commenced in this country. Except the Rhone and the Loire, nearly all the improved rivers of France are canalized, about 970 miles in all; and in Germany, where there are nearly five times as many miles of open as canalized rivers and regulation finds its warmest advocates, but little new regulation work of importance has been done since 1875. In Belgium there are four times as many miles of canalized rivers as open rivers. (Royal Commission, Waterways and Canals—Lindley.)

A fair conclusion is that the present tendency is toward the selection of canalization whenever a new system is to be chosen, particularly if the examination of the natural and economic conditions shows regulation to be inapplicable. It also seems that lateral canals are not now being regarded favorably unless the local conditions unequivocally indicate the necessity of their adoption.

The theory of the use of reservoirs as an exclusive mode of improving rivers for navigation is an old one practically abandoned now in this country by river engineers but revived from time to time by its advocates and sometimes made the subject of an academic discussion of considerable seriousness. At first glance the theory is very engaging, but experience in its application has been in the main unsatisfactory and its applicability depends on many assumptions which are themselves of doubtful tenability.

Table II.—Cost of Canalization.

River.	Length canalized part.	No. of locks.	Depth, feet.	Total cost.	Cost per mile.	Average length of pool.	Cost per reach.	Operation and Maintenance. Cost.	Cost per mile.	Cost per lock.	Fall per mile in feet.
FRANCE (British Waterways Commission).											
Saone	232	30	8.2	$ 8,765,000	$ 37,750	7.7	$ 292,000	$ 60,500	$ 261	$ 2,017	0.85
Seine, Montereau to Paris	61	12		4,955,000	81,500	5.1	413,000	54,350	891	4,528	
Seine, Paris to Rouen.	145	9	10.5	17,500,000	121,000	16.6	1,945,000	92,250	636	10,250	0.85
Seine, new works	140	9	*	12,675,000	90,500	15.5	1,410,000	......	...	.....	
Yonne	67	26		5,590,000	83,500	2.6	215,000	33,650	502	1,294	2.43
Marne	113.5	19	7.25	5,235,000	46,250	6.0	275,000	39,900	352	2,100	1.16
Aisne	35.5	7		970,000	27,350	5.1	138,500	10,650	300	1,521	
Scarpe	5	2		775,000	155,000	2.5	387,500	5,000	1,000	2,500	
Average, France					$ 80,355		$ 634,500	$ 42,329	$ 563	$ 3,459	
GERMANY (British Waterways Commission).											
Saar	19.5	6	4.25- 7.9	$ 1,772,000	$ 90,850	3.2	$ 295,300	$ 32,050	$1,650	$ 5,350	2.15
Main	23.5	5	5.9 - 8.9	2,241,000	95,350	4.7	448,200	40,050	1,700	8,000	1.40
Fulda	17.0	7	6.6 -11.9	785,000	46,200	2.4	112,150	21,925	1,300	3,125	3.30
Salle	89.5	15	4.4 - 8.8	1,917,000	21,400	6.0	127,800	45,400	500	3,025	1.27
Unstrut	40.5	12	2.5 - 8.5	528,000	13,000	3.4	44,000	14,200	350	1,175	1.72
Oder	53.2	14		6,059,000	113,900	3.8	432,800	217,100	4,075	17,000	1.90
Average, Germany					$ 63,350		$ 243,375	$ 61,787	$1,596	$ 6,279	

*Over 10.5 feet up to Paris.

The possibility of conserving the high water flow of rivers, thus reducing injurious floods and later using the stored supply during the low stages for the benefit of navigation, is fascinating alike to layman and theorist, and offers a wide field for speculation. But the attempt at practical application usually introduces virtually insurmountable difficulties.

The theory takes it for granted that sites for reservoirs, ample in number and capacity, can be obtained without greater injury to railroads, factories, towns and valuable private possessions than the benefits to be obtained for the public; that enough high dams can be safely built at reasonable cost free from danger of a breach operated intelligently and efficiently in order to create the necessary storage space for regulating the discharge. It assumes further that these reservoirs are not likely to be soon filled with silt but are practically of permanent usefulness. It assumes that increased discharge in the rivers means increased depths, and that precipitation may be foretold with sufficient accuracy to permit successful regulation. All of these assumptions are more or less debatable and some of them are plainly of doubtful reliability.

The reservoir theory has never been practically applied on a large scale as an aid to navigation except in two cases, and the results there have not been encouraging. It was early adopted on the headquarters of the Msta and Volga Rivers in Russia, where its use was the outgrowth of very favorable natural conditions. These rivers, flowing in opposite directions, take their source in a lake and swamp region at an elevation of 665 feet above sea level where land was cheap and unfit for agriculture. Here the construction of low, cheap dams was an easy task, resulting in increasing the reservoir effect very greatly without the necessity of obtaining new storage sites or going to much expense for dams and regulating works. A natural reservoir system was in fact already in operation, needing only a little artificial regulation. The capacity of this system is 35,000 cubic feet with dams only 17.5 feet high. (Reservoir sites in Wyoming and Colorado.—Chittenden.) It is usually considered a fairly efficient work in lengthening the season of navigability of the two streams.

Table III.—Cost of Canalization in the United States.

(U.S. Inland Waterways Commission, 1908.)

River.	Length canalized part.	No. of locks.	D'p'h ft.	Total cost to U. S. up to 1907.	Cost per mile.	Av'ge length pool.	Cost per reach.	Operation and Maintenance* 1909 Cost.	Cost per mile.	Cost per lock.	Fall per mile in ft.
Black Warrior	91	7	6	$2,540,397	$27,916	13	$362,914	$126,034	$1,385	$ 9,700	2.76
Coosa	25	3	8	1,048,438	41,933	8.3	349,479	7,934	317	2,645	2.58
Allegheny	25	3	..	1,337,869	53,514	8.3	445,956	46,639	1,865	15,546	2.05
Monongahela	131	15	7-8	6,845,857	52,258	8.7	456,390	173,364	1,323	11,557	2.4[5]
Muskingum	84	10	6	1,837,625[1]	21,876	8.4	183,762[1]	50,130	597	5,013	1.55
Little Kanawha	48	5	4	388,020[2]	......	9.6	77,604[2]	8,040	167	1,608	1.23[6]
Great Kanawha	90	10	6	4,223,830	46,970	9.0	422,383	84,315	937	8,431	0.84
Big Sandy	27	3	6	1,205,954[3]	44,665	9.0	401,985[3]	15,848	586	5,016	1.43
Kentucky	226	11	6	2,903,309	12,890	20.5	263,846	159,644	706	14,513	0.87
Green and Barren	190	7	5	1,638,410	8,623	27.1	234,059	75,884	399	10,840	0.49
Cumberland	131.4	8	6	2,625,380[4]	19,980	18.5	328,172[4]	33,055	252	5,509	0.67
Illinois	194	2	7	1,515,721	7,813	48.5	757,861	14,840	765	7,420	0.05
Average in United States				....	$30,762	....	$357,034	....	$ 775	$ 8,149	....

*Annual Report Chief of Engineers, U. S. A., 1910.
[1]Repairs only. [2]Operating cost only. [3]Includes operation. [4]Office records. [5]In West Virginia. [6]About.

The same favorable natural conditions were found on the upper Mississippi River and similar reservoirs were built by the government for improving navigation in the '70's. By constructing low dams across the outlet of an extensive lake area, a storage of 93,400 million cubic feet was accomplished at a total cost of only $678,300. (Reservoir Sites in Wyoming and Colorado.—Chittenden.)

Although the Russian reservoir system was in a measure successful, the effect of these reservoirs upon the Mississippi River at St. Paul, 357 miles below the dams was slight, being from 12 to 14 inches on an average, and 51 miles further down all trace of it disappeared altogether. But the dams were so beneficial for the production of power that when their abandonment by the government was being considered some years later such a course was vigorously opposed by the milling companies and other similar interests benefited, although they contributed practically nothing toward the expense of the work.

The system has never been extended in the United States although often studied. The slight assistance to navigation and the high comparative cost of construction and maintenance were reasons given for not applying this method of im-