（昭和十三年十一月六日造船協會講演會に於て講演）

Two Patent Systems of Simplified Hull Form.

By **C. Ono,** *Kogakusi*, Member.*

Introduction.

The idea of constructing the ship's lines in such simple geometrical curves as circular arcs or straight lines is not new. Great many of small sized motor boats, nowadays, have the transverse sections formed of these kinds of simple curves and are known to run quite successfully. For the ocean going merchant ships, however, the idea has not been as successfully applied as in the cases of small crafts. During the later period of the Great World's War, the transport steamers ordered by the British Shipping Controller, designated the type "N" and "N1" were designed to have transverse sections formed of the straight side and straight bottom lines and with hard chines or knuckle lines at bilges or the junction of these two sets of lines. The steel hulls of the steamers were intended to be fabricated by the bridge constructors in the country, who were not at all familiar with the usual shipyard practice. The ships were said to be economically propelled, but their sea-going qualities were being unfavourably criticised.

The fact attracted the attention of the author, who had been for some years looking after the means of simplification of the hull construction work in the usual shipwrights' way, and together with his experience in connection with a motor-boat building yard, led to invention of the two systems of the hull form which will be described hereafter.

Part I. The Straight Side System.

In PL. I. is shown the sheer draught of a ship of this system. The principal dimensions, etc., of the ship are given in it.

The body plan of the lines of this system consists of a series of transverse sections, each of which is composed of a straight side, having varying inclination, a straight or flat bottom, and an elliptical arc of the bilge connecting these two straight lines.

This system of the lines is specially adapted for a hull, to be constructed in

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an ordinary transverse framing system. The author's patented construction of the double bottoms, with intercostal longitudinal frames, may be utilized with advantage. (Zosen Kyokai Zassan No. 171.) Fig. 1 illustrates a typical transverse section of the construction of this kind, applicable for the greater part of a steel hull. With the construction of this system, every piece of the frame angle attached to the double bottom floor plate has no curvature and no bevel; the longitudinal frames have no curve and no bevel; the main frame bar in hold is straight (at ends of a ship, a short length near the foot of the frame is to be bent by angle smiths); the angle bar connecting the frame bracket plate or the outboard end portion of the tank floors to the shell plate is curved to a portion of an ellipse, the same mould of the ellipse being used for bending all the bars of the part. The shell plates in way of the straight bottom and sides can be expanded on the moulding loft floor in much easier way than otherwise, the lines of frames in every shell plate being all in straight lines. It need give hardly any explanation for the fact that the shipyard work is very much simplified and incidentally be more accurate with this system, as compared to the construction in the ordinary lines.

The process of preparing the lines of a hull in this system is as follows.

FIG. 1

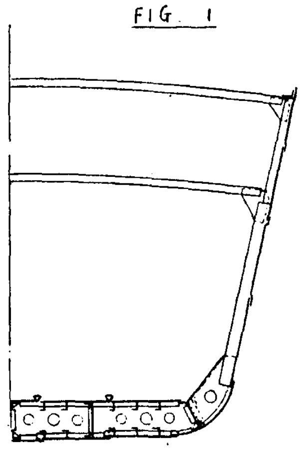
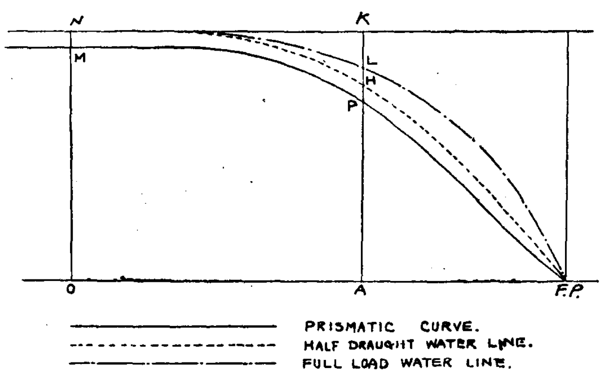


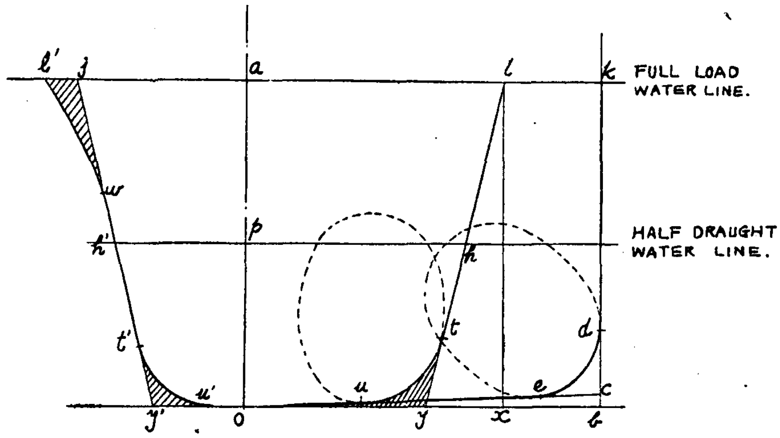
FIG. 2



The first thing to be done is to draw the prismatic curve or the curve of the longitudinal distribution of the displacement. In Fig. 2 fine full line is the prismatic curve. In this figure, the length between perpendiculars $(=L)$ is to be represented by 20 inches, and the offsets of the curve in the scale of 5 inches for the product of the half breadth into the draught $(=\frac{1}{2}B\times d)$, so that the area enclosed by the prismatic curve and the base line, in square inches represents the half volume of the displacement in the percentage of the cubical volume of $L\times\frac{1}{2}B\times d$. Any known good prismatic curve for an ordinary hull form may conveniently be adopted, or it may be said that no special feature of the curve is necessary to be given to the curve in the case of the straight side system.

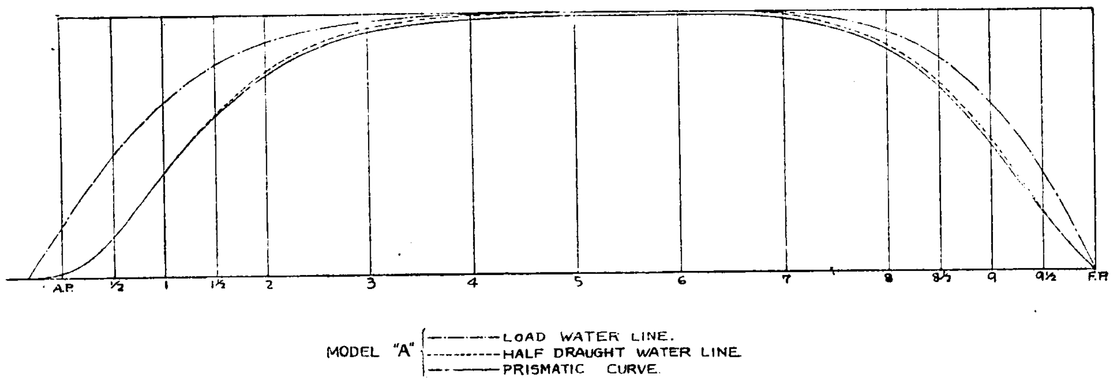
Now refer to Fig. 3. *ob* is the half breadth, *oc* the rise line, and *ak* is full draught line, up to which the prismatic curve has been drawn. At the time when these straight lines have been drawn, design the mould of an ellipse, which will be applied to the curves of bilges. When the designer get enough experience with the sheer draughts of this system, he can easily select a mould from those which he has used for a ship somewhat similar to the one designing. Apply the mould at *ed* and complete the midship section *oakdeo*. The area of *oakdeo* is *OM* in Fig. 2, and note that the area *oedbo* is represented by the distance *MN*, in the scales as described above. Now then suppose that the transverse section at a point *A* in Fig. 2, is required to be drawn. In Fig. 3, the section is shown by *oaltuo*. In this curve of the section the lines *lt* and *uo* are straight. The area represented by the offset of the prismatic curve *AP* is the area of the trapezoid *oalyo* less the curved area *outyo*. The dotted line *NH*....in Fig. 2 will be so drawn thad tlhe distance *PH* is equal to the area of *outyo*. This can easily be done, if guideby experience, and there will not be much difficulty in drawing the elliptical curve *ut* to make the area as required, if before doing so the straight line *lty* has been drawn. The offset *AH* in Fig. 2 is equal to the area of the trapezoid *oalyo*, that is equal to the product of the draught by *ph* or the offset of the half draught waterline, i. e. the curve *MH* ..., measured with the scale 5 inches to the half breadth of the ship, represents the half draught waterline. Assuming a proper load watert ine area coefficient and a proper longitudinal position of the centre of floatation, we can draw in Fig. 2 the curve of the load waterline, with the same scale, as shown in the chain line *NL*.... The distance *AL* is now read off, and put it in Fig. 3, in the scale of the body plan (*al* in the figure). Join *lh* and prolong it to *y*, then the curve *ut* will be drawn as described above, and then the line *lhtuo* completes the required curve.

FIG. 3.

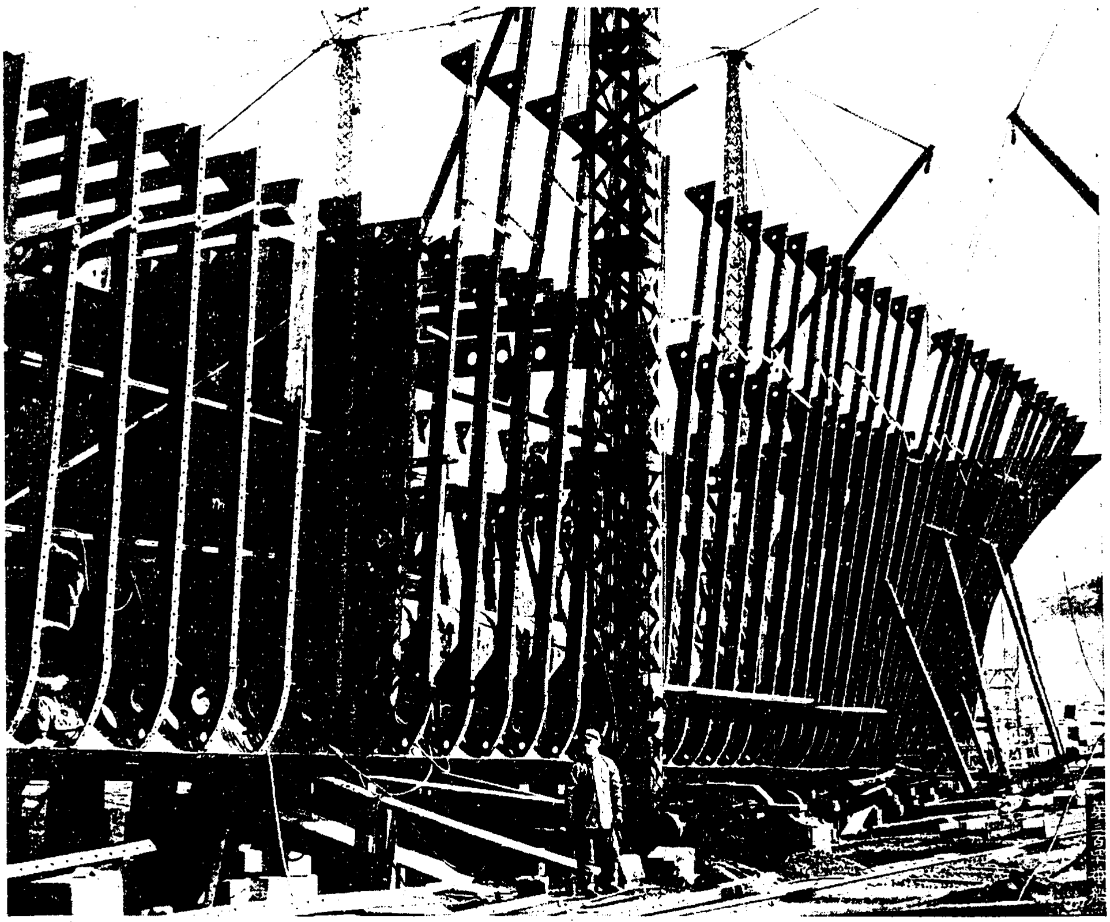


If the point A is situated near the end of the ship, where topside flaring starts somewhere below the load waterline, PH shoud be taken equal to the difference of the area $oy't'v'o$ minus $wl'jw$. (See the left hand side of Fig. 3. When the area $wl'jw$ is greater than $oy't'v'o$, the distance PH will be measured downward or in the opposite direction of the point P, that is to say AH is less than AP.

FIG. 4



The reader will refer to Fig. 4, in which are shown the complete sets of these curves for the lines of PL. I.



For the lines at the ends of the ship, where the "straight" principle are not applicable, the usual fairing process may be carried out. Either a cruiser stern or counter stern may be adopted, in association with this system of the lines.

The accompanying photograph shows a motorship of this system under construction.

Part II. The Arc Side System.

The lines of PL. II will be referred to. This set of the lines has been so designed that the ship as compared to that of PL. I, is to have the same length, draught, similar longitudinal distribution of the volume of displacement, but the different shape of the midship section and quite different character of the lines; the particulars of the hull dimensions etc. are given in the figure.

Although there had been no comments on the straight side system, about the volume of stowage of cargo, the author has been looking for some means of improvement, by which the volume per unit deadweight of cargo for a fixed displacement could be increased. The result of this improvement is the patent form of the arc side system.

Instead of the main side frame of the straight line of the earlier system, the line of the side frame in the present system is an arc of a large circle, of a radius constant throughout the ship. The line of the bilges is another arc of a circle of

FIG. 5.

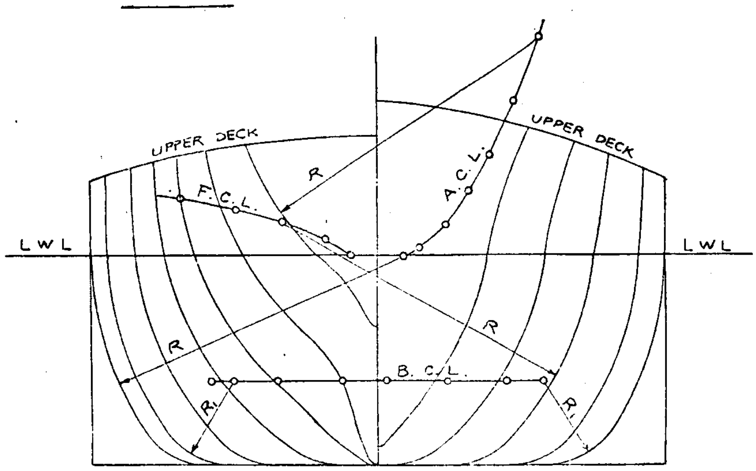
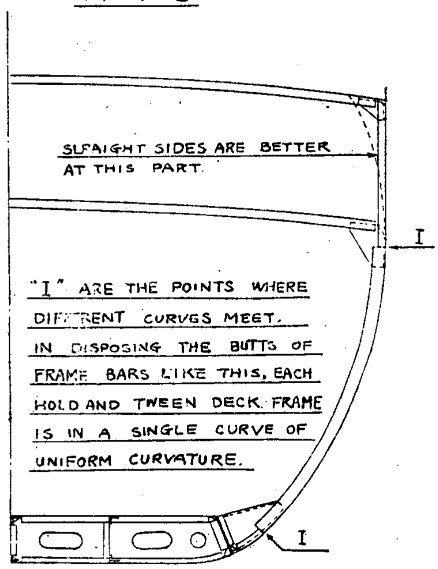


FIG. 6

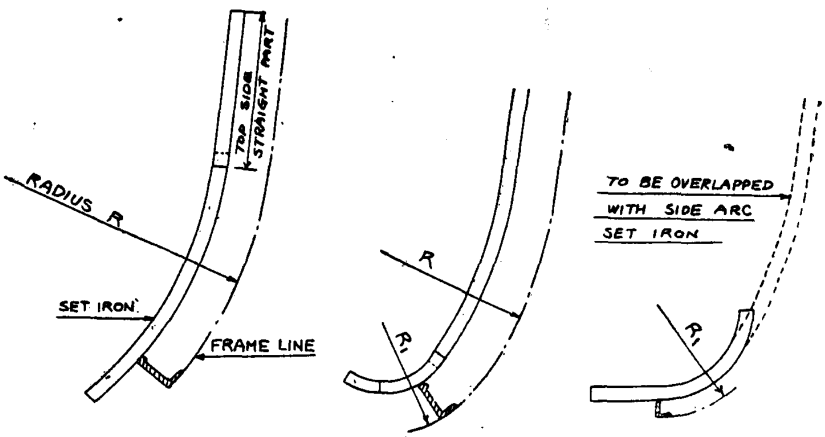


a smaller radius. The bottom of the ship is a flat plane, or the line of the frame is a straight line. (See Figs. 5 and 6).

Besides the advantage claimed for the straight side system, namely simplicity of the process of laying off, bending the frames, and working the shell plates, this system has the further advantage of better stability in the loaded condition, less area of wetted surface, larger stowage volume, and larger area for deck cargo. Raising up the neutral axis for the longitudinal bending of the hull will make better distribution of structural material of the hull.

For working the transverse frames only one or two sets of set irons are necessary. One for the topside as shown in Fig. 7A, and the other for the lower part, Fig. 7B; one only is sufficient if the tumble home of the topside is in the same curvature as that of the side. Another set iron of Fig. 7C may be necessary for working the connecting angle of the bilge bracket plate to the shell plating. It may be advised to the designer that the side frames should be stopped or butted on the bracket at the point where the side arc meets the bilge arc (Fig. 6). For the greater part of the hull, side shell plating can be bent by means of the bending rollers with only one set of the gauge of inside curvature.

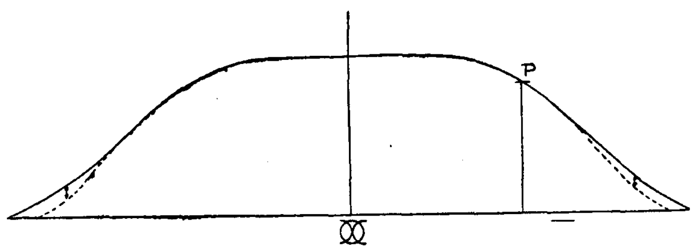
FIG. 7A. FIG. 7B. FIG. 7C.



The process of preparing the lines of this system will now be described.

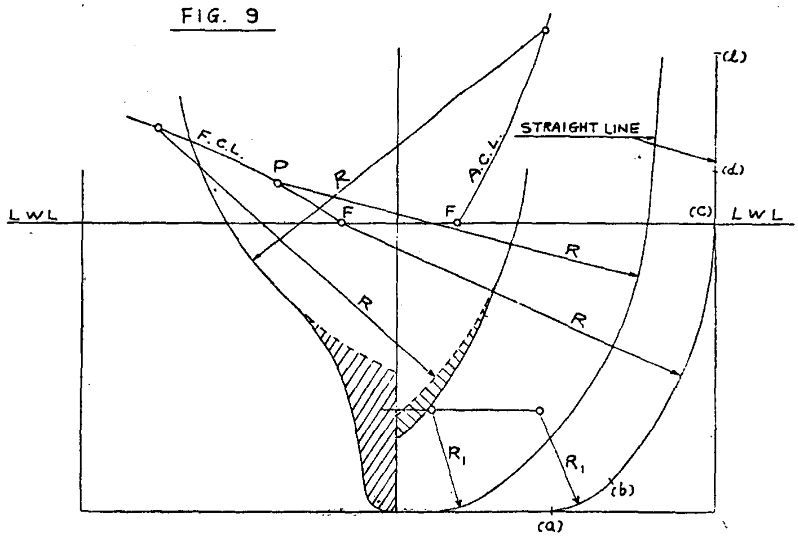
The prismatic curve is first to be drawn, as usual, (See Fig. 8) the scale being as described for the case of the straight side system.

FIG. 8



Next, draw the line of the midship or the fullest transverse section (Figs. 5 and 9). It will be easily understood that the locus of the centre of the bilge circle is a straight line parallel to the bottom rise line and distant R_1 above it, and that the centre of the arc of the side frame will also be on a locus. In the midship parallel body, the centres of the arcs are at one point in the vicinity of the centre line of the ship. The point may conveniently locate on the designed load waterline or there-about, and if the designer like may be on the centre line of the ship. In the latter case the loci of the centres for the forebody and the after-body meet at that point in the body plan.

FIG. 9



Now see that the area of the fullest section as has been drawn is as designed in the prismatic curve. The breadth of the ship should generally be taken about 10% larger than that of an ordinary form or that of the straight side form, and accordingly the coefficient of the midship section less by the same amount.

Then mark on the line of the fullest section the points, where bilge circle touch the bottom rise line (*a*), where the bilge circle touch the side circle arc (*b*), and where the side circle touch the topside straight line (*c*). Also mark the points of the sides of the decks, in the figure, the upper deck (*d*) and the bridge deck (*e*).

Next draw the loci of the centres of bilge and side circles. The locus of the centres of the bilge circle (*B. C. L.*) is a straight line, as mentioned before, parallel lo the bottom rise line ; if there be no rise of floor, the line is parallel to the base tine.

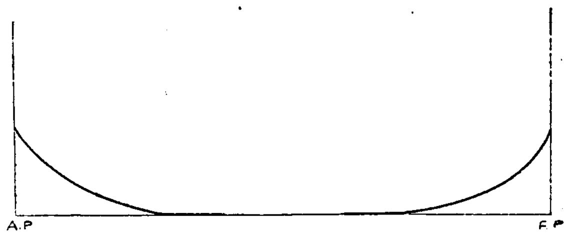
The forward and after-body loci of the centres of the side circles can be determined by experience only. However, if a designer once succeed in obtaining the proper lines, he may very easily draw the next coming sets. As are shown in the figure, the forward locus (*F. C. L.*) is rather flat, and the after locus (*A. C. L.*) a steeply rising curve.

At a random point (Fig. 9), say *P*, on the line *F. C. L.* erect the compass leg and draw the side circle of the radius *R*, and then the bilge circle to touch the side line with the radius R_1. Then measure the area of this line below the load waterline and to the centre line. Locate a point in the prismatic curve where the obtained area corresponds (the point *P* in Fig. 8). Mark the corresponding position in the sheer and half breadth plan. Proceeding in similar manner, we can obtain transverse sections and the corresponding fore and aft positions as many as we like, and thus complete the sheer draught. If the curves *F. C. L.* and *A. C. L.* be of proper character, there is no necessity of fairing work at all, for the greater part of the hull below the load waterline. Above the load waterline, the side lines may be prolonged in the arc form, or more advisable, in the straight lines as far to the ends of the ship as practicable.

At the forward end, it might be necessary to give some flaring out topsides. This portion may be faired up in the usual way, however, bearing in mind that the flare better to be given only in the part where the frames of smaller sections are to be worked, namely the tween deck and forecastle tween deck.

If the above described process be extended down to the extreme ends, the middle line profile will become like that shown on Fig. 10. The fore end of this shape may be good for some kind of design; in usual cases, however, the fuller profile of the orthodox bow end may be desirable. At the after end of the ship, the profile is to be modified to suit the stern frame and the rudder. In such cases of modification it would be found convenient to draw lines in the prismatic curve, as shown in the dotted lines in Fig. 8. The lines represent the curves of the areas of the transverse sections at the ends if the same process as at the fuller parts be extended into the parts in question, and accordingly the shaded area between the two curves shown in Fig. 9 corresponds to the displacement appendage to meet the fuller end profile.

FIG. 10



The deck outlines and sheers are to be drawn in the usual way. As described before, case is to be taken to make the topside frames as straight as possible. Such features naturally decide the character of the deck outlines.

General shape of the hull being decided as described before, we are now able to draw the body plan, waterline and profile plans and finish the complete set of lines of the hull.

Part III. Results of Tank Experiments.

The author has not had many opportunities of comparing the speed power results of tank experiments of the usual merchant ship forms versus the forms of the simplified systems. Below are given two sets of the comparative results.

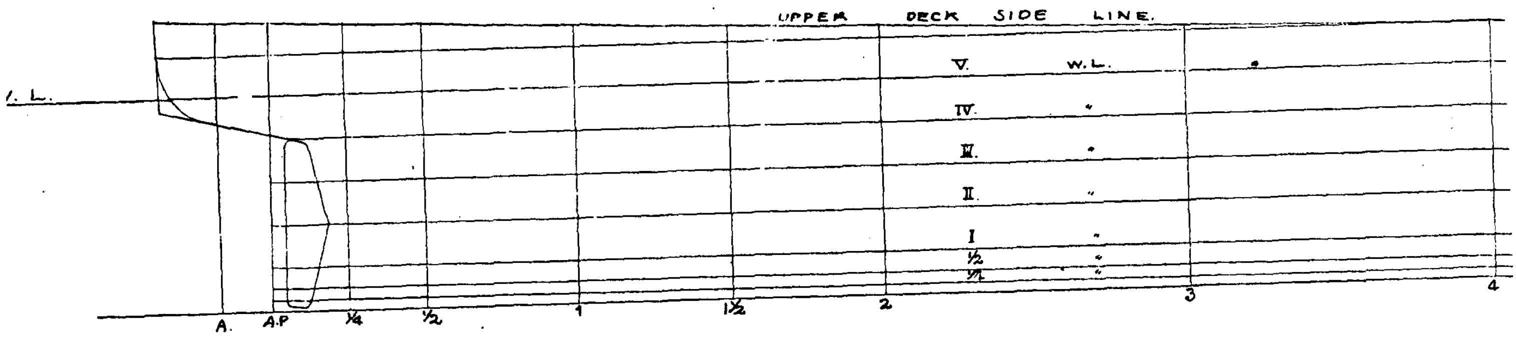
(A) The body plans of the three motorships *K*, *R* and *S* are shown in various lines in PL. III. The ships were designed by different shipbuilders. The principal dimensions are the same, but the draughts and displacements differ slightly. (See the figures in the tables contained in PLs. III and IV.) The speed E. H. P. curves are shown in PL. IV. These results were given by the experimental tank of Teishinsho. From the curves given, it will be seen that the E. H. P. of the model *K* of the straight side systems are a little smaller than those of the other two throughout the whole range of the practical sea speeds, while the difference between those of the models *R* and *S* of the ordinary forms is very slight notwithstanding the remarkably different positions of the centres of buoyancy of the hulls.

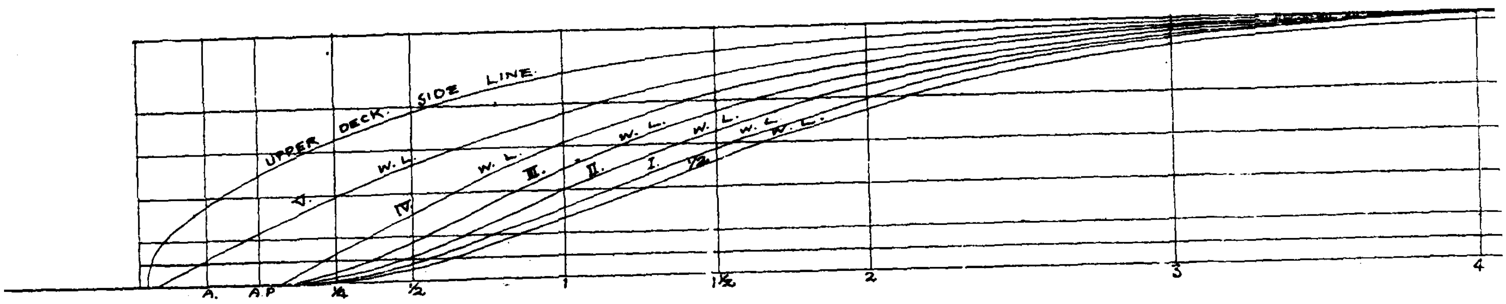
(B) The towing experiments of the two models representing the sheer draughts of PLs. I and II, designated the model *A* and model *B* respectively, were carried out at the experimental tank of the Tokyo Imperial University, by the students, Mr. K. Hashimoto and Mr. R. Shimasaki, with wooden small scale models, prepared by the Uraga Dock Co.

As the scale of the models has been very small, the numerals given by the curves of the results are considered to be approximate. However they served sufficiently for the purpose of comparison. The results are shown in PL. V, and are expressed in the total resistance in lbs. per ton displacement of the full sized hulls at three different draughts 20′-0″, 15′-10·8″ and 9′-7·8″. The principal data of the full sized ships are given in the table contained in the same.

The lines of PL. I are reproduction of those of the S. S. Seikyo Maru and her sisters. These ships are known to be good economical performers at sea. As we see no appreciable differences between the resistance curves of the models *A* and *B*, we can conclude that the ship having the hull form of the latter system might be as good as that of the former system.

(J. S. Pat. Nos. 200,163 & 225,636)


UPPER DECK SIDE LINE.
V. W.L.
IV. "
III. "
II. "
I "
½ "
¼ "
A.
A.P
¼
½
1
1½
2
3
4


UPPER DECK. SIDE LINE.
V. W.L.
IV. W.L.
III. W.L.
II. W.L.
I. W.L.
½ W.L.
A.
A.P
¼
½
1
1½
2
3
4

MODEL A.

DIMENSIONS OF FULL SIZE SHIP

295'-0" x 45'-0" x 23'-9"

SCALE.

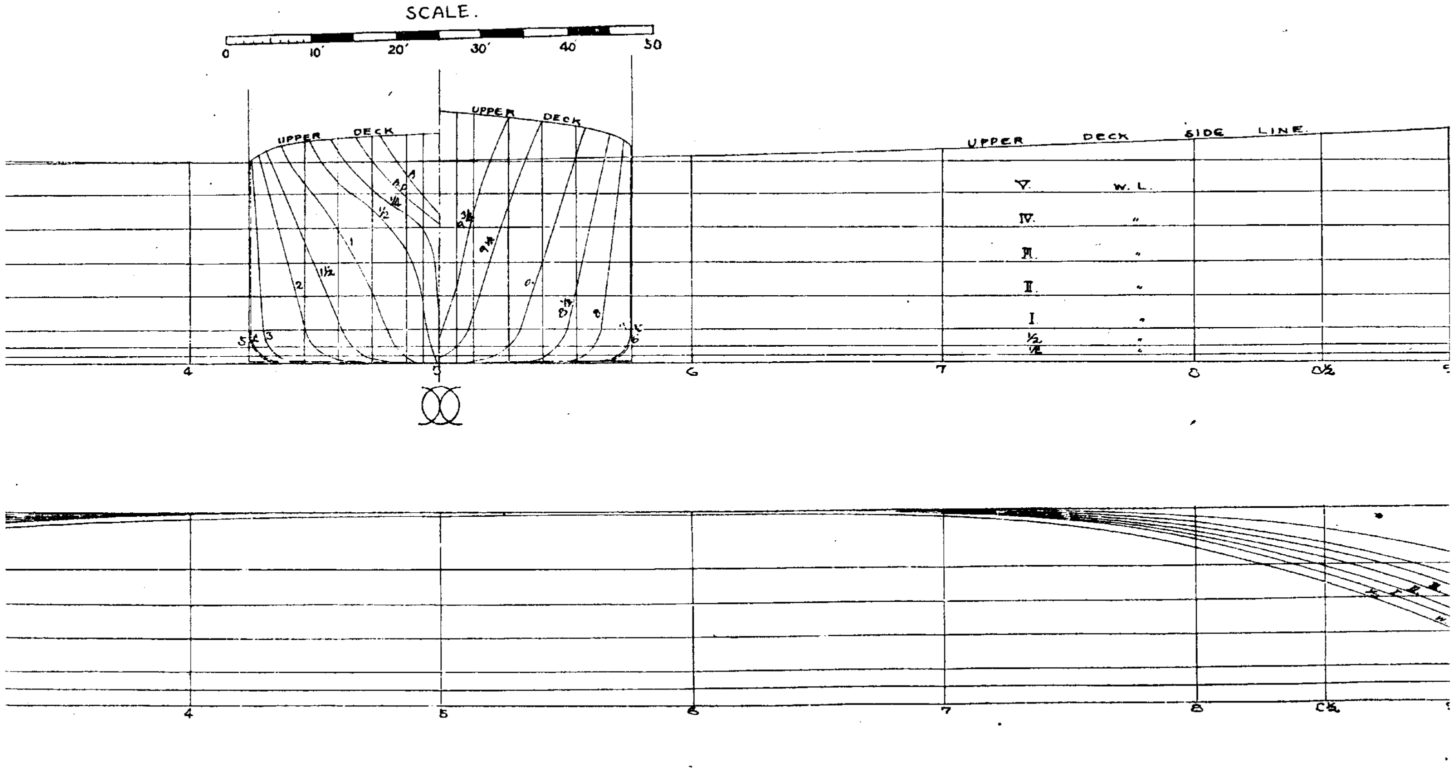


PLATE I.

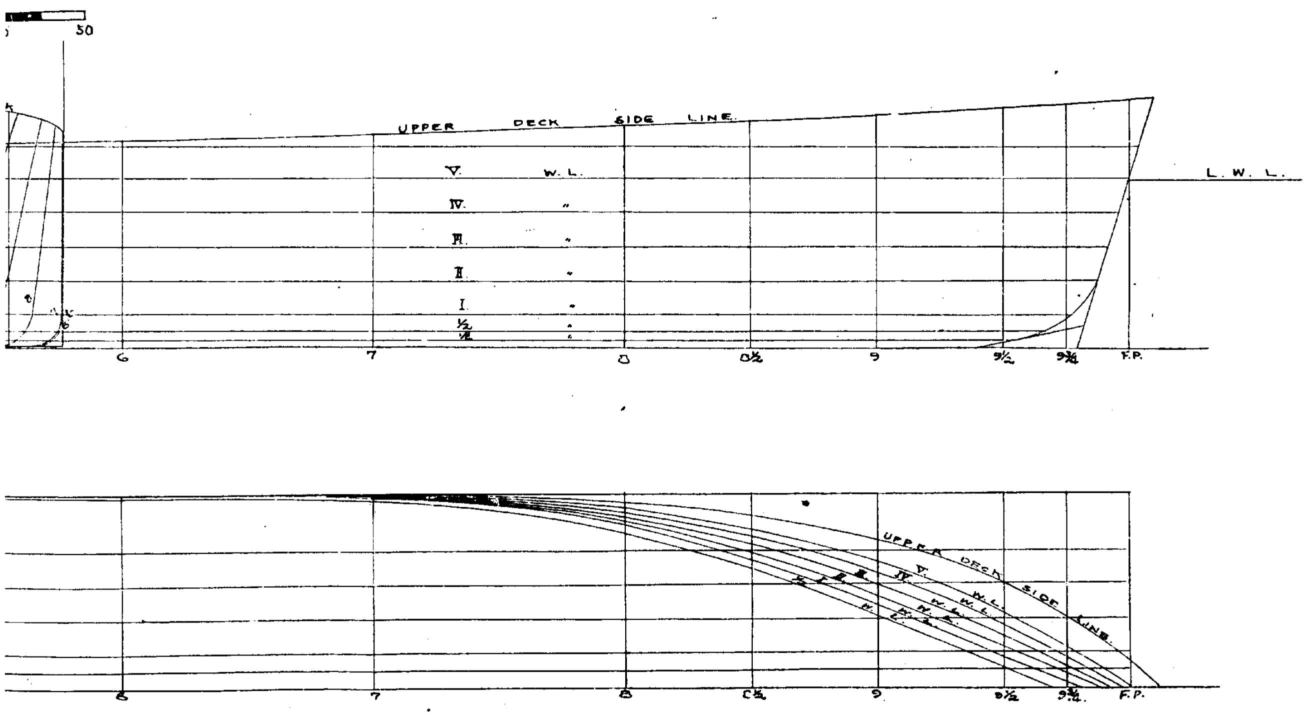

UPPER DECK SIDE LINE
L. W. L.
V. W. L.
IV. "
III. "
II. "
I. "
½ "
¼ "
6
7
8
8½
9
9½
9¾
F.P.
UPPER DECK SIDE LINE
V. W. L.
IV. W. L.
F.P.

PLATE II.

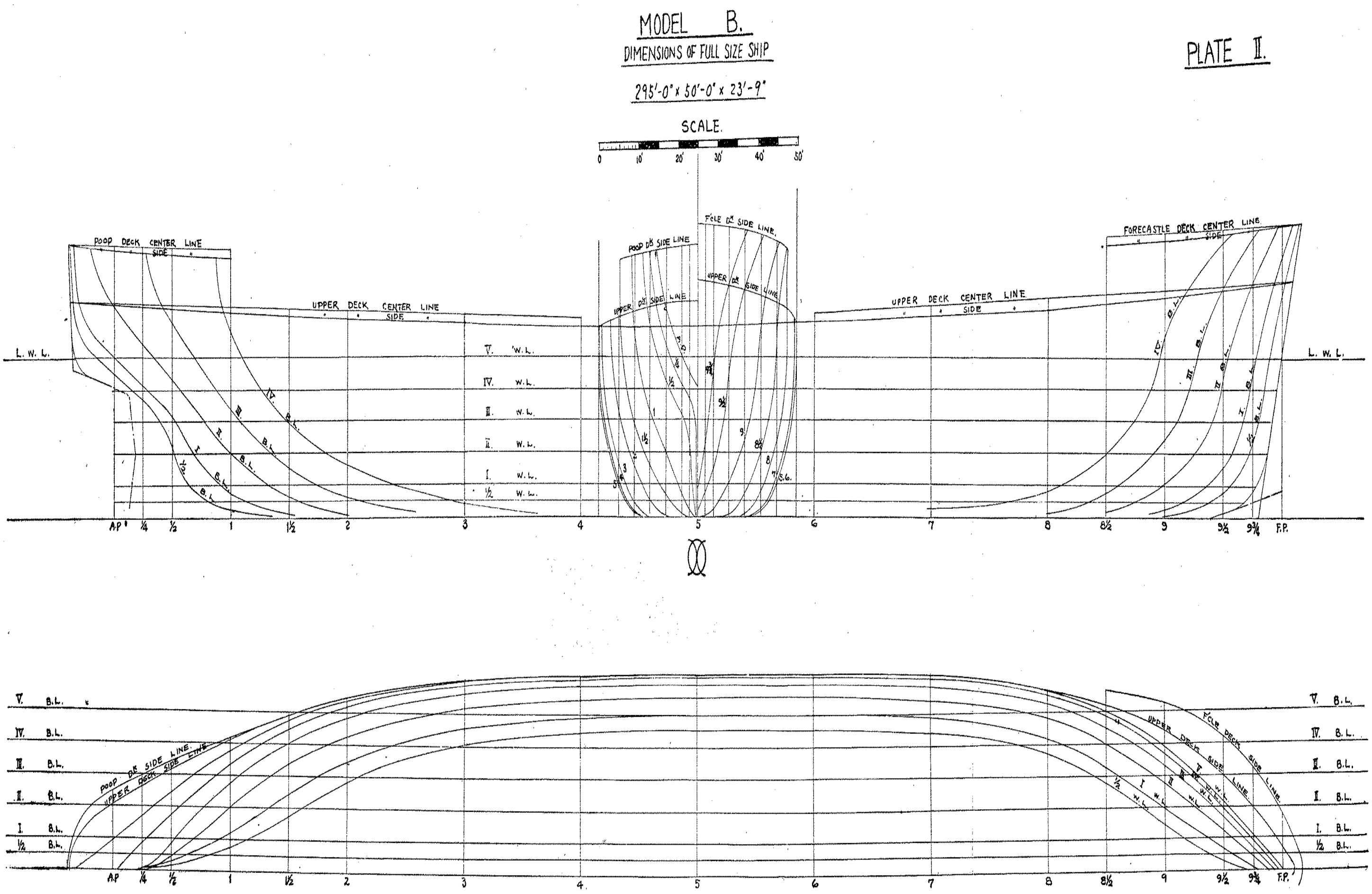

MODEL B.
DIMENSIONS OF FULL SIZE SHIP
295'-0" x 50'-0" x 23'-9"
SCALE.
POOP DECK CENTER LINE
SIDE
UPPER DECK CENTER LINE
SIDE
FORECASTLE DECK CENTER LINE
SIDE
L. W. L.
V. W.L.
IV. W.L.
III. W.L.
II. W.L.
I. W.L.
½ W.L.
AP
FP
V. B.L.
IV. B.L.
III. B.L.
II. B.L.
I. B.L.
½ B.L.
POOP Dk SIDE LINE
UPPER DECK SIDE LINE
F'CLE DECK SIDE LINE

PLATE III.

BODY PLAN OF MOTORSHIPS K, R, & S.

PRINCIPAL DIMENSIONS
415'-0" × 56'-0" × 31'-9"

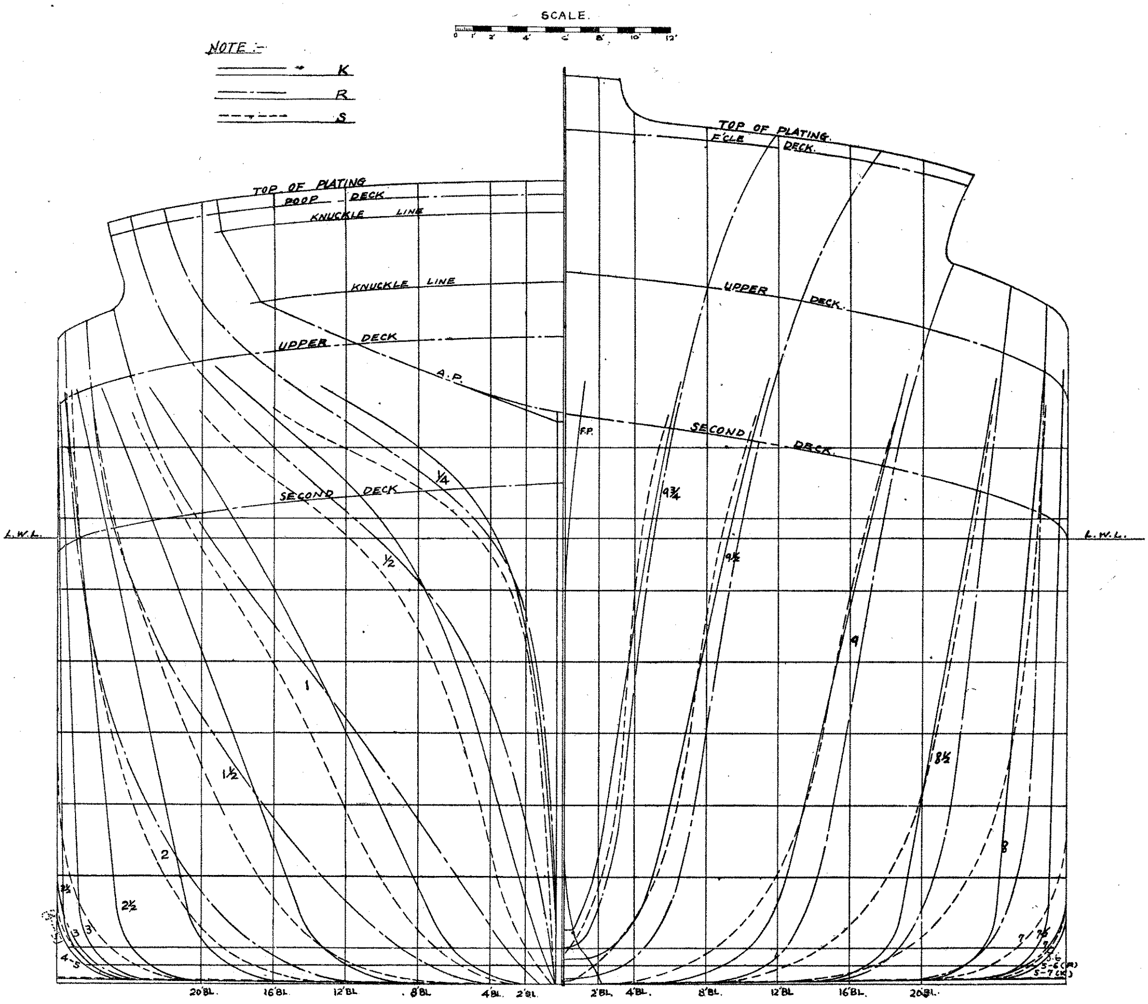


PLATE IV

EFFECTIVE HORSE POWER CURVES FOR MODELS K, R, & S.

SHIP'S NAME	DRAUGHT IN M. A. P.	DRAUGHT IN M. M.	DRAUGHT IN M. F. P.	DISPLACEMENT IN M³	REMARKS	
S.	7.701	7.701	7.701	12,663.0	NAKED HULL	------
R	7.661	7.661	7.661	12,654.0	" "	—·—
K.	7.719	7.719	7.719	12,611.0	" "	——

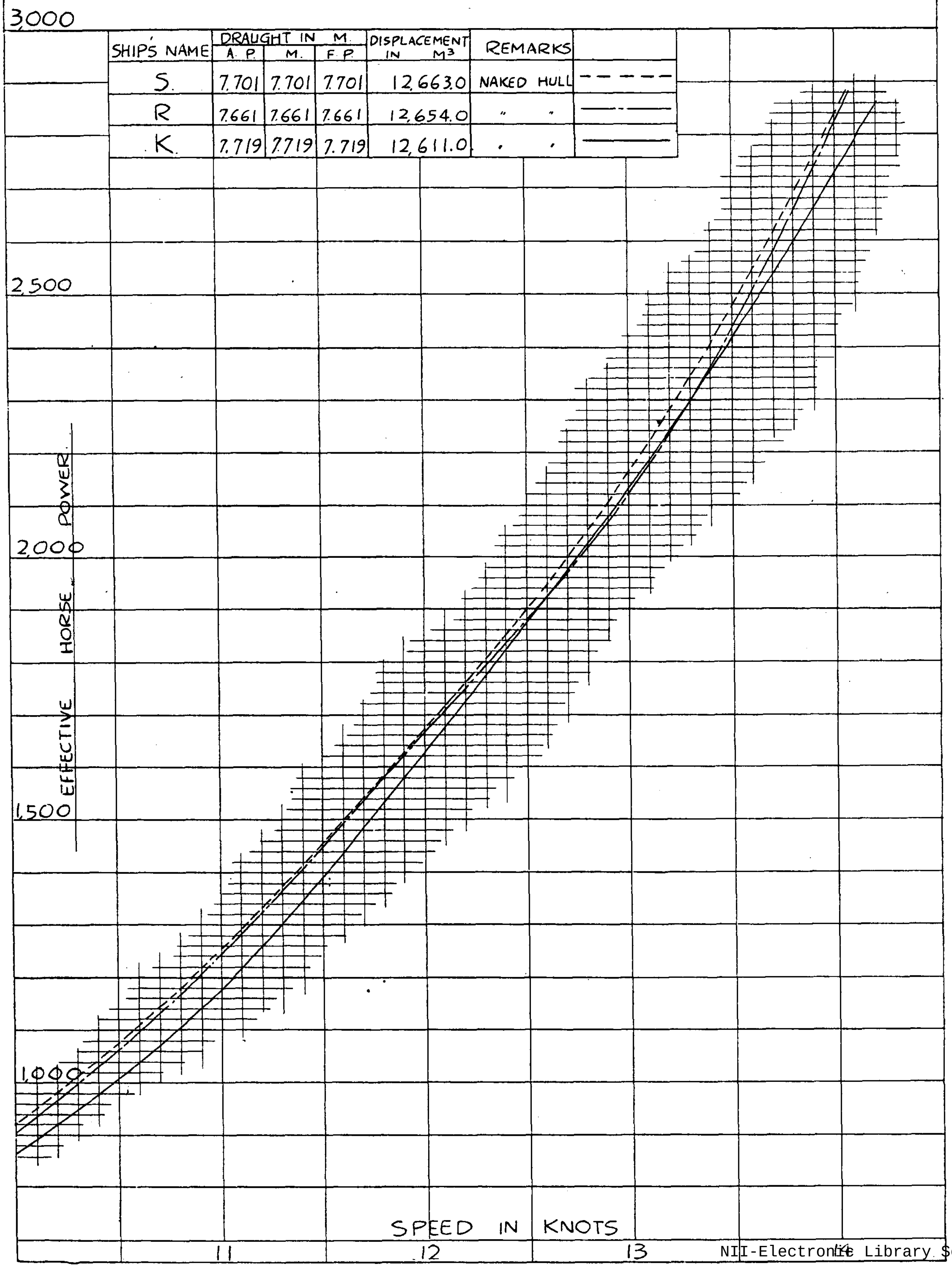
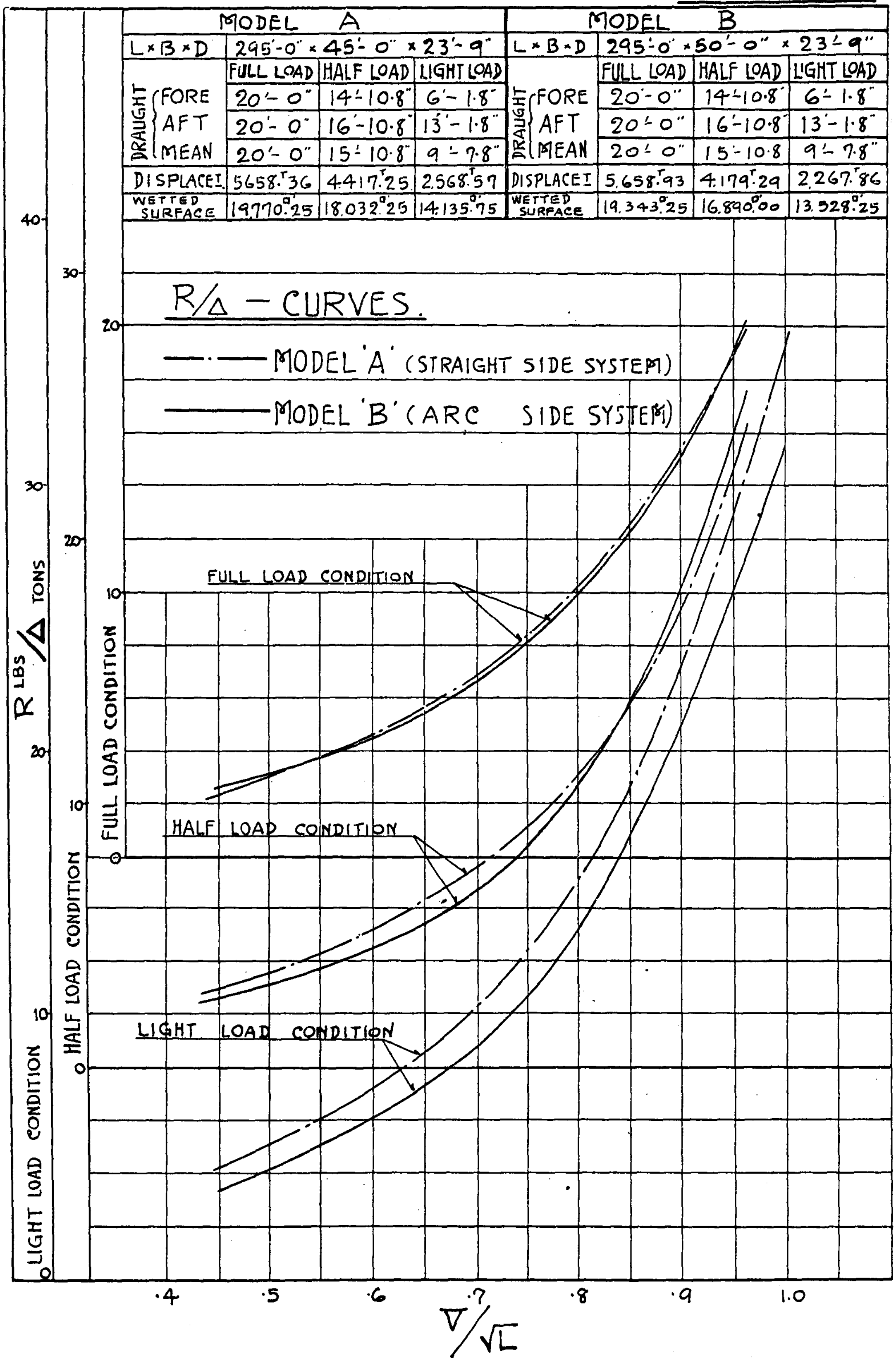


PLATE V.



	MODEL A				MODEL B		
L×B×D	295'-0" × 45'-0" × 23'-9"			L×B×D	295'-0" × 50'-0" × 23'-9"		
	FULL LOAD	HALF LOAD	LIGHT LOAD		FULL LOAD	HALF LOAD	LIGHT LOAD
DRAUGHT FORE	20'-0"	14'-10.8"	6'-1.8"	DRAUGHT FORE	20'-0"	14'-10.8"	6'-1.8"
DRAUGHT AFT	20'-0"	16'-10.8"	13'-1.8"	DRAUGHT AFT	20'-0"	16'-10.8"	13'-1.8"
DRAUGHT MEAN	20'-0"	15'-10.8"	9'-7.8"	DRAUGHT MEAN	20'-0"	15'-10.8	9'-7.8"
DISPLACEt	5658.36 T	4417.25 T	2568.57 T	DISPLACEt	5,658.93 T	4,179.29 T	2,267.86 T
WETTED SURFACE	19770.25 □'	18032.25 □'	14135.75 □'	WETTED SURFACE	19,343.25 □'	16,890.00 □'	13,928.25 □'

The curves of the PL. V, as described at the general meeting of the Society, Nov. 1938, have been revised, due to most valuable advice by Dr. M. Yamagata, the member.

討　　論

○座長(平賀　譲君)　どなたか御質問はありませんか。

○山縣昌夫君　只今のお話しに就き第二義的のことかも知れませんが、propulsion 關係に就き一言申上げます。最初に straight line form の事ですが、私が特別に實驗した譯ではありませんが、何回か浦賀船渠からの依頼により行ひました實驗結果からの感じを大體申しますと、今玆に straight line form の船と ordinary form の船が 2 隻ありまして、full load で power が同じとしますと、draft が淺くなる程 straight line form の船は performance が悪くなります。これは frame を U shape にすると side frame と bottom frame が bilge の部分で急激に曲ると同様な原因と考へられます。おもての bilge が水面に近くなるとこれが邪魔をします。船を何處で卽ちどの draft で design するかは問題でありますが、少くとも full load で performance が同じなれば、淺い所で良い方が良いのでありますから、この點から straight line form ship は餘程 full load condition で良くないと、$^3/_4$、$^1/_2$ load で E.H.P. が ordinary form のものと cross するのではないでせうか。Fig. 4 は 10 年程前に私共の所で實驗した結果と思ひます。勿論 straight frame の船は小野さんの所で設計になり、ordinary form のものは他の造船所で設計されたものでありますが、10 年後の今日では straight frame line form も進歩致しましたと存じますが、これと同時に各造船所での ordinary frame ship も充分進歩してゐますので、最近に出來た船で兩者の比較が出來れば更に良いと思ひます。次ぎに arc frame の方は私は全然實驗をやつて居ませんが、大體論として此の paper にある如く displacement constant として船幅を 10% 位增しますと、私共が當協會で 2 回程發表致しました樣に船の performance は良くなります。例へばこの船に就いて言へば、C_b が straight frame の 0.745 に對し arc frame では 0.67 でありますから、普通考へると餘程 arc form の方が成績が良くはないかと思つて居ましたが、Fig. 5 では夫れ程でもなくて、特に $^1/_2$ load では $\frac{R}{\Delta}$ の値が逆になつてゐますが、これは何か間違ひではありませんか。

○小野暢三君　御質問の最初の部分は straight side の船が full load で normal form と大體同じ performance なれば light condition と medium load の時悪くなることはないかといふ御趣旨と思ひます。それは寧ろ transverse section の U shape 對 V shape の問題と思はれます。山縣さんに實驗して戴いた船型は大體所謂 U shape が多くあつたので左樣にお考へになることゝ思ひます。U shape 對 V shape 何れを採用するかは propulsion 以外の問題にも關係するので只今は問題外と致しまして、こゝでは此の system でも U shape, V shape 何れにでも設計が出來るといふことを申上げ度い。圖に就いて言へば、斯樣に傾斜せる straight side は half draft water line の curve の取り方により、卽ち此の點線と最初の prismatic curve との距離の取り方はどうでも出來るから、下の方の曲線は小さくも大きくも曲げられることになります。大きくすれば其處の load water line

が大きくなり、大きくすれば V shape、小さくすれば U shape の船が出來ます。使ふ ellipse の ine は何れにしてもどうにか出來ます。それは geometrical な正確なものではなくて良いのです。其點に就き此 system は左程窮屈なものではありません。最近は ellipse を變へ何れの load での performance も ordinary form と餘り違はぬものも出來てゐます。arc side の方の御質問にお答へします。こゝに使はれた模型は full load displacement は同一であり且その longitudinal distribution は同じにしてあります。その上 midship area は同一であり、唯 wetted surface は arc side の方が小となつてをりますが、大體に於いて midship area が同じで更に displacement の longitudinal distribution が同じなれば、極端な form でない限り performance は餘り異ならぬものです。

○松山武秀君 arc form の船の model experiment の中で rolling に對する性能の方は如何ですか。それが悪くなるのではありませんか。

○小野暢三君 その點は實驗してをりません。悪くなると思ひます。

○平賀　讓君 arc form の方が幅が 10 %増すと GM が大分違つて來ます。又船の weight も異なると思ひますから、元の船と比較するのはどうかと思ひます。一方が 50 呎あれば他方の arc form でない方の船も 50 呎近く必要なのではないのですか。即ち同じ requirment に對しては2種のこんな幅の違ふ船は直接には比較出來ないのではありませんか。

○小野暢三君 arc side は輕い cargo を一杯に取る様な場合或は又その廣い deck に材木を積む船の様な場合には stability が大きい事が必要と思ひますから、その目的に對しては良いと思ひます。

○平賀　讓君 ですから、同じ requirement に對しては、幅の狭い A の船では design 出來ないのですね。違つた船ですね。

○小野暢三君 さうです。違つた船です(異なる種類の積荷を目的とする船)。次ぎに weight の方は輕い cargo 或は材木を積む single deck の船では却つて船體が輕くなることもあります。それは 10% 位 deck area を増したとしても夫れ以上に double bottom の weight を減ずる爲です。又 two deck の船でも top side が増すから neutral axis が高くなり、遞信省の鋼船構造規程案の様に最後に midship section modulus を出して longitudinal member の scantling を出す様にすれば、weight はそんなに殖えないと思ひます。

○座長(平賀　讓君) 別に御質問がなければ一言御挨拶申します。變つた form に就き御發表になりましたが、構造の簡單なのが第一の目的で E.H.P. の方は附屬的と思ひますが、有益な論文と存じます。全く同じ要求に對し2種を造られて比較されたのではないと思ひますが、更に御研究になれば、もつと面白い結果が出るのではありますまいか。我々にも啓發された所があつたと思ひます。拍手を以つてお禮致し度いと思ひます。(一同拍手)

Discussion on Mr. Ono's Paper entitled "Two Patent Systems of Simplified Hull Form."

H. Jasper Cox.

I am always interested in the work of the Author of this Paper as I have a great admiration for his progressive and practical ideas, and the present Paper, describing two systems of simplified Hull Form, is both progressive and practical.

There is probably no branch of Shipbuilding or Naval Architecture which has receivedl more attention in recent years than the development of economic hull forms, and a great deae of money has been, and is being, spent to equip tanks and to obtain experimental data in th race for greater and greater efficiency in this direction. Many special forms have been patented, and many Shipbuilders have developed their own types of lines as the result of personal experience combined with tank experiments.

Apart from the Hull resistance claimes made by the Author, and which I have no reason to qustion, the features in the systems under consideration which impress me particularly are the practical aid which they lend to the draughting of a set of lines, or at least to a quick approximation, and, secondly, simplification of the actual hull construction itself, all of which is clearly explained in the Paper.

It would have been of interest if the Author had explained the "patentable' difference between his "Arc Side System" and the Isherwood "Arcform" to which it has, to say the least, a very striking resemblance. Many ships have already been built on the "Arcform" system, including several large tankers and repeat orders, indicating confidence and satisfaction with this particular form, which is so strikingly different from the normal full midship section type which has prevailed for so many years.

In regard to the strength of "Arcform" vessels I might mention here that the Committee of Lloyd's Register have recognized the fact that the difference between this form and the normal form may be taken into cosideration when determining suitable scantlings, and adjustments have been made accordingly.

Reply to the above.

C. Ono

The author owes very much thanks to Mr. Cox for his kindness in forwarding a written discussion to the Society, expressing his appreciation to the author's work and giving an important notice about the attitude of Lloyd's Register in determining the scantlings of the ships to be built in the arc side system.

With regard to the "patentable" difference between the Isherwood Arc-form and the author's arc-side system, the author is in regret as to impossibility of making it clear. He has been unab'e, after a search about the literatures of the former system, to find out what were the main points of claim of the patentee of the Isherwood arc form.