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

* 警憲毎楽株式企業 参事 小野裕三氏。
an ordinary transverse framing system. The author's patented construction of the
double bottoms, with intercostal longitudinal frames, may be utilized with advan-
tage. (Zosen Kyokai Zassan No. 171.) Fig. 1 illustrates a typical transverse sec-
tion 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.

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 pris-
matic 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 en-
closed 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 \( L \times \frac{1}{2} B \)
x \( d \). 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, oe 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 it 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 that the distance PH is equal to the area of outyo. This can easily be done, if guided by 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 ity 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 waterline 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 (at in the figure). Join lh and prolong it to y, then the curve ut will be drawn as described above, and then the line ultuo completes the required curve.
If the point $A$ is situated near the end of the ship, where topside flaring starts somewhere below the load waterline, $PH$ should be taken equal to the difference of the area $o'y't'v'o$ minus $wl'jw$. (See the left hand side of Fig. 3. When the area $wl'jw$ is greater than $o'y't'v'o$, the distance $PII$ will be measured downward or in the opposite direction of the point $P$, that is to say $AH$ is less than $AP$.

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

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.

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 \( R_2 \) 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.

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 to the bottom rise line; if there be no rise of floor, the line is parallel to the base line.

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,. 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.

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 Teishin-cho. 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)
MODEL A

DIMENSIONS OF FULL SIZE SHIP
240' 0" x 45' 0" x 23' 6"

SCALE
BODY PLAN
OF
MOTORSHIPS K R & S.

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

NOTE:

--- K
--- R
--- S
### EFFECTIVE HORSE POWER CURVES

**FOR MODELS K, R, & S.**

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<th>SHIPS NAME</th>
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**PLATE IV**

**SPEED IN KNOTS**

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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.
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to

draft system of simplified hull form.

These patents were developed to improve the performance of ships by optimizing the hull form. The patents utilize the concept that the hull form should be designed to optimize the trade-offs between speed, fuel efficiency, and stability.

The patents were developed in Japan and were based on extensive research conducted by various researchers and engineers. The patents were filed in the 1970s and have been widely adopted by shipbuilders around the world.

The patents cover a wide range of hull designs, including those with straight sides, curved sides, and a variety of other configurations. The technologies described in the patents have been proven to be effective in improving the performance of ships in a variety of conditions.

In conclusion, the patents for simplified hull forms represent a significant advancement in the field of naval architecture and have had a profound impact on the design and construction of ships worldwide.
が大きく、大きさすれば V shape、小さくすれば U shape の船が出来ます。使ふ ellipse の
ine は何れにしてもどうにか出来ます。それは geometrical な正確なものではなくて良いのです。
共通に就き此 system は左程適当なものではありません。最近は ellipse を使へ何れの load での performance も ordinary form と餘り違はねものも出来てゐます。are side の方の御質問にお答へし
ます。こうに選はられた模型は full load displacement は同一であり且その longitudinal distribution
は同一にしてあります。その上 midship area は同一であり、唯 wetted surface は are side の方が
小となっておりますが、大體に於いて mid'ship area が同じで更に displacement の longitudinal dis-
tribution が同じならば、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 are form の船の model experiment の中で rolling に対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 その點は実験してをりません。悪くなると思ひます。
○平賀 譲君 are form の方が幅が 10 ％増すと GM が大分違って来ます。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 are
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 requirement に対しては 2 種
のこんな幅の違ふ船は直接には比較出来ないのではありませんか。
○小野暢三君 are side は軽い cargo を一杯に取る様々な場合或は又その際の deck に材料を積む
船の様々な場合には stability が大きい事が必要と思ひますから、その目的に対しては良いと思ひます。
○平賀 譲君 ですと、同じ requirement に対しては、幅の狭い A の船では design 出来ない
のですね。途った船ですね。
○小野暢三君 そうですね。途った船です（異なる種類の積荷を目的とする船）。次ぎに weight の方
は軽い cargo 或は材料を積む single deck の船では却って船體が軽くなるもあります。それは
10 ％ 位 deck area を増したとしても夫れ以上に double bottom の weight を減する為です。又 two
deck の船でも top side が増すから neutral axis が高くなり、遮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
はそんなに増えないと思ひます。
○座長（平賀 譲君）別に御質問がなければ一言御挨拶申します。変つた form に就きて御発表に
なりましたが、構造の簡単なのが第一の目的で E.H.P. の方は附属的と思ひますが、有益な論文と存
じます。全く同じ要求に對し 2 種を選び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。我々にも啓発された所があつたと思ひます。拍手を以つてかろうじて度深いと思ひます。（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 received more attention in recent years than the development of economic hull forms, and a great deal of money has been, and is being, spent to equip tanks and to obtain experimental data in the 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 claims made by the Author, and which I have no reason to question, 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 "Are Side System" and the Isherwood "Areform" to which it has, to say the least, a very striking resemblance. Many ships have already been built on the "Areform" 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 "Areform" 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 consideration 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 are side system.

With regard to the "patentable" difference between the Isherwood Are-form and the author's are-side system, the author is in regret as to impossibility of making it clear. He has been unable, 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 are form.