THE COMPLETED OHIO RIVER PROJECT

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Location. The early explorers and trappers who ventured westward across the "Endless Mountains," from any point along a line reaching from the mouth of the Hudson River to the mouth of the Chesapeake Bay, found soon after crossing the last range the headwaters of a stream flowing westward. This westward flowing stream invariably led them either to the Allegheny or Monongahela rivers. These streams span a north-south stretch of some 250 miles from southern New York to central West Virginia, and meet where is now located the city of Pittsburgh, Pennsylvania, to form the Ohio River. On this larger stream born of the union of the two, the trader, trapper, or settler might, with scarcely an interruption, float 981 miles on westward to its junction with the Mississippi. Then from this junction point he might proceed up the Mississippi to the Falls of St. Anthony at Minneapolis. If he preferred he could turn westward up the Missouri which would lead him to the very heart of the Rocky Mountains, or he could float down the Mississippi to its outlet into the great ocean by way of the Gulf of Mexico.

These advantages of position, direction, and connections caused the Ohio River very early to become highly important as a line of communication between the East and the ever increasingly important West.

Characteristics of the Stream. The channel of the Ohio varies in width from about 900 feet in its upper reaches to more than a mile near its mouth. The fall in the first 90 miles, from Pittsburgh to Wheeling, is 11½ inches per mile. From Wheeling to Cincinnati the gradient is only five and one-half inches per mile and from Cincinnati to the mouth four inches per mile, except that the river drops 26 feet in two miles at Louisville in what is known as the "Falls of the Ohio." (Rept. of Chief of Engineers U. S. Army, 1929, p. 1235.)

The river is subject to great fluctuations in level at different seasons of the year. The difference between high water and low water level has reached as much as 30 feet at Pittsburgh, 71 feet at Cincinnati, and 54 feet at Cairo. Before improvements were begun, shoals with a minimum depth of one foot were encountered between Pittsburgh and Cincinnati, and of two feet between Cincinnati and Cairo. Shifting channels, rocks, snags, and sand bars made navigation hazardous. Yet in spite of these handicaps, it is difficult to estimate the value of the Ohio River as a highway for the early traders, trappers, and settlers.

Early Navigation. While thousands of flat boats, rafts, keel boats, and all types of primitive craft floated down the Ohio during the early days of exploration and settlement, the real impetus to river navigation got under way with the advent of the steamboat, the first one of which appeared on the Ohio in 1811. The increased speed and reduced cost of travel, especially up stream, brought about by the

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steamboat made it the most efficient means of transportation then devised. By 1840 more than 1,200 steamboats were said to ply the waters of the Ohio. Connections with its own tributaries, and with the Mississippi and its tributaries made Ohio River ports accessible to nearly all the centers of dense population at that time west of the Appalachian Mountains. The only effort at improvement of the river to aid in carrying the large amount of traffic was the operation of snag boats and dredges.

Present Project. The first improvement of the Ohio by building permanent locks and dams dates from 1879, when Congress authorized the construction of a dam and lock at Davis Island, 4.7 miles below the junction of the Allegheny and Monongahela Rivers. In 1890, a second dam, now known as No. 6, 29.3 miles below Pittsburgh was authorized to be built. In 1896 Congress ordered four other dams to be constructed between No. 1 and No. 6. Between 1896 and 1909, funds were appropriated for the construction of seven other dams, including No. 26 just below the mouth of the Kanawha River and No. 37 in the western border of Cincinnati. In 1910 there was submitted to Congress a comprehensive plan of improving the Ohio River to provide a minimum depth of nine feet from Pittsburgh to the mouth by the construction of 54 dams with locks.

The original project has been modified by shifting the position and changing the height of some of the dams, so that it has been possible to eliminate dams No. 40 and No. 42. Dams No. 1 and No. 2 have been replaced by a stationary dam at Emsworth, Pa. Nos. 4 and 5 are being replaced by a stationary dam at Dead Man's Island, 13.3 miles below Pittsburgh. The total number of dams, all provided with adequate lockage equipment, in the completed project is 49. Their location, the period of construction, the amount of lift in each lock, and the cost of each are given in the following table.

LOCKS AND DAMS ON THE OHIO RIVER

No. of Dam	Miles below Pittsburgh	Nearest town or city	Lift Feet	Year construction began	Year opened to navigation	Cost
1	4.7	West Bellevue, Pa. (Removed)	3.1	1879	1885	$870,034 01
	6.2	Emsworth, Pa.	10.9	1919	1921	3,082,743 08
2	9.2	Coraopolis, Pa. (Removed)	7.8	1896	1906	976,766 77
3	11.0	Glenosborne, Pa. (To be removed)	7.7	1899	1908	1,144,588 18
	13.3	2 miles below Sewickley (Dead Man's Island)	13.75	1926	1930	3,668,542 23
4	18.6	Legionville, Pa. (To be removed)	7.6	1898	1908	1,071,472 21
5	24.1	Freedom, Pa.	7.5	1898	1907	1,080,132 04
6	29.3	Beaver, Pa.	6.7	1892	1904	1,123,441 80
7	36.5	Midland, Pa.	6.9	1910	1914	1,075,000 00
8	46.4	Newell, W. Va.	6.4	1904	1911	1,167,456 24
9	56.0	New Cumberland, W. Va.	7.4	1910	1914	1,177,100 00
10	66.2	Steubenville, O.	8.4	1912	1915	1,138,000 00
11	76.9	2.3 miles below Wellsburg, W. Va.	7.3	1904	1911	1,162,164 70
12	87.4	Wheeling, W. Va.	8.4	1911	1917	1,166,103 55
13	96.1	McMeehen, W. Va.	7.3	1901	1911	1,222,389 11
14	114.0	Woodland, W. Va.	8.3	1911	1917	1,132,934 65
15	129.1	New Martinsville, W. Va.	7.8	1911	1916	1,159,951 82
16	146.5	Bens Run, W. Va.	7.8	1913	1917	1,258,644 43
17	167.5	4 mi. above Marietta, O.	8.2	1913	1918	1,344,915 37
18	179.9	4½ mi. above Parkersburg, W. Va.	6.2	1902	1910	911,405 76
19	192.2	Little Hocking, Ohio	7.7	1908	1916	1,213,259 04
20	202.5	Belleville, W. Va.	7.5	1911	1917	935,926 81
21	214.5	Portland, Ohio	5.6	1915	1919	1,475,836 13
22	220.9	Ravenswood, W. Va.	7.8	1915	1918	1,209,216 84

LOCKS AND DAMS ON THE OHIO RIVER—Continued

No. of Dam	Miles below Pittsburgh	Nearest town or city	Lift Feet	Year construction began	Year opened to navigation	Cost
23	231.4	Millwood, W. Va.	8.1	1917	1921	$1,634,005 08
24	242.5	Graham, W. Va.	7.0	1913	1919	1,112,769 28
25	260.7	5 mi. above mouth of the Kanawha River	9.0	1917	1922	1,768,563 46
26	278.5	Hogsett, W. Va.	7.5	1908	1912	1,267,051 23
27	301.0	4 mi. above Proctorville, Ohio	6.4	1918	1923	2,003,295 90
28	311.6	Huntington, W. Va.	7.1	1911	1915	1,047,667 19
29	319.9	Ashland, Ky.	8.0	1911	1916	1,021,923 37
30	339.4	3 mi. below Greensburg, Kentucky	7.5	1919	1923	1,579,617 80
31	359.3	3 mi. below Portsmouth, Ohio	7.5	1912	1919	1,217,751 24
32	382.6	1 mi. above Rome, Ohio	7.5	1919	1926	2,950,379 98
33	405.1	3 mi. above Marysville, Kentucky	7.0	1915	1921	1,580,948 16
34	434.1	Chilo, Ohio	5.6	1919	1925	3,437,073 70
35	451.0	1 mi. below New Richmond, Ohio	6.4	1913	1919	1,868,849 88
36	460.9	10 mi. above Cincinnati	7.9	1920	1925	3,708,534 91
37	482.2	Fernbank, Ohio	7.8	1905	1911	1,314,178 60
38	503.3	McVille, Kentucky	7.3	1920	1924	2,857,040 24
39	531.7	1 mi. above Markland, Indiana	6.0	1914	1921	2,222,447 98
41	604.0	Louisville, Ky.	37.0	1911	1921	6,886,445 85
43	633.2	3 mi. below West Point, Kentucky	9.0	1914	1921	2,587,331 33
44	663.2	Leavenworth, Indiana	9.0	1920	1926	2,821,222 82
45	703.0	Addison, Kentucky	9.0	1920	1927	3,028,415 00
46	757.3	Owensboro, Kentucky	9.0	1923	1928	2,987,000 00
47	777.7	Newburg, Indiana	9.0	1923	1928	4,412,400 00
48	809.6	6 mi. below Henderson, Kentucky	9.0	1912	1922	2,666,000 00
49	845.0	2½ mi. below Union Town, Kentucky	11.0	1924	1928	3,085,000 00
50	876.8	1 mi. below Weston, Ky.	8.0	1924	1928	3,600,000 00
51	903.1	Golconda, Illinois	8.0	1925	1929	4,500,033 41
52	938.9	1.3 mi. below Brookport, Illinois	12.0	1924	1928	4,314,000 00
53	962.6	10.8 mi. below Joppa, Illinois	13.4	1925	1929	5,304,000 00

Total number of dams constructed, 53.
Number of dams to be used in completed project, 49.
Total cost of construction, $118,743,405.66.
(Ann. Rept. of Chief of Engineers, U. S. Army, 1929, pp. 1239-1241).

Each dam is provided with a navigable pass at least 600 feet wide which can be closed with movable wickets. (Fig. 1.) These wickets are mostly of the Chanoine type and can be raised or laid down as the neces-

Fig 1. (a) Dam No. 49 located 2½ miles below Union Town, Ky. The "needles" are all in place helping to maintain full pool stage during the drought of 1930.

(b) The lock and a portion of Dam No. 49 and the tender boat. The lock has been filled ready to receive boats from up stream.

sity demands. Each wicket is made of four timbers 12 x 12 inches, the length being determined by the height of the dam. The ones shown in Fig. 2 are 16 feet 11 inches in length and are the type used in Dam No.

37. The four wood beams are bolted to an iron horse which is hinged to the foundation. When raised, the wickets are held in place by an iron prop which weighs nearly a half ton, the weight of the entire wicket is about three tons. By a system of grooves and notches for the prop to slide in, the wickets may be raised or lowered very easily by the tender boat that forms part of the equipment of each dam. To lay the wickets down, it is only necessary to pull back the top of the wicket until the "prop" slides out of the supporting notch and into a groove which guides the end of the prop around the notch as the prop slides forward and lets the wicket lay flat on the foundation. To raise the dam, each wicket is caught on the under side and pulled up until the prop drops into its

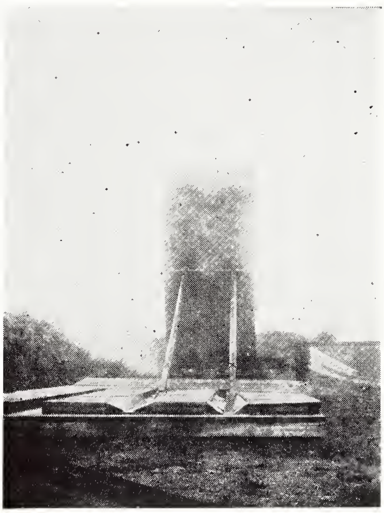
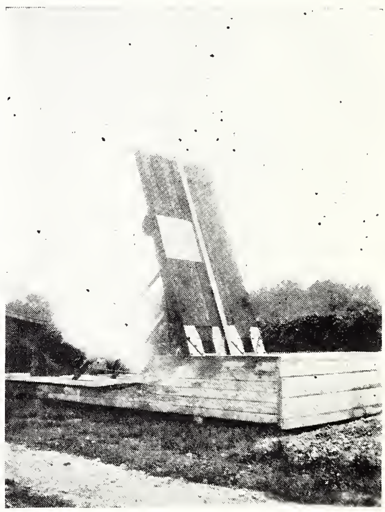


Fig. 2. (a) Down stream view of two Chanoine Wickets as they would appear in Dam No. 37. Shows the "props," their attachment and that of the timbers to the "horses" and the grooves that guide the "props" when the wickets are being raised or lowered.



(b) Up stream view of the same wickets. The "needle" fills the four-inch space between the wickets.

notch, then the pressure of the water forces the wicket into place and holds it there. A wicket may be laid down in two minutes, and a whole dam may be raised in five or six hours.

In operation of the dams to maintain a nine foot depth, the water is never allowed to get much higher than the top of the wickets. The depth of the water in the pool is regulated in most of the dams by outlet valves called "Bear Traps." These may be opened to let more water pass below the dam if the level of the pool tends to rise to heights that would cause too great pressure on the wickets. If the open "Bear Traps" fail to lower the water sufficiently, some of the wickets are laid down to let yet more water pass. A space of four inches is left between wickets. If the water becomes unusually low, as during the drouth of 1930, these spaces are closed by 4 x 4 inch timbers. In extreme need, straw or grass may be packed in back of the needles to still further aid in maintaining full pool depth of water. That the government engineers have efficiently provided for the maintainance of a nine foot depth in minimum low water conditions was well demonstrated during the unprecedented drought of 1929-1931. In spite of the lack of precipitation, all pools were kept at full pool stage throughout the summer of 1930, and no hindrance to navigation throughout the 981 miles of the river could be attributed to low water.

When flood stage approaches or ice flows are to be encountered, all the wickets are laid down and all boats use the open channel. When the wickets are raised all boats must pass through the locks in going either up or down stream. The locks with two exceptions are 110 feet wide and 600 feet long and, for the most part have a lift of 6 to 9 feet.

Dam No. 41 at Louisville differs from the others in that the fall there is greater and water power is developed by the Louisville Hydro-electric Power Co. The entrance to the locks instead of being directly from the river is through a canal two miles long. The construction of a power plant by the Louisville Hydro-electric Power Co. began in May, 1926, and by December, 1927, all eight turbines were in operation. During the fiscal year 1929, the amount of electricity produced was 218,079,810 kilowatt hours. The company built their own plant and hold a 50 year lease of water power rights for which they pay the government $95,000 annually. This dam cost the government, as shown in the table, page 7, $6,886,000. The government receives, therefore, in payment for water rights, approximately one-third the equivalent of 4 per cent interest on its investment in this one dam and locks.

Distribution of Tonnage Shipped on the Ohio River in 1930. A glance at the chart, Fig. 3, shows that most of the traffic hauled on the Ohio River is carried over two main sections. One extends from the source of the Ohio at the junction of the Allegheny and Monongahela rivers to a point about 70 miles down the river. The other section is from the mouth of the Kanawha River to Cincinnati, a distance of about 225 miles. On the remainder of the river there is relatively little traffic, although here and there the amount perceptibly is increased by local supplies of, or demand for, some bulky commodity.

A closer scrutiny and analysis of the statistics shown by the chart discloses, among other things, the following facts:

1. The maximum tonnage on any part of the river is found in the first few miles below its source in the heart of the city of Pittsburgh. Here the tonnage reaches the grand total of 10,300,000 tons.

2. At a distance of some 16 miles down stream the tonnage decreases to about 5,500,000 tons, and at 35 miles down stream to 3,100,000 tons.

3. Between a point 70 miles from the junction of the Allegheny and Monongahela rivers and the mouth of the Kanawha River, a distance of approximately 180 miles, only about 750,000 tons are shipped.

4. Between the mouth of the Kanawha and Huntington, West Virginia, the tonnage increases to 3,600,000, but 50 miles further down stream it drops to about 3,000,000 tons and remains about this amount to Cincinnati.

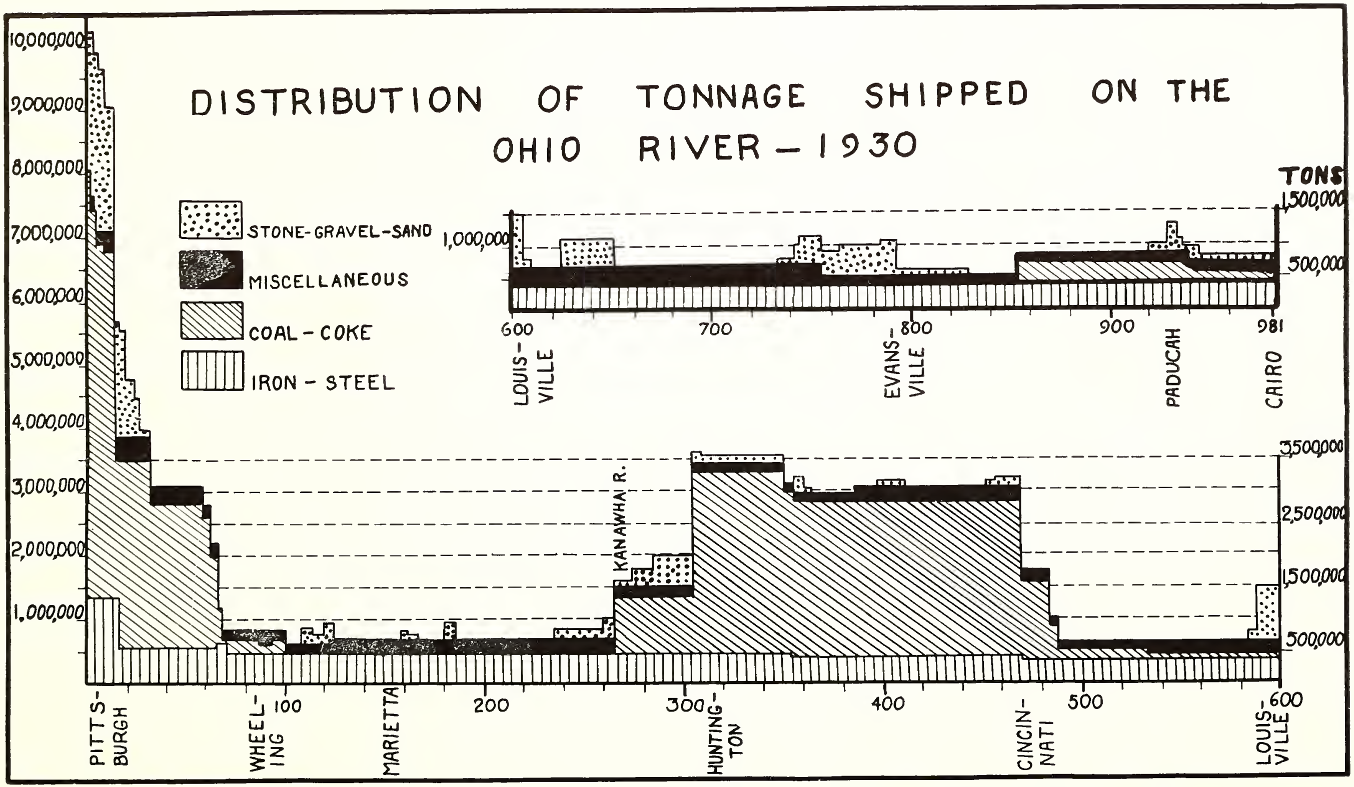


Fig. 3. A graphic representation of the distribution of the tonnage shipped on the Ohio River during the year 1930. The numbers at the bottom give the distances from the junction of the Monongahela and Allegheny rivers, those at the side represent tons shipped. (Data from the Ohio Valley Improvement Association.)

5. Down stream from the western suburbs of Cincinnati the tonnage drops to between 700,000 and 800,000 tons and, except for local increases in sand and gravel shipments, retains about this amount the remaining nearly 500 miles of the river's course.

6. The chief items of traffic are coal and coke, iron and steel, stone, sand and gravel. Iron and steel products are the only ones that have continuous shipments the full length of the river, some 250,000 tons of which reach Cairo, destined for Mississippi River ports.

By way of summary of traffic it may be noted that of the 22,337,000 tons of freight transported on the river during the year, about one half is confined to the first 16 miles of the river, which is in the city of Pittsburgh and its immediately adjoining suburbs; that about 675 miles of the total 981 miles of improved river carried an average of only about 750,000 tons during the year 1930.

Some reasons for the distribution of traffic. In the first place, the Allegheny and Monongahela rivers, likewise the Ohio, have cut their valleys deep, with steeply sloping valley walls. Pittsburgh, located at their junction point, is in a region of considerable relief. The only portions of the city having a topography suitable for factories handling heavy materials are the rather narrow strips of flat lands in the valley bottoms. These flat lands are not only favorably located in regard to traffic carried by the river, but occupy the only areas in which railways may be easily built. Hence river borne material may be readily supplemented by traffic by railways.

The Monongahela River passes through the highly productive coal field of southern Pennsylvania and West Virginia, an area of high grade coking coal, excedingly important to the steel industry of the Pittsburgh region. The river has cut through seams of the coal, and many mines "drift in" from the sides of the valley hence find it very convenient to bring the coal out to the valley and dump it in barges to be floated down stream. More than 20,000,000 tons are shipped annually in this way. Many coking plants are located near the mines and use the same method of transportation. Thus it is that a considerable part of the coal and coke tonnage on the Ohio River in the immediate vicinity of Pittsburgh is composed of Monongahela River coal and coke tonnage which, as it passes beyond the junction point of the rivers, becomes tonnage on the Ohio River. This tonnage of coal and coke amounts to about 6,500,000 for the first two miles, decreases to 5,500,000 tons at the down stream side of the city of Pittsburgh, to less than 3,000,000 tons 17 miles down stream, and to 150,000 tons at Steubenville, 70 miles below the junction point.

The shipment of approximately 1,300,000 tons of iron and steel in the first 17 miles of the river suggests the importance of the location of the steel mills near the river and of the use of the river in transporting materials between the mills. The chart shows that nearly half the iron and steel shipped by the river route is destined for down stream markets, about 100,000 tons for the Steubenville area, another 100,000 tons for Cincinnati.

Almost no coal is shipped on the Ohio between Wheeling and the mouth of the Kanawha River. The Kanawha contributes nearly a million tons of coal consigned to Ohio River ports. The far southward bend of the Ohio brings it to the coal fields of the Huntington district which supplies an additional two million tons, consigned to the Cincinnati area. A small amount of this coal is carried as far as Louisville, Kentucky.

In the last 100 miles of the river the producing coal mines of western Kentucky and southern Illinois furnish another source of supply of coal for shipment. This area ships some 250,000 tons between Caseyville and Paducah, and 100,000 tons from Paducah to the mouth.

Stone, sand and gravel become conspicuous items in the tonnage only for local areas, notably in the vicinities of cities or where the conditions of the river channel require considerable dredging.

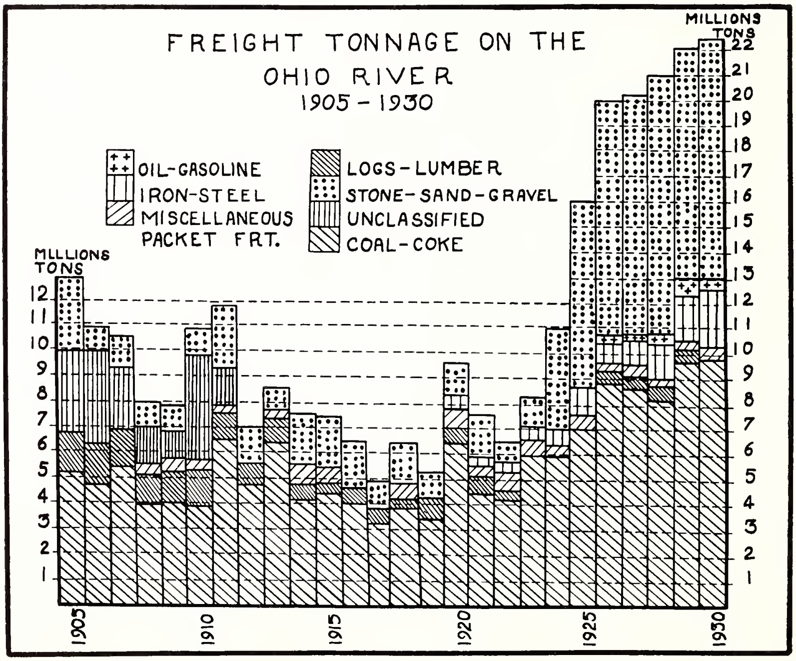


Fig. 4. Tonnage of groups of commodities shipped on the Ohio River during the years 1905-1930. (Adapted from chart furnished by the Ohio Valley Improvement Association.)

Miscellaneous freight is composed of cement, logs, lumber, oil and gasoline, and packet freight. Oil and gasoline form about two-thirds of the miscellaneous freight between Louisville and Owensboro (mile 755) and constitutes part of the tonnage nearly the whole length of the river.

Traffic on the Ohio River from 1905 to 1930. Figure 4 shows the total freight tonnage on the Ohio River during the past 26 years. At a glance one is impressed with the great increase in tonnage shipped due, apparently, to the improvements that have been made. The data of the chart must be examined closely to appreciate the full import of the facts shown. It is shown that the marked increase in tonnage shipped dates from 1925, and that the increase has been largely in stone, sand and gravel, which since 1924 have constituted about 40 per cent of the total tonnage. Methods of compiling statistics of sand and gravel shipments were changed in 1925 and since then sand and gravel dredged from the channel are rated as "tonnage" even though it may not be shipped out of the pool in which it is dredged. Since the average haul of sand and gravel is less than 15 miles, in only a few cases could more than one lock be used in the transportation of any consignment. It may be noted in Fig. 3 that sand and gravel shipments are confined to very local areas, approximately two-thirds of which are in the first 30 miles of the river's course. It would seem that where a local demand exists, gravel would be dredged regardless of any general plan of navigation improvement. Aid to shipment of sand and gravel then, can hardly be urged as an important reason for the construction of a large series of dams and locks to make the river navigable from its head to its mouth.

The benefits of improvement of the river should be expressed in terms of increase of tonnage of commodities that actively enter into commerce, which tonnage would not be transported on the river if the improvements had not been made. Omitting from the picture for the present the items of stone, sand and gravel, let us see how the tonnage of the other items compare during the different years.

The 26 years of record may be divided into three periods of variation in shipments, i. e., the years of 1905-1911 inclusive, in which the tonnage shipped ranged fairly high; the years 1912-1923 in which the tonnage shipped was relatively small; and the last seven years, 1924-1930, in which there was a steady increase in shipments. Omitting sand, gravel and stone, the chart shows that the freight shipped in 1905, 1906, 1907, 1910 and 1911, was not exceeded until 1926, and but slightly until 1929 and 1930. The average annual tonnage shipped during the first period (1905-1911) was 8,750,000 tons while that for the last period (1924-1930) was 10,600,000 tons or 1,850,000 tons greater. The very small tonnage of the middle period is no doubt partially a reflection of the conditions during the World War when speed was a very important item in transportation. The increase in tonnage of coal and coke, and of iron and steel, and the use of the river in transporting oil and gasoline during the last period should be noted.

In 1905 only Dam No. 1, just below the city limits of Pittsburgh, and No. 6 (29.3 miles down stream), had been completed. By 1911 there had been completed and opened for navigation the first six dams with their locks, also Nos. 8, 11, 13, 18, and 37. Between 1911 and 1923, twenty-six additional dams and locks had been completed and put into use. Yet in spite of this additional improvement of the river for carrying trade, the tonnage was appreciably less than during the 1905-1911 period. By 1928 all locks and dams were practically completed and the minimum depth of 9 feet was maintained throughout the river's length. The freight tonnage during the last two years of the record was (besides stone, sand and gravel) 13,000,000, tons, only about 3,000,000 tons greater than that of 1905 and 1906, when only two dams and locks were in operation.

Cost of the project and of transportation. The estimated cost of the construction of all the dams, locks, and their associated works (made by the Chief of Engineers) is $118,743,405.66 (Ann. Rept. Chief of Engineers, U. S. Army, 1929, p. 1241). This does not include the cost of improvement of the channel by dredging, the average annual cost of which has been $110,000 for a century.

Neither do these estimates include the salaries of the government engineers who have contributed much of their time in making surveys and supervising the work of construction. Their salaries are paid out of funds appropriated for and charged to maintenance of the U. S. Army. To these items should be added interest on the sums expended from the time of the expenditure to date.

And estimated annual cost of maintenance of the completed project is $2,000,000 (Ann. Rept. Chief of Eng., U. S. Army, 1929, p. 1237).

Fig. 5. Homes of the employees at Dam No. 37. These beautiful houses of brick are built on the grass covered levee facing the river, but are high enough to be out of reach of flood waters. The dam and lock are just beyond their front yard.

At most of the dams nine men are employed. They are furnished homes in which to live, some of the best types of which are shown in Fig. 5.

The total *annual cost* to the government of maintaining a minimum depth of nine feet for the length of the river is made up of at least the following items:

1. Interest at four per cent on at least $118,000,000 which is $4,-720,000.
2. Cost of maintenance $2,000,000.
3. Salaries of army engineers who are devoting their time to the supervision of the operation of locks, dredges, and dams.
4. Interest on sums spent in "maintenance" since operations of the locks began.

Since these sums are all paid out of the treasury, it matters not whether bonds bearing interest have actually been sold for this especial use, for the sums invested in this and all other similar projects could otherwise have been turned to the reduction of the bonded indebtedness of the government. Directly or indirectly, it comes from the purses of the people, and since no tolls are charged for the use of the locks, there is no direct way in which it can possibly *ever* be returned to the treasury. The making of any appropriations for the retirement of the sums invested, or for paying interest on those sums, must come from the same source as the original sums. They can be paid only by "taking money out of one pocket and putting it into another," a mere matter of bookkeeping, not of reducing the debt, so far as treasury funds are concerned. Financial returns on the investment then must be found on reduced freight rates on an adequate amount of tonnage for an adequate length of haul to repay to the people at least a reasonable interest on the money invested.

It is clear that approximately two-thirds of the river is little used. In the little used portions there have been constructed 28 dams and locks at a cost of over $70,000,000. Interest on this sum at four per cent (the war debt rate) is $2,800,000. The cost of maintenance of these dams and locks, based on the engineer's estimate of the cost of maintenance of the whole project, is at least $1,200,000 annually. Thus a conservative estimate of the annual cost of this portion of the project, not providing for liquidation of the original sum, is at least $4,000,000. The tonnage hauled over this portion, as already noted, averages approximately 750,000 tons. The cost to the people of the United States, therefore, averages about five dollars for each ton shipped over these portions of the improved river. This sum is expended to maintain a highway free of charge, to companies operating boats and barges, that they may haul freight somewhat cheaper than it can be hauled by rail, trolley or bus, on the theory that this competition will keep down all freight rates. Is this an economic way of securing cheap transportation?

The tonnage hauled over the first 70 miles of the river's course and over that portion between the mouth of the Kanawha and Cincinnati may be considered adequate to warrant the improvement of those areas. It yet remains to be demonstrated that the expenditure of the vast sum for the improvement of the whole river has been an economic investment.