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Dimensions to be given to maritime canals. (Technical point of view. Probable dimensions of the sea-going vessels of the future.)

GENERAL REPORT

BY

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San Francisco, Cal.

Executive Committee — Office of the Secretary General
38, Rue de Louvain, 38
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DIMENSIONS
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There have been six papers submitted to the General Reporter on the above question. These are as follows :

No. 63, by G. DE THIERRY, Baurat, Professor an der Königl. Technischen Hochschule Charlottenburg, Mitglied der Internationalen Technischen Commission des Suez Kanals, Berlin-Halensee, Germany;

No. 64, by H. VANDER VIN, Ingénieur en chef Directeur des Ponts et Chaussées, Antwerp, Belgium;

No. 65, by Dr. Sc. E. L. CORTHELL, Civil Engineer, New York, United States;

No. 67, by J. FOSTER KING, Chief Surveyor to the British Corporation for the Registry of Shipping, Glasgow, Great Britain;

No. 68, by C. LEEMANS, Civil Engineer, Amsterdam, Holland;

No 69, by E. I. ZAMJATIN, Naval Engineer, St. Petersburg, Russia.

A seventh paper by E. Quellennec, Ingénieur en chef des Ponts et Chaussées, France, was announced but had not been received by the General Reporter at the date when it was necessary to forward this review.

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The question "Dimensions to be given to Maritime Canals. (Technical point of view. Probable dimensions of the sea-going vessels of the future.)" is understood by the General Reporter to relate specifically to the minimum dimensions of the canals and to the dimensions of the large sea-going vessels. The inter-relation of the size of the largest sea-going vessels and of the required dimensions of the canals is recognized in the question.

If it be admitted that the dimensions of the sea-going vessels are to be determined solely by the needs of trade and commerce, by economy of operation, and by the demands of passengers for speed, comfort, and luxuries, without regard to harbor facilities and without regard to the possible usefulness of the vessels to their Governments in case of war, then it becomes comparatively easy to predict future growth. As Dr. Corthell contends, the law would really be inexorable, and no one could foresee a limit to the size of the largest vessel.

But, and perhaps fortunately, there are other considerations to be taken into account, notably the general usefulness of large vessels, which, according to their size and particularly their draught, may be materially restricted by the dimensions of maritime canals and the depth of the approaches to the principal harbors of the world. To this point particular attention is asked and the Twelfth International Navigation Congress may well consider whether or not it is desirable to point out other means of restricting the rate of increase in the size of vessels than only by the demands of the shipowners and the ability of the shipbuilders to comply with these demands.

It appears from all of the papers which have been submitted that there is no check yet apparent to the rate at which the dimensions of the largest sea-going vessels are increasing. The vessel of over 50,000 tons is being built and those who should know, expect the vessel of 70,000 tons or more to put in her appearance soon.

Would this be possible without Government aid? Some of the transatlantic steamship companies are so heavily subsidized that their ships are practically in Government ownership. On the Pacific too the economic success of transportation in large vessels is made possible by subsidies in one form or another. Our own country which does not subsidize is out of the running. It has no merchant marine to speak of. In other words, the operation of large steamers without subsidy is not profitable, at any rate not in competition with subsidized vessels.

And yet, if commerce between nations had been developed without Government aid, and if the commerce on the high seas had been and were carried on only by vessels of moderate size, there would have been a suitable adjustment to such conditions and there would be little if any less volume of business between nations than is found today.

Perhaps, upon careful analysis, it may, even under established conditions, be found preferable to operate ten steamers of 10,000 tons each, rather than only two of 50,000 tons. From the standpoint of the Government of any maritime country it would certainly be more desirable to have at its disposal when needed ten ships of 10,000 tons than two of 50,000 tons. The papers which have been submitted will now be briefly reviewed.

Review of paper No. 63

Mr. G. de Thierry after making the statement that the largest ocean vessels are always those on the routes between Europe and North American ports, refers to the fact that there is an ever increasing size of vessels on other routes. He calls attention to the falling off in the number of vessels of smaller tonnage. He illustrates with a reference to the aggregate tonnage of British steamers in classes according to size, showing a decrease in aggregate tonnage of the small steamers, less than 1,000 tons, after 1884; and showing also a decrease of the aggregate tonnage of steamers from 1,000 to 2,000 tons after 1895.

How the ever increasing size of vessels has compelled the enlargement from time to time of maritime canals and harbor approaches is referred to and examples are cited. Among these are :— Such instances as the improved Weser where the present requirements were not foreseen when the improvements were planned by Franzius in 1879 to 1881; the Kaiser Wilhelm Canal built in 1887 to 1895 and now being enlarged at a great cost; the Suez Canal which has been made wider and deeper and now has sufficient depth for vessels with 28 feet (8.53 meters) draught.

The report of Mr. de Thierry then contains valuable facts relating to the Suez Canal, and he shows that with every increase in depth larger vessels have made use of the canal. But notwithstanding this fact, he says, it is not justifiable for economic reasons to take the ultimate dimensions of ocean vessels as a guide in planning a canal. However, due consideration should be given at the outset to the possibility of future canal enlargement.

In part three of his report Mr. de Thierry treats the construction of ships canals from the technical standpoint, dealing exhaustively not alone with the dimensions in their relation to the requirement of the shipping which is to use the canal, but also with the more involved engineering problems. This part of the report is full of valuable information for the engineer with extended references to the Suez Canal and to The Kaiser Wilhelm Canal.

In the matter of the relation of the sectional area of the waterway to the area of the immersed portion of the largest vessel which is to use the canal, Mr. de Thierry reaches the conclusion that the former should be five times the latter.

Among the conclusions which Mr. de Thierry formulates there may be particularly noted his first, according to which only the dimensions of vessels ruling at the time of the canal construction should be taken into account; his fifth, that the depth of water under the vessel of greatest draught should be 1 meter (3.28 feet); and his sixth, already noted, that the area of the canal section should be at least five times that of the largest vessel.

Of these the first seems predicated upon purely financial reasons and, if literally construed, would in most cases be too severe a restriction. It is in line, however, with his view that at first recourse should be had to sidings rather than to a width throughout that would be required for passing vessels at any point of the canal. The conclusions with reference to depth of water under the keel and the area of the canal section come with full force from an engineer of experience. Anything less than the values here suggested would be more or less of a restriction upon the usefulness of a canal.

Review of paper No. 64

Mr. H. Vander Vin, referring to the dimensions of larger vessels, believes that, especially draught and length considered from the point of view of stability, the maximum point on the curve of increase may have been reached.

The author emphasizes the interrelation between draught of vessels and the depth of harbors and the inconvenience that would result if vessels have such draught that they can enter the ports only during the short period of high tide. Based mainly on the data collected by Dr. Corthell and published by him in his report to the Tenth Congress of this Association at Milan on the "Rapid Increase in the dimensions of steamers and sailing vessels etc." Mr. Vander Vin presents instructive tables showing existing or contemplated entrance depth of harbors at mean low water and at mean high water, from which it appears that among those with less than 9 meters (29.5 feet) there would be such important ports as :

In Australia :	Melbourne	with	8.50	meters
	Williamstown	"	8.20	"
	River Yarra	"	7.90	"
	Port Adelaide	"	7.00	"
	Newcastle	"	6.10	"
In Belgium :	Ghent Canal	"	8.70	"
	Antwerp	"	7.50	"
In England :	Manchester	"	8.50	"
	Hull	"	7.30	"
	Barry Docks	"	6.60	"
	Blyth	"	6.10	"
In France :	St. Nazaire	"	7.00	"
	La Pallice	"	6.90	"
	Boulogne	"	6.80	"
	Dieppe	"	6.40	"
	Bordeaux	"	6.10	"
	Havre	"	6.10	"
	Bayonne	"	6.00	"
	Nantes	"	6.10	"

In Germany :	Lübeck	with	8.50	meters
	Harburg	"	8.20	"
	Bremer Haven	"	8.00	"
	Hamburg	"	8.00	"
	Koenigsberg	"	6.50	"
	Stettin	"	6.50	"
	Warnemünde	"	6.00	"
In Greece :	Corinth	"	8.00	"
In Holland :	Rotterdam	"	8.00	"
In Italy :	Savona	"	8.80	"
	Venice	"	8.20	"
	Cagliari	"	8.00	"
	Spezia	"	7.80	"
	Civita Veccia	"	7.20	"
In India :	Bombay	"	8.70	"
	Calcutta	"	8.20	"
In Ireland :	Dublin	"	6.10	"
In Mexico :	Tampico	"	8.20	"
In Russia :	Cronstadt	"	8.50	"
	St. Petersburg	"	8.50	"
	Libau	"	7.90	"
	Riga	"	6.70	"
In Roumania :	Constantza	"	8.50	"
	Sulina	"	7.30	"
In Sweden :	Stockholm	"	7.70	"
	Malmö	"	6.70	"
In Scotland :	Greenock	"	7.00	"
	Dundee	"	6.70	"
	Glasgow	"	6.70	"
	Aberdeen	"	6.10	"
In the United States :	Norfolk, Va.	"	8.50	"
	San Diego, Cal.	"	8.50	"
	Charlestown, S. C.	"	7.90	"

In the United States :	Astoria, Wash.	with	7.60	meters
	Port Arthur, Texas	"	7.60	"
	Portland, Oregon.	"	7.60	"
	Providence, R. I.	"	7.60	"
	Mobile, Ala.	"	7.00	"
	Savannah, Georgia.	"	6.60	"
	Wilmington, Del.	"	6.40	"
	Brunswick, Georgia.	"	6.20	"
	New Haven, Conn.	"	6.10	"
	San Pedro, Cal.	"	6.10	"

Mr. Vander Vin enumerates among the harbors which have less than 9 meters (29.5 feet) of water at mean high water such important harbors as :

In Africa :	Durban (Port Natal)	with	8.50	meters
	Dar el Salaam	"	8.50	"
	Tunis	"	7.10	"
In Australia :	River Yarra (Vic.)	"	8.70	"
	Newcastle (N. S. W.)	"	7.30	"
In the Argentine Rep.:	Buenos Aires	"	8.20	"
In Belgium :	Ghent Canal	"	8.70	"
In Brazil :	Pernambuco	"	7.00	"
In China :	Shanghai	"	6.10	"
In England :	Manchester	"	8.50	"
In France :	Bayonne	"	8.90	"
	Rochefort	"	8.90	"
	Nantes	"	8.50	"
	Bordeaux	"	7.30	"
	Rouen	"	7.20	"
In Germany :	Lübeck	"	8.50	"
	Pillau	"	8.00	"
	Swinemünde	"	8.00	"
	Geestemünde	"	7.70	"
	Stettin	"	7.70	"

In Germany :	Dantzig	with 7.00	meters
	Kiel	" 7.00	"
	Koenigsberg	" 6.50	"
In Greece :	Corinth Canal	" 8.00	"
In Italy :	Venice	" 8.20	"
	Spezia	" 8.10	"
	Civita Veccia	" 7.70	"
In India :	Calcutta	" 8.20	"
In Russia :	Cronstadt	" 8.50	"
	St. Petersburg	" 8.50	"
	Libau	" 7.90	"
In the United States :	Savannah, Ga.	" 8.70	"
	Bangor, Me.	" 8.20	"
	Brunswick, Ga.	" 8.20	"
	Wilmington, Del.	" 8.20	"
	Port Arthur, Tex.	" 8.10	"
	New Haven, Conn.	" 7.90	"
	San Pedro, Cal.	" 7.60	"
	Mobile, Ala.	" 7.50	"
	Washington, D. C.	" 7.00	"

It has not been possible for the General Reporter to verify these figures of entrance depth, but they are quoted from the tables in order to show that among the harbors that have an entrance depth of less than 9 meters, there are many of importance.

Unless they can be improved to greater depth at reasonable cost the vessels entering them will be limited in maximum size by the harbor depth. It follows from this that the growth of commerce on new routes of travel, the increasing commerce of Europe and America with South America and with the Orient, with China, with Japan and Australia which, with the completion of the Panama Canal may be expected to grow more rapidly than that between New York and Europe, will have a retarding effect upon the rate at which the size of the large ocean vessels as a class is increasing. At the same time it may reasonably be assumed that it will be without effect upon the rate of increase in the size of the largest vessels which are found only upon the route between Europe and New York.

The author points out how of necessity a canal of small dimensions would exclude the large vessels and gives a summary of the vessels which entered the port of Antwerp in 1910. Of the total number, 6,973, he says that only 0.7 % had a draught of 7.50 meters.

He believes that in the maritime canal which extends inland from the sea that a depth of 0.75 meters (2.45 ft) under the keel would be adequate and that the minimum navigable depth in such a canal should be 8.25 to 8.50 meters.

The ratio of the sectional area of the submerged part of the vessel in a canal and the water in which it floats he places at 4 to 5, using in his estimate of required minimum canal width the factor 4.5. For 3 on 1 bank slopes the bottom width should be 129 feet (39.50 meters).

The author refers to the satisfactory results, on the canal from Ghent to Terneuzen, of the facing of the banks with timber work immediately below the water line.

He considers that prudence demands that any canal constructed to meet only the demands of the present and of the near future should be so constructed that it will permit of future enlargement.

Review of paper No. 65

Perhaps no one is better qualified to discuss the probable future dimensions of ocean vessels than Dr. E. L. Corthell. He has given this matter close attention for many years and in 1898 wrote an exhaustive report on "Maritime Commerce" for the Fiftieth Anniversary of the Association for the Advancement of Science in the United States of America, in which he dealt with this subject, and he now points out in Paper No. 65 that his predictions as then made are behind the actual dimensions of today, and that in the case of load draught the actual average of the 20 largest steamships of 1911 exceeds his predictions for 1948 by 2 feet (0.61 meters).

Dr. Corthell emphasizes the need of giving consideration to the Transatlantic "liners" and to the war ships of the world. The former must receive consideration in planning the dimensions of maritime canals because every one of the great maritime Powers of the world may in the case of war make requisition for any ship of its flag for war purposes.

There is not, therefore, he says, any great maritime canal that may not be called upon at any time to let these ships pass, that is, the Olympic, Aquitania, Europa, and other of the great North Atlantic liners.

After the dimensions of the Panama Canal locks were fixed by the Isthmian Canal Commission, in 1905, at a usuable length of 1,000 feet and a clear width of 100 feet (the minority of the Board of Consulting Engineers had recommended a length of 900 feet and a width of 95 feet) it was found by the General Naval Board of the United States that these dimensions might at an early date prove inadequate and they were increased. The locks as now being built will be 110 feet wide and will have a usable length of 1,000 feet.

Such facts as these are, says Dr. Corthell "simply illustrative of the statement that a maritime canal must be designed to take the largest merchant and naval ships of the world, and that their requirements are not sufficiently appreciated".

That these views are to prevail is borne out by the fact, according to Dr. Corthell, that the locks of the Kaiser Wilhelm Canal are to be 1,083 feet (330 meters) long, 148 feet (45 meters) wide and 45 feet (13.77 meters) deep, and also by the fact that the Port of London Authority has fixed the dimensions of entrance locks as follows :

For South Albert Dock, 850 feet (259 meters) long, 110 feet (33.5 meters) wide and 48 feet (14.6 meters) deep on the sills.

For the North Albert Dock, 1,000 feet (304.8 meters) long, 120 feet (36.5 meters) wide and 52 feet (15.8 meters) deep on the sills.

For Tilbury Docks, 1,050 feet (302 meters) long, 130 feet (39.6 meters) wide and 55 feet (16.8 meters) deep on the sills with means for extending the lock to take vessels 1,250 feet (381 meters) long by the use of a caisson at the inner end.

Dr. Corthell contends "that the size of Merchant ships is determined by the inexorable laws of commerce, trade, economy of transportation and the demands of passengers for room and comfort". He quotes in this connection Sir William H. White, formely chief Constructor of the British Navy and later designer of the Cunard ships "Mauretania" and "Lusitania", also Prof. J. H. Biles, one of the greatest experts in Naval Architecture, and also Lord Pierie to substantiate his contention that the building of large ships is economical and that the size of merchant ships is determined by the inexorable laws of commerce.

Dr. Corthell points out too that it is incorrect to assume that a maritime canal built for the largest commercial ships, will be large enough for the war vessels and he refers again to errors in conclusions of the Consulting Engineers for the Panama Canal (1905) who suggested dimensions of locks that would have been too small for war ships already building.

The majority of the Board of Consulting Engineers, in 1905, though they favored a sea-level canal and merely considered the lock type as an alternative, suggested locks 1,000 feet long by 100 feet wide.

Dr. Corthell draws the conclusion from the relative dimensions of the Panama and the Suez Canals that the latter must be further enlarged to give commerce what it requires, so that competition will redound to the benefit of all the world. He notes the reluctant concessions which have been made by the Authorities of the Suez Canal to the steamships in the matter of draught: 7.50 meters (24.6 feet) in 1869; 7.80 meters (25.5 feet) in 1890: 8.00 meters (26.2 feet) in 1902; 8.23 meters (27.0 feet) in 1906; 8.53 meters (28 feet) in 1908. This is the authorized draught in 1911, the canal having been deepened to 9.50 meters (31.2 feet).

Speaking of the fact that increase in the draught of steamers 500 feet (152.4 meters) long and upwards falls short of the normal increase, Dr. Corthell says that this is evidently due to the shallow depth of the Suez Canal and to the lack of depth in the approaches to the Port of Buenos Aires and other harbors of restricted depth. He assumes that maritime canals of the larger class should be large enough to allow the passage of the larger class of commercial steamships in two directions simultaneously. There should, he says, be the same space at least between these ships and between them and the foot of the slopes as the width of the ships. From this the conclusion is reached that with bank slopes of 1 on 2 the wet section should be about 21,000 square feet (1,951 meters square) and the bottom width about 375 feet (114 meters). In rock or between retaining walls the bottom should be about 455 feet (138.6 meters). The desirable clear height in the case of fixed bridges is placed by Dr. Corthell at 250 feet (76.2 meters).

The locks should be large enough for vessels 1,100 feet (335 meters) long; 110 feet (33.5 meters) wide, with 40 feet (12.2 meters) draught. Their dimensions should be as follows: Usable length 1,150 feet (350.5 meters); width 130 feet (39.6 meters) and depth of water 45 feet (13.7 meters).

To canals of lesser importance the same general principles may be applied. "The canal should be planned to take the largest possible ship that may wish to pass through within half a century, should the canal be a lock canal. A sea-level canal can be enlarged by dredging, or by under water excavation if the material is rock."

Review of paper No. 67

The largest vessel is the least likely to suffer from the destructive powers of the sea says Mr. Foster King, the author of Paper No. 67, and this fact coupled with economy of operation leads the shipowners on to the construction of the largest vessels justified by their interpretation of trade conditions. But the tendency to exceed certain limits of size is opposed by the dimensions of existing dry docks and by the depth of water at the entrance to ports.

Mr. King proceeds on the assumption that maritime canals include not only such as the Manchester Ship Canal, the Suez Canal, the Kiel Canal, and the Panama Canal but also entrances to ports such as the river Clyde, the Elbe, Ambrose Channel at New York and others which have an influence upon the dimensions of ships and whose own dimensions are in turn influenced by the size of the largest vessels using them.

By the aid of diagrams he points out that the increase in length of the largest ships in the world from 1837 to 1907 has been about 66 feet (20.1 meters) in 10 years and that after 1907 a number of vessels indicate a higher rate of increase bringing the rate of increase up to 150 feet (45.8 meters) in 10 years. The largest vessels have been built for service between New York and Europe.

Vessels on other routes alone being considered, makes the incrase in length of the largest vessels about 50 feet (15.3 meters) in 10 years.

Mr. King finds that apart from the "abnormal" steamers of Lusitania, Mauretania, Olympic, Titanic, Emperator and Aquitania type, the increase of breadth of beam has been at the rate of 8 feet (2.44 meters) in 10 years, and that this rate applies as far back as 1864. The abnormal vessels, however, indicate a rate in recent years of 21 feet (6.14 meters) in 10 years.

The draught in 60 years for passenger steamers other than those classed as "abnormal" has, he says, increased 50 per cent (practically one-third of the draught of today). The same increase in draught is noted for cargo steamers. The half dozen large vessels of abnormal dimensions seem to have a mean draught of about 36 1/2 feet (11.1 meters).

Mr. King believes that the very large vessels plying between New York and Europe should be regarded as being in a class by themselves.

Referring to the largest passenger vessels on other routes, he says, that it is apparent that some influence is holding back the rate at which their dimensions might otherwise be expected to increase. He intimates that the depth of navigable water in the important harbors of the world and the dimensions of the Suez Canal have been potent restraining factors but believes that the depth of water in the Panama Canal—adequate for vessels with a draught of 40 feet (12.2 meters)—and satisfactory traffic conditions on the Suez Canal will stimulate the rate at which the depth of the latter will be increased and that these canal facilities will react upon dimensions of ships and therefore also upon the harbors of the world.

Mr. King anticipates draughts of 27 to 40 feet in 1970 for the bulk of ocean shipping of all types.

So long as there is uninterrupted development of the commerce between nations, and progress in the art of ship building and increase of population, barring any unforeseen revolutions in the means of transportation, there will be no material change in the rate of increase in the size of ocean vessels. This is substantially the conclusion of Mr. King and he believes, therefore, that those countries which desire to maintain their relative positions in the world must improve their harbors and canals to keep pace with this indicated growth of the vessels which are to use the ports or canals.

Review of paper No. 68

Mr. C. Leemans, the author of Paper No. 68, devotes considerable attention to the character and size of vessels on the various ocean routes of commerce, and predicts for each a more or less specific and for each a considerable increase in the size of the largest vessels. He dwells upon the fact that the enlargement, and particularly the deepening of maritime canals has at once been followed by their being used by larger vessels, and he recommends two sets of dimensions for the maritime canals and canal locks of which the first is for steamers serving the lines to New York, to Boston, and Canadian ports, and the second for steamers of other ocean routes.

The dimensions of canals for steamers of the first class he would fix as follows:

Bottom width on straight section . .	120 meters	
Bottom width on curves	140 »	
Depth	15 »	
Slope of banks, 1 on 3 to 1 on 3.5		
Useful length of locks	470 »	
Useful width of locks	55 »	
Useful depth of locks	15 »	at high water.

The dimensions of other maritime canals he would fix a follows:

Bottom width on straight section . .	80 meters	
Bottom width on curves	90 »	
Depth	11 »	
Slope of banks, 1 on 3 to 1 on 3.5		
Useful length of locks	250 »	
Useful width of locks	35 »	
Depth of locks	12 »	at low water.

The larger canal dimensions would be required to fulfill "the greatest demands of the future, navigable by a vessel 160 feet in width, having a draught of 14 meters". It is the author's contention that the conditions in the harbor of New York really determine the dimensions of the maritime canals of the first-class, because that port is frequented by all the largest vessels. He believes it desirable that the principal harbors of Europe should offer the same depth as the harbor of New York. The entrance into the New York harbor, the Ambrose Channel is being maintained at a depth of 12.19 meters (40 feet) at low water or 13.8 meters (45.5 feet) at high water.

Southhampton and Dover afford only 12 meters (39.4 feet) in depth at low water and the navigable waterway at Hamburg is to be dredged to 12 meters (39.4 feet) below high tide.

Without dwelling upon the fact that the motor boat by reason of economy in weight and space of machinery and fuel will increase the efficiency of the vessels of whatever size in which used, and will thereby be in some measure a restraining influence upon the rate of their growth, the author expresses his confidence in the petrol motor and its adaptability for use on sea-going vessels of large size.

The author refers to the obvious disadvantage under which harbors at some distance inland, which must be reached by river or canal, compete with the sea ports on the shore line. In some respects the maritime harbors which are made accessible by canal may be considered better off, he says, than those located on rivers because it is nearly always possible to secure the necessary canal dimensions, while it may be difficult to accomplish and maintain the desired result in a large river.

Mr. Leemans would be taking an advanced view when he expresses his conviction that it is an undeniable necessity for a maritime nation, such as Holland, to have at least one port which is accessible to the largest vessels of the present or of the near future, if he did not qualify his statement to this effect with the clause "if it may be assumed that such vessels will call at the port in question."

That it is desirable that each maritime country should have such a port will probably be conceded by all. It is equally true that this is a condition not easily realized if the dimensions of the largest vessels continue to increase as in the past. The fact that the securing of ports of practically unlimited draught in every one of the important maritime countries is out of the question is one reason why some limit to the increase in draught of the largest vessels should be set other than any limit determined only by the needs of commerce or by structural limitations, or by economy of operation and like considerations.

In this connection Mr. Leemans points out that the financial results of operating the large vessels are not always satisfactory. Government aid in the form of subsidies or otherwise is necessary. No reliable returns are available to demonstrate the unsatisfactory results of operating the largest type of vessels, but it seems probable that without Government aid in the past there would have been a much less rapid rate of increase in dimensions.

Mr. Leemans believes that special consideration should be given to the vessels built with large freight capacity and for moderate speed, 16 to 19 knots. Within another 15 years he thinks we may see on the Atlantic vessels of a gross tonnage of 70,000 to 75,000 with a draught of 12.5 meters (41 feet), and he ventures to prophecy the economic, and technical possibility of vessels 1,500 feet (458 meters) long and 160 feet (48.8 meters) beam, having a draught of 14.5 to 15 meters (47.6 to 49.2 feet).

Review of paper No. 69

Mr. E. I. Zamjatin refers to the increasing size of vessels as demonstrated by the size of those visiting Russian ports as well by reference to vessels in general. The conclusion is reached that the maximum rate of growth has been passed. This is in part attributed to such financial disturbances as those of 1901-04, and 1907-09 and in part to the fact that small owners—as distinguished from large aggregations of capital—are finding it profitable to enter the transportation field. The man of small capital must necessarily content himself with vessels of a more modest type than Lusitanias and Mauretanias and his activity holds down the average size that might otherwise be expected.

The suggestion is also made by the author that the risk of inadequate business increases with the size of the vessels. He admits, however, that these premises do not justify any positive conclusion, that the falling off in the rate of increase of size will continue, nor that any decrease of average tonnage of vessels is to be expected.

The author refers to the fact that the purpose of the increasing size of vessels is to reduce freight rates.

The reduction in the cost of transportation decreases with the size of the ship because the freight capacity in its relation to dead weight increases with the gross tonnage, and because the operating expenses decrease with the increasing size.

For purposes of comparison the author makes the weight of machinery and fuel proportional to $D^{\frac{2}{3}}$ where D represents the displacement. He estimates that increase in the gross tonnage from 5,000 to 10,000, for vessels making 5,000 miles at a speed of 12 knots, should reduce the weight of fuel and machinery by 3 1/2 % of the net tonnage, and the weight of the body of the vessel by 1 % of the net tonnage. At higher speeds the reduction of weight of machinery and fuel will be still greater.

The conclusion is emphasized that the relative decrease of power and the corresponding decrease of fuel required is the chief source of profit to the owner resulting from the increase of size.

The author at this point might well have taken into account the risk of loss or at any rate of lessened profits due to the fact that vessels do not always carry full cargo and are not always in continuous service.

Mr. Zamjatin draws particular attention to the value of the internal combustion engine in comparison with steam engines for the propulsion of large vessels. He believes that the steam engine will be displaced. The utilized caloric energy of the internal combustion engine is given at 37% as compared with 17% for the steam engine. Boilers and stokers are eliminated. The mileage of the vessel equipped with an internal combustion engine is given at 4 to 6 times the mileage of a vessel propelled by steam. The weight of the fuel required will be one-fourth to one-sixth of the former when compared with the latter. The weight of the machinery will be only one half. The cost of fuel too will be only about one half (taking naphtha at 30 roubles ($23.83) per ton- the price at St. Petersburg) and about 0.67 to 0.57 of the cost of fuel for steam if the average price of oil in the world's market be introduced into the calculation.

In tabular form a comparison is given between vessels of about 9,000 tons—two equipped with steam engines and two equipped with "Diesel Motors." At speeds of 12.5 knots the author finds the carrying capacity of the vessel using Diesel motors to be 67 % of the displacement to be compared with 49 % for the vessel equipped with steam engines. At speeds of 18 knots the former should have a carrying capacity of 58 % as compared with 26.5 % for the latter.

The operating expenses including 3 % for depreciation and 10 % for interest and profit are given for the lower speed at 60,500 roubles ($48,000) per annum for the Diesel motor boats and at 76,900 roubles ($61,000) for the steam boats and for the 18 knot boats at 78,370 roubles ($62,200) for the former and 101,100 roubles ($80,500) for the latter.

Based on an equal percentage of profit the author concludes that at 12.5 knots a Diesel motor boat of 14,000 tons may compete successfully with a steam boat of 21,000 tons; and at 18 knots a Diesel motor boat of 14,000 tons may compete with a steam boat of 36,500 tons.

Remarks and Conclusions.

Having given consideration to the views of the experts as presented in the foregoing papers, the General Reporter desires to add that no evidence has been found by him and none is presented in the papers which would indicate tnat for the present any other consideration than the demands of commerce and the willingness of the travelling public to pay for room, comfort and luxuries, and the ability of the ship builders to build the ships will set a limit to the size of the ocean liner. In other words, if the deepening of the harbors and of harbor approaches is continued without restriction the size of the largest ocean liners will, under ortherwise permanent conditions, continue to increase.

Without any restrictions upon the size of vessels, they will be built constantly larger as demanded by economy of operation and by the needs of commerce, and only those ports can hope to be favored with the visits of the largest vessels which find it worth while to afford suitable harbor facilities.

The growth of vessels, therefore, exerts a strong influence upon the concentration of the export and import business at certain points, such as New York harbor where nature has made possible the construction of the facilities demanded by the ship owner who wants to operate the largest boats that can with safety and without delay be taken into and out of the best harbors on the two sides of the Atlantic.

It follows from this that it is to the interest of the port which is less favored by natural conditions that some artificial limit be set to the size of the ocean carriers, particularly in the matter of draught, in order that harbor improvements may be planned with reasonable certainty that they will be adequate.

There should be an international agreement entered into that some depth of water at low tide is the standard to which the important harbors of the world should be improved and there should be no Government aid in the form of subsidy or otherwise to vessels whose dimensions are such as to make the entrance into a harbor of standard depth impossible.

It would be unwise for example for the United States to construct or to encourage by subvention or otherwise the construction of vessels too large to pass through the locks of the Panama Canal.

The usefulness to the Government in time of war of a vessel depends upon its adaptability to the momentary requirements. It should be large enough, and yet not of such colossal dimensions that it can not make port at some unforeseen new destination.

By the construction of the Panama Canal, a stupendous undertaking, the United States has practically set an upper limit for the dimensions of vessels whose construction can be encouraged by the Government. The Canal and the lock system on the canal have cost too much to be readily modified. For the time being the useable lock length on this Canal of 1,000 feet, the breadth of 110 feet and the depth of 41.5 feet on the sills of the lock gates, equal to 40 feet in salt water or to 12.2 meters, has fixed the maximum dimensions both of war vessels and other vessels that are likely to be constructed by the United States or by American owners under Government aid.

But if standard maximum dimensions for the largest desirable sea-going vessels be thus set by the United States, or by an international agreement participated in by the important maritime nations, this will not set a limit to the further improvement of shipping. There is room for improvement even when the limit of size has been reached. The internal combustion engine for example is full of promise and may, as forecast by Mr. Zamjatin, be of material aid in increasing cargo capacity. The gain in cargo capacity resulting in the use of internal combustion engines would, moreover, be of particular value because it is obtained without an increase in displacement. So, too, in the matter of speed there need be no limit set, unless for subsidized vessels it be a lower limit. If the reduction of weight of machinery and of fuel in the motor boat compared with the steam boat even approaches the figures given by Mr. Zamjatin, there should be ample opportunity for securing high speed without being compelled to give the vessels abnormal dimensions.

It remains to be stated that the largest vessels on such special routes as the one between New York and European ports stand apart in a class by themselves, and their dimensions need not be taken into account in forecasting the dimensions of the vessels for whose use the great maritime canals such as the Suez Canal and the Panama Canal and other canals of the first rank are constructed.

The following conclusions appear to be justified and are recommended for adoption by the Congress.

I. *It is desirable that a limit be set to the draught of sea-going vessels.*

II. *Government aid should not be extended to the building or operation of sea-going vessels whose draught exceeds 9.5 meters (32.2 feet).*

III. *There should be an international agreement fixing the maximum dimensions of sea-going vessels built or operated under Government subvention, and there are tentatively suggested the following :*

Length over all	*: 900 feet (275 meters)*
Breadth	*105 feet (32 meters)*
Draught	*32.2 feet (9.5 meters)*

IV. *Any maritime canal which has locks with a usable length of 1,000 feet (305 meters), a width of 110 feet (33.6 meters) and a depth of water on the sill of 35 feet (10.7 meters) will fulfill every reasonable requirement of commerce.*

V. *In a maritime canal a wet section 5 times as large as the immersed portion of the largest ship which is to use the canal is desirable, as also a depth of one meter under the keel; but these values are functions of the speed at which the canal is to be navigated and therefore to some extent also of the volume of commerce, and are to be determined by local conditions.*

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