

provement to the St. Croix, Chippewa and Wisconsin Rivers, which were examined several times a few years later by engineers' boards. (Annual Report, Chief of Engineers, 1887, page 1692.)

It is stated that early in the last century the plan was adopted to some extent in France for the control of floods, and in 1856, after a flood of unusual destructiveness, it was thoroughly studied, more particularly with reference to its applicability to the Rhone, Seine, Garonne and Loire. As a result of this investigation it was decided not to construct the reservoirs proposed for these streams owing to the "uncertainty and doubtful efficacy of their action." In 1881 this system was definitely abandoned by the Corps de Ponts et Chaussées and its use for the control of rivers condemned in France. (Annales des Ponts et Chaussées, 6 sem., vol ii, 1881.)

The plan was proposed for the improvement of the Ohio in 1873 but was not favorably considered after careful investigation. The board in whose hands this investigation was placed stated "The first of these plans (viz., storage reservoirs) the board deems impracticable on account of the difficulty, if not impossibility, of finding locations for the necessary reservoirs, the immense cost of the system, its interference with navigation of the tributaries on which the dams are located, its injury to agricultural, mining, and railroad interests in the valleys of these rivers, the difficulties of regulating the supply from the reservoirs, and the terrible effects that could be caused by accidents." (Annual Report, Chief of Engineers, 1873, p. 541.)

Table IV.—Cost of Lateral Canals.

Location.	Length, miles.	Locks.	Cost, FRANCE.	Cost per mile.	Cost per reach.	Operation and Care. Cost.	Cost per mile.
Loire, Dizion to Briare.	121.7	37	\$10,355,000	\$ 85,000	\$ 280,000	\$ 31,650	
Garonne	120	53	12,420,000	103,500	235,000	37,500	312.50
UNITED STATES.							
St. Marys Falls.	1.1	2	\$ 8,057,252	\$7,324,775	\$8,057,252	\$103,096	\$93,723.00
Des Moines Rapids.	8	3	1,553,045	197,880	791,323	38,772	4,846.00
Muscle Shoals.	18	11	3,151,726	177,318	290,157	51,420	2,856.00
Colbert Shoals.	8	1	2,207,941	275,993	2,207,941		
Cascades Canal.	7½	2	3,820,325	7,640,650	1,910,162	14,379	28,758.00

In 1909 the plan was again suggested to a board of engineers having in their charge the project for the improvement of the Mississippi River, and again the plan was abandoned for lack of sufficient reservoir sites, high cost, and uncertainty of action. The board stated in its report that "In order to use this reservoir system for the benefit of the improvement of the river below St. Louis it would be necessary to commence the discharge at the reservoirs at least two months before it was needed at St. Louis, and a still greater interim would be necessary for the benefit of the improvement of the river below Cairo. Experience does not justify such long forecasts, and the service of the reservoirs would necessarily have to be based on general annual averages, an unreliable and unsatisfactory basis." The board also stated that "There was no instance on record where this system has been applied with benefit commensurate with the expense." (House Ex. Doc. 50, 61st Congress, 1st Session, p. 17.)

More recently while a project for the improvement of the Ohio River was being considered by a board of river engineers, a reservoir plan was brought forward by some officials of the U.S. Geological Survey who urged its adoption. Their preliminary estimate of cost of the reservoir project was given as \$125,219,000, which was later admitted to be much too small. It was found on more detailed examination that the cost would likely be nearer ten times this amount. The enormous cost of the reservoir plan and the uncertainty as to its successful operation, combined with its unsuitability to the topography of the Ohio River Valley, were reasons for its rejection and for the selection of the cheaper and more certain method of improvement by canalization, using movable dams. The estimated cost of the adopted plan for 9-ft.

depths by locks and movable dams is about 63¼ million dollars.

The general impression among river engineers in America seems to be that storage dams for the benefit of navigation alone will never be warranted. Similar dams have been constructed in many places for industrial purposes, such as power development and irrigation; but these purposes are not always in harmony with channel improvement, and the incidental benefits likely to be received on navigable streams from dams built for several combined purposes cannot always be determined in advance nor their value accurately estimated.

If an added flow at low water be furnished from such dams, the valuable scouring effect of low water may not be obtained without a supplemental series of contraction works at further additional cost, and the increased discharge may not mean increased depths on many sediment-bearing streams. For example, on the Mississippi, where much material is rolled along the bottom, bars often rise and fall with the gage heights, the low water being largely relied on to restore the channels in such cases.

Then, too, the location of the dams on the tributaries would usually be such as to intercept much of the flow of silt in suspension in the portion of the stream where the scour is greatest. In no other way could the water be clarified. This clarification is an assumed advantage of the reservoir system that has often been mentioned.

There is no known way of safety and easily removing silt from behind storage dams, more particularly if it is expected to do so without much injury to the river channels below. A constant diminution in storage capacity would be one of the inevitable results of the system, or an injurious deposit in the lower channels it is intended to benefit.

Notwithstanding these disadvantages, there may occur special cases where some incidental benefit may be derived, but experience seems to point out that such benefit will hardly ever be sufficient to very strongly influence the location of any storage dams or warrant any considerable portion of the cost being borne by the navigation interests.

As a summary of this discussion, the following conclusions are briefly stated:

1. Regulation in some suitable combination with channel excavation should always be first studied as a method of river improvement and adopted in all cases where economically applicable. It will be oftenest used wherever the funds available are small in amount, the increase of depth needed not great, the river flow comparatively large, the banks low and the width of the river considerable, velocities low and regimen more or less fixed.
2. Canalization with movable or fixed dams will be adopted wherever regulation with channel excavation is insufficient or unsuitable. It will usually be applied where the slope is steep, discharge small, and depths obtainable by regulation insufficient.
3. Lateral canals should never be selected for use unless imperatively demanded by the local conditions.
4. Reservoirs are too uncertain, too unsafe and too expensive for exclusive use in river improvement. They will seldom be relied on, except in special cases in connection with other enterprises where their use for industrial purposes warrants the cost and the water flow can be sufficiently controlled to operate beneficially on the channels.

Messrs. Sydney V. Kendall and Leonard Martin, F.R.I.B.A., architects, of London, England, have won the award in the competition conducted by the Toronto Housing Company, for plans of houses for the development of the company's land in the east end of Toronto.