"This plant, so far as the work in the dry is concerned, is being provided and delivered on the ground and the roads are being laid in, so that I see no reason why the dry excavation work should not be commenced almost immediately."

Mr. John N. Popham, a native of Virginia, has been engaged in railroad building and other enterprises on the Isthmus for many years past. Upon the occasion of a recent visit to the United States he made the following statement:

"Prior to last May (i.e., May, 1905) the conditions on the Isthmus may have been open to just and intelligent criticism, caused by the delay in improving the physical condition of the Panama Railroad, purchase of necessary rolling stock, and improving the terminal facilities. But those conditions are forgotten history. The fair-minded residents of the Isthmus appreciate the magnificent efforts and splendid results accomplished since that time.

THE PANAMANS ARE SATISFIED WITH THE SITUATION.

"The statement made by Mr. Poulton Bigelow is so far from being fair, the views so distorted, and the inference so frail, that it is only laughed at on the Isthmus, and it was so fully covered at home by that part of the President's communication to Congress the 8th instant, under the heading of 'Scandal-
mongers,' that there is little left for a self-respecting American resident of the Isthmus to add. The people of Panama are intelligent, capable people. They appreciate the results accomplished: they have been and are anxious and willing to continue to help our people in the great enterprise that means so much to the whole world.

THE LABORERS ARE WELL TREATED.

"After sixteen years experience on and in the vicinity of the Isthmus and knowing, as I do, the homes of the West India laborers in the great banana-producing districts near Colon, and having for many years employed from 400 to 700 Jamaicans daily at our mines, thirty-five miles from Colon, I feel competent to judge and to tell you that the West India laborer has never known and in his most pleasant dreams has never hoped for, the splendid care and liberal treatment he is receiving from our government on the Isthmus of Panama.

"My knowledge of the affairs of the Canal company only enables me to speak of conditions on the Isthmus and the work in progress there. But in every department of the Canal work during the past seven months on the Isthmus the people of this country can rest assured that the investigation to be made by the Senate committee will confirm the following lines found in the President's communication to Con-
gress: 'The work on the Isthmus is being admirably
done, and great progress has been made.'"

The cost of the operations on the Isthmus has af-
forded subject for facetious articles and comic car-
toons in the public press. Let us look at some of the
items of expenditure and we shall thereby improve
our conception of the greatness of the enterprise, and
of the complexity of its details.

In June, 1902, Congress appropriated $10,000,000
for the use of the Canal Commission and all expenses
up to the close of the year 1905 were paid out of that
amount. The purchases range over the greatest va-
riety and degrees of magnitude, from steamships to
handcuffs. Four million dollars has been paid for
general supplies, including fuel, explosives, lumber,
machinery, roofing, paving and plumbing material,
medical and sanitary supplies, garbage carts, laundry
equipment, steel vaults, scientific instruments, and
other innumerable and diversified items. During
1905, upwards of one million dollars was laid out on
steel flat cars, half a million on steam shovels and
three times as much on locomotives.

A CLEAN AND WELL-DIRECTED MANAGEMENT.

The Commission has observed strict business prin-
ciples in all these purchases. There has been no op-
portunity for graft and hence without doubt has
arisen a great deal of the dissatisfaction expressed
with its management.
The conduct of the enterprise so far should be a source of pride to Americans. There have been mistakes, of course, but no blunders. Errors of judgment and miscalculations have been quickly recognized and rectified. Not a justifiable suspicion of graft has been connected with the operation since it came into American hands. Influence and favoritism have been singularly absent from the appointments. The men at the head of affairs have nothing but reputation to gain from the undertaking and it is not their purpose to allow incompetents to hazard their prospects in that respect. As the conditions of life on the Isthmus become more healthful and comfortable greater pressure will doubtless be exerted by the drones who attach to the skirts of Congressmen and officials, but it is safe to predict that as long as the present Executive Committee of the Commission retain their positions such efforts will be unavailing.

THE COMMON SENSE OF THE SITUATION.

We approach the construction stage of the undertaking with the management of the enterprise in thoroughly capable hands, supported by an experienced and efficient staff. The organization is admirably calculated to work harmoniously, for the heads of departments have been at pains to secure the services of men who had been associated with them in
former important works and with whose characters and capabilities they are familiar. In many cases these men are making sacrifices in thus accepting service under their old chiefs, for the salaries are not such as to attract first-class men under the circumstances that surround life on the Isthmus at its best.

The Commission deserves the support of the American people and press. Common sense demands that we refrain from the puerile nagging and fault-finding which has hitherto been our only reward for honest, energetic and patriotic work. The present Congressional investigation will prove that we have been acting a very ungrateful part. At the close of it we should open a new chapter in the history of the Canal. There should be a cessation of slander and obstruction and a disposition toward truth and fair play.
APPENDIX

GREAT CANALS OF THE WORLD.
APPENDIX.

GREAT CANALS OF THE WORLD.*

The Suez Canal — The Cronstadt and St. Petersburg Canal —
The Corinth Canal — The Manchester Ship Canal — The
Kaiser Wilhelm Canal — The Elbe and Trave Canal — Can-
nals Projected in Prussia — Ship Canals Connecting the
Great Lakes of North America — The Welland Canal — The
Sault Ste. Marie Canals — Lake Borgne Canal — The Chi-
cago Sanitary and Ship Canal — Other Canals — Canals
of the United Kingdom — Canals of the United States —
The Economic Effects of Ship Canals — Canals of Holland
— Manchester Ship Canal — Effect of Suez Canal on Shipping — Traffic of Suez and St. Mary’s Canals Compared —
Changes in the Lakes Shipping — Effect of “Soo” Canal
on Iron Business — Enormous Wheat Traffic of the Lakes —
Influences of St. Mary’s and Suez Canals — Canals in China
— The Canal System of India.

Ship canals connecting great bodies of water, and
of sufficient dimensions to accommodate the great
modern vessels plying upon such waters, are of com-
paratively recent production and few in number.
The one great example of works of this character
which has been a sufficient length of time in exist-
ence and operation to supply satisfactory data as to
cost of maintenance and operation and practical value

* The following matter is extracted from the monograph
under this title issued by the Department of Commerce and
Labor, Washington, D. C.
to the commerce of the world is the Suez Canal, and for this the available statistics begin with the year 1870, while its new and enlarged dimensions only date from the year 1896. For the Sault Ste. Marie Canal, connecting Lake Superior with Lake Huron, statistics date from 1855. Statistics of the Welland Canal date from 1867, but for the canal in its present enlarged form cover but four years of operation. The other great ship canals of the world are of much more recent construction, and data regarding their operation therefore cover a comparatively brief term, and in some cases are scarcely at present available in detail.

The artificial waterways which may properly be termed ship canals are nine in number, viz.:

1. The Suez Canal, begun in 1859 and completed in 1869.

2. The Cronstadt and St. Petersburg Canal, begun in 1877 and completed in 1890.

3. The Corinth Canal, begun in 1884 and completed in 1893.

4. The Manchester Ship Canal, completed in 1894.

5. The Kaiser Wilhelm Canal, connecting the Baltic and North Seas, completed in 1895.

6. The Elbe and Trave Canal, connecting the North Sea and Baltic, opened in 1900.

7. The Welland Canal, connecting Lake Erie with Lake Ontario.
(8 and 9) The two canals, United States and Canadian, respectively, connecting Lake Superior with Lake Huron.

THE SUEZ CANAL.

The Suez Canal is usually considered the most important example of ship canals, though the number of vessels passing through it annually does not equal that passing through the canals connecting Lake Superior with the chain of Great Lakes at the south. In length, however, it exceeds any of the other great ship canals, its total length being 90 miles, of which about two-thirds is through shallow lakes. The material excavated was usually sand, though in some cases strata of solid rock from 2 to 3 feet in thickness were encountered. The total excavation was about 80,000,000 cubic yards under the original plan, which gave a depth of 25 feet. In 1895 the canal was so enlarged as to give a depth of 31 feet, a width at the bottom of 108 feet and at the surface of 420 feet. The original cost was $95,000,000, and for the canal in its present form slightly in excess of $100,000,000.

The revenue of the canal is apparently large in proportion to its cost, the latest report of the company for 1903 giving the net profits for that year at 65,579,347 francs, and the total amount distributed among the shareholders 64,565,634 francs, or over
12 per cent of the estimated cost of $100,000,000. The canal is without locks, being at sea level the entire distance. The length of time occupied in passing through the canal averages about eighteen hours. By the use of electric lights throughout the entire length of the canal passageways are made with nearly equal facility by night or day. The tolls charged are 8.50 francs per ton net register, "Danube measurement," which amounts to about $2 per ton United States net measurement. Steam vessels passing through the canal are propelled by their own power.

The canal has accommodated the following traffic since its opening:

<table>
<thead>
<tr>
<th>Year</th>
<th>Gross Vessels</th>
<th>Tonnage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1870</td>
<td>486</td>
<td>654,915</td>
</tr>
<tr>
<td>1875</td>
<td>1,494</td>
<td>2,940,708</td>
</tr>
<tr>
<td>1880</td>
<td>2,026</td>
<td>4,344,519</td>
</tr>
<tr>
<td>1890</td>
<td>3,389</td>
<td>9,749,129</td>
</tr>
<tr>
<td>1895</td>
<td>3,434</td>
<td>11,833,637</td>
</tr>
<tr>
<td>1900</td>
<td>3,441</td>
<td>13,699,237</td>
</tr>
<tr>
<td>1903</td>
<td>3,761</td>
<td>16,615,309</td>
</tr>
</tbody>
</table>

THE CRONSTADT AND ST. PETERSBURG CANAL.

The canal connecting the Bay of Cronstadt with St. Petersburg is described as a work of great strategie and commercial importance to Russia. The canal and sailing course in the Bay of Cronstadt are about 16 miles long, the canal proper being about 6
miles and the bay channel about 10 miles, and they together extend from Cronstadt, on the Gulf of Finland, to St. Petersburg. The canal was opened in 1890 with a navigable depth of 20½ feet, the original depth having been about 9 feet; the width ranges from 220 to 350 feet. The total cost is estimated at about $10,000,000.

The Corinth Canal.

The next of the great ship canals connecting bodies of salt water in the order of date of construction is the Corinth Canal, which connects the Gulf of Corinth with the Gulf of Ægina. The canal reduces the distance from Adriatic ports about 175 miles and from Mediterranean ports about 100 miles. Its length is about 4 miles, a part of which was cut through granite soft rock and the remainder through soil. There are no locks, as is also the case in both the Suez and Cronstadt canals, already described. The width of the canal is 72 feet at bottom and the depth 26½ feet. The work was begun in 1884 and completed in 1893 at a cost of about $5,000,000. The average tolls are 18 cents per ton and 20 cents per passenger.

The Manchester Ship Canal.

The Manchester Ship Canal, which connects Man-
chester, England, with the Mersey River, Liverpool, and the Atlantic Ocean, was opened for traffic January 1, 1894. The length of the canal is 35 1/2 miles, the total rise from the water level to Manchester being 60 feet, which is divided between four sets of locks, giving an average to each of 15 feet. The minimum width is 120 feet at the bottom and average 175 feet at the water level, though in places the width is extended to 230 feet; the minimum depth 26 feet, and the time required for navigating the canal from five to eight hours. The total amount of excavation in the canal and docks was about 45,000,000 cubic yards, of which about one-fourth was sandstone rock. The lock gates are operated by hydraulic power; railways and bridges crossing the route of the canal have been raised to give a height of 75 feet to vessels traversing the canal, and an ordinary canal whose route it crosses is carried over it by a springing aqueduct composed of an iron caisson resting upon a pivot pier. The total cost of the canal is given at $75,000,000. The revenue in 1902, according to the Statesman's Yearbook, was £358,491, and the working expenses, £217,537.

THE KAISER WILHELM CANAL.

Two canals connect the Baltic and North seas through Germany, the first, known as the Kaiser Wilhelm Canal, having been completed in 1895 and
constructed largely for military and naval purposes, but proving also of great value to general mercantile traffic. Work upon the Kaiser Wilhelm Canal was begun in 1887, and completed, as above indicated, in 1895. The length of the canal is 61 miles, the terminus in the Baltic Sea being at the harbor of Kiel. The depth is 29½ feet, the width at the bottom 72 feet, and the minimum width at the surface 190 feet. The route lies chiefly through marshes and shallow lakes and along river valleys. The total excavation amounted to about 100,000,000 cubic yards, and the cost to about $40,000,000. The number of vessels passing through the canal in 1903–4 was 32,038, with a tonnage of 4,990,287, and the dues collected amounted to 2,414,499 marks.

**The Elbe and Trave Canal.**

A smaller canal, with a length of about 41 miles and a depth of about 10 feet, was opened in 1900, known as the Elbe and Trave Canal, and is described by the International Yearbook, 1900, as follows:

"The Elbe and Trave Canal, in Germany, was opened by the Emperor of Germany on June 16, 1900. It has been under construction for five years, and has cost about $5,831,000, of which Prussia contributed $1,785,000 and the old Hanse town of Lübeck $4,046,000. The length of the new canal is about 41 miles, and is the second to join the North
Sea and the Baltic, following the Kaiser Wilhelm Canal (or Kiel Canal), built about five years ago at a cost of $37,128,000. The breadth of the new canal is 72 feet; breadth of the locks, 46 feet; length of locks, 261 feet; depth of locks, 8 feet 2 inches. It is crossed by 29 bridges, erected at a cost of $1,000,000. There are seven locks, five being between Lubeck and the Mollner See (the summit point of the canal) and two between Mollner See and Fauenberg-on-the-Elbe. At this point it may be noted that the Germans began experiments during 1900 with electric towing on the Finow Canal between Berlin and Stettin. A track of 1-meter gauge was laid along the bank of the canal, having one 9-pound and one 18-pound rail laid partly on cross-ties and partly on concrete blocks. The larger rail serves for the return current, and has bolted to it a rack which gears with a spur wheel on the locomotive. The locomotive is 6 feet 10 inches by 4 feet 10 inches, mounted on four wheels, with a wheel base of 3 feet 6 inches, and weighing 2 tons. It is fitted with a 12-horsepower motor, current for which is furnished by a 9-kilowatt dynamo, driven by a 15-horsepower engine. The current is 500 volts, and is transmitted by a wire carried on wooden poles 23 feet high and about 120 feet apart. The boats are about 132 feet long and 15 feet 6 inches beam, and carry from 150 to 175 tons on a draft of 4 feet 9 inches. During 1900 the Stettin-Swinemund Canal, with a length of 35 miles, has been dredged through-
out, and is now open to steamers drawing 22 feet of water. Swinemund is on the Baltic Sea.

"Among the various projects for European canals may be mentioned one connecting the Danube a little below Vienna, Austria, with the Adriatic Sea at Trieste, a distance of about 319 miles. The construction will cost some $120,000,000. Late in 1900 a canal from Liege to Antwerp, in Belgium, was being seriously discussed, in order to connect the prosperous city of Liege with the sea, and make it, like the city of Manchester, England, a seaport. The promoters propose a canal 84 miles long, 200 feet wide, and 23 feet deep from Antwerp to Liege, with locks at Liege, Hasselt, Herenthals, and Antwerp. The difference in level to be overcome by locks would be 175 feet, and it is thought that thirteen single locks and one double lock would be sufficient. The total estimated cost of the work is $25,200,000."

**Canals Projected in Prussia.**

According to a recent report of United States Consul-General Guenther, of Frankfort, Germany, the committee on canals of the Prussian Diet has reported, with a favorable recommendation, a bill providing for the following construction:

1. A navigable canal between the rivers Rhine and Weser, with a connection to Hanover, and the canalization of the River Lippe:
(a) A navigable canal from the Rhine in the vicinity of Ruhrort, or from a more northern point, to the Dortmund-Ems Canal or the vicinity of Herne (Rhine-Herne Canal) inclusive of a branch canal from Datteln to Hamm; estimated cost, 74,500,000 marks ($17,731,000).

(b) Several additional works on the Dortmund-Ems Canal between Dortmund and Bevergern; estimated cost, 6,150,000 marks ($1,463,700).

(c) A navigable canal from the Dortmund-Ems Canal in the vicinity of Bevergern to the River Weser, connecting with Hanover; branch canals to Osnabrück, Minden, and Linden, construction of reservoirs in the upper parts of the River Weser and some regulation works of the Weser below Hameln; estimated cost, 120,500,000 marks ($28,679,000).

(d) Canalization of the River Lippe or construction of branch canals of the Lippe from Weser to the Dortmund-Ems Canal, near Datteln, and from Hamm to Lippstadt; estimated cost, 44,600,000 marks ($10,614,800).

(e) Improvement of the cultivation of the soil in connection with the works under items a to d, and the completed Dortmund-Ems Canal; estimated cost, 5,000,000 marks ($1,190,000).

The total estimated cost of the work, items a to e, is placed at 250,750,000 marks ($59,678,500).

2. The construction of a deep waterway between
Berlin and Stettin; estimated cost, 43,000,000 marks ($10,234,000).

3. Improvement of the waterway between the rivers Oder and Weichsel, also of the river Warthe from the mouth of the river Netze to the city of Posen; estimated cost 21,175,000 marks ($5,039,650).

4. The canalization of the river Oder from the mouth of the river Glatzer Neisse to the city of Breslau, experimental works on the line between Breslau and Fürstenberg and the Oder, construction of one or of several reservoirs; estimated cost, 19,-650,000 marks ($4,676,700).

The entire cost of the projects named is placed at 334,575,000 marks ($79,628,850).

SHIP CANALS CONNECTING THE GREAT LAKES OF NORTH AMERICA.

Three ship canals intended to give continuous passage to vessels from the head of Lake Superior to Lake Ontario and the St. Lawrence River are the Welland Canal, originally constructed in 1833 and enlarged in 1871 and 1900; the St. Marys Falls Canal at Sault Ste. Marie, Mich., opened in 1855 and enlarged in 1881 and 1896, and the Canadian Canal at St. Marys River, opened in 1895. In point of importance, measured at least by their present use, the canals at the St. Marys River by far surpass that
of the Welland Canal, the number of vessels passing through the canals at the St. Marys River being eight times as great as the number passing through the Welland, and the tonnage of the former nearly forty times as great as that of the latter. One of the important products of the Lake Superior region, iron ore, is chiefly used in the section contiguous to Lake Erie, and a large proportion of the grain coming from Lake Superior passes from Buffalo to the Atlantic coast by way of the Erie Canal and railroads centering at Buffalo. The most important article in the westward shipments through the Sault Ste. Marie canals, coal, originates in the territory contiguous to Lake Erie. These conditions largely account for the fact that the number and tonnage of vessels passing the St. Marys River canals so greatly exceed those of the Welland Canal.

THE WELLAND CANAL.

The Welland Canal connects Lake Ontario and Lake Erie on the Canadian side of the river. It was constructed in 1833 and enlarged in 1871 and again in 1900. The length of the canal is 27 miles, the number of locks 25, the total rise of lockage 327 feet, and the total cost about $25,000,000. The annual collection of tolls on freight, passengers, and vessels averages about $225,000 and the canal is open on an average about 240 days in a year. By order
in council dated April 27, 1903, the levy of tolls for passage through Dominion canals has been abolished for a period of two seasons of navigation.

THE SAULT STE. MARIE CANALS.

The canals at Sault Ste. Marie, Mich., and Ontario are located adjacent to the falls of the St. Marys River, which connects Lake Superior with Lake Huron, and lower or raise vessels from one level to the other, a height of 17 to 20 feet. The canal belonging to the United States was begun in 1853 by the State of Michigan and opened in 1855, the length of the canal being 5,674 feet, and provided with two tandem locks, each being 350 feet in length and 70 feet wide, and allowing passage of vessels drawing 12 feet, the original cost being $1,000,000. The United States Government, by consent of the State, began in 1870 to enlarge the canal, and by 1881 had increased its length to 1.6 miles, its width to an average of 160 feet, and its depth to 16 feet; also had built a single lock 515 feet long and 80 feet wide, with a depth of 17 feet on the sills, which was located 100 feet south of the State locks. The State relinquished all control of the canal in March, 1882. In 1887 the State locks were torn down and replaced by a single lock 800 feet long, 100 feet wide, with a depth of 22 feet of water on the sills. This lock was put in commission in 1896. The canal was also deepened to 25
feet. The Canadian canal, 1 1/3 miles long, 150 feet wide, and 22 feet deep, with lock 900 feet long, 60 feet wide, with 22 feet on the miter sills, was built on the north side of the river during the years 1888 to 1895. In 1900 the number of vessels passing through the United States canal was 16,144, and through the Canadian canal, 3,003, showing an increase of 1,350 in the number of vessels passing through the Canadian canal, and a decrease of 1,901 in the number through the United States canal, the increase in the number passing through the Canadian canal having been due to the development of the Michipicoten district. The tonnage passing through the United States canal in 1903 was: Registered tonnage, 22,998,864 tons, against 19,901,463 in the year 1900; the freight tonnage in 1903 was 20,172,252 tons, against 23,251,539 tons in 1900. The Canadian canal shows: Registered tonnage in 1903, 4,737,580 tons, against 2,160,490 in 1900; and freight tonnage in 1903, 5,502,185 tons, against 2,018,999 in 1900. A marked contrast between the business of the St. Marys Falls and Welland canals is found in a comparison of their figures for a term of years. The number of vessels passing through the Welland Canal in 1873 was 6,425, and in 1902, 1,568, a reduction of over 75 per cent in the number of vessels. The number of vessels passing through the St. Marys Falls Canal in 1873 was
2,517, and in 1903, through the American and Canadian canals, 18,596.

The following, supplied by the office of the Chief of Engineers, War Department, shows the details of the Sault Ste. Marie and Welland canals:

The total cost of the St. Marys Falls Canal, Michigan, and of the locks now in service is $6,033,533, made up as follows:

<table>
<thead>
<tr>
<th></th>
<th>Dollars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canal</td>
<td>2,250,786</td>
</tr>
<tr>
<td>Weitzel lock</td>
<td>983,355</td>
</tr>
<tr>
<td>Poe lock</td>
<td>2,799,392</td>
</tr>
</tbody>
</table>

The length of the canal is 1.6 miles, depth 25 feet, and width varying from 110 to 1,000 feet. The size of the locks is as follows:

**Weitzel lock:**
- Depth of water at mean stage........ 17
- Length between gates.................. 515
- Width of chamber..................... 80
- Width at gates....................... 60

**Poe lock:**
- Length between gates.................. 800
- Depth of water at mean stage........ 22
- Width .............................. 100

The lift of both locks varies from 16 to 20 feet.

The Canadian lock at Sault Ste. Marie, Ontario, Canada, has a length between gates of 900 feet and
a width of 60 feet; the depth of water over miter sill of lock and in canal is 22 feet at mean stage (20 feet 3 inches at lowest known water level). The total amount expended on construction to June 30, 1900, was $3,770,621.

The Welland Canal is 26.75 miles long and 100 feet wide; it has 25 lift locks and one guard lock; the locks are 270 feet long, 45 feet wide, and have a depth of water of 14 feet; the total lift is 326.75 feet. The total amount expended on construction to June 30, 1900, was $24,293,587.

According to the International Yearbook, 1900, the most notable occurrence of the year 1899 in canal construction was the opening of the Soulanges Canal by which the Canadian Government completes the last link in its long-projected 14-foot waterway from the head of Lake Superior to the mouth of the St. Lawrence River.

LAKE BORGNE CANAL.

The Lake Borgne, Louisiana, Canal was formally opened in August of 1901. It opens continuous water communication with lakes Maurepas, Pontchartrain, and Borgne, the Mississippi Sound, Mobile, and the Alabama and Warrior rivers, and the entire Mississippi River system, and has an important bearing as a regulator of freight rates between these sections. The effects of the canals may be
briefly summed up as: Shortening the distance between New Orleans and the Gulf points east of the Mississippi; bringing shipments from the Gulf coast direct to the levees at New Orleans; saving the trans-shipment of through freights, with a consequent reduction in freight rates; enabling sea-going vessels, drawing 10 to 12 feet of water, to come within 20 miles of New Orleans, saving all such craft the cost of tonnage and shortening, by 60 miles, direct water communication between New Orleans and the deep water of the Gulf. In addition to these effects may be enumerated the cheapening of coal for consumption at New Orleans. Coal has hitherto been floated down the rivers from Pittsburg, a distance of 2,100 miles. The canal opens up the coal fields in the interior of Alabama for New Orleans consumption and reduces coal prices considerably, giving an additional advantage to domestic industries and to steamers purchasing bunker coal. The canal is 7 miles long and from 150 to 200 feet in width. Bayou Dupre forms a portion of the canal. The lock chamber is 200 feet long, 50 feet wide, and 25 feet deep, and connects the canal with the Mississippi River.

THE CHICAGO SANITARY AND SHIP CANAL.

The Chicago Sanitary and Ship Canal connects Lake Michigan at Chicago with the Illinois River at Lockport, a distance of 34 miles. The canal was
cut for the purpose of giving to the city of Chicago proper drainage facilities by reversing the movement of water, which formerly flowed into Lake Michigan through the Chicago River and turning a current from Lake Michigan through the Chicago River to the Illinois River at Lockport and thence down the Illinois River to the Mississippi. The minimum depth of the canal is 22 feet, its width at bottom 160 feet, and the width at the top from 162 to 290 feet, according to the class of material through which it is cut. The work was begun September 3, 1892, and completed and the water turned into the channel January 2, 1900. The flow of water from Lake Michigan toward the Gulf is now at the rate of 360,000 cubic feet per minute, and the channel is estimated to be capable of carrying nearly twice that amount. The total excavation in its construction included 28,500,000 cubic yards of glacial drift and 12,910,000 cubic yards of solid rock, an aggregate of 41,410,000 cubic yards. In addition to this the construction of a new channel for the Desplaines River became necessary in order to permit the canal to follow the bed of that river, and the material excavated in that work amounted to 2,068,659 cubic yards, making a grand total displacement in the work of 43,478,659 cubic yards of material which, according to a statement issued by the trustees of the sanitary district of Chicago, would, if deposited in Lake Michigan in 40 feet of water, form an island 1 mile
square with its surface 12 feet above the water line.

All bridges along the canal are movable structures. The total cost of construction, including interest account, aggregated $34,000,000, of which $21,379,675 was for excavation and about $3,000,000 for rights of way and $4,000,000 for building railroad and highway bridges over the canal. The city and State authorities by whom the canal was constructed are now proposing to Congress to make this canal a commercial highway in case Congress will increase the depth of the Illinois and Mississippi rivers to 14 feet, with locks for fleets of barges from Lockport, the terminus of the drainage canal, to St. Louis. This, it is argued, would give through-water transportation from Lake Michigan to the Gulf by way of the drainage canal, the Illinois River, and the Mississippi River, and would enable the United States in case of war to quickly transport light-draft war vessels from the Gulf to the lakes. This work of deepening the Illinois River would also give through-water connection from Rock Island, on the Upper Mississippi River, to Lake Michigan via the Illinois and Mississippi Canal, elsewhere described, which extends from Rock Island, on the Mississippi River, to Hennepin, on the Illinois River. The estimate of the Chicago sanitary district trustees of the cost of deepening the Illinois and Mississippi rivers from the terminus of the ship canal to St. Louis to a depth
of 14 feet is $25,000,000, including five locks and dams.

OTHER CANALS.

In addition to the above ship canals, there is a number of other important waterways worthy of mention. The great North Holland Canal, cut in 1845 from Amsterdam to Helder, a distance of 51 miles, to avoid the shoals of the Zuider Zee, has a depth of 20 feet, a width of 125 feet at the surface, and carries vessels of 1,300 tons burden, and is described as "the chief cause of the great prosperity of Amsterdam."

The Caledonian Canal, which connects the Atlantic Ocean and North Sea through the north of Scotland, is 17 feet in depth, 50 feet in width at the bottom, and 120 feet at the surface, with a surface elevation at the highest point of 94 feet above sea level. The canal proper is 250 miles long, and the distance between the terminals over 300 miles. The cost has been stated at $7,000,000, including repairs.

The Canal du Midi, cut through France from Toulouse, on the Garonne River, to Cette, on the Mediterranean, a distance of 150 miles, is 60 feet wide, 6½ feet deep, has 114 locks, and is, at its highest point, 600 feet above the level of the sea. Its cost was $3,500,000, and it is navigable for vessels of 100 tons.
A ship canal to supply passage of seagoing vessels from Antwerp to Brussels, Belgium, a distance of about 30 miles, is under contemplation.

The Illinois and Mississippi Canal, which is to furnish a navigable waterway from the Mississippi River, at the mouth of the Rock River in Illinois, to the Illinois River, at Hennepin, Ill., and thence by river and canal to Lake Michigan, was begun in 1892, and the section between Rock Island and Hennepin is now nearing completion. The canal is about 80 feet wide, 7 feet deep, and is supplied with locks 150 feet long and 35 feet wide, capable of passing barges carrying 600 tons of freight.

The canal systems of European countries and of Canada differ from those of the United States in that they are operated in conjunction with, and made complemenatal to, the railway systems of those countries. Canada's six great systems of government canals afford, with the St. Lawrence River connections, important inland communications. The total length of the canals in operation is 262 miles, but the aggregate length of continuous inland navigation rendered available by them is nearly 3,000 miles. The receipts in 1903 were $230,213, and the working expenses, including repairs, $581,976. The amount expended in the construction and maintenance of these canals, including the Sault Ste. Marie Canal, to June 30, 1903, is $85,300,000. In India the
canals constructed primarily for irrigation purposes, at a cost of about $15,000,000, are utilized to a considerable extent for inland navigation. In Germany the canals, aside from the Kaiser Wilhelm, are 1,511 miles in length, and the canalized rivers 1,452 miles. In France the length of the canals in operation is 3,021 miles.

**Canals of the United Kingdom.**

In the United Kingdom the length of canals belonging to railways is 1,139 miles, and that of canals not belonging to railways 2,768 miles. The traffic of canals belonging to the railways amounted in 1898 to 6,009,820 tons; of those not belonging to railways 33,348,573 tons. The total revenue of both classes of canals was, in the same year, £2,408,534, and the expenditure £1,764,037. The tonnage figures do not include the 1,142,477 tons carried on the Manchester Ship Canal. The London Daily Mail Yearbook for 1902 says of the canal system of England: "There are 3,520 miles of inland navigation in England and Wales, of which 1,234 miles are under the control of the railways, the London and Northwestern and Great Western railways owning nearly 700 miles between them. The paid-up capital (from all sources) of the independent canals (excluding the Manchester Ship Canal) falls little short of £20,000,000, ac-
According to the board of trade returns. Including railway-owned canals, this amount will probably exceed £30,000,000. The annual traffic runs about 37,000,000 tons, comparing unfavorably with a probable 320,000,000 tons carried by the railways. The improvement and development of these internal waterways is regarded by the chamber of commerce as a matter of urgent necessity, and they are formulating proposals with regard to the subject to put before the Government."

**Canals of the United States.**

The canals of the United States still used for commercial purposes are stated by the New York World Almanac for 1905 as being 37 in number, with an aggregate length of 2,443 miles, the total cost of their construction being about $180,000,000. The most important of these, aside from that connecting the Great Lakes, of course, is the Erie Canal, 387 miles in length, with 72 locks and a depth of 7 feet. Next in length is the Ohio Canal from Cleveland, Ohio, to Portsmouth, Ohio, 317 miles in length, with 150 locks and a depth of 4 feet. Next in length is the Miami and Erie Canal, from Cincinnati to Toledo, 274 miles in length, with 93 locks and a depth of 5½ feet. The Pennsylvania Canal, from Columbia to Huntingdon, Pa., is 193 miles in length, with 71 locks and a depth of 6 feet. The Chesapeake and
Ohio Canal, from Cumberland, Md., to Washington, D. C., is 184 miles in length, with 73 locks and a depth of 6 feet. The Lehigh Coal and Navigation Company’s Canal, from Coalport to Easton, Pa., is 108 miles in length, with 57 locks and a depth of 6 feet. The Morris Canal, from Easton, Pa., to Jersey City, N. J., is 103 miles in length, with 33 locks and a depth of 5 feet. The Illinois and Michigan Canal, from Chicago, Ill., to La Salle, is 102 miles in length, with 15 locks and a depth of 6 feet, and the Champlain Canal, from Whitehall, N. Y., to West Troy, is 81 miles in length, with 32 locks and a depth of 6 feet.

**COST OF MAINTENANCE AND OPERATION OF CANALS.**

In order to form an estimate of the cost of maintaining and operating the Isthmian Canal, the Isthmian Canal Commission obtained data bearing on this point from the Suez, Manchester, Kiel, and St. Marys Falls canals, as follows:

There are no locks on the Suez Canal, but the channel is through drifting sand for a great part of its length. The entrance to the harbor of Port Said on the Mediterranean intercepts the drift of sand discharged from the Nile and carried along the coast by the easterly current. The maintenance of the Suez Canal therefore requires a large amount of dredging and consists mainly of this class of work. The oper-
ating expenses are also large, the great traffic involving heavy costs for pilotage. The general expenses for administration have necessarily been greater for the Suez Canal than for the Kiel or Manchester canals, on account of the distance of the work from the point of central control, a disadvantage which would also attend the operation of the Isthmian Canal. The annual cost of maintenance and operation of the Suez Canal is about $1,300,000, or about $13,000 per mile.

The annual cost of maintenance and operation of the Kiel Canal is $8,600 per mile. The cost of maintenance only of the Manchester Canal is $9,500 per mile. These canals have locks and other mechanical structures, and therefore might be expected to have a higher cost of maintenance than the Suez Canal, which has none, but this appears to be more than offset by reduced cost of maintaining the prism and more economical central control. The traffic being light on these canals, the cost of pilotage and port service is small. The mechanical structures are now nearly new, and will soon require larger annual outlays for maintenance, while, with the increase of traffic, operating expenses will become larger.

The St. Marys Falls Canal, when compared with those just mentioned, is remarkable by reason of its short length, large proportion of mechanical structures, and immense traffic. Its length is about 1 1/2 miles. Its annual traffic, limited by the severity of
the winter to a period of about eight months, is nearly three times that of the Suez Canal, eight times that of the Kiel Canal, and ten times that of the Manchester Canal. Both maintenance and operating expenses are therefore very large, amounting to from $70,000 to $90,000 per year, or $46,000 to $60,000 per mile. The annual cost per mile of maintenance and operation, however, for comparison with other canals, should be determined by considering the 18½ miles of dredged channel ways in St. Marys River as part of the canal. Then for the 20 miles of canal and canalized river the expenses per mile would be from $3,000 to $5,000 annually.

Tolls were collected by the State from 1855–1881. Since its ownership by the Government no tolls have been charged.

THE CANAL SYSTEM OF INDIA.

In a few of the colonies of the world, notably India and Ceylon, irrigation works of great value have been constructed by the colonial governments. While these have been costly, the expense has been entirely borne from colonial funds or from loans which are borne by the colonial government, and the cost has been many times repaid by the increased production of the irrigated areas. It has been estimated that the value of a single year's crop produced in the irrigated sections of India in excess of that which would have been
produced without irrigation more than equals the entire cost of the irrigation system.

Sir John Strachey, in his "India," put the cost of the Indian irrigation works up to that time at 320,000,000 rupees (present exchange value of rupee about 33 cents), and adds that the estimated value of the produce of the lands irrigated by works constructed by the government was in 1892 more than 550,000,000 rupees. These works after their construction are not only self-supporting through the charges made for the water distributed, but produce in addition to the annual expenditures a net return of about 5 1/2 per cent on their cost. In Ceylon the colonial government has recently taken up the work of reconstruction of ancient irrigation tanks and the construction of new irrigation works, and by this process it is expected that large additions will be made to the productive area of the island. The irrigating system of India is described by Sir John Strachey as follows:

THE IMPORTANCE OF CANALS IN INDIA.

"In India the very existence of the people depends upon the regular occurrence of the periodical rains, and when they fail through a wide tract of country, and, still worse, when they fail in successive years, the consequences are terrible. The greater part of India is liable periodically to this danger, but the
country is so vast that it never happens that all parts of it suffer at the same time. Improvements in the economic condition of the people, and especially more diversity of occupation, can alone bring complete safeguards and render general famine, in its extremest form, through a great tract of country impossible. But this must be a long and gradual process. Meanwhile it has been found by experience that although the entire prevention of famines, the most destructive of all calamities, is beyond the power of any government, we can do much to mitigate them by removing obstacles which hinder commercial intercourse and which diminish the productiveness of the land. The instruments by which we can do this are roads, railways, and canals.

IRRIGATION CONSTANTLY REQUIRED IN PARTS OF INDIA.

"In northern India, even in good seasons, artificial irrigation is a necessity for the successful cultivation of many of the more valuable crops, and when there is a general failure of the periodical rains there is no other means by which drought and scarcity can be prevented. A large portion of northern India is now protected by canals of greater magnitude than exist in any other country of the world.

"Little of the old irrigation works of our predecessors is retained in the existing canals. Practically all of these have been made by ourselves, and the
often-repeated statement, prompted, I believe, by that strange inclination to depreciate their own achievements which often besets Englishmen, that the old canals have been more profitable than those constructed by ourselves has not the least foundation of truth.

IRRIGATION SYSTEM UNDER ENGLISH RULE.

"The most important of these works in the northwestern provinces are those which distribute the waters of the Ganges and Jumna. In the winter and spring, before the Ganges has been swollen by the melting of snow in the Himalayas and when water is urgently required for agricultural operations, nearly the whole visible stream of the great river at Hardwar, where it leaves the mountains, is thrown into an artificial channel. The works on the first 20 miles of its course are in a high degree remarkable, for the canal intercepts the drainage of the Lower Himalayas and has to be carried across rivers which often become furious torrents, bringing down enormous floods. These obstacles have been overcome by various methods with a skill of which our Indian engineers may well be proud. One torrent flows harmlessly in a broad artificial bed over the canal which runs below; over another, still more formidable, with a bed more than 2 miles wide, the canal, which is virtually the whole Ganges, is carried by an aqueduct. Some 200
miles farther down, the Ganges has again become a large river, and nearly all its water is again diverted into a second canal. The two canals together are capable of discharging nearly 10,000 cubic feet of water per second; the ordinary supply of each is more than double the volume of the Thames at Teddington in average weather, and this great body of water is distributed over the country by a number of smaller channels for the irrigation of the land. The length of the main channels exceeds 1,000 miles, and there are more than 5,000 miles of distributaries.

"Three canals of smaller dimensions, but which in any other country would be looked upon as works of great magnitude, distribute in a similar way nearly the whole of the water brought by the Jumna from the Himalayas. In Bahar, the border province of the Bengal lieutenant-governorship, which in its physical character closely resembles the adjoining provinces of the northwest, another great canal is taken from the river Son.

"There are other important irrigation canals in Orissa and in Bengal; but in the latter province irrigation is not ordinarily so essential as in countries farther north, where the climate is drier and the seasons are more precarious.

GREAT ECONOMICS IN CANAL OPERATION.

"The following facts, which I take from the report
of the Indian famine commissioners, will give some idea of the value of the irrigation works of the northwestern provinces:

"Up to the end of 1877-78 the capital outlay on completed canals had been £4,346,000. The area irrigated in that year was 1,461,000 acres, the value of the crops raised on which was estimated at £6,020,000. Half the irrigated area was occupied by autumn crops, which but for irrigation must have been wholly lost, and it may be said that the wealth of these provinces was consequently increased by £3,000,000; so that three-fourths of the entire first cost of the works was thus repaid to the country in that single year.

"In 1891-92 the area irrigated by canals in the northwestern provinces exceeded 2,000,000 acres."

"In the Punjab works of equal importance have been constructed to utilize the waters of the Sutlej, the Ravi, and other rivers, and their value has been as great as in the northwestern provinces.

"During the droughts of 1877-78, Sir Henry Cunningham tells us, 'their benefits were extended to 1,333,000 acres, the greater portion of which but for canal irrigation would have been absolutely barren. During this period the land irrigated by the two principal canals produced food grain to the amount of 300,000 tons, worth £2,000,000, and enough to keep 1,800,000 people for a year; while the non-food crops — sugar, dyes, spices, etc.— were reckoned to be
worth another £1,000,000. In other words, the value of the crops saved by the two canals in a single season was more than equal to the entire cost (£2,260,000) of the completed system.

"The benefits described by Sir Henry Cunningham have become far greater since this passage was written. The Sirhind Canal, which distributes the water of the Sutlej throughout not only our own territories but through the native State of Patiala, Nabha, and Jhind, is a work of greater magnitude than either of the canals from the Ganges. It is capable of discharging more than 6,000 cubic feet of water per second; the length of its main channel is 540 miles, and that of its distributaries 4,700 miles, and it can irrigate 1,200,000 acres. Its cost has exceeded 40,530,000 rupees, and the direct returns to the State in 1890-91 amounted to about 4.6 per cent on the capital invested.

"Different systems of irrigation prevail in other parts of India. In central and southern India large tracts of country are dependent for their supply of water on lakes and reservoirs, known by the not very appropriate name of tanks. These are in some cases natural lakes, but often they have been formed by the construction of dams of masonry or earth across the outlets of valleys in the hills, and they are fed sometimes by rivers and sometimes by the rainfall of a more or less extensive area. They vary in size from ponds irrigating a few acres to lakes of several
miles in circumference. Some of them are works constructed in the times of which we have no historical record.

**GREAT TANKS OF SOUTHERN INDIA.**

"These are not the only means of irrigation in southern India. Work hardly inferior in importance to those of the northwestern provinces and Punjab, but on a different system, have been carried out by the British Government in the Madras Presidency for utilizing the waters of the Godaveri and Kistna rivers. At the head of each of the deltas which they form before they reach the sea a great weir, or, as it is locally called, an 'anicut,' is thrown across the river, which is diverted into irrigation canals and distributing channels, some of which are also used for navigation. A large area, with a population of nearly 2,000,000, thus obtains complete protection against failure of rain, and these works have not only been in the highest degree beneficial to the people, but very profitable to the State. In the famine of 1876–77 these irrigated tracts produced rice to the value of 50,000,000 rupees, a large part of which was available for the relief of the suffering districts. Without canal irrigation there would have been no crops at all, and the value of the produce in a single year was four times as great as the whole capital expended on the canal works by the Government. Farther south, in
Tanjore, works of a similar kind provide the means of utilizing through a large tract of country, in the delta of the Kaveri, almost the entire water supply of that river. In northern India the ordinary rental of land is doubled by irrigation, and it is often more than quadrupled in Madras.

"In the province of Sind another system prevails. Little rain falls there, and without irrigation there would be no cultivation. In the same way that agriculture in Egypt depends upon the inundation of the Nile, it depends in Sind on the floods brought down by the Indus in the season of the periodical rains. There is great room for further improvement, but the existing irrigation renders the province fairly prosperous, and gives the means of subsistence to some 2,400,000 people.

EXTENT, VALUE, AND COST OF IRRIGATING SYSTEM.

"Altogether there are in India, under the management or supervision of the British Government, some 36,000 miles of canals and other works, irrigating nearly 14,000,000 acres, or more than 21,000 square miles. Although some of the canals have been financially unsuccessful and others were incomplete, the irrigation works of India, taken as a whole, yielded in 1891-2 a net return of 5½ per cent on their cost, which amounted to about 320,300,000 rupees. It is a remarkable illustration of their great
utility that this sum falls far short of the annual value of the crops they protect. In the single year of 1891-92 the estimated value of the produce of the land irrigated by works constructed by the Government was more than 550,000,000 rupees.

"No similar works in other countries approach them in magnitude, and it is certain that no public works of nobler utility have ever been undertaken in the world."

**Canals in China.**

There are several features of the canal system of China, especially of the Imperial or Grand Canal, which can be studied with profit by the people of the United States. One of these is the use of the canal for the production of food in addition to its uses as a means of transportation. Allied to this is the use of the muck which gathers at the bottom of the waterway for fertilization. Another is the use of every particle of plant life growing in and around the canal for various purposes.

The Chinese secure a vast quantity of food of one sort or another from their canals. To appreciate the exact situation with respect to the waterways, it must be realized that the canals of China cover the plain country with a network of water. Leading from the

Grand Canal in each direction are smaller canals, and from these lead still smaller canals, until there is hardly a single tract of 40 acres which is not reached by some sort of ditch, generally capable of carrying good-sized boats. The first reason for this great network is the needs of rice cultivation. During practically all of the growing season for rice the fields are flooded. Wherever a natural waterway can be made to irrigate the rice fields it is used, but, of course, from these to the canals or larger rivers there must be waterways. Where natural streams can not thus be adapted the Chinese lead water in canals or ditches to the edge of their fields and raise it to the fields of rice by the foot-power carriers which have been described so often by tourist writers. However the water is supplied to the rice, it is evident that there must be a waterway leading to the field and back to a principal stream, which is generally a branch canal. These waterways naturally take up a considerable portion of the land, and the Chinese make as profitable use of them as of the land itself.

The first use of the waterways is for fishing. The quantity of fish taken from the canals of China annually is immense. The Chinese have no artificial fish hatcheries, but the supply of fish is maintained at a high point by the fact that the flooded rice fields act as hatcheries and as hiding places for the young fish until they are large enough to look out for themselves. In the United States this fish-propagation annex to
the canals is probably neither possible nor needful in view of the work done by the State and National bureaus, but in China it is nothing less than providential.

Chinese Canals Supply Fertilizer.

Along the canals in China at any time may be found boatmen gathering muck from the bottom of the canal. This muck is taken in much the same manner that oysters are taken by hand on the Atlantic coast. In place of tongs are large bag-like devices on crossed bamboo poles which take in a large quantity of the ooze at once. This is emptied into the boat, and the process is repeated until the boatman has a load, when he will proceed to some neighboring farm and empty the muck, either directly on the fields — especially around the mulberry trees, which are raised for the silkworms — or in a pool, where it is taken later to the fields. From this muck the Chinese farmer will generally secure enough shellfish to pay him for his work, and the fertilizer is clear gain. The fertilizer thus secured is valuable. It is rich in nitrogen and potash and has abundant humus elements. This dredging of the canals for fertilizers is the only way by which the Chinese have kept their canals in reasonably good condition for centuries. The fertilizer has paid for itself both ways. Recently there were complaints filed at Peking that the
ashes from the steam launches plying on the canal were injuring the muck for fertilizing purposes, and the problem has been considered a serious one by the Chinese Government.

In addition to securing fertilizers from the canals, and thus keeping the canals in condition, the farmers' help keep them purified by gathering all floating weeds, grass, and other vegetable debris that they can find upon them. Boatmen will secure great loads of water plants and grasses by skimming along the surface of the canal. The reeds growing along the canals are used for weaving baskets of several grades, and for fuel. In short, no plant life about the canal goes to waste.

**Utilization of Swamp Land.**

Where there are so many canals there is more or less swamp ground. In China this is utilized for the raising of lotus roots, from which commercial arrow-root is largely obtained. There is no reason why much of the waste swamp land in the southern portion of the United States should not be used for a similar purpose, and the commercial returns from a venture of this sort in that part of the country ought to be satisfactory. Where the canals of China widen, by reason of natural waterways or for other reasons, the expanse of water not needed for actual navigation is made use of in the raising of water nuts of several
varieties, especially what are known as water chestnuts. These nuts are raised in immense quantities. They are, strictly speaking, bulbs rather than nuts. They are rich in arrow-root and are prolific, an acre of shallow water producing far more than an acre of well-cultivated soil planted in ordinary grain or similar crops. These nuts, also, could be produced to advantage in the United States where there is land inundated for the growing season to a depth which will give ordinary water plants a chance to thrive and which is not capable of being drained for the time being. The nuts or bulbs are toothsome when roasted, and are wholesome, but probably would be more valuable in the United States for the manufactured products which can be secured from them.

There are duck farms all along the canals in China. These are profitable. Chinese canals, as a rule, considering the population upon them and their varied uses, are cleaner than canals in the United States. There are few if any factories to contaminate them. The Chinese use of certain sewage for fertilization also prevents contamination to a great extent. The canal water is used for laundry, bath, and culinary purposes indiscriminately. A canal in the United States could never be what it is in China, but the Chinese have a number of clever devices and ideas in connection with canals which can be adopted in the United States with profit.
THE ANCIENT GRAND CANAL OF CHINA.

The Grand Canal system in China has existed in almost its present shape since about the time Columbus discovered America. The Grand Canal itself, extending from Hangchau to Peking, is about a thousand miles long. Much of it is banked with stone, and all of it is in such condition that with the expenditure of a little money the system could be put upon a modern and effective basis. As it is, the canal handles practically all the internal trade of China, and this trade is far greater than its foreign trade. The coming of railroads will affect the canals somewhat, but not so much as may be imagined, for the railroads will very largely build up a trade of their own. A little money will make China's canal system in the future what it has been in the past, the greatest on earth.*

THE ECONOMIC EFFECTS OF SHIP CANALS.†

Much has been written concerning the ship canals of the world as great works of engineering; much, too, on their political and military importance; but of the part they have played in the great economic

* Mr. Anderson's closing statement is open to question when the canal system of India is considered.
changes, the result of the marvelous development of transport industries during this last half century, it is not so easy to find definite or satisfactory accounts. At the same time vague and indefinite statements frequently made indicate that their economic importance has been significant; and, in fact, it is only as they are influential in this way that they become commercially profitable undertakings. The attempt is made in this paper to trace with some degree of precision these economic effects, showing how, in consequence of the canals, important changes have been made in business machinery, in business methods, in producing and marketing commodities, and in general economic development.

The ship canals do not form a connected part of the world’s transportation system, and in consequence the economic results of each are, in the main, independent of all other canals. Furthermore, the economic importance of the different canals presents the widest variations. Each opens the way for the creation of many and extensive carrying routes; but, while the influence of some has been merely local, the consequences of others have been felt throughout the commercial and industrial world. These conditions suggest the natural method of treatment to be a consideration of each canal separately, tracing so far as possible the economic effects that have resulted from its existence.

The Amsterdam and Manchester canals, each con-
structed to serve the needs of a single port, do not present the possibilities of any large and general economic results. The Wolland, Corinth, and Kiel canals have a larger field of possibilities, but their actual consequences have as yet been small. The results of these less important canals are therefore but briefly considered in this paper. The examination of the vastly more important and significant results of the Suez and St. Marys Falls canals will comprise the larger part of this study.

**CANALS OF HOLLAND.**

In a country as well supplied with smaller canals as Holland is, it was natural that the idea of a ship canal should present itself to Amsterdam, when the shallowness of the Zuyder Zee and other difficulties of approach were causing her to lose trade to her rival, Rotterdam. The idea soon took practical form, and in 1826 the Helder Canal, with an 18-foot channel, offered an easier approach to the Dutch port. With the development of the shipping industry the dimensions of this canal became inadequate after a few decades, while its length (50 miles) and the difficult entrance in the passes of the Texel proved additional disadvantages. To maintain the commercial position of Amsterdam the construction of a new and larger canal, built by the shortest line to the sea, was decided on, and in 1876 the North Sea Canal,
15 1/2 miles in length and 23 feet in depth, was opened for use.

The effect of the new canal on the commerce of Amsterdam was instantaneous. For twenty years the tonnage statistics for shipping at that port had shown an almost complete stagnation, while at Rotterdam the shipping had trebled. In six years after the new canal was opened the tonnage entering and clearing at Amsterdam had more than doubled, rising from 802,000 tons in 1876 to 1,734,000 tons in 1882. In the former year the Amsterdam shipping was but little over one-quarter that of Rotterdam; in the latter year it was almost a half. Since 1882, however, the increase has been at a much slower rate, while the continued rapid upward movement of the Rotterdam figures shows that there is no falling off in the general trade. Evidently the larger and deeper draft vessels now constructed find the 23-foot channel too shallow, and an enlargement of the canal will be necessary to enable Amsterdam to retain even her existing position.

MANCHESTER SHIP CANAL.

The Manchester Ship Canal resembles the Amsterdam Canal in connecting a large city with the open sea, and in being constructed with a view to its effects on the city at its inland terminus. There is the difference, however, that the promoters of the English
canal aim not simply at retaining and developing an already existing trade, but at creating a new port. The expectation of the promoters and of the corporation of Manchester, which has bonded itself heavily to secure the completion of the canal, is that the raw materials for Manchester manufactures will be brought via the canal, this route saving the heavy expenses connected with the transfer to the railroad at Liverpool. It is perhaps too early to say whether these expectations will be realized; although the estimate of a traffic of 3,000,000 tons within two years of opening has not been fulfilled, a large trade has been developed. The canal was opened on January 1, 1894, and during the first year 1,280 seagoing vessels and 1,660 boats for coast traffic came up to Man-
canals have not produced immediate effects equal to the anticipations of their promoters. The Corinth Canal was opened in October, 1893, and the total traffic at the end of December, 1895 (twenty-six months), had been but 4,589 ships, with a tonnage of 596,000 tons. The first year’s operation of the Kiel Canal between the Baltic and North seas showed a record of 7,500 steamers and 9,300 sailing vessels, but these were mostly small vessels, and the receipts from tolls were under 900,000 marks, against an estimate of 5,000,000 marks.

It is evident, however, that these canals have been in operation too short a time for a full development of their possibilities. The future may demonstrate that these routes offer a net advantage to shipping on account of the saving in distances and the greater safety from shipwreck; and a considerable traffic may develop with important economic results. The Welland Canal does not seem at first sight to offer this hopeful outlook. The present 14-foot channel has been in use since 1887, yet the traffic does not exceed 1,000,000 tons a year. But a deepening of the channel and the enlargement of the locks, so as to reduce the number, might result in a considerable increase in the traffic.

There may be latent possibilities in the traffic of each of these canals we have been considering, but thus far the great bulk of the trade they were intended to get remains undiverted from old routes,
little new trade has been developed, and no important economic results have appeared. This, however, is not the case with the Suez and St. Marys canals.

THE SUEZ CANAL.

In December, 1858, a company was found to undertake M. de Lesseps' audacious scheme of connecting the Mediterranean and Red seas; in the following spring work was commenced, and in 1869 the Suez Canal opened a new water route to the East.

It takes but a glance at the statistics of traffic to notice the enormous difference between the trade that has developed through the Suez Canal and that of the canals already considered. Beginning in 1870, with 486 vessels, having a tonnage of 436,000 tons, there was a steady increase until 1875, when it had reached nearly 1,500 ships and over 2,000,000 tons. After a few years of quiescence came a second period of rapid increase, from 1880 to 1883, in the latter year the figures of 3,300 ships and 5,800,000 tons being reached. Since then there has been a slowly increasing tonnage, reaching the maximum figure of 8,700,000 tons in 1891, but falling off somewhat since that year. In 1896 the figures were 3,409 ships with a tonnage of 8,594,307.*

*The tonnage for the year 1906 will probably exceed 18,000,000.
The importance of these figures may be made clearer by recalling the fact that the foreign tonnage entering at the port of New York has rarely exceeded 7,500,000 tons in any year, and that the foreign tonnage for all the ports of the United States, both entering and clearing, is about 35,000,000 tons; that is, the traffic through the Suez Canal, measured by volume, is almost a quarter of the total foreign trade of the United States. But if measured by value, the importance of the canal traffic is seen to be much greater. The imports and exports of India, via the Suez Canal, are equal in value to $360,000,000, which is nearly one-quarter of the value of the foreign trade of the United States. As the Indian trade constitutes rather less than one-half the total traffic of the Suez Canal, the value of the whole of that traffic must be not far from a half of the foreign trade of the United States.

EFFECT OF SUEZ CANAL ON SHIPPING.

The development of a trade of such an extent and value by a new route within the space of twenty-five years could not but have an important and far-reaching influence on the economic interests of the world. Perhaps the most striking results of the opening of the canal route to the East were those on the machinery of trade — meaning by this term both the material appliances and the business organization of
trade. One effect might have been in part anticipated. The new route saved nearly 3,000 marine leagues on the voyage from the ports of western Europe to the East, or almost half the distance to Bombay. The obvious result of the use of the new route would be that half of the vessels engaged in the Eastern trade would be out of employment. In fact, however, the change came more indirectly. Sailing vessels did not find it advantageous to use the canal, and continued on the old route around the Cape of Good Hope. But the canal, by making practicable the use of steamships in the oriental trade, brought about an even greater revolution in the character of the shipping business to the East. By the Cape route coaling places were few, and the facilities for coaling expensive. The consequence was that the enormous expense of coaling at these out-of-the-way places, with the loss of freight room for the extra space needed for coal, made the use of steamers unprofitable. But by the canal route a steamer could coal at Gibraltar, Malta, Port Said, and Aden, where coal could be furnished at moderate rates, while the space saved from coal could be used to carry a larger cargo. Accordingly, a large number of new iron screw steamers were soon constructed for the trade with the East, and replaced a large percentage of the sailing vessels. It has been estimated that 2,000,000 tons of vessels were thus thrown out of employment, and the effect of this can
be seen in the immediate reduction in the tonnage of sailing vessels. In 1869 the sailing tonnage in the British foreign trade was 3,600,000 tons; in 1876 it was but 3,230,000 tons.

**GREAT ORIENTAL STEAMSHIP COMPANIES.**

In the construction of the new steamers for the canal trade two lines already in existence — the Peninsular and Oriental Steamship Company and the Messageries Compagnie — took prominent parts. But new companies also were rapidly organized, which built steamers and established new lines to the East, among which may be noted the British India Steam Navigation Company, the Clan Line, the Austro-Hungarian Lloyds Company, the Italian Steam Navigation Company, and the Rubbotino Company, of Genoa. It is not possible to get at the amount of shipbuilding made necessary by the change in the kind of ships used in the Eastern trade, but some idea of the importance of the change may be seen by noting the fact that the total steam tonnage in the British foreign trade increased from 650,000 tons in 1869 to 1,500,000 tons in 1876. It would, of course, be possible to learn the number and tonnage of ships now engaged in the trade between Europe and the East, but to account for all of this by the Suez Canal would be to exaggerate its effects. Improvements in marine engines and in the construction
of steamers make much longer steamer voyages possible to-day than were possible in 1870, as is shown by the lines to Australia and across the Pacific Ocean. It is, therefore, certain that if no Suez Canal had been built, there would have been by this time steamers in the Eastern trade; but the change would have come at a much later period, and sailing vessels would continue to carry a large, perhaps a dominant, share of the traffic. The effect of the Suez Canal was to make the transition from sail to steam sharp and decisive, and to bring it about in the decade 1870–1880.

AN ANTICIPATED EFFECT NOT REALIZED.

One change in the shipping industry that was expected from the construction of the Suez Canal has not been realized. It was predicted that the geographical advantage given to the Mediterranean ports by the new route would soon enable them to regain the position they had held in the Middle Ages as the carriers of Eastern produce to the markets of Europe. In England it was felt that the canal would seriously threaten British maritime supremacy, but the results have been otherwise. It was only in England that the capital was at hand to build the large screw steamers which alone could profitably use the canal, and from the start three-fourths of the vessels using the canal have been British. Of late years there has
been a slight decline in the percentage of British vessels, but this has been due not to an increase in the ships of southern European nations, but to an increase in German, Dutch, and Belgian vessels.

But while the carrying trade is still in British vessels a much larger and a growing share of the traffic is carried from the East directly to the Continent, and England has declined in relative importance as a warehousing and distributing point for Eastern goods. Under the old régime of sailing vessels around the Cape, when voyages from India took a good part of a year, and the time of arrival could not be calculated on within a month or two, it was necessary that large stocks of goods should be kept on hand to enable dealers to meet the varying demand for their goods. Steamers by way of the Suez Canal make the voyage in thirty days and the time of their arrival can be regulated within a day. Shorter voyages and punctuality of arrivals make it possible for local dealers both in England and on the Continent to order directly from the East and the change in the method of this business rendered useless to a large extent the immense warehouses at London, Liverpool, and other English ports. A few statistics will show the extent to which direct trade between the East and the Continent has taken the place of trade via England. In 1870 the value of exports from India to the United Kingdom was nearly $70,000,000, to the rest of Europe $13,000,000; in 1893–94 the
value of Indian exports to the United Kingdom was $93,000,000, to other European countries $85,000,-
000. In other words, while the total export trade of
India and the total exports to Europe have doubled
in value within twenty-three years, and the exports
to European countries other than Great Britain have
multiplied sixfold, the exports from India to the
United Kingdom have increased but 40 per cent.
The proportion of Indian exports to Europe, that
are landed first in the United Kingdom, declined
from 83 to 53 per cent.

DIRECT EXPORTS FROM INDIA TO EUROPE.

This change in the direction of trade has not been
simply the transfer of the distributing points from
England to the Mediterranean ports of southern
Europe. The towns of Italy, Greece, and southern
France have been almost as greatly disappointed in
their expectations of becoming trade centers as in
their hopes of controlling the shipping trade to the
East through the operation of the Suez Canal. To
be sure there has been a heavy increase in Indian ex-
ports to Italy, Austria, and Russia; and the Mediter-
ranean ports, notably Genoa, have increased in im-
portance. But the most striking feature of the
change in the direction of Indian exports lies in the
increased traffic to France, Holland, Belgium, and,
above all, to Germany. The statistics of Indian ex-
ports to these countries show that there is no longer any one country pre-eminent as a distributing point for Eastern produce, but that all Europe trades directly with the East. Nevertheless, with this great change in the character of the Indian export trade the imports of European goods to India continue, as in the days before the canal, to come almost entirely from England.

The termination of the warehouse distribution system of England was one of the forces which led to the disappearance of the class of merchant princes who had hitherto monopolized the Eastern trade. The system of bank discounts and commercial loans, by enabling men of ability to secure capital at low rates of interest, also played a large part in driving out of trade the old houses doing business on their own capital, from which they expected large rates of interest. But as long as large stocks of goods had to be kept on hand for six months or more at a time, it was difficult for the new business man to get the credit that would enable him to supplant the old-established houses in the eastern trade. When, however, the new route by the Suez Canal, by bringing steamers into use, enabled a cargo to be sold and delivered within a month after the order had been sent the advantages on the side of the man working with borrowed capital were decisive.

As a result of the opening of the Suez Canal sailing vessels, warehouses, merchant princes, dealers in
six months' bills found their old occupations slipping away. The old modes and channels of business were altered and new adjustments had to be made. In the meantime the confusion and disturbances in the business world were so great that the London Economist has said that they constituted one great general cause for the universal commercial and industrial depression and disturbance of 1873.

The effect of the opening of the Suez Canal and the new route to the East on the production and marketing of Eastern produce is by no means so easy to trace as the effects on the machinery of trade. If all the necessary statistical material were at hand it would be an almost endless task to disentangle from the complex results of complicated causes the exact changes that have been due to the canal. It is possible, however, to see the effects produced by the canal in the case of a few leading commodities, and in other respects the general tendency of the new route can be recognized.

**EFFECT ON CERTAIN COMMODITIES.**

A few commodities will serve to show that not every article in the Eastern trade has been affected by the new route and the new methods of business brought about by it. The exports of Indian cotton have remained at about the same figure since the opening of the canal, showing that for that article
the sailing vessel and the Cape route provided as cheap a road as the canal route. The exports of Indian wool and of spices have increased to some extent, but with nothing to indicate that the increase is greater than would have taken place in the ordinary development of trade. The exports of tea from India show an astonishing increase from 11,000,000 pounds in 1870 to 120,000,000 in 1893–94. But with an article of such high value the direct effects of the canal through cheaper freight rates can have had little influence here, though indirectly the increased Indian production may be due in part to the easier communication with the West that was made possible by the canal. In the earlier arrival of the new season's teas the influence of the canal in shortening the time from India to England is clearly evident. Tea imports to England in July, 1870, were 711,000 pounds; in July, 1871, 4,000,000 pounds; in July, 1872, 23,000,000 pounds—the enormous increase being the direct result of the use of steamers via the canal in place of sailing vessels and the long Cape voyage.

Rice is a commodity the trade in which has been subject to important changes as a direct result of the use of the canal route to the East. Rice is a staple Italian cereal and a leading article of Italian export. It had formerly been imported into European countries by the Cape route, but by the canal route Eastern rice was enabled to reach markets in southern
Europe formerly inaccessible, and even to be sold in Italy itself, much to the displeasure of the Italian producers. In the six years following the opening of the Suez Canal the export of Indian rice doubled and has continued to increase since. It constitutes the largest single item in the export trade of India.

INDIA AS A WHEAT-EXPORTING COUNTRY.

The creation of the wheat export trade of India is due directly to the opening of the Suez Canal route to Europe. Efforts had been made to carry wheat around the Cape, but the liability to heat during the long voyage and the loss from weevil in the cargo made all such attempts unsuccessful. The possibility of carrying wheat by the new and shorter route was soon demonstrated, and a trade was established that has grown until India has become the second wheat-exporting country in the world. In 1870 the wheat exports of India were 130,000 bushels; in 1876, over 4,000,000 bushels; in 1883, 35,000,000 bushels; in 1891, 50,000,000 bushels.

Since the last date there has been a considerable decline in the extent of the export owing to poor crops, but under ordinary conditions the Indian product is an important item in the wheat market of the world. It will be observed that the great increase in this Indian export trade did not begin until after the year 1876. The extension at that time came
about through the reduction in freight rates made possible by improved steamers. It is nevertheless true that the establishment of the wheat export trade of India and the possibility of any such trade existing at all is to be ascribed to the Suez Canal.

Of the imports into India the direct influence of the Suez Canal seems to be striking in the case of but one commodity—petroleum from the Russian oil fields at Batoum. Before the discovery of these fields the imports of oil into India were insignificant. The value of such imports in 1869 was about $110,000 and in 1876 had risen only to $175,000. But when the Batoum oil fields were discovered an extensive trade to India, via the Suez Canal, immediately developed. In 1880 the imports of oil into India were 6,500,000 gallons, valued at $1,360,000; in 1885 this had risen to 26,300,000 gallons; in 1890, to 51,800,000 gallons, and in 1893, to 86,600,000 gallons. For a considerable period the Indian demand absorbed more than half the total product of the Russian oil wells, and to-day it takes more than a quarter of their output. As the distance from Batoum to India around Africa is as great as that from the American oil fields, it does not seem possible that any of this Russian oil would have found its way to India by the Cape route. Some trade might have arisen by the overland route to India, which, when railroad connections from the Caspian Sea to India are complete, would have become important, but the
oil imports of India as they stand to-day are made possible only by the existence of the canal route.

It may be well while dealing with particular commodities to note that nearly 1,000,000 tons of coal are annually brought to Port Said for the steamers passing through the canal. This coal makes a considerable item in the Mediterranean trade due to the Suez Canal.

If the question be asked, What is the total significance of the Suez Canal on the production and marketing of commodities? the answer can be given only in general terms. A superficial observer might base an estimate on the increase in Indian trade with Europe from $280,000,000 in 1870 to $700,000,000 in 1894. If, however, it is borne in mind that this increase has been at a less proportionate rate than that from 1850 to 1870 without the canal, and if the large extensions of the foreign trade of Australia, South Africa, Argentina, and the United States within the last twenty years are also remembered, it must be evident that other and more general causes than the opening of the canal have affected the development of India. On the other hand, to limit the effects of the canal to those results which can be directly traced, such as the development of the trade in rice, wheat, and petroleum, is to err by understatement. The greater case of communication by the canal route has brought much more Western life into personal contact with the East, and this has had
much to do with the development not only of the foreign trade of the Eastern countries, but also of their internal resources. One phase of this general development in which the canal has had an indirect share may be seen in the tonnage statistics of some of the Eastern countries. From 1870 to 1894 the total foreign tonnage of India rose from 4,000,000 tons to 7,660,000; of Ceylon from 1,420,000 tons to 6,360,000 tons; of the Straits Settlements from 1,650,000 tons to 10,000,000 tons; of Hongkong from 2,640,000 tons to 10,160,000 tons. How much of this increase is to be ascribed to the canal and how much to other causes can not be calculated or even roughly estimated. We must remain content, in this part of our inquiry, with recognizing that the canal is one of the factors in the great economic development of southern Asia.

To recapitulate: The construction of the Suez Canal has led to the immediate and rapid development of the use of steamers in the Eastern trade, has brought about the disuse of most sailing vessels in that trade, has caused the decline of the warehouse distribution system of England, and the rise of a direct trade between the East and the consuming countries of Europe. The shorter and more direct route has also made possible the wheat export trade of India, and the trade in oil from Batoum to India, and has doubled the rice exports of the latter country. The canal has also been one of the many factors in
other important economic changes, among which may be mentioned the crisis of 1873 and the general development of trade and industry in the East.

THE ST. MARYS FALLS CANAL.

There has been a canal around the falls in St. Marys River between Lake Superior and Lake Michigan, available for vessels drawing not more than 12 feet of water, from 1855 on, but fifteen years later the average annual increase of 21 per cent. of each year's freight traffic over that of the preceding year made it so evident the canal would soon be inadequate for the increasing commerce that the United States Government began improvements, and by 1881 had completed a 17-foot channel between the lakes, and provided a 515-foot lock, with a single lift of 20 feet, for carrying vessels from the level of one lake to that of the other. The continued growth of the traffic led to an improved 20-foot channel, provided with an 800-foot lock in 1896. Following the example of the United States the Dominion Government built a canal around the Canadian side of the falls in 1895.

TRAFFIC OF SUZ and ST. MARY'S CANALS COMPARED.

The volume of traffic through this canal far ex-
ceeds that through the Suez Canal. In 1881 the traffic of the old St. Marys Falls Canal was 1,560,000 tons, as against 4,130,000 tons through the Suez Canal; but with the enlargement of the American canal a rapid increase in traffic immediately developed. By 1889 it equaled that of the Suez Canal (about 7,000,000 tons in each); in 1895 a tonnage of 15,000,000 tons went through the St. Marys Falls Canal, as compared with 8,500,000 tons through the Suez Canal; and in 1901 the figures for the St. Marys Falls Canal were 28,403,065 tons.* The present traffic through the American canal exceeds the total foreign trade of the port of New York and is equal to nearly half the total volume of the foreign trade of the United States. In value the traffic through St. Marys Falls Canal presents less imposing figures, though even in this respect it is by no means insignificant. The value of the freight passing through the canal in 1896 is estimated at $195,000,000, and in 1901 at $290,000,000.† The Indian traffic alone through the Suez Canal in 1896 is valued at $360,000,000. Nevertheless, a trade increasing

* In 1905 they were 36,617,699.
† The discovery and utilization of the mineral wealth of the Great Lakes region, supplemented by timely appropriations by Congress for the improvement of navigation, have brought about a maritime growth in that portion of our country which is without parallel in maritime history. Our lake fleet alone is greater than the fleet of any foreign nation except Great Britain or Germany.
nearly $100,000,000 a year within a period of five years, may, prima facie, be expected to have had important economic effects.

As in the case of the Suez Canal the most striking results have been on the machinery of trade, the influence of the St. Mary's Canal on the shipping industry of the Great Lakes being especially marked. It is not too much to say that the development of the carrying trade on the Great Lakes both in the number and kind of vessels used is due almost wholly to the "Soo" Canal. From 1881 to 1895 the volume of commerce through the Detroit River increased from 17,500,000 tons to 29,000,000 tons. During the same period the volume of commerce through the St. Mary's Falls Canal increased by 13,500,000 tons, and as the larger share of the canal traffic goes through the Detroit River to Lake Erie ports, the increase in the traffic through the Detroit River is seen to have been mainly in the traffic from Lake Superior made possible by the existence of the canal and locks at Sault Ste. Marie. This increase in traffic has meant a corresponding increase in the number of vessels in the lake-carrying trade, and probably half of the 3,230 vessels on the lakes are employed in business depending on the canal. Between 1883 and 1897 the total tonnage on the lakes increased from 720,000 to 1,410,000 tons, the increase being more than the total increase in the American merchant marine during this time. Further, while in 1883 the lake ton-
nage was but a sixth of the total American merchant marine, in 1897 it was nearly two-sevenths of that total.

CHANGES IN THE LAKES SHIPPING.

Not only has there been this increase in traffic and shipping due to the canal, but within the last ten years there has been a rapid and striking change in the material and structure of the ships on the Great Lakes, which could hardly have taken place had it not been for the canal. There has not been any sudden displacement of the old vessels such as was occasioned by the Suez Canal, but the new ships built for the increased traffic and to replace those that were out are not sailing vessels of wood, but large steel and iron steamships with double bottoms, water-tight compartments, triple-expansion engines, and modern electrical appliances. In 1870 there were 1,699 sailing vessels and but 642 steamers on the lakes; in 1897 there were 993 sailing vessels and 1775 steamers. In 1870 the average tonnage of vessels on the lakes was 175 tons; in 1897 it was 440 tons. In 1880 a 1,000-ton vessel was a rarity. In 1895 there were five lines owning together 60 steamships of from 1,750 to 3,000 tons, and in 1901 over 100 steamers and sailing vessels from 5,000 to 8,000 tons, and 10 over 8,000 tons.

The “Soo” Canal is connected in two ways with
these changes in the lake shipping. In the first place, the increase in lake traffic, which has necessitated large numbers of new ships and thus hastened the introduction of larger and modern ships, has been, as we have seen, mainly in the traffic from and to Lake Superior, made possible by the canal; in the second place, the iron ore from which the iron and steel ships are constructed comes from the iron mines of northern Michigan and Wisconsin, which have been made available by the canal route from the mines to the ports in the southern lakes.

EFFECT OF "SOO" CANAL ON IRON BUSINESS.

The mention of these iron ores brings up the second phase of the economic effects of the "Soo" Canal — those on the production and marketing of commodities. The case of iron and steel may well be given the first place as the largest item in the traffic through the canal. The most striking features in the iron and steel industries since 1880 have been the decline in the importance of the Pennsylvania mines, the development of the Lake Superior region, and the transfer of the manufacture of pig iron and steel from the east to the west of the Alleghenies. Several factors have served to bring about this remarkable shift. The Superior ores are of the quality available for making steel by the Bessemer process; the large deposits have made profitable the use of labor-saving
machinery in mining and the construction of special terminals for loading and unloading the ore. But an equally important factor is the low rates of freight from the mines to the manufacturing points in Ohio, western Pennsylvania, and Illinois by the water route through the canal. In 1895 the rate from the mines to Erie ports was 80 cents per ton, equal to nine-tenths of a mill per ton-mile. The lowest railroad rate per ton-mile would equal a charge of $2.59 a ton from Duluth to Cleveland; and as the price of red hematite ore of Bessemer quality at Cleveland in 1895 was $2.80 a ton, the dependence of Lake Superior ore on the water route may be easily seen.

An interesting case of interacting causes is to be seen in the relation between the Lake Superior iron mines and the shipping on the Great Lakes. It was the development of the iron mines which furnished the trade of the large steel steamships, and also the material for constructing them, while the use of the larger and better ships has lowered freight rates and still further developed the iron industry.

The development of the Lake Superior iron mines has been an important factor in causing the great reduction in the price of Bessemer steel during the last sixteen years, and it is this reduction that has made possible the largely increased use of steel in shipbuilding, in bridges; in heavier rails, and in the tall buildings of our large cities. Indirectly, then, all these improvements have depended to a large degree
on the existence of the St. Marys Falls Canal. The extent of this relation may be indicated in some degree by the statistics of the iron-ore movement through the canal. From 1860 to 1881 the amount of iron ore passing through the canal increased from 100,000 tons to 750,000 tons per year, but since the construction of the larger lock the increase has been at a much greater rate. In 1887, 2,500,000 tons went through the canal; and for each of the years 1895, 1896, 8,000,000 tons; and in 1901, 18,000,000 tons. Throughout the period since 1881 the traffic in iron ore has formed about one-half the total tonnage passing through the canal. The figures for 1895 and 1896 are equal to four-fifths of the total production of the Lake Superior mines, which in turn constitutes two-thirds of the total iron-ore output of the United States.

ENORMOUS WHEAT TRAFFIC OF THE LAKES.

The most important part of the traffic through the "Soo" Canal, however, is not iron ore, but wheat and flour and other grains. The value of these items in the canal traffic is one and a half times that of the iron ore, and equal to $84,000,000, or nearly a third of the valuation of the total commerce through the canal. In volume the traffic has grown from 3,500,000 bushels of wheat and 600,000 barrels of flour in 1881 to 63,250,000 bushels of wheat
and nearly 9,000,000 barrels of flour in 1896. The last figures account for a large fraction of the 467,000,000 bushels of wheat raised in the United States in 1896, being in fact almost equal to that portion of the crop exported. The movement of wheat through the canal just about equals the total receipts at Buffalo and Erie.

It is not, however, possible to give the canal alone the credit for having developed this wheat trade. The production of the wheat was only made possible by the construction of railroads through Minnesota and the Dakotas, and these same railroads provide a means of getting the wheat to market via Chicago. But if all-rail rates had to be paid, Minnesota and Dakota wheat and flour could not compete so well with that from the country near the eastern markets as it does by having water rates from Duluth to Buffalo. It should also be borne in mind that railroad building in Dakota and Minnesota began on a large scale only after the enlargement of the canal, when it was seen that they could connect with a through direct water route to Buffalo. The canal has therefore been an important factor in developing wheat production in the country west of Lake Superior.

Besides wheat there has been a considerable traffic in other grain, but this first assumed large dimensions in the year 1896, when 27,000,000 bushels of grain other than wheat went through the canal, as against
8,000,000 bushels in the previous year. As yet this is a less important item than that of wheat, but the relations between the canal and the development of the traffic are the same in both cases.

DEVELOPMENT OF LUMBER TRADE.

The same relations can also be traced in the development of the lumber traffic. This grew from 82,000,000 feet in 1881 to 685,000,000 feet in 1896. As in the case of wheat, a considerable increase would have resulted from the construction of railroads, but the construction of railroads has been hastened and increased by the existence of the water route to the East through the canal, and it is only by cheap water rates that such a huge traffic has been developed. If, however, the cutting down of forests is the true explanation of the destructive spring floods in the Mississippi Valley, the encouragement given to the lumber traffic by the canal may not, after all, have been of economic advantage to the country as a whole.

The other important item in the south-bound traffic through the canal does not seem to have been dependent on the canal. The amount of copper going by this route increased from 29,000 tons in 1881 to 116,000 tons in 1896; but the cheaper freights made possible by the canal can have had little effect in promoting the production of an article valued at $200 a ton.
Of the north-bound traffic the only item of large dimensions is that of coal. In 1881, 295,000 tons of coal passed through the canal; in 1896, over 3,000,000 tons. The whole of this traffic may be said to have been created by the canal. The lowest railroad rates would be too high to allow any coal to be carried to the country around Lake Superior, but the lake steamers, going back empty for their cargoes of iron ore and wheat, can afford to carry coal at rates which seem incredible. In 1890 the average freight rate on coal from Buffalo to Duluth was 45 cents a ton. It is through such rates that the northward movement of coal and the consequent development of a large iron manufacturing industry near the ore mines are made possible.

INCREASES OF POPULATION DUE TO THE CANAL.

The geographical changes in production that have resulted from the operation of the St. Marys Falls Canal have been accompanied by important movements of population. A definite connection can be shown between the canal and certain particular population movements, but with other changes the canal has been only one of several factors. The increase of population around the shores of Lake Superior may fairly be ascribed to the development which has been given to that country by the canal. Taking the counties bordering on Lake Superior, we find that from
1880 to 1890 the population of the Michigan counties increased from 61,750 to 116,600; of the Wisconsin counties, from 8,000 to 41,000, and of the Minnesota counties, from 6,400 to 54,700. The total increase is not a startling figure in the United States, but compared with the percentage increase in these same States as a whole the result is striking. During the decade the population of Michigan and Wisconsin increased in each case about 27 per cent, and of Minnesota about 70 per cent; in the Lake Superior counties the percentage of increase was, in Michigan 90 per cent, in Wisconsin 400 per cent, and in Minnesota 800 per cent. The only explanation of the difference is that new lines of industry have been opened up by the larger "Soo" Canal. One conspicuous feature of this increase of population in the Lake Superior region is the development of cities. Of the total increase of 136,000, 72,000 occurs in the six cities of Duluth, Superior, Ishpeming, Ashland, Marquette, and Iron Mountain. Duluth, from a town of 3,500 in 1880, had become a city of 33,000 in 1890, and six years later had a population of 60,000. Ishpeming increased during the ten years from 6,000 to 11,000; Superior, from 4,700 to 9,000, while the other three places were not in existence in 1880, but had populations between 8,500 and 12,000 in 1890.

Among the movements of population where the effects of the "Soo" Canal have been greater but are
not so exactly calculable, may be mentioned the settlement of the Red River Valley and the increase in the cities on and near the southern shores of Lake Erie. The first of these is connected directly with the development of wheat production in that region, in which, as has been seen, the canal had a most important influence. The second is due, in large part, to the development of the iron and steel manufacturing industries, brought about by the use of iron ore from the Lake Superior region.

INFLUENCES OF ST. MARY'S AND SUEZ CANALS.

A comparison of the influence of the St. Marys Falls Canal with that of the Suez Canal, shows that both have led to a rapid change in the material and character of ships used, that brought about by the Suez Canal being the most important, both in the extent of new shipping and in the consequent dislocation of old forms of industry. Both canals, too, have led to important changes in the sources of production of several commodities, and the effects of the American canal on iron and wheat production are greater than any effects traceable to the Suez Canal. In the case of the more general changes in which the extent of the influence of the canals can not be measured, no accurate comparison between the two is possible but considering the greater area and
affected by the Suez Canal, it is evident that its influences on general development have been greater.

Both canals have led to the production of wheat on a large scale in areas hitherto unused for that purpose, these districts constituting a large part of the total increase in the area devoted to wheat production. In consequence of this total increase of wheat-raising area during the last fifteen years, and the cheaper transportation to European markets, there has been a large reduction in the normal price of wheat. Cheaper food and less distress from famines and the fall in prices received by farmers in the old wheat-producing districts have been due in no small degree to the canals.
With Summit Elevation at 85 Feet
Profile of Proposed Lock Canal
Lock Canal Project
Panama Canal
Board of Consulting Engineers