向未来的造船技术挑战

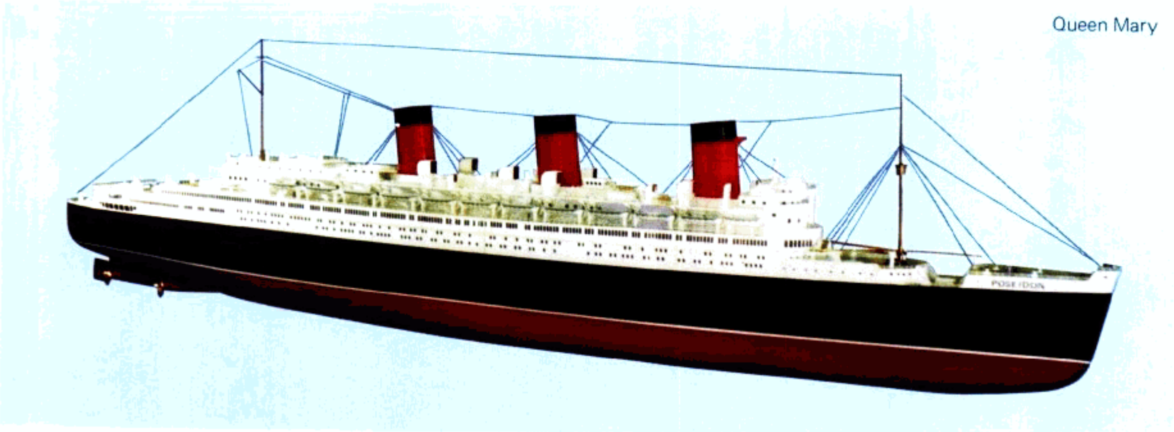
—未来的造船技术与支撑这技术的船舶用品—

向未来的造船技术挑戰

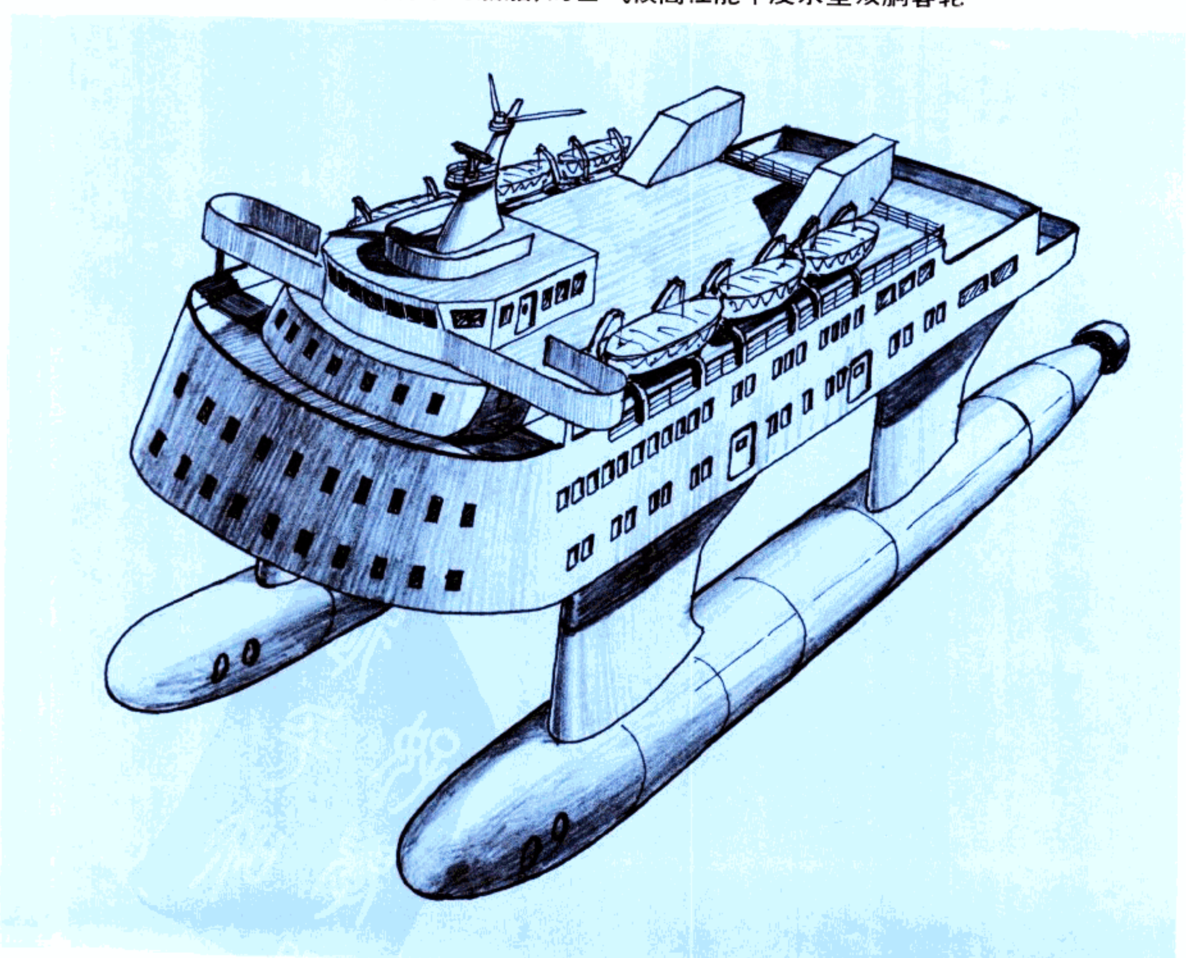
—未来的造船技术与支撑这技术的船舶用品—

財団法人　日本舶用機器開発協会

A luxury ship built by technical essence of early days of twentieth century.
集20世纪初期的技术的精华而成的豪华客轮



All weather, high speed, fuel saving, twin-body semi-submersible ship, passenger ship of late twentieth century (Future Ships)
20世纪末期(将来的船舶)的全气候高性能半浸水型双胴客轮



坚持不懈的调查和技术研制

"日本船用机器开发协会"自从于1966年创立以来，在日本政府的指导和日本船舶振兴会的格外关照下，一直为船用机器、海洋机器的研制和实用化以及开辟新市场而做着调查工作。

这10年来，我们所干与过的有关计划大小共达200件以上，而其中几件计划已经分别在各个领域付诸实用。

以"石油冲击"为转机，世界性不景气造成了海洋运输量上升率下降，而且又遭到航空货物运输量急剧伸展的影响，海运界目前面临着深刻的不景气。

正当这个时候，我正在积极努力研究今后海洋运输应有的方式，包括建造省能量船舶、依靠新主意船只确立新的海洋运输方式，研制与此有关的船用机器等。

在这里，要介绍我们关于今后海洋运输应有的方式的想法，并介绍与此有关的船用机器新制品和试制中的机器。我们的这一努力相信将有助于世界海运、造船界的发展。今后我们愿坚持不懈地进行调查工作和技术研制。

財団法人 日本舶用機器開発協会
理事長 **濱 田 昇**

Unwearying investigations and developments

Japan Ship's Machinery Development Association, established in 1966 under the guidance of the Government of Japan and the subsidy funds of The Japan Shipbuilding Industry Foundation, has continued market survey and development projects of ship's machinery and oceanic machinery to this date.

During the past ten years, the total number of projects are well over two hundreds, and many of them have been already put into practical use.

The world wide depression due to the oil crises and at the same time competition by air cargo transportation caused decrease of marine transportation activities.

In this critical time, I have been investigating new methods and programs to improve the marine transportation system, for example, design of marine transportation ships incorporating fuel saving, ship of new concept, and development of ship's machinery which support future ship designs.

I would like to introduce here the future marine transport system and the ship's machinery which are presently being developed.

It is my great pleasure and I firmly believe that these could contribute to the marine transportation and the shipbuilding industries of the world.

It is our intention to continue our efforts for investigation, research, and development of the shipbuilding technology.

N. Hamada
Noboru Hamada
President
Japan Ship's Machinery
Development Association

Profiles of Member of the Board of Directors

Shinobu Akasaka
President
Akasaka Diesels Limited

Yoshio Akita
Vice President
Nippon Kaiji Kyokai

Hideo Fujita
Instructor
Meiji University

Kiyotaka Furuno
President
Furuno Electric Co., Ltd.

Kenji Hasegawa
Executive Counsel
Kawasaki Heavy Industries, Ltd.

Toshio Itazawa
President
Kamome Propeller Co., Ltd.

Masao Kanamori
President
Mitsubishi Heavy Industries, Ltd.

Kichijiro Kinoshita
President
The Hanshin Diesel Works, Ltd.

Masao Kinoshita
Executive Vice President
Hitachi Shipbuilding &
Engineering Co., Ltd.

Shunsuke Kohno
President
Tokyo Keiki Co., Ltd.

Iwao Koizumi
Professor
Tokyo Electrical Engineering College

Masanori Kurokawa
Managing Director
N Y K Line

Noboru Makita
President
Makita Diesel Co., Ltd.

Norihiko Nagai
President
Mitsui O.S.K. Lines Ltd.

Osamu Nagano
Executive Vice President
Ishikawajima-Harima Heavy Industries Co., Ltd.

Tamotsu Nakashima
President
Nakashima Propeller Co., Ltd.

Tomio Nojima
President
Niigata Engineering Co., Ltd.

Tetsuya Okihara
President
Volcano Company, Ltd.

Tsuneo Ono
President
Heishin Engineering & Equipment Co., Ltd.

Kisaburo Shibata
Chairman
Daihatsu Diesel Mfg. Co., Ltd.

Yoshishige Shintaku
President
Ibuki Kogyo Co., Ltd.

Takashi Takahashi
President
Toyo Seimitsu Zohki Co., Ltd.

Eiichi Tasaka
President
Japan shipbuilding Industry Foundation

Koichi Toyama
Executive Counsel
Nippon Kokan K.K.

Mitsuhiro Ueda
President
Ueda Iron Works Co., Ltd.

Takuzo Yamada
President
Taiyo Electric Mfg. Co., Ltd.

Isamu Yamashita
President
Mitsui Engineering & Shipbuilding Co., Ltd.

Shigeo Kuramoto
President
Kuramoto Instrument
Manufacturing Co., Ltd.

Tsutomu Minoura
Senior Executive Managing Director
Nagano Keiki Seisakusho, Ltd.

Noboru Yoshitomi
Executive Director
Japan Ship's Machinery
Development Association

目　　录

Contents

全气候高性能半浸水型双胴船舶

半浸水型双胴船具有优良高速性能、耐波性能和宽敞的空间等特性，所以它是很有可能性为下一个时代的海洋运输和海洋开发带来革命的一种新型式船舶。

我们以开发这个新式船舶为目标，在船型、推进性能、运动性能、结构强度、推进方式和控制等领域，一直做了广泛的研究。在这些研究的基础上，1977年试制了小型实验艇并进行综合性海上实验，确认了本船具有优良性能。(图3、4)

目前，已经开始建造第一艘实用化船。(图1、表1)

半浸水型双胴船的形状，是排水量的主要部分(LOWER HALL)被安排在水面以下的尽下方，而水面以上的上部结构和浸水部分的船体用比较薄的流线状支柱结合而成的双胴型船舶。

与普通的单胴型船舶比较，它具有如下的技术特点：

1 高速性能优良

激波低抗小，所以普通的单胴型船舶所难于实现的高速域中，能够节减所需马力。

2 波浪中的运动性能良好

半浸水船的水线面积小，所以固有周期长，并且波浪外力也小，所以通常所遭遇的波浪中的船体运动极小。再说，由于船体运动的控制翼，可以积极地使船体运动减少。因此，坐起来安稳舒适，亦可以减少货物的损伤。

3 波浪中的速度低减很少

半浸水船不易受波浪的影响，船体运动也小，所以在波浪中的速度低减比其他形式的船舶极小，因此可以提高船舶的经济性。

4 甲板面积增加

因为双胴船，所以同一排水量它的甲板面积较大。因此适合于需要大载货面积和大体积的货物的装载。并且货物装载空间在水面以上，可以造成箱形，所以载货效率高。

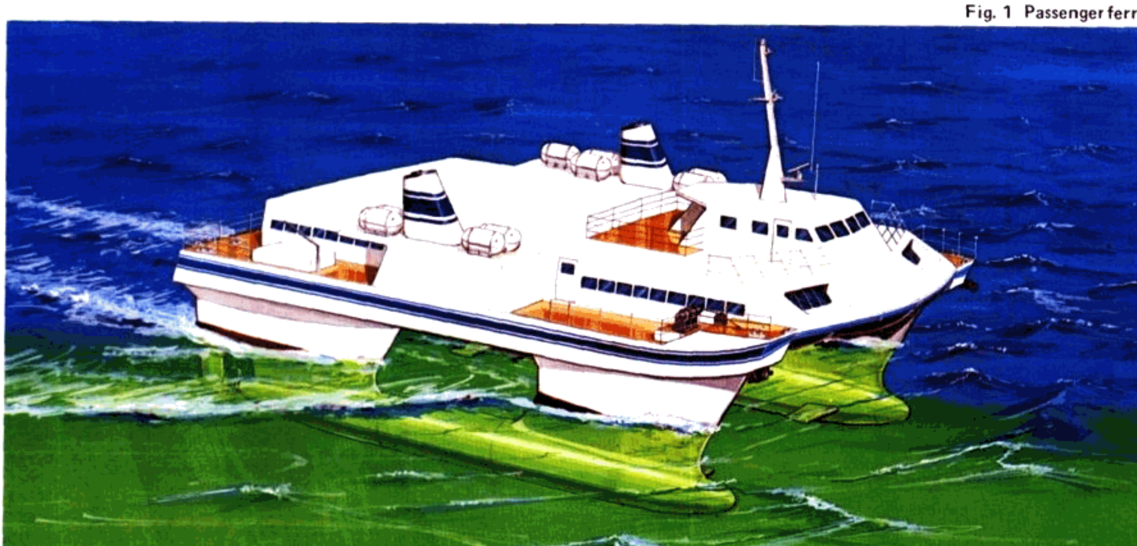
5 装卸效率和工作效率高

宽敞的装货空间设在水面以上，布置上自由度高，因此能够提高装卸效率，并且因甲板中央设有开口，故海中各种机器的升降方便。

世界上第一艘半浸水双胴型实用化船，将于1979年年底建造完成。本船为耐蚀铝合金制高速度客轮，设计上能航行有义波高3.5米的波浪海面。

由于半浸水船具有如上所述各种特点，能够有效地利用于海上运输和海洋开发领域。(图2)

Fig. 1 Passenger ferry



財団法人 日本舶用機器開発協会　三井造船株式会社

All Weather, High Speed, Fuel Saving, Twin-Body Semi-Submersible Ship

The semi-submerged type catamaran is one of the new unconventional ship types which has a potential to play an important role in the fields of marine transportation and ocean development in the next generation for its high speed performance, favorable sea keeping qualities as well as availability of abundant space.

For us to develop this type of advanced ship, extensive researches have been conducted on hull form, resistance and propulsion, seakeeping qualities, hull structures, propulsion systems, motion control systems, etc. Based on these researches, an experimental craft of 12 meters long has been constructed in 1977 and its overall performances have been confirmed by sea trials. (Fig. 3, 4) The actual first vessel of SSC is now under construction. (Fig. 1, Table 1)

The semi-submerged catamaran has a unique configuration in which the lower hull constituting the major portion of the ship's displacement is located well under the water surface and the upper structure over the water surface is connected to the lower hull by means of relatively thin stream-lined struts.

Because of this unique configuration the semi-submerged catamaran has the following technical features as compared with the conventional monohull ship.

1 Superior high speed performance

Because of low wave-making resistance the required power is much less than the conventional monohull in the high speed range where the monohull resistance tends to increase prohibitingly high with ship's speed.

2 Superior motion characteristics in waves

Due to smaller water-plane area, the natural period of motion is longer and the wave exciting forces are smaller, and as the consequence the motion responses in waves ordinarily encountered are much less than those of a monohull.

The motion control fins can further reduce the ship motions. Therefore, the semi-submerged ship will offer a comfortable ride and reduce the damage to the cargos.

3 Superior ability to sustain speed in waves

Since the semi-submerged catamaran is less affected by waves with the consequence of reduced ship motion, the reduction of speed due to waves will be much less than that of other types of ships and the operating economy will be much improved.

4 Availability of abundant space

Because of the catamaran hull a much larger deck space is available than a monohull ship of the same displacement, and therefore, the semi-submerged catamaran is suitable for carrying cargoes requiring large deck area and cargo space. Further, due to the box-shaped upper-structure above water the stowage efficiency is high.

5 Higher efficiency in cargo handling and easier operation

Since higher freedom is possible in cargo space arrangement for its configuration, a highly efficient cargo handling system can be realized. The catamaran hull also makes it possible to arrange a well at the deck center, through which the miscellaneous equipments can be easily lowered to sea or lifted.

The first SSC in the world used in commercial services is to complete in the end of 1979. This craft is a high speed passenger ferry which is made of anti-corrosive aluminum alloy and design wave height for cruising is 3.5 meters.

Since the semi-submerged catamaran has these advantageous features, this type of ship can be effectively utilized in both marine transportation and ocean development ships. (Fig. 2)

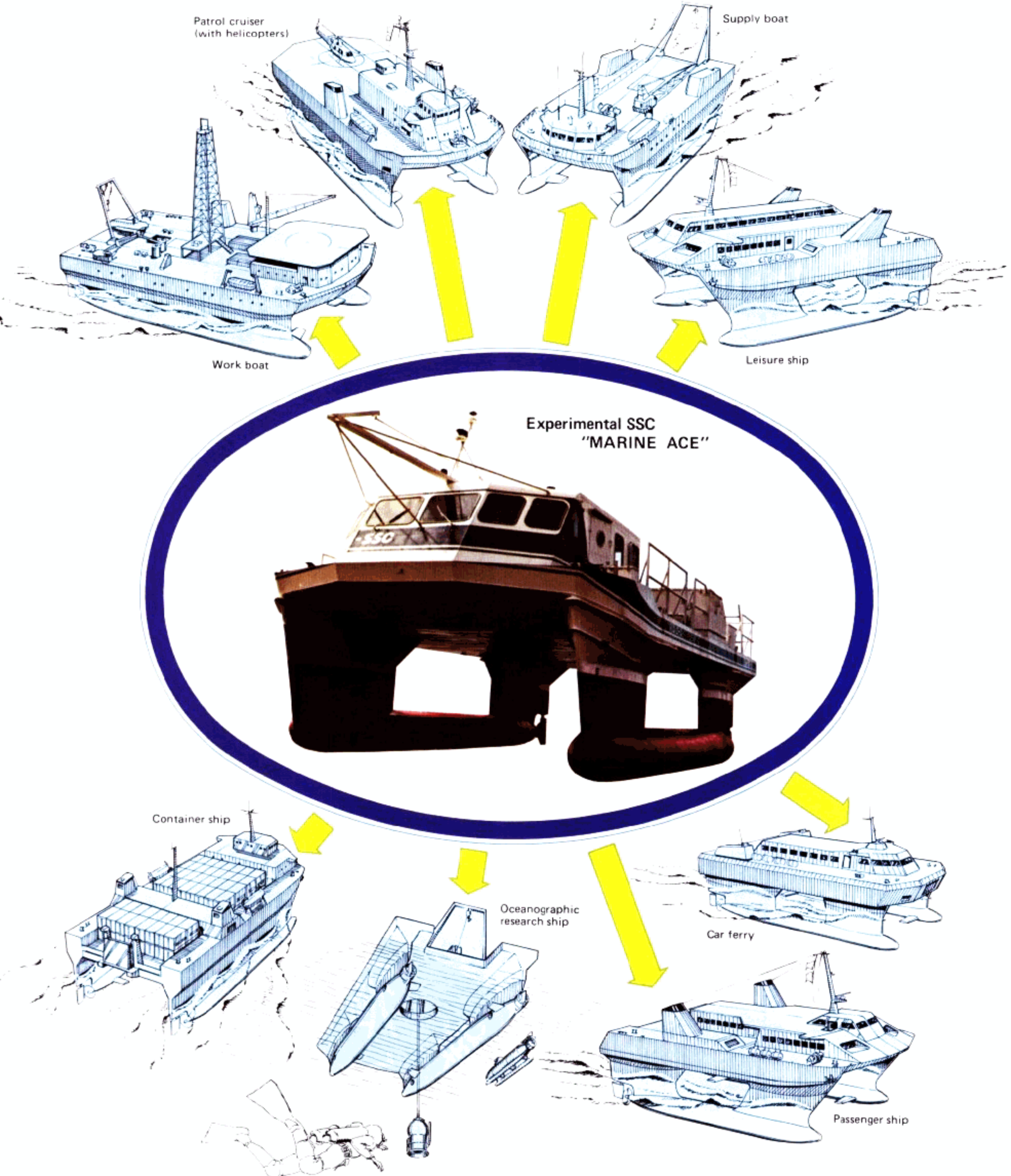
Table 1 Principal dimensions of passenger ferry

Length (bp)	30.00 m
Breadth (moulded)	18.00 m
Depth (moulded)	7.60 m
Full load draft	3.50 m
Service speed	abt. 24 knots
No. of passenger	abt. 430
Main engine	high speed diesel engine 4050 HP X 2
Motion control system	4 sets of fin stabilizer with automatic control system

MITSUI ENGINEERING & SHIPBUILDING CO., LTD.
Head Office: 6-4, Tsukiji 5-chome, Chuo-ku, Tokyo
Tel: Tokyo 03 (544) 3131
Telex: J 22821 MIT ZOSEN
Cable Address: "MITSUIZOSEN TOKYO"

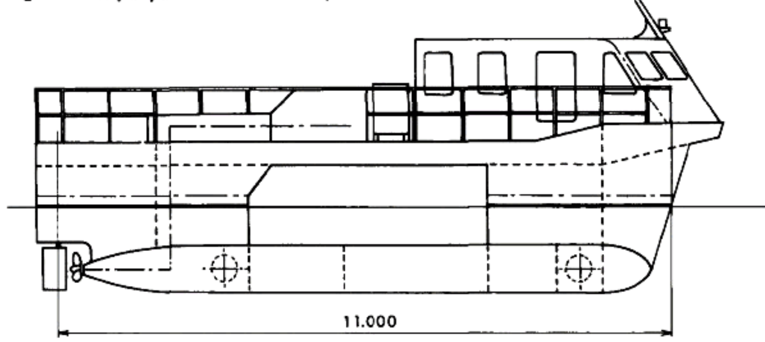
JAPAN SHIP'S MACHINERY DEVELOPMENT ASSOCIATION

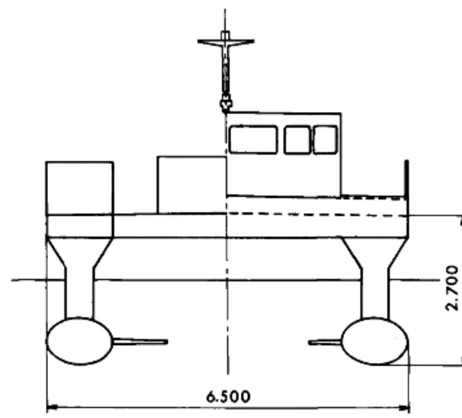
Fig. 2 Future applications of high performance semi-submersible catamaran



財団法人 日本舶用機器開発協会 三井造船株式会社

Fig. 3 Principal particulars of the experimental SSC "Marine Ace"





1. Principal dimensions
   Length (bp): 11.0 meters
   Breadth (moulded): 6.5 meters
   Depth (moulded): 2.7 meters
   Design draft (moulded): 1.55 meters
   Ship speed (max.): About 18 knots
2. Hull material
   Corrosion resistant aluminium alloy
3. Main engine
   4-cycle gasoline engine
   200 HP X 2 sets
4. Ship motion control system
   Fin stabilizer with automatic control system

Fig. 4 "Marine Ace" at sea trial

MITSUI ENGINEERING & SHIPBUILDING CO., LTD.
Head Office: 6-4, Tsukiji 5-chome, Chuo-ku, Tokyo
Tel: Tokyo 03 (544) 3131
Telex: J 22821 MIT ZOSEN
Cable Address: "MITSUIZOSEN TOKYO"

JAPAN SHIP'S MACHINERY DEVELOPMENT ASSOCIATION

最适合于能量节省时代的船型
—15%省能量船舶—

1　降低螺旋桨的转速，提高推进效率

——世界各国都在挑战——

自从闹油荒以来，能量的节省已成为产业上的一个课题。在海洋运输方面，目前的暂时解决办法就是，把船舶的航行速度减低下来，节省燃料经费。

但是，这不能算是个根本的解决办法。所以其趋势还是在如何保持向来的船速而又能节省燃料经费。换句话说，其急务是在减少马力。

但减少马力的方法，只靠改良船头的外壳弯曲的一向办法已经到了限度。

因此，降低螺旋桨转速提高推进效率的办法就引人注目了。当然这只是一个构想吧了。但对这种办法，丹麦的B＆W公司所发表的新的船型以及其他造船国家都早已做出了种种的提案。

降低螺旋桨转速以达到最大推进效率，螺旋桨直径就要变大，因此容纳螺旋桨的船尾其形状也将改变。

并且，已往的柴油主机，其转速不能降到100rpm以下，所以就须另有减低螺旋桨的装置。因此我们相信，从10年以前就在日本运输省船舶局的大筹划之下所开发，而现在被广泛的采用于中速柴油机减速装置的行星式齿轮减速装置将可用来最有力的减低螺旋桨的转速。

Fig. 1 The arrangement of T-type stern

財団法人 日本舶用機器開発協会　三井造船株式会社

Optimum Ship Design That Meets Fuel Saving Requirements
– Ship Design Featuring 15% Fuel Savings –

1 To increase the propulsive efficiency by reducing the speed of propeller revolution

– The whole world is challenging to this problem –

Fuel saving is the current topic in industrial fields of the world since suffered from the Oil Shock. In the shipping world, fuel saving was put in practice by decreasing the ship speed. But this method has not solved the problem in essence. The best way will be developing a basic plan to save fuel (to decrease the required horsepower) without reducing the ship speed.

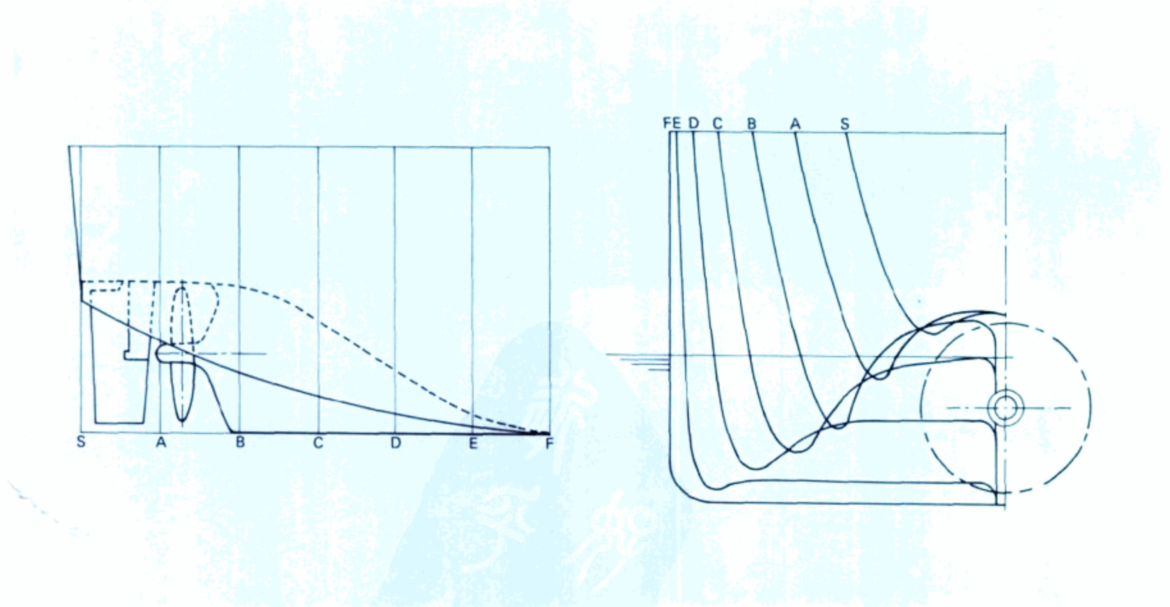
Development of bow arrangement like bulbous bow has already reached to the limit as method to decrease the propulsive power. Therefore, the concept to increase propulsive efficiency by decreasing the speed of propeller revolution has recently been high-lighted.

This concept was suggested by B&W in Denmark as well as other shipbuilding countries.

Decreasing the speed of propeller revolution to achieve maximum propulsive efficiency means a large diameter of propeller requiring modification of the stern arrangement.

And the reduction gear of planetary gear type will be adopted as the leading part because the revolution of diesel propulsion engine can not decrease its revolution under 100 rpm. The reduction gear with IMT planetary gear which was developed as the large project of Ship Bureau, Ministry of Transport since 10 years ago and has been adopted for many actual applications, will be fully utilized as a measure to reduce the shaft revolution.

Fig. 2 Conceptual drawing of T-type stern



MITSUI ENGINEERING & SHIPBUILDING CO., LTD.
Head Office: 6-4, Tsukiji 5-chome, Chuo-ku, Tokyo
Tel: Tokyo 03 (544) 3131
Telex: J 22821 MIT ZOSEN
Cable Address: "MITSUIZOSEN TOKYO"

JAPAN SHIP'S MACHINERY DEVELOPMENT ASSOCIATION

2　新颖而大胆的船后部形状

(1)　新式的船尾形状的概要

新式船尾是为了要采用大直径螺旋桨，把从来的船型大胆的加以变形的。从船中央起，直到容纳螺旋桨的船尾，形成隧道状，并且它的形状也加以单纯化了。

这是我们开发协会的滨田理事长构想出来的，所以也可说是“滨田式新船型”，但通常被称为T船尾（隧道式船尾船型）。（参照图1．T式船尾形状——专利申请中）

本新船型改善了从来肥胖船型船尾水流不顺的缺点，另一方面使其能装配大直径螺旋桨。（图2）

(2)　新式船尾形状的特点

采用新式船尾船舶跟从来的船舶的比较

a）　减少发动机马力，节省燃料费用。

b）　由于减小发动机的占位和燃料库，所以就增加了载货重量和载货空间。

c）　因为采用少弯曲的单纯船尾形状，所以船壳工作费用就减少了。

有这些优点，所以它可说是一种划时代的大胆的尾形式船舶。

3　水 槽 试 验

(1)　在回流水槽里观察船尾的水流状态

为了要明白上面所述的意图，究竟实现了什么程度，在运输省船舶技术研究所支援之下，就以2米长度的小模型在回流水槽里做了试验。

把它装在回流水槽里，观察船尾的水流状态。如图3（船尾附近的水流状态）所示，隧道内部外部，以及其他的境界处的水流是极为顺畅的。并且也发现了一点，就是在吃水浅的压载状态下，因沿着隧道有水上来，所以也能使螺旋桨十分的浸于水中。

(2)　以6米长度的大模型做推进性能试验

因为回流水槽的试验结果，知道了可得到予期的效果，所以再进一步以长6米的大模型（参照图4．6米模型），在曳航水槽里做了自航试验。其结果不但证明了提高推进效率的本来的目的可达成，并且也知道了和从来的船型比较，更可以减少船体抵抗。

还有以具体的问题来说，螺旋桨的效率，由于转速的降低和水流的改善而可以大为上升，但一方面也有和所谓伴流增益相当的船壳效率的减少而有一部的抵消，但这大胆的船尾形状，总合起来说，是可提高推进效率的。

再说，这种新船型，要从模型试验结果测定实船的实际性能，一般被认为是极为困难的。但如果，由于螺旋桨伴流的比例影响的修正法有相差而可容许做宽容的测定的话，实船的实际性能也不是说不能推测的。

Fig. 3 Water flow around the stern

2 Concept of the advanced stern arrangement

(1) Summary of the advanced stern arrangement

The hull bottom rises gradually from after part of midship to the stern to enclose the propeller like tunnel. This idea was conceived by Noboru Hamada, President, JSMDA, and a patent was applied for this so-called tunnel stern. (Fig. 1 The arrangement of T stern)

This advanced stern shape is able to improve the water flow at stern of a full form ship and to house a large sized propeller. (Fig. 2 The conceptual drawings of T stern)

(2) Distinct features of the advanced stern arrangement

Comparing with a conventional ship, it has the following special features.

a) Resulting from the less required power, the fuel cost will decrease remarkably.

b) Resulting from the reduction of engine space and fuel tank space, dead weight capacity or cargo space will increase.

c) Resulting from the simplified stern arrangement with less curvature, cost of labor on hull construction will decrease.

3 Ship model tests

(1) Tests in the circulating water channel

Tests were carried out to investigate the water flow at stern of 2 m length model in the circulating water channel under the support of the Ship Research Institute, Ministry of Transport.

The water flows of inside, outside and the boundary district of the tunnel are quite smooth as shown in Fig. 3.

Even at shallow draft, the propeller is always submerged in water coming up alongside the tunnel wall.

(2) Propulsive performance tests with 6 m length model

Based upon the conviction attained from the test result in the circulating water channel, resistance and propulsion tests with 6 m length model (Fig. 4) to investigate the propulsive performance were carried out by the towing model basin. The test results have verified the improvement of propulsive efficiency and furthermore the reduction of hull resistance compared with a conventional ship.

The propeller efficiency increases remarkably due to both the reduced revolution speed and improved water flow, but some losses in hull efficiency arises due to the decrease of stretch of wake flow. However, this stern arrangement has achieved in total the increase of propulsive efficiency.

In case of such a new arrangement, it will be rather difficult to estimate the actual performance from the result of model test. But it will be possible to estimate the actual performance by permitting the error in correcting the scale effect of propeller wake.

MITSUI ENGINEERING & SHIPBUILDING CO., LTD.
Head Office: 6-4, Tsukiji 5-chome, Chuo-ku, Tokyo
Tel: Tokyo 03 (544) 3131
Telex: J 22821 MIT ZOSEN
Cable Address: "MITSUIZOSEN TOKYO"

JAPAN SHIP'S MACHINERY DEVELOPMENT ASSOCIATION

4　以74000DWT大容量运输船的情形来，把采用新式船尾形状的船舶与从来的船尾船舶做比较

推进转速设定于70rpm而来看巴那马斯型74000DWT大容量运输船的情形。经推定计算可得出如图5（74000DWT大容量运输船的速度马力曲线）的速度和马力的关系来。

这个图表示在一发动机马力有0.2kt（取满载状态和压载状态的平均值）程度的推定宽容范围。

现在假定可以得到这范围的中间的性能，即新船型与从来的船相比可得到约12%的马力的节减。计算所用的船体、发动机等的重要项目列示如表1（新船型和从来的船相比较）。就是说，这个74000DWT大容量运输船的情形是，同样要得到速度16.6kt，从来的船需20500马力的发动机，而新型船即需18000马力就好。

不用说，为此而需将螺旋桨的转速由从来的船舶的114rpm降低到70rpm。

按照上述的例子来说，螺旋桨转速降低到约60%时，马力的减少约为12%，但可以再把螺旋桨转速降低而使马力减少到15%程度。

5　建造这新船型船舶所必须考虑的几点

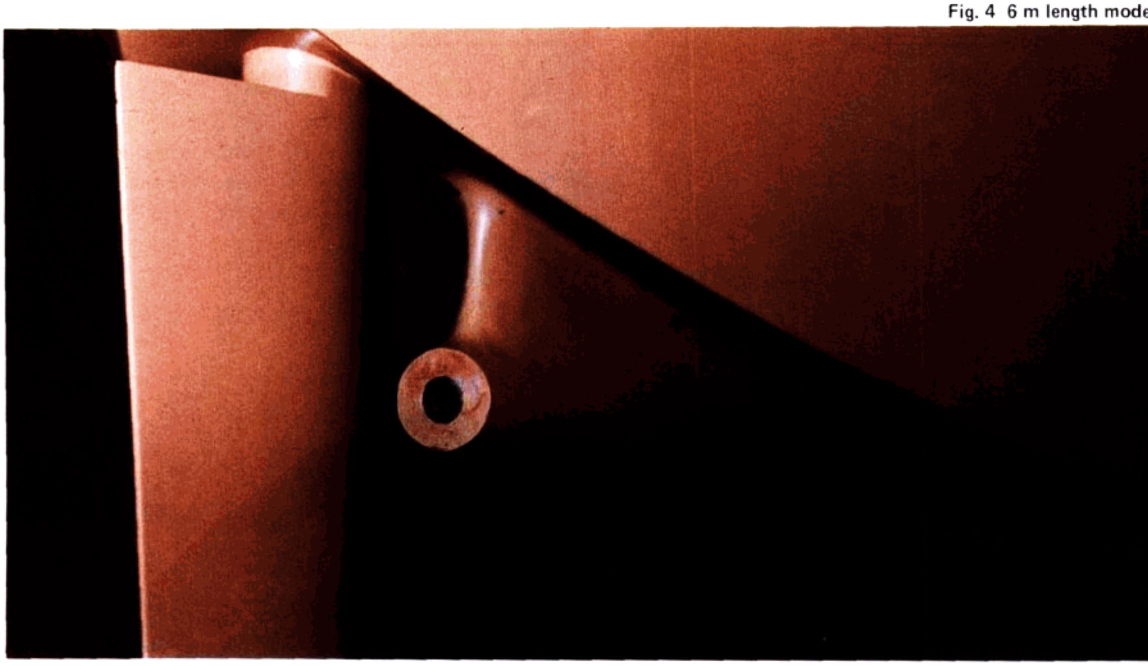
但一旦要实际去建造新船型船舶，就得比起要建造从来的船更非十分的检讨下列的几个问题而进行不可，那是不用多说的。

① 螺旋桨的起振力和螺旋桨的气蚀

② 后退等时的操纵性能以及追波中的保针性能

③ 波浪中的螺旋桨的轨道和发动机负载变动等等

Fig. 4 6 m length model



財団法人 日本舶用機器開発協会　三井造船株式会社