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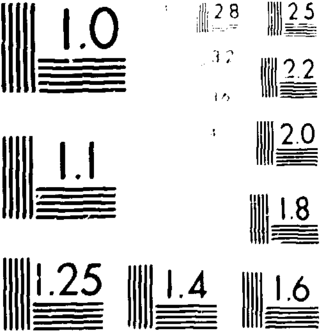
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APPLICATION OF WIND POWER FOR SHIP'S DRIVE *

prepared by

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1. INTRODUCTION

During thousands of years the winds of beaches and oceans have been the energy suppliers for the seatransport. However, from the beginning of steamers /steam ships/ the number of different merchant sailing vessels under construction has decreased whilst after introduction of motorships the above sailing vessels have declined from the world seas totally. Today merchant sailing vessels may be met only in some exotic countries.

In the last years the problem of application of the wind energy for the drive of merchant vessels comes again into sight and is the subject of very wide considerations connected with a certain amount of interesting designs. It has to be here mentioned that the renewed interest in the use of wind energy for ship drive is connected mainly with the increased in the last years costs of other kinds of energy and mainly costs of fuel. Independent on the above, however, it may be in any case stated that the application of wind energy /read sails/ for driving of merchant and fishing vessels is fully possible, although since 60 years no practical experiences in this field exist.

The top of the sailing freighter created the American gaff schooners /about 1900/ and the American and English clippers /about 1850/. They were the absolute optimum when taking into consideration the then existing technology. The so fast introduction of motorships took place mainly because of the considerably low ratio between the used and available amount of wind energy and because of considerably bad cruising characteristics of the sailing vessels. Also the considerably hard service

/operating/ conditions could not be improved when taking the then oxisting state of the technology.

It is quite evident that the sailing freighters might today in some points differ considerably from the sailing vessels used about 100 years ago. The development of sailing boats used in yachting and particularly the introduction of very modern and sophisticated operation equipment on these boats is a proof of the above statement. The significant improvement in the field of aerodynamics and machine building connected with a wide use of different hydraulic elements and details opened for the sailing freighters quite new possibilities, particularly, that the requirements concerning the staff for the modern vessels may be reduced due to the possible use of servo-drivers and full automatization.

Taking the above statements into consideration two ways may be introduced to use again the wind energy in the shipping industry, namely, first concerning the improvement of the previous sails systems and second through introduction of new wind resistence systems. The first solution concerns the introduction of improved forms of sails, mechanical reefing and trimming of sails as well as aerodynamical advantageous forms of masts which may be also rotational. The second solution takes into consideration special profiled wings partially with flaps similar to used in modern airplanes and equipped with modern rigging. One problem, however, the modern technology may not overcome, namely, the dependence of the ship velocity from the weather conditions. This mean that the future traders equipped with sails may be recognized as motorships supported by the wind energy or sailing traders supported by motors. The priority of the driving system into consideration depends on the assumed amount of fuel which have to be saved and on the planned permanent operating velocity of the sailing ships. In any case the economical calculations are showing a certain profit from the introduction of wind energy for driving of different kinds of ships.

When considering the possibility of introduction of sails for driving of traders following assumptions haveto be made:

1. The auxiliary sails can't limit the access to the cargo hatches and can't create a hindrance in the loading and unloading of ships into consideration.

2. The auxiliary sails can't increase the operating costs what also means that its installation can't increase the number of staff members, etc.

3. The auxiliary sails have to be installed at minimum investment costs.

In the following different possible solutions will be described mainly from the point of view of modern shaps of sails and operating possibilities. It should be mentioned that the introduction of sails may require a quite different shape of the hull.

2. EXISTING TENDENCIES CONCERNING LARGE MERCHANT VESSELS

In some countries the sails for small traders are still in use not mentioning the big amount of yachts /sailing boats/ which may have very sophisticated equipment allowing on the maximum possible use of wind energy. The sails in previous years have been used mainly for fishing boats. The purpose of these sails was not only to decrease the amount of fuel used for the boat drive, but also to keep the fishing boat during fishing in the necessary position with a significant decrease of the angle. As an example of these boats the Polish cutters KS-17, B-12 and B-25s /Fig.Fig. 1,2 and 3/ may be presented. They have had a small fore sail placed in the triangle between the deck and the fore mast /main mast/ and two triangle sails fastened to the fore mast /main mast/ and stern mast /mizenmast/.

In the last time also conventional sailing ships /training ships/ have been built. An example is the Polish three mast frigate "Dar Młodzieży" /Fig.4/ with a total length of 108.8 m, width 14.0 m and the sails area of 3.015 m^2.

The above ships as well as the normal sailing boats /yachts/ use the conventional shape of sails and present two main solutions, namely, in the first the motorships supported by the wind energy /fishing boats/ and as sailing ships supported by motor /yachts and sailing ships/. These solutions however can't as said before be used for drive of large merchant vessels. Here the possibility of installation of sails on existing reloading equipment may be considered, what means, that on derrick booms and masts some hoisting yards might be installed on which the sails on each ship's side will be set /Fig.5/. The service of these sails with considerably small supplement of rigging will be assured by cargo winches recently on many ships automatized. During the loading and unloading of the ship the sails will be furled, the hoisting yards placed along the derrick booms or masts, creating only a considerably small hindrance.

The triangle sails may be set between masts and horizontally placed derrick booms /Fig.6/. It is a simpler solution

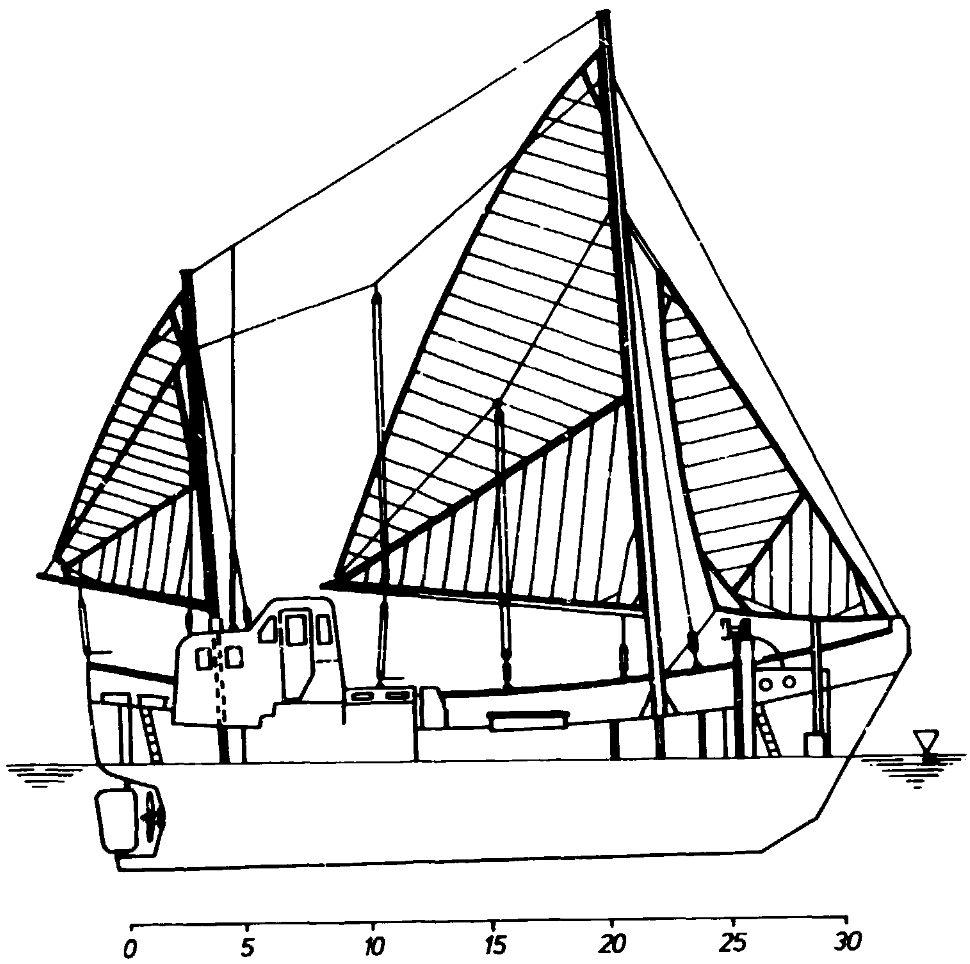

Fig.1. Cutter KŠ-17

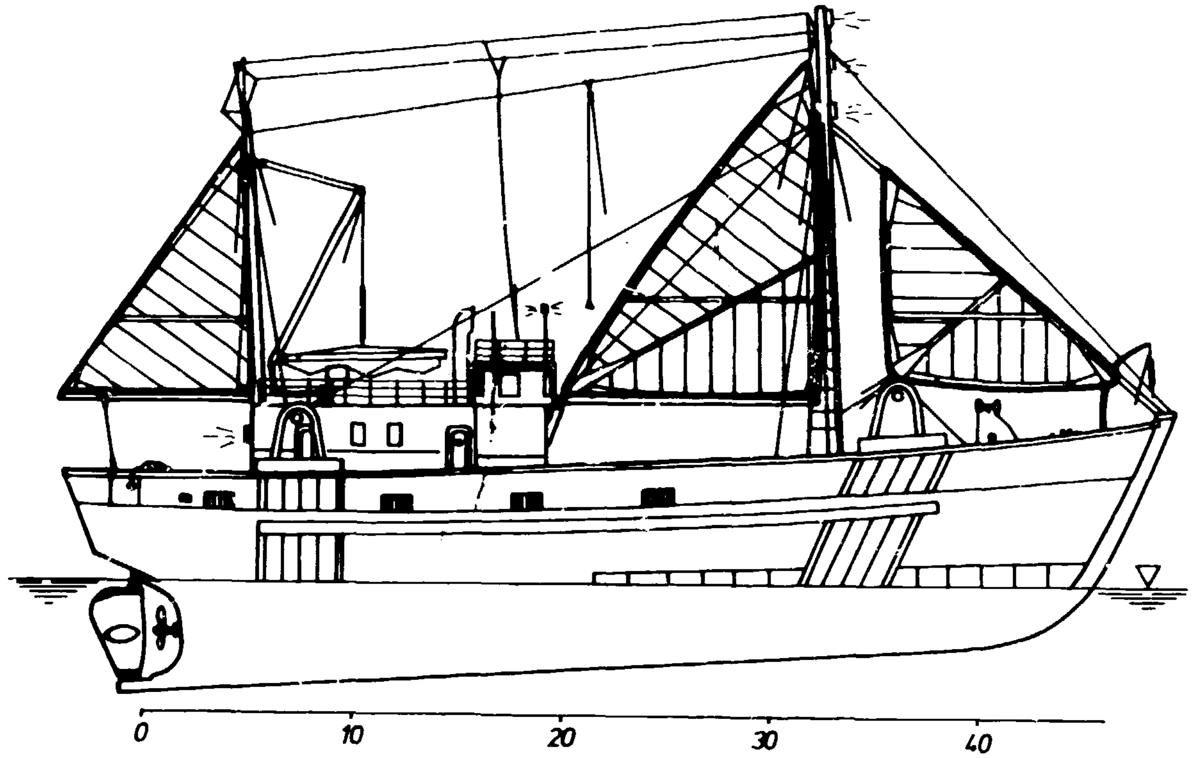

Fig.2. Supercutter B-1

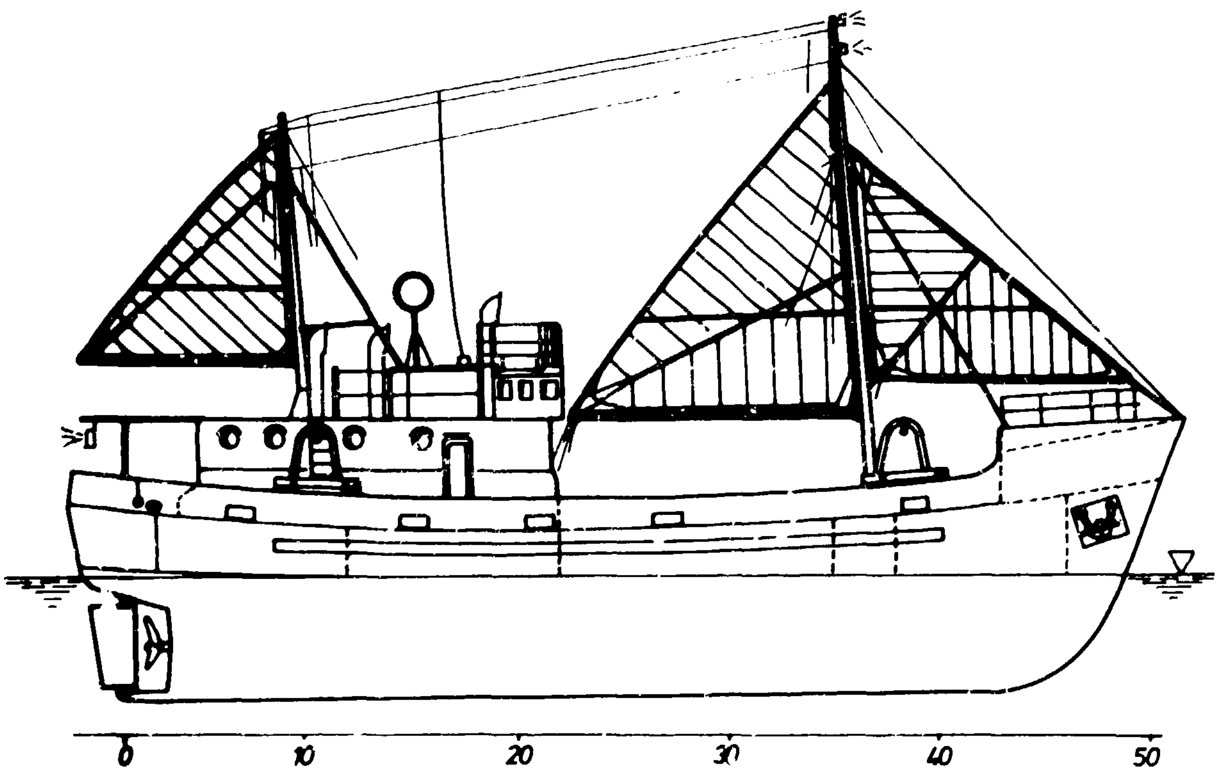

Fig.3. Supercutter B-25 s

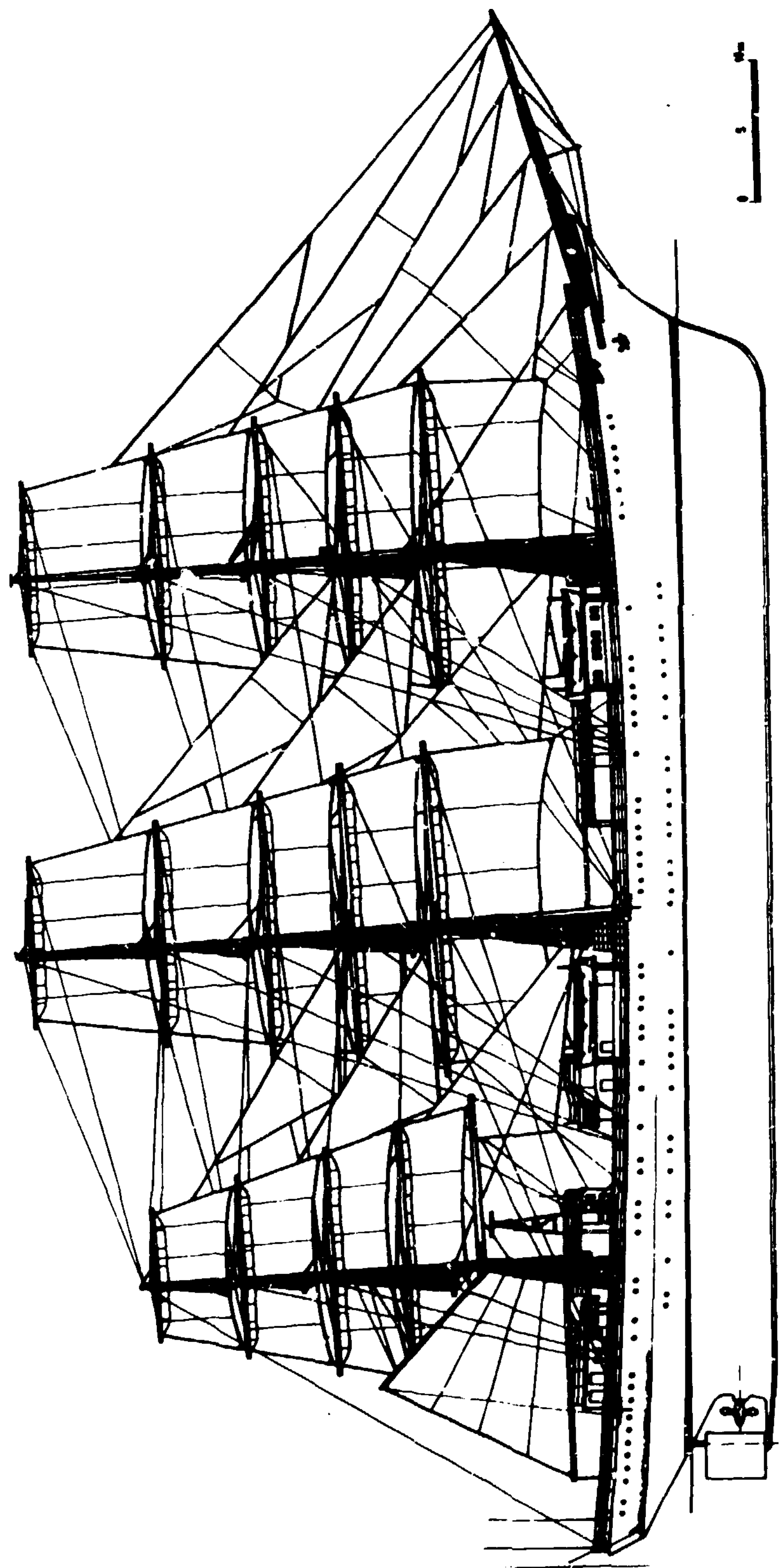

Fig. 4.

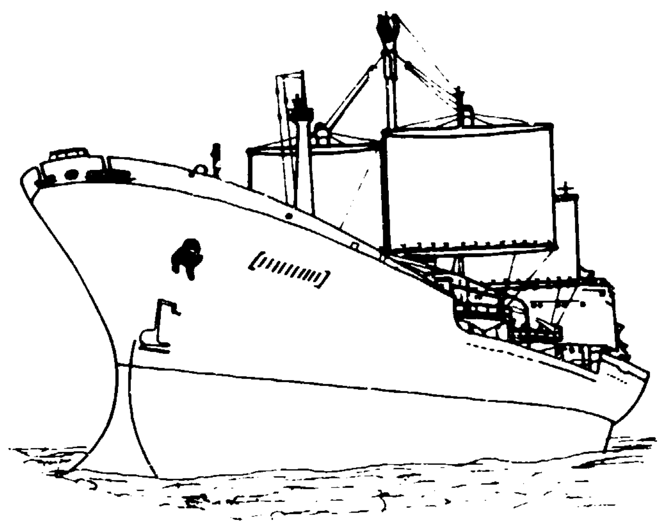

Fig.5.Merchant vessel with sails on derrick booms

which does not require to install additional hoisting yards. However, the dimensions of the modern reloading equipment are considerably limiting the area of sails which may be set on the ship into consideration. This means, that the ship owners which would like to decrease the use of fuel will be forced to increase the height of masts /Fig.7/. It is not connected with big costs but gives a considerably increase of sails. The disadvantage of this system which can be realized mainly on cargo and container ships with a very rich cargo handling equipment concerns the dependence of the efficiency of the system from the relative wind direction. The big amount of booms and masts, suitable for setting of sails is also a hindrance in the optimum evaluation of wind energy. A very serious hindrance are creating also the very high superstructures characteristic for the modern ships. The fuel saving is exactly dependent on the design of the ship construction. It is, however, not foreseen, that the savings may exceed a few percentage.

The solutions suitable for cargo ships can't be taken into consideration for bulk carriers or tankers which have not masts. On the tankers the solution is much easier because the sails don't create a considerable reloading hindrance. Therefore probably the first sail-motor ship "Shin Aitoku Maru" was a tanker.

On bulk carriers due to the structural solutions of the holds also a full easiness in the installation of sails exists which, however, during the reloading time must be reduced as much as possible.

It has to be mentioned here that a design of H.J.Berekoven exists which is based on the Arabic dhau. It contains a not

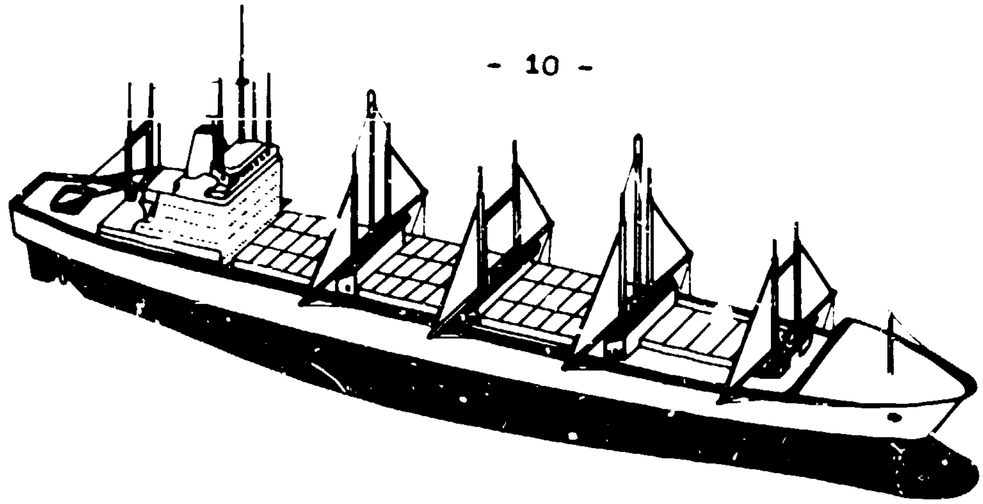

Fig.6. Auxiliary triangle sailu on a cargo ship

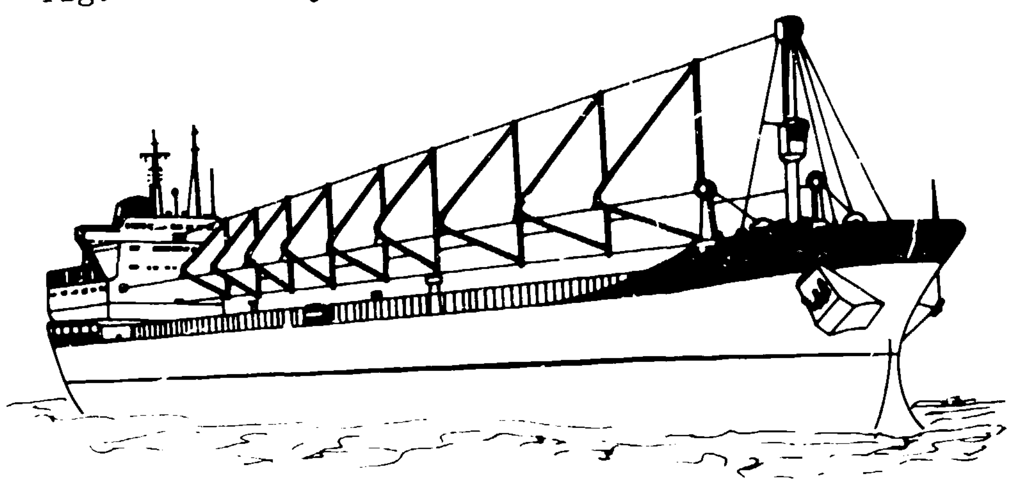

Fig.8. Serial sails on a tulk carrier

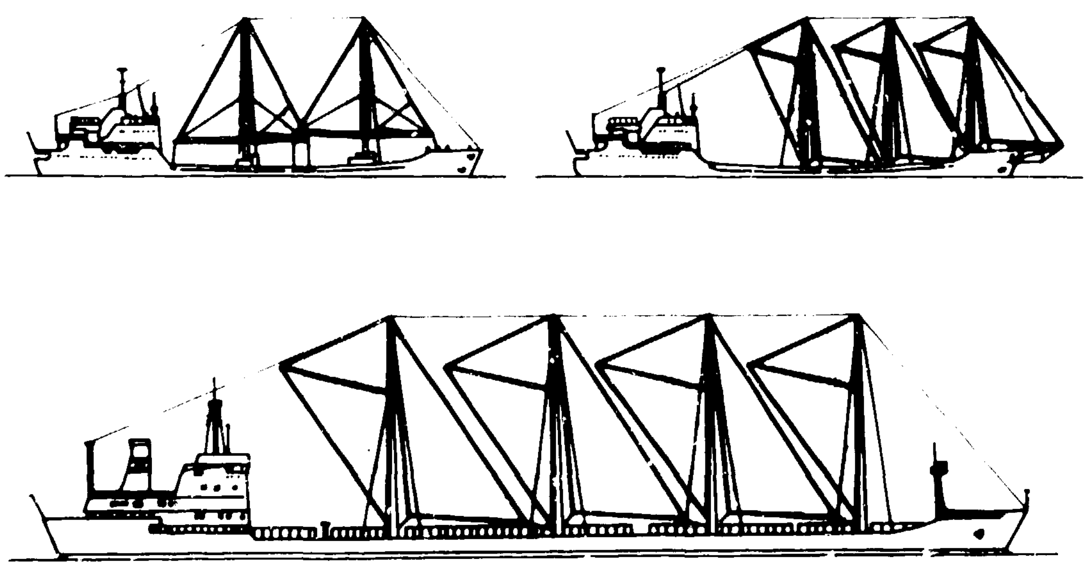

Fig.7. Sails on auxiliary masts on different types of ships

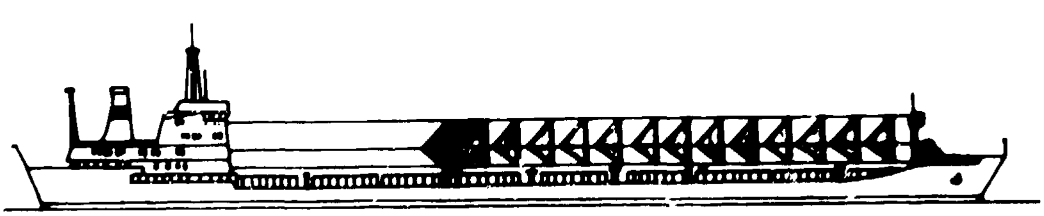

Fig.9. Serial sails on a bulk carrier

high but very light and stiff mast which is inclined under the angle 25° in the bow direction and doesn't require stays or shrouds. Along the mast a carriage is moving to which at 2/5 of its length an aluminium yard of the slant Lateen type sail is fastened. An electrical winch allows to heave up and haul down the sail which for the time of reloading is put together with the yard in a special box installed on the deck. The lower yard arm /at the site of the shorter part measuring from the fastening on the mast/ is connected by a hinge with a rotational hydraulic driven semi-boom, fastened on an axis seated permanently in the deck in front of the mast. The free end of the sail is fastened by two sheets to two sheet winches having the possibility to move in the direction perpendicular to the longitudinal axis of the ship. The whole service is automatic without crew work. A computer installed on the ship allows on optimization of the positioning of the sails depending on the actual weather conditions and giving the maximum fuel saving. It is foreseen that the above system gives a 20% fuel saving.

The next solution proposed by August Bolten concerns the serial sails foreseen as an auxiliary drive possible for installation on bulk carriers and tankers /Fig.8/. The serial sail consists of several triangle sails of the same form and size set between two bearing ropes placed one above the other along the ship axis. A single sail has the shape of equilateral triangle with the base /fore leech/ strengthened by a stiff bracing fastened between the bearing ropes. Bearing ropes on a conventional bulk carrier or tanker may be fastened to the frontal wall of the superstructure and to a mast placed on the bow. On many ships such a strong mast is normally installed.

For reloading the sails are put together in a pack placed near the mast /Fig.9/. The distance between the sails is kept constant by a special distance ropes. Depending on the wind direction the whole set of sails is served by a common sheet placed on the left or right side of the ship. The calculation shows that on a space with the length of 125 m and height 16 m above the deck, serial sails of an area of 1.000 m^2 may be installed. For a wind force of 5^oB, it is for the wind velocity of 15 to 19 knots, this area should substitute a power of 1,400 HP what for a considered bulk carrier may be about 16% of the total engine power. The final saving will be in this case from 20 to 30%. An additional advantage of the serial sails is the possibility of unification e.g. for the whole fleet of one owner.

A modern solution represent the profile wings which may be installed on all kinds of ships specially designed for this purpose. The profile wings are steared by electro-hydraulic systems and suited to the actual wind direction. When closed the profile wings create rectangular towers. This solution is applied on the ship "Shin Aitoku Maru" /Fig.10/ and may be used e.g.on special catamarans /Fig.11/.

As said before the use of sails on merchant ships is possible on ships of conventional or special design. On Fig.12 special designs are shown characterized by very high masts and considerably large sail area. In the first case special reefing gears have to be installed. The staysails will be rotated about the stays whilst the wishbone gaff goes into the mast. The second case concerns the rectangular gaff sails which allow on sailing with advantageous streamlines. The reefing take place by electro-hydraulic system using an integrated reef roller. The third case consists on a square rigged sailing vessel with

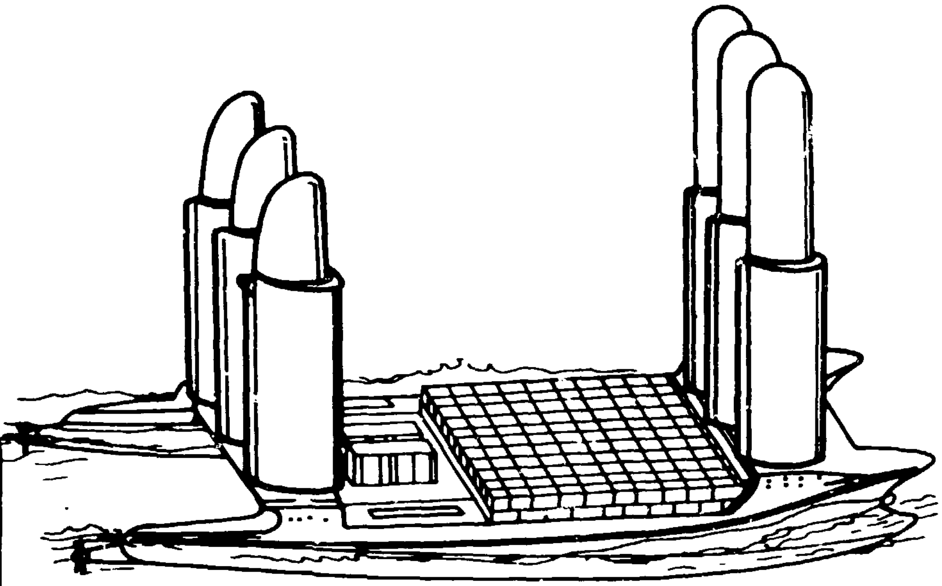

Fig.11.Catamaran with profile wings

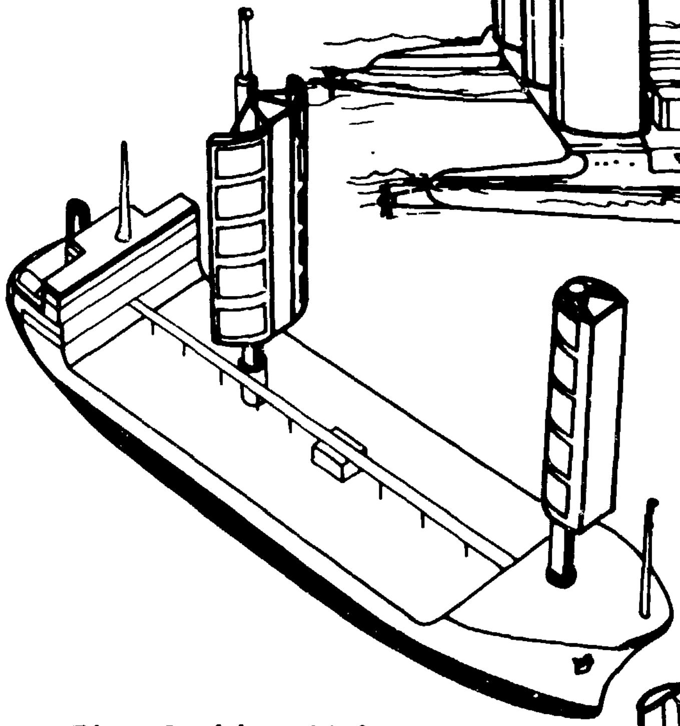

Fig.10.Shin Aitoku Maru

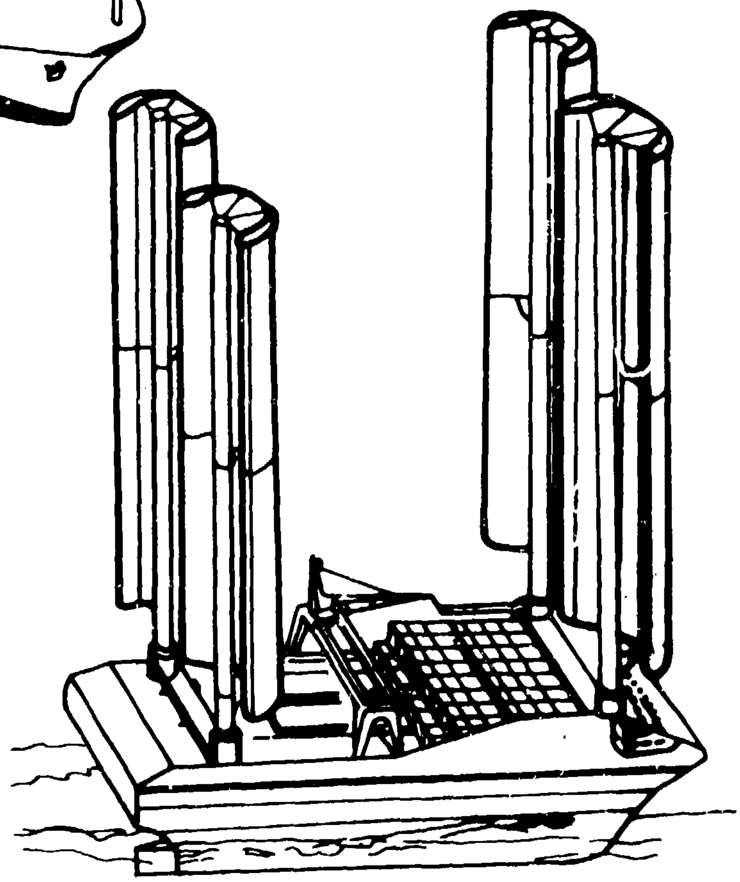

Fig.11.Catamaran with profile wings

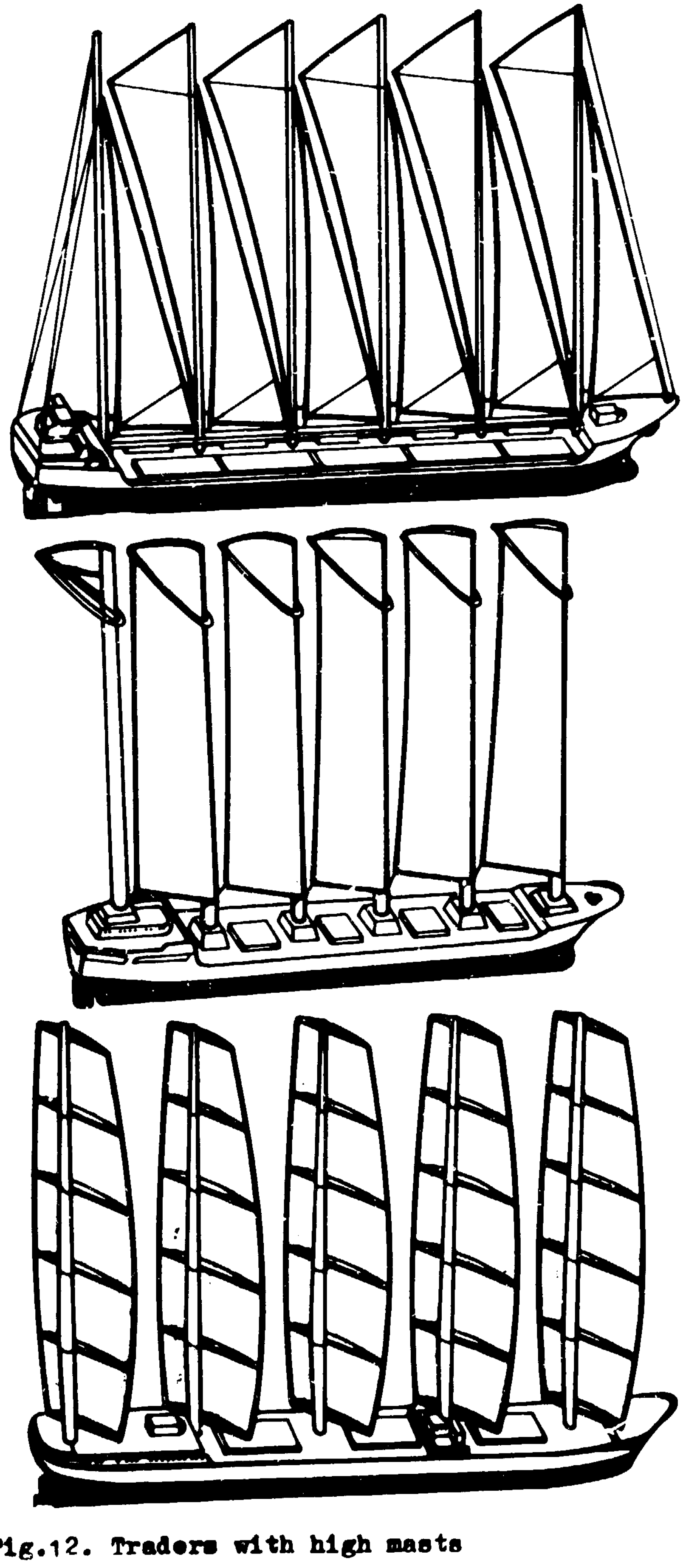

Fig.12. Traders with high masts

masts of eliptic cross-section and curved yards. The sails create together a wing with an advantageous side ratio. This allows to sail very fine. The reefing takes place in the mast direction.

In the last time very sophisticated designs of rigs have been made.E.g. on Fig.13 a design of Arwin Drechsel is presented which consist of a kind of framework allowing for a maximum reduction of stays and shrouds. This solution improves the aerodynamics of the rig. A spatial solution of the frameworks is also possible which reduces considerably the transverse forces. The masts are inclined to avoid hindrance to the sails from shrouds and spreaders. The whole rig is fully automatic steared by a computer.

3. SAILS FOR FISHING BOATS

A very interesting question presents the use of sails for drive of fishing vessels. In this field als ver eresting solutions are elaborated which concern not o shape and operation of sails but also the construction of the hull.

On Fig.14 a coastal fishing boat is shown, however, with a modern rig. The sails are reefed around a rotational mast whilst they may be doubled when sailing with wind. The operation is made by using electrical drive. In very narrow areas the mast can be layed down and telescopic shortened. The application of these sails allow to save until 80% of fuel.

As an example of application of sails for fishing vessel drive is the tuna boat shown in Fig.15. The sails are of stay type with a very effective wind entrance edge. Reefing and sheeting is made by electro-hydraulic arrangements. A similar solution presents the trawler shown on Fig.16 on which all sails are automatically reefed. The schooner sail is reeled here in the mast. For both boats the sails create an additional drive for the motor. In any case, however, these solutions offer a significant reduction of the fuel consumption particularly during travel of these ships.

A very important question concerns the full automatic reefing equipment. On Fig.17 a staysail schooner is shown which allows to reel all sails of an area of 570 m^2 in five seconds. This is possible only due to a special shape of the sails allowing on a electro-mechanic reeling. The search for fully automatic has brought to a design of a fishing boat shown in Fig.18. It is a catamaran type with profile sails being an additional drive. The main advantage is a very large sail which is set between two telescopic mast, which are inclined when setting this sail. All sails are electro-hydraulic operated from a operation bridge with two movable cabins. This alows to see the sails and fishing nets /gears/ from the best angle whilst the sails are set up using monitors. The fishing boat is also fully automatic whilst the fishes are directed into the ship through a large funnel.

4. CONCLUSIONS

The presented solutions of different ships using as an additional drive the sails, indicates that the application of sails for merchant ships and fishing boats is possible independent on their size and function. Technical solutions are recently

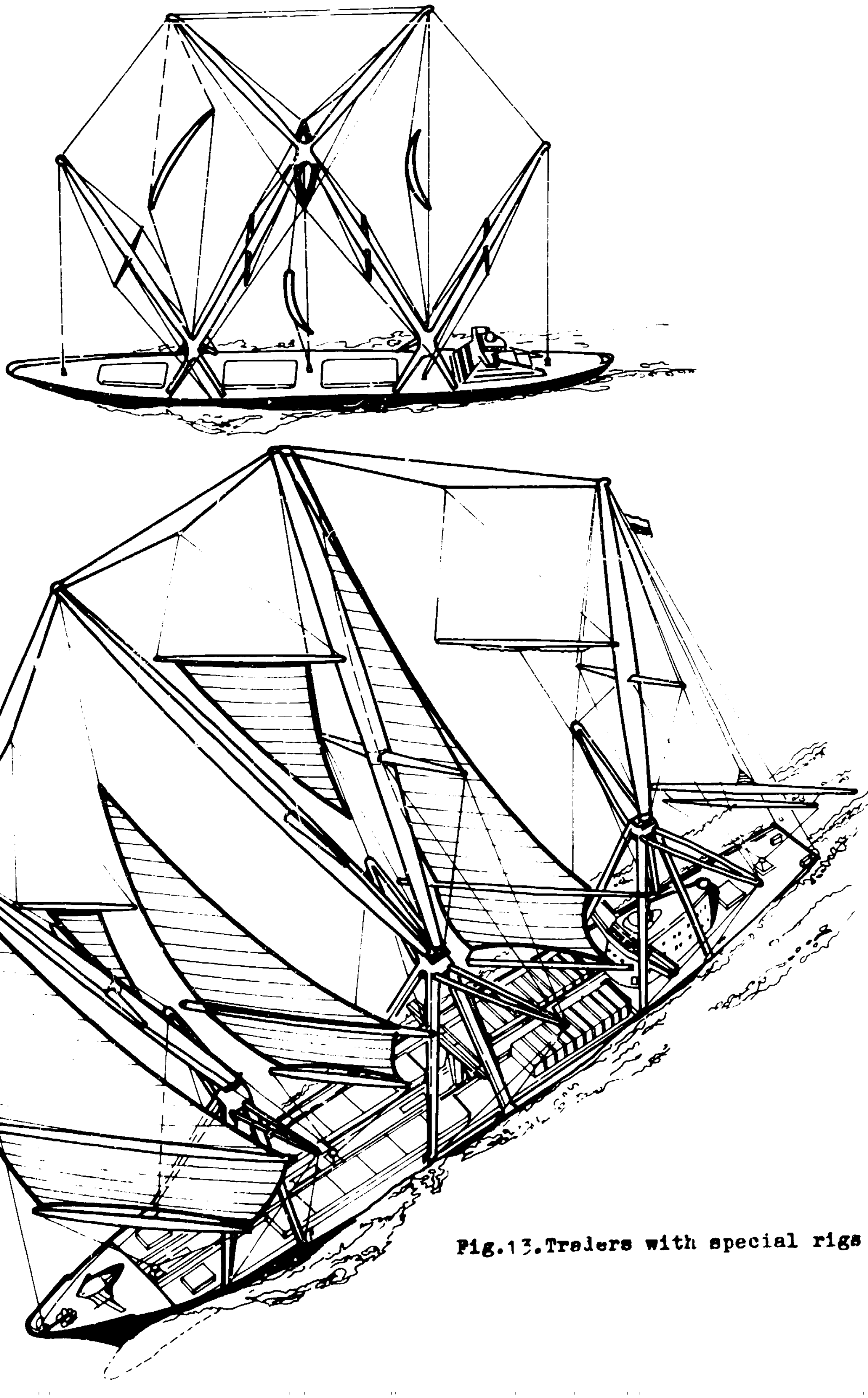

Fig.13.Tralers with special rigs

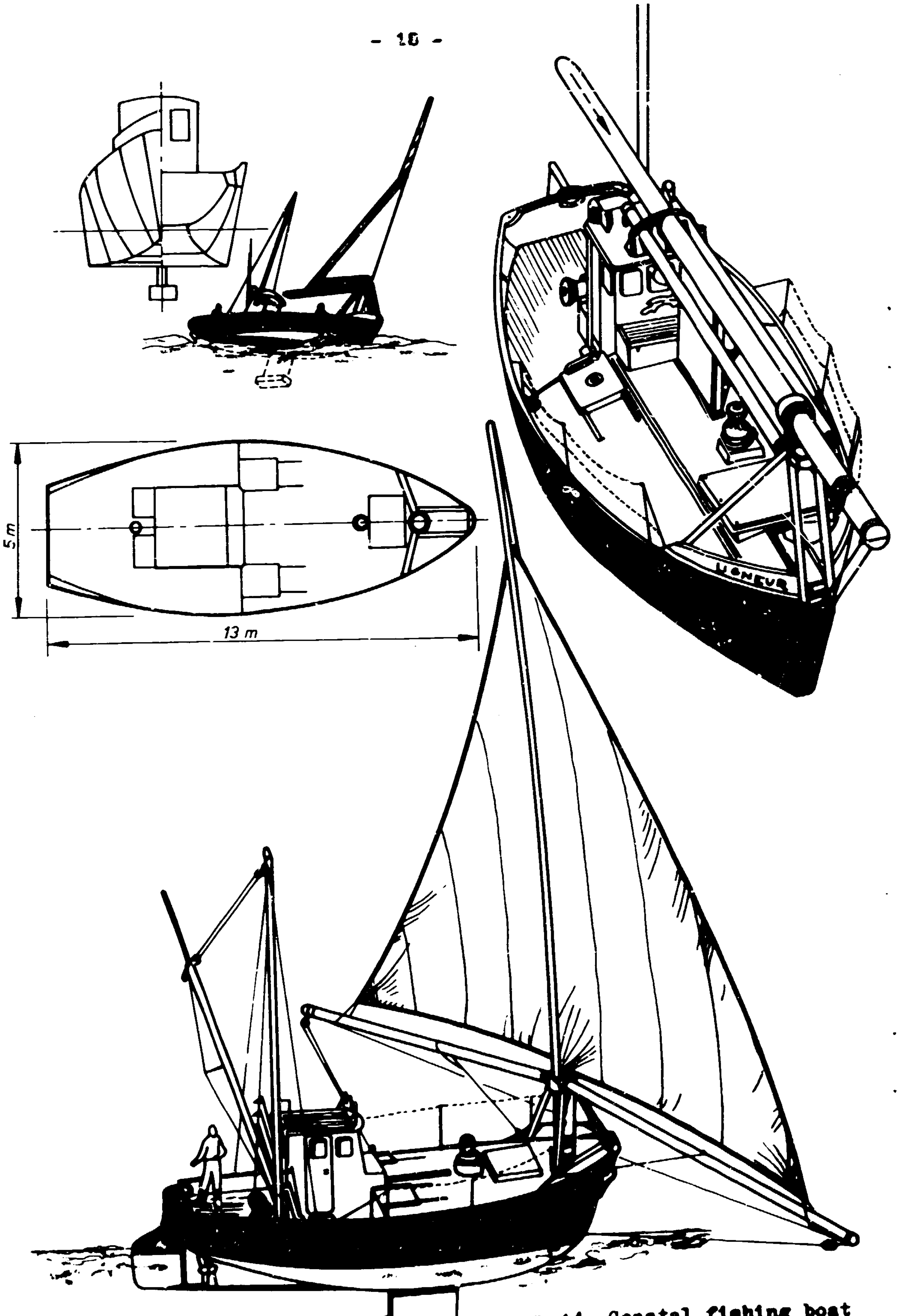

Fig. 14. Coastal fishing boat

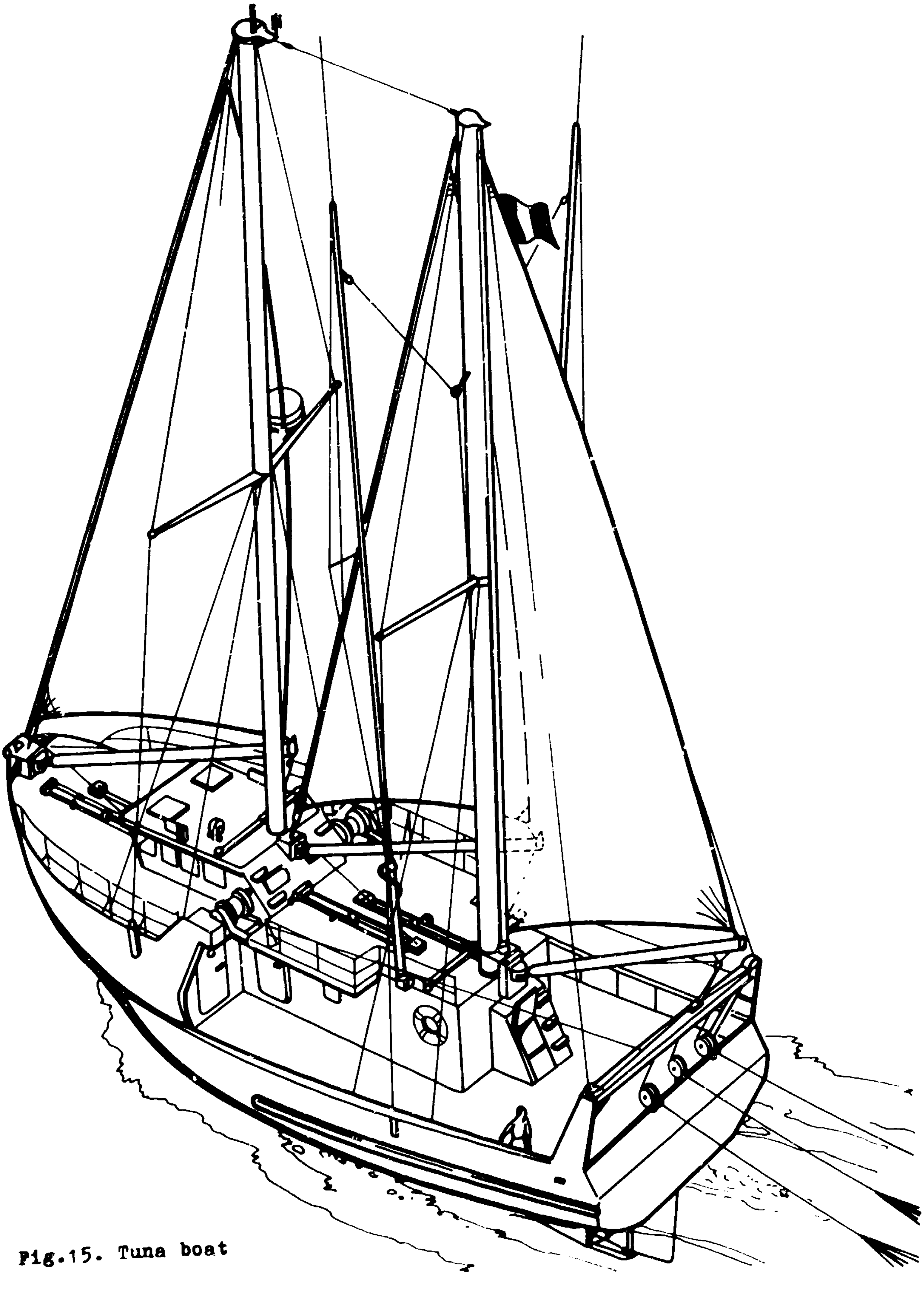

Fig.15. Tuna boat

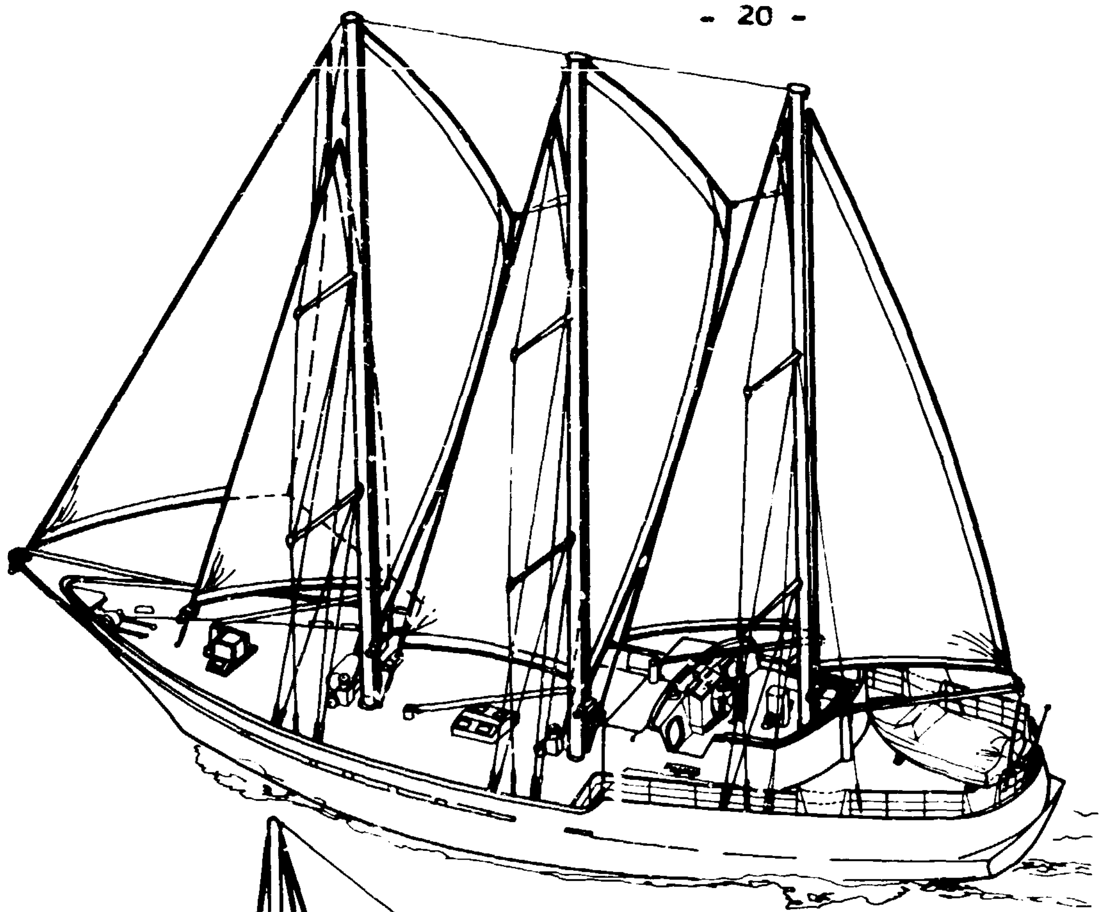

Fig.17.Staysail schooner

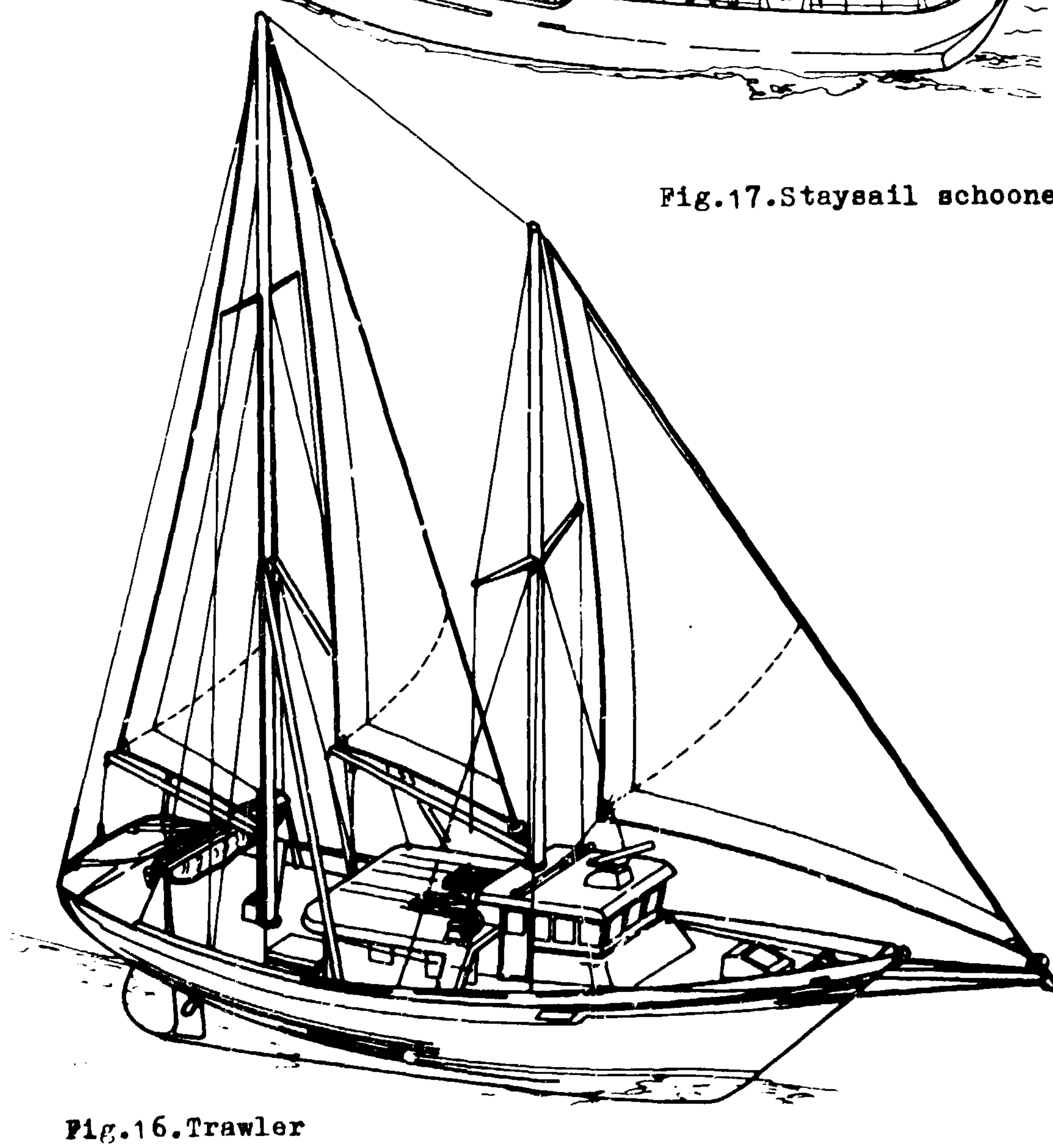

Fig.16.Trawler

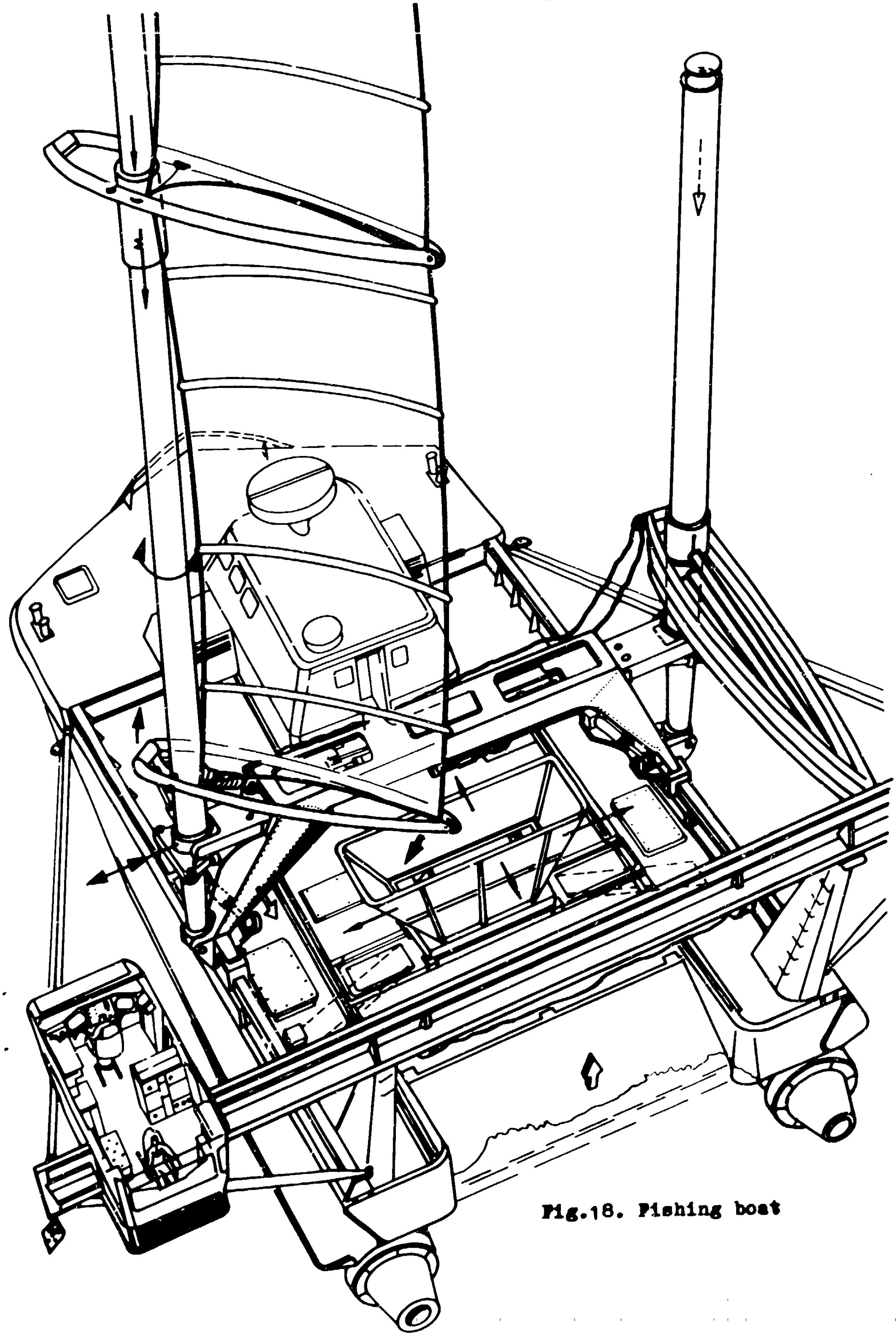

Fig.18. Fishing boat

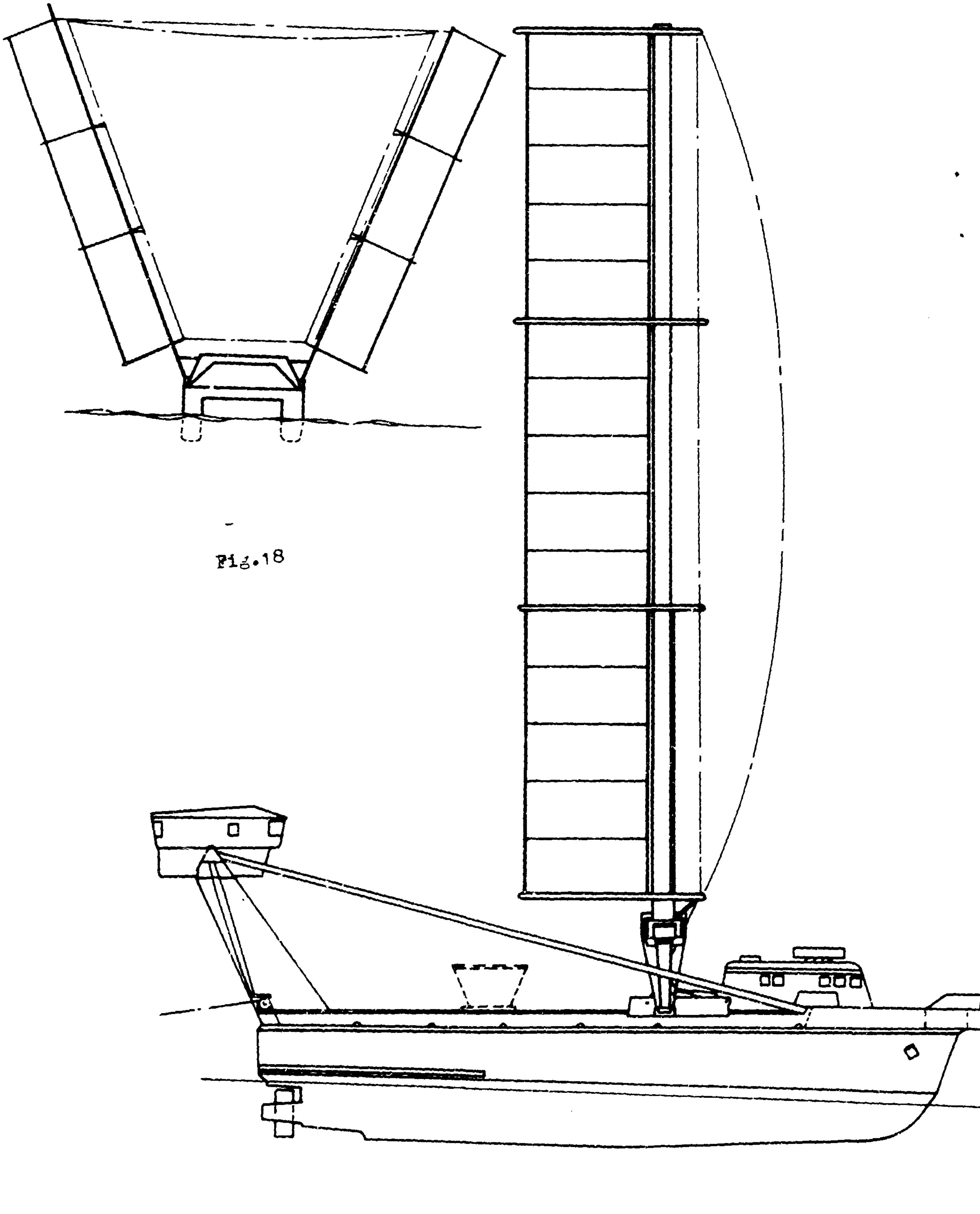

Fig.18

the subject of many designs whilst some practical applications are also known. It may also be here mentioned that as a ship's drive a kite may be used. It is not a new idea but at the time being very intensive investigations of this type of drive are in full progress.

Independently from the actual situa in this field it may be stated that the need of additional .ces of energy must in any case increase the interest in application in the future of wind energy for ship's drive. The presented examples indicate that this application is not only possible but gives also considerable savings of fuel used for running of marine engines.