISSOURI, AND ARKANSAS RIVERS—SURVEYS AND IMPROVEMENTS AT VARIOUS POINTS ON MISSOURI RIVER—SURVEY OF MISSOURI RIVER FROM ITS MOUTH TO SIOUX CITY—IMPROVEMENT OF ARKANSAS RIVER AND OF WHITE RIVER AT BUFFALO SHOALS.

Officer in charge, Maj. C. R. Suter, Corps of Engineers, with Capt. Thos. H. Handbury, Corps of Engineers, under his immediate orders.

1. *Removing snags and wrecks from the Mississippi, Missouri, and Arkansas Rivers.*—During the past season, snagging operations have been carried out on the Mississippi, from the mouth of the Missouri to Vicksburg, 846 miles, and on the Missouri from its mouth to Kansas City, 431 miles. No work was done on the Arkansas, owing to low water.

Surveys and observations have been made at various points on the Mississippi, Missouri, and Arkansas Rivers, to furnish information needed in perfecting plans for the improvement of those streams.

The rebuilding of two of the old snagboats has been in progress, and the new boats will soon be ready for service. The officer in charge renews his recommendation that one of the remaining wooden boats be repaired and fitted up for wrecking purposes, and that the other receive an iron hull. Estimates for the purpose are submitted.

During the coming season it is proposed to devote 13 months' snagboat work to the 3 rivers, distributed as follows, viz, Mississippi, 6 months; Missouri, 4 months; Arkansas, 3 months.

APPENDIX N.

ANNUAL REPORT OF COLONEL J. H. SIMPSON, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1879.

ENGINEER OFFICE U. S. ARMY,
Saint Louis, Mo., July 28, 1879.

GENERAL: I have the honor to forward herewith my annual report upon the improvement of the Mississippi River between the mouths of the Illinois and Ohio Rivers, and upon Osage River in Missouri and Kansas, for the fiscal year ending June 30, 1879.

In addition to my regular duties I have served as a member of the Board of Engineers upon the improvement of the low-water navigation of the Mississippi and Missouri Rivers, constituted by Special Orders No. 71, Headquarters Corps of Engineers, dated July 8, 1878.

I have been aided in the duties of this office, since September 28, 1878, by Capt. O. H. Ernst, Corps of Engineers, to whom I am indebted for very faithful and valuable assistance.

I desire also to express my appreciation of the faithful and very efficient manner in which Assistant Engineer R. E. McMath, and my chief clerk, S. S. Hutchins, assisted by Salem G. Clark, in the office, have performed their respective duties.

Assistant Engineers D. M. Currie, Chas. S. True, W. S. Simpson, and Overseer John J. McDonald, employed in conducting work in the field, and Assistant Engineers Wm. Popp and Preston O. F. West, engaged in surveys, also deserve credit for the zealous and able discharge of every duty assigned to them.

Very respectfully, your obedient servant,

J. H. SIMPSON,
Colonel of Engineers, Bvt. Brig. Gen., U. S. A.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

N 1.

IMPROVEMENT OF THE MISSISSIPPI RIVER BETWEEN THE MOUTHS OF THE ILLINOIS AND OHIO RIVERS.

BETWEEN THE ILLINOIS AND MISSOURI RIVERS.

No work was done within these limits during the year. The dams at Piasa and Ellis Islands are in good condition, though the latter has been somewhat flattened by the action of ice last winter. The appropriation of \$20,000 of June 18, 1878, is still available, and with the \$15,000 appropriated March 3, 1879, will enable some new works to be commenced. It is proposed to apply this money to the improvement of the naviga-

tion near Maple Island. The exact location of the works and their estimated cost cannot be given until after the completion of the survey authorized in the act of March 3, 1879.

SAWYER BEND.

The revetment of this bend was repaired, but urgent demand for funds at other localities prevented any extension of it.

The expenditures were :

2,073.32 cubic yards riprap	\$2,590 49
Excavation	243 07
Engineering and contingencies	154 50
	<hr/>
	2,988 06

The unprotected parts of the bend are caving now but slightly, and it is proposed to limit the operations next year to such repairs and small extension as may be found necessary to protect the old work.

VENICE.

No work was done at this locality and none is proposed for the coming year. A report upon the "damages, if any, done or to be done to riparian owners of lands and improvements thereon, at or in front of the town of Venice, Ill., near Saint Louis, Mo., by reason of government improvements made, or to be made, at or near said town of Venice," together with a historical memoir by Mr. Robert E. McMath upon the harbor of Saint Louis, was submitted April 10, 1878.

A report upon the "practicability, cost, and utility of a dike from Bloody Island, opposite the city of Saint Louis, Mo., north, to the dike or dam opposite Brooklyn on the Illinois shore," the latter being sometimes known as the Venice Dike, or Long Dike, was submitted February 8, 1879. These documents discuss quite fully the conditions of the locality. On the 14th of January, 1879, the House of Delegates of the city of Saint Louis adopted the following resolution :

Resolved, That the security of the harbor of this city and the perpetuity of a deep-water channel along the wharf of this city require the construction of a dike or dam upon the Illinois side of the Mississippi from the head of Bloody Island to the west end of the Brooklyn dike built by the Federal Government, and that the Harbor Commissioner be and hereby is requested at once to apply to the Engineer Department of the United States, represented in this city by Col. James H. Simpson, for a recommendation of the advisability and necessity of the suggested improvement to be made by the United States in the interest of its harbor at this city, and in time for action by Congress in providing for river and harbor improvements for the current year.

This resolution was transmitted to me by the Harbor Commissioner with the following letter :

OFFICE OF HARBOR AND WHARF COMMISSIONER,
Saint Louis, Mo., January 17, 1879.

SIR: I have the honor to call your attention to the following resolution adopted by the honorable House of Delegates of this city on January 14, 1879, viz :

Being perfectly familiar with the condition of the harbor of Saint Louis, you will appreciate the importance of the construction of the proposed dike for the river business of this city.

As matters are now, a great portion of the wharf along the northern part of the city cannot be utilized in times of low-water on account of sand-bars in front thereof, and after every flood we find the levee covered with river deposits several feet in depth, all caused by the lack of sufficient current on this side of the river. The city of Saint Louis having no jurisdiction on the east side of the river is unable to help herself in this matter, and depends upon the United States for assistance.

Already in 1876 the mayor and city council of Saint Louis petitioned Congress for an appropriation for the work referred to in the resolution above given. I understand that you have since made all necessary preliminary surveys and have also prepared plans and estimates for the work. In compliance with the request of the honorable House of Delegates, expressed by the above resolution, and in view of the great importance of the contemplated work for the navigation of this harbor, I herewith most respectfully ask you to report the matter favorably to the Chief of Engineers as soon as possible, so that it can be considered by Congress in providing for river and harbor improvements for the current year.

Very respectfully,

CHARLES PFEIFER,
Harbor and Wharf Commissioner.

JAS. H. SIMPSON,
Colonel United States Engineers.

I replied that I could not make such a recommendation, and requested the Board of Public Improvements of the city of Saint Louis to call at my office and examine my maps when I would explain to them my reasons. The Board called January 23, as requested, and the case was presented to them as follows:

GENTLEMEN: In my letter to Mr. Pfeifer, of the 17th instant, I assumed that the language used in the resolution of the honorable House of Delegates referring to a dike above Bloody Island was not to be literally interpreted. The resolution speaks of a dike from the head of Bloody Island to the west end of the Brooklyn dike. The Brooklyn dike is opposite North Market street, and it is plain that the dike described in the resolution can have no beneficial effect upon the Saint Louis wharf at North Market street or above. The resolution no doubt intended to refer to such dike, wherever placed, as would be most likely to have the desired result. I shall endeavor to show you that it will be necessary to alter the location of the north wharf before success can be expected from any works on the Illinois side.

The proper location of that wharf depends mainly upon the direction in which the river approaches from above. Its present position was given it about the year 1854, when it was intended to bring the main body of the river down through Cabaret Slough. The works designed for that purpose at the Chain of Rocks failed and were abandoned in 1868, and the approach through Sawyer Bend has been accepted ever since. A stone revetment now extends from the water-works up stream in a straight line a distance of 4,600 feet. This line intersects the wharf-line at the water-works, making an angle of deflection of $23^{\circ} 30'$, the wharf-line being straight for a length of 12,030 feet from the angle. The question is whether this great river, having a well-established line of direction, can be suddenly turned about an angle of $23^{\circ} 30'$ made by two straight lines. There are few things that cannot be done if money enough is expended, and it is possible that if the river is sufficiently contracted it can be made to turn that angle in such a way as to give deep water along nearly all, if not all, of the present line of wharf. I have had some computations made to ascertain what contraction would be required and what depth of water would result upon the Illinois side at a low stage. These show that the greatest width allowable would be 500 feet and the depth on the Illinois side at least 30 feet. The shape of the cross-section would be a right-angled triangle, of which the apex would be on the east side, making it doubtful even then if the water would be deep enough on the Saint Louis side. The main current 60 feet deep would flow parallel to and in contact with the new dike, necessitating massive construction. The cost of such a dike would be enormous.

But to contract the river to that width cannot be thought of. A low-water width of 1,560 feet is the least that can be allowed, and our computations show that even this with banks sloping up on each side upon the ordinary grade of a wharf, will be a dangerous contraction in time of great floods. That width will leave the water shoal on the Saint Louis side above North Market street.

Supposing the river to be held, however, against this line, trouble will be made below Ashley street. Some deposits have already been made there, and these will be increased if in its approach from above the river is compelled to follow the unnatural line proposed. So that actually for the protection of the central wharf it is necessary to push out the northern wharf.

The true line for the north wharf is, in my opinion, a curve, tangent at the water-works to the line of revetment in Sawyer Bend, having the present wharf-line as a chord and a versed sine of about 625 feet. I give that as an approximation. If the honorable Board of Public Improvements should conclude to make the change the exact location could be fixed after further discussion.

The arguments which have been brought forward to oppose any change are—

1st. Much money has been spent in establishing the present line. The answer is that when an error is recognized, the sooner it is abandoned the better and cheaper.

2d. There would be some difficulty in lengthening established sewers. The answer is that the mouths of the sewers being choked with sand now the grade is practically flattened, and their course as open channels extended as far as would in any case be necessary. It is even now considered a necessity that the sewers should empty into a swift current that the *débris* and filth may be swept away, and the time is not far distant when by the growth of the city the increased volume and offensiveness of the sewage will render it an intolerable nuisance if permitted to enter the river and pass along the front of the city. In time an intercepting sewer will be necessary; the construction of a section on this part of the front would merely anticipate and render doubly useful what eventually will be required for the single use of abating a nuisance.

3d. It would require time to reclaim the new area to a height useful for building. The answer is that it is not a question whether land shall be reclaimed, but only where it shall be. The river must be narrowed, if not by encroachment from the city side, where the value of the ground will repay to a great extent, if not entirely, the cost of reclamation, then land must be reclaimed on the Illinois side, where it is almost valueless.

4th. Claims for indemnity would be made by property owners whose ground would then be inland instead of river-front property. The answer is that claims for damages will arise whichever front be extended. It is true that Saint Louis will not be liable for those on the Illinois side if the United States executes the works, but with an honorable people that fact does not weaken the force of the argument.

You are no doubt aware that the city of Saint Louis received in 1849 the consent of the Illinois legislature to construct certain works upon the Illinois side, of which the dike mentioned in the resolution of the honorable House of Delegates, literally interpreted, is one, and gave bonds to execute some of those works in a manner which has never been carried out. The joint resolution giving this consent may be found in Public Laws, Illinois, 1849, pages 238, 239. It is referred to merely to show that the city has recognized its responsibility to the riparian owners on the Illinois side, and that in transferring the improvement of its harbor to the United States it should join the latter in reducing the claims for damages to a minimum. Now it so happens that to place the east side of the river at a distance of 1,560 feet, or even 1,600 feet, from the present north wharf, will expose the United States to large claims for damages, while if it is placed at a similar distance from the wharf that nature requires these claims will be avoided, because the city of Saint Louis, under city ordinance 805, acquired the title in 1841 to construct the works in that position.

It seems to me that these arguments are conclusive.

In their annual report to the mayor for the year ending April 7, 1879, the Board make the following remarks:

In regard to the northern wharf (from Bissell's Point to O'Fallon street), the United States Engineers have proposed a change of the wharf-line, pushing it out into the river about 600 feet in its central portion opposite North Market street, and have urged its adoption by the city. But after a full consideration of the subject the Board feels compelled to report adversely to the proposed change. The proposed line would undoubtedly conform better than the present line to the current of the river, and would enable a greater depth of water to be maintained along its whole extent. But the large expenditure already incurred on the present line and the great cost of improving to the new line furnish strong arguments against the change.

The expenditures of the city for dikes on this part of the wharf prior to 1870 were about \$230,000. The improvement of the wharf since 1870 has cost \$219,300—making a total of \$450,000. This is exclusive of money expended for real estate, much of which would, if the change were made, be entirely useless for wharf purposes and revert to the original owners. The land dedicated for wharf purposes would obviously go back to the donors.

The cost of simply constructing a longitudinal dike (14,000 feet in length) on the proposed line would cost \$240,000, and the necessary spur-dikes about \$110,000—making a total expense of \$350,000. But this would be only the skeleton of the wharf. To construct the wharf itself so as to afford the same facilities to business as the present wharf would cause an additional expense of at least \$300,000.

But outside of all financial considerations, which in themselves are conclusive, an equally urgent reason against the adoption of the line proposed is found in the fact that the construction of the works would for a number of years make the upper part of the wharf unavailable for the large business now done there, and would work almost the destruction of the lumber business of that part of the city.

The change appears the more unwarranted when we consider that the depth of water on this portion of the wharf has not within the last few years been materially reduced.

As there is a good channel for general navigation at all stages in this part of the river, the main object of additional works would be to pro-

cure deep water along the Saint Louis wharf. It is recommended that nothing more be done here by the United States until a wharf-line shall be adopted by the city of Saint Louis which will offer reasonable facilities for the success of our works and protect the United States from claims for heavy damages from riparian owners.

CANOKIA CHUTE.

The dam across the chute east of Arsenal Island was completed as a low dam, the level of its crest being about 9 feet above low-water. It is proposed to leave it at this height, unless my recommendation of former years that the part of the chute below the dam be made an ice-harbor should be carried out. The operation of closing the main channel of the Mississippi was one of great magnitude, and this being the first attempt of the kind, its details are of special interest. They may be found in the report of assistant D. M. Currie, to whose energy and skill the success of the undertaking is mainly due, which report is hereto appended and marked A.

One of the phenomena developed by this work was a very marked deepening of the river for a considerable distance above the dam. Soon after the brush foundation had been placed it was discovered that the depth of water had increased upon the east side about 5 feet, and upon the west side about 2 feet.

It is much to be regretted that hydrographic surveys were not made before and after the construction, to show exactly how far this scour extended. The fact, however, was not anticipated, and exact data upon the subject are therefore wanting. The dam is completed.

PROTECTION OF ARSENAL ISLAND.

During the winter the broad flat sheet of sand in the west chute at Arsenal Island gave way and left a good navigable channel, at the same time taking off the heavy strain upon the dam in the east chute. The increased body of water passing through the west chute rendered it necessary to continue the revetment of the west side of Arsenal Island.

That portion of the island which had been eroded to the line fixed for the east shore of the river was therefore protected. Such portions as projected beyond the line fixed are left for further erosions.

The expenditures were:

FOR THE DAM.

53,563.66 cubic yards riprap, 865.06 cubic yards spalls, 171.95 cubic feet anchor-stone	\$53,543 40
997 piles	7,762 90
6,167.57 cords brush	11,060 11
Grading	908 17
Engineering and contingencies	3,472 05
	<hr/>
	76,746 63

FOR REVETMENT OF ARSENAL ISLAND.

10,012.48 cubic yards riprap	\$9,132 38
Excavation	115 37
Engineering and contingencies	423 10
	<hr/>
	9,673 85

HORSETAIL BAR.

When operations were resumed there were several breaks in dike 5, the largest of which was 200 feet wide and 18 feet deep at the deepest part. In dike 3 there was a break about 300 feet wide and 45 feet deep at its deepest part. About 200 feet below dike 3, opposite the break,

there was a hole over 70 feet deep, and there was a gap in dike 4. After partially filling the gaps in dike 5, it was decided to discontinue work upon these dikes and to rely upon the training-wall, with some supplementary works, to accomplish the contraction of the river. Beginning at a dry sand-bar nearly half a mile above dike 2, this wall has been carried down stream a distance of 5,950 feet, at a cost of \$9.75 per foot, exclusive of engineering and contingencies, or, including these items, \$10.16 per foot.

The current striking this wall obliquely is pushed off in the desired direction, without bringing to bear the tremendous forces which dikes perpendicular to the current must resist. The necessity of connecting the training-wall with the main shore to prevent its destruction by ice-gorges or a sudden change in the direction of the channel is evident.

The most perfect connection possible is a solid mass of earth and sand, and this the river itself will furnish. Deposits in the dead water behind the wall had already begun, but it was thought desirable to hasten them, as well as to make them more uniform over the whole area. Accordingly a series of continuous hurdles was constructed at intervals of about 100 yards.

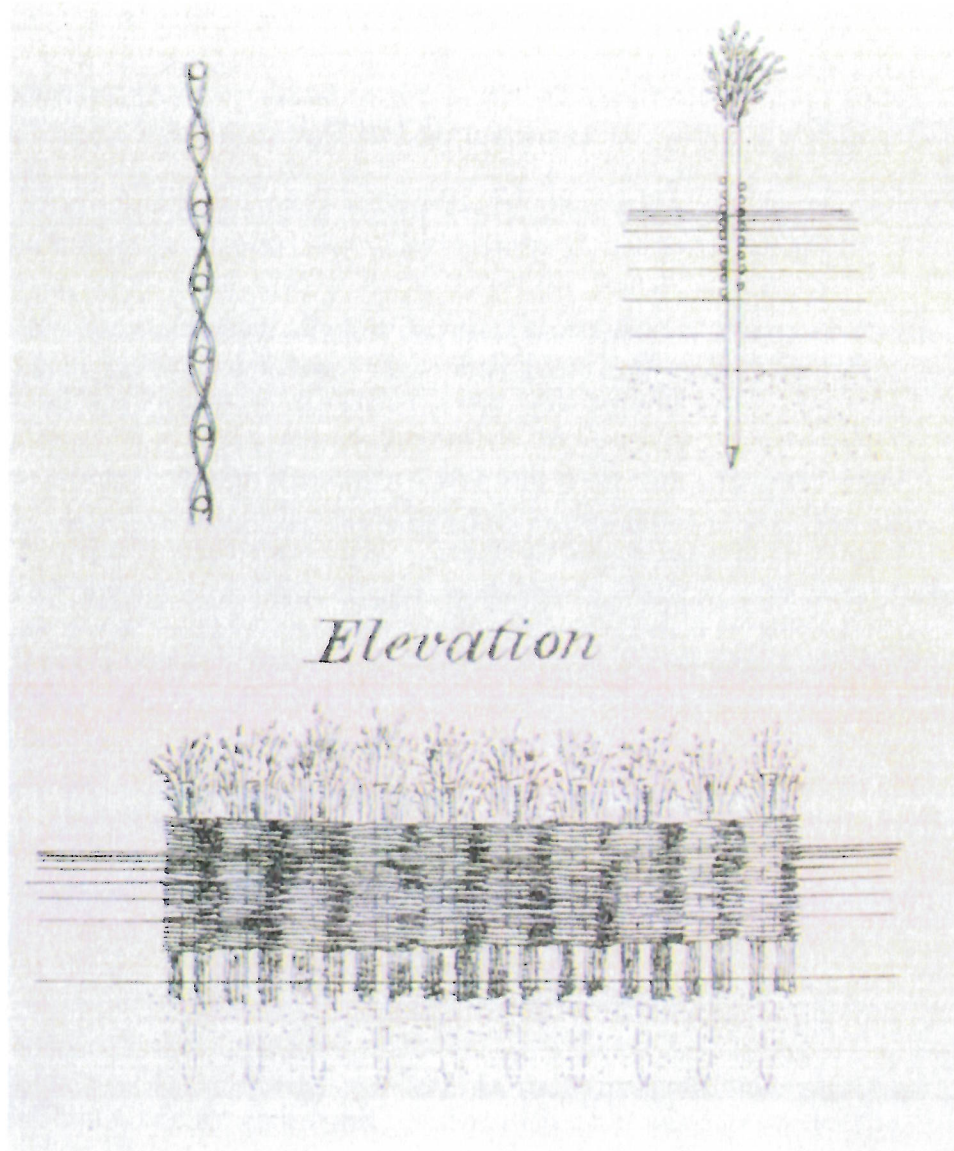
Each hurdle runs from the wall to the high bank upon a line perpendicular to the wall. A sketch of a portion of a hurdle is transmitted. To construct it a row of light piles is driven 5 feet apart. With these are interwoven courses of willow brush, something after the manner of military hurdles. After the wattling has been completed pieces of brush are pushed vertically into the triangular spaces left between the piles and the point where the different courses cross each other until these voids are completely filled. The vertical pieces are driven down into the bottom, if possible. The branches are left on at the top and project about 8 feet above the wattling. The greatest depth below the surface to which we have succeeded in sinking the lower courses is about 8 feet, and where the depth of water has been greater than this there has of course been a free space left below the wattling. Nevertheless, the efficiency of such a hurdle in creating deposit has been remarkable. A line was constructed in 23 feet of water in the first half of May. By the 1st of June there was a deposit at that place 7 feet thick. Equally remarkable results were achieved by those constructed in shoaler water where the wattling extended to the bottom. During a short rise in April the completed hurdles collected a mass of mud, the top surface of which was about level and flush with and extending to the top of the training-wall, and to a depth in some places of 6 feet. The whole of this deposit cannot be claimed for the hurdles, since the training-wall itself must be instrumental in causing it, but it is evident that the hurdles greatly assisted, from the fact that where they existed the shoaling was far more rapid than where they did not. Their cost was about 80 cents per linear foot.

The navigation upon this part of the river has been good throughout the year. The least depth at any time was 5 feet, which was but temporary, and due to the training-wall being rapidly extended across the deepest channel. The expenditures were:

Dike No. 2:		
1,614.57 cubic yards riprap	\$1,594 39	
Engineering and contingencies	94 29	
	<hr/>	\$1,688 68
Dike No. 5:		
4,929.44 cubic yards riprap. 27 cubic feet anchor-stone.....	4,884 72	
Engineering and contingencies	295 42	
	<hr/>	5,180 14

HURDLES

Scale 1 Inch = 20 Ft.



Scale 1 Inch = 20 Ft.

Training-wall (5,600 feet):			
39,545.10 cubic yards riprap, 35 cubic feet anchor-stone	\$37,219 44		
896 piles	7,078 40		
6,306.28 cords brush	10,502 84		
Excavation	65 20		
			\$55,266 88
Plank training-wall (350 feet):			
1,517.18 cubic yards riprap	1,383 82		
150 piles	712 50		
139.55 cords brush	207 93		
Labor, &c.	439 20		
			2,743 45
Hurdles (5,500 feet):			
593 piles	\$2,816 75		
237.18 cords brush	398 10		
Timber	190 35		
Labor	972 72		
		4,377 92	62,388 25
Engineering and contingencies			2,454 80
			64,843 05

It is proposed during the coming year to continue the construction of the training-wall and hurdles. As the extensive use of riprap in the training-wall makes it quite costly, it is desirable to seek some cheaper material. A form of construction has been designed by Captain Ernst, which is now undergoing the test of experience. For details see appended report of Mr. Currie.

The section built this spring has been left without the sand filling, with the expectation that the deposits from the river will render a part, if not all of it, unnecessary. This filling will be required for those portions built in the fall, and it is thought that it can be put in cheaply by means of a sand pump. Although the section actually built has cost \$7.85 per foot, it is estimated this wall, exclusive of the sand filling, may be constructed at a cost of \$4.75 per running foot in the same average depth of water as that worked in this year, or 14 feet. No accurate estimate can now be given of the cost of the sand filling. It may vary from 0 to \$2.50 per running foot; but with proper appliances should not exceed \$1 per running foot, even where no assistance is received from the river deposits. In any case there is a considerable margin in favor of this method over the \$9.75 per foot which the other has cost.

PORT CHARTRÉS DAM.

No work done or contemplated.

TURKEY ISLAND DAM.

No work done or contemplated.

PROTECTION OF BANK NEAR KASKASKIA.

The apprehensions expressed in my last annual report concerning the work done at this point proved well founded. When the water fell, it was found that the channel had cut in behind the revetment placed there in the fall of 1877, and that it was a total loss. This is an excellent illustration of the evil resulting from the requirement so often attached to the appropriation bills that certain small sums shall be expended at certain points.

A new protection was begun last fall at the head of the bend, and the brush foundation was extended downstream a distance of 2,725 feet. A covering of riprap was extended up the face of the bank to a level about 10 feet above low-water. This covering has been further extended this spring to a height sufficient to cover the most treacherous part of the bank, and the revetment, completed as it advanced, has been extended downstream a distance of 1,700 feet, making 4,425 feet in all for the year.

The peculiar soil of this bank and the unfavorable direction of the approach of the river make it the most difficult work of the kind that we have yet undertaken. There is a layer of very fine sand extending from below the surface of the water to a height varying in different places from 18 to 30 feet above low-water. When the water comes in contact with this sand it "melts it like sugar," and a strip 50 feet wide will go out in a few days. The method employed elsewhere of protecting the lower part first and allowing the upper part to grade itself before covering it, cannot be employed here. It is necessary to grade the bank by hand and cover it to a height above the sand layer before the occurrence of high water. This adds materially to the cost and to the time required to check the erosion at any given point.

The amount specially appropriated for this work in the act of June 18, 1878, was \$10,000, and by act of March 3, 1879, \$8,000, which were supplemented by additional allotments of \$10,000 and \$12,000, in order to procure substantial results.

The funds available will scarce be sufficient to put the work already begun in safe condition. Work will necessarily be suspended at an early date.

The expenditures were:

23,298.74 cubic yards riprap	\$23,000 68
1,844 cords brush	4,825 01
127 piles	1,011 77
Mattresses	399 45
Excavation	430 35
Engineering and contingencies.....	1,166 29
	<hr/>
	30,923 55

LIBERTY ISLAND.

As stated in my last report, the river had washed away the earth back of the upper end of the old revetment. A new revetment was constructed over a length of 670 feet behind the old one, and was then extended upstream a distance of 1,285 feet. The total length of continuous protection on the Missouri shore is now 7,325 feet. It has all been put in good repair this spring, and extends to a height about 25 feet above low-water. The total expenditure upon this protection has been \$45,129.40, or \$6.16 per linear foot of bank.

The expenditures this year were:

7,218.61 cubic yards riprap	\$8,050 57
58 piles	590 00
293 cords brush	761 10
Excavation	25 20
Engineering and contingencies.....	585 56
	<hr/>
	10,012 43

It is proposed to limit the operations during the coming year to such repairs and small extension as may be required to protect the work done.

DEVIL'S ISLAND.

The dike and dams remain in good condition. No work was done during the year and none is contemplated.

DICKEY ISLAND TO MOUTH OF THE OHIO.

The brush and stone foundation for the protection in rear of Cairo was extended up-stream a distance of 7,300 feet. The stone covering was extended up the face of the bank to a height about 10 feet above low-water. It is intended to allow the bank to grade itself to a gentler slope before completing the covering. Stone was deposited upon 1,150 feet of the old work where this grading process had occurred.

The expenditures were:

27, 082.09 cubic yards riprap	\$42, 352 06
113 piles	732 44
737.28 cords brush	1, 948 12
Mattresses	6, 884 28
Grading	141 95
Engineering and contingencies	2, 992 08
	<hr/>
	55, 051 53

SURVEYS.

Surveys and examinations have been made under resolution of the Board of Engineers, convened by Special Orders No. 71, Headquarters Corps of Engineers, 1878, at Saint Louis Harbor, Brickey's Mill, Vancill's Landing, and Dickey Island.

These surveys were designed to furnish data for the study of the general problem of the improvement of the Mississippi through determination of volume at different stages, the amount and character of sediment carried by the river and its variations; also the movements of bars and bar-material at the bottom of the river. Much valuable material was collected, and it was hoped that the series of observations might be continued so as to include periods of both high and low water. The creation of the Mississippi River Commission by a recent act of Congress placed the further prosecution of such investigations in other hands, and the observations were suspended at the close of the fiscal year.

A survey was made to "ascertain the practicability, cost, and utility of a dike from Bloody Island opposite the city of Saint Louis, Missouri, north to the dike or dam opposite Brooklyn on the Illinois shore," the map and report of which were submitted February 8, 1879. For this survey \$500 was allotted and expended from appropriation for examinations and surveys, &c., June 18, 1878.

EQUIPMENT.

Four new-model barges, built by contract, were added to the fleet, and a small steam-launch was received from Major Farquhar. Pile-driver No. 1 was dismantled, her hull having become too weak for the service. Her machinery was placed in store, and the hull fitted up as a quarter-boat for one of the surveying parties.

GENERAL REMARKS.

The progress made during the year towards the great object aimed at, of procuring 6 feet depth of water at the lowest stage from the mouth of the Illinois to Saint Louis and 8 feet from Saint Louis to Cairo, has been

as great as the means provided by Congress would permit; but the fact must be recognized that that progress has been comparatively slight, and not at all satisfactory either to the people for whose benefit the work is being prosecuted or to the officer in charge.

The estimated cost of the improvement is \$7,684,200, but this estimate is based upon the supposition that funds are provided as rapidly as they can be judiciously expended. With annual appropriations of \$200,000, as have prevailed, it is my belief that the improvement will occupy at least a century and will cost \$20,000,000. But enlarged operations will leave more unfinished works at the end of each year and subject the government to greater loss from their destruction by the failure of appropriations for the following year, for it is rarely advantageous to entirely complete any work in one season. In our revetments we sometimes protect the bottom of the bank first and then leave it, returning to it the following season when the river has usually saved us the expense of grading it to a gentle slope by hand; but if we leave it too long the river cuts in behind it and our work is destroyed.

In contracting a wide part of the river the object of the works is to create deposits from the river, and these always require considerable time; but until the deposits are secured the works are in a precarious condition, and require constant watching and repairs; the want of \$1,000 at the opportune moment may result in an expense of \$50,000. The only security against failure and waste of the public money is to be found in the command of abundant means, not only for the current expenses of extensive works, but to insure their continuation at the proper time in future. The *least* amount that can be profitably expended during the fiscal year ending June 30, 1881, is \$500,000. To give an idea of the demands upon the annual appropriations for this district, I append copies of some of the petitions received during the year. The demands of the city of Saint Louis have already been referred to, while the great and overwhelming demands of general navigation need no mention.

Copy of petition of September 27, 1878, signed by 13 residents of Monroe County Illinois, Appendix B.

Copy of letter from Common Council of Alton, Ill., December 10, 1878, Appendix C.

Copy of petition of February 5, 1879, signed by 219 citizens of Saint Genevieve, Mo., Appendix D.

Copy of letter from Mayor and Common Council of Cape Girardeau, Mo., without date, received June 17, 1879, Appendix E.

It is to be remarked that the works referred to in the petitions marked D and E have nothing to do with the evils complained of. The interests represented by these petitions are mainly local, but many of them could be protected in carrying out the main scheme of general improvement, while now it is altogether impossible to give heed to them.

It is not intended to commence any new work during the fiscal year ending June 30, 1880, except possibly at Alton or Maple Island.

The allotments made from the undistributed part of the appropriation of March 3, 1879, were—

Horseshall Bar	\$70,000
Kaskaskia Bend	12,000
Repairs and contingencies	10,000
Unallotted	55,000
	<hr/> \$147,000

The specific allotments by Congress were—

Illinois to Missouri	15,000
Kaskaskia Bend	8,000
Dickey Island to mouth of Ohio	30,000
	<hr/> 53,000
	<hr/> 200,000

The estimate of \$500,000, already given, for the fiscal year ending June 30, 1881, is intended to cover the completion of the works now in progress, and to commence improvements much needed at several points, for which detailed estimates cannot be given in advance of the actual commencement of each particular work.

All work during the year has been done by hired labor and the purchase of material in open market, with the usual satisfactory results. It is intended to pursue the same system the coming year.

The work is located in the collection-district of New Orleans.

Amount of revenue collected at the port of Saint Louis for the fiscal year ending June 30, 1879, was \$1,136,417.85.

Construction account.

Name of work.	Expended previous to July 1, 1878.	Expended during year ending June 30, 1879.	Total cost to June 30, 1879.	Required to complete.	Total estimated.
Piasa Island Dam	\$32,333 30	.....	\$32,333 30	\$8,877 43	\$41,210 73
Alton Dam	33,023 02	.....	33,023 02	0,370 08	40,000 00
Sawyer Bend protection	93,815 57	\$2,088 06	90,803 03	45,407 00	142,211 02
Venue Dikes	36,341 85	.....	36,341 85	3,638 15	40,000 00
Arsenal Island protection .....	.....	0,073 85	0,073 85	.....	0,073 85
Closing Cahokia Chute	26,403 20	76,740 63	103,140 80	1,450 11	104,600 00
Horseshall Bar, dike 1	40,549 53	.....	40,549 53	.....	.....
Horseshall Bar, dike 2	21,911 58	1,688 68	23,600 20	.....	.....
Horseshall Bar, dike 3	82,092 54	.....	82,092 54	.....	.....
Horseshall Bar, dike 4	41,200 11	.....	41,200 11	37,195 34	347,502 80
Horseshall Bar, dike 5	31,753 73	5,180 14	36,933 87	.....	.....
Horseshall Bar, training-wall, &c	20,308 10	61,843 05	85,241 21	.....	.....
Fort Claiborne Dam	30,812 80	.....	30,812 80	9,750 00	40,562 80
Turkey Island	24,403 85	.....	24,403 85	8,101 61	32,505 46
Kaskaskia protection	4,514 31	30,923 55	35,437 86	6,562 14	42,000 00
Liberty Island Dam	5,053 01	.....	5,053 01	.....	5,053 01
Liberty Island protection	35,116 07	10,012 43	45,120 40	.....	45,120 40
Devil's Island, dike 1	65,871 17	.....	65,871 17	.....	.....
Devil's Island, dam 1	49,848 58	.....	49,848 58	17,001 95	150,000 00
Devil's Island, dam 2	16,078 30	.....	16,078 30	.....	.....
Cairo protection	30,092 95	55,051 53	85,144 48	87,355 52	172,500 00
Total	729,566 45	257,107 02	986,674 37	232,336 32	1,219,010 69

Property and material account.

Class of property.	Balance July 1, 1878.	Dr.	Cr.	Balance June 30, 1879.
Office furniture	\$204 05	\$28 00	\$120 00	\$172 05
Instruments and survey material	850 00	704 50	525 30	1,080 20
Pile-drivers	9,014 07	1,328 47	0,800 00	4,347 44
Barges	24,358 00	10,267 22	14,705 81	25,880 01
Two tow-boats, one tug, one launch, and expenses	41,709 10	30,413 08	50,472 32	27,710 52
Small boats	58 10	314 07	227 00	145 28
General expenses of property	10,660 04	1,770 15	.....	21,437 09
Material and quarry privileges	2,079 33	213,377 36	212,644 46	2,012 23
Tools and appliances	258 61	3,213 42	2,827 40	644 03
Quarters for workmen, shops, &c	4,135 07	734 38	700 00	4,080 05
Totals	103,340 52	274,237 25	280,168 20	88,418 48

Engineer Office, United States Army, in account with United States.

Dr.

Cr.

To appropriations, allotments, &c., prior to July 1, 1878	\$1,242,630 28	By expenses of office	\$53,832 00
To appropriation for improvement of Mississippi River between the Illinois and Ohio Rivers, approved March 3, 1879	200,000 00	By surveys	34,606 62
To allotment for surveys	500 00	By consttue. ons	90,340 17
To miscellaneous receipts and for fuel sold to officers	90 62	By balance on account of property ..	980,074 37
To unpaid percentage	900 17	By cash on hand and in Treasury ..	88,418 48
To liability for labor, material, &c.	7,989 74		200,245 27
	1,452,110 71		1,452,110 71

Abstract of proposals for four model barges for improvement of Mississippi River between the Illinois and Ohio Rivers, opened at Engineer Office, United States Army, Saint Louis, Mo., at 12 m. July 20, 1878, in accordance with advertisement dated July 8, 1878.

No.	Name of bidder.	Address.	Price per barge.	Price for four barges.	Remarks.
1	Salem T. Lamb	New Albany, Ind	\$2,650 00	\$10,600 00	
2	James Mack	Cincinnati, Ohio	2,700 00	10,800 00	
3	Bernard W. Nadal	Louisville, Ky	2,815 00	11,260 00	
4	Eberman, McFall & Co	California, Pa	3,000 00	12,000 00	Not in duplicate.
5	Covington Dock Com- pany.	Covington, Ky	3,150 00		Bid for only one or two.
6	McCaskoy & Kerr	Freedom, Pa	3,300 00		Bid for only two.
7	D. G. Stuart & Co	Madison, Ind	3,300 00	13,200 00	
8	Saint Louis Sectional Dock Company.	Saint Louis, Mo	3,375 00	13,500 00	
9	William Knox & Son	Marietta, Ohio	3,600 00	14,400 00	
10	John Young	Mason, W. Va		14,700 00	
11	Alfred Cutting	Metropolis, Ill	3,900 00	15,600 00	

The contract was awarded to Salem T. Lamb for \$10,000.

Money statement.

July 1, 1878, amount available	\$256,307 62	
Miscellaneous receipts	56 92	
Amount appropriated by act approved March 3, 1879	200,000 00	\$456,304 54
July 1, 1879, amount expended during fiscal year	256,119 27	
July 1, 1879, outstanding liabilities	8,889 91	265,009 18
July 1, 1879, amount available		191,355 36
Amount (estimated) required for completion of existing project		6,289,600 00
Amount that can be profitably expended in fiscal year ending June 30, 1881 ..		500,000 00

A.

REPORT OF MR. D. M. CURRIE, ASSISTANT ENGINEER.

SAINT LOUIS, MO., July 7, 1879.

COLONEL: I have the honor, respectfully, to submit the following report of operations for the improvement of the Mississippi River between the Illinois and Meramec rivers, during the fiscal year ending June 30, 1879, to the duty of conducting which I was assigned by your order dated July 18, 1878:

Work was carried on under your direction during the year as follows:

Repairingrevetment and cross-dikes at Sawyer Bend.

Constructing dam across Cahokia Chute.

Repairing and extendingrevetment on west shore of Arsenal Island.

Repairing dike No. 5, and constructing training wall and hurdles at Horsetail Bar.

SAWYER BEND.

The current had cut away the bank between the cross-dikes so as to leave their shore connections narrow salient points, which would readily yield to a slight additional attack. One dike at the upper end of the protection had its connection with the shore severed, and a short section of the bank there had been revetted to check the erosion, but had not fully succeeded in doing so.

The revetment below the cross-dikes had been somewhat damaged by the action of the current at points which were filled in the original grading.

Four of the cross-dikes having been repaired during the spring of 1878, were in good condition at the beginning of the fiscal year. The others were repaired by revetting the salient points mentioned in the preceding paragraph, and by raising those which needed it to the top of the bank, for the stone had disappeared from the upper part of a few of them, whether by the action of the current or other causes is not known.

The revetment at the upper end of the cross-dikes was raised to the top of the bank and extended up-stream about 200 feet. That below the cross-dikes was repaired, restoring it as nearly as practicable to its original condition.

DAM ACROSS CAHOKIA CHUTE.

When work was resumed at the beginning of this season Cahokia Chute was the principal branch of the river, and contained the only channel navigable at low stages of water. These conditions, having existed for several years, were apparently well established.

When the stage of the Upper Mississippi is higher than that of the Missouri its clear water remains distinct from the turbid water of the Missouri to some distance below the mouth of the chute. Such relative stages prevailed and excluded the Missouri water from the chute when turbid water would have lent material aid in the construction of the dam by depositing its sediment.

The above are the principal causes which rendered the construction of a dam across Cahokia Chute difficult. The fact that it was the only practicable channel for navigation at low stages made it necessary to commence the construction of the dam at a high stage, and push it fast enough to cause a navigable channel to be opened in Arsonal Chute before the low-water season. Those who have attempted to turn the principal branch of a large silt-bearing river from a chute in which it has become well established will readily understand the difficulties to be overcome. The difficulties arising from the clear water were of a negative character, as explained in the preceding paragraph.

Another cause contributed to make the construction of Cahokia Dam difficult, namely, the condition of Arsonal Chute. A broad, flat bar of sand or gravel, whose crest was everywhere above low-water, extended from the head of Arsonal Island to the Missouri shore. The water spread over the bar with nearly equal depth from side to side, and with a current insufficient to scour. This bar proved tenacious, and did not begin to yield until the head of water at Cahokia Dam became greater than the fall between the upper and lower openings of the chute.

Owing to the great depth of water (30 feet) and strong current near the Illinois shore, piles were not considered an efficient means of holding brush in position while being sunk. Therefore, mattresses or rafts of brush were constructed and sunk there without the use of piles.

Temporary "ways" having been constructed on Arsonal Island, below the west end of the dam, 100 feet long by 30 feet wide, a grillage of grub plank was laid spaced from 6 to 8 feet between lines of plank. The plank were nailed together at the intersections, and two holes having been bored through at each intersection, the ends of a small line were passed through and temporarily made fast to a stake driven near by, at about the height of the top of the mattress when finished. The brush was then placed in alternate layers parallel with and at right angles to the length of the mattress, the first or bottom layer being parallel with it. When all the brush was placed a grillage was laid on top, with intersections and holes corresponding to those at the bottom. The ends of the lines were then taken from the stake and passed through the holes and the stake drawn out. The next step was to heave a sufficient strain on the lines to thoroughly compress the brush in the mattress. The compression was then secured by driving a small pin into the hole by the side of the line. The line used was $\frac{1}{2}$ inch diameter at the marginal and $\frac{1}{4}$ inch diameter at the interior intersections. Of the four mattresses constructed, one was 24 by 80 feet, two 24 by 96 feet, and one 30 by 96 feet; all of these were about 2 feet thick when completed.

The mattress having been launched was taken in tow ahead of the boat, with a barge on each side containing stone to be used in sinking it, and after being brought into the exact position laterally, and slightly above it transversely, the lines to be used in lowering were adjusted by passing their bights through toggles attached to the mattress and drawing taut. The mattress having been loaded as heavily as the

lines would bear, an active man stood at each line, and under the direction of the foreman slacked away until it rested on the bottom. Sufficient stone was then placed to secure it in position and the lines withdrawn. The mattresses were placed with their length parallel with the current.

Before removing the lines ranges were set on the sand bar above to mark the position of a line drawn through an edge of the mattress to direct the location of the next one so that there would be no vacant space between them.

The plan of the apron of the dam did not differ essentially from that of similar works which have been constructed under your direction during the past five or six years. The plans of some of those works having been described in former reports, a repetition here may seem superfluous. Still it is repeated with the hope that sufficient has been added to make it interesting.

A line of piles was driven 50 feet below the center line of the dam, and another 65 feet below, making 15 feet between these two lines. The piles were 10 feet apart in each line. When the piles had been driven in both lines on a section as long as the loaded length of a brush-barge, a mat of brush about 2 feet thick was formed on them in alternate courses, parallel with and across the current. The heaviest course was laid parallel with the current with the tops down stream and butts just above the upper line of piles. The brush being 30 feet to 35 feet long, the tops extended 15 feet to 20 feet below the lower line of piles. The top or sinking course was laid across the current parallel with the lines of piles and filled the space between them. The brush in this course was laid as shingles are placed on a roof to completely cover the lower courses and bind the whole together. The barge was moved on when a section of mat was completed and another section formed in the same way. The mat when finished was loaded with stone distributed as equally over the surface of the sinking course as practicable, care being taken to load it so the ends of the course parallel with the current would sink nearly together.

The process of forming and sinking went on until a continuous mat extended from side to side of the chute. This will hereafter be called a *tier* of brush.

Frequent reference will be made to the lines of piles; therefore they are designated by numbers, beginning with No. 1, 65 feet below the center line of the dam, and proceeding up stream to No. 6, 10 feet above it.

The first tier of brush having been completed, the third line of piles was driven 20 feet from the second, and with 15-foot spaces between piles. The second tier of brush was then placed in the same manner as the first, with the butts of the brush in the course parallel with the stream just above the third line of piles, and the tops lapping on the first tier. The fourth line of piles was then driven 20 feet from the third line, with 10-foot spaces between piles, and the third tier of brush was placed as the preceding tiers had been. Then the fifth and sixth lines of piles were driven, and the fourth tier of brush was placed with tops up stream and butts above the fourth line of piles. This tier and a part of the third properly formed the foundation of the dam. The fifth line of piles being driven chiefly for support to the large body of brush that was to be placed in the dam, was not filled out, but extended across the deep water where such support would be needed.

The spaces between piles in the fourth, fifth, and sixth lines were made short, to furnish needed support for this same body of brush.

The next step was to bring the profile of the dam as near the same level as practicable. This was done by placing a mat between the fourth and sixth lines of piles. The thickness of the mat was regulated by the depth of the water. But it was not practicable to level it with a single mat, therefore short mats were placed in the deep water to level up the inequalities before the commencement of the long one. In this way the profile was brought so nearly to the same level that there was no more than 2 feet difference in depth of water from one end of the dam to the other.

The dam having been raised to about 5 feet above low-water with brush and stone, the use of brush was discontinued, and the construction of the dam was continued with stone alone. This condition was reached October 23, and from that date to the last of the month leveling the profile was continued by placing stone on the low places, which were found only near the Illinois shore and near the west end.

The shaking of the piles near a point about 500 feet from the east abutment late in the afternoon of October 31 indicated that a scour had commenced under the brush. During the night a breach was formed extending eastward from the point above mentioned a distance of 200 feet. There was 18 feet of water in the deepest part of it on the morning of November 1. A pile stood erect about the middle of the breach. That pile had been driven about 15 feet, therefore the scour could not have exceeded that depth.

November 2 the pile still stood erect in the middle of the breach, showing that the scour had not increased much, if at all. A barge-load of stone was placed in the breach near each side to prevent its widening in either direction. Eight hundred cubic yards of riprap had now been placed in the breach, in addition to that with which the brush was loaded when placed, probably as much more.

Monday, November 4, the pile was gone from the middle. The overfall and current remained about the same. Work was done that day on each side of the breach to secure the ends of the uninjured portions of the dam against the scouring force of the strong current that was passing around them into the breach.

Tuesday, November 5, the increased current and smooth-flowing water showed an increased depth in the breach. The overfall had decreased until it was scarcely perceptible. Barges made fast to any of the clumps of mooring piles above the dam and allowed to swing freely in the current pointed directly to the breach, although there was from 3 to 5 feet of water over the whole length of the dam except about 100 feet out from the Illinois shore, and about 150 adjoining the breach on the west. The steamer A. A. Humphreys passed through, sounding, found 31 feet, then came back into the breach and found 36 feet. Soundings taken from the side of a barge that was lying in the breach gave 32 feet. The discrepancies between these soundings could be satisfactorily explained by supposing that no two of them were exactly on the same point, and all of them may have been correct. Still it is doubtful whether any of them were so, although they were carefully taken by experienced leadsmen with a heavy lead (11½ pounds) and small line. It is known, however, that the true depths did not exceed those given.

After passing through the breach soundings were taken across the chute. Fortunately soundings on the same line were taken October 30, before the breach occurred. Sections made from these soundings show a decided increase of depth in front of the breach and a corresponding decrease each side of it.

A few days later a longitudinal scour was developed close above the dam along its entire length. This scour of course exposed a face composed of the movable material of the river-bed to the action of the current, while the water rolling over the dam and the eddies caused by the torrent pouring through the breach were scouring below and gradually bringing the deep water nearer to the dam, thus threatening the formation of other breaches by tunneling under the brush, when the ridge of sand would become too narrow to resist the pressure. To protect against this and to keep the breach within its original limits occupied until about the middle of November, without any special effort being made to fill the original breach.

The dam commenced settling at several points; at but one, however, was any considerable damage sustained. About 120 feet adjoining the breach on the west settled 10 feet.

While these protective works were in progress efforts were being made to procure a more economical material than the riprap of ordinary size to be used in filling the breach. To this end proposals were received and accepted from the owners of quarries at Grafton, Ill., for furnishing stone containing not less than 2 cubic feet. At the same time experiments were made with the ordinary riprap inclosed in open crates containing about a cubic yard. They were placed in the deep water of the breach with one end of a small cord attached while the other end was kept on board the barge, but they rolled beyond the limits of the base of the dam. An experiment was then made with a close box filled with riprap and sand, containing about 21 cubic feet, placed in the same way. It remained in position. The cost, however, was a few cents per cubic yard in favor of the larger stone, which determined its use. The first barge was received November 17, when the work of closing the breach may be said to have commenced. The maximum depth of water was about 35 feet, and the width of the breach was about 200 feet. The dam had been strengthened from the breach to each end, so that we were ready to commence filling the breach on the arrival of the large stone.

The large riprap ranged in size from about 2 cubic feet to 37 cubic feet. It was used in conjunction with the riprap of ordinary size.

The large stone was placed first in the deepest part and the small stone then placed above it. In this way the small stone was retained in the desired position.

The depth of water was decreased to 20 feet by the 30th of November, and to 12 feet by December 7. The difference in elevation between the upper and lower pools was measured on each of these dates; on the former it was 2.1 feet at the west end of the dam, and 2.2 feet at the east end; on the latter date the head was measured only at the west end of the dam, and was 2.45 feet.

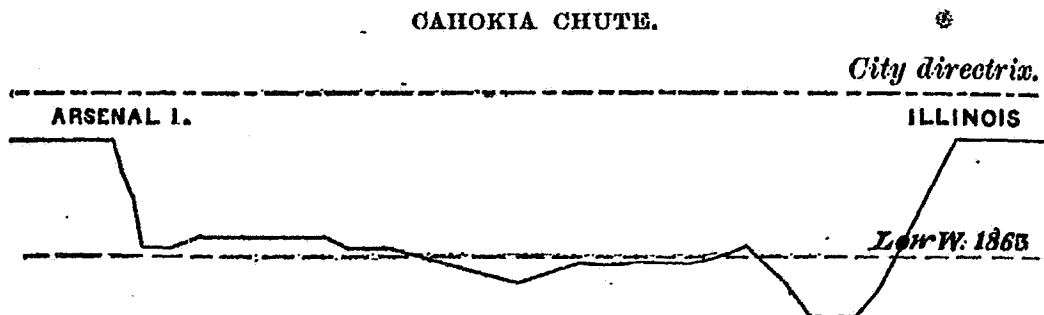
The work continued until the ice commenced forming a gorge above the dam, December 15. There was then only about 4 feet of water in the breach. Its width remained about 200 feet, though its location had changed. About 100 feet on the west had been raised to the surface of the water, while the stone had been washed off the top of the dam about the same distance eastward from the breach.

To check the erosion from the eddies below, it became necessary to place additional riprap on the brush in the lower side of the apron both ways from the breach to the east shore and a distance of about 300 feet to the westward.

Until the strong current was thoroughly broken, care was taken to work as equally on each end as practicable.

Soon after the brush had been placed in the foundation of the dam, the depth of water above it was discovered to be increasing near the east shore and toward the west shore. The increase of depth at the first-named point was from 3 to 5 feet, and at the latter about 2 feet.

CAHOKIA CHUTE.



Horizontal scale 1 inch to 500 feet.

Vertical scale 1 inch to 50 feet.

A cross-section of the dam accompanies this report which shows the mode of construction. This section is made for a depth of water about 16 feet at a stage 9 feet above low-water, or the same as the elevation of the top of the dam. A cross-section of the chute on center line of the dam is also transmitted.

After the close of operations, Cahokia dam was visited on the 30th of December. The ice had formed a gorge above the dam and another about 2 miles below. The latter backed the water at the dam so that the overfall was reduced to a foot or less. In the mean time the small stone on top of the dam had been carried away to a distance of about 200 feet.

The ice-gorge broke February 4, 1879, carrying the stone off the top of the dam in several places. After the ice had gone, the depth of the water in the breach was about 10 feet.

Work on the dam was resumed February 10, and continued until it was completed, April 12, the general elevation of its crest being about 9 feet above low-water.

The bar across the head of Arsenal Chute yielded during the winter, enlarging the water-way on that side and diminishing the pressure on the dam. Still the current in the breach was strong enough to roll small stone dropped from a barge and distribute them over a broader base than desired; therefore large stone was again used in connection with them.

ARSENAL ISLAND.

In obedience to your verbal instructions the old revetment on the west side of Arsenal Island was repaired and extended 125 feet up stream, and down stream as far as the action of the current had eroded the bank to the proposed shore-line, a distance approximately 3,500 feet.

HORSETAIL BAR.

Work was resumed on dike No. 5, Horsetail Bar, the 6th day of August, with a view to filling several small gaps. The largest of these gaps was about 200 feet wide with a maximum depth of 18 feet. There were two other small gaps between the larger and the eastern shore; these were only a few feet in width and needed to be raised 4 or 5 feet. All of them were outside of a small towhead near the shore. Work on this dike continued until the 24th day of August, when it was suspended on account of the small depth of water in the channel. The gaps named were filled to the desired height, but the dike was not made as heavy as it would have been had the channel remained navigable. Another gap about 300 feet further to the westward was not filled.

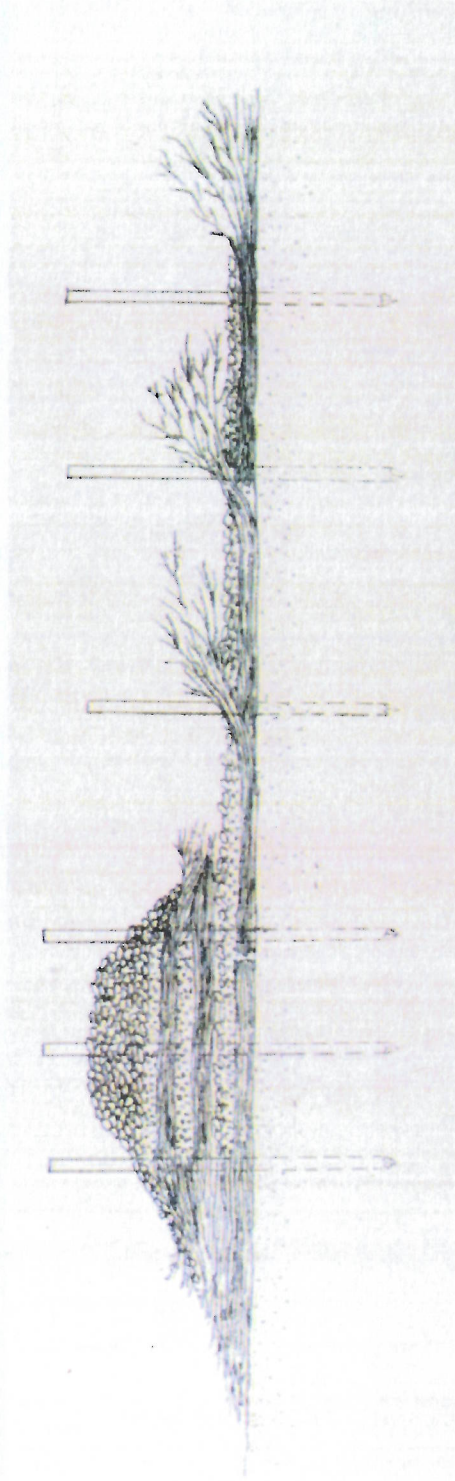
After the close of work at dike No. 5 the construction of the training-wall was resumed at a point about 2,250 feet above dike No. 2, being the intersection of the line of the wall with the dry sand-bar. It was constructed down to dike No. 2, the dike being extended 200 feet to connect with it; then the wall was extended about 2,750 feet below, toward the outer end of dike No. 3, before the work stopped on account of ice.

In this distance the wall crossed the best channel for navigation, which had a maximum depth of 22 feet. Above dike No. 2, the wall was raised to about 14 feet above low-water, while below the dike it was left about 10 feet above at the close of the fall season.

During the winter the ice broke through the wall just below dike No. 2, making a

CAHOKIA DAM

Cross Section



.Scale 1Inch = 20 Ft.

gap about 800 feet long with a maximum depth of 20 feet, which extended about 200 feet, while deeper water was found on both sides of the wall opposite the gap; on the channel side 30 feet, and behind the wall 43 feet, so near that stone would slide into it before taking its natural slope. After resuming work in the spring of 1879, the wall was extended up-stream about 600 feet to a willow bar, and below dike No. 2 it was raised to about 14 feet above low-water.

The wall was then extended 350 feet down stream, under instructions contained in your letter dated May 5, 1879, of which the following is a copy:

ENGINEER OFFICE U. S. ARMY,
Saint Louis, Mo., May 5, 1879.

SIR: With a view to reducing the cost of the training-wall at Horsetail Bar, you are requested to employ the following experimental construction at some suitable point in prolongation of the line already commenced.

Drive two rows of piles about 5 feet apart, the distance between the rows being equal to about half the depth of the water, and place a brush foundation as heretofore, except that the body of the brush should project towards the channel, and there should be but little projection towards the shore. Place vertically against the piles on the channel side of each row a sheathing made of cottonwood boards in panels. These panels should be about 16 feet long in one direction, and long enough in the other direction to reach from the bottom to the surface of the water at a 12-foot stage.

They may be made by laying four pieces of 3 by 4 inch scantling of a length suited to the depth of water, parallel to each other, and nailing upon them cottonwood boards 16 feet long. After being sunk they should be spiked to the piles.

Place a revetment of riprap on the channel side of the outer row of sheathing. Brace the two rows of piles together by cross-pieces of 5 by 5 inch scantling at intervals of 10 or 12 feet. Fill the space between the two rows of sheathing with sand dredged from the bed of the river at some point not very close to the training-wall, and cover the top with a thin layer of riprap.

Very respectfully,
By command of Colonel Simpson,

O. H. ERNST,
Captain of Engineers.

Mr. D. M. CURRIE,
Assistant Engineer.

The 350-foot section built was left unfilled in accordance with verbal instructions received through Captain Ernst subsequent to the date of the above letter.

Eight lines of hurdles were constructed in the rear of the training-wall in accordance with instructions contained in your letter dated March 10, 1879, of which the following is a copy:

ENGINEER OFFICE U. S. ARMY,
Saint Louis, Mo., March 10, 1879.

SIR: With a view to securing the full benefit of the deposits which may be expected during the coming high-water in the rear of the training-wall at Horsetail Bar, you are requested to connect that portion of the wall which has been completed with the Illinois shore by a series of continuous hurdles, made as follows:

Drive a row of light piles, 8 to 10 inches in diameter at the butts, 5 feet apart, sinking them 6 to 8 feet into the bed. Interweave with these piles courses of willow-brush. The brush should be from 20 to 30 feet long and from 2 to 3 inches in diameter at the butt, with most of the branches cut off. The smaller branches at the end may be woven together about the main stalk. Two pieces of brush are then bound together end to end, having an overlap of 6 feet, four withes being used for fastening, thus making a single rod from 35 to 55 feet long. Beginning at the training-wall, this rod is placed on the up-stream side of the first pile, on the down-stream side of the second pile, the up-stream side of the third, and so on, until it comes to an end. In continuing the course with a new rod, it will be better to fasten it to the end of the old in the same manner as the two were made into one; but if the practical difficulties are great, the new one may simply be laid in prolongation of the old one, with an overlap of 6 feet. The courses will be sunk by the weight of men as low as possible, but at all events at least 3 feet below mean stage of water, or say 6 feet above low-water. The most flexible rods should be selected for the lower courses. Having carried one course through, another is laid on the opposite sides of the piles, and then a third on the same sides as the first, and so on, until the height of the hurdle is equal to that of the training-wall or a little greater.

After the wattling has been completed, pieces of brush should be pushed vertically into the voids, until the latter are all completely filled. They should be driven down into the bottom, if possible. The branches are left on the top, and should project 4 or 5 feet above the wattling.

The general direction of these hurdles should be perpendicular to the training-wall and the interval between them about 100 yards. Where the depth of water is considerable, it may be advantageous to reduce that interval to as little as 50 yards.

You will please keep full notes of the cost and results accomplished.

Very respectfully,
By command of Colonel Simpson,

O. H. ERNST,
Captain of Engineers.

Mr. D. M. CURRIE,
Assistant Engineer.

Of the eight lines constructed, seven are above dike No. 2, and are either in shoal water or on dry sand-bar during mean and low stages. The eighth is below dike No. 2, and was constructed in deep water, the maximum depth being 23 feet with the river at a stage about 12 feet above low-water. The wattling was pushed down to the bottom when the depth of water was not greater than 8 feet, but that was about the maximum depth to which it was possible to force it by the weight of men standing upon it. Heavy forks were procured, with the intention of using them to push the rods down singly, and to greater depths, but work was suspended on account of high-water before an opportunity to use them was presented.

The line below dike No. 2 was constructed during the first half of May, and mud was deposited there shortly afterward to a depth of 7 feet. The training-wall being above water surface caused still water behind it, and thereby contributed more or less to the deposit.

The river rose to 18 feet above low-water after five lines of hurdles above dike No. 2 had been completed. The rise, coming chiefly from the Missouri, was accompanied by the supply of mud expected from that source. When the water subsided, the whole of that part of the space protected by the hurdles was filled with semi-fluid mud to the top of the wattling. The depth of the mud ranged from 0 to 6 feet, according to the depths of water during the rise.

This mud solidified before the last or June rise, so that it would bear the weight of a man walking carefully on it, and settled from about 1.5 feet to 0, in proportion to its depth. The late rise has covered the space again, and a further deposit may be confidently expected.

The aggregate length of the eight lines of hurdles constructed is 5,500 feet.

The following tabulated statement shows the quantities and kinds of materials used in the several works named in the foregoing report:

Localities.	Stone on rip- rap.	Spalls.	Brush.	Piles.	Linear feet of pile timber exclusive of piles.	Number of poles for pil- ing.
	<i>Cub. yds.</i>	<i>Cub. yds.</i>	<i>Cords.</i>	<i>No.</i>		
Sawyer Bend	2, 073.32					
Dam at Cahokia Chute	53, 503.00	805.00	6, 107.57	997		
Dike 5, Horseshall Bar	4, 020.44					
Dike 2, Horseshall Bar	1, 014.57					
Training-wall, Horseshall Bar	41, 002.28		0, 445.83	635		201
Hurdles, Horseshall Bar			267.18	593	700	140
Revetment Arsenal Island	10, 012.48					
Totals	113, 255.75	805.00	12, 880.58	2, 225	700	401

The accompanying cross-section of Cahokia Chute, on center line of the dam, was prepared from survey made under your direction by Mr. William Popp, assistant engineer, to whom I am indebted for the execution of the tracing as well as for that of the cross-section of the dam.

Very respectfully, your obedient servant,

D. M. CURRIE,
Assistant Engineer.

Col. J. H. SIMPSON,
Corps of Engineers, U. S. A.

B.

PETITION FROM RESIDENTS OF MONROE COUNTY, ILLINOIS.

IVY POST-OFFICE, MONROE COUNTY, ILL.

The undersigned citizens and residents of Monroe County, Illinois, owners and occupants of lands in the locality hereinafter described, respectfully present to you, as United States Engineer in charge of Mississippi River improvement, the following facts, viz:

That for many years last past the Mississippi River has been changing its channel from a point near to and below Rush Tower, on the Missouri side, to a point near to and above Fort Chartres, about 6 miles. In this change of channel the river is widened, bars formed, and navigation of the river endangered. Also, many thousand acres of valuable land have fallen into the river. The banks at places farther back get lower, and there is great danger that the river will break its way to and run through the lakes or lower lands nearer the bluffs, thus subjecting the undersigned and many others to great pecuniary loss, and endangering the safe navigation of the river. Your petitioners therefore respectfully call your attention to this portion of the river (as shown by the accompanying plat), and request that you will, at as early a day as your duty and the public interest will allow, construct such works as will protect and secure the safe navigation of the river, and incidentally secure your petitioners and others against further loss and danger from its continued and recently rapid changes of its channel.

(Signed by Philipp A. Mans and forty-two others.)
General J. H. SIMPSON.

The undersigned is a resident of said county of Monroe, State of Illinois, and has personal knowledge of the truth of the facts set forth in above petition, and therefore urges upon your attention the necessity for some improvement in the river at said point, in the interest both of river navigation and the owners of adjacent property.

Respectfully, &c.,

W. R. MORRISON.

C.

LETTER FROM COMMON COUNCIL OF ALTON, ILLINOIS.

- ALTON, ILL., December 10, 1878.

DEAR SIR: We, the undersigned committee, lately appointed by the Common Council of the city of Alton, Madison County, Illinois, would most respectfully call your attention to a few important facts connected with the present alarming condition of Alton Harbor.

For many years there has been a large bar just below our harbor near the Illinois shore, which has oftentimes been almost entirely cut away by the action of the current, and at other times it has rapidly filled up by the accumulation of sand, &c., whenever the current or channel changed again or was diverted over to the Missouri shore.

The head of this bar a few years ago was fully 300 yards below the foot of Alton Harbor, and when the Alton dike was first completed or built 10 feet above low-water mark this bar commenced to gradually disappear, but since the cutting down of this dike by the ice it has been rapidly increasing and filling up, until to-day it extends up into Alton Harbor, destroying fully one-third of our harbor for navigation purposes.

A careful examination of Alton Harbor discloses the startling fact that unless some early measures are adopted that will afford speedy relief this bar will continue to grow and extend up the Mississippi River until our harbor will be totally destroyed, and steamboats will be compelled to abandon our levee and land entirely above our city.

When Alton dike was first completed it accomplished just what was anticipated by the government engineers, for the main current or channel of the river was forced over to the Illinois shore, and passing down through Alton Harbor rapidly cut away Alton Bar, and this bar would have entirely disappeared if the Alton dike had been built above high-water mark; but unfortunately this dike was only built 10 feet above low-water mark, and the ice now having cut it down fully 6 feet, it of course in its present condition totally fails to accomplish the result so confidently expected.

We believe that if this dike should again be built only 10 feet above low-water mark it would be a useless expenditure, because the ice would again cut it down, and

we are confirmed in this opinion by Mr. McMath, the officer detailed by you to make a personal examination of Alton dike.

We confidently believe that if this dike were built above high-water mark that it would be the true solution of all our harbor difficulties, for the natural effect would be, in our opinion, to cut away in a very short time this bar in our harbor that now so obstructs the general navigation of our river. We recognize, general, that you are in possession of all the facts necessary to arrive at a correct understanding of this whole question, and we only respectfully call your attention to the above statement of what we believe is the true condition of Alton Harbor, so that you may see that we are ready and willing to cordially co-operate in any measures you may adopt for the purpose of granting our city some relief against the total destruction of our harbor.

If you should decide, general, that it is necessary to have Alton dike raised above high-water mark, and there is not sufficient government funds in your hands to warrant such an extra expenditure, we desire to assure you that we will do everything in our power to assist in getting a special appropriation from the general government for this object. We are very desirous of having a personal conference with you, and would respectfully ask that you name an early day so that our committee may call and see you at your office, and believing that you will give this whole subject the attention its great importance would justify, we remain,

Very respectfully, your obedient servants,

LUCAS PFEIFFENBERGER.
G. H. WEIGLER.
F. SHELBY.
J. Q. BURBRIDGE.
R. G. PERLEY.

General J. H. SIMPSON.

D. -

PETITION FROM CITIZENS OF SAINT GENEVIEVE, MISSOURI.

The undersigned citizens of the city and county of Saint Genevieve, in the State of Missouri, respectfully call your attention to the following facts, and show—

1. That our city, possessing a commercial importance and doing an annual business far greater than many, even in fact a majority, of the minor municipal subdivisions of this country, is wholly dependent upon the Mississippi River as a medium of commerce and a highway by means of which to interchange our commodities for those of other States and communities in this country.

2. That the nearest and only means of railroad communication we possess are by the Saint Louis, Iron Mountain and Southern on the west; the Saint Louis and Cairo Narrow Gauge and the Chester and Tamaroa on the east; that the nearest point to either or any of these railroads is as follows:

The Iron Mountain and Southern at De Lassus or Bailey's Station, each of which places is 31 miles distant and can be reached only by means of a natural dirt road, impassable for any kind of vehicle for one-fourth of the year; that is during the winter months, and during the winter, fall, and early spring months impracticable for profitable transportation purposes, owing to the soft and yielding nature of the soil which it traverses.

3. That the Saint Louis and Cairo Railroad is only accessible at Red Bud, in the county of Randolph and State of Illinois, 22 miles distant; and the Chester and Tamaroa at Chester, 20 miles distant, both of which places to be reached will necessitate crossing the Mississippi River. The landing at Saint Genevieve, except in high-water, is so precarious and changeable that the rates of ferriage necessarily charged thereby render absolutely futile and ineffectual any attempts at commercial intercourse by way of Red Bud. That the road hence to Chester traverses a marshy, boggy, and wet loam, cut up and crossed by innumerable springs, making it, except in midsummer, absolutely impassable for loaded conveyances. That even when the Mississippi River, our natural and only commercial highway, is in fair and ordinary boating stage, it is 2 miles distant from our city to any accessible steamboat landing. That we believe that the improvements made by the United States Government north of our city at or near Turkey Island have been the means of causing the channel of the river to gradually deflect towards the Illinois shore and away from our city; in consequence of which a "bar" has extended above Rock Haven, our only landing, to a point opposite a perpendicular bluff of solid rock, where it would be absolutely impossible to construct, by any outlay of means within our power, a practicable landing. That the only other landing possible in an ordinary stage of the river would be in the Big Common Field, between 1 and 2 miles south of the utmost limits of the city, only accessible after the construction of a macadamized, plank, or other road, necessitating the expenditure of thousands of dollars.

We further respectfully show you that, by statistics carefully compiled from statements of our merchants and business men, our annual trade amounts to \$600,000, representing between 10,000 and 12,000 tons of merchandise of every description, on which has been paid between \$30,000 and \$35,000 freight per annum.

Therefore, in view of the foregoing facts, and of the further fact that no part of any appropriation of Congress for the improvement of Western rivers, or the Mississippi River particularly, has ever been applied to any scheme of improvement resulting beneficially to our city, and believing further that the delegation to Congress by the States of the power "to regulate commerce with foreign nations and among the States," &c., was meant to operate impartially and equitably among all the States and their minor subdivisions, we respectfully request that, if not inconsistent with law and the public welfare nor antagonistic to any plan of improvement of the Mississippi deemed most practicable and feasible in your judgment, a part of the appropriation of Congress under your control be expended, and such works and barriers be erected at or near our city as will, in your opinion, with least outlay consistent with effectiveness, prevent the further deflection of the channel of the river and the complete isolation of our city from all commercial intercourse with the world.

The above is respectfully submitted for your consideration.

CHARLES C. ROZIER, *Mayor*.

HENRY S. SHAW, *City Attorney*.

JULES B. GUIGNON, *City Clerk*.

LOUIS DELCOMMUN, *City Marshal*.

JACOB YEALY, *City Collector*.

VALENTIN SEITZ, *Alderman*.

JOS. BORCKLE, *Alderman*.

F. C. ALBERT, *Alderman*.

J. B. C. LE COMPTE, *Alderman*.

VALENTINE ROTTIER, *Alderman*.

C. W. HAMM, *Alderman*.

JOHN L. BOGY, *County Clerk and Probate Judge*.

JOHN A. SCHUBER, *President Anchor Line, &c.*

And 249 others.

General JAMES H. SIMPSON,
Colonel Engineer Corps, U. S. A.

E.

LETTER FROM MAYOR AND COMMON COUNCIL OF CAPE GIRARDEAU, MISSOURI.

We, the Mayor and Council of the city of Cape Girardeau, respectfully represent that serious damage is likely to result to this city and to property on the Illinois shore opposite this city, from the effect of the dike built by the United States Government at Devil's Island, a few miles above this city, deflecting the main current and channel of the Mississippi River against the Missouri shore, above Cape Rock, by which it is again deflected so that it does not flow in full volume against and along the shore and wharf of the city of Cape Girardeau, as heretofore, but against and along the Illinois shore opposite, thus rapidly abrading the said Illinois shore and permitting the formation of a sand bar and the filling up of the channel along and in front of the wharf or landing of this city to such an extent that the total ruin of the landing is threatened.

We therefore pray that you will take measures at as early a date as practicable to avert the danger and damage threatened to this city by the causes aforesaid, which we would respectfully suggest might be done by a dike built out from the Illinois shore from a suitable point to deflect the current and main channel of the river back to the Missouri shore along the front of this city.

Respectfully,

G. H. CRAMER, *Mayor*.

LEO. DOYLE,

WILLIAM WARNER,

W. H. WILLER,

FRITZ HENNINGER,

GEORGE HIRSCH,

WILLIAM THIENERKAUF,

FERD. HANNY,

Councilmen.

General SIMPSON.

IMPROVEMENT OF MISSISSIPPI RIVER BETWEEN THE MOUTHS OF THE ILLINOIS AND OHIO RIVERS—ICE HARBOR AT SAINT LOUIS, MISSOURI—IMPROVING MISSISSIPPI RIVER AT OR NEAR CAPE GIRARDEAU AND MINTON'S POINT, MISSOURI—IMPROVEMENT OF OSAGE RIVER IN KANSAS AND MISSOURI.

Officers in charge Col. J. H. Simpson, Corps of Engineers, to March 30, and since that date Capt. O. H. Ernst, Corps of Engineers.

1. *Mississippi River between the Illinois and Ohio rivers—Piasa and Alton Dams.*—These works remained as at the beginning of the year. No work was done between the Illinois and Missouri Rivers during the year. The sum of \$33,825.85 remains available for expenditure within these limits, which it is proposed to apply to the improvement of the channel near Piasa Island, that being the point where the greatest obstructions to the general navigation exist. A survey has been made of the locality with a view to preparing a plan of the works required.

Sawyer Bend and Venice Dikes.—No work was done during the fiscal year or contemplated, unless some repairs should become necessary.

Cahokia Chute.—The present project for the improvement of this locality was adopted in 1876, the object being to stop the inroads of the river into the Illinois bank, and the consequent deterioration of the navigation. The amount expended to June 30, 1880, is \$116,088.60, and has resulted in completely stopping the erosions.

Arsenal Island Revetment.—No work was done during the fiscal year, or contemplated at present.

Horsetail Bar.—The present project for the improvement of this locality was adopted in 1873 and modified in 1879, the object being to afford a channel not less than 8 feet deep. The natural channel was often not more than 4 feet deep at the shoalest part. The amount expended to 30th June, 1880, is \$395,450.91, and has resulted in securing a channel at least 400 feet wide in which the depth during the past year has not been less than 8 feet. The results are not regarded as secure, and further work will be required to perpetuate them. An allotment of \$150,000 has been made to this locality from the appropriation of June 14, 1880. This is expected to practically complete the work, though it will be the object of care for an uncertain number of years.

Fort Chartres and Turkey Island.—No work done or contemplated.

Kaskaskia Bend.—The present project for the protection of this bank was adopted in 1876 and modified in 1880, the object being to stop the caving in a bend 23,000 feet long. The amount expended to June 30, 1880, is \$54,139.28, the result of which is 5,975 feet of bank partially protected. The sum of \$20,000 has been assigned by Congress to this work from the appropriation of June 14, 1880, which will be employed in re-enforcing and extending the work already done. This work being a very costly one, and not now needed in the interest of general navigation, it is desirable that the funds required for its prosecution should be separately provided. The officer in charge submits an estimate of \$50,000 as the amount that can be advantageously expended during the year ending June 30, 1882, if separately and independently provided. The appropriation of that amount is recommended. It is proposed to employ it in extending the revetment down stream about 4,000 feet.

Protection near Liberty Island.—No work done and none contemplated unless some repairs should become necessary.

Devil's Island.—No work done or contemplated.

Protection between Dickey Island and the mouth of the Ohio.—The present project for the protection of this bank was adopted in 1876, the

object being to stop the caving in a bend 11,500 feet long. The amount expended to June 30, 1880, is \$113,351.43, and has resulted in the protection of 10,700 feet of bank previously unprotected and in the repair and strengthening of the works previously built by the Cairo Land Company, covering a length of 3,500 feet more, making in all, 14,200 feet of protected bank. To entirely complete this part of the protection a small amount of work will be required this year. The original project will then be completed, and any extension of the protection will be of secondary importance in the interest of navigation. If the work is continued the funds should be provided separately from those intended for the improvement of the navigation. The officer in charge submits a separate estimate of \$50,000 as the amount that can be judiciously expended during the year ending June 30, 1882, if separately and independently provided. The appropriation of that amount is recommended with that proviso. With it it is proposed to extend the protection down stream a distance of about 1,500 feet and to remove portions of two of the the old spur dikes built by the Cairo Land Company.

Miscellaneous.—The officer in charge, in his annual report, offers proof that the navigability of the Mississippi is deteriorating. He also invites attention to the unsettled condition of the doctrine of riparian rights, and points out the difficulties which are likely to arise from this source in prosecuting the improvement of the Mississippi.

Estimate.—The appropriation of \$1,100,000 asked for is to be applied to completing the works now progressing and those to be begun this year at Piasa and Widow Beard's Islands, and to beginning works near Herculaneum, Platin Rock, Fish Bend, Fort Chartres Island, Jones's Point, and Hat Island. At each of these places the channel depth is liable to become as little as 4 feet, and at each it is proposed to secure a minimum depth of 8 feet. The appropriation of this sum is recommended.

July 1, 1879, amount available.....	\$191,355 36	
Miscellaneous receipts.....	30 00	
Amount appropriated by act approved June 14, 1880.....	250,000 00	
		\$441,385 36
July 1, 1880, amount expended during fiscal year.....	156,625 30	
July 1, 1880, outstanding liabilities.....	1,421 49	
		158,046 79
July 1, 1880, amount available.....		283,338 57
Amount (estimated) required for completion of existing project.....	6,039,600 00	
Amount that can be profitably expended in fiscal year ending June 30, 1882.	1,100,000 00	

(See Appendix P 1.)

2. *Ice-harbor at Saint Louis, Missouri.*—A special appropriation of \$50,000 was made by the river and harbor act of June 14, 1880, for the construction of an ice-harbor, the plan of which is not yet determined upon. The officer in charge submits an estimate of \$100,000 as the amount that can be profitably expended upon this work during the year ending June 30, 1882. Although the project is not complete, enough is known of the case to justify asking for that amount, the appropriation of which is recommended.

Amount appropriated by act approved June 14, 1880.....	\$50,000 00
July 1, 1880, amount available.....	50,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.	100,000 00

(See Appendix P 2.)

APPENDIX P.

IMPROVEMENT OF MISSISSIPPI RIVER BETWEEN THE MOUTHS OF THE ILLINOIS AND OHIO RIVERS—ICE-HARBOR AT SAINT LOUIS, MISSOURI—IMPROVING MISSISSIPPI RIVER AT OR NEAR CAPE GIRARDEAU AND MINTON'S POINT, MISSOURI—IMPROVEMENT OF OSAGE RIVER IN KANSAS AND MISSOURI.

REPORT OF CAPTAIN O. H. ERNST, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1880, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

ENGINEER OFFICE, UNITED STATES ARMY,
Saint Louis, Mo., July 28, 1880.

GENERAL: I have the honor to herewith transmit my annual reports for the year ending June 30, 1880.

I assumed charge of the works on the 30th of March, relieving Col. James H. Simpson, Corps of Engineers. I had previously been connected with them, under Colonel Simpson's orders, from the beginning of the year.

My reports cover the operations of the entire year.

Very respectfully, your obedient servant,

O. H. ERNST,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

P 1.

IMPROVEMENT OF THE MISSISSIPPI RIVER BETWEEN THE MOUTHS OF THE ILLINOIS AND OHIO RIVERS.

BETWEEN THE ILLINOIS AND MISSOURI RIVERS.

No work was done within these limits during the year other than surveys and the establishment of gauges. The appropriations, of \$20,000 of June 18, 1878, and of \$15,000 of March 3, 1879, are still available, with the exception of \$1,174.15, the amount expended for the purposes above mentioned over and above a previous balance.

This money, having been appropriated for the improvement of the Mississippi between the Illinois and Ohio rivers, must, I think, be applied so as to benefit the greatest number of persons interested in the navigation of the entire stretch of river lying between those limits. There is no doubt that one important feature of an improved river is convenient access to landings; but the *most* important result to be attained by the improvement, and the one first to be aimed at, is cheap

through transportation for freight. Passenger traffic is secondary, and so is the freight for any single point. The estimate of the cost of the improvement is for procuring this cheap *through* transportation, and does not include the cost of improving harbors in cases where special works are required for that purpose.

The harbor of Alton, which is the most important landing in that section of the Mississippi, is in need of improvement; but there is no difficulty with the navigation in that vicinity for vessels that do not stop there, and unless Congress should expressly appropriate funds for that work it should be deferred, I think, until the river has reached such a stage of improvement that attention can be turned from the primary object of securing good *through* navigation, to the secondary one of providing convenient access to landings. Additional estimates can then be submitted to cover the cases of such landings as remain inconvenient after the general improvement has been completed.

Considerable difficulty is found near the head of Piasa Island. The channel is exceedingly tortuous, and near the island is a ledge of rock which is dangerous at low-water. On the 23d of April I recommended that the available funds be applied to the improvement of that locality, and requested authority to make a hydrographic survey, with a view to preparing a plan of the works required and an estimate of their cost. This recommendation was approved so far as to authorize the survey, and the latter was begun in May. The field work was completed in June, and the map is now being prepared. A plan will be submitted for your consideration at an early day.

The dam at Ellis Island remains as reported last year by my predecessor.

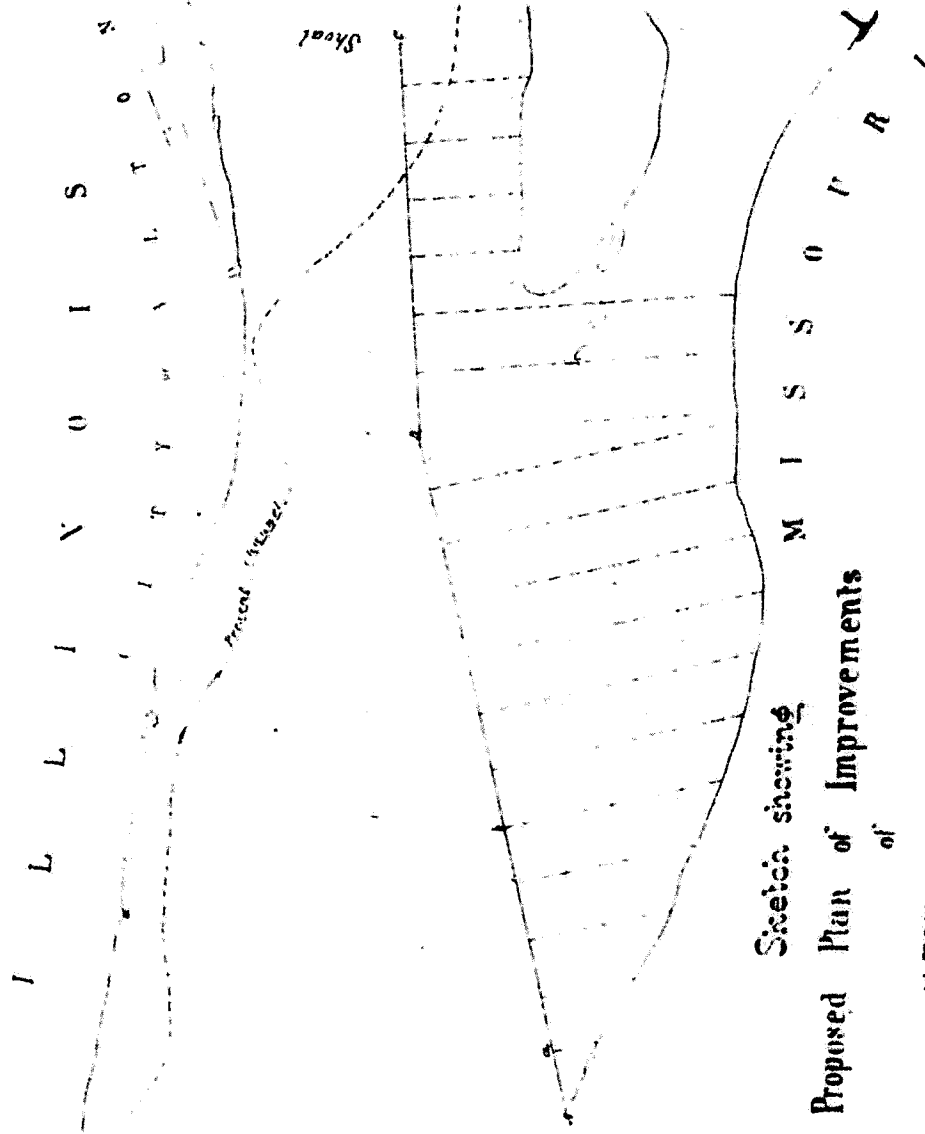
The sum of \$1,500 was allotted for the purpose of making the survey near Piasa Island, to which \$200 was afterwards added for the purpose of closing a gap between Eagle Nest and Hop Hollow, which existed in the permanent triangulation of the district. The completion of that work will give a connected triangulation from the mouth of the Illinois to the mouth of the Ohio.

The expenditures were:

For hydrographic survey	\$1,507 85
For water gauges	192 15
Total	1,700 00

The river and harbor act of June 14, 1880, contains in the item appropriating \$250,000 for the improvement of the Mississippi River between the Illinois and Ohio rivers, the following proviso, viz, "of which sum * * * \$15,000 *may* be expended on the harbor at Alton," the italics being mine. The authority here given implies a desire that the sum mentioned shall be expended at Alton, and this desire should be complied with unless there are good reasons to the contrary. Strong reasons, based upon general principles, have already been given. There are others appertaining to the particular circumstances of this case which have their weight. The estimated cost of the works required for the improvement of Alton Harbor is \$71,000 (see report of Col. James H. Simpson, Corps of Engineers, dated February 9, 1880), and that portion of the works which should be built the first year is estimated to cost \$39,000. An examination of the plan of improvement shows that an expenditure much less than \$39,000 will have little or no beneficial effect.

The works proposed include a dike, A, B, C (see adjoining sketch), connected by hurdles at intervals of about 400 feet, with the Missouri



Sketch showing
Proposed Plan of Improvements
of

ALTON HARBOR, ILL.

shore. Their object is to collect all the waste water of the river at stages below 14 feet and throw it against the main channel as it comes down the Illinois shore, thus diverting that channel and causing it to attack the shoal in front of the Alton Landing. The \$15,000 under discussion could only be applied to beginning the dike near the point A. The money would be sufficient to cross the deep water near *a* and to carry the dike as far as somewhere near *b*. The work stopping here could not be expected to exert any beneficial effect upon the harbor. It would exert an injurious effect, however, upon its own future. The foundation near *b* is now a bar, which is dry at low-water. The estimate is based upon utilizing this bar with a view to cheap and rapid construction. If the dike stops here for a season the bar will be scoured out; and it will be necessary to increase the estimate. Without the dike the bar may be expected to remain substantially in the same position for a considerable period. The only alternative is to make a further allotment of \$24,000 from the general appropriation, so that the work can be pushed through as far as the point B in one season. That cannot properly be done for the reason that the general fund is at best not large enough to answer the demands of the general navigation interests, and the diversion of any portion of it at this time to the work referred to must be indirectly an injury to commerce.

SAWYER BEND.

The revetment here remains in good condition. No work was done during the year and none is contemplated for next year, unless some repairs should become necessary.

VENICE DIKE.

No work done and none contemplated.

CAHOKIA CHUTE.

The June rise of last year having filled up to a considerable degree the shallow channel at the upper part of the west chute, a heavy strain was brought to bear upon the dam across Cahokia Chute by the falling river, the result of which was, in the latter part of August, a breach in the dam. It being necessary to close this breach to prevent the destruction of the dam; and the special appropriation being exhausted, an allotment was made for the purpose from the general fund.

The breach was repaired in September, and the dam was afterwards strengthened at points which seemed to require it, and it has since remained in good condition.

Details of the work will be found in the report of Assistant Engineer D. M. Currie, hereto appended and marked A. Extensive shoaling has taken place above it, and it is thought that the severe strains will not be renewed.

The expenditures were:

9,556.77 cubic yards riprap.....	\$12,280 65	
118.09 cords brush	246 81	
		\$12,527 46
Engineering and contingencies.....		411 25
		<hr/> 12,938 71

HORSETAIL BAR.

The term Horsetail Bar includes a stretch of river about 5 miles long extending from the river Des Peres, the southern boundary of Saint Louis, to the foot of Carroll's Island. The average width when the works were begun was about 5,000 feet. There were several large movable bars which obstructed the navigation, and it was no uncommon thing to find as little as 4 feet depth of water in the channel during the low stages of the autumn, the obstacle being sometimes at one point and sometimes at another. The bottom being composed of shifting sands and mud, this shallow water was evidently the result of the inordinate width, and the obvious means of increasing the depth was to reduce the width. It was decided to undertake the contraction of the river to a width of 2,500 feet. For this purpose a series of jetties or dikes perpendicular to the shore were planned, and their construction begun in 1873. Their outer extremities were to be connected by longitudinal dikes or training-walls located upon the lines of the new banks. The construction of one of these training-walls was begun in 1877. The object of these works was to confine the water of the river within the prescribed limits by means of their own solidity and weight. They were built of rip-rap upon a foundation of brush. The great volume and velocity of the Mississippi, combined with the treacherous nature of the soil upon which these structures rested, rendered the jetties a comparatively easy prey to the currents. The attacks upon them were facilitated by their great length and by the considerable intervals which separated them from each other, neither of which could well be reduced in a river of such magnitude. The training-wall, receiving the shock of the stream in a more favorable direction, was not so liable to destruction by the current; but a breach 800 feet long, occasioned by an ice-gorge, in the winter of 1878-'79, showed that this part of the work had in the climate an enemy which was quite as redoubtable. It was then concluded that to resist all the destructive forces at work nothing less than a solid mass of earth between the new and old banks would answer, or, in other words, that the land must be wholly reclaimed, and that works in the stream relying wholly upon themselves were not sufficient. In the spring of 1879 the upper part of the area included between the training-wall and the Illinois shore was divided up by hurdles similar to those used on the Garonne and described in the last annual report. Their object was to cause the water to deposit its sediment behind the training-wall as it progressed. The solid form of the latter was preserved, but a cheaper method of construction was introduced, employing temporary instead of permanent materials. The stone jetties were in a dilapidated condition and were abandoned.

The remarkable results obtained from the use of the hurdles last year led to the application this year of that class of construction to all parts of the work. At many places, particularly in the line of the training-wall, the water was too deep for the advantageous use of piles. At such points the hurdles, or equivalent brush obstacles, instead of being made continuous and in position, were constructed either continuous or in sections upon floating ways from which they were launched. One side was secured to the bottom by anchors, while the other side was held up at the surface of the water by buoys. Various forms of brush obstacles were used. They are shown in figures 2 to 8, and are fully described in the report of Assistant Engineer D. M. Currie, by whom most of them were designed. His report is appended, marked A, and is intended to form part of this report. At first these floating obstacles

were anchored to a horizontal mattress or sill (see figures 2 to 7), the latter being intended to prevent the scour that was to be feared from placing them in contact with swiftly running water. Increasing confidence in their efficiency led to the temporary abandonment of the horizontal member for economical reasons. Further experience is necessary to determine whether it will be advantageous to resume that method of construction.

The governing principle is the same in all of these forms of construction. This is to utilize the building power of the river by inclosing the ground to be reclaimed within slight permeable obstacles. These, while smoothing out the boils and whirls and checking the velocity of the water sufficiently to cause it to drop a part of its load, present no great obstacle to its flow. They are dike-builders rather than dikes themselves. Allowing the water to circulate freely they constantly introduce new supplies of fully loaded fluid, and thus gradually and easily build up the new banks. Under this system the progress has been rapid, economical, and thus far satisfactory in its results.

A map showing the plan of the works and their present state of completion is herewith transmitted.

Soundings taken in March, 1880, are written upright so as to read with the title. Those taken upon each day are inclosed in brackets opposite which the date is written. The stage of the river for that day is found in the gauge record at the margin of the sheet. Soundings taken on the 29th and 30th of June, 1880, are written at right angles so as to read when the map is revolved 90° to the right. These soundings are reduced to the same stage as those of March. Those having the minus sign indicate that the ground would be uncovered with the river at that stage. The heavy, broken, and dotted lines show the plan of the works not yet begun; the full lines those now completed. Upon each line of hurdles are given the dates when it was built and when it was repaired.

It is no easy matter in the case of a silt-bearing stream to show definitely upon paper the effect of the works of improvement upon the channel. A statement that a certain depth existed before the execution of the works and another depth existed afterwards might be strictly true, but at the same time might be misleading and unfair. The channel is constantly shifting its position and the bottom fills or scours with the rise or fall of the water surface. It is a common occurrence after the summer rise that a gradual fall of 15 inches on the gauge is attended by an increase of 9 inches in the depth; that is, that during this fall of 15 inches there is a scour of 2 feet. Comparative sections of the channel are therefore useless for indicating the effects of the works. Knowing that with banks not too far apart there will always be somewhere between them a good channel at all stages, we must turn for definite information to the process of building up the new banks.

Several sections embodying information obtained at dates earlier than those of the written soundings are given upon the map showing the results of the operations thus far. These may be supplemented by the statement that the least depth of water found in the channel at any time during the year was 8 feet. In examining these sections it is to be borne in mind that the works are built to a height of about 15 feet above low-water, and that that portion of the river bed lying below that level is mainly to be considered when making inquiry as to their effect.

Section on E F shows a maximum fill of 27 feet since March, 1880, over a width of about 320 feet and an average fill of about 10 feet.

Section G H shows a maximum fill of 64 feet since the spring of 1879, and an average of about 10 feet since March, 1880.

Section I K shows a maximum of 20 feet since April, 1879, and an average of about 6 feet since January, 1880.

Section L M shows a maximum of 48 feet since April, 1879, and an average of about 3 feet since January, 1880.

Section N O shows a portion of ground which was reclaimed to a height of about 15 feet above low-water last year. Young willows began at once to grow upon it, and deposits have now been secured to a maximum height of 19 feet 6 inches above low-water. These deposits have been obtained under unfavorable circumstances. Most of the building material comes from the Missouri River.

If the Upper Mississippi is relatively high, the water of the Missouri is kept on the west side of the river and away from the works. That has been the case during the larger portion of the last spring. The works have cost more and the results, large as they are, have been less than may reasonably be expected under ordinary circumstances.

The shoaling action is still going on, and during the present high water may be expected to progress more rapidly than ever, as it is at such times that the great movements of silt take place.

These results are satisfactory. Nevertheless it is well to be cautious about accepting them as final. They are still to be secured and rendered permanent. A great flood choking up the present low-water channel of the river might throw it over into our new made land and undo a large part of this work.

Fortunately these obstacles are as cheap as they are frail, and can be often renewed without excessive cost. When the land behind them has once become consolidated they may be expected, with some additions, to secure it from future attack. The improvement cannot be regarded as secure until the land has been raised to a height of at least 25 feet above low-water. The hurdles are built to a height of about 15 feet above low-water, and are expected to cause deposits to that level. They cannot be advantageously built much higher, because they would be exposed to rapid decay, while their action would be limited to the short periods of high-water. It is proposed to secure the additional height of deposit by a growth of willows covering the entire area to be reclaimed. These with their roots will consolidate the land already formed and with their branches will cause further deposits at high-water. The number of years which will be required to raise the land to a secure height is altogether uncertain, depending upon the height and duration of the spring freshets, and also upon the relative height of the Upper Mississippi and the Missouri rivers during those freshets. It is necessary that the government should control the land and the willow growth; and this raises a question of riparian rights which will be again alluded to further on.

The willow springs up spontaneously upon the newly formed alluvial lands in the Mississippi; but observation is wanting to show what is the lowest level at which it will grow, and how much time can be gained by planting cuttings. To gain some information upon the subject, as well as to ascertain the best season for planting, I have had a few cuttings planted at different levels about the first of each month during the present season, using pieces of willow from $\frac{1}{2}$ inch to 4 inches in diameter. All the cuttings planted in March lived. Many of those planted in April and all those planted in May and June died. It is proposed to continue these experiments throughout the working season.

The greatest size that can be given to the enclosed areas is not as yet fully determined. The size of those constructed this spring has been

about 1,400 by 400 feet, the shorter dimension being measured parallel to the bank. It is thought that this dimension can be increased. The other dimension being measured perpendicular to the bank depends upon the amount that the river width is to be contracted, and may be made the full length from the old to the new bank.

The total cost of the fixed hurdles in the transverse lines, including engineering and contingencies and all repairs, was \$1.43 per running foot. Of this, 44 cents, or 31 per cent., was the cost of transportation and wear and tear of the equipment. The cost of the curtains or floating obstacles was \$1.87 per running foot; but with these, owing to the adverse circumstance before referred to, of a relatively low Missouri River, it was necessary to go over the same ground many times. To construct and repair 2,500 feet of dike consumed 21,000 feet of curtains, the total cost of which was \$39,382.42, or \$15.75 per running foot of dike. This, while not more than one-third what a stone dike would cost in the same depth of water, is hardly a fair showing of the economy of this system. At any point far enough below the mouth of the Missouri for the waters of the two rivers to have become thoroughly blended, or at Horsetail itself, under circumstances which are common, if not usual, there in the spring, the same results might have been obtained at a cost 50 per cent. less. Of the \$15.75 above given, \$4.08, or 26 per cent., was for transportation of material and the wear and tear of equipment.

The items of transportation, &c., have been separated in the statement of cost with a view to showing some of the pecuniary advantages which would result from increased annual appropriations and enlarged operations. Works were carried on last year at Cairo and Cahokia Chute, points separated by a distance of 180 miles. It being impracticable for one boat to do the towing for works so far apart, two boats were employed. Either of them could have done twice to three times the work it actually did do; yet neither could be dispensed with. The barges were more fully employed, but for similar reasons were not worked up to their full capacity. With the equipment fully employed, the cost of transportation might be reduced at least one-fourth. As it forms about 28 per cent. of the cost of the works at Horsetail, this would be equivalent to reducing the cost of those works 7 per cent.

The expenditures were—

Training-wall (2,500 feet):	
2,301.56 cubic yards riprap	\$2,871 77
3,759.85 cords brush	6,699 82
23 piles	101 43
Labor, rope, wire, equipment, &c	27,489 40
	<hr/> \$37,162 42
Hurdles (32,000 feet):	
2,855 feet piles	13,519 00
15,140 feet piles	3,276 00
4,697.37 cords brush	8,671 89
100 cubic yards riprap	129 00
Labor, rope, wire, equipment, &c	17,661 65
	<hr/> 43,257 54
Engineering and contingencies	4,723 43
Total	<hr/> 85,143 39

The works at Horsetail have been under the immediate supervision of Assistant Engineer D. M. Currie, to whose report reference has already been made. He is entitled to credit for intelligent study and zealous devotion to his work.

I have obtained useful hints as to some of the details of the structures, particularly the anchors, from Maj. Chas. R. Suter, and his assistant,

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Capt. T. H. Handbury, Corps of Engineers, who have been working on a similar field in the Missouri River.

An allotment of \$150,000 has been made to this work from the appropriation of June 14, 1880. It will be employed in the construction of brush obstacles similar to those used this spring, covering all the remaining ground to be reclaimed, in accordance with the plan herewith transmitted. It is expected that this will practically finish the work, though, as above explained, it must be the object of care for an uncertain number of years.

FORT CHARTRES DAM.

No work done and none contemplated.

TURKEY ISLAND DAM.

No work done and none contemplated.

PROTECTION OF BANK NEAR KASKASKIA.

This work was extended down stream a distance of 1,100 feet in July, when the funds allotted having been exhausted, it was suspended. It was discovered, however, in August, that owing to a considerable scour in front there were a number of slides, and that there was danger of great damage being done unless steps were taken at once to check the scour.

Accordingly \$15,000 from the general appropriation were allotted in addition to the sums mentioned in Colonel Simpson's last annual report. This was employed in placing brush mattresses 50 feet wide along the foot of the slope, outside the former work, for a length of 3,305 feet. The danger of immediate destruction was thus removed, but the work is still in a precarious condition. For details, see the report of Assistant Engineer Charles S. True, which is hereto appended and marked B.

The expenditures were:

7,870.50 cubic yards riprap	\$11,406 44
2,100.20 cords brush	3,262 50
Excavation	153 30
Labor, rope, &c.	2,599 47
	<hr/>
	\$17,421 71
Engineering and contingencies.....	1,279 71
	<hr/>
	18,701 42

The direct protection of this bank is a difficult undertaking. The plan of construction has been that successfully employed at other points, viz, a brush mattress at the foot of the slope extending up to low-water mark, and above that level a covering of stone. This plan has not been here altogether successful.

A light covering of stone is not sufficient, and the soil is not stable enough to bear the weight of a heavy one. A continuous thatching of brush might answer the purpose temporarily, but it would soon decay. The act of June 14, 1880, contains a proviso allotting the sum of \$20,000 to this work, which it is proposed to employ in an attempt to change the direction of attack of the river, and to finally cause deposits where there is now a scour. Beginning at the extreme upper end of the bend, permeable dikes of hurdle work will be run out at intervals into the stream.

The cost of the work seems to have far exceeded the expectations of Congress, by whose order it is being prosecuted. The appropriations for 1877, '78, and '79 were, respectively, \$5,000, \$10,000, and \$8,000. The

expenditures were \$5,000 (which was a total loss), \$20,000, and \$30,000, the differences being taken from the fund provided for the improvement of the navigation between the Illinois and Ohio Rivers. The original sums allotted by Congress being also taken from that fund, it would seem to be carrying out the will of Congress to add to them if the circumstances of the case require it. But the fact ought to be stated that this work is not now in the interest of the general navigation, but is mainly of importance as a protection of lands. Bank protection is a useful aid to navigation by stopping the supply of channel-choking material and by preventing the river from increasing its width; but the river in this vicinity is in a bad shape for perpetuation, and the advantage to be derived from protecting the bank is more than counterbalanced by the ugly shape of the channel and by the absorption of the funds so much needed elsewhere. It is much to be desired that any sums which are to be expended upon this work should be provided in addition to those designed for improving the navigation.

The cost of continuing the protection to the end of the bend is estimated at \$204,000, of which \$50,000 can be expended to advantage next year, if specially and independently provided.

LIBERTY ISLAND PROTECTION.

No work done and none contemplated unless some repairs should become necessary to the old work, which is now in good condition.

DEVIL'S ISLAND.

No work done and none contemplated.

DICKEY ISLAND TO MOUTH OF THE OHIO.

Operations were suspended about the middle of October, the appropriation being exhausted. The revetment was extended up stream a distance of 2,900 feet. It has been raised to a height of about 20 feet above low-water throughout its extent. The report of Assistant Engineer Chas. S. True, who had charge of the work, is appended, marked B, to which attention is invited for details.

One remarkable fact incidentally noted by Mr. True is the low-water width of the Mississippi River. A section was taken by him on the 25th of September, when the Gray's Point gauge read 7.07 feet above low-water, and it was found that the whole volume of the river was passing through a space 743 feet wide.

A still less width was noticed lower down but was not measured. In each case the channel was bounded on one side by an ordinary sand bar. This shows that no practicable amount of contraction of the river will insure deep water all the way across, and is to be borne in mind when projects are under consideration for improvement of Saint Louis Harbor or other important harbors.

The expenditures were:

13,648.90 cubic yards riprap	\$21, 616 12	
1,621.30 cords brush	4, 872 79	
Excavation	100 35	
Labor, rope, &c.	315 91	
	<hr/>	\$26, 935 17
Engineering and contingencies		1, 271 78
		<hr/>
		\$28, 206 95

The revetment at this locality now covers a length of 14,200 feet, including that portion previously covered by the spur-dikes of the Cairo Land Company. The latter was repaired and strengthened by the United States. The work wholly new covers a distance of 10,700 feet built in 1876, '77, '78, and '79. It consists of a brush mattress covering the foot of the slope, and a covering of stone above low-water mark, the latter extending to a height of about 20 feet above low-water. It is proposed to protect the bank above that level to a height of about 30 feet above low-water by a plantation of willows. For this purpose \$5,000 have been allotted from the appropriation of June 14, 1880.

When that is done the original project will be completed and the work will have reached a stage when it becomes of secondary importance in the general scheme of improving the navigation. The local interest desires its extension, and this, while not of primary importance, will be useful to the navigation interests. It would be injurious to the latter, however, if it be allowed to absorb the funds needed so much more at other points.

It is recommended, therefore, that this work be separately provided for. The sum of \$50,000 can be expended to advantage during the year ending June 30, 1882, if specially and independently provided. It is proposed to employ it in removing portions of two of the old spur-dikes, and in extending the protection about 1,500 feet down stream.

SURVEYS.

To comply with the provisions of the river and harbor act of March 3, 1879, a special survey was made of Alton Harbor and of the Mississippi River opposite to the mouth of the Missouri, for which the sum of \$2,000 was allotted and expended from the appropriation for examinations and surveys and contingencies of rivers and harbors. Two different subjects of discussion being involved, the map was divided, and that part covering Alton Harbor was forwarded with Colonel Simpson's report of February 9, 1880, and the remainder with his report of March 25.

Much office labor was expended in working up the data obtained the previous year for the Board of Engineers upon the low-water navigation of the Mississippi and Missouri rivers, with a view to putting the information obtained in proper shape for transmittal to the Mississippi River Commission.

This work was under the immediate direction of Assistant Engineer R. E. McMath, who was assisted by Assistant Engineers Wm. Popp and W. S. Mitchell. His report, with 21 tables and 49 sheets of diagrams, was forwarded to Col. Z. B. Tower, Corps of Engineers, on the 7th of February, in compliance with your instructions of January 20, 1880.

Included in the surveys undertaken for the Board, which were suspended upon the organization of the Mississippi River Commission, was a line of levels to extend from the mouth of the Illinois to the mouth of the Ohio.

The establishment of permanent bench-marks along the bank being necessary in carrying on the duties of this office, a party was organized to continue that work. Advantage was taken of the opportunity to re-trace the shore lines, and correct the topography of our maps. This work has been carried down as far as Kaskaskia Bend, where it was suspended on account of the appropriation being exhausted. It was conducted by Assistant Engineer P. C. F. West, who is entitled to credit or skillful management.

A resurvey was made of the protected bank near Cairo.

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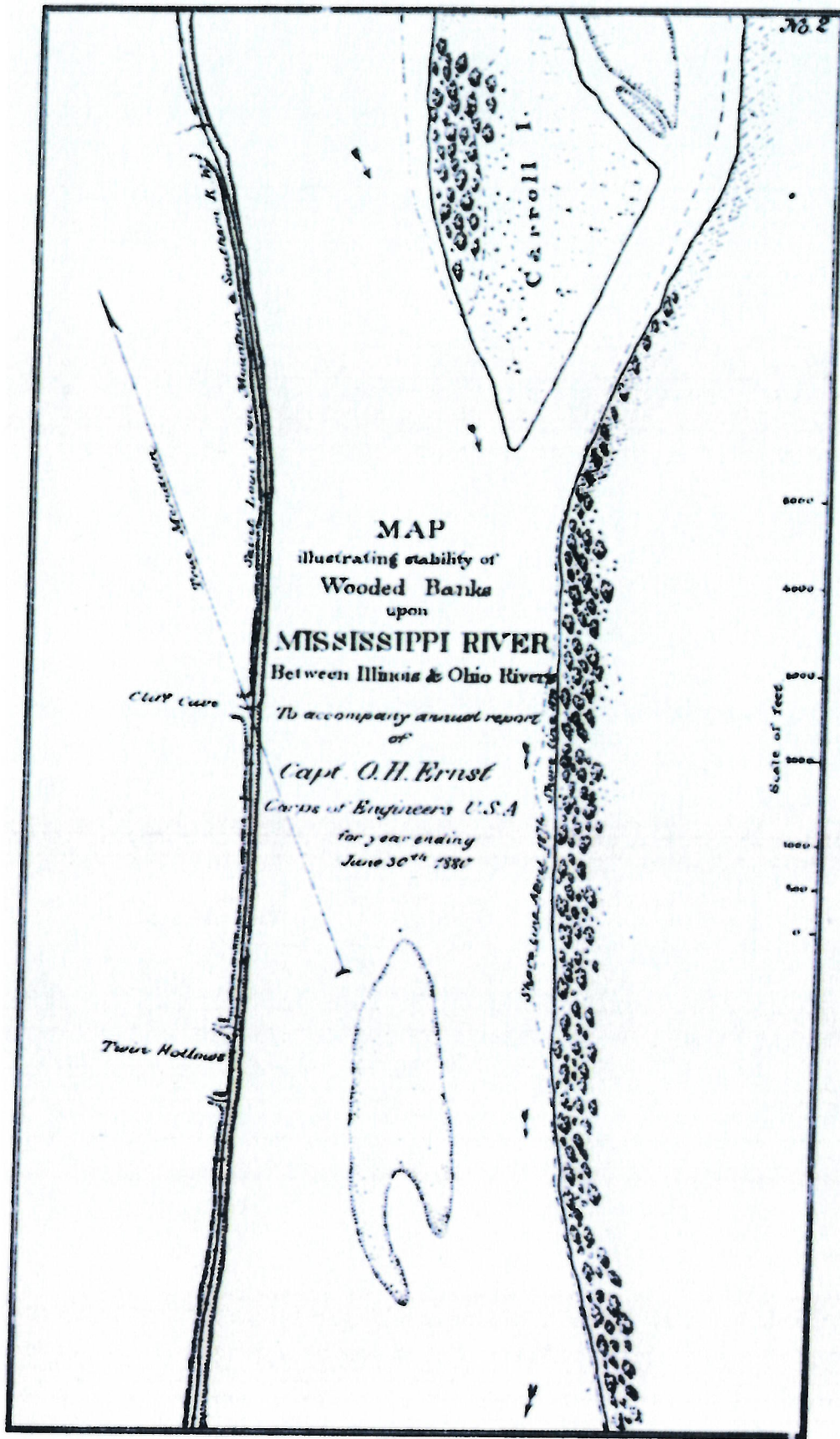
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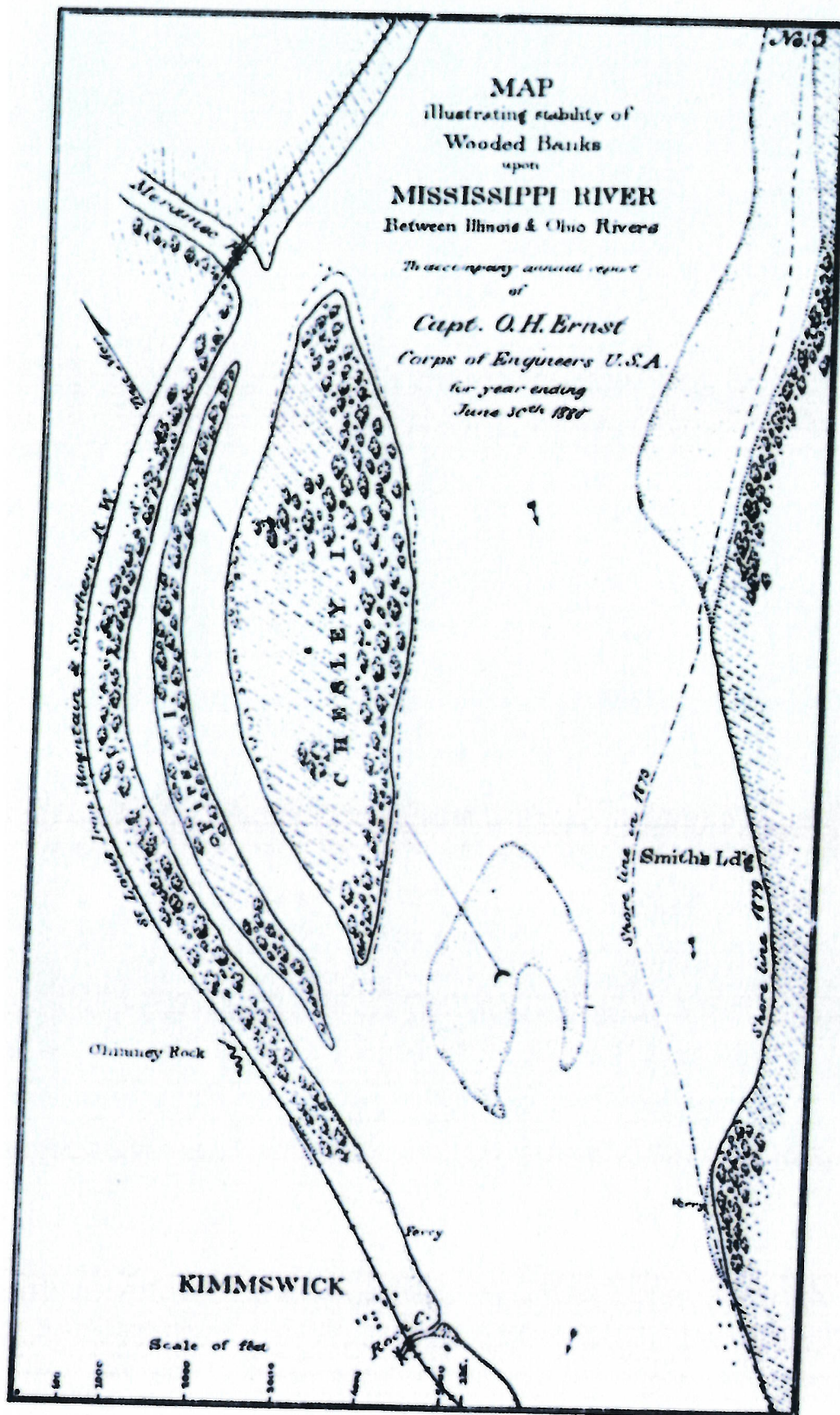
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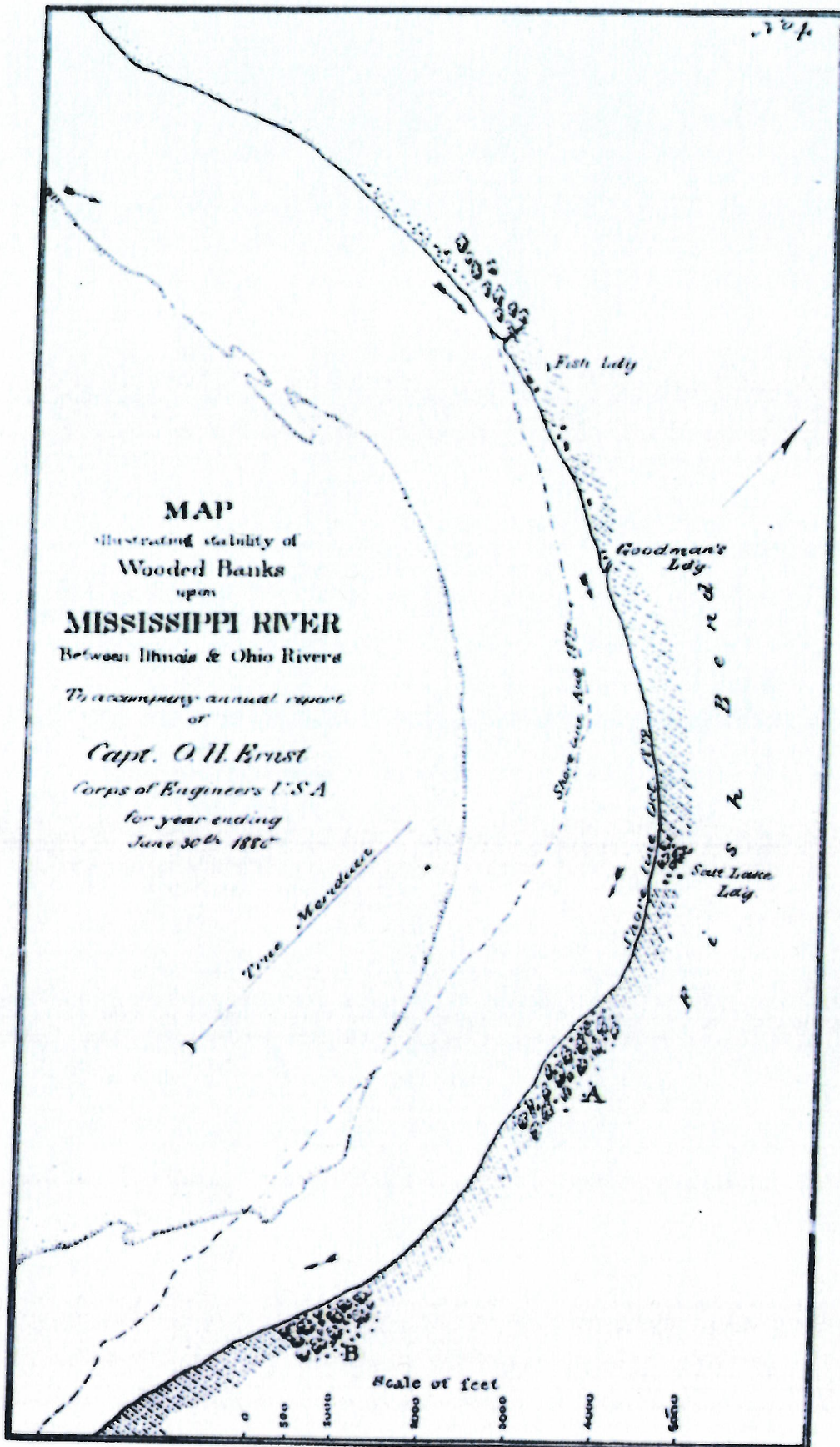
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The gauge at Gray's Point has been read daily throughout the year. Gauges were established in April at Grafton and Alton, and daily observations have since been recorded.

The expenditures were:

Survey at Alton Harbor, &c	\$2,000 00
Examinations, &c., required by Board of Engineers on low-water navigation of Mississippi River.....	4,848 09
Level and topographic survey.....	6,890 80
Hydrographic survey near Piasa Island.....	1,507 85
Survey at Cairo protection.....	220 75
Water gauges, including the \$192.15 reported above for gauges between the Illinois and Missouri.....	282 15
Total	15,749 64

An allotment of \$5,000 has been made for the purpose of continuing the work of leveling and correcting the topography from the appropriation of June 14, 1880.

Operations will be resumed as soon as the stage of the river will permit.

One of the most important developments of this survey is the evidence which the present position of the shore lines affords, that the stability of the banks has decreased with the settlement of the country and the clearing away of the forests. Weakened banks permit more rapid erosions, give the river greater width, and therefore less depth, and the navigation is injured. The fact that the river has materially widened within the last 60 years is generally acknowledged by those best informed, but all evidence that can be procured in support of it is useful in resisting claims for damages, by establishing the position that our works of improvement are works of conservancy. And if this widening process is still going on it is evident that the navigation is still further deteriorating. An examination of the shore line shows that in every case where cleared fields along a caving bank are interrupted by a patch of woods the latter projects out into the river. It is easy to believe that the binding quality of the roots, and the protection formed by the fallen trees at the foot of the bank should have this effect. Wooded banks yield finally, of course, but the rate of erosion is so slow that the river has time to build up on the opposite side, and there is no increase of width. Four extracts from Mr. West's maps, selected at points which had been previously covered by authentic surveys are submitted in illustration of this point.

Extract No. 1 shows the shore line opposite the mouth of the Missouri as it was in 1870 and in 1879. In nine years the caving at the upper end of this ground, where the bank was stocked with woods, was almost nothing; at the middle portion, the ground being cleared, there was an erosion of over 900 feet, and at the lower portion where woods are found again there was from 100 to 200 feet of erosion. No. 2 shows a wooded bank just below Carroll's Island, as it was found in 1872 and in 1879. It has been exposed to the attack of the main channel for seven years, and the erosion is nowhere greater than 200 feet, and in some places is less than 20 feet. No. 3 shows a bank alternately cleared and wooded just above Kimmswick, as it was found in 1873 and in 1879. An erosion of 1,000 feet in the deepest part where the bank is cleared has occurred in six years, and the river has been widened that much. The wooded point at the lower end has held on in a remarkable manner. No. 4 exhibits Fish Bend, where the erosion has been more rapid than at any other point covered by Mr. West's survey. Nearly 2,000 feet has been washed away in the deepest part in the five years since 1874. The prominence of the

patch of woods, marked A, near the middle of the bend is apparent to the eye. The next patch below, marked B, though at first glance its prominence is not so apparent, has held on so as to make the river at this point narrower than at any other within these limits. The survey of 1874 gives only one bank of the river.

The facts of which these are examples lead to the belief not only that the navigation has been deteriorating in the past, but that the process is still going on, and will increase in rapidity as further clearings are made, and that, unless energetic measures are adopted to replace the guards established by nature and removed by man, the day will come when the navigability of the river for vessels that now use it will be destroyed.

EQUIPMENT.

The greater number of the works in this district being situated at points where it is impracticable to procure suitable boarding accommodations for the force employed, it is necessary to provide public quarters. To construct buildings on shore would necessitate the acquisition of land and the services of a keeper throughout the year when the work is suspended, and in many cases the buildings would be needed but a short time. A better arrangement is to provide floating quarters which can be moved from point to point, and be brought together for safe-keeping with the other property when the work is suspended. Two quarter-boats having a capacity of 48 laborers each, with the necessary kitchen and office room, and with accommodations for the overseer, &c., were built at a cost of \$2,000 each. It is proposed to gradually increase the number of these boats as appropriations are made.

Barges No. 4 and No. 6 having become unserviceable, were condemned and dropped.

The hull of the steamer Anita is nearly worn out, but can probably be made to answer through the coming year.

RIPARIAN RIGHTS.

One of the most important questions connected with the improvement of the Mississippi River is that of riparian rights. The reasons why it is of special interest to the Engineer Department are that under the present frequent, if not general, interpretation of the common law: 1st, the boundary between private property on the banks and the public highway is not defined, while it is of great importance that it should be defined if the government is to be held liable for damages caused by its works, and it is important in any event in order to avoid trespass; 2d, the accretions caused by the works belong to the owner of the adjoining land, while it is absolutely necessary that the government should control these accretions for a considerable period after they emerge from the water; 3d, the United States has no title to alluvial islands formed by nature, or to lands reclaimed by its works, while it requires such lands for the cultivation of willows, and should in equity fall heir to them as they are formed.

It is uncertain how far the laws declaring the Mississippi a public highway have impaired the right of private ownership of the bed. Of the two States bordering upon my district, the courts of Illinois hold that this right still exists; those of Missouri that it does not. The Supreme Court of the United States has decided that it does, and again that it does not. But I believe that a majority of the States hold that it does, and this must probably be considered the present law of the land.

It cannot be considered good law, because it is not good policy. The reasoning by which the adverse decisions referred to were reached was probably based upon the supposition that the public requires only a *passage over* the bed. That is not the case. The public requires to go down *to* and *under* the bed to establish substantial works upon it and to keep them there forever. It requires to remove the water from parts of the bed, and to put such parts to its own uses for an indefinite period. If the right of private ownership is recognized, the United States can do nothing without trespassing upon private property; there can be no further argument as to the ownership of accretions or "tow-heads," and it is in the power of any ignorant or malicious riparian owner to place endless obstacles in the way of the improvement.

Considering the bed as a whole, the question of ownership is of far greater interest to the United States than to any individual, for to the former it is a necessity as the site of its works, while to the latter it is of little practical value. But at the margin of the stream the interests are more nearly equal. Conceding that from the nature of the case it is necessary that the government (whether State or national) should own the bed of the stream, it remains to define what is meant by the bed, and to fix a boundary between the public and private property. This boundary is necessarily a movable one, and must be the water edge at some given stage, a low, a high, or a mean stage. The question has been decided in France according to the old Roman law, "*ripa ea putatur esse quae plenissimum flumen continet*," and there the bed comprises all the ground covered by the water when it has reached its greatest elevation before overflow.

Whatever elevation the waters may reach, so long as there is no overflow or flood they are within their own domain, and this is properly considered the bed. The question of determining the exact level at which flood begins at any locality is left to the executive. This arrangement has worked well there, and would probably work equally well here.

The contraction of the river, where it is excessively wide, results in the formation of considerable bodies of reclaimed land. It is necessary that this land should remain under the exclusive control of the government for an uncertain number of years, until by successive deposits from the river it has been raised to a height at which, with suitable protection, it is secure from ever becoming again the site of the river. As riparian rights are now interpreted, these formations become the private property of the adjoining land owner as soon as they emerge from the water. This doctrine seems fair enough when the accretions are the result of natural causes, but when they are the result of large expenditures of money, its fairness is questionable. The accretions may be an injury to the riparian owner by removing from him water for his animals and his land; but from the nature of the case they would not be caused in any but places that are already shoal or liable to become so, and could not cut him off from *navigable* water any more than the shoals did before. On the contrary, by giving him a right of way across the new-made land, his approach to deep water would be facilitated.

It seems to me that the small injury of compelling him to go somewhat further for his water is one of those that the individual must always be ready to suffer for the benefit of the public, and that if a right of way be allowed across the new land to the river, no injustice will be done in declaring these reclaimed lands the property of the United States. This question has been solved in a different way in France, by fixing as the boundary between public and private property the water-edge at a high stage. The new-made land thus remains under

the exclusive control of the government until it has reached a height at which it can be cultivated. It then reverts to the adjacent proprietor, the right of the government to exact an indemnity being recognized. Probably this solution would be a less shock to legal prejudices than for the government to assume the ownership outright. The indemnity exacted, however, could only be the difference between the value of the land before improvement and that after. The former being nothing, the financial result to the riparian proprietor would be the same under either solution.

Aside from the necessity, from an engineering point of view, of controlling the reclaimed lands for a series of years, they are of great value to the government in the cultivation of the willows, which are a vital necessity of the improvement. The supply of willow brush in the wild state is limited. There is even now no great surplus, and if the operations should be extended there will be great difficulty from this source. At present the price is low, but it would not be difficult for an enterprising individual to secure such a monopoly as would enable him to exact a price many times as high. The only safeguard against exorbitant prices or a failure of the supply altogether is to own willow plantations. Now the means by which it is expected to cause deposits upon the reclaimed land, and thus raise it to a secure height, is a plantation of willows. We have therefore not only made the land, but we have also stocked it with a growth that is of great value to us for improvements elsewhere. There is every reason, then, why the government should take possession of these lands if it can be properly done.

Alluvial islands of recent formation, or, as they are generally known upon the river, "tow-heads," are of equal value to the United States for this purpose, and of no value whatever to any other person, unless the United States becomes a purchaser of the product. These belong either to the owner of the adjacent land or to the riparian State, but in no case to the United States. A title to them could be obtained from the legislatures of the riparian States if it is once settled that they belong to those States. But looking at the subject independently of the law, it would seem that these formations should belong to the United States, because they are of value to it and to no one else, and because in exercising its power of conservancy it often finds it necessary to assume ownership to the extent of removing parts of them as public nuisances; also, because it is often practically impossible, in a stream a mile wide, with a frequently-shifting channel, to tell to which one of two opposite States the formation would belong.

It seems to me that these various considerations should receive the attention of the government now, while the interests at stake are comparatively small. The rectification of the Mississippi River will give an intrinsic value to ownerships which are now but little more than leases. The value of the principal product, willows, now almost nothing, is increasing, while increase of the population must necessarily increase the value of the land. To leave them to work their own solution in the common law is at best an expensive method, and judging by some recent decisions it is one which may result in rendering a prosecution of the improvement impracticable. The difficulty can be solved by legislation declaring the bed of the river a part of the public highway, and therefore public property, and defining the bed to be all ground lying below high-water mark, the determination of the exact line which shall be considered high-water mark at any locality being left to the executive. It is respectfully recommended that steps be taken to secure such legislation.

DAMAGES CAUSED BY THE WORKS.

Closely related to the foregoing is the question of damages to riparian owners, caused by the works of improvement. Although its settlement may not be within the reach of legislation, its present discussion will be profitable if it shall be found that the government can properly assume a position opposed to all such claims. Having taken up such a position, no opportunity should hereafter be lost to obtain and record evidence which may affect it.

Engineering operations upon the river, though they will eventually benefit all riparian owners, will at first affect some of them favorably and some unfavorably. One man's property will be washed away, while another's will receive accretions. One water front will become inaccessible, while another will receive the main channel. These changes are constantly occurring in the course of nature, and are submitted to now as inevitable. But when the losses can be charged to the operations of the government, the sufferers will be less placid. If engineers are working in the vicinity the changes will be attributed to them, whether rightfully or wrongfully, and claims for damages are to be expected.

In an opinion of the Attorney-General, Mr. Caleb Cushing, dated October 19, 1853; it is shown that while the jurisdiction and ownership of the shores and bed of a navigable stream are vested in the States and not in the United States, "a power exists in the Federal Government—a *jus majestaticum*—for the conservation of the public rights of navigation and commerce," and he remarks that "the power to regulate the use of the shores and beds of navigable waters, so that the lawful purposes of commerce and navigation shall not be hindered, is quite distinct from the right of eminent domain."

The subject under discussion by him was the power of the United States to prevent the construction *by man* of a nuisance in a navigable water; but it seems to me that the application of the principles laid down may be extended to such natural but temporary nuisances as are constantly being constructed by a silt-bearing stream like the Mississippi. Among these are snags, islands, "tow-heads," bars, and other shoals. Indeed, such application is tacitly recognized by the appropriation of money for the removal of these nuisances.

But the government is liable in these operations to be considered as acting on the offensive instead of, as is the fact, on the defensive. The distinction is a very important one, when the claims for damages by riparian owners are under consideration. If the works of improvement are works of conservancy, and are planned so as to do no willful and malicious injury to an individual, there can be no valid claim for damages. If on the other hand a new state of affairs, never known before, is being produced, and the water highway is really being made better than it ever was before, and to the injury of a riparian owner, as in a slackwater improvement, damages may properly be claimed.

The shoals in the Mississippi are constantly shifting their position, and there are very few spots now occupied by them where there has not been deep water within a recent period. It is pretty well established that there was in former years a depth of water throughout the navigable channel at the lowest stage at least equal to what we shall endeavor to obtain by our works. It would of course be impossible to show that the form given to the river after improvement was the same as that it once had, but it would be sufficient to show that only the works necessary to remove the nuisance and to keep it from returning had been constructed.

It is a fact that we are not attempting to make an unnavigable river.

navigable, nor even to obtain a greater depth at any given point than often naturally exists there. Although the river as a whole may, when the work is completed, be in better condition than it ever was before, and the character of the stream *as a whole* is thus being altered, the same cannot be said of any small portion of it. Considering a section bordering upon the property of any individual, our object is simply to restore what once existed, and to do it in such a way that the restoration shall be permanent. The river may, for this purpose, be compared to a railroad constructed originally with two steep slopes in its cuts. Constant slides obstruct the use of the highway. A removal of the obstructions and a correction of the slopes put the road as a whole in better condition than it ever was before; yet these are strictly works of conservancy. There is no doubt, therefore, in my mind, that all works of improvement of the general navigation to the extent of obtaining a channel depth of 10 or 12 feet below Saint Louis at the lowest stage may be properly regarded as works of conservancy.

This view of the matter can work no hardship to the present riparian owners. As before intimated, no man who now possesses a deep-water front can count upon long retaining it; nor can the owner of land be assured of any period during which the river will leave him in possession. He holds his property with this understanding, and it is valued accordingly.

CONTRACT SYSTEM.

All work during the year has been done by hired labor and the purchase of material in open market. It is intended to continue this system during the coming year, as the work here cannot be done by contract without injury to the public interest. Both systems have been tried, and the contract system has been found the more expensive of the two. (See Annual Report of the Chief of Engineers for 1877, page 514.) But a consideration of still greater importance is that the present system enables us to make advances in the art of river improvement which would not be practicable under the contract system. The *plan* of the improvement is one thing; the *method of construction* is another. No change is contemplated in the former. It is the plan recommended for rivers of this character by every engineer of repute from the time of Frisi to the present day. It is in brief to concentrate all the waters of the river in a single water-way of moderate width; that is, to close island chutes and contract the width of the river where it is inordinately great. It is the plan lately recommended by the Mississippi River Commission, and there is no presumption in saying that it is the only possible plan by which the navigation can be improved. But the methods of construction have been greatly altered and improved. Using at first, in 1873, the method successfully employed upon some of the largest European rivers, we have by successive steps developed a totally different system, as is shown above in the description of the works at Horsetail. Each step forward has been an experiment, and to this the contract system would have been directly opposed. The present method is considered good, but it cannot be asserted that no further advances are to be made, and until that becomes practically the case, the contract system will be an injury to the interest of the government.

The treacherous foundations of the Mississippi render it necessary that the engineer should have full liberty to change his plans whenever necessary; the varying height of the water makes it essential that he should be able to push his work or to slacken it according to circumstances; and the superior building power possessed by the river at one season

compared to what it possesses at another, renders the season of the year at which the work shall be energetically pushed far from a matter of indifference. The engineer in charge must, therefore, have full control of his works and all their details.

To place their execution in the hands of a contractor would almost certainly involve failure. Even if this were not the case the contract system would necessarily increase the cost. There are serious difficulties in the way of preparing specifications. All estimates are necessarily uncertain.

As the conditions change, the character of the work is liable to change. If the water becomes suddenly deep a different form of construction is required from what would be used if it remained shallow. A shifting of the channel, or other causes, may make work difficult which promised to be easy, and *vice versa*. Knowing these risks, responsible contractors will not bid without a wide margin of profit. The result is either to pay a high price for the work or to throw it into the hands of irresponsible persons. The latter would probably be the more usual result, and it would in the end be far the more costly. The forfeiture of bonds is a poor return for the damage caused by the loss of a working season and the possible necessity of preparing new plans, involving the removal of work which, in competent hands, would have proved beneficial, but which has become an obstruction to navigation. It may be said that a careful scrutiny of the business reputation of bidders will prevent the latter evil. The answer is that between those persons who are well known to be responsible and those known to be the reverse there is a wide field of character, containing all grades of honesty and capacity, and that many bidders may be found to whom no valid objections could be raised in advance, but who would, nevertheless, hold a position in the business world far below what the work on this river requires. And it should be borne in mind that the field is open to all of them. The character of the work is totally different from that being executed by any private individual in this country. If a bidder could come prepared with his plant and with experience in similar work elsewhere, there would be a fair chance of his shutting off many of those who have neither; and there would at least be a pretext for awarding him the contract, even when lower bids had been received from others. But here no one has the experience, and few, if any, have the plant. With competition under these circumstances there can be but one result, and that is to award the contract to the person who, groping his way in the dark, is willing to take the greatest pecuniary risks with the least profit as inducement. It is not reasonable to expect that that person will be the one who will have the inclination and the power to carry out his contract at any and all costs to himself.

APPROPRIATION OF JUNE 14, 1880.

The allotments made from the appropriation of June 14, 1880, amounting to \$250,000, were, for—

Repairs and contingencies	\$10,000
Levels and topography	5,000
Horseshoe Bar	150,000
Cairo protection	5,000
Located by Congress	20,000
Total	190,000

Which leaves a balance of \$60,000, available for beginning a new work.

The two worst places between Saint Louis and Cairo are in the vicinity of Widow Beard's Island, between Carroll's Island and the mouth of the Meramec, and just below Kaskaskia Bend. The least depth of water found last autumn at the former was 4 feet 4 inches, and at the latter 4 feet.

The changes going on at Kaskaskia Bend and just above render it impossible to foretell what the shape of the river will be in a few years from this time, and what will be the line of its approach to any works which might be planned for the improvement of the locality mentioned.

Attention will therefore be turned to that portion of the river lying between Carroll's Island and the mouth of the Meramec. A survey of the locality will be undertaken as soon as the river has fallen to a suitable stage, and a plan of the works required, with an estimate of their cost, will be submitted as soon afterwards as practicable.

COMMERCE TO BE BENEFITED.

It is not practicable to give with accuracy the amount of commerce that will be benefited by the completion of this work. The statistics collected by Colonel Simpson in 1877 showed that the value of the commerce which actually floated upon the Mississippi between the Illinois and Ohio rivers was then \$178,000,000, exclusive of the value of vessels. This evidently is no measure of the commerce to be benefited, since the rates by river affect the rates by rail. A considerable part of all the commerce of the Mississippi Valley, whether by land or water, must be benefited by the improvement. There are no reliable data within my reach for estimating the value of this commerce. It has been estimated by some persons at \$5,000,000,000. Much of this is independent of the river, and the value itself may be too high or too low; but, without claiming any approach to accuracy, the figures serve to give a general idea of the magnitude of the interests involved. If they be divided by 10; a value of \$500,000,000 will still remain, and this will undoubtedly fall below the truth.

ESTIMATE FOR YEAR ENDING JUNE 30, 1882.

It has been shown in the annual reports from this office that the great difference between the annual estimates and the amounts appropriated would result in very much overrunning the total estimate before the work is completed; and the opinion was expressed last year that, with annual appropriations of \$200,000, as have prevailed, the final improvement would cost \$20,000,000 instead of \$7,684,000, as estimated, and would occupy a century. Two hundred thousand dollars is less than 3 per cent. of the total estimate; and \$250,000, the amount of the appropriation for next year, is about 3¼ per cent. As 2 or 3 per cent. of the total cost would not be an extravagant estimate for keeping the works in repair after they were once wholly completed, it is evident that the time and the cost given above are rather under than over stated. The estimate of \$7,684,200 was submitted in 1876, previously to which time \$725,000 had been appropriated, leaving \$6,959,200 to be provided. The annual appropriations since that date have varied from nothing to \$250,000. There is, therefore, reason now to add to the original estimate, but it is retained for the present with the hope that enlarged operations and improved methods will render it possible to recover the ground lost. There remained to be appropriated on the 30th of June, 1880, \$6,039,600. Leaving out of account the immense financial advan-

tages to the government and the public which will result *annually* from securing cheap through transportation at the earliest possible moment, it may be stated that the work will be accomplished with the least outlay by six annual appropriations of \$1,000,000 each. The less the annual appropriation the greater the final cost. I therefore submit an estimate of \$1,000,000 as the amount that can be advantageously expended during the year ending June 30, 1882. And, in order that this sum may produce the greatest results, it is of the highest importance that it should be applied exclusively to the works of primary importance to the navigation interest. To expend any considerable portion of it at this time in the protection of local interests, as at Alton, Kaskaskia, Cairo, and similar places, must evidently be injurious to the interests of commerce. It is desirable that such of these works as Congress thinks proper to prosecute at this time should be provided for separately. Separate estimates for those which have been begun, viz, Kaskaskia and Cairo, have been given under their respective headings. These aggregate \$100,000, which is added to the amount required for the navigation interest, making \$1,100,000 in all. It is proposed to employ this sum in completing the works now progressing and those to be begun at Piasa and Widow Beard's islands, and in beginning works near Herculaneum, Platin Rock, Fish Bend, Fort Chartres Island, Jones's Point, and Hat Island, of which detailed estimates cannot be given in advance of the survey required for the actual beginning of each work. It is possible that obstacles may be developed at other places before that appropriation becomes available, which may be worse than those now existing at the points mentioned. In that case the programme given would be modified.

In submitting this estimate attention is again invited to the fact that the forces which have injured the navigation of this portion of the Mississippi are still at work. It cannot be stated too often or too plainly that the navigability of the river is in danger. The question involved is not simply whether better navigation shall be secured, but whether such as now exists shall be preserved. The works required to accomplish the one object may be made to accomplish the other. The longer the execution of them is postponed the more there will be to do, and, as before stated, the slower they progress the more they will cost.

The work is located in the collection district of New Orleans.

Amount of revenue collected at the port of Saint Louis for the fiscal year ending June 30, 1880, was \$1,176,000.57.

Money statement.

July 1, 1879, amount available.....	\$200,245 27	
Amount received for fuel sold to officers.....	30 00	
Amount appropriated by act approved June 14, 1880.....	250,000 00	
		\$450,275 27
July 1, 1880, amount expended during fiscal year:		
By Col. J. H. Simpson, Corps of Engineers.....	127,118 66	
By Capt. O. H. Ernst, Corps of Engineers.....	38,396 55	
July 1, 1880, outstanding liabilities.....	1,421 49	
		166,936 70
July 1, 1880, amount available.....		283,338 57
Amount (estimated) required for completion of existing project.....		6,039,600 00
Amount that can be profitably expended in fiscal year ending June 30, 1882.....		1,100,000 00

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Construction account.

Name of work.	Expended previous to July 1, 1879.	Expended during year ending June 30, 1880.	Total cost to June 30, 1880.	Total estimated.	Required to complete.
Phasa Island Dam	\$32,333 30	.....	\$32,333 30	\$41,210 73	\$8,877 43
Alton Dam	33,023 02	.....	33,023 02	40,000 00	6,976 98
Sawyer Bend Protection	90,803 03	.....	90,803 03	142,211 62	45,407 99
Venice Dikes	30,341 85	.....	30,341 85	40,000 00	3,658 15
Arsenal Island Protection	9,073 85	.....	9,073 85	9,073 85	.....
Closing Cahokia chute	103,140 89	\$12,038 71	110,088 60	110,088 60	.....
Horseshall Bar, Diike 1	40,540 53	.....	40,540 53	40,540 53	.....
Horseshall Bar, Diike 2	23,000 20	.....	23,000 20	23,000 20	.....
Horseshall Bar, Diike 3	82,002 54	.....	82,002 54	82,002 54	.....
Horseshall Bar, Diike 4	41,200 11	.....	41,200 11	41,200 11	.....
Horseshall Bar, Diike 5	30,033 87	.....	30,033 87	30,033 87	.....
Horseshall Bar, Training Wall and Hurdles	85,241 21	85,143 30	170,384 00	320,384 00	150,000 00
Port Charles Dam	30,812 80	.....	30,812 80	40,502 80	9,750 00
Turkey Island	24,403 85	.....	24,403 85	32,505 40	8,101 01
Kaskaskia Protection	35,437 80	18,701 42	54,130 28	258,130 28	204,000 00
Liberty Island Dam	5,053 01	.....	5,053 01	5,053 01	.....
Liberty Island Protection	45,120 40	.....	45,120 40	45,120 40	.....
Devil Island, Diike 1	05,871 17	.....	05,871 17	150,000 00	17,001 95
Devil Island, Dam 1	40,848 58	.....	40,848 58		
Devil Island, Dam 2	10,078 30	.....	10,078 30		
Calro Protection	85,144 48	28,200 05	113,351 43	172,500 00	50,148 57
Totals	080,074 37	144,000 47	1,131,004 84	1,014,580 02	512,021 78

Property and material account.

Class of property.	Balance July 1, 1879.	Dr.	Cr.	Balance June 30, 1880.
Office furniture	\$172 05	\$112 00	\$400 00	\$224 05
Instruments and survey material	1,080 20	42 50	75 00	1,050 70
Pile-drivers	4,347 44	050 28	3,067 00	1,610 72
Barges	25,880 01	3,023 40	0,434 23	20,000 24
Two tow-boats, one launch, &c., and expenses	27,710 52	31,302 70	30,888 07	22,124 55
Small boats	146 20	505 08	250 00	401 24
General expenses of property	21,437 00	1,845 30	.....	23,282 45
Material and quarry privileges	2,012 23	73,438 52	73,853 20	2,407 40
Tools and appliances	044 03	3,855 01	2,035 23	1,805 01
Quarters, shops, &c.	4,080 05	4,795 32	1,380 00	7,405 37
Totals	88,418 48	120,471 73	128,203 39	80,020 82

Engineer Office, United States Army, in account with the United States.

To appropriations, allotments, &c., prior to July 1, 1879	\$1,443,220 80	By expenses of office	\$50,351 51
To allotment from appropriation for examinations, surveys, &c.	2,000 00	By general engineering	34,170 22
To appropriation for improvement of Mississippi River between Illinois and Ohio rivers, approved June 14, 1880	250,000 00	By surveys	100,008 81
To appropriation for improvement of Mississippi River at or near Cape Girardeau and Milton's Point, Mo., approved June 14, 1880	20,000 00	By constructions	1,131,664 84
To appropriation for ice harbor at Saint Louis, Mo., approved June 14, 1880	50,000 00	By balance on account of property, &c.	80,020 82
To cash for fuel, sold to officers	30 00	By cash on hand and in Treasury	351,700 00
To unpaid percentage	000 17		
To liability for labor	521 32		
Total	1,700,078 29	Total	1,700,078 29

A.

REPORT OF MR. D. M. CURRIE, ASSISTANT ENGINEER.

SAINT LOUIS, Mo., July 8, 1880.

CAPTAIN: The following report of operations for the improvement of the Mississippi River at Cahokia Chute and Horsetail Bar during the fiscal year ending June 30, 1880, is respectfully submitted:

CAHOKIA CHUTE.

The dam across Cahokia Chute was broken on or about August 30, while the water was approaching the low stage. The breach after being fully developed was 300 feet wide with 24 feet maximum depth. Its location was eastward from a point 100 feet from Arsenal Island.

The revetment on Arsenal Island below the dam was seriously injured by the strong current pouring through the breach, which eroded the bed to great depths and undermined it. The dam had settled at several points along its length so that its crest presented an uneven surface and an irregular width.

The work of closing the breach was commenced on the 2d and completed on the 20th of September. In closing this breach large stone was used to break up strong currents and was found to be in the interest of economy. A considerable saving was made in the amount of material required by a change in the alignment, deflecting it up stream, so that the hole in which the maximum depth was found extended only into the lower slope instead of across the whole base of the dam, as it would have done had the dam been reinstated upon its original line.

After closing the breach the crest of the dam was dressed to an even surface and as nearly to a regular width as practicable at moderate expense. Its general elevation was left 9 feet above low-water with approaches at each end rising by gradual slopes to 14 feet.

A mat of brush was placed in the base of the revetment below the west end of the dam, and a revetment of stone was extended up the slope of the bank to about 12 feet above low-water. The bank above that elevation being vertical, or nearly so, was left to receive a slope by the action of the river at high stages before being revetted. All of these repairs were completed by the last of October.

The following statement shows the quantities and cost of material expended:

9,556.77 cubic yards stone placed as riprap	\$12,280 65
118.09 cords brush	246 81
Engineering and contingencies	411 25
Total	12,938 71

HORSETAIL BAR.

The work of this fiscal year at Horsetail Bar was in continuation of the construction of the training wall, and the hurdles in rear of it.

During the two years immediately preceding, a section of the training wall was built between dikes Nos. 3 and 4, and another from the willow bar above dike No. 2 down stream, a distance of 5,950 feet, leaving a gap 2,500 feet long, which had an average depth of 22 feet with the stage of the river at 12 feet above low-water. To close that gap was the object of this year's work on the training wall.

On the map of Horsetail Bar, showing progress of work and the results obtained, this gap is shown between points marked P and Q.

Of the lines of hurdles shown on this map, all of those above dike No. 2, and the third one below the dike, were built last year.

The progress of the silting up, or the results obtained, may be seen in a general way by comparing the soundings which are shown on this map, after being reduced to the same plane, from surveys made at different dates, as follows: March 25 to April 4, 1879; January 26 to 28, March 5, 9, and 17, and June 29 and 30, 1880; or, better, by comparing profiles made from soundings which will be introduced in the details of the work.

The first-named survey extended only down to dike No. 3. At that time there was a hole below dike No. 3, 70 feet deep at low stages of the river; while below dike No. 2 a hole is shown 52 feet deep. Both of these had filled considerably before the operations of this fiscal year commenced, the former to about 50 feet, and the latter to 33 feet.

Training-wall.—In obedience to verbal instructions, estimates of the probable cost of closing the gap in the training-wall were submitted September 9, in which seven different forms of construction were compared, ranging in solidity between a solid

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wall of stone placed in riprap on a brush foundation, as shown in estimate No. 1, to a permeable structure made by planting feathers upon a foundation mattress, as in estimate No. 7; and in probable cost between \$100,000 for the structure contemplated in estimate No. 1, to \$17,000 for that in No. 7.

The form proposed in estimate No. 7 was approved, and its construction proceeded with in obedience to instructions received per letter, of which the following is a copy:

"ENGINEER OFFICE, UNITED STATES ARMY,
"Saint Louis, Mo., September 9, 1879.

"SIR: Your letter of this date, submitting estimates of cost for closing the gap in the training-wall at Horsetail Bar, using various forms of construction, has been received.

"Your design numbered 7, consisting of mattress and 'feathers,' promises good results, and is worthy of a trial. You will please proceed with the work, using that form of construction, keeping careful notes of cost and results.

"By command of Colonel Simpson, and in his absence.

"Very respectfully,

"O. H. ERNST,
"Captain of Engineers."

The following extract from the letter submitting the estimates, describes the essential features of design numbered 7 to which reference is made in the foregoing letter:

"ESTIMATE NO. 7.

"For a permeable structure, which may be made by planting a sufficient number of feathers on a foundation mattress to check the current and cause deposits.

"A feather may be made by taking two saplings as long as can be obtained conveniently and nailing smaller saplings or brush to them (see diagram 3 a) as close together as may be practicable throughout their entire length, and then it may be planted on the mattress while afloat by anchoring its butt end to the bottom grillage and attaching its top to a buoy. The buoys may be boxes, barrels, or booms formed of dry logs or driftwood."

Other details were given which may be omitted here, as they will be found in the description of the work actually done.

In accordance with verbal instructions, suitable floating ways for constructing and launching mattresses in place were prepared, using for this purpose barge No. 3, which had become unserviceable for the transportation of heavy material. To prepare the barge for the reception of the ways it was cut in halves after running bulkheads across on either side of the midship section, cutting the gunwales away to give the proper slope to the ways, and firmly connecting the parts together as shown in Fig. 1.

In Fig. 1, which is a perspective view of the ways, illustrating their form of construction, A A are parts of the barge connected together by the beams B B. The ways a a, &c., project over the end of the barge to ease the mattress into the water, and at the opposite end a clear space was left on the barge for convenience in handling lines and material.

The ways had an available width of 58 feet, and about the same available length was all that could be obtained. A platform was suspended from the beams which supported the ways over the space between the parts of the barge, and a portion of the deck was left off the barge so that men could pass under the mattress while constructing it.

These preliminary preparations having been completed, the work of closing the gap was begun at the upstream end September 27, and was vigorously prosecuted from that date to December 15, when it was suspended on account of ice running in the river. It was resumed January 12, and continued until the close of the fiscal year with a greater or less force, according to circumstances, the force being regulated to some extent to suit the varying conditions of weather, stage of river, and state of available funds.

A permeable system of works has been adhered to throughout the year. The following forms of construction, however, have been tried experimentally: The mattress, with feathers attached; the mattress, with curtains; and, without the mattress, the open curtain and the closely woven curtain. Each of these presents novelties which may make a special description interesting.

Referring to the accompanying tracings, Fig. 2 is a perspective view of the form of construction made by attaching feathers to a foundation mattress in which A is the mattress, E F are feathers attached to it by flexible connections, c c and B B are buoys supporting the tops of the feathers at any desired height. Fig. 3 is an end view of the same, and Fig. 3 a is a cross-section of a feather.

The mattress A was constructed of a lower series of poles, a, attached to the longitudinal ties C; above the poles a longitudinal poles b were laid; above these two tiers

Fig. 1

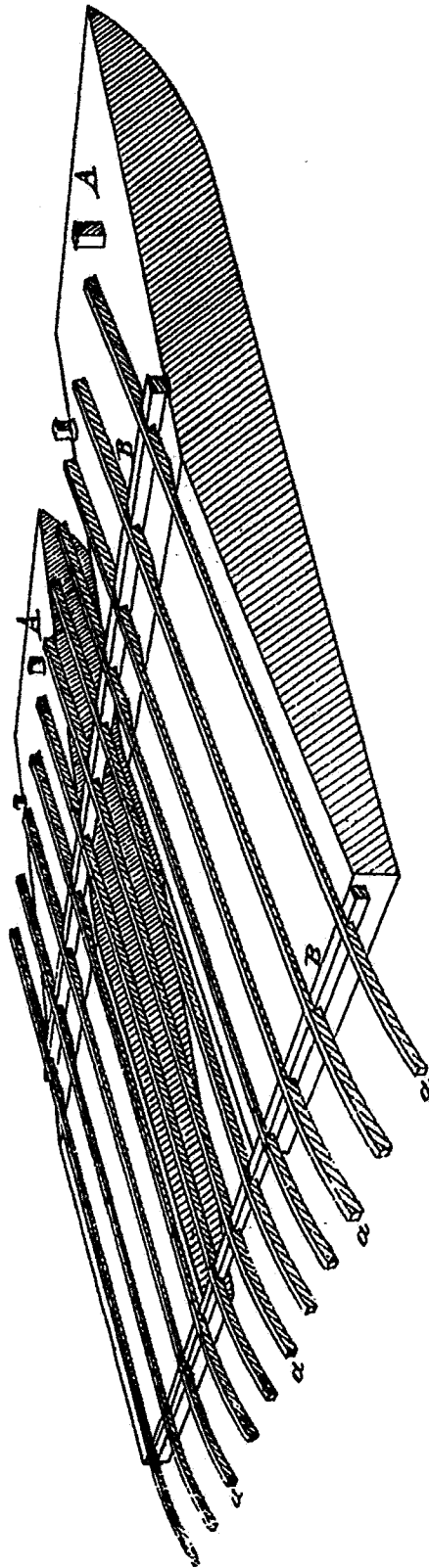


Fig. 2

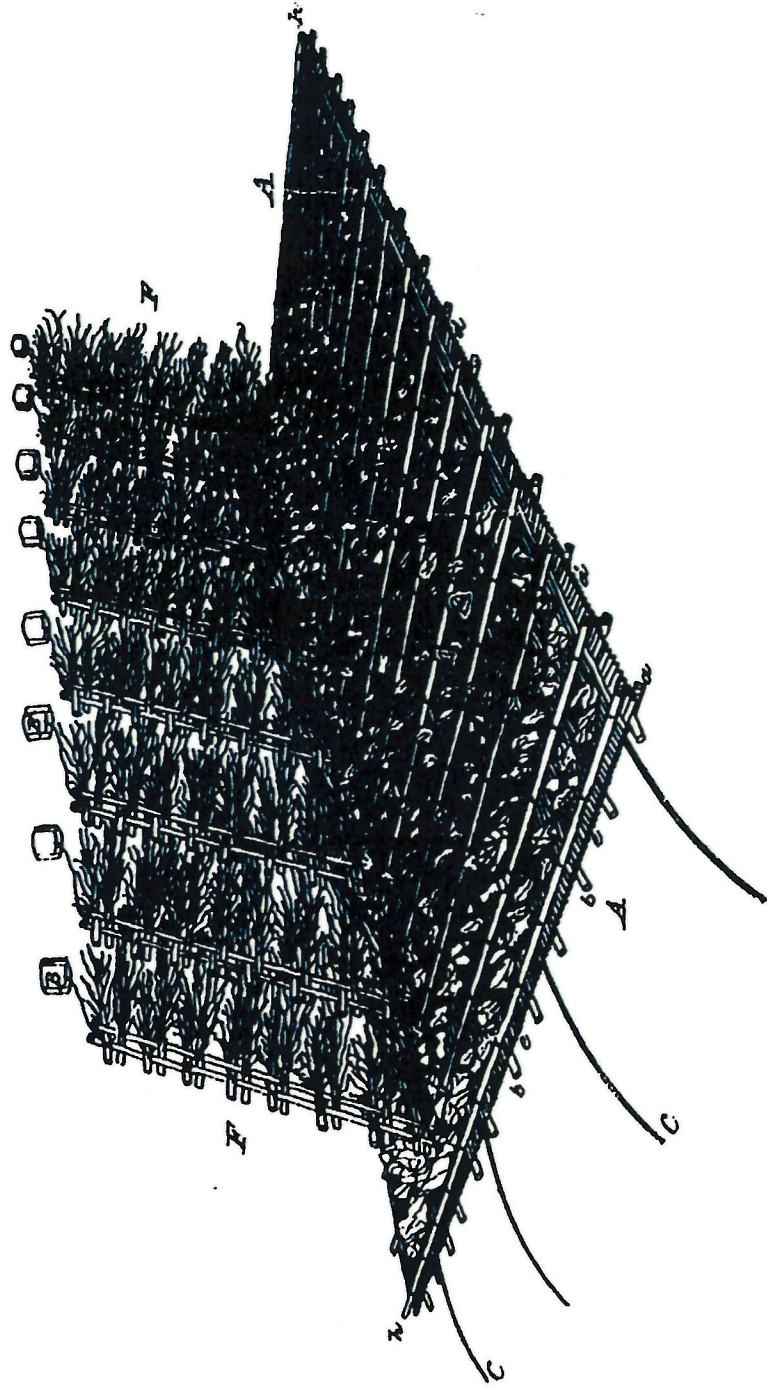


Fig. 3

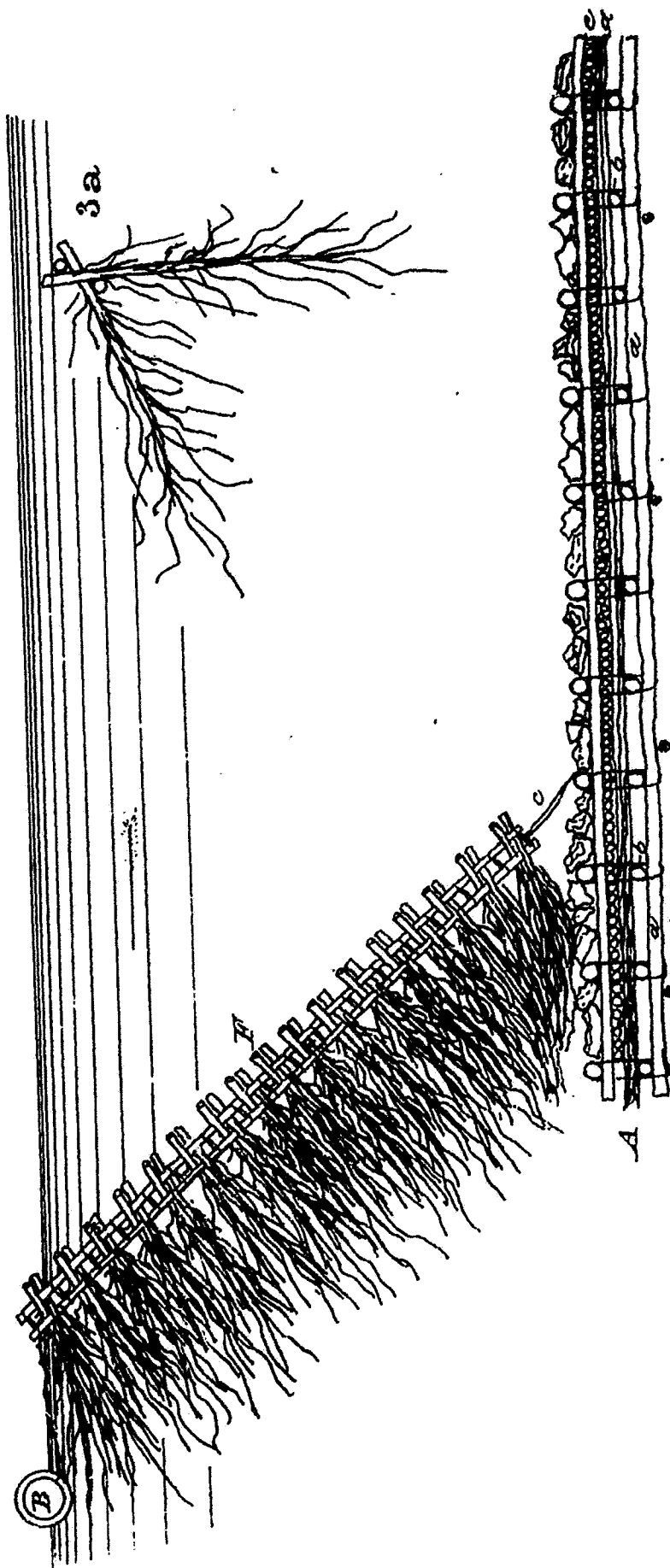


Fig. 4

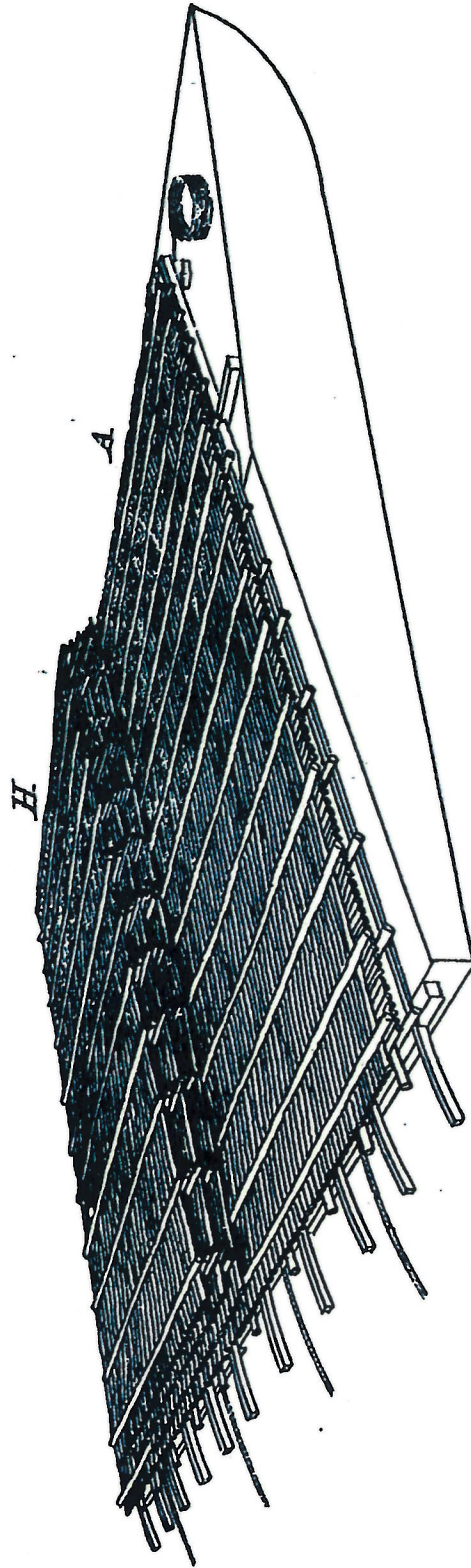


Fig. 6

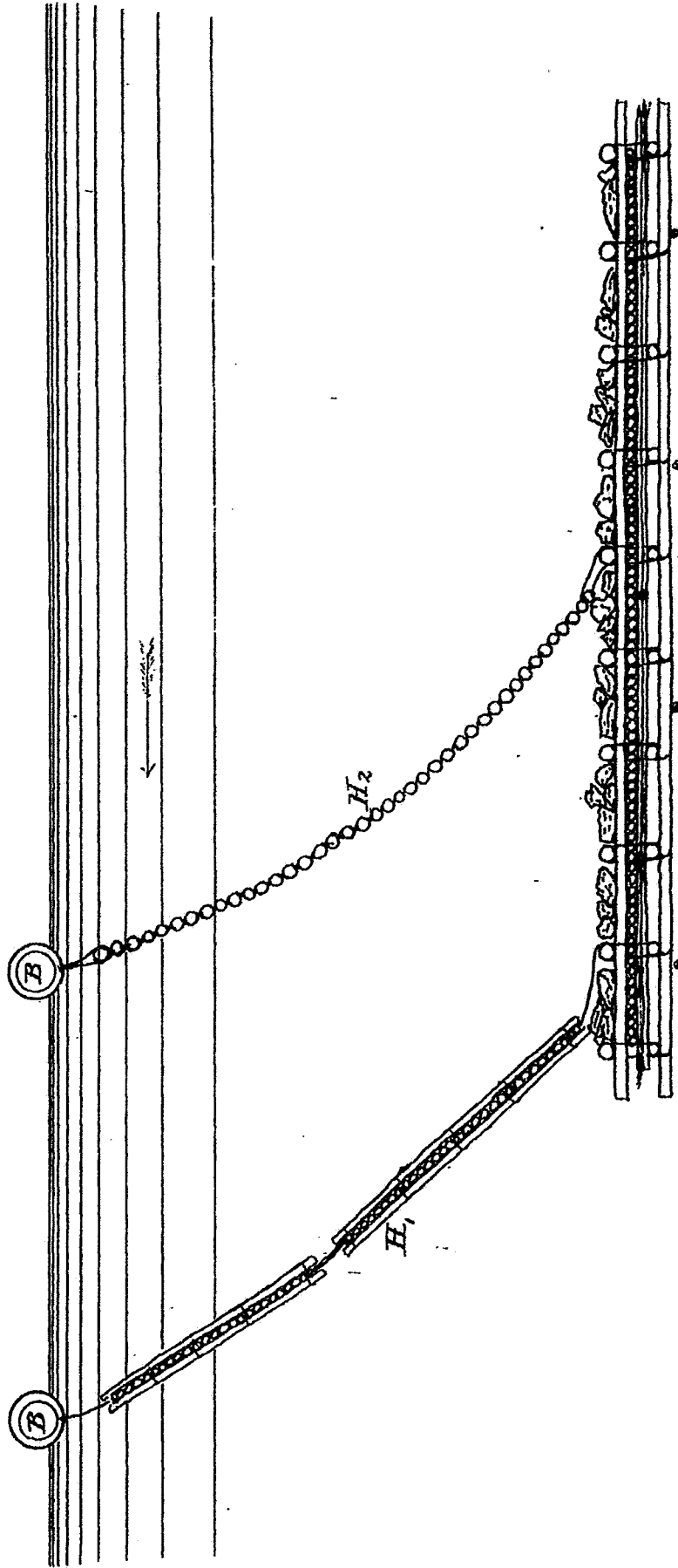


Fig. 7

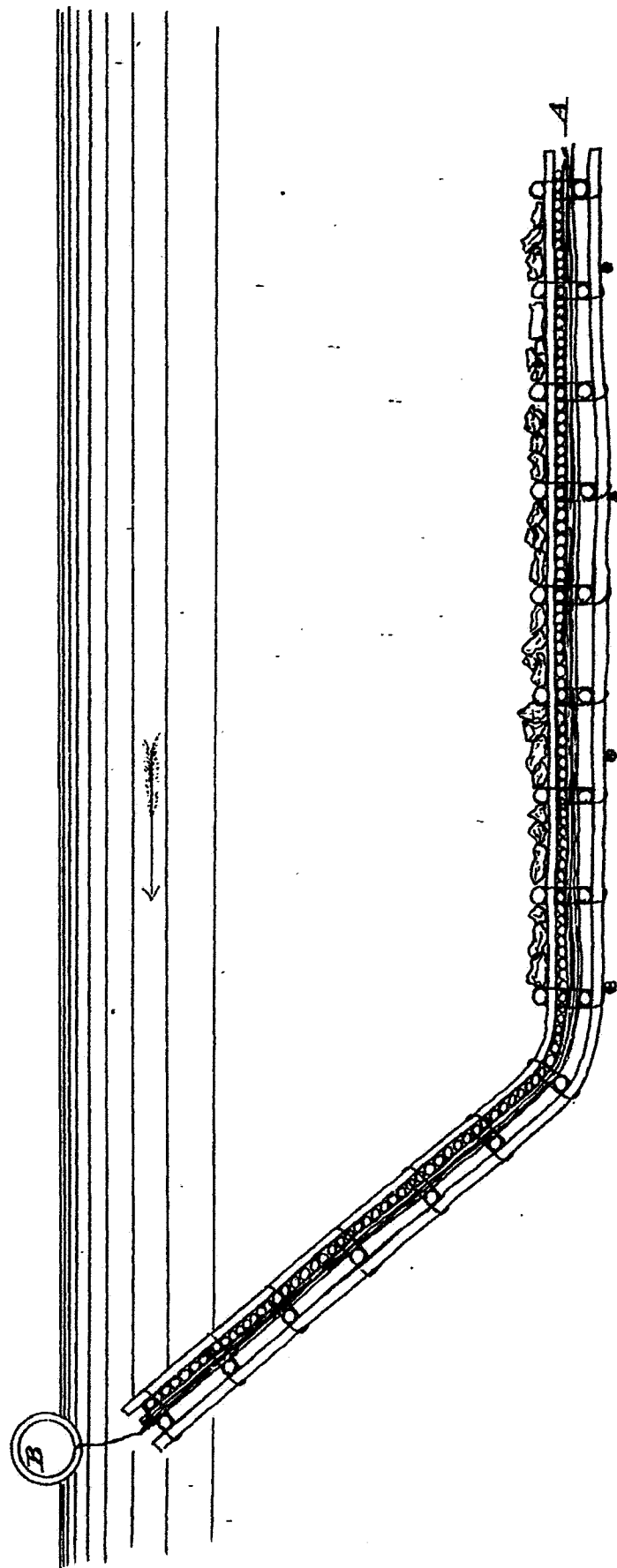


Fig. 8

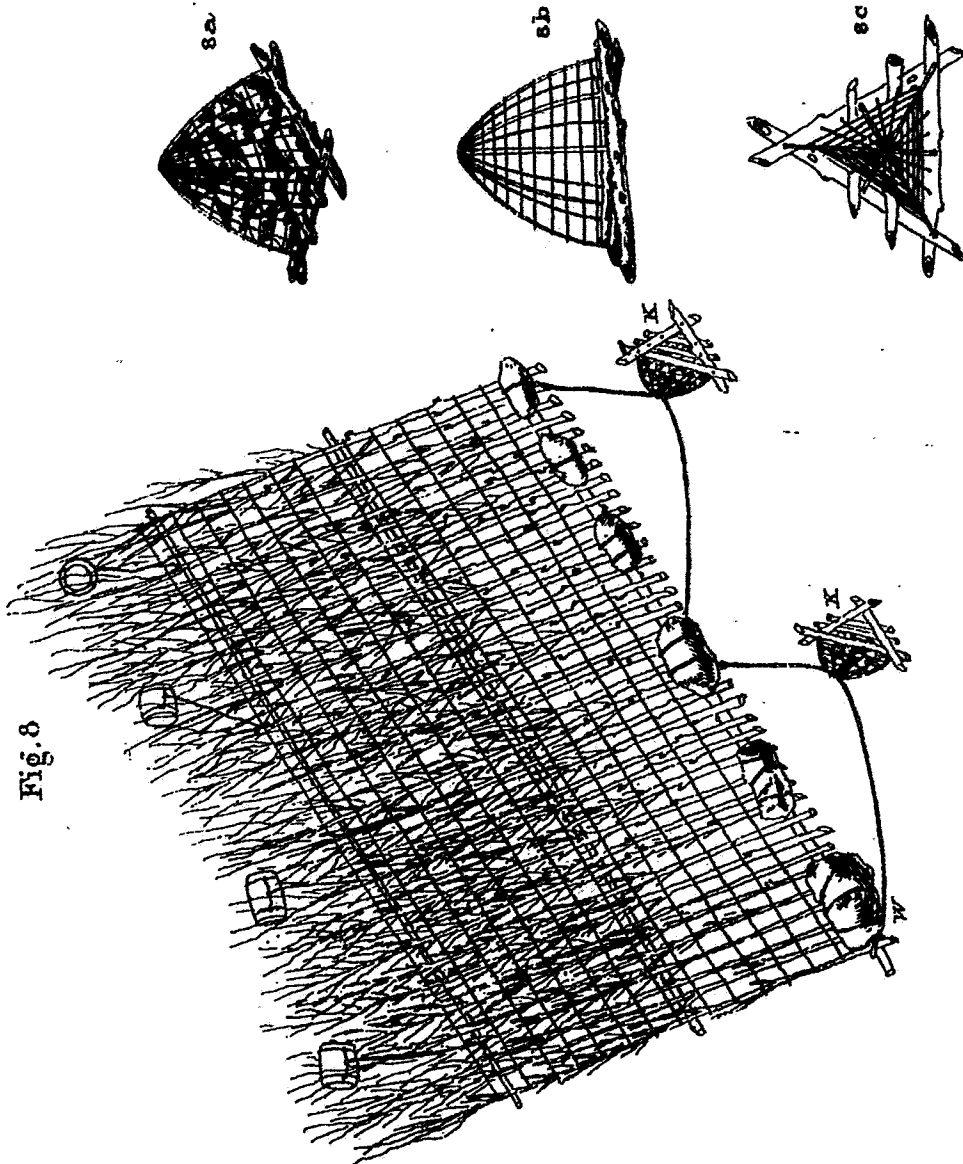


Fig. 9.

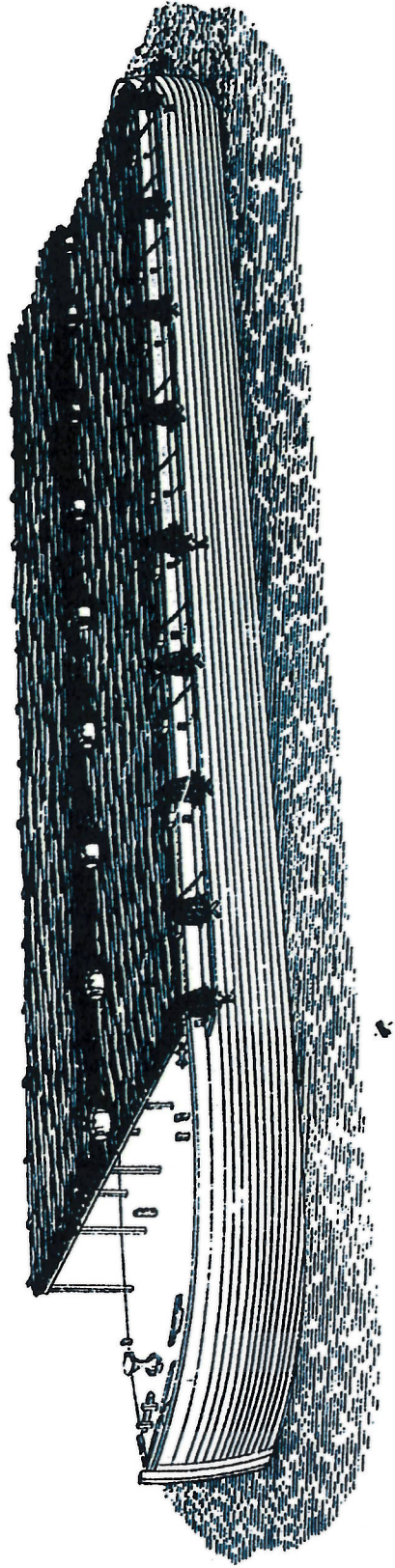


Fig. 10

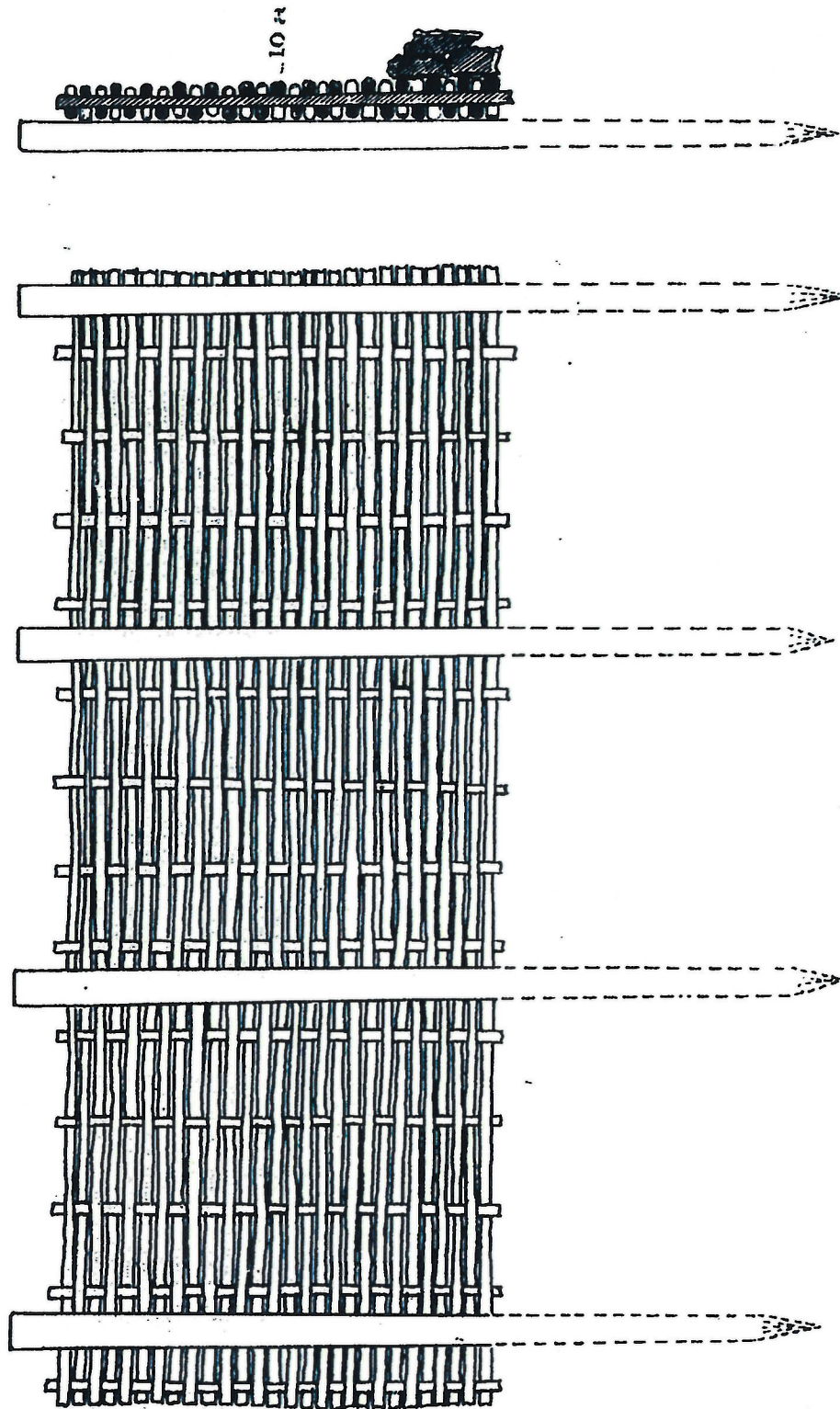


Fig. 11

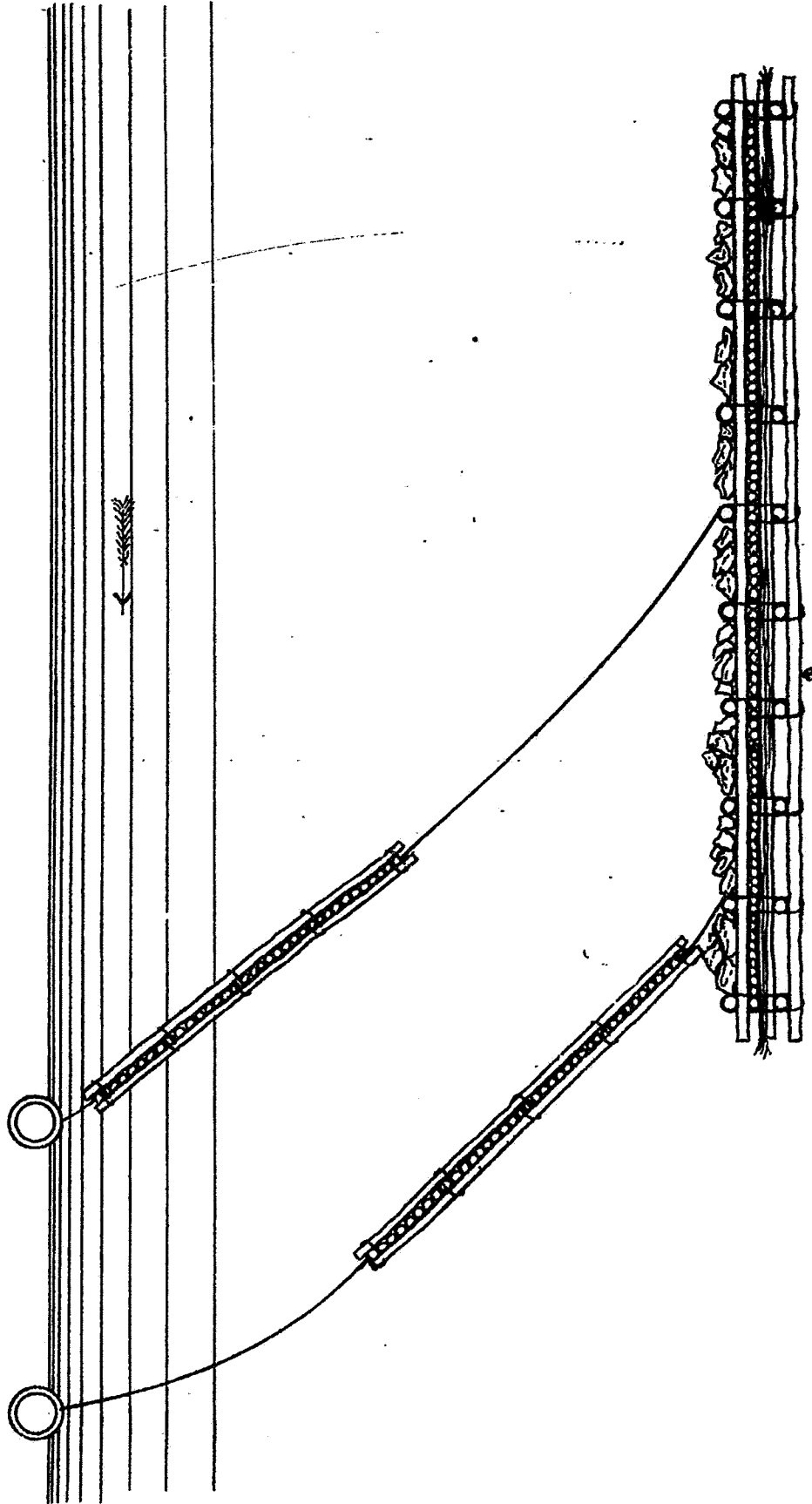


Fig. 12

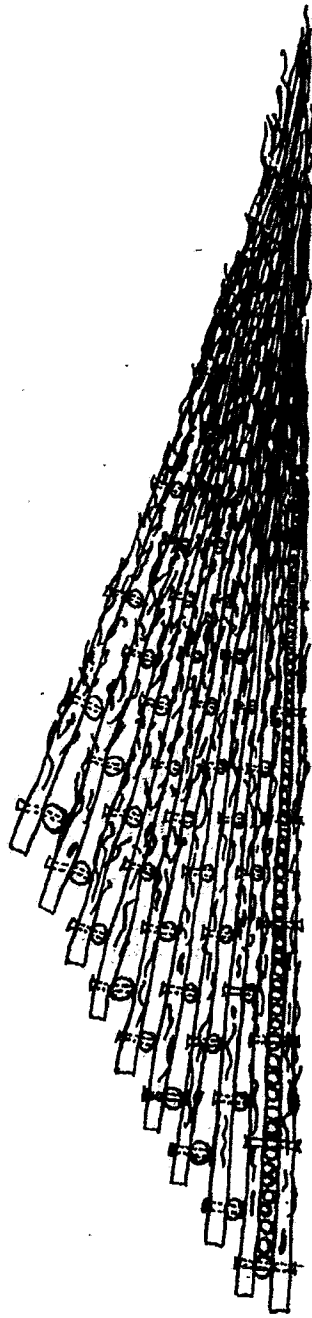


Fig. 13

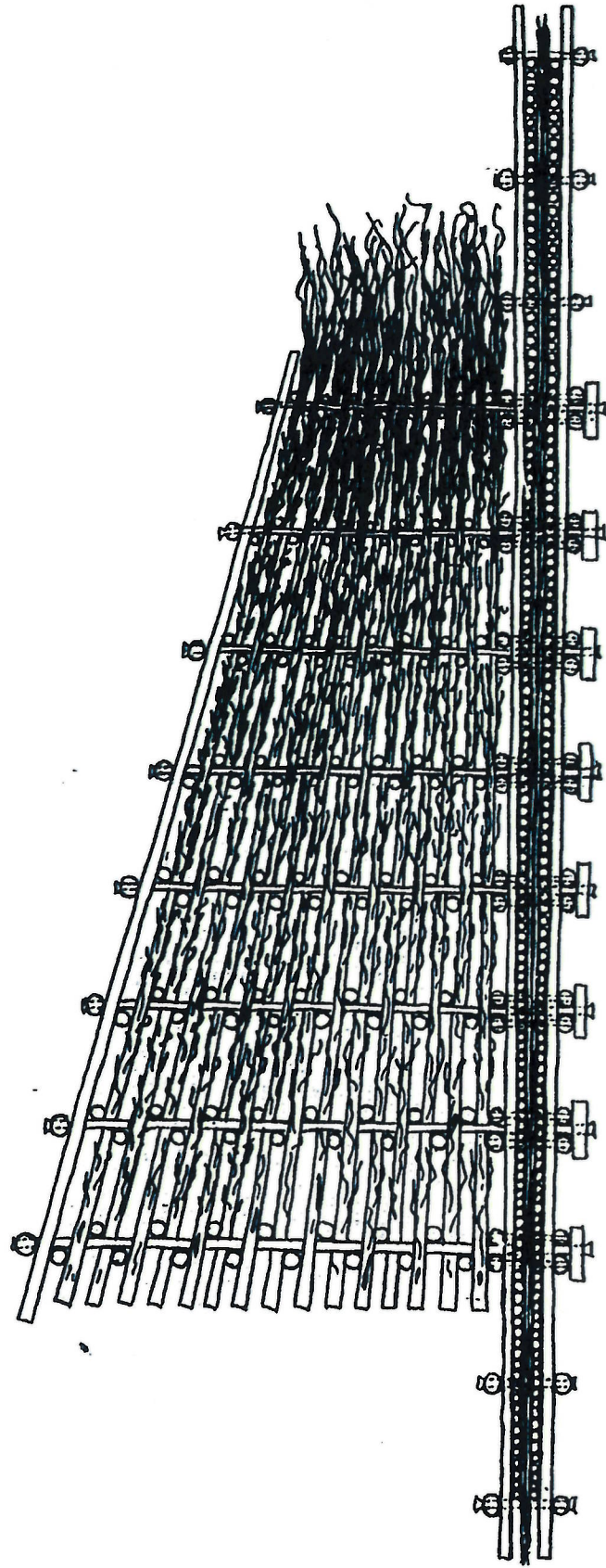
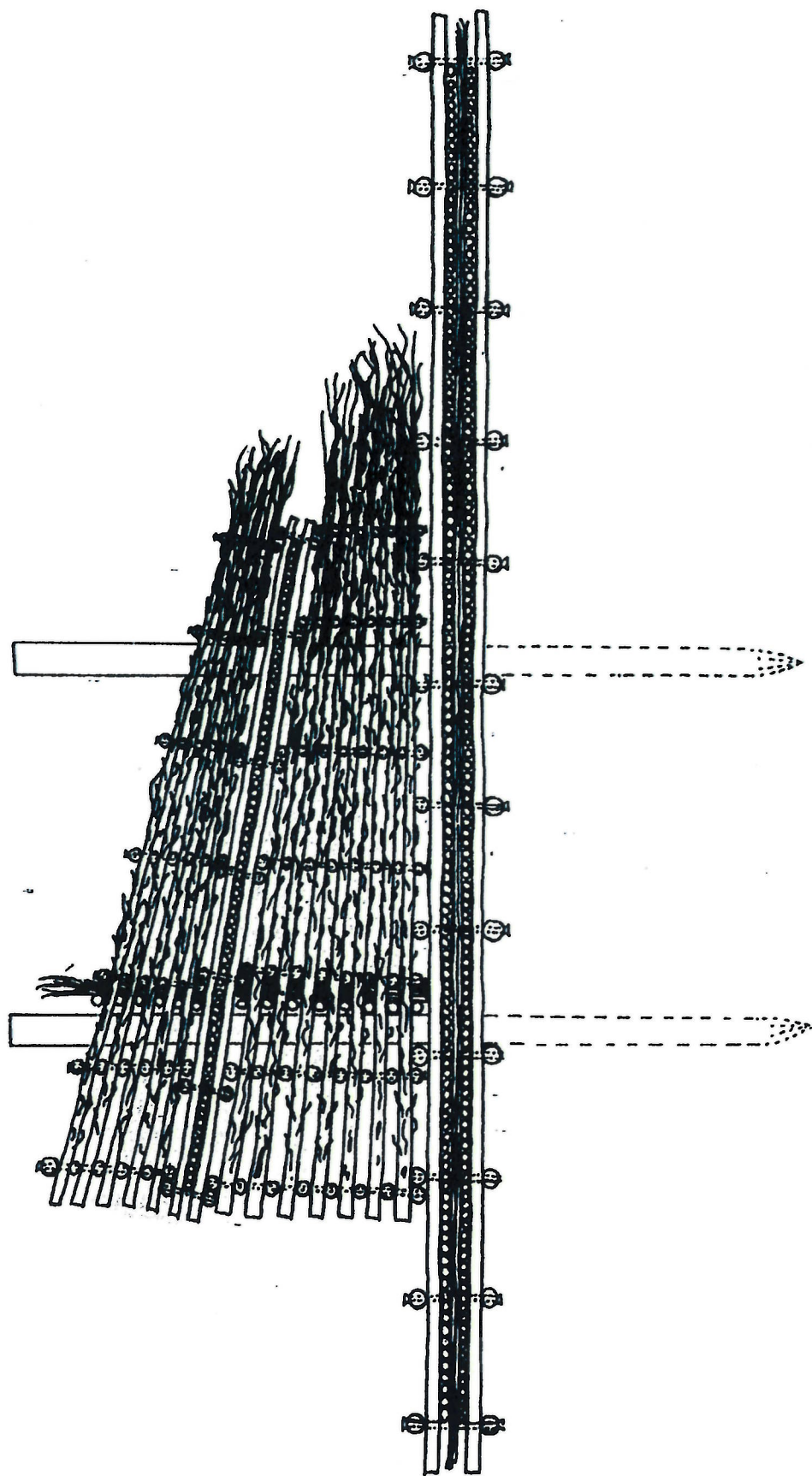


Fig. 14



of brush, *d* and *e*, were laid, crossing each other as shown; and above these a series of poles, *a*. The whole was bound together by wires or small lines of sisal, manila, or tarred rope passing through the mattress from the upper to the lower series of poles. Lines of sisal rope were, for economical reasons, more used than the others, though all were used experimentally.

The ties *C* were used to give tenacity and strength to the mattress, and to facilitate the ease with which it could be moved and sunk in long sections or continuously. To serve this purpose required that they should have tenacity and strength sufficient to resist the force presented by the different velocities, depths, and directions of currents, driftwood, and other *débris* incident to variable stages of the river, together with the weight of the ways and a floating section of mattress. They were usually four in number, of manila rope of from 4 to 5 inches in circumference, according to the forces they would probably have to resist.

Lines were also attached to the mattress transversely at suitable intervals, to be used in hauling it into position and holding it there while being sunk. These lines were so attached that they could be removed after the mattress was placed. This was done by weighting long sections of the foundation mattress with stone keeping always a short section afloat to keep up the continuity. Although the form of mattress herein described was that most generally used, other forms, consisting some of 3 tiers of brush, and some of only 1 tier were tried.

The feathers were attached at the most convenient time after the mattress was completed, regardless of the time of launching. They were made in place by taking two poles selected from the brush of larger size, having a length about equal to twice the depth of water, and nailing brush to them as shown in Figs. 2, 3, and 3a. Their butt ends were attached to the foundation mattress by means of small lines of sisal rope. These lines were usually about $\frac{1}{4}$ inch in diameter. Buoys made of second-hand water-tight barrels were attached to the tops of the feathers by means of lines of small sisal rope.

Although the feathers made and attached, as shown in the accompanying tracings and described in the preceding paragraph, proved to be an excellent device for the purpose for which they were designed, and especially well adapted for use in strong cross-currents on account of their freedom to swing in the current from being attached to the foundation mattress at a single point, as a consequence presenting a minimum surface to the action of the current, still their construction proved to be tedious and the progress made was slower than had been anticipated.

Experiments were therefore made with other devices for the vertical or inclined member in order to find some form equal to feathers in efficiency, which could be constructed more rapidly and at less cost. These experiments were successful and led to the substitution of a design which is described in the following extract from a letter amending the original design and asking authority to make further experiments, which was submitted October 15.

"Design for a mattress to protect the bottom against scour, combined with a permeable suspended component to check the current and cause deposits in the rear of it; said suspended component may be composed of feathers, weeds or curtains, or any combination of them, and should be attached to the mattress while afloat. The mattress when sunk will form the anchorage for the suspended component. Feathers were defined in the letter to which this refers. Weeds may be the Brownlow weed or any modification of it. Curtain, as used here, means a suspended mattress, and may be made in any of the usual forms having any desired degree of flexibility and permeability, and either in sections of any convenient length or continuous. An edge of the curtain having been attached to the mattress, the opposite edge is kept afloat by one or more buoys. The curtain and mattress may be constructed together by slaking one side of the mattress and buoying the other. In that case flexibility may be obtained by severing the mattress on the line of division of the sunken and suspended portions and connecting the parts by ropes, wires, or other suitable means.

"The sections may be made in two or more sections, vertically, in convenient lengths, and may be folded on the mattress for convenience in making and placing them, or they may be made to roll up after the manner of Venetian blinds.

"The mattress may be made in sections of any desired length or continuous.

"This design in some of its forms is applicable to the improvement of silt-bearing streams, as dams in closing chutes or other branches for the protection of caving banks below low-water, for contracting channel widths, and for giving direction to currents, and it may be used in either shoal or deep water."

Authority to make further experiments having been granted, the forms of construction shown in Figs. 4, 5, 6, and 7 were used experimentally. In Fig. 4 is shown a perspective view of mattress A, with curtain H, folded upon it on the ways to illustrate the mode of construction. The curtains were usually constructed, however,

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after launching the mattress. Fig. 5 is a perspective view of the mattress and curtain after being placed.

In Fig. 6 an end view is shown of the mattress with 2 forms curtains H and H², H being the same as shown in Figs. 4 and 5, except that one section is left off. Fig. 7 shows an end view of the mattress with an edge supported at the desired height to form the inclined member. H and H² are mattresses made in the usual form with one or two tiers of brush as was desired to suit the wants of each case. They were jointed and folded on the foundation mattress for convenience in handling during construction. H² was made by weaving brush on a warp of wire or sisal ropes. It was rolled up on the foundation mattress during construction and unrolled itself in placing it.

The forms shown in Fig. 2 to 7, inclusive, were used prior to December 1, and in location from the upper end of the gap down stream a distance about 1,500 feet. The foundation mattress was built in two sections, one extending 965 feet and the other from that to the lower point to which this form was used. A section of mattress with curtains attached went adrift during a storm November 18, and another section was lost December 1, while being placed. The stage of the river at that time was unfavorable for placing mattresses in long sections in that part of the training wall, the bars on the east side of it being submerged while the solid portion of the upper section of the wall was above water, which caused a strong current to set eastward across that part of the wall under process of construction, which combined with the improbability of having continued favorable weather after the 1st of December, made it inexpedient to continue the form of construction that had been used.

The construction of the training wall was continued with a light form of curtain in compliance with instructions contained in your letter dated December 2, of which the following is a copy:

"ENGINEER OFFICE, UNITED STATES ARMY,
"Saint Louis, Mo., December 2, 1879.

"Sir: In continuing the construction of the training wall at Horsetall Bar, you will please use during the remainder of the season a simple open work curtain without the horizontal mattress. This curtain is to be anchored to the bottom by stones, the upper side buoyed as before. It will be constructed of willow brush of the size now used, and it will consist of a single thickness, the pieces being placed 12" apart from center to center, thus leaving an open space between the pieces of about 8 inches. The pieces will be so placed that they will occupy a vertical position when anchored. They will be bound together with wire as verbally explained to you.

"You are requested to prepare one of the barges for attaching the anchors and tripping them all together, as verbally explained to you. The curtains should be made in lengths as great as practicable to sink at one operation. The limit will probably be about the length of the anchoring barge.

"By command of Colonel Simpson.

"Very respectfully,

"O. H. ERNST,
"Captain of Engineers.

"Mr. D. M. CURRIE,
"Assistant Engineer."

The work was continued with a single line of this open curtain until interrupted by ice, December 15, when it had been extended to the upper end of the lower section of training wall, though not quite to the portion above water.

The last of these curtains was placed December 13, and had their buoys cut off soon after by ice, which commenced running heavily two days later, giving them an insufficient test.

The form of construction described in the foregoing letter and used from December 2 to 15, is shown in perspective with anchorage attached in Fig. 8, in which K are anchors, W weights of stone attached to the lower edge of the curtain. Pending the preparation of a barge, the curtain was constructed upon temporary ways erected on one of the barges by placing stage plank with one end raised upon trestles, which served the purpose well, except that the length was limited to from 25 feet to 30 feet by the spaces between the hog-chain braces.

The anchors K, shown in Fig. 8, were made by filling with stone a receptacle prepared by taking three pieces of saplings about 4 feet long, and placing them in the base in the form of an equilateral triangle, with sides about 2 feet long, letting the ends of the saplings project. Having bored holes through the intersections and middle points of the sides, these hoop poles were bent and an end of each passed through the holes in the middle points of the sides and the other ends passed through the holes through the opposite intersection of the saplings, and all were fastened in place with wedges. Then wire or small rope was woven on the poles, forming an open basket or receptacle, with meshes small enough to hold stone, the bottom being of rough boards or saplings. These anchors are shown in horizontal, vertical, and isometrical projections in Figs. 8a, 8b, 8c, respectively. They contained from 600 pounds to 1,000 pounds

of stone. They were used throughout the remainder of the year but the manner of attaching was changed from that shown in Fig. 8 to that shown in Fig. 9, by which the weights attached directly to the lower edge of the curtain were replaced by anchors attached by short lines.

Instructions to resume work on the training-wall were received per letter, dated January 9. The scale of operations contemplated, and the form of construction to be used are shown in the following extract from that letter:

"ENGINEER OFFICE, UNITED STATES ARMY,
"Saint Louis, Mo., January 9, 1880.

"Sir: As the present mild weather and open river offer a favorable opportunity to complete the closing of the East Channel at Horsetail Bar, which was interrupted by ice in December, you will please make arrangements to resume operations upon a small scale at that point.

"The method of construction will, for the present, be the same as that last used, viz, a light curtain of brush, anchored at the bottom and buoyed at the top, and made in lengths as great as practicable.

"By command of Colonel Simpson.

"Very respectfully,

"O. H. ERNST,
"Captain of Engineers."

"Mr. D. M. CURRIE,
"Assistant Engineer."

Work was resumed January 12, in accordance with these instructions.

The work which had been done during the fall season had stood the ice that had caused its suspension without sustaining any very serious damages.

A few buoys had been cut from the curtains above dike No. 3, leaving a small gap there, and the buoys had been cut from the open curtains that were placed at the lower end of the gap after December 1. On the remainder of the wall the work was in good condition.

The first work after resumption was to repair the damages to the open curtains by commencing at the up-stream end of the space, which had been filled with them, and refilling that space with curtains made in the same form, except that the barge mentioned in the letter dated December 2, having been completed the length of the curtains, was increased to 96 feet.

After filling this lower space with curtains, another line of them was placed, commencing at the upper end of the gap above dike No. 3, and extending to the lower end of the work, thus doubly covering the lower space with open curtains. Still the water passed through with too great velocity to admit of much deposit. This was remedied, in part, by reducing the spaces between the poles or pieces of brush, and still more by placing another series of poles in the spaces between the poles of the first series, attaching them by wires to the first.

The current still passing through with too great velocity, another form made by weaving brush on poles was used, in accordance with verbal instructions. This form had been designed during the fall season, and was submitted with the report of operations, for the first half year, as a suitable device to be used in deep water, and in lines of hurdles or transverse lines. This form, together with barge and with anchors attached, is shown in perspective in Fig. 9, in which H is curtain, with joint *h*.

The brush, or smaller poles *b*, are woven or wattled on the larger poles *a*. The anchors *K* are resting upon a platform *P*, which is hinged to the side of the barge, and is raised by means of chains *n* attached to the shaft *S*, having a winch at each end, the dogs of which are connected by an iron rod, so that both may be tripped simultaneously by pulling a lever. The joint *h* was used chiefly to gain width for use in deep water, but it also increased flexibility, and that may be the more valuable advantage.

With time, the buoys which had withstood the winter's ice, became unserviceable from various causes; such as being filled under pressure constantly applied during long intervals of time, rotting of lines, blows received from drift-wood and other debris, so that it became necessary to place another line of curtains on the whole length of the gap. This was done, commencing at the upper end of the gap April 15, and reaching the lower end June 2, after which a small working party kept the works in repair until the close of the fiscal year. The close curtain shown in Fig. 9 was used in this line, except that the brush having been procured without the construction of that form in view, some of it was too stiff to be used in that way, and to utilize all of the material on hand, the use of the wired curtain was continued, making them close by making the meshes small, and by attaching an extra series of poles.

Of the lines of hurdles shown in rear of the training wall (see map) 19 were built during the fiscal year. They are those below dike No. 2, with the exception of the 3d from that dike, which was built before those between it and the dike, because the

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water there was very deep at that time, 52 feet having been found in that vicinity, with the river at 12-foot stage on the Walnut street gauge, Saint Louis.

On resuming work on hurdles September 17, of this fiscal year, this line was found to have been somewhat damaged and was repaired.

The order of construction of the lines for this fiscal year was Nos. 11, 12, 13, 14, 15, 16, 17. Lines numbered 11, 12, 13, 14 were broken during the winter on the shoal-water, near the edge of the sand-bar. These were repaired, and the lines below to dike No. 4 were constructed during the second half year.

During the high-water in April, lines Nos. 11 to 23 were broken and were repaired.

The aggregate length of hurdles constructed during the year is 32,000 feet, including the reconstruction of broken portions of lines. The dates at which lines were constructed are shown on the map; the first in order of time showing completion of construction, and the others that of repairs.

Two forms of construction were used. The first was the same as that used during the fiscal year ending June 30, 1879, in which the horizontal rods were wattled directly upon the piles, and the voids were filled with brush placed vertically. Horizontal rods were pushed to the bottom in water 25 feet deep, by means of the hurdling forks. The other form was made by wattling the brush on poles selected from the larger brush. This form was placed by attaching the upper edge to the piles and weighting the lower edge with stone. It was designed and submitted with report of operations for the first half of the fiscal year, as a suitable form of construction, to be used in lieu of hurdles, where the depths of water are so great that horizontal rods cannot be pushed to the bottom. In Figs. 10 and 10a, respectively, are shown a horizontal rear view and a cross-section. The advantages claimed for it were that the spaces between the piles could be increased to from 12 to 15 feet, and that in water too deep for piling, the upper edge could be supported by buoys. More important claims may be added, that if attached loosely to the piles, it will sink into any scour that may occur, and that it will exert no buoyant effort to raise the piles out of their places.

In the accompanying profiles, the dotted free-hand lines show the bottom at the dates of the surveys made in the spring of 1879, from March 25 to April 4, and the broken lines show the bottom from surveys of January and March, 1880. The free-hand lines show the bottom at the close of the fiscal year. The planes of low-water, and of 15-foot stage, or the heights to which the horizontal rods of the hurdles were extended, are shown.

The sections were made from soundings obtained from the surveys named, and their lines selected away from the hurdles because the average progress of the silting up is correctly shown there, while the hurdles cause disturbances in their immediate vicinity.

The following statement shows quantities and cost of material expended—

1. Training-wall:

a. 2,300 linear feet mattress, with curtains, &c., expended constructing and repairing 1,500 feet of wall, in which were used—		
1,431.67 cubic yards stone	\$1,030 60	
1,375 cords brush	1,111 92	
Labor, rope, &c	5,352 48	
		\$7,495 00
Transportation, equipment, tools, &c		2,750 14
b. 13,700 linear feet curtain, expended constructing 1,000 feet, and repairing 2,500 feet of training-wall, in which were used—		
869.89 cubic yards stone	486 94	
2,384.85 cords brush	1,614 10	
23 piles driven	80 35	
Labor, rope, wire, &c	17,278 65	
		19,460 04
Transportation, equipment, tools, &c		7,448 24

2. Hurdles:

32,000 linear feet constructed, in which were used—		
100 cubic yards stone	55 00	
4,697.37 cords brush	3,508 83	
3,671 piles driven	12,824 38	
Labor, yarn, rope, &c	12,808 38	
		29,196 59
Transportation, equipment, tools, &c		14,060 95
Engineering, contingencies, &c		4,723 43
Total		85,143 39

All of the forms of construction that were actually used during the year have been described. Still the study of some of the practical difficulties has led to designs which may prove valuable during the future progress of the work here or at other places. They are submitted with that hope, and with the conviction that the permeable system promises success to an extent which entitles it to a full and impartial trial, regardless of the specific form of construction which may, in the end, prove most suitable.

The loss of a section of mattress, with curtains attached, December 1, while it was being placed in deep water, having a strong current crossing the line of the wall at an angle not less than 45 degrees, was certainly not calculated to inspire confidence in the practicability of placing continuous mattresses, with curtains attached, under such conditions. The following solution of that problem secures the practical advantages of continuity without incurring any great risk of loss.

The foundation mattress may be loaded to a greater density than that of water by placing stone or other suitable material between the courses of brush during the process of construction, and before launching make ropes fast to it at any greater distance than the depth of water from the down-stream end, and lay off on the ropes a distance equal to that from the point at which they are made fast to the down-stream end of the mattress. Having completed the section of mats and curtains, launch and sink in the usual way, adding sufficient weight to the top course of brush to secure the whole in place. Commence constructing the next section of mat at the points marked on the ropes attached to the sunken mats so that when the new section is placed it will join that previously placed, securing the advantages due to continuity without encountering the practical difficulties that may be expected in placing continuous mats in strong transverse currents and deep water, with unfavorable weather or variable stages of the river, with its drift-wood or floating ice. In deep, turbulent water, if the curtain were continuous or jointed in all imaginable directions, and under such conditions, it would not be practicable to bring an equal strain upon all the connections with its anchorage or to determine in advance the strain which any of the connections would have to bear at times. The problem would be greatly simplified by breaking the continuity of the curtain in vertical section as shown in Fig. 11, which is an end view of the mattress, with curtains attached.

Other practical difficulties have been encountered, which are chiefly due to the peculiar conditions presented at Horsetail Bar, which may lead to an essential modification of the design to adapt it to these conditions. These conditions arise from the introduction of the clear water of the Upper Mississippi River, which maintains itself distinct from that of the muddy Missouri whenever higher stages prevail in that river, rendering it only an intermittent silt-bearer.

No data is available upon which an estimate can be based to determine approximately in what portion of the year such conditions might be expected to exist. It is known, however, that since these works have been in progress such conditions have prevailed the greater portion of the time. The effect of this is to lengthen the time required to secure deposits and to increase the possibilities that works, though suitable for continuous silt-bearing rivers, may be destroyed or injured to such an extent as to render them inefficient before they accomplish their work.

The forms of construction used during the year were designed to accomplish their work in a single season, and were not prepared with a view to have them withstand heavy blocks of ice or drift-wood running continually, nor is it probable that any economical design can be found that will resist these destructive agents indefinitely.

The buoys are the parts of these works most liable to destruction both on account of their exposed position while floating on the surface and their tendency to become water-logged when submerged. It is not practicable to construct a buoy at any economical cost that will withstand heavy ice or drift-wood, nor has any satisfactory form of submerged buoy been discovered, keeping economy of cost in view.

An attempt to decide at this time whether the conditions named habitually exist at Horsetail Bar would be premature. A series of observations conducted through a long period of time would be necessary to obtain the facts, and they, when collected, would decide the question whether a form of construction designed to resist these destructive agents, or which would be less exposed to their action even at a small advance in first cost, would not be more economical in the end.

The subject was studied with a view to prepare to meet an emergency which the long continued clear water at this locality suggested might arise, and the results of that study are submitted with the belief that whether or not it should become desirable to change the form at Horsetail Bar, they are suitable forms for works wherever the conditions named prevail.

In the following designs the buoys have been dispensed with, and the vertical members are made self-supporting by placing successive courses of grillages or open net-work mats of brush, cane, or other suitable material as shown in cross-section, Fig. 12.

In this section the grillages are shown without any foundation mattress, and this form would be suitable wherever there was no tendency to scour the bottom.

When so used they could be placed by attaching weights in any suitable manner; for instance, several grillages could be bound and a flooring made to hold the weighting material as shown.

In Fig. 13 the grillages are shown attached to a foundation mattress which serves the double purpose of anchorage to the grillages and protection to the bottom. The grillages are shown here bound to each other and to the foundation mattress by wattling the poles of which they are composed on other poles suitably attached to the mattress. This is only intended to show one of the many ways in which the attachment can be made.

In Fig. 14 is shown a permeable screen through which the water may be made to pass in a finely divided state if the grillages should be too open, and the whole is shown as built upon two lines of piles. This form would be suitable wherever the depths are not very great. The distances between piles should be regulated to suit the necessities of each case.

All of the forms composed of grillages are especially suitable for the base of works or that portion below the plane of ordinary low-water.

The material used in constructing any of the forms should be homogeneous, or at least should possess equal lasting qualities in the positions they respectively occupy. With this in view experiments were made with hoop-poles of white oak and hickory woods as fastenings of curtains to their anchorages or joining sections of curtains together. These experiments show conclusively that selected poles, free from knots or other defects, would be suitable means of attaching curtains, fenders, or other devices to their anchorages joining sections of said devices, and that pins or "grubs" of the same woods would be suitable means of binding mattresses or open grillages together.

Two other important considerations should receive attention in designing works to improve silt-bearing rivers, by securing a deposit of a portion of their sediment. These are the degree of permeability and the height that should be given works in order to secure the best results. The degree of permeability which promises the best result is that which permits the water to pass through with such small velocity that vortices having transporting energy will not be formed, and at the same time sufficient to keep up the circulation and convey away the water which has deposited its load of sediment. This degree of permeability is indicated by an oily or glassy appearance of the surface flowing smoothly without boils or whirls. The height that would be most effective would be above the stages from which deposits are expected to be obtained, for while the works are submerged there is a stratum of water above them having a free flow while that below is obstructed; in other words a greater velocity superposed upon a less, which would tend to form vortices, and, if the difference between the two velocities is great, vortices may be formed having energy sufficient to scour in the immediate vicinity. This effect may be seen well defined in a thin sheet of water pouring over a weir. It is difficult to secure deposits immediately behind solid works which are submerged only at mean and high stages on account of the scour produced by vortices generated by the water pouring over them. The effect of permeable works differs from that of solid in degree only. If the velocity could be checked so that on entering the lower pool it would not differ greatly from that of the pool, vortices having scouring energy would not be generated and deposits would be secured close to the work as well as further away. In permeable works this is done while the works are not submerged.

Willows were planted on the bar in rear of the training-wall, in compliance with instructions per letter, of which the following is a copy:

"ENGINEER OFFICE, UNITED STATES ARMY.

"Saint Louis, Mo., February 23, 1880.

"SIR: With a view to ascertaining the best season and the best level at which to plant willow cuttings upon the soil reclaimed from the river, you will please make some experimental plantations at the first of each month during the coming season, beginning on the 1st of March.

"The cuttings used for the purpose will be fresh cuttings, 3 feet long and of any size, from $\frac{1}{2}$ to 4 inches in diameter, the growth of last year, however, being considered the best. They will be sharpened at one end and thrust into the ground to a depth of 12 to 18 inches. They will be planted in groups of 10 each, in quincunx order, the distance between them being 3 feet.

"A group will be planted at the level 14 feet above low-water, one at 15 feet above low-water, one at 16 feet, &c., up to 25 feet, making twelve groups each month. These levels are to be ascertained instrumentally.

"The groups for each month will be arranged upon a straight line, at a sufficient distance from the other plantings to prevent any difficulty in identifying them. The positions and dates of the plantings will be recorded upon a sketch of the ground.

"You will please keep such notes upon these plantations as will enable you to make a full report upon the subject at the end of the season.

"By command of Colonel Simpson.

"Very respectfully,

"Mr. D. M. CURRIE,
"Assistant Engineer."

"O. H. ERNST,
"Captain of Engineers."

The groups were planted as nearly in accordance with the instructions, both in time and in order, as was practical. They were delayed on account of the rush of other matters incident to the work about the first of each month.

The contours of the ground rendered it impracticable to maintain strictly all the conditions required by the foregoing instructions—groups of 10 at each foot of elevation, in quincunx order and in straight lines. The groups of 10 could be planted in quincunx order only at elevations 17 and 18 feet above low-water, these being the elevations of the crest of the bar. The higher elevations were found only on the steep slope of the bank at the main shore, and the lower where the bar slopes rapidly.

After careful examination, a location was finally selected between hurdles, lines numbered 11 and 12, and a line was fixed by stakes 40 feet north of and parallel with line No. 12, as the center line of the groups planted March 9. These were small cuttings in groups of 10 at each foot of elevation, from 14 to 25 feet above low-water. Those planted at elevations from 18 to 25 feet were on the slope of the main shore, and extended 50 feet from a large stake set near the edge of the bank. The other groups were planted on the bar between distances 500 and 560 feet from the stake mentioned. With the exceptions named, the cuttings in each group were planted on the same elevation, instrumentally determined.

The next groups were planted April 9, on a line 12 feet north of and parallel with those planted in March, and in elevation at each foot between 15 and 25 feet above low-water, the plane of 14 feet being submerged at that time. Three sets of groups were planted at this time, one of small cuttings thrust into the ground, one of small cuttings buried in trenches 15 inches deep, with the tops turned up, and one of pieces 3 feet long by from 3 to 4 inches in diameter, freshly cut and set in holes 18 inches deep bored with a post-auger. These groups cover a space about 36 feet wide.

On the 11th of May three sets of groups were planted as in April, between elevations 18 and 25 feet. These are located north of the April plantings.

The next and last set of groups were planted June 8, adjoining those planted in May on the north and at each foot of elevation between 19 and 25 feet.

Of these plantations all those planted in March lived, while of those planted in April only the larger pieces and the cuttings planted below 18 feet elevation took root. The May and June plantations all dried except a few of the larger pieces. When planted, after the rise of the sap the larger pieces seem to prosper better for a time than the small cuttings, but saplings from which these pieces were obtained would live for some time after being cut if only protected from the direct rays of the sun. Nothing can be positively asserted in relation to their prospects for future growth.

On the map of Horsetail Bar made under your direction to show progress of work from surveys made by Mr. Preston C. F. West, assistant engineer, and to which reference has been frequent in this report, the locations of these groups of willows may be seen.

Receivers of material, Mr. William S. Mitchell and Mr. C. D. Lamb, who were respectively connected with the work during the first and second halves of the fiscal year are entitled to more than a passing notice for faithful and intelligent service rendered in keeping records of labor and material expended, and assisting in the details of the administration of the work.

Very respectfully, your obedient servant,

Capt. O. H. ERNST,
Corps of Engineers, U. S. A.

D. M. CURRIE,
Assistant Engineer.

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REPORT OF MR. CHARLES S. TRUE, ASSISTANT ENGINEER.

SAINT LOUIS, Mo., January 12, 1880.

GENERAL: The following report of work done at Cairo Protection and Kaskaskia Protection during the half year from July 1, to December 31, 1879, is respectfully submitted:

CAIRO PROTECTION.

Work in progress at Cairo Protection on the 30th day of June, 1879, was continued till October 14, 1879. The revetment of the bank was extended upstream 2,900 feet

above previous works by sinking rafts of brush out to deep water and covering the sloping bank between these rafts and the steep top banks with a thin layer of stone. The brush rafts were mostly 70 feet wide, and the protection of stone inside the rafts was irregular in width according to the shape of the bank, but would average about 75 feet. The height to which the revetment was carried was about to a 20-foot stage of water in the Mississippi River when the Ohio River is low, or a 25-foot stage when the Ohio has a good navigable depth. The protection begun during the first half year of 1879 was raised to a similar height, and some additions were made to the work of former years to repair weak places. Some work was done to protect the bank between the spur-dikes placed by the Cairo Land Company.

About 1,000 cubic yards of stone were taken from the outer end of the upstream spur, yet remaining, and placed on the bank above and between the spurs. Of this stone, 291.70 cubic yards were moved on a barge, and the remainder by wheelbarrows.

A brush raft was sunk just below the upper spur, and a curtain of brush was stretched between the 3d and 4th spurs to break the current of the eddy and induce deposit. This curtain was secured at the surface of the water by a boom of dry logs, and the free edge of the curtain was weighted with stone to carry it to the bottom.

The quantities of material used on the protection during the half year, including 314.20 cords of brush on barges, July 1, but not including stone taken from the spur-dikes, were: on continuation of protection begun in 1879, 1,819.10 cords brush, 13,103 cubic yards stone, and on repairs of revetment of former years, 116.40 cords brush, 540.90 cubic yards stone.

The brush used was cut by hired labor on tow-heads in the Mississippi River, and the stone was quarried by hired labor at leased quarries at Gray's Point, Mo.

The transportation of material was by barges and tow-boat, owned and operated by the government.

The new protection placed during the year 1879 covered a front of 7,600 feet. This was rather light, and will need additions and repairs when the river shows its weak places. The revetment will need to be raised some when the top bank is sloped enough to carry stone with safety. The total length of banks at Cairo Protection, on which work has been done, including the stone placed by the Cairo Land Company, is 14,200 feet. The river is attacking the banks below this work, and the protection may need to be extended some in both directions. The condition of the work when last examined was good.

Two bad piles of stone, formed by the river washing the bank back from the two upstream spur-dikes placed by the Cairo Land Company, endanger navigation during low-water. In the early part of October the water over these stones was but two feet deep. At that time the width of channel between the upstream pile and the Illinois shore was 545 feet, and between the downstream pile and the shore 336 feet. A new shore line was run and stakes set each 100 feet to refer work to. The line begins at a stone set 700 feet downstream, from the lower end of the revetment, and runs upstream. It was connected with points marked Δ 12 and Δ 14, of Lieutenant Lockwood's survey, and with the street system of Cairo. A section of the Mississippi River, taken September 25, 520 feet up stream from O point of shore line, showed the river at that place to be but 743 feet in width. Nearer the mouth of the Ohio, and just below the incline of the C. A. and T. Railroad, was a narrower part of the river, but the width was not measured. The whole volume of the Mississippi passed in one channel at both points. Changes in the slope of the Mississippi River, near the mouth of the Ohio, were shown by levels taken September 6 and September 25. The Ohio at the United States gauge in front of Cairo fell 13.5 feet during the time, while the Mississippi back of Cairo, at the line of Twenty-eighth street, fell but 8.93 feet—a difference of 4.57 feet.

The shallowest water during the season between Cape Girardeau and Cairo was near Power's Island, where the river was divided into four channels by Santa Fé Island, Beaver Dam, Towhead and Power's Island. At one time in September the greatest navigable depth was 4½ feet.

To illustrate some details of work done during the half year, I will state that the rafts sunk along the middle of Cairo Bend, when out of deep water, left a wide slope to be covered with stone; for this reason the width of the rafts was increased to 70 feet. The upstream part of the revetment placed has rafts of this width for a length of 2,125 feet. The quantities of material placed on this part of the bank were 1,570.90 cords brush, 6,344.70 cubic yards stone, which gives about 0.74 cords brush and 2.99 cubic yards stone per linear foot of bank.

On the bank next below this upper section 2,351.30 cords brush, 15,931.80 cubic yards stone, were placed in 5,475 linear feet of revetment, which gives about 0.43 cords brush and 2.91 cubic yards stone per linear foot of bank. Acting on some ideas partly gained from a conversation early in July with Principal Civil Assistant Engineer R. E. McMath, and from whom I understood such a course would be approved, I used earth for the chief weight for sinking rafts. To hold the earth the rafts had to be made closer than large willows such as we had been using would make them;

for this reason the middle course of the new rafts was made of weeds and small willows. The rafts were loaded as nearly uniformly as practicable with earth taken from the bank; then a few stone were placed on them to complete the sinking. The experiment was tried on some rafts of loading entirely with earth. When the rafts were a few feet below the water's surface the strong current over them washed much of the earth from them, so that the expense of extra labor required to completely sink the rafts with earth was greater than the cost of stone necessary for the final weight to be used after the raft passed below the surface would have been. A small quantity of stone was put on each raft after it was sunk, to help keep it in position and to make the connection of the raft with the riprap certain.

The method used for sinking brush rafts with earth can be employed advantageously when the current is not more than 2 miles per hour, but in a strong current it will be economical to put the earth required for the last weight's to sink the brush in some envelope to give it the necessary firmness to resist the washing of the water.

In localities where, for any reason, stone cannot be readily obtained, earth, sand, or mud can be used as weights for sinking any other material, or for anchors to hold any structure or device used for the improvement of the river. I think, however, that on the Mississippi River above Cairo, when brush is to be sunk in a deep, strong current, it will be, generally, more economical to use stone for weights. The use of stone rather than earth, as a sinking material, will be economical in some cases in comparatively slack water which is readily accessible to steamboats and barges; as brush to be sunk by stone can be used in thin open mats while, when earth is to be used it must be put in some envelope, or the mats must be thick and close enough to hold a large per cent. of the earth or sediment brought in contact with it.

Such a thing as a simple, direct current does not exist in a great river, and any obstruction placed in the current adds new complications to the direction of the forces of the water. In sinking rafts or mats it is important that the anchorage be located so as to help carry the rafts to the bottom, and at the same time prevent their being twisted by the currents. On our shore work a combination of surface and bottom anchorage gave the best results as to direction of strains.

The surface anchorage used was a number of lines from barges moored upstream from the raft, and side lines from the shore to prevent the raft swinging out too far.

The bottom anchorage was by lines from the head of the raft to anchors placed in the river above the raft. Two such lines were usually sufficient.

At Kaskaskia, the rafts already sunk were used for the bottom anchorage with good success. This was suggested by the method used by Assistant Engineer D. M. Currie for anchoring hinged mats and curtains at Horse-tail Bar. Bottom anchor lines had little effect till the raft began to sink when they were brought into use by slacking the surface lines so as to keep an even but not severe strain on them. The bottom lines were gauged in length to regulate the connection between the rafts sunk, and some of the lines were arranged with an outward strain to prevent the raft swinging towards the shore while sinking. With long rafts additional lines towards the middle and foot of the rafts to help hold and guide them were found beneficial. Long rafts are not always economical where the current is strong. More time is required for their construction, and they are more liable to accidents from drift-wood, storms, boats, and other causes, than short rafts. Long rafts are harder to hold than short ones, and from the tendency to neglect the even distribution of loading material, and the greater difficulty of rapid and even application of final sinking weights, they are more liable to be badly sunk.

On shore work where the inner edges of rafts were sunk in water varying from 10 to 25 feet in depth, and the outer edges in depths of 25 to 43 feet, the rafts being weighted with stone from barges 165 feet long, the most satisfactory length for rafts was from 175 to 225 feet. The most usual length was about 200 feet.

Shore or floating ways to build brush protections on are economical in many places, as the brush can be formed into thin mats or screens on them, while rafted brush must have thickness and buoyancy enough to carry workmen.

KASKASKIA PROTECTION.

Work at protecting Kaskaskia Bend was carried on during the first nineteen days of July. The work done consisted of making 340 linear feet of brush rafts and sinking them at the foot of the bank; and of placing stone riprap on the slope of the bank from a height of 22 to 25 feet above low-water downward below low water level. The protection was extended 1,100 feet beyond former work.

Work was suspended from July 19 to September 22, when it was resumed.

The work done in September, October and November consisted of making brush rafts, 50 feet in width, and sinking them at the foot of the slope outside of the revetment on the bank. The outer edges of the rafts were sunk in water varying from 25 feet in depth near the head of the bend to 43 feet about 2,000 feet farther down stream, when the stage of water was from 8 to 10 feet on the Saint Louis gauge. The length

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of bank along which rafts were sunk was 3,305 feet. A length of 2,915 feet was at the upstream end of the protection torevet the foot of the bank in front of from station 1+75 to 30+90 of the new shore line.

Just below the work of 1878 and in front of station 34+50 to 36+90 of new shore line, 240 feet of raft was sunk close to the bank, to protect the bottom of the eddy in the cove and stop a cut in the bank below. At the lower end of all stone work a raft 150 feet long was sunk to stop cutting of the eddy below the stone. This raft was close to the bank and in front of station 60 to 61+50 of new shore line.

Earth was used to help sink some of the rafts. Stone used for sinking rafts was taken from the revetment already on the bank. Two barge loads of new stone were added to the protection at the upstream end of the bend.

The quantities of new material placed on the protection were as follows: In July 190,86 cords brush and 7,350.93 cubic yards stone; and in September, October, and November 2,100.20 cords brush and 519.60 cubic yards stone.

The changes made in position of material already on the bank consisted of picking up 1,474 cubic yards stone where the revetment above water was heaviest, loading it on barges, and unloading it on the slope of the bank, where the former protection had sunk below the surface of the water.

The total length of bank on which work has been done at Kaskaskia Bend is 5,975 feet. The up-stream part of the bend for the length of 2,500 feet is partially protected to a height of 10 feet above low-water, and the bank down-stream from this for a length of 3,325 feet, as reported by Mr. McDonald, to a height of 22 to 25 feet above low-water. The downstream 150 feet has a single brush raft 50 feet in width reaching up to low-water level.

The condition of the work at Kaskaskia cannot be called good.

The bank is too steep to carry stone safely, which gives the stone a greater tendency to slide forward into deep water than to settle down vertically. The bank slides some at the base along the up-stream end of the work, and washes above the stone when the water is above the revetment. The bank needs additional protection and some grading to give it a proper slope. As the sand washes too fast to trust the grading to the river, the most convenient way to do that work will probably be the one proposed by Captain Ernst, to wash the bank down by large pumps.

After the bank is graded the inclined surface can be protected for a time by thin brush-mats fastened to the ground beneath the mats.

Some additional stone will be useful to make a good connection between stone already on the bank and any new protection that may be placed above it. There is now quite a body of stone at the foot of the bank, along the up-stream part of the bend, and if the bank above water is graded flat enough, say to 25° or 30° rise from a horizontal plane, stone will probably lie on the bank and can be used to form the upper protection, if deemed advisable to use it.

The auxiliary brush-mats you have adopted for the foot of the slope, beneath the water, are required for an additional length of 3,060 feet from in front of station 30+90 of shore line down stream to the lower end of the protection.

The protection will need be extended down stream a few hundred feet to prevent a wash across a low neck of land to the Kaskaskia River.

The shore line run in 1878 was partly washed into the river. A new line was run and stakes set 100 feet apart to refer work to.

The up-stream, or O, end of the line is at a set stone at the head of the bend, and 175 feet up-stream from the present revetment. A stone set at station 25 is the same as station 18 of line of 1878. Stones were set at points of survey of March, 1876, at point near bend of Kaskaskia River, 2 feet from forked pecan tree, and at point near Struo's house, 6 feet from locust.

CHARLES S. TRUE,
Assistant Engineer.

General J. H. SIMPSON,
Corps of Engineers, U. S. A.

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ICE HARBOR AT SAINT LOUIS, MISSOURI.

The river and harbor act of June 14, 1880, contains the following items, viz:

For iceharbor at Saint Louis, Mo., fifty thousand dollars: *Provided*, That no part of this sum shall be expended until a Board of Engineers shall have been convened and determined upon a plan for the construction of the work.