MESSAGE

FROM THE

PRESIDENT OF THE UNITED STATES,

TRANSMITTING A REPORT

OF THE

Board of Engineers

ON THE

OHIO AND MISSISSIPPI RIVERS,

MADE IN THE YEAR 1821.

JANUARY 22, 1823.

Read, and ordered to lie upon the table.

WASHINGTON:

PRINTED BY GALES & SEATON.

1823.

To the House of Representatives:

To carry fully into effect the intentions of Congress, in making an appropriation of 5,000 dollars, by the act of the 14th of April, 1820, for the survey of the Ohio and the Mississippi rivers, from the Rapids of the Ohio, at Louisville, to the Balize, for the purpose of facilitating and ascertaining the most practicable mode of improving the navigation of those rivers; orders were given, through the proper department, to the Board of Engineers, to examine and survey the said rivers, with reference to those objects, and to report their opinion thereon, which they have done; and which report I now communicate for the information of Congress.

JAMES MONROE.

January 22, 1823.

DEPARTMENT OF WAR,
January 22*d*, 1823.

SIR: I have the honor to transmit, herewith, a report of the Board of Engineers, on the Ohio and Mississippi rivers, made in obedience to your instructions.

I have the honor to be,
Your obedient servant,
J. C. CALHOUN.

The PRESIDENT *of the United States.*

ENGINEER DEPARTMENT,
January 16th, 1823.

SIR: I have the honor to lay before you, duplicate copies of the Report of the Board of Engineers of a reconnoisance of the Ohio and Mississippi rivers, made in the months of September, October, November, and December, 1821.

I am, Sir, very respectfully,
Your most obedient servant,
ALEX. MACOMB, *Maj. Gen.*
Chief Engineer.

Hon. J. C. CALHOUN,
Secretary of War.

REPORT

OF THE

BOARD OF ENGINEERS,

ON

THE OHIO AND MISSISSIPPI RIVERS.

From an examination made in the months of September, October, November and December, 1821.

NEW YORK, *December* 22, 1822.

SIR: The following report of the Board of Engineers, on the Ohio and Mississippi Rivers, is respectfully submitted.

Your obedient servants,

S. BERNARD,
Brigadier General.

JOS. G. TOTTEN,
Maj. Eng'rs. Brevet Lt. Col.

To Brevet Maj. Gen. MACOMB,
Col. Com'd't of the U. S. Engineers.

In connexion with this report, are the following plans:

1st, A plan of the Ohio, from Louisville to its mouth.
2d, A plan of the Mississippi, from St. Louis to New Orleans.
3d, A plan of the Falls of the Ohio.
4th, A survey of Bars, No. 2, 3, 6, 7, 14, and 21.
5th, Sketches of Bars, No. 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19, and 20.
6th A sketch of the Canals, projected on the Kentucky shore, to avoid the Falls of the Ohio.

Report on the Ohio and Mississippi Rivers.

THE OHIO RIVER.

The latter part of autumn and the spring, are the proper seasons for navigating the Ohio. It is not until December, that the rains, which fall in the extensive basin of this river, begin to swell its tributaries, and to render it passable below Louisville, with five or six feet draught. In January, the river is frozen; and, it is at the breaking up of the ice in February, and the melting of the snows at the same period, that the flood commences. These floods increase until May; then gradually diminish until July; after which, in July, August, and September, the river is very low every where, and can only be navigated below the falls by boats drawing two feet water. Rains of some continuance, however, occasion casual elevations of water, even in these months. It is proper to remark here, that there is little precision in the periods just assigned to the different stages of the water; these periods vary with their causes, viz: rains, dry weather, frost, and thaws: they are sufficient, nevertheless, to show, that in general, the Ohio, below Louisville, is navigable, with five feet draught, only about six months in the year.

At the junction of the Alleghany and Monongahela, (at Pittsburg) the Ohio begins; from this point to Louisville, by popular estimate, the distance is 700 miles; thence, to the mouth, 400 miles: giving a total from Pittsburg, along the sinuosities of the channel, to the Mississippi, of 1,100 miles.

It is a peculiarity of all rivers, that, the nearer we approach the source, the greater we find the declivity of the bottom: During the season of floods, therefore, the velocity of the current should be greater in the Ohio above, than below the falls; and to this cause, without doubt, we may attribute the great difference which exists at those seasons, between the height of water above the summit of the falls, and at the foot of them; the water is, in fact, raised but about 35 feet on the summit, while it is at an elevation of from 57 to 60 feet immediately below. We may add, that the falls preventing all resistance to the upper current by the mass of waters below, the current must be more rapid, and its expense of water greater than the current below the falls: the water flows over these falls with an accelerated velocity, caused both by the declivity of the bottom, and the declivity of the surface.

The greater inclination of the bottom of the channel above Louisville, the falls accelerating the current at that point, and the less number of the tributaries, which the part receives, are so many reasons why, at the season of low water, the navigation is so much more obstructed by shoals above, than below that place. But

amongst the great number of obstacles which the Ohio river presents to navigation, the falls at Louisville are certainly the first in importance, for, if boats, coming from above and bound for the Mississippi, do not arrive at Louisville at the period when the superior and inferior waters are on a level, or nearly so, from floods, they are either obliged to pass the falls at great risk, or they are detained until the following year, or are compelled to discharge their cargo, and transport it in vessels constructed below the falls. All the country, therefore, connected with the Ohio, above Louisville, is deeply interested in opening a passage round the falls, which shall be practicable at all seasons when the river is so.

The falls commence about half a mile below the mouth of Bear Grass Creek, and flow over ledges of compact and hard calcareous rock. At low water these ledges are visible in many places; they then afford three passages.

1st. The northern, or right pass, between Goose Island and the right bank of the river. This is called the "Indian Shoot;" it is the principal channel, but cannot be used at low water; at such times it is subdivided by the centre rock into two, of which the right hand pass (the best) is in one place sixteen feet wide, with sixteen inches draught at a mean of low water, and in extreme low water, only 13 inches. 2d. The pass between Goose Island and Rock Island, called the "Middle Shoot;" when the water is at a mean height, this is practicable. 3d. The pass between Rock Island and the Kentucky shore. This, called the "Kentucky Shoot," is only navigable at high water.

During low water, the fall, from the mouth of Bear Grass Creek, to the surface of the water at Clarkesville, is 22½ feet. We have observed before, that, during a flood, the water rises more at the foot than at the summit of the fall: it would be satisfactory to have a table indicating the heights of the water, both at the foot and summit, taken at corresponding times; but the construction of such a table would require a series of observations during the increase, continuance, and decline of the successive floods, and would require the actual presence of the observer for at leat six months.

Bear Grass Creek affords, at its mouth, an excellent anchorage, well sheltered from winds and from ice. This anchorage extends down to Corn Island. We found there 12 feet depth at low water. Between Rock Island and the Kentucky shore, is another anchorage, (for boats) called Rock Harbor. There is also a third at Sandy Island, opposite Shipping-Port.

Several canals have been projected to get round these falls, and to connect the navigation of the river above with that below them. One proposition is, to leave the river half a mile below Bear Grass Creek, and rejoin it just below Shipping-Port: this is to have a single level, extending the whole distance, with four connected locks at the lower extremity: two traces have been suggested, of which one makes the distance 2,600 yards, the other 3,150 yards: the first would require a mean excavation of 24 feet; the second, a mean excavation of 30 feet. The bottom of the canal to be four feet below low water, above the falls: the earth to be removed appears to be, for the first fifteen feet, yellow clay; and then, a stratum of blue clay, mixed with sand,

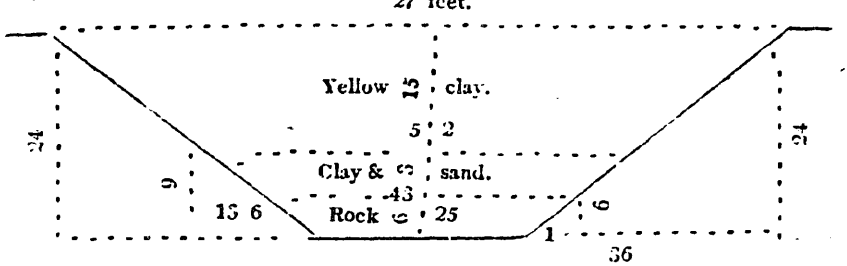
three feet thick: below this is a ledge of limestone, which, on a mean, must be excavated to the depth of six feet, for the bottom of the canal. It would be prudent to shut out the water of floods at the upper end, otherwise the banks of the canal would be much worn, and the locks endangered.

Another canal has been projected for the same side of the river; it is to leave the river between Corn Island and the Kentucky shore, and, following the windings of the shore, is to have its outlet between Shipping-Port and Rock Island. Its length will be about two miles, but it will require little excavation. As it will be entirely submerged by the floods, however, its four connected locks at the lower end, and its banks, will require a peculiar and very expensive construction to secure them from destruction.

A canal has also been proposed for the Indiana side; this is to follow the courses of two ravines, of which one enters at Jeffersonville, above, the other at Clarkesville, below the falls; it will be a little more than two miles in length. Having seen no details of this scheme, we can say nothing as to the nature and depth of the necessary excavations.

To judge of the comparative merits of these projects, it is indispensable to have well studied and minute plans and estimates. All that the Board can say, is, that they are, all of them, practicable; and, as to the expense, taking the first as an example, it can hardly be less than $140,000.

Adopting this as a mean profile of the first canal, with a length of



2,600 yards, the expense cannot be estimated below $131,464 76, to wit: 522,829 cubic yards of yellow clay, to be excavated and removed, at 20 cents per cubic yard, - - - - $64,565 80

41,165.8 cubic yards of sand and clay to be excavated and removed, at 20 cents per cubic yard, 8,233 16

58,931.6 cubic yards of rock to be excavated and removed, at 50 cents per cubic yard, - - 29,465 80

Masonry, &c. of locks for, at most, 24 feet of elevation, to obtain a general level, supposing that the stones derived from the excavation may be used for the purpose, 24 feet, at $800 per foot, - - - - - - 19,200

Dam at the head of the canal, supposing that the stones excavated may be used in the masonry, 10,000

Total 131,464 76

Besides the great obstacle of which we have been speaking, there are many minor ones, which, however, completely intercept the navigation of the Ohio in its low stage, except to boats with very little draught. These are shoals of gravel or sand, extending quite across the river. The deepest water over these, is confined to very narrow channels, generally: and great attention and experience, on the part of the pilots, are necessary to hit these channels, and to avoid being drawn, by the lateral currents, upon the shoals. Though these bars have water enough for "keel and flat bottom boats," which draw but about 18 inches, to descend the Ohio, from Shipping-Port to the mouth, at almost any season of low water; they have so little, as to prevent the navigation by steam boats, (which draw from four to seven feet) for five or six months every year.

Between Shipping Port and the Mississippi, there are twenty-one of these bars; which we proceed to describe, successively, beginning at the Falls, premising, that the depths, as they are given, were actually ascertained by us in our examination, (between the 16th of October and 3d of November, 1821); and that, according to information obtained by us, the minimum depth may be about 10 inches less.

The length of the bars are taken in the direction of the stream:

1st. Just below Shipping Port, between Sandy Island and the Kentucky shore, there is a chain of rocks, running N. W. and S. E. across the river: on which, close to Sandy Island, there is six feet. Before arriving at the rocks, a sand bar is crossed, on which there is but four feet water.

2d. A little above the mouth of Salt River, the channel is obstructed by a sand bank, about 70 yards in length, which has but three feet water.

3d. About one mile above Big Blue River, there is a bank of stones and coarse gravel: it is about 200 yards long, and has 3½ feet water.

4th. Below the same river, there is a bar of stone and gravel, on which there is four feet: its length is about 80 yards: the current is very rapid.

5th. Five miles above Little Blue River, there is a bank of quicksand, having three feet water, of 200 yards in length.

6th. Immediately below Flint Island, there is a sand bank which narrows the channel between it and a similar bank, making from the opposite shore: the channel is 90 yards wide, with a depth of at least three feet, and a very rapid current.

7th. A mile and a quarter below the same Island the river is obstructed by a sand bank of about 1200 yards in length; for the distance of 360 yards there is three and a half feet water; for 240 yards, but two feet; and for the remaining distance of 600 yards, three and a half feet: the shoalest part is also the narrowest, the breadth being about 180 yards. This current is moderate. On the right shore, below Deer Creek, there is a rock, about 15 yards from the bank. At the surface of the water it is about 50 feet long, (its length parallel with the shore) and 15 feet broad, and rising 15 feet above the sur-

face. In time of high water, this rock, covered by a few feet of water, requires much attention on the part of the pilot.

8th. Two miles above French Island, there is a sand bar of about 200 yards in length, and on which from 20 inches to two feet, only, are to be found. The channel is narrowed between the left bank and the upper shoal of French Island, being, in the narrowest part, but about 50 yards across. Between this Island and the left bank, there could be found but three or three and a half feet depth: here, and upon the bar, the stream is very rapid.

9. The bar above Henderson, is about 150 yards long, and has 3 feet water: the breadth of the channel is about 70 yards—the current very strong.

10. The bar below Henderson, is 50 yards long—the channel 50 yards wide, and the least depth 2½ feet.

11. Below Straight Island is a bar of two parts, one of compact, and one of moving sand. The current is extremely rapid. The least depth is 2½ feet. The length of the bar 150 yards, and breadth of channel about 40 yards.

12. Between Willow Island and the right bank, (in the Mississippi bend,) the stream is very rapid. Below the island is a sand bank, on which the least depth is 2½ feet: its length is 100 yards; the breadth of the channel about 50 yards.

13. Three miles below Highland Creek, at the mouth of Lost Creek, a chain of rocks extends from the Kentucky shore, and narrows the channel upon the right bank to about 60 yards: at this place there is a bar of quicksand, on which is a depth of 3 feet—the length of the bar is about 100 yards.

14. Above Hurricane Island lies Walker's bar. Between this island and the Kentucky shore the channel is but about 60 yards wide, with a very rapid current. Walker's bar is of quicksand, its length about 100 yards; the least breadth of channel 160 yards, and the depth of water 3 feet. The channel is very tortuous—the stream rapid, and the passage difficult.

15. Above the first Sister Island, at Buck and Deer Creek, there is a bar of quicksand 50 yards long, where the channel is about 40 yards broad, and 3 feet deep.

16. Below the third Sister Island, there is a bar of quicksand, on which there is 3½ feet water; its length is about 130 yards.

17. Below Stewart's Island there is a sand bank about 70 yards long, with 3 feet water.

18. There is a bar of moving sand opposite Lower Smithland, and below Cumberland Island; its length is 30 yards, and the depth over it 2 feet.

19. Two miles below the bar just mentioned, there is another, on which is a depth of 3 feet; its length is 60 yards.

20. The bar to the east of Tennessee Island is formed of moving sand: it is about 80 yards long, and has over it 3½ feet water.

21. The "Grand Chain" is a part of the river, where are many dispersed and detached rocks, resting on a bank or bed of rocks:

the channel between these obstacles is very serpentine: its bed is of sand and gravel: its breadth is about 300 yards, and its depth is 3 feet. The stream is very rapid.

The bar at the confluence of the Ohio and Mississippi, having from 7 to 7½ feet water, is not an obstacle to the navigation, and is not, therefore, enumerated with the preceding.

From the details just given of the bars which obstruct the channel of the Ohio at low water, it will be seen, that, excepting those numbered 7, 8, 10, 11, 12, and 18, they have at least a depth of 3 feet: and that these six, having, respectively, 24, 20, 30, 30, 30, and 24 inches—only such boats as draw less than 20 inches, can, at low water, navigate that river.

Before entering into an examination of the means which art and experience may present for removing these obstacles—a result greatly to be desired—it is proper to offer some general considerations in relation to the subject.

There are few rivers (except tide rivers) which are equally navigable during the whole year: for, as they are mainly supplied by rains and melting snows, their quantity of water must vary with the seasons. But the transition from high to low water, is more or less sudden, and depends upon the nature of the country which the river and its tributaries traverse: the higher and more sudden the floods, the shorter their duration, and the sooner the river descends to, and the longer it remains at, its minimum. The floods of rivers are in fact, not only in proportion to the surface of the basin which supplies it, but, also, in proportion to the declivity of the sides of the basin: if the country be gently undulating, and slightly inclined towards the river, the rains and melted snows arrive slowly at the river, and even a part is imbibed by the earth, to be added to the river only after the tedious process of filtration: in this case, floods must be gradual in their increase, must fill the channel for a considerable time, and must be slow in their decline.

The height of floods, as well as their continuance, depends also on the duration of the season of rains and melting snows. The shorter this season, the greater, in proportion, the excess of water, and the more brief its continuance; especially if these rains and snows are general, and arrive simultaneously by all the tributaries. In such cases, the floods are almost instantaneous—the expense of water is very great, and the channel, widened by the flood, is too broad for seasons of low water; for the river, expanded over this greater surface, has given up in depth, what it gained in surface.

A geographical circumstance, of great importance as regards the supply of rivers, is the situation of large lakes at or near their sources; these, by retaining the waters, are so many reservoirs, regulating the expense of water in seasons of floods, and supplying an equivalent to this expense, long after the causes of floods have ceased.

Lastly, when a river takes its source among high mountains, where the melting of snows and ice is continued till midsummer, the supply must be much more gradual and continued than when the source lies in a secondary chain; for, in low mountains, the thaw begins eve-

ry where at the same time, and is soon over. Now, applying these principles to the Ohio, we shall see that this river is dependant on a country which is so situated as to favor a sudden elevation of its waters, while it is without those geographical circumstances which, by economising the expense of water, prolong the duration of the mean waters. 1st. Though the declivities of the basin are generally gentle, they are, on the Alleghany side, very rapid. 2d. The rains take place at the same time in every part of the basin, and affect, at the same time, all its tributaries; the case is the same with the melting snows, because the southwest wind, which prevails to the west of the Alleghanies, for nine or ten months of the year, blows exactly in the direction of the valley of the river, and acts in the same manner, at almost the same instant, on every part of the valley. It is only in January and February, that the N. W. and N. E. winds predominate; the latter takes the direction of the valley; the other affects the tributaries of the Ohio less equally. 3d. The Ohio has no large lakes at its source, nor has it auxiliaries. 4th. The chain of mountains to the east of the upper part of the river, is not sufficiently elevated above the level of the sea, to prevent the melting of the snows in the higher region from immediately following the thaws below; and the southwest wind will cause the thaw to take place sooner, and to occupy less time on the side of the chain tending towards the Ohio, than on the other. 5th. Finally, the Ohio has its banks so high as to be seldom overflowed, which also contributes to the prompt discharge of its waters.

To be able to give an example of circumstances opposite to those of the Ohio, we will cite the case of the Rhine. This river has its sources amongst the Alps, where the melting of the snows is successive, from points nearest the level of the sea, up to 8,300 feet of elevation; that is to say, up to the average height at which the eternal ice and snow of these mountains commence; this thaw is prolonged till June, and even till July. The Rhine, in its upper part, traverses lakes, which economise the expense of water, and serve as reservoirs for seasons of scarcity. Lastly, from the varied aspects of the numerous surfaces which form the basin of this river, and the different directions of winds, blowing at the same time in different parts of the general valley, the tributaries bring their contributions in succession. The floods of the Rhine are, therefore, not great: at the bridge of Bale, the water scarcely rises 17 feet, and at Strasburg, but 8½ feet.

But, to return to our subject: The bed of the Ohio, enlarged to receive the mass of waters furnished by the floods, is, as we have said above, thereby too much expanded for the small quantity of water which passes at the low stage of the river; the water has gained surface and lost depth, and now becomes divided into small currents, which deepen their several channels a little, and leave the rest of the bed shoaler than before. The effect of these currents is modified by several causes; such as the nature of the bottom being less resisting in some places than in others; the direction and nature of the shores; the places, the form, the height, and the nature of the Isl-

ands; and the result produced upon the bed, the shores, and the Islands, by the mean and flood waters.

As to what concerns the effect of the waters upon the banks, at high and mean stages, it is evident that the parts the most friable and most opposed to the direction of the current will be most affected; salient and acute points in the river, offering less resistance, will be more perceptibly acted on than those which are obtuse. But the current, having worn off the parts most tender and most exposed to its action, may encounter veins of more consistence, or of less favorable position for its operation; it will then suddenly change its direction, and attempt upon the opposite shore the work of destruction, which was at last resisted by the shore it abandons. It happens also, that the current, having undermined a portion of the shore, will leave at the foot of the breach a portion of the ruins; these change, as they increase, the nature of the slope along which the river rushes against the bank, diminishing constantly the velocity of the current and the wear of the banks, until at last the waters are diverted from that course by the greater slope, which conducts them to an attack on the other side of the river. This continual wear of the current upon the banks, gives to rivers a course which is more or less serpentine, in proportion to the greater or less effect of this wear, and it is always observed that rivers passing through countries where they can produce such an effect as that above, are much more crooked than when they are found bounded by firm and durable banks, such as rocks; in this last case, the course of the river is generally a near approximation to a straight line. But, whatever may be the course of a river, whether more or less tortuous, if the depth and breadth of its channel be sufficient to confine the floods within its banks, or if a natural deficiency in this respect be remedied by dykes along the shores, there will be established, after a lapse of time, a sort of equilibrium between the shores, the bottom, and the velocity of current; after this period the changes will be of little consequence, except perhaps to the islands. The Ohio, perhaps, may be considered as having arrived at this state of equilibrium, and its limpidness shows, that its waters, and those of its tributaries, have but little effect upon their banks, for otherwise they would be turbid and charged with terreous particles.

Disregarding the banks, and the materials which compose them, entirely, in this view of the subject, if the bed of the river be homogeneous throughout, it will follow a uniformly inclined plane; for there will exist no reason why it should be scooped out in one place rather than in another. But such is not the fact; in time of low water the stream winds along the bottom, and, during floods, the line of most rapid current passes through the points of greatest elevation, in the several transverse sections of the river. If the river, in its course, encounters shoals of materials somewhat firm, the result of deposition, or the ruins of breaches made by the mean waters or the floods, the waters accumulate as behind a dam, and, passing with great velocity over their tops, soon wear out a channel; the matter, thus displaced, is borne along by the stream until it loses its veloci-

ty, when it is deposited to form a new bar. In this respect it is with larger rivers, at low water, as with smaller ones in ordinary times; if the bottom is of materials which can be abraded, such as earth, sand, gravel, &c. the bed is deepened in the narrow parts, as far as to where the bed begins considerably to expand. This has been shewn by profiles, taken lengthwise of rivers, with a view to modify their course, a sort of undulation in the bed being evident, giving the greatest depth to the narrowest, and the least, to the widest parts of the channel.

It follows from what has been said above, that if, to render a secondary river, or the channel of a principal river, more navigable at low water, a uniform slope be given to the bottom, not only will nature be continually acting counter to the expensive project, but, should it be continued, the water, by running down an inclined plane of great length, will acquire an accelleration of velocity, which will increase the expense of water to the prejudice of navigation. With respect to the expense of water it is proper to observe, that it will not do to judge of the quantity of water that passes, by the mean depth of the rivers; but by the mean height of water over the most elevated parts of its bed. In the Ohio, below Louisville, this mean height at low water, is about three feet; all projects which have for object to render this river navigable for boats drawing more than five feet, should be so contrived as to augment this mean height the least possible, for with it will increase the expense of water.

The only means which appear practicable to us, is the construction of dykes, which, obliging the current to pass at a determinate point, will cause the deepening the channel at that point. These dykes are commonly elevated a little above low water; they operate by diminishing the velocity of the current above them, thereby economising the expense of water: at the same time constraining the current to rush with greater velocity through the narrow spaces to be deepened. These dykes across the river, are ordinarily formed by rows of piles, driven with force into the bed, and strongly wattled together; the spaces between the rows being filled with such rough stones, or large paving stones, as the neighborhood can supply. This kind of dyke is the more stable, as, being only of the height of low water, floods, whether partial or general, pass over without injuring them. Such dykes may be constructed upon all the bars (of which there are 21) which obstruct the channel of the Ohio. But, as they must, with the exception of the sluice or passage way, extend quite across the river, the length of the whole cannot be taken at less than 15 miles; the expense will, therefore, be considerable. The experiment might first be made upon those bars which have less than three feet water, which, succeeding, would open the navigation to boats of two and a half feet draught, and would indicate, with much precision, how far the experiment would fulfil the object in view. Before engaging in so great a work, it is proper, at first, to be content with experiments; to study the habits of the river, at

high, mean, and low water; to be certain as to the best direction to give the current, which is to remove the bars; and, also, to ascertain the breadth which the sluices should have, so as neither to endanger the dykes by their narrowness, nor to fail of their object by their width.

As to the excavations which might be made across the bars, such a work would have a durable result, only where shoals are composed of firm and compact materials; but, being of sand, not well compacted, or of moving sand, or even of quick-sand, (with one or two exceptions at most) the excavations would be filled nearly as soon as made.

The Loire opposes (at the season of low water) to navigation nearly the same kind of obstacles as the Ohio: there are only from 16 to 20 inches of water on the bars, and the boatmen are obliged to dig a channel of 17 or 18 feet wide, for the passage of their boats. To do this, the boatmen, to the number of 8 or 10, get into the water, and, while a part hold planks, with one end of each in the sand, guiding them with their hand, others draw along these planks by means of cords. These channels are made sometimes in less than six hours; at other times they require a day and a half; but they do not long remain after the passage of the boat, and are filled entirely in a day or two.

Amongst the first attempts for the improvement of the Ohio, should be that at removing certain rocks, (especially in the "Grand Chain,") which, besides rendering the navigation more difficult and dangerous in low water, are extremely dangerous when covered by a mean state of the river, or during the rise and decline of floods.

The expedient proposed above, for obtaining a greater draught of water in the Ohio, is the only one we can devise. The Board, however, are not sanguine in their belief of its efficacy in all cases requiring remedy. It is certain that, by the dykes and narrow passages, the water may be deepened, at any required point; but, it is to be feared, that, in some places at least, the localities may be such, that the very materials, thus carried off by the rapid waters, may be deposited, when they become comparatively quiescent, in such a way as very soon to form a new bar below. The very great importance of the object in view, and the want of any other resource, will, nevertheless, justify an experiment.

Such are the remarks we have to offer as to the Ohio. We come now to the Mississippi.

MISSISSIPPI RIVER.

This magnificent River, which unites, in a manner, the Gulf of Mexico with the Canadian Lakes, is the great thoroughfare by which all waters from the Alleganies to the Rocky Mountains pass to the Ocean.

From the Gulf of Mexico to the mouth of the Ohio, the distance along the channel is reckoned by the best informed Pilots at 1100 miles: from the Ohio to the mouth of the Missouri, 220 miles; making 1320 miles from the last River to the Gulf. The mouth of the Missouri may be considered as about halfway to the Falls of St. Anthony—reckoning this half also by the windings of the channel.

The Missouri contributes much more than the Mississippi proper to the mass of waters which flow down the Lower River: and should therefore be considered the principal: it is singularly cold, muddy, and rapid. Its floods are annual, but do not arrive at any fixed period; they occur generally in June, and subside in July: producing one in the Lower Mississippi, of 15 or 20 days continuance. This flood is preceeded by another, which arrives in April and May, caused by the rains and melting snows of the Upper Mississippi and its tributaries. This, preceeding as it does, by at least six weeks, that of the Missouri, seems to indicate, either that the sources of this last River are furthest north, or more elevated above the level of the sea; or, that their aspect retards the influence of the sun for a longer time than those of the Mississippi; or, finally, all these causes may conspire to delay the period of flood. Be that as it may, the numerous tributaries of the Mississippi, having their sources in succession from about the 34th to 47th degree of north latitude, throw their floods in succession into this common recipient, which is thereby gradually swollen, and also thereby affected differently, in different parts of its course. The floods in the lower part of the River, commence sometimes in January, and decline in June; often, however, the autumnal rains of the southern region hasten their arrival, while long and rigorous winters in the north protract their duration.

In ordinary winters, this River is closed at "Cap-Cinq-Hommes," (12 miles below Maddensville,) by ice, for five or six days in December or January; and in severe winters, as long as 15 or 20 days: at such times, only 2½ or 3 feet, it is said, can be carried from the Ohio to St. Louis. In common seasons, at low water, there are about 3 or 3½ feet—we found in November from 4 to 5 feet, and in a mean state of the water there is about 9 feet.

From St. Louis down to Cape Girardeau, the Mississippi runs between banks generally of limestone, and, being thus confined by solid banks, its course is but slightly meandrous; conforming pretty closely to a straight line. But, below this Cape the shores are low,

alluvion, and easily abraded by the current, which becomes very crooked. This Cape has been considered by geologists, it is believed, as a part of a broken barrier, formerly retaining the upper waters, which were spread out into an immense Lake.

Above the confluence of the Missouri, the Mississippi is as limpid as the Ohio; but below, the waters are very turbid, with the great quantity of earthy matter which they hold in mixture; and this turbidness is always in proportion to the comparative quantity of water furnished by the Missouri. This, however, is not the sole supply to the turbidness of the Mississippi waters; because, all its western tributaries, as well as the Missouri, are charged with terreous particles, and the Mississippi itself, constantly acting with great violence upon its alluvial banks, carries along its rapid current much of the finer particles, which it displaces. Such being the causes, it is evident that the water must be most charged with foreign matter during floods.

When the floods of the Mississippi have attained their greatest elevation, the whole valley through which it runs is submerged, and presents a breadth of water, in some places, of 50 or 80 miles: but while the outspread waters of the last, return, on the wane of the flood, again to the river, those to the west remain, forming lakes and swamps. It is necessary to observe here, that the most elevated parts of this valley are directly upon the edges of the River, or are, more properly speaking, the banks of the River themselves; which may be accounted for in this way; that the waters, on leaving the channel, have a velocity so diminished, that they can deposite a part of the matter they hold in mixture: the banks, therefore, not only receive the grosser particles, but the greater proportion; for, as the water moves on, it has continually less and less to deposite.

While the waters of this river are over its banks, the operation of the current being in proportion to its elevation, and consequent increase of velocity, the changes which are produced in the bed of the river are great, sudden, and numerous; then are produced those multiplied turns and elbows, which so strikingly characterise this great river, and which increase its length to the double of what it would have been if its banks could have resisted its current. The corresponding concave parts of these turns are sometimes separated only by a very narrow neck, which, being cut through by the waters, which often happens, present a new and navigable channel, of perhaps half a mile in length, in lieu of the old one, of 15 or 20 miles. The abandoned channel is, in time, entirely divided from the river, except in floods, and, on the west side especially, becomes a lake.

Below "Baton Rouge," however, the Mississippi ceases to carry on its work of destruction and creation, and is, in a manner, mastered by the artificial embankments, which confine it to its channel: here, also, its bed is deeper, and its floods rise to a less height above its banks. In proportion as population increases, these dykes will be extended up the river to arrest its ravages: time can alone people the extended margins of the river, and from it, alone, can we expect the complete embankment of its shores. Like the Rhine, the Meuse;

the Loire, the Po, &c. the Mississippi will one day be confined, by stable limits, to its bed, and have yeilded to its ravages and the empire of its caprice, only the islands which lie in channel. Now, the hand of man, in that region, is too weak to contend with so mighty an adversary.

The Mississippi is more remarkable for its length and depth, than for its breadth. The channel is rarely a mile wide, below the mouth of the Ohio, and is often not more than half a mile. This breadth diminishes sensibly in the lower part of the river: below Natches, the river, becoming narrower and narrower, gains in depth what it loses in width, and the force of the stream being in the ratio of the height of the water, the islands are very powerfully attacked by it: for this reason, they are much less numerous below than above Natches, in the same distance; and below Baton Rouge, there is scarcely one.

The Mississippi has never been regularly sounded in its whole length; it is considered, however, that the mean depth of low water, between St. Louis and the Ohio, is about 15 feet: this depth augments gradually on descending the river; at Natches, it is 72 feet; at La Fourche, 180 feet; at New Orleans and below, 240 feet. But at the junction of the river with the Gulf of Mexico, the current being resisted by the quiescent waters of the sea, gradually loses its velocity, and deposites the earth with which it is charged; here is formed a bar, on which is a depth of only 14 or 15 feet: other deposites, besides this bar, composed of alluvion, and of trees brought along by the current, exist near the mouth: these deposites, at first unsteady, and even floating, became fixed in time, and presented so many islands, obstructing the confluence with the ocean; but the passages between these islands being protected from the waves and currents, by the islands themselves, were very favorable for deposition, so that, in course of time, they became one, and, joining the continent, projected it thus much into the sea. It is not, therefore, improbable, that the mouth of the Mississippi was, formerly, just below Baton Rouge, and that the delta of the present day is but the work of ages.

The bed of the Mississippi being thus elevated at its mouth, the waters at the bottom can only escape by filtration; the great passage of water is, however, at and near the surface: and if we consider the great number of issues by which this passage takes place, and the great space over which the water is spread, we need not be astonished at not finding at the mouth a sensible difference between the surface, at seasons of low water and floods. Besides, the difference of level between the Gulf, and the low water of the river at Baton Rouge, is so inconsiderable, that tides, when aided by winds, are frequently perceptible at that place.

As to the difference between high and low water, in the river, this varies in the several parts of its course: at St. Louis, it is from 12 to 15 feet; at the mouth of the Ohio, from 15 to 20 feet; at Natches, (380 miles from the Gulf) 50 feet; at Baton Rouge, (200 miles from the sea) 30 feet; at New Orleans, (80 miles from the Gulf) 12 feet; and at the Balize, upon the Gulf, it is nearly imperceptible. The difference,

therefore, augments, in ascending the lower part of the river, and in descending the upper. This fact accords with the observation, that, in all rivers subject to inundation, the maximum elevation of waters is near the middle of their course—and it may be thus accounted for: the upper part is continually increased by the accession of its tributaries, while the lower has numerous issues, and a wider space through which to eject its waters.

We now pass to the difficulties which the Mississippi presents, in its actual state, to navigation. Those which result from the continual changes in the course of its channel, can, as we have said, only be remedied by time. Those which are wrought by the current acting upon the shores and islands, are accompanied by earthfalls of even acres of forests. Of the trees which are in this way precipitated into the river, some are borne off by the stream, some are lodged upon the shores, where they form "rafts," obstructing the navigation of certain "branches," and require to be avoided with great care; for, such boats as "flat-boats" and keel-boats, which are difficult to manage, being once within the draught of the current of these branches, can hardly hope to escape being wrecked upon these rafts. Others of these trees become fixed in the bed of the river. When so fixed as to preserve an immoveable position, they are called "planters;" but when, being inclined from the vertical, and pressed upon by the current, they move in regular or rather in uninterrupted oscillations, they are called "sawyers;" "snag" is a term applied to either. When the whole river shall be dyked, or when the margin shall be deprived of its forests, then will these snags cease to accumulate, and be gradually removed; few now are to be seen below Natches, and scarcely one below Baton Rouge. There are few islands below the former place to furnish them, and the descent of the heavy rafts of timber for the supply of New Orleans has almost cleared this part of the river of this obstacle to navigation. Nothing can prevent, in the present state of things, these snags from being annually fixed in the river; but they can be removed; machines can be contrived to raise them, or to break or saw them off at a proper depth. It is true that the labor will be continual; that the channel is constantly changing its course, and that some of this labor will be in vain; but it is also true, that the annual destruction of property, by these impediments to the navigation, is immense; and it is certain that the risk may be materially lessened. Many particular parts of the river, such as sudden bends, narrows, and shoals, which are extremely dangerous, have continued nearly in their present state for a great many years; even some particular and prominent snags, are well known to have kept their stations for very many years; this indicates, pretty clearly, that the risk may be diminished. Besides, as regards the labor, this will be gradually diminished, it is presumed; because, if in the beginning, when it will have to encounter the ruins of ages, it can make a sensible impression, it cannot be long before this labor can be compassed by moderate means.

The safety of navigation must depend mainly, however, upon the kind of boats employed, and upon the prudence and experience of the

pilots. The boats in use are "Flat-boats," (or Kentucky boats,) "Keel boats," and "Steam boats." The first can be managed only slowly and with difficulty, and are not, therefore, well adapted to avoid the obstacles which suddenly present themselves; they cannot at all contend with the current. Their pilots are seldom well acquainted with the habits of the river. They make but one voyage a year, which is insufficient to inform them as to the changes which are constantly occurring in the channel. Keel-boats are much more manageable, and are generally provided with good pilots. But Steam boats, by the frequency of their passages, by the precision and certainty with which they may be steered, and by the experience of the Pilots, of whom great pains are taken to secure the ablest, are the only boats adapted perfectly to the navigation. These have almost entirely superseded the use of Barges, which were formerly the largest boats in use. Since the practice has obtained of separating the forward part of the hold, in these vessels, from the rest, by a water-tight bulk-head, which measurably secures them from serious accidents, even when they encounter snags, not much remains to be done for the security of navigation, *as to these vessels*, whether as regards the upward or downward passage. Constant watchfulness on the part of the Pilot, and abstaining from running at night, are still indispensable conditions of a voyage without accident.

We shall close this report by pointing out another species of hazard which such boats as are not easily and promptly managed must encounter.

At the time of high water, currents of excessive velocity set directly from the river over the banks, towards the interior; if a boat gets within the draught of one of these currents, it is only with great effort and labor that it can hope to regain the channel; they are often drawn in by them, and dashed to pieces against the first obstacle. Dykeing the river along its banks can only prevent these lateral currents, and time alone can produce this result.

For the present, the security of navigation will depend, as has been said above, upon the kind of boats employed, upon the talents, the prudence, and the experience of the Pilots, and upon the success of the attempts to diminish the number of snags.

All which is most respectfully submitted.

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