in a favorable stage, as compared with the slackwater navigation, the difference of time in a round trip would be trifling; and in low water, that difference would be in favor of the slackwater. There are various other considerations which the intelligent communication of Captain Batchelor cannot fail to suggest to the reader, some of which have been discussed in the text. The equalization and reduction of the cost of freighting which will surely attend the opening of the slackwater navigation, is not the least among them.

While the season of 1856 was remarkably unfavorable for river business on account of long continued low water, causing immense losses to merchants, manufacturers, and others, and curtailing and injuring the coal trade; that of 1857, owing to a better supply of water, has been quite favorable. As a consequence, the commercial and other interests along the river have been in a highly prosperous condition, and the coal business has been greatly stimulated. This extensive business will this year exceed a million of tons, and quite a large proportion of it is now carried on by means of *barges*, even with the river in its natural state; so that what was considered experimental a few years ago, is now an established custom. It needs only a constantly reliable navigation to render it universal.

Appendix E.—Respecting the Improvement of the Mississippi River.

The United States Government has been engaged for several years, in the execution of a plan for improving the lower rapids of the Mississippi.

These rapids are designated as the "Des Moines rapids" or "lower falls." They extend from Montrose to Keokuk, at the extreme southeastern corner of Iowa, and occupy about 12 miles of the river.

The total fall in this distance is 24 feet, or an average of 2 feet per mile—divided between a number of ripples and pools.

The stream is from three-fourths of a mile to one mile in width.

Its bed is solid limestone rock; not in one smooth even declivity, but disposed, as just intimated, into *comparatively* level parts, and intervening broad flat ridges, extending across the stream; partially broken by a very irregular winding channel, which in low water becomes useless.

In very low water, vessels drawing two feet cannot pass. During floods, and generally for about two or sometimes three months of the spring and early summer, steamers drawing four feet, or more, can ascend and descend; and during this period, the immense rafts of timber and lumber from the upper waters, float safely over. But usually, for the remainder of the year, even light steamers are compelled to run the falls empty, while the freight is conveyed by lighters, drawn by horses. Occasionally, of late years, small steam tugs, instead of horses, have been used part of the time.

During the present year (1857), a railroad has been opened along the west bank of the river from Keokuk to Montrose, 11 miles, affording a new conveyance for passengers and freight, *around* the falls. This is the first completed division of the Keokuk, Mount Pleasant, and Muscatine Railroad.

About 10 years ago, a company was incorporated under the laws of Iowa, with authority to construct a *hydraulic ship canal* around the rapids. Surveys, maps, estimates, and reports, were made. Nothing more has yet been done, except to continue the company in being.

The plan adopted by the General Government is, to blow out the rocks under water, so as to form an artificial channel through the flat ridges, sufficiently wide and deep for the convenient passage of steamers and other craft, at all times.

Although several years have elapsed since this work was commenced, and many thousands of dollars have already been expended, very little has yet been accomplished. Nothing that is yet of any practical use. It is evident to those who have had opportunities of witnessing the scene, and the operations, knowing the short period each season during which they can be carried on, that many years of tedious and costly labor will be required to complete a channel on this plan. When completed, the channel would be crooked; and although steamers might ascend it safely, some trouble would be encountered in descending. It is doubtful whether the large rafts could be navigated through it at all.

The effect of cutting such channel, or channels, through the ridges, (which are in fact rock-dams) must necessarily be, to *reduce the natural depth* in the intervening pools, and on the ridges, and in all parts of the stream, except immediately in the channels. In the channels, the depth must be increased, though not to the full extent of the excavated depth; while, at the same time, the velocity of the flow through the channel will be greater. The worst effect will be, the reduction in the depth of water *above the head of the rapids* at Montrose, and for some distance above. This may prove to be a serious evil, inasmuch as there are shoals on that part of the river which will not admit of any reduction in the depth of water over them without permanent injury to the navigation.

A more philosophical, and the writer thinks, a more feasible and much cheaper plan, admitting of completion in one, or at most two seasons, would augment the depth in the channels, and increase the depth on the shoals immediately above the rapids. Thus, instead of attempting to blow out a channel through the solid rock ridges, let the channel be formed by bolting timbers (on the ridges,) across the stream from either shore; leaving a given width, say 500 feet, near the middle, or in the most convenient part, in its natural state. Suppose three lines of square timber laid side by side bolted to the solid rock; two lines of timber bolted on this lower course; and one line of timber bolted to the second course; we have a solid timber dam, say 3 feet high above the top of each ridge. This would raise the water at each ridge not less than 2 feet—perhaps $2\frac{1}{2}$ feet or more, and afford 4 or 5 feet depth from one end of the rapids to the other, at the same time raising the water at the head of the rapids, not less than two feet above the low water height. Assuming the river to have an average width of 4500 feet, and that there should be eight such semi-dams, it would take 192,000 feet lineal of 12 inch square timber at 30 cents per foot; and allowing 270,000 pounds of wrought bolts, at 15 cents per pound, and twenty per cent. for contingencies, the entire cost would be but $153,720!

Another mode of improving these rapids is, by means of a *single dam*, raising the water 24 feet at the lower end, with two locks of 12 feet each, which is entirely practicable, at a cost of less than a million of dollars!

Ultimately, should the General Government fail to improve these rapids radically; and perhaps in any event, the hydraulic ship canal will be constructed on the Iowa side by the company named, affording one of the most magnificent water powers in the world, and giving a constant reliable navigation. A small portion of the surplus water will be used in supplying the growing City of Keokuk with pure wholesome water. Is there any good reason why the government should not construct this canal?

ERRATA.

Page 23, line 12—after the word "*even*" there should be a comma.
" 17—for "*shores and*" read "*thousand.*"
24, " 8—for "*cleaning*" read "*clearing.*"
26, " 6—for "*cleaning*" read "*clearing.*"
76, " 15—for "*high*" read "*height.*"
78, last line for "*draughts*" read *droughts.*'
80, line 17—for "*draught*" read *drought.*"
80, " 20—for "*foot*" read "*feet.*"
84, " 20—the semicolon should be a colon.

For the Journal of the Franklin Institute.

*On the Calculation of Road Excavations and Embankments, when the Ground is a Warped Surface.** By W. M. Gillespie, LL. D., Professor of Civil Engineering in Union College, N. Y.

When an engineer is laying out a road or railway, he has to determine the amount of earth necessary to be removed in making the "cuts" and "fills" of the road. To do this, his most usual course is to take "cross sections" or "profiles," of the ground at right angles to the line of road, at convenient intervals, and then to calculate by various methods, commonly near approximations, the volume included between each pair of these cross-sections. The distances apart at which these cross-sections are taken, are determined by the engineer according to the nature of the ground; his aim being that there shall not merely be no abrupt change of height between each pair of these cross-sections, but that the surface from one to the other shall *vary uniformly;* gradually passing, for example, from a small to a great degree of slope, or from a slope to the right into a slope to the left, without any sudden variation at any one place.

The surface fulfilling this condition of varying uniformly, since it is everywhere straight in some direction, is evidently a *ruled surface;* and since the extreme profiles are seldom parallel, it will be a *warped* or *twisted* surface.

Our engineers have been accustomed to consider these surfaces as not admitting of precise calculation, but only of a degree of approximation

*An abstract of the earlier portion of this paper was read at the late Montreal meeting of the "American Association for the Advancement of Science."