A

CONSIDERATION OF THE PLANS

PROPOSED FOR THE

IMPROVEMENT OF THE OHIO RIVER.

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THE

IMPROVEMENT OF THE OHIO RIVER.

The elaborate treatise of Charles Ellett, Jr., on the improvement of the Ohio and Mississippi Rivers, and the preventive of inundations, has probably been read by few without a feeling of obligation to this gentleman for the exceedingly valuable contribution to practical science which he has given to the world. He has undertaken the solution of one of the most grand and important problems that could occupy the human mind. He has grappled with the difficulties which it presented, and has apparently proved with the clearness of demonstration that it is possible for man, limited as his physical powers are, to say to the father of waters, thus far shalt thou go, but no farther, and here shall the mighty volume of thy turbid waves be stayed. He has attempted to show that the region of the Lower Mississippi may be protected against inundation, that the freshets which annually cause immense destruction to life and property, and the effects of which, by a continuation of the present order of things, must become more mischievous from year to year, are perfectly controllable, and that too with an expenditure of capital which, in comparison with the advantages to result from it, would be absolutely insignificant.

The surface of high water in the Lower Mississippi is nearly twenty feet above the surface of the country at points several miles distant; the sole protection against overflow is by means of slight banks, called levees, raised upon the sides of the stream. These embankments are in constant danger of destruction from the pressure of water in high floods, causing breaks or crevasses, which are annually becoming more disastrous in their effects.

In proportion as the upper portions of the great basin of the Mississippi become peopled, and the forests recede before the axe of the settler, the drainage becomes more rapid and the volume of water discharged in a given period is increased; other causes are also in operation which accelerate the discharge from the Upper Mississippi, and hasten the inevitable fate of the doomed regions of the delta, unless timely aid from artificial means shall be afforded.

No improvement should be considered more truly national in its character than that which would afford protection to this garden spot of the Western Hemisphere. It is the extension of the boundaries of freedom; it is the sale and settlement of the public lands in the new States and Territories, and the reclamation of swamps by the construction of new levees along the tributaries of the Mississippi. It is to the operation of all these causes that the danger to life and property in the delta can be traced. But these operations are indispensable to the prosperity of the nation, and imperatively demanded by that irresistible spirit of American progress, which is even less controllable than the waters of the Mississippi. It is unfortunate that the extension of improvements, of arts and civilization, cannot be secured without attendant evils; but these evils can be mitigated if the people of the West, who are the recipients of the benefits, will permit a very small expenditure from the national treasury to compensate for the disturbance in the primitive condition of things, which their agency has produced. Mr. Ellett believes that a small appropriation by the general government will be sufficient to check the ravages of flood, to control and regulate the discharges of the Mississippi, to reclaim thousands of acres of the richest lands now subject to inundation, and relieve the river plantations from the increasing expenditures required in the annual extension of their levees. All portions of the Union are interested in securing objects so national in their character, particularly when other advantages resulting from the means to be employed are taken into consideration.

The most important of these incidental advantages, and that to which it is proposed to direct attention in the following pages, is the improvement of the tributaries of the Mississippi, and the commencement of a plan of artificial inland navigation more extensive than the world has ever yet witnessed; more beneficial in its influences upon national prosperity than any other of which it is possible to conceive; and more economical in first cost, and in subsequent expenditure, than any other means of inland communication.

Mr. Ellett has considered this subject in connection with the regulation of the floods, and has shown from an accurate record of observations, extended over a period of six years, that the fall of water upon the surface drained by the Ohio is sufficient, exclusive of loss by evaporation, to maintain a regular current of sufficient depth for navigation throughout the year, and a similar condition of things would no doubt exist upon nearly all the other great tributaries of the Mississippi.

The plan proposed by Mr. Ellett for accomplishing the double purpose of preventing the possibility of inundation, and, at the same time, of furnishing a constant depth of water for navigation, consists of the construction of immense reservoirs, forming lakes in the mountainous regions in which the sources of these streams are found. He has shown that the average annual discharge of the Ohio River, from observations at the Wheeling bar, is 835,323,000,000 cubic feet, sufficient to maintain the river at a uniform height of $8\frac{94}{100}$ feet during the entire year, but that the quantity which it is necessary to retain to prevent the injurious consequences of the highest floods, is only 44,196,000,000 cubic feet, a volume equal to the discharge of the river during a five feet stage in fifty days. A single reservoir four miles square, and about one hundred feet deep, would be sufficient for this object, or an equivalent number of smaller ones.

It is by such calculations that Mr. Ellett demonstrates the feasibility of his reservoir plan, and proves very clearly that, if locations can be found, it is competent to prevent the injurious effects of floods, while it secures at the same time the equally beneficial result of maintaining a constant depth of water sufficient for navigation by vessels of moderate draught.

That some modification of the reservoir plan, or some addition to it, is the proper one for securing the objects sought, there can be but little doubt; but there is room for diversity of opinion on the question of the location of these reservoirs, whether in the mountainous regions at the sources of the streams, or in the beds of the streams themselves, by the formation of successive pools along their channels. The relative advantages and disadvantages of these two modes of construction will be discussed hereafter.

The subject of the improvement of the Ohio is no new idea; it has long engaged the attention of the highest intellects in the United States. The consequences of low water, suspended navigation, fluctuation of rates, stagnation in the stream of inland commerce, and other attendant evils, were too serious to escape the observation of public spirited individuals who labored in devising plans to overcome the difficulties, but these plans, in general, sought only to palliate the evil, not to eradicate the disease; they were mere temporary expedients, in most instances applied for local relief, not general in their character, or sufficiently comprehensive to embrace all the defects of the existing systems and satisfy the just claims of the community.

Some years since, a large national convention met on the western waters, which gave the subject of improvement by slackwater a favorable consideration. The lamented and gifted statesman, John C. Calhoun, was President of this Convention, the members of which represented the highest talent in the nation, but the deliberations of this body were not followed by action. Prompt energetic action, even if sometimes hasty or misdirected, is more beneficial in its results than that timid caution which hesitates to act for fear that it might not act precisely right; delays are often fatal, and if an improvement of the Ohio is ever to be effected, it will be the result of a commencement made by individuals actuated by considerations of public good rather than by the stimulus of interest. The improvement never will be commenced if that commencement is dependent upon the action of Congress, and is delayed until members have expended their verbal ammunition upon the subject.

If it be considered important to control and regulate the discharges of the rivers of the country, confining their fluctuations within prescribed limits, preventing the devastations of floods, and providing a permanent supply of water for the purposes of navigation; if commerce between the distant States of our vast Republic is an object deserving of encouragement; if low rates of transportation and facilities for effecting exchanges tend to the development of natural resources, and to the increase of wealth—then must the improvement of our great rivers be regarded as an object of national importance, in view of which sectional interests and local prejudices should be laid aside, and the representatives of the nation unite in a plan for efficient and immediate action.

Although the citizens of Pittsburg and the inhabitants of the State of Pennsylvania may reap a more abundant harvest from the improvement of the Ohio than other portions of the Union, yet it is difficult to conceive of any improvement, the beneficial influences of which would be more generally diffused throughout the extent of our land. Pittsburg, it is true, would become the head of the most extended inland navigation in the world, but Philadelphia would not monopolize all the advantages of a connection with it. By means of the Alleghany Valley Railroad, New York would tap this trade with a six feet gauge connecting with the Erie Railroad, while a still shorter line to New York would soon be completed through the Sunbury and Erie Railroad, the improvement of the Ohio would carry with it, as a necessary consequence, the completion of the Alleghany Valley Railroad connecting with the New York and Erie Railroad, and the Sunbury and Erie, which, with the Catawissa and other roads, would form the shortest and best line of communication between the city of New York and the Great West.

The New England States and cities would communicate with this great channel of trade by means of the same improvements, and an immense amount of eastern capital and influence would thus become directly interested in the early completion of these Pennsylvania railroads.

Maryland, by means of her Baltimore and Ohio and Northwestern railroads, would tap the trade of the Ohio before it reached Pittsburg. And possessing so great an advantage over all competitors, Maryland and Virginia can, of course, be relied upon to give the proposed improvement not only an approving smile but a liberal appropriation of material aid.

Ohio will be directly benefited in various ways: In the facilities afforded for obtaining a regular supply of fuel from the great bituminous coal fields of Virginia and Pennsylvania, and at fixed and moderate rates; in the transportation at extreme low rates of live stock and all kinds of agricultural products; and in the increased value which these facilities will confer upon the lands in the State. Even the Ohio railroads, which, at first view, might be supposed to suffer injury from a loss of a portion of their heavy freights, will, in fact, be gainers from the increased travel and the exchange of commodities requiring rapid movement, to which facilities for the cheap transportation of heavy freights give rise.

The experience of New York has shown that her canals and railroads, instead of being antagonistic, mutually assist in sustaining each other, and the facilities afforded by one increase the business of the others. So it must be with the improvement of the Ohio; the shippers of coal and other heavy freights will travel by railroad to anticipate the arrival of their property, and having effected sales, will seek the same channel of conveyance to return.

Time is money, and the value of time is so fully understood and appreciated, that no tax imposed upon travellers within reasonable limits will drive them from the railroad; the greater the extent to which business can be increased upon the river, the greater will be the travel upon the railroads of Ohio.

The same remarks are applicable to Indiana and other States west and south of Ohio; and these, with the new States and Territories in the Northwest, are bound, by a solemn duty to their fellow-citizens, to aid, if possible, in retarding the progress of that destructive element, the effects of which are increased by their improvements. If the reservoir plan is practicable, and the floods of the Ohio can be retained, it is evident that the increased drainage of the other tributaries of the Mississippi will not, for a long period, increase the heights of the floods in the lower part of the valley beyond the present limits.

To the inhabitants of Louisiana, Mississippi, and Arkansas, the improvement under consideration should be a boon of inestimable value. The success of the Ohio improvement would establish a precedent, soon to be followed by similar operations upon the Upper Mississippi, the Missouri, and their tributaries, diffusing the benefits of commercial facilities to the most distant portions of our territory, but, what is of more value to them, holding the waters in artificial lakes until the wants of man required their discharge, and by these means so regulating the flow of the streams, that crevasses and inundations would be known only by the records of history.

The evils and defects of the present navigation are universally admitted; during the present season, a continual suspension existed for the period of six months, during a portion of which the exposed channel of the Ohio exhaled death-dealing malaria, adding the calamities of a fatal epidemic to the distresses of suspended business and financial embarrassment.

Government has in vain attempted to cure the evil; the remedy has, it would seem, in some instances, been as bad as the disease; the wing-dam system could, at best, add but a few weeks to the period of navigation; it has no power to control the floods, or retain the surplus to supply deficiencies.

The wants of the country require a permanent navigation, free from the injurious fluctuations with which it is now visited, a depth of water sufficient to float the largest steamers of the Mississippi, and to carry them at all seasons. This much the public interest demands, and with less than this the public will not be satisfied.

RESERVOIRS.

The plan proposed by Mr. Ellett consists, as previously stated, in the construction of immense reservoirs upon the Alleghany and other tributaries of the Ohio.

The feasibility of the plan is discussed with the ability for which the writer is distinguished, and there can be no doubt that if suitable locations for the reservoirs can be formed, sufficient water may be retained to make a decided impression upon the heights of floods, and retain a moderate depth of water in dry seasons for navigation by ordinary steamers; but there may be doubts whether reservoirs can be formed of sufficient capacity, and properly located, to contain the immense volume required to maintain a sufficient depth of water in the channel at all times for boats of the largest class; and if formed, it may also admit of doubt whether the dams required in the construction of these reservoirs in the mountains would be less expensive than the reservoirs in the valleys, formed by the successive pools of an ordinary slackwater. It is certain that a given depth of water can be maintained with less waste by the construction of a slackwater than in any other way. During a period of low water, the only loss will be that due to lockage, leakage, and evaporation, which would be but a small portion of the discharge of the whole stream in a boating stage. The reservoir plan *may* answer, and Mr. Ellett seems to have demonstrated his positions, but the slackwater *will* answer beyond peradventure; and no experiment is required to decide the question if the object is merely to improve the navigation.

One of the most important objects which it was purposed to secure by the construction of the mountain reservoirs, was the retention of a sufficient quantity of water to reduce the heights of the floods, and prevent the destructive effects of inundations.

Upon this subject, Mr. Ellett has furnished exceedingly valuable data—some of which are here stated.

During a period of six years, from 1843 to 1848 inclusive:—

	Cubic feet.
The maximum discharge of the Ohio at Wheeling, was, in 1847	1,142,258,000,000
The minimum discharge was in 1845	555,482,000,000
The annual average . . .	835,323,000,000

Which was sufficient to have maintained the river at a uniform height of $8\frac{94}{100}$ feet.

The minimum discharge in 1845 would have been sufficient to maintain a depth throughout the year of seven feet.

	Inches.
The annual drainage for the same period, averaged	$14\frac{8}{10}$
The maximum, in 1847	$20\frac{2}{10}$
The minimum, in 1845	$9\frac{8}{10}$
The average annual fall of rain at the head of the Ohio, is	36

"The discharge is, therefore, about 40 per cent. of the total fall, showing that 60 per cent. of all the rain and snow that come to the earth in this latitude is carried back to the clouds in vapor, and never reaches the ocean."

The writer also states that a great flood in the Upper Ohio rarely continues at its extreme height more than ten or twelve hours, and but a single instance can be found, in the record of eleven years, in which a rise exceeding twenty-five feet continued longer than four days. When the river attains its maximum height at any point, it is rising one hundred miles below and falling one hundred miles above, the velocity of the highest floods being sixty-one miles in twenty-four hours.

To protect the country from inundations, it has been stated by Mr. Ellett, that it is only necessary to retain the top of the wave, and as a flood of twenty-five feet is found, by experience, to be productive of no injurious results, efficient protection will be secured by holding back the discharge in any given time exceeding that of a twenty-five feet stage.

Taking the flood of 1841 as a practical example, the total discharge of nine days, from March 24 to April 1, inclusive, was 158,964,000,000 cubic feet.

The discharge for nine days, in a twenty-five feet stage, would have been 114,768,000,000 cubic feet. The difference, or 44,196,000,000 cubic feet, is the volume to be retained in reservoirs, to control such a flood and render it harmless.

This quantity is equal to the discharge of a five feet stage in fifty days.

The possibility of controlling the floods of the Ohio, and maintaining a sufficient depth of water for the purposes of navigation, has apparently been proved, by figures, with the clearness of demonstration; but a cautious prudence may still find room for doubt; and in looking forward to the various contingencies that may arise, there is reason to fear that, in this case, as in many others, the deductions of theory and the results of practical operations may not be entirely consistent.

It has been shown, by the practical example above cited, that in the year 1841, the retention of 44,196,000,000 cubic feet of the March flood would have kept the rise at Wheeling within the moderate limits of twenty-five feet. And this would have required a reservoir, or a number of reservoirs, equal in capacity to an area of four miles square, or sixteen square miles, with a depth of one hundred feet.

Now, it must be observed that these reservoirs, it constructed, cannot secure the desired object unless they are entirely empty before the flood commences—if partly filled, a corresponding increase of capacity will be required.

The question will naturally arise: Is it possible in practice so to operate these reservoirs as to insure at all times the conditions upon which their efficacy depends? Can we have them always empty before a flood, and always full in advance of a period of drought? Would not the attempt to fulfil these conditions require the performance of impossibilities? Would it not demand a prescience with which mortals have not been favored?

It is not necessary to enlarge upon a point which is so self-evident. However capacious the reservoirs may be—were they capable of holding ten times the volume which forms the injurious excess in floods, they cannot retain this volume if previously filled by rains, and cases may arise in which they would not secure the desired object; the remedy cannot be infallible.

But there are other difficulties. The maintenance of a sufficient stage of water for the purposes of navigation requires a constant depth of not less than six feet. No improvement should be considered as satisfactory which does not secure this as the minimum depth beyond peradventure. A smaller depth will, of course, be an improvement upon the present dry channel, but the requirements of commerce, the interests of the nation, can be satisfied with nothing short of a permanent 6 feet stage, and 10 feet would be still better. Will the reservoir plan provide a constant depth of 6 feet? We will examine this question.

The present year, 1854, has witnessed a longer continuance of drought and of suspended navigation than, perhaps, any other upon record. For a continuous period of six months, the larger packets have been tied up. The records of this year would, therefore, be peculiarly valuable, as the basis of a calculation, and the writer has requested a copy of the Wheeling observations; but, in the absence of these data, we will take the results of the year 1845.

It has been shown that the total discharge of the Ohio at Wheeling in this year was

555,482,000,000 cubic feet;

and, by an application of Mr. Ellett's formula, this would have been sufficient to maintain a uniform flow of 7 feet on the Wheeling bar. To secure this uniform flow, it is evident that no excess over 7 feet could have been permitted at any period in the year—an obvious impossibility.

With a uniform depth of 6 feet upon the Wheeling bar, the annual discharge would have been

424,860,000,000 cubic feet;

leaving 130,622,000,000 cubic feet

as the surplus to escape in stages exceeding 6 feet.

We have before us a record of the observed depths of water on the Wheeling bar daily. From these observations the discharge can be readily obtained.

By estimating the discharges over and under 6 feet for each period of fluctuation, *starting on the supposition that the reservoirs were empty at the commencement of the observations*, deducting from the excess of one period the deficiencies of the next, and continuing the calculation until the end of the year, allowing, also, for the escape of the excess over 6 feet, the maximum capacities of the reservoirs would be ascertained. But, as our present object—which is the illustration of a principle—does not require a close examination of details, it will be sufficient to take the monthly, instead of the daily discharges.

The average monthly discharge, with 6 feet depth of water, would be

35,405,000,000 cubic feet.

The actual average monthly discharge was

46,290,000,000 cubic feet.

The difference is

10,885,000,000 cubic feet.

	Cubic feet.
In the month of January, the actual discharge was	93,843,000,000
In February	77,542,000,000
In March	136,774,000,000
Total for 3 months above average	268,159,000,000
Deduct discharge at 6 feet stage .	106,215,000,000
Difference	161,944,000,000

	Cubic feet.
During the months of April, May, June, July, August, and September, the discharge was below the 6 feet average, and amounted to	136,585,000,000
The discharge of a 6 feet stage during the same time would have been	212,430,000,000
The deficiency to be supplied by the reservoirs would have been	75,845,000,000

The capacity of the reservoirs to retain this quantity of water, with an average depth of 50 feet, would be 55 square miles.

By examining the record of January, it appears that the excess in that month, over the discharge of the 6 feet stage, was 65,438,000,000 cubic feet, or only 10,407,000,000 less than sufficient to fill the reservoirs of the capacity of 75,845,000,000 cubic feet.

During the next month, the discharge being 77,542,000,000 cubic feet, the reservoir would have been filled, and 31,730,000,000 excess over the 6 feet discharge would have been wasted.

In this position of affairs, the March floods find the reservoirs already overflowing, and not a drop of the 136,774,000,000 cubic feet—the greatest discharge and highest flood of the year—could have been retained. The reservoirs would have been utterly powerless, in this case, to hold back any portion of the flood or afford any protection against inundation. It is true that the maximum rise this year did not exceed 24 feet, but had it been 40 feet the result would have been the same—the reservoirs could have afforded no protection, for the simple reason that they were already filled.

But suppose the March floods had been anticipated, and that, by suitable arrangements, the accumulations of the previous month had been discharged; in that case, the flow of March would have filled the reservoirs, furnished the 6 feet discharge, and an excess of 36,000,000,000 cubic feet would have been wasted. This is precisely the result desired, and, if it could always be secured, the reservoir plan would fully satisfy the expectations of its advocates, in securing the double object of retaining the injurious excesses during floods, and furnishing sufficient depth for navigation in seasons of drought. But the practical operation of the system depends too much upon conjecture. Should the reservoirs be emptied in anticipation of a flood, and the flood be delayed, suspended navigation would be the consequence.

The only protection against such results, and the only way of rendering the reservoir plan practically efficacious, appears to consist in constructing the reservoirs of sufficient capacity not only to supply all the water required for navigation, but also to retain, in addition to this, the excess necessary to prevent injurious overflows.

It has been shown that the records of 1845 give 75,845,000,000 cubic feet as the capacity required during that year to supply a six feet stage of water on the Wheeling bar. The records of the present year would probably indicate that more than 100,000,000,000 would be necessary. Mr. Ellett has stated that floods not exceeding 25 feet at Wheeling do no serious damage, and that of the flood of 1841, 44,196,000,000 cubic feet should have been retained in reservoirs to afford the necessary protection.

It would appear, therefore, that, to insure sufficient water for navigation and restrain excessive floods, a reservoir capacity of about 140,000,000,000 cubic feet should be provided, and so contrived that the flood excess would be discharged as quickly as possible after the waters commenced to fall.

To retain this quantity, the aggregate area of the reservoirs, with an average depth of 50 feet, would be 50 square miles.

It has been proposed to construct these reservoirs upon the tributaries near the sources of the streams, where the lands are of comparatively little value.

The time has passed when lands in the valleys of the mountain streams of Pennsylvania can be considered valueless. The great amount of surface which is covered with rocks, or is too steep or too barren for cultivation, adds proportionately to the value of the bottom lands, where all the farms, and where the forges, rolling-mills, and factories are located. As no careful examinations have been made to determine whether a sufficient number of such locations exist, it will not be safe to assume their existence as a fixed fact, and erect the superstructure of a vast system of improvement upon such a foundation. It is also proper to observe that a long distance intervenes between the city of Wheeling and the proposed locations of the reservoirs; a large portion of the volume of the stream would be due to accessions between these points, and if located too near their sources amongst the mountain gorges, the necessary supply to fill the reservoirs might sometimes be deficient.

But suppose all these conditions can be fulfilled, and that locations for reservoirs can be found with a sufficient supply of water and moderate damages for the destruction of property by overflow, how many reservoirs will be required to answer the purpose?

This problem cannot be solved by any data in the possession of the writer, but if the valleys near the sources of the Alleghany, Monongahela, and Youghiogheny are similar in their main features to the valleys of Conemaugh, Black Lick, Yellow Creek, and others, on the west slope of the Alleghanies, with which he is better acquainted, it may be considered that the average width of the pools will not exceed one-third of a mile, allowing 5 feet fall to the mile, and the dams to average 30 feet in height. The cubic capacity of one of these pools would be

836,352,000 cubic feet; to retain the amount of 140,000,000,000 cubic feet would require 175 such reservoirs with dams of 30 feet.

If the dams should be increased in height, a smaller number would suffice, but the expense of each dam, with its sluices and machinery for discharging the waters, would be increased.

It is doubtless true that in ordinary seasons reservoirs of half the capacity here indicated might be sufficient to maintain a 6 feet stage in the Ohio; but it is necessary to provide for extreme cases, and it is doubtful whether security against floods and droughts, at all times, could be insured with a less liberal provision.

It is not probable that sites for 175, or even for 75 reservoirs, could be found near the sources of the streams which form the Ohio. If constructed at all, they must be commenced at points not very remote from Pittsburg, in which case the damage to property from overflow would be largely increased.

These considerations, if they are not based upon sufficiently reliable data to demonstrate that the reservoir plan by itself is inadequate to fulfil all the requirements of the improvement, will, at least, be sufficient to excuse the writer for entertaining and expressing doubts of its practicability and success.

SLACKWATER.

We propose now to examine the effects that would be produced by dams in the Ohio, and the advantages and disadvantages of a slackwater navigation.

The improvement of a navigation by means of slackwater is not an untried experiment; it has been tested upon two of the tributaries of the Ohio, the Monongahela and the Youghiogheny, and with the most favorable results. It has been successful wherever tried, and there is no better guide in judging of the future than by the past. That there are defects and disadvantages in the system cannot be denied, and these disadvantages we propose to consider.

The distance from Pittsburg to Cincinnati is, in low water, nearly 500 miles, and the fall 200 feet. If 15 feet be assumed as the average difference of level between the foundations of the dams, 14 dams would be sufficient to overcome the whole fall, forming a succession of pools, the average length of which would be 33 miles. To ascertain the average height of the dams, it is necessary to add to the difference of level of the foundations the required depth of water below the dams, and deduct the fall from one dam to the next, due to the velocity of the water in the pools.

In practice, it will be necessary to disregard this fall in calculating the heights of the dams, as the current would be inconsiderable during a period of continued drought, and it is essential that the supply should never be deficient.

If 6 feet be taken as the minimum depth of water, these conditions would give, for an average elevation of the dams, 21 feet.

To avoid any unnecessary waste of water, and also to facilitate the passage of boats, the locks should be double, and one of them should be of sufficient capacity to admit the largest steamers which float upon the Ohio or Mississippi Rivers; the other lock may be of smaller dimensions, if economy of water be found necessary or desirable.

These locks should be protected by guard-walls, sufficiently high to be above the floods, if it is desired to insure an uninterrupted navigation at all times. For the purpose of retaining a portion of the surplus water during freshets, reducing the heights of the floods, and regulating the discharges, an additional height might be given to the dams, with a wide chute, or waste-opening of the same depth, for the purpose of holding back a sheet of water at each pool, equal to the surface area, with any required depth, and discharging it rapidly until the ordinary surface level is regained.

The effect of this arrangement, in connection with a comparatively small number of reservoirs in the tributaries, will now be examined, to ascertain if it will accomplish the objects of providing a permanent first class navigation, and preventing the damages of floods.

The only data in our possession are those furnished by Mr. Ellett; but these will probably be sufficient to conduct the inquirer to safe practical conclusions.

No cross section of the Ohio has been given at the place at which the observations were made, but it is stated that the width of the water-line, corresponding to a depth of $5\frac{38}{100}$ feet, is 1,066 feet; and taking the slope, which is known to exist at other places, it will not cause any material error to assume the water-line, with a depth of 36 feet, to be 1,500 feet; and the area of the cross section, with a depth of 36 feet, as determined by these dimensions, will be 44,640 square feet.

The effects produced by the erection of dams across large streams, and the increase in the height of floods due to their action, does not appear to have been very clearly explained by writers on mechanics who have investigated the laws which govern the motion of fluids. It is difficult to find any results that are precisely applicable to the cases under consideration; and, in the absence of time for more thorough investigation, we must content ourselves with the nearest approximations to correct practical results that we can obtain.

The first inquiry will be: What must be the height of water above the crest of a dam to discharge the cubic quantity vented by the Ohio at Wheeling, at a depth of 36 feet?

If the dam be supposed to be 21 feet high, its length would be about 1,300 feet.

The discharge of the Ohio, in a 36 feet flood, is 22,500,000,000 cubic feet in 24 hours, or 260,416 cubic feet per second.

The formula of Wiesbach, which applies to this case, is

$$Q = \frac{2}{3} b \sqrt{2 g h^3}$$

in which Q is the discharge per second in cubic feet; b, the breadth; g, the constant 32.22 which represses the accelerating force of gravity; and h, height.

Substituting the proper numbers in this equation, the value of h will be found to be $11\frac{2}{10}$ feet.

This represents the height of water falling freely over a dam 1,300 feet long, and discharging the same quantity as the Ohio in a 36 feet flood.

Were it possible for the water to fall freely, the whole height would be $21 + 11\frac{2}{10}$ feet $= 32\frac{2}{10}$ feet, which is less than the supposed depth of the stream.

But the water does not fall freely in such a case as that supposed; the backwater would completely cover the crest of the dam; the falling water would experience a resistance which would retard its velocity, and, as a consequence, add to its height. To arrive at practical conclusions, we must examine more particularly into the circumstances of the case, and the effect of the obstructions upon the current.

Where there is no obstruction, the stream straight, and the section regular, the velocity at different depths will be nearly constant, except that the portions near the bottom and sides are retarded by friction, and consequently the lower portions of the section discharge less freely than those which are near the top, and less than the average of the whole.

Upon approaching a dam, the velocity of these lower particles is reduced, and they are forced, by the resistance of those which lie nearest the obstruction, to change their course and pass upwards, flowing through a contracted area with greatly increased velocity, where free egress is allowed, or through an area proportioned to the velocity where the discharge is obstructed.

In the case supposed, which is that of a dam 21 feet high obstructing the passage of water in a river 37 feet deep, it appears evident that an increase of elevation must be caused by the dam, since the volume of the stream must be passed through a reduced sectional area, which necessarily requires an increased velocity and increased fall; but an increased fall necessarily presupposes an increased elevation.

It is evident, therefore, that the first effect of the construction of an ordinary slackwater navigation, will be to increase the height of the floods, unless provision be made by means of reservoirs to retain sufficient water to counterbalance these effects, and the water so retained must be discharged as soon as a fall commences, that the reservoirs may be in readiness to receive the next contributions.

The plan of slackwater is, therefore, not without its disadvantages, and the adoption of any mode of improvement should be postponed until after a full examination of localities, and a careful study of the probable consequences of proposed alterations in the natural regimen of the stream.

A second effect of dams will be to reduce the velocity of the current. When the discharge is only sufficient to maintain a depth of 2 feet on the Wheeling bar, the fall per mile in the pools will be a small fraction of an inch, in fact, scarcely appreciable; it is determined as follows:—

With a dam 21 feet high, the cross section of the stream above the dam has been found to be 23,940 cubic feet. The discharge at a 2 feet stage is 228,-000,000 cubic feet in 24 hours, or 2,600 cubic feet per second, the velocity of the current will be $\frac{2600}{23980} = .10$ feet, or 1.2 inch per second.

The formula for determining the fall is

$$v \frac{11}{8} \sqrt{Rh}$$

in which v = velocity per second in feet = .10, R = area of cross section divided by perimeter in contact with water, which is in the present case 20 feet.

h = fall per mile in feet,

substituting these values, we find h = .00037 ft.

The velocity of $\frac{1}{10}$ of a foot per second is equivalent to 1½ mile per day of 24 hours.

The effect of this reduction will be to facilitate the formation of ice in cold weather, but the delays resulting from this cause will not be so serious as would naturally be anticipated. The following statement of the detentions caused by ice on the Monongahela slackwater has been furnished by J. K. Morehead, Esq., and embraces a period of 10 years, from 1845 to 1854 inclusive.

1845, Feb. 7 to Feb. 14,	inclusive	8	days
" Dec. 7 to Dec. 31,	"	25	"
1846, Jan. 1 to Feb. 1,	"	32	"
1847, Dec. 11 to Dec. 16,	"	6	"
1849, Jan. 10 to Jan. 18,	"	9	"
" Feb. 15 to Feb. 26,	"	12	"
1851, Feb. 1 to " 2,	"	2	"
" Dec. 17 to Dec. 31,	"	15	"
1852, Jan. 12 to Jan. 31,	"	20	"
1853, Jan. 26 to Feb. 1,	"	7	"
" Dec. 28 to Jan. 15, 1854	"	19	"
Total number of days . . .		155	

or an average of 15½ days in each year.

Mr. Morehead also states that "*the Ohio River has been obstructed by ice nearly the same length of* *time.*" It would appear from these records that the period of obstruction from ice in consequence of the construction of a slackwater, would not be very serious. It would be nearly the difference in time between the observed periods of suspension of navigation from ice on the Ohio and on the Monongahela slackwater, which it is fair to assume will not average one week in the year, and even then the navigation could be kept open by fitting the steamers to act as ice-boats.

It is probable that the reduction in the velocity of the current, and the consequent necessity which would exist for employing towage for the descending tonnage, would constitute one of the most formidable objections to the use of a slackwater. It is doubtless true that the losses in the ordinary way of conducting the coal business are enormous, and would be sufficient to pay a much larger toll for the use of the improvement than would be demanded, but it would change the present mode of conducting the business and render it necessary that tow-boats should be furnished by the company operating the improvement, or by individuals, a condition of things which, at first, might lead to difficulties, but which in the end would no doubt be so systematized and managed as to promote the interests of all parties, and give entire satisfaction.

HIGH DAMS WITH RETAINING RESERVOIRS.

The objections that have been stated apply to dams of 21 feet or upwards, and the most serious of these objections appears to be the increased rise of the waters in times of flood, which they would occasion.

Reservoirs could be formed by raising the dams several feet above the line required for the maintenance of a proper depth of water, leaving wide sluices, to discharge in a few days all above the navigation level. This plan deserves examination; and the effect of such an arrangement will be illustrated by an example.

To form some idea of the probable influence upon the floods at Cincinnati, that would result from the construction of these reservoirs upon the pools of the dams, it will be necessary, in the absence of data obtained from actual measurements, to make use of such as will probably express the conditions of the problem obtained from other sources.

The discharge at Cincinnati, from an examination of the area of drainage, should be nearly twice as great as at Wheeling in the same flood.

	Feet.
The width of the Ohio at Cincinnati, at an elevation of 60 feet above low water is .	2,100
And at 50 feet the width will be . .	1,750
The width at low water is	1,000
At a height of 21 feet, it is . . .	1,360
At a height of 26 feet, it is . . .	1,440

A flood of 36 feet at Wheeling is usually followed by a rise of 50 feet at Cincinnati.

	Cubic feet.
The area of cross section for a depth of 50 feet, is	70,000
The area of cross section, for a depth of 26 feet, is	31,720
The discharge, at 26 feet, with a mean velocity of 4 feet per second, will be .	126,880
The whole discharge, with an average mean velocity, the same as at Wheeling, of 5.8 feet per second, would be . .	406,000

The surface velocity is supposed to be 8 feet per second.

The increase in the height of the flood caused by a dam 26 feet high would, as the result of some imperfect calculations that have been made, be found between the limits 4 and 6 feet.

If 5 feet be supposed to represent the increased elevation due to the dam, and the duration of the flood, within 5 feet of its maximum, to be 4 days, its velocity being 100 miles per hour, it would be necessary to retain in reservoirs a column, equal in breadth to that of the river at Cincinnati, 5 feet deep and 250 miles long.

Allowing for the contraction in width in the upper part of the stream, this column would be sufficient to extend two-thirds of the distance to Pittsburg.

These calculations have not been made with any pretensions to accuracy; they are, at best, mere conjectural estimates approaching to probabilities. They are sufficient, however, to justify the opinion that the rise of water caused by dams of 21 feet, with an addition of 5 feet for reservoir, could be so checked by means of the reservoirs as to compensate entirely for the dams at a distance of 300 miles from Pittsburg; and, if the same system should be continued, the floods below that point would be reduced.

To keep the floods at and near Pittsburg within the present limits, additional reservoirs above Pittsburg must be provided.

These reservoirs, with a slackwater navigation, consisting of high dams, and the guard walls of the locks raised above the floods, constructed, as such an improvement should be, in the most substantial manner, will involve an expenditure of not less than six millions of dollars, and probably more.

LOW DAMS AND CHUTES.

The case which has been considered is that of an application of the ordinary slackwater principle by means of high dams and locks. The objections to it appear to be numerous and formidable, but not insurmountable, and the importance to the general interests of the country, of an uninterrupted navigation, would be sufficient to justify the expenditure, even if it were quadrupled. But before the adoption of such a system of improvement, although apparently more popular at this time than any other, it would be proper to inquire whether no other plan can be devised which will secure the desired object with fewer attendant disadvantages.

A system of low dams, with chutes of very moderate inclination, would be free from the delays of lockage; would oppose less obstruction to floods; would be less expensive in first cost, and less expensive in operation, and would throw but little impediment in the way of the descending coal and lumber trade. These are essentially important considerations, and the practicability of the plan deserves a serious examination.

In entering upon this investigation, it will be assumed that the depth of ordinary low water upon the Wheeling bar is 2 feet. We will also assume the breadth of the water-line as 700 feet at this depth

The area of the cross section is about .	2000 feet
The discharge per second . . .	2500 "
The mean velocity per second . .	1.25 "
The mean velocity per hour . .	0.72 mile.

The fall per mile, in a channel of uniform dimensions, will be determined by the formula

$$h = \frac{88\ v^2}{121\ K}.$$

In which, $h =$ fall per mile in feet; $v =$ velocity per second in feet; $K =$ reduced depth, or whole area, divided by water perimeter.

This equation gives the fall per mile 4½ inches.

If 6 feet be taken as the least depth that will suffice for a permanent navigation, 2 feet as the ordinary depth in the channel at low water, the velocity of the water in passing through a section 6 feet in depth will be reduced to 0.46 foot per second, which corresponds to a fall per mile of only $\frac{3}{10}$ of an inch.

Now, if the channel of the river be supposed to have a uniform slope, the erection of a dam 6 feet in height from the bottom, or 4 feet above low water, would give a depth of 6 feet only at the dam, from which point the fall would increase from $\frac{3}{10}$ of an inch per mile to 4½ inches per mile, when the effect of the dam would cease, and the water be found at its original depth of 2 feet. To secure a sufficient depth for navigation, the heights of the dams should be about 10 feet. The velocity of the water near the dam would be 4 inches per second, and the fall per mile less than one-tenth of an inch.

If the surface of the water be supposed level, and the slope of the bottom 5¼ inches to the mile, which is the average slope of the Ohio, a dam of 10 feet would give a depth of 6 feet at a distance of $9\frac{1}{10}$ miles; but, in consequence of the slope of the surface in the pool of the dam—which would average about ⅛ of an inch per mile—the water at a distance of $9\frac{1}{10}$ miles would stand at a depth of $7\frac{1}{2}$ feet, and there would be 6 feet water at a distance of 12 miles.

It is proper to assume, therefore, that the average distance between dams 10 feet high to maintain a depth of water of 6 feet at the lowest stage, will not exceed 12 miles. The difference in level between the water surfaces above and below the dams will be 4 feet, which it is proposed to overcome by means of long chutes.

The inclination of these chutes must be determined by the condition that the velocity shall not exceed a given rate per hour.

Assuming that steamboats with ordinary full loads in slackwater, can move at the rate of 10 miles per hour, it would not be expedient to allow the maximum velocity of the current through the chutes to exceed 5 miles per hour, which is equivalent to 7.3 feet per second.

The velocity of the central surface thread in the chute being 7.3 feet per second, the mean velocity of the section will not exceed $6\frac{1}{2}$ feet, the discharge being 2,500 feet per second. The width of the chute must be 68 feet. The fall per mile in the chute corresponding to these dimensions will be $4\frac{3}{10}$ feet.

It appears, therefore, that a chute 1 mile long would be sufficient to overcome the fall of the dam with a velocity of 5 miles per hour, but the width of the chute is not sufficient for the passage of two large steamboats at the same time. If the width of the chute is increased to 200 feet, which is the least width that should be allowed, the discharge would exceed the supply at low water, and the depth be reduced below the six feet required for navigation.

The discharge through an opening 200 feet wide and 6 feet high, with a velocity of 6½ feet per second, will be 7,800 feet per second. The actual discharge of the stream at low water being 2,500 cubic feet, the difference will be 5,300 cubic feet. A pool 12 miles long and 1,100 feet wide, would be reduced by this discharge 1 foot in 2⅕ hours.

This deficiency might be supplied by reservoirs, and the capacity of the reservoirs could be thus ascertained.

A discharge of 7,800 cubic feet per second is equivalent to 675,920,000 per day, which corresponds with a depth of 4⅓ feet on Wheeling bar.

The longest interval during which this deficiency of 5,300 cubic feet per second may be supposed to continue, is about 2 months. To supply this deficiency will require 27,475,200,000 cubic feet.

This capacity, with a proper allowance for evaporation and leakage, would be two-thirds of the estimated capacity of a reservoir to reduce the floods at Wheeling to a maximum of 25 feet; it would be equivalent to a basin 6 feet deep, 1,200 feet wide, 700 miles long.

It is extremely doubtful, in the estimation of the writer, whether reservoirs of such capacity can be formed upon the smaller streams, and until this question shall have been settled by actual surveys, it is better to place no reliance upon such assistance in reducing floods. A careful examination may possibly establish the fact that the only system of reservoirs, applicable at the present day to the abatement of the floods in the Lower Ohio and Mississippi, will be by surface pools in the rivers themselves, formed by raising dams to a greater height than is required for the purposes of navigation, as previously explained.

The supply of water furnished by the river being insufficient to fill a chute of the dimensions required, it is necessary either to supply the deficiency by reservoirs, or reduce the velocity by a change of inclination.

We therefore propose to determine the inclination by the condition that a discharge of 2,500 cubic feet per second, shall fill a chute 6 feet high and 200 feet wide.

The mean velocity of discharge in this case will be 2 feet per second. The fall would be 5 inches per mile, and the chute would become a continuous canal, extending from one dam to the next, which is precisely the result that should have been anticipated, as the quantity of water discharged is not more than would fill a canal 6 feet by 200, with a fall equal to the average fall of the stream.

If it be assumed that the length of the chute shall be 2 miles, the fall per mile will be 2 feet;

the velocity of discharge 4.35 feet per second, or $2\frac{9}{10}$ miles per hour, and the discharge per second 5,220 cubic feet, leaving 2,720 cubic feet to be supplied at the lowest stage. To insure this supply, will require a reservoir capacity of 14,000,000,000 cubic feet.

If the Alleghany River should be slackwatered, and the dams increased in height upon the Monongahela and Youghiogheny, this quantity of water might be supplied at a moderate cost; it would be but one-fifth the quantity that would be required to maintain an equal depth over the whole bed of the stream.

It is certain that without any reservoirs whatever, using simply the low dams and chutes, a six feet navigation could be maintained whenever there was a depth of water of only 3½ feet in the ordinary channel.

It is to be observed that the case considered is that in which the slope of the stream is supposed to be uniform, and the dams at equal distances of 12 miles. This is the most unfavorable case that could occur to test the applicability of the system; the river presents a succession of shoals and rapids; dams of 10 feet, instead of backing water 12 miles, may frequently extend the 6 feet depth to 30 miles, and the fall from one pool to the next, instead of being 4 feet, may be 8 or 10 feet. These are extremely favorable circumstances, as advantage can be taken of them to increase the lengths of the chutes and reduce the number of the dams; in fact, as the whole fall is overcome by chutes, if this fall should occur within a distance of 100 miles, the upper and lower pools could be connected by a chute with a slope of 2 feet to the mile, and the work would be completed.

It is also to be observed that the larger pools would maintain the required depth in the chutes for a longer time. The discharge through the chute, with a depth of 5 feet, would be 4,350 cubic feet per second; the supply of the stream being 2,500 cubic feet, the difference is 1,850 feet, which would reduce a pool, 1,100 feet wide and 25 miles long, 1 foot in 22 hours, and a depth of 4 feet in the chute would reduce it to the same extent in 77 hours.

By reducing still further the slope of the channel which forms the communication between the pools, the discharge would be lessened, and with it the quantity of water necessary to maintain a constant navigation.

It may be interesting to present the problem, which has been under consideration, in a modified form, and, assuming the fall of the channel to be only one foot per mile, to calculate therefrom the velocity of the current, the whole discharge and the reservoir capacity required to supply deficiencies at the lowest stage :—

The formula $v = \frac{11}{8} \sqrt{Rh}$ in which $R = \frac{1{,}200}{212} = 5.2$, gives for the velocity in feet per second 3.13.

The discharge with this velocity would be 3,756 cubic feet. The discharge at a 2 feet stage at Wheeling being 2,500 cubic feet, the difference, which must be supplied by reservoirs, would be 1,256 feet.

The stage of water that would furnish 3,756 cubic feet per second at Wheeling is 2 feet 8 inches.

Whenever the quantity of water in the Ohio would be sufficient to give a depth of 2 feet 8 inches on the bar at Wheeling, there would be sufficient to maintain 6 feet depth of water in an artificial channel, 200 feet wide, flowing at the rate of 3.13 feet per second, or $2\frac{1}{10}$ miles per hour.

It will correspond very closely with the results of observations, to assume that a stage of water below 2 feet 8 inches rarely continues as long as six weeks, and during that period the average is not below 2 feet. The difference between the discharge at 2 feet and at 2 feet 8 inches is 1,256 cubic feet per second, or 4,560,000,000 cubic feet in a period of 6 weeks.

A reservoir one-third of a mile wide and an average of 10 feet deep, must be 58 miles long to contain this amount.

A reservoir capacity of this extent, which is only one-tenth of that proposed by Mr. Ellett, might be obtained without difficulty by slackwatering the Alleghany River, using the pools both for navigation and for reservoirs, and constructing additional reservoirs at the sources of the Monongahela and the Youghiogheny.

It is unnecessary to enter into an examination of the plan of improvement which consists in constructing a continuous bank for the whole distance from Pittsburg to Cincinnati, forming a contracted channel of sufficient width to maintain a uniform minimum depth of 6 feet. This plan is no doubt practicable, but the cost would be more than double that of alternate pools and channels, and the advantages not as great.

The opinion is generally entertained that the plan of improvement, by the construction of a slackwater navigation, is the only one practicable. It is almost unnecessary to remark that this is not the opinion of the writer; he is satisfied that the true plan, for the best improvement of the navigation, differs from any that has yet been proposed, and consists of a succession of pools, formed by low dams of from 6 to 10 feet, connected by open channels, not less than 200 feet wide, through which the water will flow, free from locks or any other obstruction, at the moderate velocity of 2 miles per hour.

Preparatory to the construction of any improvement, or to any positive decision upon the plan to be adopted, it would be expedient to make a careful survey of the river at its lowest stages, or consult the records of previous surveys, to obtain an exact longitudinal profile of the channel. In addition to this, surveys should be extended along all the principal tributaries of the Ohio, to determine the proper locations of the reservoirs, which must be relied upon to supply the deficiency in low water. If, after such examination, it shall be found that suitable locations exist for retaining reservoirs sufficient in capacity to make a material abatement to the heights of the floods, the construction of such reservoirs would appear to devolve as a duty upon the general government; it would not be a subject in which the State of Pennsylvania, or any company incorporated for the purpose of improving the navigation, would have any special interest.

In the construction of the improvement, the dams could be so located as to form slackwater and capacious basins at all the principal towns on both sides of the river; and the open channels should, of course, be made where the fall of the stream is greatest.

Such an artificial navigation would be without an equal in the world. A canal, or portions of canal, 200 miles in aggregate length, between Cincinnati and Pittsburg, 200 feet wide at the water-line, with intervals of 300 miles of slackwater, with no locks or other obstructions, and no impediments to the descending navigation, would constitute the richest boon that could be offered as a tribute to the inland commerce of the nation.

Such an improvement, the tonnage capacity of which would be almost unlimited, could be constructed at a cost less than one-fifth of an equal length of railroad, and less than the cost of a slackwater navigation, such as the Ohio would require.

It will, no doubt, be offered as an objection to this plan, that the banks will be liable to injury from floods, and from ice-freshets. To this it may be answered that they lie not across but in the direction of the channel; that the current is always moderate; that the exposure would not be as great as that of the canal banks on the improvements along the rivers of Pennsylvania, which are rarely injured, even when entirely submerged; and that a coating of stone, placed by hand, upon the slopes, will be an effectual protection. The facilities for obtaining and transporting all kinds of material upon the river, would reduce the cost of the banks within moderate limits, and no mechanical work would be required upon the whole improvement, except at the dams, where it would be of the most inexpensive character.

By making the banks 10 feet high, the period during which they would have been submerged, or in which the depth of water was not less than 10 feet, appears from the record to have been as follows:—

In 1843	. . .	123 days.
" 1844	. . .	76 "
" 1845	. . .	51 "
" 1846	. . .	104 "
" 1847	. . .	124 "
" 1848	. . .	97 "
		485 "
Average	. .	81 days each year.

The course of the embankment should be marked by buoys, to prevent boats from coming in contact with it. There is, however, but little danger from this cause, as the shore would always be a certain guide—the direction of the bank being parallel to it.

The fall of the Ohio, between the principal points, is as follows :—

		Miles.	Ft.	In.		Whole fall. Feet.
From	Pittsburg to Beaver,	26	1	$1\frac{8}{10}$	per mile =	30
"	Beaver to Wheeling,	62	0	$9\frac{1}{2}$	"	49
"	Wheeling to Marietta,	90	0	$6\frac{53}{100}$	"	49
"	Marietta to Le Tart's Shoals,	31	0	$6\frac{17}{100}$	"	16
"	Le Tart's Shoals to Kanawha,	55	0	$7\frac{26}{100}$	"	33
"	Kanawha to Portsmouth,	94	0	$6\frac{13}{100}$	"	48
"	Portsmouth to Cincinnati,	105	0	$4\frac{30}{100}$	"	42
"	Cincinnati to Evansville,	328	0	$4\frac{10}{100}$	"	112

By an examination of the above table, it appears that the fall from Pittsburg to Wheeling is nearly one foot per mile, while the supply of water is, of course, less than at Wheeling. As it has been shown that the supply of water at Wheeling, with a 2 feet 8 inch stage, would be just sufficient to maintain navigation in a channel 200 feet wide and 6 feet deep, with a slope of 1 foot per mile, it follows, necessarily, that the quantity at Pittsburg will be insufficient, even if the channel be made continuous all the way to Wheeling. In this case the assistance of reservoirs or the construction of a portion of slackwater, would be indispensable. If a slackwater be adopted between Wheeling and Pittsburg, the dams could be made high enough to act as retaining reservoirs, to supply the channel below Wheeling; but it is probable that the advantages of a perfectly free and unobstructed navigation would give a preference to the Alleghany as the location of the reservoirs, leaving no locks below Pittsburg, unless they should be required at some of the great falls, as at Louisville, where it is not probable that any other plan could be successful.

If it should appear, after a careful survey and examination, that locations can be found on the streams above Pittsburg of greater capacity than we have supposed probable, and if these reservoirs can be constructed at moderate cost, this fact should modify the plan of the improvement, and the channels which connect the pools could be made either wider or shorter. An increase in width, retaining the velocity of 2 miles per hour, would be preferable to a reduction in length, but it would, of course, be more expensive.

LOW DAMS WITH RETAINING RESERVOIRS.

Finally, it is possible to convert the whole bed of the Ohio, from Pittsburg to Cairo, into a succession of retaining reservoirs, so contrived as to oppose no impediment to free navigation at low water, which would be a great improvement upon the ordinary slackwater, which requires locks and gates at all times.

To illustrate this plan, suppose dams 20 feet high are erected at suitable points, the required depth for navigation being, as before, 6 feet.

The communication from one pool to the next will be, as before, by means of the canal with slope of one foot per mile. A pair of gates and lock-chamber would be placed in the upper part of this canal, so arranged as always to discharge, by a self-acting apparatus, the quantity of water requisite for the canal. Whenever the depth is above 6 feet, this lock would be used in the ordinary way. When not above 6 feet, the gates would be thrown open, and boats pass without detention.

As one or two of the upper dams would be sufficient to retain the water necessary for navigation, and the lower ones would be useful only to control the floods, they should be so constructed as to discharge rapidly down to the level of navigation, that they may be self-acting and always ready. Such a series of dams, continued from Pittsburg to the mouth of the Ohio, would retain at least 100,000,000,000 cubic feet.

According to Mr. Ellett's calculations, a discharge of 35,000 cubic feet per second, continued during 60 days of high water, would raise the surface of the Mississippi, below Red River, 12 inches during the whole of that period. This quantity is equal to 177,000,000,000 cubic feet. The Ohio reservoirs, therefore, if in action at the time of the Mississippi flood, would reduce the surface 7 inches, which

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would be a very important reduction in that stream. A similar system of improvement extended to the other tributaries of the Mississippi would completely neutralize the effects of flood, and give permanent security to the inhabitants of the lower Mississippi.

Any improvement for the prevention of floods can only be made with propriety by the general government, as the benefits to result from it are not local, but national, affecting interests thousands of miles distant to a much greater extent than in their immediate vicinity. It is a favorable circumstance that such arrangements for the conversion of the bed of the Ohio into reservoirs, can be made at any future time, without affecting a previous improvement by the system of low dams and open canals; additions to the works will be required, but nothing need be lost. The control of the floods, therefore, may be left to future legislation. It will be sufficient at present to attend to the improvement of the navigation. The accomplishment of this object will be glory enough for one generation.

A brief review has been given of the various plans suggested for the improvement of the Ohio, for the purpose of presenting the subject to those who are interested in the consummation of such an enterprise, and of eliciting an interchange of opinions from gentlemen who have given it their attention. A more important benefit could not be conferred upon the State of Pennsylvania than the completion of such an improvement. The extinguishment of the State debt, desirable as it is, would be a benefit of less value to our citizens than the gift of an uninterrupted 6 feet navigation of which Pittsburg would be the terminus. Upon such an object, labor will be well expended, and, if the efforts are unsuccessful, they cannot be injurious. It will be understood that the plans presented are mere suggestions, not based upon any positive data, but offered for the purpose of eliciting inquiry and examination.

The object sought is a permanent 6 feet navigation in the lowest stages of the river. The problem is to determine the best and cheapest mode for its attainment. Were it to cost twenty millions, the expenditure even then would be small in comparison with the advantages that would result from it; but one-fourth of this sum will probably suffice. Hundreds of millions have been expended upon railroads which collectively will not accommodate a greater tonnage.

It was the intention of the writer to review more in detail the government operations, and availing himself of the results of surveys, to adapt the plan of improvement to the localities as they exist, instead of confining himself to general principles. Also to enter into an exposition of a plan of organization, of the principles which should regulate the management of the improvement, and the rates of tolls; to present statistics of the present business of the Ohio and Mississippi, its probable increase, and the effect of the improvement upon it; the importance of such a national highway, in case of war, and other subjects connected with the proposed improvement; but all of these must be postponed for a period of greater leisure than is now afforded; if not taken up by others better prepared to do them justice, they may form the subject of some future publication.

Whatever plan may be adopted, it will be obvious to every one who has observed the evils of public management that the improvement should not be operated by the general government, or controlled by any State administration. Were there no other precedents, that of Pennsylvania, with her State works, should be sufficient to show that improvements of any kind managed by State or government officials become political machines, engines of widespread corruption, contaminating all who are brought within their influences, and notorious illustrations of extravagance and mismanagement. Millions have been expended upon the public works of Pennsylvania; every year the reports of State officers have shown a fair balance of net receipts, consoling to unsophisticated tax-payers; but when the results of operations from the beginning are examined, when estimates are added for deterioration, renewals, and repairs, the discovery is made that the whole system has not yet paid a cent, and that the interest on the debt incurred in the construction of their works has been paid by revenues derived from the odious process of taxation.

We are almost prepared to exclaim, better let the Ohio remain forever unimproved, than, if improved, be managed and controlled by partisan agencies.

We fully concur in the opinion expressed by the Hon. Jeremiah Black, of the Supreme Court, that the improvement should be made and managed by a company. This company should be formed of citizens, and under a charter approved by all the States bordering on the Ohio. Let Pennsylvania, at the present session, and as early as possible in the session, take the initiatory by granting a proper charter; other States will no doubt follow suit. The general government can well afford to make a liberal appropriation in consideration of being forever released from the present annual expenditures. The States immediately interested should do something, and be entitled to a representation in the direction, and individuals would do the rest. Upon this improvement, the rates of toll should be restricted to such an extent as to afford no greater revenue than will suffice to keep the work in proper condition, and pay the individual stockholders moderate dividends. Any appropriations made by the general government should go to reduce the tolls, or abate them altogether upon certain articles.

It is not probable that the improvement will ever be completed unless it is undertaken by a company;

and, if completed, the experience of the past warrants the opinion that it would be sure to be mismanaged; but no company should be allowed to enrich itself at the expense of the nation. Stockholders should receive a full and just remuneration for their capital, but no more.