a depth of 25 to 35 feet below low-water. Soundings at various stages showed the river-bottom to be on this stratum, and it was believed to be the limit of the scour. Accordingly a width of mattress-work of 50 feet was fixed upon as sufficient for the more exposed localities. The upper mattress-works on Eastport Point, in anticipation of its receiving the full force of water in the bend, was made of this width and further secured by an upper bank protection and a root, which was deemed sufficient to prevent cutting out. Below this a lighter protection was deemed sufficient, as being in the lee of certain configurations of the shore line and secured by the more ample protection above.

The work at the head of the island consisted of 600 feet of mattress-work in the slough designed as a header, commencing with a width of 30 feet and increasing to 50 feet at the corner of the island, and 1,030 feet, 50 feet in width, and 970 feet of a width of 44 feet across the head of the island. At the corner of the island the work was carried to the top of the bank, as here the chief force of the river was expected. The 2,745 feet of sand fence extended out as a spur from the island across the bar, a distance of 2,300 feet, the balance being a **T** on the end and spurs on the upper side. Its object was chiefly experimental, and incidentally to close high-water-ways over the bar which forced the main river-current over against Eastport Point.

The work in Civil Bend, above Wyoming, commenced in a root 160 feet long and consisted of 2,300 feet of 44-foot mattress-work, followed by 700 feet of 50-foot. The banks of the upper section appeared to be quite permanent and so situated in regard to the river and its probable future course that severe action was not anticipated. The lower section was on less stable material and exposed to the full force of the river.

The 506 feet of sand fence opposite Wyoming was simply designed to close a high-water chute.

The methods of construction adopted are believed to be for the most part novel. It was realized that with the forms hitherto in use permanent improvements of the extensive character required at this point could not be made with the limited funds likely to be available. For the utmost latitude in methods I am indebted to you.

The chief desiderata in mattress-work are cheapness and flexibility. To secure the first, rock for sinking was to be avoided if possible, and a minimum quantity of material used. It was thought that the rank bottom-grass, often 9 feet high, could take the place of brush in part, and that the number of poles, always difficult to obtain, could be reduced to a minimum. To secure the second, the mat must be made thin and compact, with few or no poles, the fastenings chiefly of wire. To launch such a mat and handle it in strong water was believed to be unfeasible by the ordinary plan. To secure these objects made the work essentially experimental.

To combine as many of these desiderata as possible, it was seen that a boat on which to build these mattresses, and from which to sink them in place, would be required. Accordingly a mattress-boat, nicknamed the Spider, was designed and constructed, from which the first mat was launched on October 14.

Illustrations and a description of this boat will be found elsewhere.

The ways of the *Spider* were 41 feet in length, and so supported as to take any desired inclination; on these ways a mat 50 feet in width was constructed, *i. e.*, 50 feet from the outer edge to the shore edge on the bank. The general plan of construction was to lay poles, from 4 inches to 5 inches in diameter, lashed in lengths of 56 feet, upon the ways. On these a layer of brush was laid at right angles, butts out, then a layer of hay, and again a lighter layer of brush. The first plan of fastening was to place a second series of poles immediately over the first, and then to draw all solidly together with the jack, and tie with No. 10 wire at 42 points. After some 400 feet of work was constructed this method was changed, the upper poles abandoned, and the brush sewn to the lower poles by No. 14 and No. 13 wire, used in a shuttle, in stitches 12 inches to 18 inches long. This method has been adhered to on the boat. The first idea was to weight the mats with earth between two layers of hay, but subsequently it was found that earth placed on top of the mat was sufficient. The general thickness of mat was 8 to 12 inches. After all was made ready a little jarring by men on the mat was ordinarily sufficient to effect a launch. Occasionally sparring would be required.

The best result obtained with the *Spider* was above Wyoming, where 3,000 feet of mattress-work was built in 10½ days; 700 feet of 50-foot mats were built in 2¾ days, at a cost for material of 31 cents, and for labor of 27.7 cents per linear foot.

Another system of construction was adopted in the *Peanut* boats, illustrated and described elsewhere. The size of mats was about 30 by 35 feet, and they were put in for 1,854 feet above the Transfer Landing at Eastport Point. On this system the size of the mats is limited; swift currents cannot be contended with, and the pulling of skids after the mat is dropped is a nuisance. The *Peanut* helped to bring the work to an early termination, and was sufficiently efficient for the narrow mats.

At the head of the island 750 feet of work was put in by hand. When quiet water existed the bank was first sloped and the mats were built on skids 10 or 12 feet in width at a time and slid out, and thus continued until the desired width was obtained. In other places the mat was built on the surface of the bar. Poles being available only in part, a very good substitute was made out of heavy brush twisted and lashed together. No hay was used, the brush being laid in one layer. This work was bound by the brush jack, which works as well on the ground as when the under surface of the mat is accessible.

The Eastport root, as also the one above Blair's, consisted of an excavation to the water-line, filled with series of sliding mats. These roots curved back at the inland end as a precaution against cutting out. The one at Eastport was provided with a large surface-mat, placed in the angle above.

The mats used in the roots were built without poles, and consisted uniformly of an upper and lower layer of brush, an upper and lower layer of hay, and an intermediate layer of earth. In their construction several forms of wire sewing or stitching was tried, viz: sewing to an under wire with shuttle; the harness-stitch with two shuttles; the chain-stitch with one shuttle; the lock-stitch with hook-needle and shuttle; and finally the hook-needle fastening, in which the operation of sewing is similar to the lock-stitch, a brush or stick, however, taking the place of the upper wire. Of these the chain-stitch is unfeasible on account of difficult manipulation. The sewing to a wire instead of a pole and the lock-stitch are difficult to draw tight, and the wire is cracked and weakened where it crosses itself. The harness-stitch has too much back-slip, and requires 4 men to make it, and the breakage of a wire leaves the seam loose for a long distance. The hook-needle fastening was most satisfactory.

Of the many forms of fastening thus far tried, the sewing to a pole with a shuttle, or overhand without the pole, the hook-needle fastening, and the overhand sewing of the curved needle are cheapest and most satisfactory. The two last forms can be worked equally well when the under surface of the mat is inaccessible as on the ground surface.

The upper bank protection consisted of a layer of hay, over which was shingled successive layers of brush, buts upstream. This was cross-staked and wired every 4 feet, each successive layer covering up the previous cross-stakes. The cross-stakes were placed 3 to 4 feet apart, the wire passing through holes in the stakes, and then around the top. The whole was then covered with earth. A section with the brush at right angles to the bank was laid, but was found less efficient.

The sand-fence is cheaply and rapidly made, and is very strong. In its construction two men are required to place the brush, one on each side to stick the butts into the trench, and place the brush alternately against the wire. A third man pushes it back solidly, and so interlaces the brush as to make it self-sustaining. No other fastening is required, and after completion it will stand any wind with the wires pulled out. It is sufficiently illustrated and described at the end of this report.

The experience of the spring of 1879 has not been such as to confirm the judgment of 1878. It is believed, however, that it has been very valuable, and that it is to the good of the ultimate success of a project at this point that it occurred so early in the history of this work.

On my arrival here on April 14, I found that a very remarkable and rapid rise for that season of the year had occurred, reaching to within a foot of the June rise, on April 10 having been out of the banks in Eastport bend. The river rose 5 feet in 5 days, on one day rising 2½ feet, and the currents were correspondingly strong. It fell with equal rapidity. For ½ mile immediately above the works the cutting had been about 300 feet, and near the head of Eastport bend a swath was started which has since traveled downstream 6,500 feet, and attained a width of 1,200 feet. Just below the head of the work an ice-gorge had formed at the breaking up in March, raising the water about 3½ feet. This had disturbed the upper bank protection somewhat, and may have injured the mattress work

The course of the river was directly toward the head of the work, and in striking it the main current was deflected through an angle of about 80° in a distance of 300 feet, leaving a large bar in front of Eastport and cutting out some 600 feet of land at the mouth of Nebraska Island Slough. The point of bar opposite the root and the reef above were less than 400 feet distant.

The surface mat at the root held until the day before our arrival, acting as anticipated, though its size was not sufficient to accomplish fully its purpose. The root proper had cut, perhaps, 10 feet. The upper bank protection had been carried away, except at three points of limited extent, and three pockets had been cut in the face of the bank by powerful eddies which discharged into each other successively, the upper pocket, immediately below the root, being some 50 feet in width.

Soundings made the same day, found that none of the mats had been carried away; except in these pockets, they were found in proper position. In the upper pocket, 12 to 14 feet was found on the inner edge of the mats with 20 feet behind, in the focus of the eddy. In the lower pockets less depth was found. The bottom of the river had apparently cut from 3 to 5 feet, but at a distance from the mats.

The immediate cause of this trouble was the powerful eddy created by the root which swept away the upper bank protection, although the stakes were from 3 to 6 feet in length. This eddy cut the upper bank away above the mats until the focus passed the edge, when it dug rapidly down lowering the mat from behind. Such action has been frequently observed since. In this case it may have been aided by the cutting out of the bottom and consequent slipping, the bottom filling rapidly as the water fell, but this is partly negatived by the fact that no slipping between the eddies had occurred.

On the 15th, the putting in of weeds in order to check the cutting, commenced. It was the intention to remattress to the top of the bank, lapping on to the old mats for about 1,500 feet, and then run a deflecting dike of weeds from the end of this new revetment toward the opposite shore.

The supply of brush available by teaming on Eastport Point being nearly exhausted, no great amount of work could be economically undertaken until the tug Clytie was available. Meantime the Spider was overhauled, guards, 4 feet wide, placed upon her, and her ways lengthened 6 feet. Three brush barges were also constructed.

On May 12 mattress work again commenced. The river at the works, since April 14, had attained a depth of 40 feet and caving had increased. Nearly 1,000 cords of brush and 4,000 gunny sacks in the form of weeds had been put into the first eddy, about 250 feet long, with very unsatisfactory results; in fact, many of the ropes twisted away and the earth oozed out of the sacks in part, while cutting was but partially and temporarily checked. The root went away by inches, and was, no doubt, the salvation of the work, although not intended for the deep scour which took place.

By the 25th of May, 1,250 feet of mattress work had been put in, of 60 feet width, lapping well on to the old mats. Immediately below the root the mats were 110 feet in width, made from the boat in two launches. The upper bank was much better secured than in 1878.

Earth was first used for ballast, but its removal by boils, and the consequent loss of a couple of mats, after sinking, necessitated the putting of it in gunny sacks wired to the mats. These sacks of earth were subsequently replaced with rock wired to mats, as being cheaper, an available quarry having been found below the city.

This new work had not been completed before bad settlement and caving developed itself, and also heavy cutting immediately below. The reef and point of bar opposite had begun to move downstream, throwing the impact of the current farther down. A few mats were put in at the places where settlement had occurred.

The caving or settling soon increased and knuckle mats, 50 feet wide—25 feet on shore and 25 feet over the new mats—were put in.

Below the previous work, mats 80 feet wide, of which 25 feet were on shore, were from time to time extended downstream, as the deep water moved in that direction, until finally the new work terminates 3,000 feet below the root.

The water, which on June 11 reached 48 feet, on June 21 was 57 feet deep, or 60 feet from the top of the bank, and the current measured 7 miles per hour. At the time of highest water, 60 feet depth was found, and the current was estimated at 8 miles.

A boring had been made at the root, and rock was found at 77 feet overlaid with 30 feet of quicksand.

The mattress work was added to on the shore as the banks settled, and generally all caving stopped when the mats were of a width of twice the depth from top of bank. Occasionally this settling of the banks would progress faster than the mats could be extended, and patching with knuckle mats would be required.

Most of the mattress work now has an unbroken width of 120 feet, and in some cases of 150 feet in the water, and enough has since been added to provide for a scour to rock.

The head of the work was terminated by a surface mat 300 feet long, and of an average width of 150 feet. This mat was made of two layers of brush, laid at right angles, with an intermediate layer of hay, and was sewed in seams at right angles both ways and on both diagonals every 4 feet, with a curved needle. It was weighted with stone wired in place.

It is needless to say that the action of the river described was not anticipated, and that the work for the first six weeks was totally inadequate. The scour would probably have reached rock had the river continued rising sufficiently long.

The holding of Eastport Point, with the delays incidental to towing, took all our available resources, and no other work of importance was done. It has been expensive, but the statistics are not available until the work is definitely closed.

The "catch-sand" fence, built so late in the season, accumulated only a few inches of sand before the April rise. Three sections across high-water chutes were caved out, although the evidence seems to show from 3 to 5 feet of water against it before it went. Since then it has thrown up a remarkable bank, and is no doubt a successful construction when built in proper season.

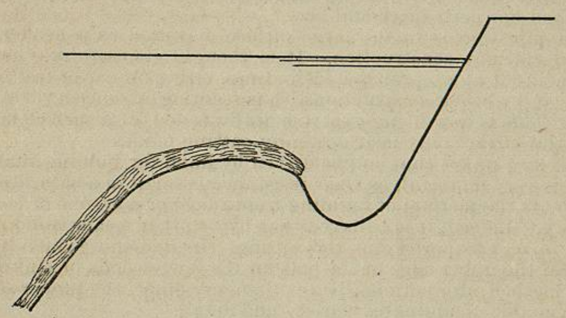
The experiments in weeds have been tested as yet inadequately, and it is not deemed important to notice them at length in this report. The methods thus far practiced, as partially illustrated, are developing ample success in the construction and in the placing of the curtains.

The ordinary limit of scour is not the limit when the bank is held, provided the ordinary scour does not extend to permanent strata. The causes which induce heavy cutting will induce heavy scour, provided that cutting is stopped, which will extend to permanent strata if the causes continue sufficiently long. In strata so unstable as those at Nebraska City any revetment that maintains itself is either down to permanent strata, or else the tendency to cut has practically ceased for the time being.

In many of the borings which have been made here indurated clay balls with vegetable matter covered with a coating of sand, along with a motly collection of gravel stones, are found within a short distance of permanent strata. A precisely similar collection containing gumbo balls in a soft state was dredged from 60 feet depth at the works. These balls are from cutting banks, and the proof is conclusive that since the river has been running in silt banks as at present, scour has occasionally, at least, reached permanent strata at 70 to 90 feet depth.

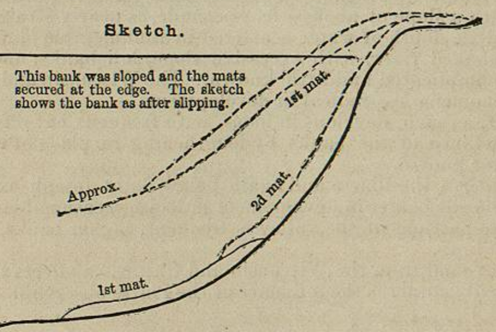
In any purely local or protective works, at this point, revetment must provide for scour to permanent strata, as the river is sure at some time to take such a course as to reach this strata if the banks are maintained immovable. Where it is assumed to control a river in an easy course for many miles and establish a permanent regimen, it is probable that revetment for ordinary limit of scour, viz, 35 to 50 feet depth from top of bank, will be sufficient, especially after such course is obtained.

To provide for such scour flexible mattress work of a width equal at least to twice the depth taken as the limit of scour, measured from the top of the bank, must be used, and it must have a strength sufficient to sustain the tremendous tearing action of the settling bank which it is designed to protect, and it must be weighted in a manner to make it hug said bank closely. It should also be made continuous, in order to prevent gaps from unequal local action. In all places where the mattress work has stopped the cutting, the width is fully twice the depth from top of bank to outer edge of mat.



The chief mode of cutting as exhibited at the surface, is by eddies and boils. When ever the boil limit was wide and active in front of the work, sometimes attaining a width of 150 feet, or when the water was sufficiently quiet to drop a lead-line vertically, settlement of bank was soon after expected.

Sketch.



An eddy can easily cut a bank in 3 feet of water over the edge of a mat, and once that action is initiated, the focus may soon pass the edge of the mat and dig rapidly down behind it; but the action often ceases after the first swath is cut out. This local eddy action usually commences at the lower part of the irregularities or bights in the shore-line working up stream. The prominent points of the revetted shore easily maintain themselves. Mats, from eddy action, have been found in this position:

The bank which settles under the mat is usually vertical to the water-line, after which is a slope of 1 to 1 or 1¼ to 1 for a depth of 20 feet, gradually changing thence to a more gentle slope as the point of deepest scour is reached. Heavy weighting of the mat over the edge of the bank usually prevents tearing at that point from the great strain and the change of direction. Mats not secured at the upper edge have been carried bodily out by the "flow" of bank and left nearly flat on the bottom of the river.

In a few cases mats have been torn, although, if uniform and careful work could be secured in all cases, it is not believed that this would have occurred. Still, the mats should be made as strong as possible, and that system which will secure the greatest strength and flexibility adopted. To secure these objects the use of poles, always a source of weakness and inflexibility, must be avoided, and the mattress-work made thin of brush and wire alone, the wire seams being frequently and tightly stitched or woven. A layer of bottom hay greatly helps a thin mat, especially at the wave line. The ballast should be secured to the mat. With hay, coarse gravel retains its place in the interstices of the brush, and will answer well for this purpose.

Mats of dogwood brush (sp. gr. 99 per cent.) may be successfully sunk with earth alone in ordinary currents. With willow brush (sp. gr. 89 per cent.), and in fact with any brush in heavy currents and boils, something besides loose earth is expedient.

Mattress work may also be made on a plan introduced by Assistant Yonge, of selected brush alone woven in basket-work form. Its practical utility is now undergoing trial here.

In all cases the mattress-work should be secured at the bank edge. Whether it is best to put the full width of mat into the water or only sufficient for ordinary limit of scour, providing for further cutting by additions to the shore edge, cannot be stated. The latter method has been successful here.

Its extreme application is in the large surface mat used as a header, which is believed to be an efficient construction. It is thought its usefulness may be greatly extended in placing it along proposed shore lines, either on bar or fast land, the river being forced to it by other constructions, thus securing at once a revetted shore line where desired. This is now being experimentally tested in a surface mat 185 by 154 feet placed on the surface only near a rapidly-cutting bank.

The utility of any stakes that can be driven by hand for holding mattress-work at the shore edge is very doubtful, as their resistance is small in a saturated bank.

In swift currents the method of building from a boat or a system of boats is thought most satisfactory. Indeed, it is believed that by no other means could mattress-work have been put in on Eastport Point this spring. In launching, inch lines and No. 8 wire, which held the upper edge of the mat for the few seconds of sinking, have been broken. This method also permits, better than any other, the proper securing of the ballast. It is capable of unlimited variety and detail.

To what extent the Missouri River is capable of improvement for the needs of navigation is an unsettled problem. Its physics are characteristic, and as yet imperfectly studied. It is a sand and silt bearer, and as such differs in character both from the best type of sand bearer, the Platte, and also from the best type of silt bearer, the lower reach of the Lower Mississippi, and both types differ from the clear stream which flows in an immovable channel, or whose slope is too gentle to cause erosion.

The Platte, with a slope of about 7 feet per mile, is nearly straight and 1 to 2 miles in width, with little depth of water scattered in innumerable chutes. It is a radical type of a sand-choked river, with excessive slope, low banks, and wide valley. Its phenomena are complicated and little known. The Wisconsin and the Chippewa present similar phenomena less radical in development.

The silt bearer, as such, develops in loops, with frequent cut-offs, adjusting its current to the resistance of the banks by lengthening in place of widening. Its phenomena are better known.

The Missouri above the Platte and again below Saint Joseph exhibits many of the phenomena of the silt bearer in development in loops, occasional cut-offs, of which the evidence in these portions of the valley is frequent, higher banks, and less width between fast shore lines.

As the influx of sand from the Wisconsin and Chippewa affects the Mississippi, in a much more radical manner is the influence of the Platte observable for 100 miles below its mouth.

In the valley of this reach the evidences of cut-offs are infrequent, and only one has recently taken place (Peru, 1869). The banks are low and unstable, the distance between fast shore lines is great, the slope is more than the average, and the tendency is rather to straighten than to develop in bends. The valley is also wide.

That there is a tendency to widen and straighten still more is not clear. The fast banks in this vicinity undoubtedly show a greater width of river than formerly as

Six "brush-barges" were constructed for towing with the *Clytie*, and they prove a most convenient size for this class of work, and run easy. Two of them were fitted with floors for transporting rock.

These boats were 52½ feet by 12 feet by 2 feet 8 inches over all, with rakes of 3 on 1 rounded to a radius of 8 feet at the angle. Gunwales, 5 inches thick, bolted, and 3 longitudinal 2-inch by 10-inch bulkheads. Deck, 3 feet at each end. Capacity, 50 cords of brush or 25 tons of rock.

Plates II and III.—*Mattress tools and fastenings.*—The brush-jack is very powerful, simple, and light, and its operation is easy. It is made of Norway iron, and a blacksmith with a helper can make one in a day. In using it the handle and two hook-clutches are slid to the upper end of the standard; the lower hook is then passed through the mat and engages the lower pole, the upper hook meantime dropping to the upper pole. A few strokes of the pump-brake or handle draw all solidly together. A No. 10 wire is then passed through the eye of the needle-bar and pushed through the mat. A man below removes it, and on the needle being pushed through on the opposite side of the pole replaces the wire in the eye to be drawn back. The wire is cut, the two ends twisted together, and the jack released by prying or hitting the lower or hook clutch on the back end.

Figs. 3, 4, and 5, Plate II, illustrate the jack and needle, and Fig. 1, *a* and *b*, Plate III, the style of fastening. The use of the jack was early discontinued, as the upper pole was felt to be a detriment. In fascine work it might be rendered valuable in somewhat different form.

The harpoon shuttle has been the standard tool for sewing. Its weight is about 10 pounds, and its cost $3. It is wound with 200 feet of No. 14 wire (the ordinary size for sewing), and in operation is used by three men, two above and one below the mat. Two men pass the shuttle back and forth and around the pole in stitches 12 inches to 18 inches long, while a third tramps down the brush and holds the wire while the next stitch is being made. (See Figures 1 and 2, Plate II, and Figure 2, *a* and *b*, Plate III.)

The shuttle may also be used in making an overhand or back stitch, the pole being omitted.

It was also the method employed in sewing to a wire (see Fig. 5, III); 2 shuttles were used in the harness-stitch, Fig. 7, III, and a short shuttle in the chain stitch, Fig. 8, III, and in combination with a hook-needle it is used as a bobbin in making the lock-stitch, Fig. 6, III. Of these methods the sewing to a wire and the lock-stitch turn the wire too short; the chain-stitch is of difficult manipulation, and the harness-stitch is expensive to make and has great backslip when broken.

The hook-needle is used in making the lock-stitch previously described, and also in the hook-needle fastening. The method of working is as follows: The wires are laid upon the ground or acrossways, as the case may be, and the material for the mat laid over them. The needle is passed the mat, and engaging the wire pulls a loop up through the mat; through this loop a bobbin is passed in the lock-stitch or the but-end of a brush in the hook-needle fastening. A man at the end of the wire pulls all down very solid, and a third man stands on the wire where it crosses the brush or toggle to prevent backslip, and presses the brush down while the next stitch is being made. The hook-needle fastening with toggle is efficient. (See Fig. 6, II, and Fig. 3, *a*, *b* and *c*, III.) The curved needle is rather prodigal in the use of wire, but it is cheap to operate with one or two men, and sews best on the ground. It has been used this spring almost wholly for surface mats with No. 13 wire. In the construction of the surface mat at the root, two layers of brush with an intermediate layer of hay were laid down and sewed in seams 4 feet apart both ways, and diagonally both ways. Probably one of the strongest mats of brush and wire is to lay the brush in two layers at right angles, and to sew diagonally of the brush in seams at right angles. The curved needle is most useful in all forms of surface mat, as it can sew under almost all circumstances. (See Fig. 7, II, and Fig. 4, *a* and *b*, III.)

The shuttle and the curved needle answer nearly every purpose, with perhaps an occasional use of the hook-needle when heavy work is desired.

Plate IV.—The root has been quite fully described already, and is shown in Fig. 1. This surface mat, as indeed all the surface work, is covered up with earth in order to guard against fire, and to prevent the brush from becoming brash. The sliding mats in the root acted as anticipated, but they were not adequate to the unexpected scour which took place. The surface mat is cheaper, and it is believed will answer the purpose better.

The sand fence, figures 3, 4, 5, and 6: This is sufficiently described previously. To work to best advantage requires a gang of 9 men, 2 to place the brush on each side, 1 to pass it back and interlace it, 2 to set the stakes, and 2 to shovel. Tools required: 2 shovels, 1 mattock, 2 axes, 2 hatchets or hand-axes, 1 maul, and 1 wire-cutter and plyers combined. Such a gang will complete from 300 to 500 feet per day. The fence, when done, is 8 feet to 10 feet in height.

It was built from the 5th to the 20th of December, 1878, and only a few inches of sand accumulated previous to the April rise. A portion was removed at that time, although it stood 5 feet of water before going out. It has removed sand, as shown in figure 6. It is believed that sand fences will be found efficient in building up bars rapidly, and in cheaply confining high-water to one channel.

Curtain construction: This branch of construction has not been sufficiently developed to merit lengthy description. The general idea is to make a curtain or grating of willow brush of a width equal to twice the depth of water in which they are to be used, and of any depth desired. Each brush is held separately at points 4 feet apart, and the spaces between the brush are from three to six times the cross-sections of the brush.

As used they have been made in lengths of 100 feet and rolled up in rolls, in which form they are transported to the place of sinking and unrolled by the side of two barges with ends lashed together. To the gas-pipe tumbling-beam on the gunwale of the barge sufficient rock is attached by slings of No. 10 wire, and the edge of the curtain is wired to the rock. Buoys can be attached to the other edge if desired. The boats are then swung into position and the tumbling-beam tripped.

The curtains are rapidly and cheaply made, and the method of handling is very easy. One cord of brush will make 2,000 square feet. They are woven on ways, 32 feet long, and rolled up as fast as made. At the anchor edge No. 12 wire is used in place of No. 13, in two seams 1 foot apart. The strength of this construction is very great.

Figure 10 illustrates the first method tried, the brush being attached to No. 10 wire by No. 18 wire, used in a small shuttle, Fig. 11. This plan was tedious, and lacking in strength and other qualities. The second plan is illustrated in Fig. 12 and Fig. 13, *a* and *b*. The two wires (No. 13) were run through eyes in the end of a distance-bar, which was twisted alternately in opposite directions as the brush was put in. This was slow and unsatisfactory.

The third and eminently satisfactory plan is illustrated in Fig. 7, *a* and *b*. Brush are laid on ways, No. 13 wires stretched above and below and twisted together between each brush by the pin-wheel, Fig. 8, *a* and *b*, or by the awl, Fig. 9. The construction is rapid. Mushroom anchors and suckers have been tried, but not conclusively tested. The best anchor for mooring yet found is a modified form of Chinese anchor, far excelling dead weights or even the ordinary iron fluke of the same weight. It can be constructed by one man in an hour, and costs complete about 25 cents.

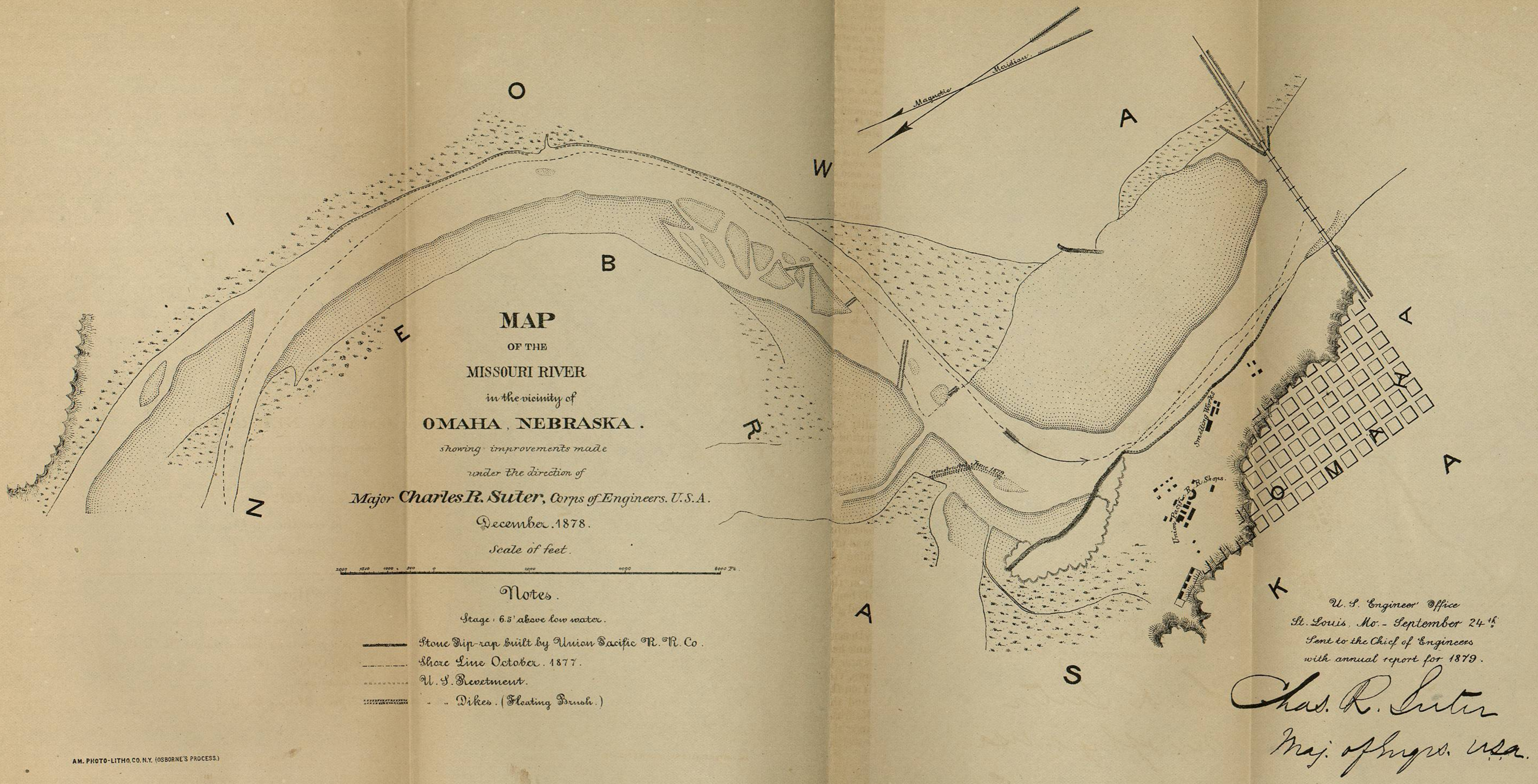
O 10.

IMPROVEMENT OF MISSOURI RIVER AT OMAHA, NEBRASKA, AND COUNCIL BLUFFS, IOWA.

At the date of the last annual report a resurvey at this locality was in progress to fix definitely the plan for expending the appropriation of $80,000, made by act approved June 18, 1878, and for carrying the work to completion. A report of this survey with plans and estimates was submitted to you under date of August 19, 1878, and your approval having been received, work was at once begun, Assistant Max Boehmer being in charge.

The plan proposed contemplated the protection of the Nebraska shore above the railroad bridge, as far up as the stone revetment constructed by the Union Pacific Railroad Company. On the Iowa side it was proposed to carry a revetment from the point of high ground adjoining the low point opposite Omaha upstream as far as funds would allow. It was also proposed to place floating brush-dikes in the bend on the Nebraska side, with a view to throwing the channel out of this bend, thereby relieving the heavy strain on the Nebraska revetment and giving a more easy curve to the channel-way above the bridge.

Work was prosecuted vigorously until stopped by cold weather, December 20, 1878. During the season an aggregate of 12,856 feet of bank had received a revetment of brush mattresses, extending from low-water 40 feet out into the river. This revetment was distributed as follows, viz: On the Iowa side, 9,796 feet, extending from the point upstream; on the Nebraska side, between the Union Pacific Railroad revetment and the smelting-works, 2,030 feet; between the lower Union Pacific Railroad revetment and the bridge, 1,030 feet. Throughout this distance the upper portion of the bank had been graded and protected by a covering


MAP
OF THE
MISSOURI RIVER
in the vicinity of
OMAHA, NEBRASKA.
showing improvements made
under the direction of
Major Charles R. Suter, Corps of Engineers. U.S.A.
December. 1878.
Scale of feet.
2000 1500 1000 500 0 2000 4000 6000 Ft.
Notes.
Stage: 6.5' above low water.
Stone Rip-rap built by Union Pacific R. R. Co.
Shore Line October. 1877.
U. S. Revetment.
" " Dikes. (Floating Brush.)
I O W A
N E B R A S K A
O M A H A
Magnetic Meridian
Constructed June 1879
Union Pacific R. R. Shops.
Smelting Works
U. S. Engineer Office
St. Louis, Mo. - September 24th.
Sent to the Chief of Engineers
with annual report for 1879.
Chas. R. Suter
Maj. of Engrs. U.S.A.
AM. PHOTO-LITHO. CO. N.Y. (OSBORNE'S PROCESS.)