hollow tile instead of brick, as was formerly the practice, the foundation being built of concrete reinforced with steel.

The hollow tile were specially made for the purpose, were radial, 6 x 12 x 12 in size, hard burned, salt glazed, and laid with wire mesh in the joints, in cement mortar one to two. The finished stack is shown in Fig. 1, resting on its octagonal base, and extending to a height which makes a telegraph pole look like a toothpick. Owing to the numerous air cells formed in the walls of the stack by the countless dividing partitions of the hollow tile, there is no perceptible heat loss from the stack. This conservation of heat increases the draft of the chimney, so that the capacity is far beyond the ordinary rated capacity of a stack of this height and diameter. These air spaces further lessen the weight of the stack by many long tons, which in turn reduced the liability to lean or settle, over a stack of ordinary weight. At the same time the strength of the structure is increased by the less number of joints, and the radial shape of the blocks which makes them fit and interlock together. The cost of the stack was not considered, for efficiency and stability were the main requisites. Incidentally, though, the cost of the stack was much less than would be a like chimney built of bricks, and there was a further saving in time, the entire stack above the ground level having been built in about seven weeks.

RIVER IMPROVEMENT BY REGULATION AND DREDGING.*

By Major Wm. W. Harts.

In undertaking any river improvement for the benefit of navigation many considerations necessarily enter into the determination of the methods to be followed. It sometimes occurs that the solution is so obvious as to be self-determining, as at the Cascades of the Columbia River, where the advantages of a short lateral canal across a convex bank were so plain as to practically exclude other methods from consideration, but in the usual case there is a choice among several methods and usually considerable study is required to select the most suitable. This selection often depends more on the character of the river than it does on the nature of the use to which the work will be put.

For example, at Rock Island Rapids in the Mississippi River, where the channel has been successfully used for many years as the result of open river regulation, it was at first thought that a lateral canal would be necessary and such an improvement was proposed, even for the depth of 4½ ft. then needed. But a fuller study of the problem showed that the character of the river was such that the needs of navigation, as then existing, could be adequately met in an artificial open waterway supplemented by dikes and other contraction works.

The influences affecting the choice of a method of river improvement are changing, being constantly modified by later experience and by newer and better mechanical appliances. From present tendencies there seems small doubt but that in many instances lateral canals would probably no longer be so freely chosen at the present day as formerly, but that some type of canalization would be adopted instead if the project were up for determination anew.

The reasons which may incline the engineer to the selection of any particular type of improvement may be analyzed with advantage. The marked advance in recent years in the efficiency of machinery for excavation is one of these reasons which has more or less changed the economy of channel building and has had its effect on the choice of methods to be followed. Many harbor channels that originally could not be deepened owing to the high cost of effective improvement are now being dredged to depths suitable for deeper draft vessels. In New York harbor the Ambrose Channel, seven miles long, 2,000 ft. wide, and 40 ft. deep, is being dredged with sea-going hydraulic suction machines at the surprisingly low total cost of 5.4 to 5.7 cts. per cubic yard. (Professional Memoirs, Engineer Bureau, U.S. Army, January-March, 1909, pp. 61-62). Some years ago it was believed by many engineers that an effective entrance channel to this harbor could only be secured permanently by the adoption of protecting jetties of rip rap. The high cost of such work and its physical difficulties deterred engineers from undertaking it for a long time, and only within recent years has the construction of the entrance channel been considered economically possible, mainly through the greater perfection of dredging machinery.

This same tendency is felt to a certain degree on our rivers, and our ideas of improvement are likewise undergoing some readjustment, both as to practicability and as to choice of methods. Although this choice is often not as free as might be liked, since local conditions sometimes place narrow limits upon it, still, whenever one of several plans is to be selected for adoption the changing circumstances must be borne in mind.

For example, soft digging with a dipper dredge was done on the lower Tennessee River in 1910 for 3.6 cts. per yd., place measure, including all current field expenses, but excluding extensive repairs, plant cost and overhead charges. At Muscle Shoals Canal a record of 19 years shows that sediment has been removed from the canal at the same average cost, with a ladder of continuous bucket dredge. Including all charges the cost has been 5.16 cts. per yard at the latter place. In excavating through rock ledges exceptionally reasonable work has been done at Allens Bar, near Hobbs Island, where the entire cost, including blasting, dredging, loading on barges and dumping in dikes amounted to only 28.1 cts. per yard, including all current field expenses. These low prices are undoubtedly largely due to careful management, but improved machinery is nevertheless the important factor.

Before discussing the methods of river improvement, it may be desirable to enumerate the various classes of work used. The four principal divisions of river improvement methods are as follows:

(1) Contraction, including the use of spurs, sills, training walls and bank protection.

(2) Excavation, including dredging.

(3) Canalization, including locks and dams; and

(4) Lateral canals.

These methods are all well recognized and are in extensive practical use to-day. To these is sometimes added a fifth—reservoirs.

Engineers are ordinarily largely guided by their prepreferences for certain classes of work, usually those met with in their own experience, and are often inclined to look with some disfavor on methods with which they are less familiar. But it would undoubtedly be best to recognize at once the good points of each tried method and combinations of two or more of them whenever found by experience to be advantageous. Untried theories and purely experimental modes of improvement will usually not receive extensive application at the hands of practical men.

On one point, however, most engineers will doubtless be agreed, i.e., that the navigable part of the river must be studied as a unit rather than piecemeal, and work must be

*Abstract of paper delivered before International Congress on Navigation.