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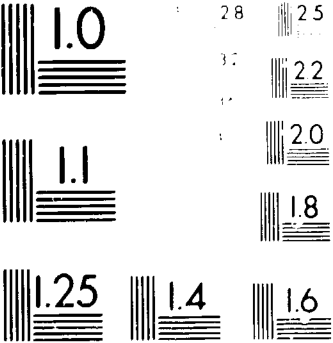

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BOATYARD AND SHIPYARD STRUCTURES FOR BUILDING AND REPAIRING OF BOATS AND SHIPS*

prepared by

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Content

1. INTRODUCTION

The organization of boat building and boatrepair as well as shipbuilding and shiprepair activities in a developing country has a significant bearing on the economy of that country. The existence of these activities allows not only the enlargement of the fleet but also helps to maintain the fleet in good condition which, in turn, results in a longer life span for the fleet. However, to organize a boat or ship yard it is necessary to build the boat or shipyard structures which allow first of all the launching and docking of boats and ships.

To start the activity in boat - or ship building one has to decide of course for which purpose the boats or ships have to be used. Let's assume here, as it is mostly the case in the reality in the developing countries, that a boatyard for building, maintenance and repair of fishing boats will be mainly considered. At the beginning of course many questions are normally raised concerning mainly the large investment costs which seem to be connected with this activity. It has to be therefore stressed that the start of boat - or ship building does not need to be immediately connected with planning of large expences which of course depend mainly on the size and type of the yard which is the function of the boat or ship size, the yearly capacity or output, the type and amount of equipment in the yard and the material which has to be used for boat or ship construction. A very important factor is of course the rate of mechanisation of all shipbuilding works which is connected with the purchase of certain equipment, for instance for wood working, etc. The above means that when one starts with a boatyard for fishing vessels based on local materials, local labour and on very low level of mechanisation, then he may reach very low investment costs, particularly at the beginning of the event. To give a general idea concerning the development of a yard let's consider a fishing vessels yard and all factors which influence the design of that yerd.

First the material and production technology problem might be considered. In the chapter concerning materials and production technologies an analysis of this problem for small ships is given. Ten probable materials and production technologies are distinguished from which for the developing countries are also recommended boats made from ferro-cement. That recommendation which concerns particular countries which have no wood and have small import possibilities, can be made due to the following characteristics of the ferro-cement, namely:

a/ Its basic raw materials - sand, cement and reinforcing mesh - are readily available in most countries.

b/ It can be fabricated into almost any shape to meet the needs of the user; traditional designs can be reproduced and often improved. Properly fabricated, it is more durable than most woods and choaper than imported steel.

c/ The skills for ferro-cement construction are quickly acquired, and include many skills traditional in developing countries. In the case of boats a trained supervisor can achieve the requisite amount of quality control using fairly unskilled labour for the fabrication.

d/ Ferro-cement construction does not need heavy plant and machinery.

e/ Ferro-cement could be easily and rapidly repaired in the boatyard.

It may be stated that ferro-cement applications are relatively inexpensive due to the low cost of material. Major cost goes to unskilled labour which, however, is very cheap in developing countries. Also the volume of material required is comparatively small what reduces the transportation costs.

In some countries it may be also favourable to build boats from marine plywood mainly because the good boat building timber is rapidly increasing in costs and expensive new equipment can plunge the fisherman into debts and a trap of loan repayments. A special technology is here recommended in which the precut sections of marine plywood are wired together and then the joints are sealed with epoxy resin and covered with terylene tape. When the resin has set the wires are cut and the finish is applied. This method requires minimal carpenter skills and avoids the traditional boat builder's dependence on sectional timber, not readily available in many developing countries. It may be stated that the use of plywood reduces the cost below comparable locally made boats. Easily boats of the length up to 7-8 m may be build.

The use of timber for building of boats, particularly fishing boats, is still in some countries actual and may be further developed. In this case, however, a more improved technology should be applied, meaning among others the introduction of mechanical woodworking equipment, etc.

The erection of a boat or shipyard requires to start with a technological design connected with a civil engineering project which may be not only the basis for all decisions concerning the boat or shipyard into consideration, but also the basis of civil engineering works, purchase and installation of equipment, training of personnel, etc. Following remarks concerning small boatyards may be here made:

First, the location of the yard. It may be here stated that for a small boatyard no special requirements in this field may be raised. It is, of course, very essential to situate the yard on a beach which is sheltered from waves whilst the soil conditions allow to use simple, direct founded structures. Concerning the necessary land area, it may be assumed that an area of about 5000 sqm is sufficient for each type of boatyard for small vessels.

It is of course recommended to prepare an adequate surveying plan, as well as to make all levelling works and certain soil investigations, the last through some excavations to a depth of about 1.0 m from the assumed foundation base level. A special attention should be paid to the existing ground water levels. If possible, record from many years are here very valuable and most recommended.

Secondly the boatbuilding and boat repair hall. It should be here particularly stressed that the first factor in the choice of an adequate structural solution are the weather conditions i.e. the outside temperature, rainfall, wind force. These factors are sometimes not fully taken into consideration what means for instance that for tropical countries assembly halls are constructed which contain heavy concrete block walls, fully closed inside spaces. etc. It may be proved that for this case a very light shed is fully sufficient, particularly, if the production is based on the use of very simple machines and equipment.

The third problem concerns the repair possibilities of the boatyard. The repair may concern the hull and the engine and all other installations, if any. The repair of the hull will be done using almost the same tools as for erection of the hull. However, the repair of installation and particularly of the engine may require machines as lathe, milling machines, boring machines, etc. Therefore, it should be decided at the very beginning, if for instance, the engine will be dismantled and brought for repair to a specialized repair workshop and later after repair installed on the boat or if it will be totally repaired at the boatyard. It seems rational to use the first method of engine repair, particularly, that for small fishing boats outboard motors may be also used. Of course if the yard will in the future develop its activity an own mechanical workshop may be established equipped with proper machines. This requires, of course, very skilled labors and therefore it may be suggested to increase the boatyard activities gradually.

In connection with the boat engines, it may be stated that in the present period of a very intensive oil savings, the application of sails or wind energy for boats drive is fully recommended.

The last question concerns the structures or arrangements for launching and docking of boats. In the following chapters a detail analysis of different types of these arrangements is given, namely of derrick hoists, marine hoists, lifts, slipways, shipways, floating docks and dry docks. It is possible to choose between these structures, of course, taking into consideration the financial possibilities at the time of the yard erection. It may be, however, stated that a very simple launching and docking systems containing cradles on tyred wheels which are moving on the slope of the beach, paved for instance with a concrete slab, is possible. Such a cradle, can be very easy assembled using very simple tools and at the site available materials.

A very essential point connected with the erection of a boat or shipyard is the supply with electrical energy, fresh water etc. The best solution is of course to locate the yard in the vicinity of an electrical as well as water supply network. However, at the time being in the case of lack of these installations, a possibility exists to erect an own power station supplying the yard with electrical energy while the water may be obtained from deep wells or as rain water from especially erected reservoirs. This creates certain construction problems which, however, may be gradually overcome.

A very essential problem connected also with the protection of the environment create the sanitary arrangements, disposal of sewage and drainage of rain water. It is recommended to construct an own network connected to a septic tank cleaned in certain necessary periods.

It may be here suggested that in any individual case a kind of advice may be necessary which may be given either by an expert or an adequate design office. One has, however, to say, that the best results are obtained through discussion with local authorities taking into consideration local skill, local boat building tradition, local weather and environmental conditions, as well as local possibilities in the field of purchase of the final product. Of course, the best solution is to promote the whole event by the state and base on certain financial credits sufficient for erection of the yard, and for start of full production. It may be, however, in many cases wise not to wait for the full financial support from the state but to start the erection of the boatyard with a certain help e.g. of international agencies and using the experiences of other countries which have already developed their own ship building and ship repair industry.

The shipyard structures for building and repairing of boats and ships are divided into the following categories: hoists, lifts, shipways, slipways /marine railways/, floating docks and drydocks. These facilities may be used for building and repairing /hoists, lifts, slipways floating and drydocks/ or only for building /shipways/.

In this paper a short description of these facilities will be presented which will show the need for these structures when planning a new shipyard.

The size of the hoist, lift, shipway etc. depends upon the size of the boat or ship which have to be built or repaired. It should be noted, however, that the principles are the same regardless of size. Thus it is not necessary to present structural solutions for each size of the chosen shipyard structure. It is more relevant to describe the general principles required in order that a solution to the area under consideration is found.

2. HOISTS

The hoists are used primarily for the launching and docking of small boats. They are divided into boat hoisting derricks, trailer hoists and marine hoists.

A fixed derrick hoist /Fig.1/ is usually located at the waters edge. It can be the mast and jib type, or a column type with revolving boom, or a pair of boat davits, or an A-frame type with overhead travelling hoist, or any combination of these basic types. Hoisting, slewing and rolling movements are usually made by electrical motor winches. The boats are lifted by means of wire slings which should have sufficient strength to support the weight of the boat, and adequate padding so as not to damage the boat at the contact area. Spreaders and spacing pieces, or rigid frames to which the slings are attached, are also required. A heavier boat may be first placed on a cradle then slings fastened to it before hoisting.

Trailer hoists are designed for loading, off-loading, launching or lifting boats from shore and vice versa. The shore may be unprotected or protected by a concrete pavement. The trailer hoists are manually or hydraulically operated and connected to a heavy duty tractor through a gooseneck.

The trailer hoist is immersed in the minimum amount of water required to provide draught clearance. Then the boat is guided into position where it will settle automatically into the heavy duty lifting slings.

When the lifting slings have adjusted to fit snugly under the boat keel, the hydraulic controls are put into operation resulting in an independent lifting of each beam which allows the boat to be levelled. The manual lift has four hand chain blocks installed in place of hydraulic equipment.

As an example, let us refer to the heavy duty trailer hoist produced by WISE HANDLING LTD., England, /Fig. 2/. The standard structure is fabricated from hollow steel box section members with bolted sections for easy assembly. The two rams with piston rods are controlled by independent hydraulic valves mounted on gooseneck. They are available in 8, 12 and 16 ton capacities.

This company is also producing the marine hoist which is fully mobile and independently powered for lifting craft up to 100 tons deadweight /Fig. 3/. The main frame is fabricated from hollow steel sections with an open ended frame for mast or tower clearance. Cross beam bearings enable side frames to pivet independently thereby eliminating torsion stresses. The driving platform on four wheels has a driving position located on the side frame. This gives good all-round vision.

All control valves are positioned on the platform and include "Forward", "Reverse", "Steering" and two or four independent winch controls. The power unit consists of a Diesel Engine up to 150 BHP. It is equipped with fuel tank, battery, ammeter, oil pressure gauge, water temperature gauge and key switch. It drives a hydraulic power system consisting of oil reservoir, control valves and pumps for wheels, winch drives and steering rams. There is a hydro-mechanical drive to each steering wheel. Two or four hydraulic winches with "fail safe" brakes are capable of independent or synchronized operation for boat levelling, hoisting or lowering.

The marine hoist operates above a harbour basin of a width which depends on the inside width of the hoist. The basin may have walls built as heavy retaining walls or it may be created by use of finger piers of a width varying from 1.4

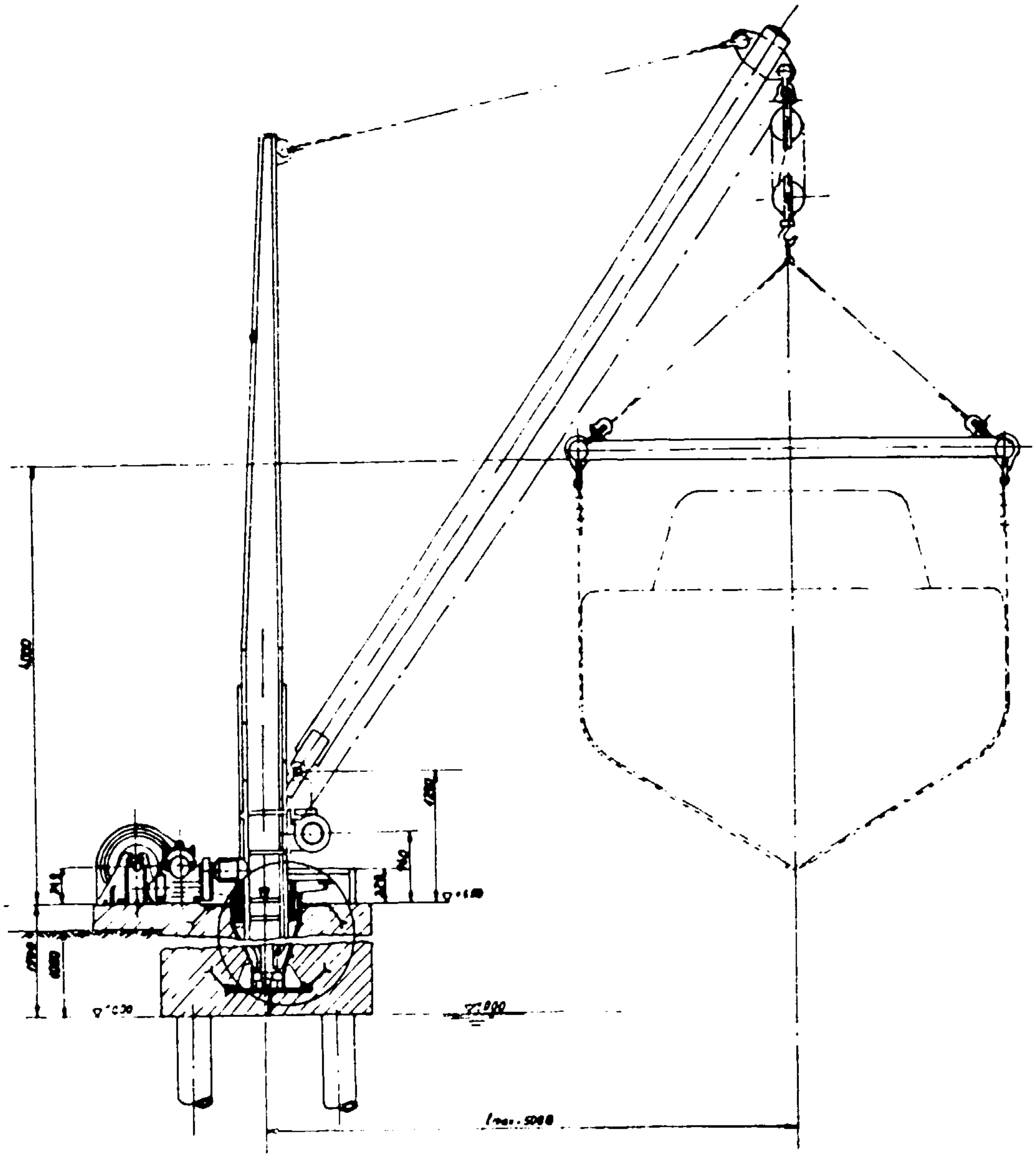


Fig.1. Fixed derick hoist

HYDRAULIC LIFT MODELS	W 8		W 12		W 18	
	Imp	Metr	Imp	Metr	Imp	Metr
Capacity	8 t	8000 kg	12t	12000 kg	18t	16000 kg
Width A	12 ft	3660 mm	12 ft	3660 mm	14'6"	4420 mm
Length B	24 ft	7320 mm	26 ft	7925 mm	28 ft	8535 mm
Lift height	5 ft	1500 mm	5 ft	1500 mm	5 ft	1500 mm

MANUAL LIFT MODELS	M 8		M 12		M 18	
	Imp	Metr	Imp	Metr	Imp	Metr
Capacity	8 t	8000 kg	12t	12000 kg	16t	16000 kg
Width A	12 ft	3660 mm	12ft	3660 mm	14'6"	4420 mm
Length B	24 ft	7320 mm	26ft	7925 mm	28ft	8535 mm
Lift height	5 ft	1500 mm	5 ft	1500 mm	5 ft	1500 mm

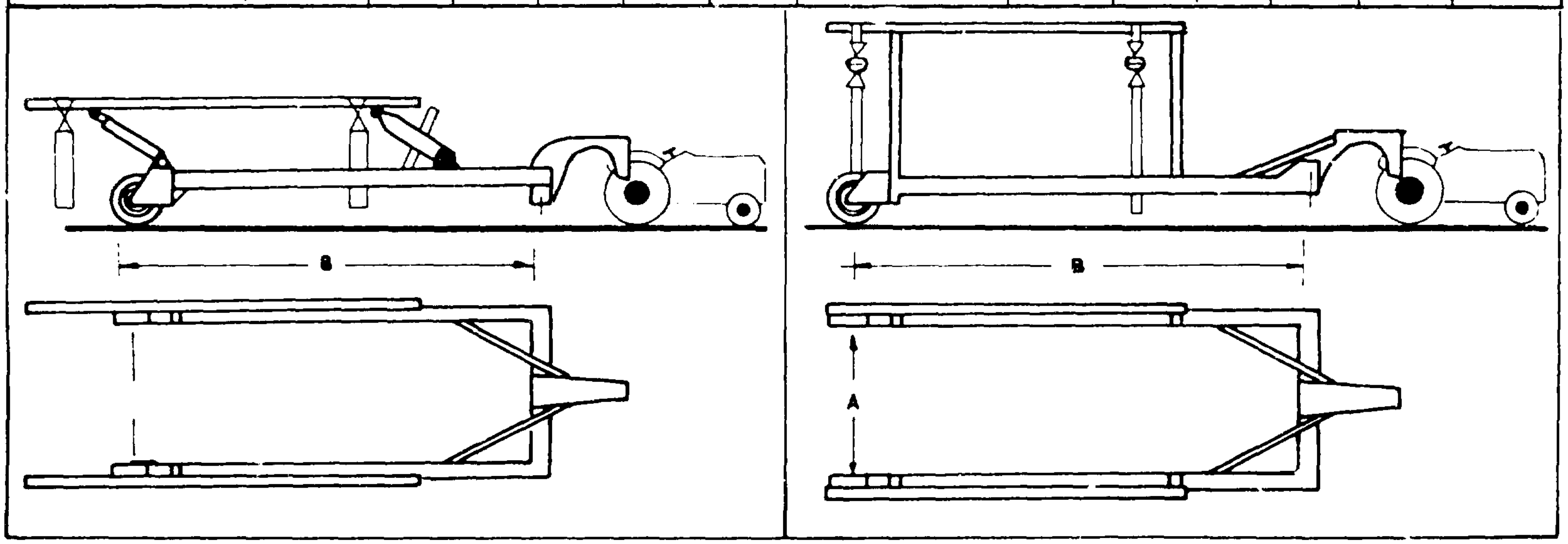
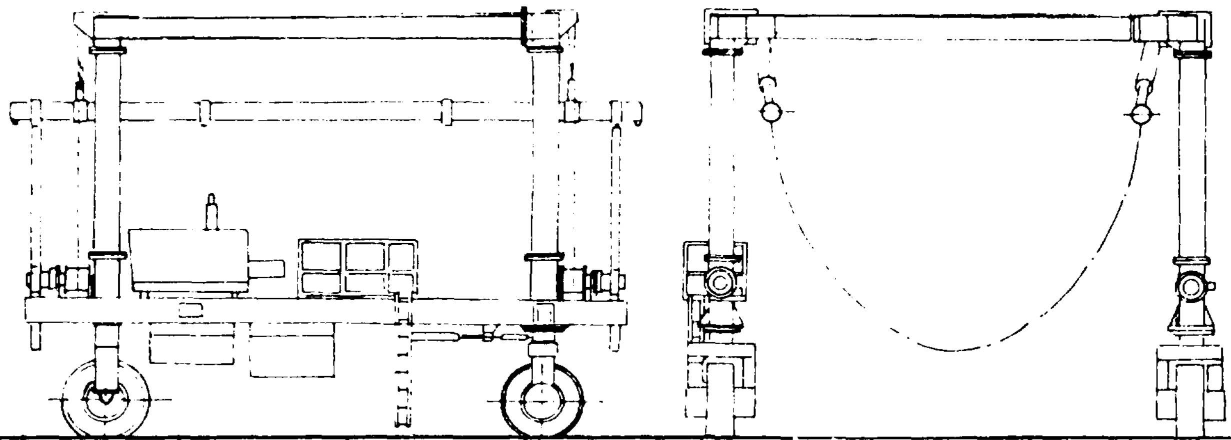


Fig.2. Trailer hoist



Model	W 20/2	W 25/2	W 25/4	W 30/4	W 40/4	W 50/4	W 60/4	W 80/4	W 100/6
Capacity,kg	20.000 kg	25.000 kg	25.000 kg	30.000 kg	40.000kg	50.000 kg	60.000 kg	80.000kg	100.000kg
Inside width, mm	5181	5800	5800	5800	6100	6100	6400	7925	8535
Inside height, mm	5181	5181	5181	5500	5800	6100	6400	7315	7925
Overall width, mm	6850	6850	6850	7150	7620	7925	8230	10.160	10.465
Overall height	5100	6300	6300	6300	6600	6700	7010	8686	9296
Wheel base mm	4572	4574	4572	6100	6100	6100	6100	9750	9750
Max. sling spacing, mm	7010	7620	7620	8535	9140	9140	9750	12.800	12.800
Lift speed	3m/min	3m/min	3m/min	3m/min	2m/min	1.5m/min	1.2m/min	1.2m/min	1.2m/min
Gradability	6%	6%	6%	6%	5%	5%	4%	4%	4%
Tyre size	46x16	46x16	46x16	46x16	49x17	49x17	50x20	49x17	49x17
Nr.of tyres	4	4	4	4	4	4	4	8	8

Fig. 3 Marine hoists

to 1.9 m minimum. It should be noted that the inside clearance of the hoist, and thus the width of the basin, varies between 5.180 m and 7.925 m. Although the length of the basin does not need to be stipulated, it can be built so as to correspond to the hoist length which varies from 13.1 to 22.85 m.

3. LIFTS

Recently many types of lifts have been designed and constructed. It seems sensible, however, to focus on the lift called "SYNCROLIFT" since this is the one used most frequently in the world at the present time. It should be noted that for a developing country only a shipyard structure which allows both the building and the repairing of a ship should be recommended. This means that the SYNCROLIFT, which fulfils all requirements in this field, should be the one considered.

Other recently produced lifts are:

1. "HYDRANAUTICS" with a net rated capacity from 1,100 to 7.700 tons
2. "HYCU" with a net capacity from 15 to 5,000 tons
3. "LIFT-DOCK" /Schiess Defries/ with a net capacity of 2.940 tons
4. "KRUPP HYDRAULIKLIFT" with a net capacity of 450 tons.

As has been said before the general principles are more or less the same. Where differences occur they mainly concern the power units which may be hydraulic, electrical or mechanical. This means that the detailed description of the "SYNCROLIFT" produced by Pearlson Engineering Co. Inc., Miami, USA, should correspond with the principles of other types of lifts.

"SYNCROLIFT" /fig. 4,5,6,7/ is a large elevator which can be lowered into the water, where a vessel is positioned over it. The elevator and vessel are then lifted vertically to the ground level of the shipyard. There are three principal components: a decked, structural steel platform; a number of synchronized motor powered wire rope hoists to raise and lower the platform; and a central electrical motor control center to operate the system.

Ships are drydocked on the "SYNCROLIFT" platform using conventional procedures for setting the keel blocks and placing the bilge blocks. "SYNCROLIFT" platforms consist of a series of steel main transverse lifting beams lifted by a hoist at each end. The ship's keel support is provided by placing intermediate transverse beams between the main beams. These intermediate beams are supported by longitudinal members.

The lifting hoists are supported on fixed pier structures /Fig. 4/ which are normally constructed of concrete and standard marine piling.

The synchronized electrical motors used to drive the hoists are designed to operate up to a maximum required capacity at a fixed rate of speed, regardless of load variations imposed by the distribution of the weigth of the vessel. All the motors are controlled from one central point. In the event of malfunction of any one motor, the entire system is automatically stopped.

"SYNCROLIFT" can be expanded in length with little change to the initial equipment by the simple addition of extra platform sections and hoists. Additional controls can be included initially so that the control centre will not have to be modified when hoists are added.

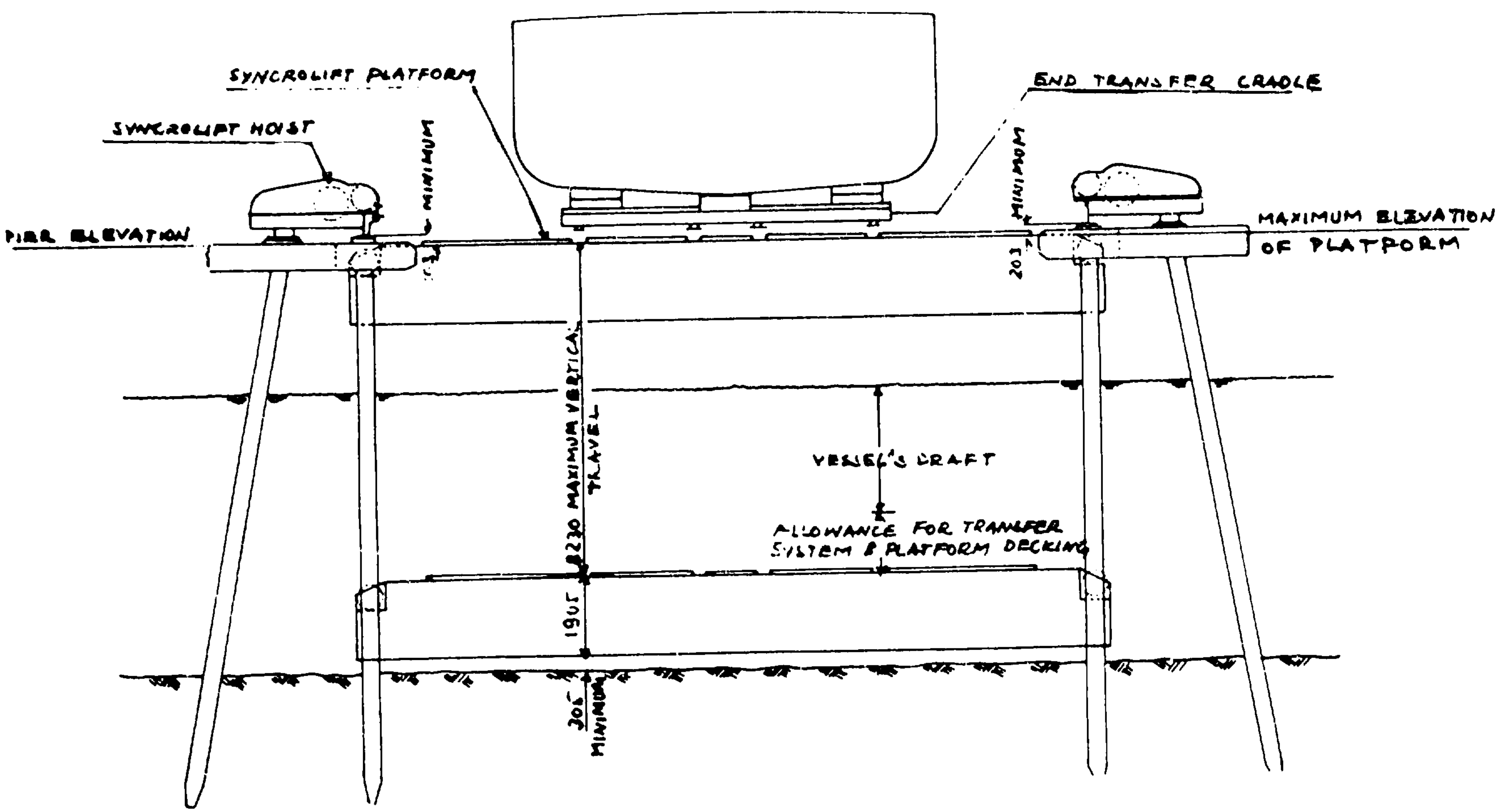


Fig. 4 Cross section of "SYCROLIFT"

A transfer system can be added to a basic "SYNCROLIFT" shiplift by providing railroad or crane-type rails on the platform and on the adjacent land area. The rails are arranged so that a transfer cradle, with a ship on it, can be rolled to the land area when the platform is at the yard elevation. The onshore transfer system can be designed to permit movement in both directions.

Each hoist assembly consists of an electric motor with a marine - type integral brake, gearing, wire rope drum, ratchet and pawl bacstop, sheaves, miscellaneoue accessories, and cover. All are assembled on a steel base ready for installation. The accessories for each hoist consist of one limit switch assembly, limit switch actuator, and the platform sheave assemblies. The hoist drum drives a multiple part wire rope system by reeving wire rope trough sheaves mounted on the hoist, and sheaves mounted in a housing.

The cable drum is grooved and provides for the maximum amount of travel with a single layer on the drum. One layer of wire rope will be on the drum when the platform is fully raised.

The hoist has two separate and distinct braking systems. The motor has an integral magnetic disc brake which releases when power is applied and engages by spring action when power is disconnected.
The cable drum has a ratchet and pawl-type backstop. When the platform is being operated in the downward direction all pawls are automaticlly withdrawn from the ratchests. Under all other conditions the pawls are held in an engaged position by springs in the cylinders. The ratchet-pawl system also allows removal of the motor-brake unit intermediate gears with full

Fig.5.General view of a "SYNCROLIFT"

Fig.6 TYPICAL ARRANGEMENT
Multiple Unit Syncrolift
To 20,000 Ton Capacity

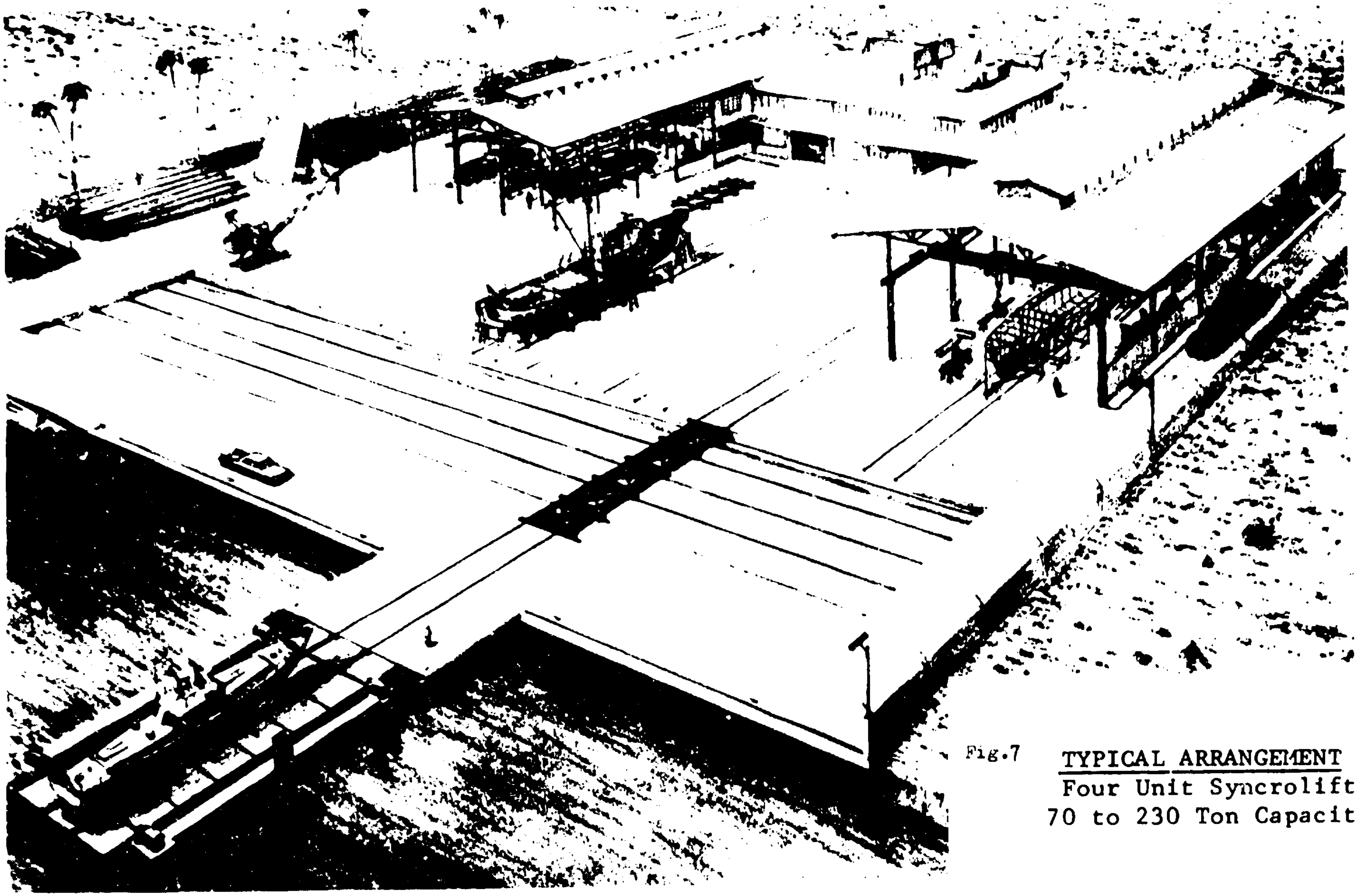


Fig.7 TYPICAL ARRANGEMENT
Four Unit Syncrolift
70 to 230 Ton Capacity

load on the hoist. An interlock in the control system prevents the platform from being operated in the downward direction when any pawl is in place. The brakes are of a watertight, marine construction and are mounted directly onto the motor frame and keyed to the motor shaft.

A control center operates the "SYNCROLIFT" with a minimum number of settings. There is an ammeter for each hoist which indicates the relative load carried by each hoist during the operation of the "SYNCROLIFT". Safety provisions are incorported to automatically stop all motors instantaneously if any one motor exceeds the designed capacity of the "SYNCROLIFT". In this event the platform can only be operated in the downward direction.

Provision is also made to automatically stop all motors when the platform reaches the upper or lower limits of travel.

The control centre is free standing with a floor mounted cabinet. The starters are controlled from a single console using pushbutton and selector controls. All motors are protected against overload. The controls are arranged for simultaneous synchronized operation of all motors and for individual operation for maintenance purposes.

Power supply to the "SYNCROLIFT" is 3 phase, 3 wire. Frequency may be 50 or 60 cycles. Preferred voltages are as follows:

Total KVA 50 or less	220, 380, 440, 550
Total KVA over 50	380, 440, 550

The number of hoists is varied to provide the required drydocking capacity. The minimum number is 4 and the hoist sizes are 91 t, 183 t and 244 t.

The standard 8 unit Syncrolifts refer to the following sizes:

Hoist size	Platform size	Normal capacity	Maximum capacity	Load	Available travel
91 t	42.0x12.0 m	345 t	518 t	12.1t/m	7.6 m
183 t	57.0x16.0 m	635 t	955 t	16.6t/m	11.0 m
244 t	67.0x18.0 m	833 t	1,250 t	18.6t/m	11.0 m

This allows different sizes of lifts to be chosen depending upon the required ship size. To demonstrate this point, dimensions and capacities of some other realized lifts are presented below.

Lifts require a minimum amount of space and can be constructed off-shore where its access piers may be utilized as wet dock space. Vessels are drydocked on an even keel at yard elevation with no obstructions impeding the work area.

Platform size	Nominal capacity, t	Maximum capacity, t
22.9 x 7.32 m	71	96
25.9 x 9.76 m	152	198
30.5 x 9.76 m	229	305
44.5 x 12.81 m	559	914
57.3 x 16.47 m	711	1,219
64.7 x 18.30 m	874	1,473
72.0 x 20.13 m	1,219	2,083
74.4 x 20.74 m	1,422	2,388
79.3 x 21.96 m	2,184	3,251
97.5 x 20.00 m	2,424	3,634
102.5 x 22.00 m	2,678	4,018

91.5 x 22.57 m	3,048	4,674
93.6 x 30.50 m	3,530	4,540
117.0 x 22.00 m	3,736	5,604
104.9 x 25.00 m	3,810	5,609
106.7 x 25.00 m	4,200	5,735
134.0 x 25.00 m	4,400	6,900
108.6 x 25.00 m	4,445	6,604
106.0 x 18.00 m	4,494	6,741
125.0 x 27.00 m	4,916	7,375
130.0 x 25.00 m	5,815	8,723
140.2 x 27.00 m	5,962	8,943
152.5 x 25.00 m	6,248	9,347
150.0 x 26.00 m	6,580	9,870
167.1 x 26.23 m	6,807	10,160
171.6 x 30.00 m	8,326	12,490
184.8 x 32.00 m	11,000	16,000

For a rough estimation of costs a "SYNCROLIFT" system designed to handle 250 t vessels with a platform 30 x 10 m wide would cost US $ 500,000 ready to operate. The materials and services that the company supplies wold be about US $ 260,000 of the total amount.

4. SLIPWAYS /MARINE RAILWAYS/

Slipways /Fig. 8 to 17/ consist of inclined ways of timber, stone or concrete, running up from a sufficient depth of water to the requisite height above high water level, upon which a series of rails is fixed. On these rails suitable carriages run to support the vessel, and are hauled up or

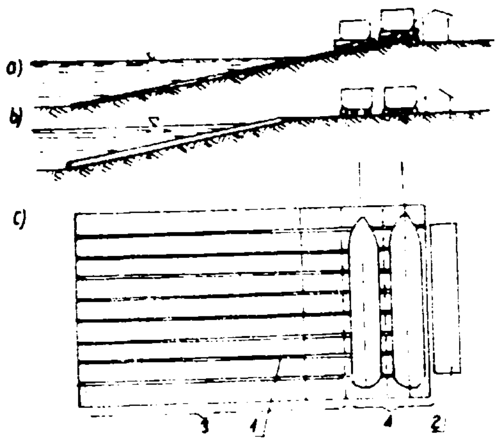


Fig. 8

Broadside slipway arrangements: a/cross-section of single slope, b/cross-section of double slope slipway, c/plan of slipway for both kinds of slopes, 1-rails, 2-machine room, 3-operation, 4-repair or building berths

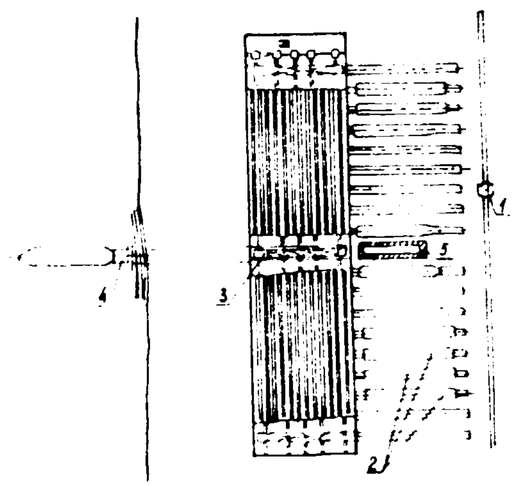


Fig. 9

Longitudinal slipway with a transfer system: 1-movable winches, 2-upper cradles, 3-transfer carriage, 4-slipway, 5-machine roo

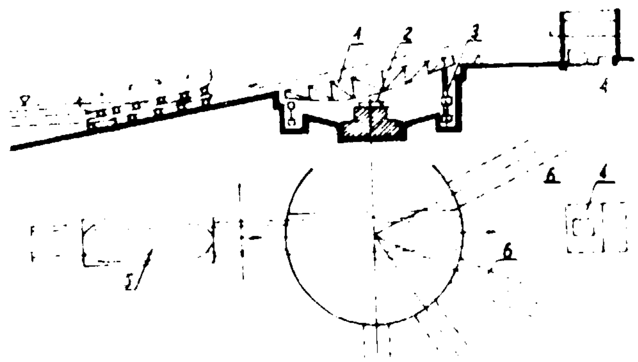


Fig. 10

Longitudinal slipway with a turn-table: 1-turn-table beam, 2-middle ring, 3-cradles with hydraulic jack, 4-machine room, 5-cradle, 6-repair or building berths

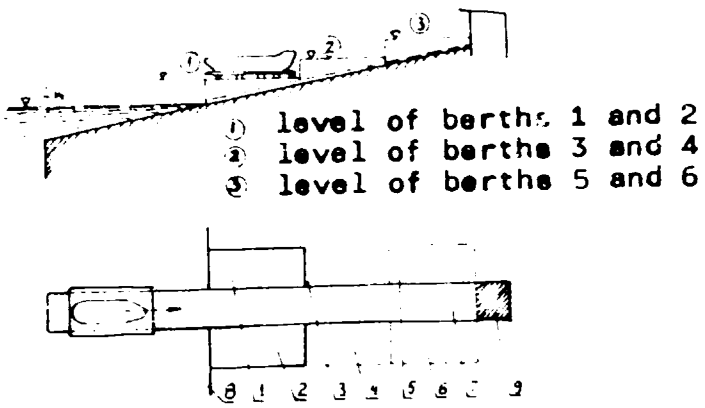


Fig. 11

Longitudinal /end-on/ slipway with side repair or building berths 1 to 6 - repair or building berths, 7-operation area, 8-harbour basin, 9-machine room

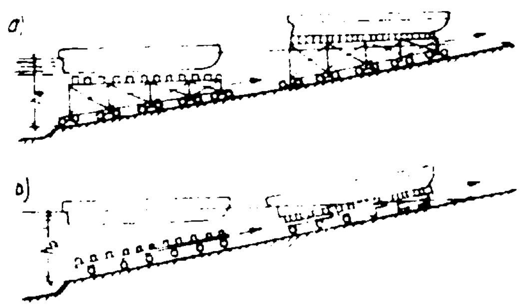


Fig. 12

Types of longitudinal /end-on/ slipways: a/with wedge /triangle/ cradle, b/with rectangle cradle

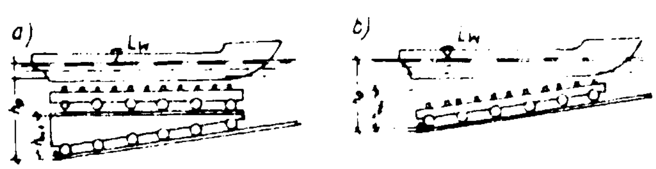


Fig. 13

The depth of the sill for a longitudinal /end-on/ slipway: a/ with triangle /wedge/ cradle, b/ with rectangle cradle

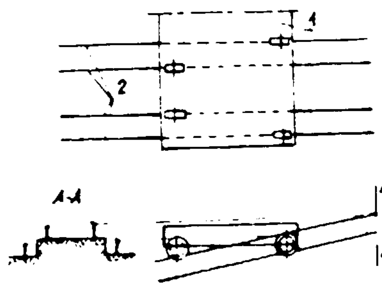


Fig. 14

Rail arrangement for a double slope slipway: 1-cradle, 2-rails

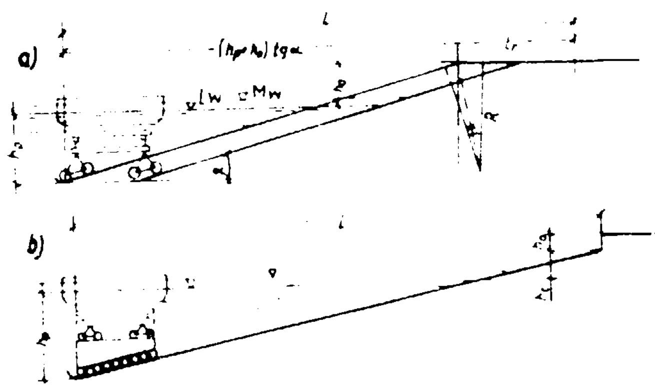


Fig. 15

Typical arrangements of bradside slipways: a/broadside slipway with double slope, rectangular cradle, two levels rails, b/ broadside slipway with one slope and upper rectangular cradle, lower wedge cradle

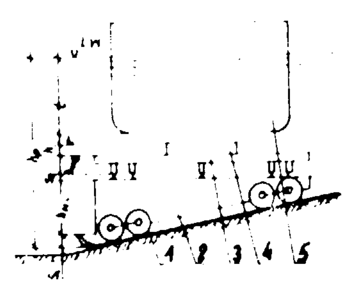


Fig. 16

The depth of the sill of a broadside slipway: 1-slipway rail, 2-lower cradle, 3-upper cradle, 4-keel-block, 5-ship hull

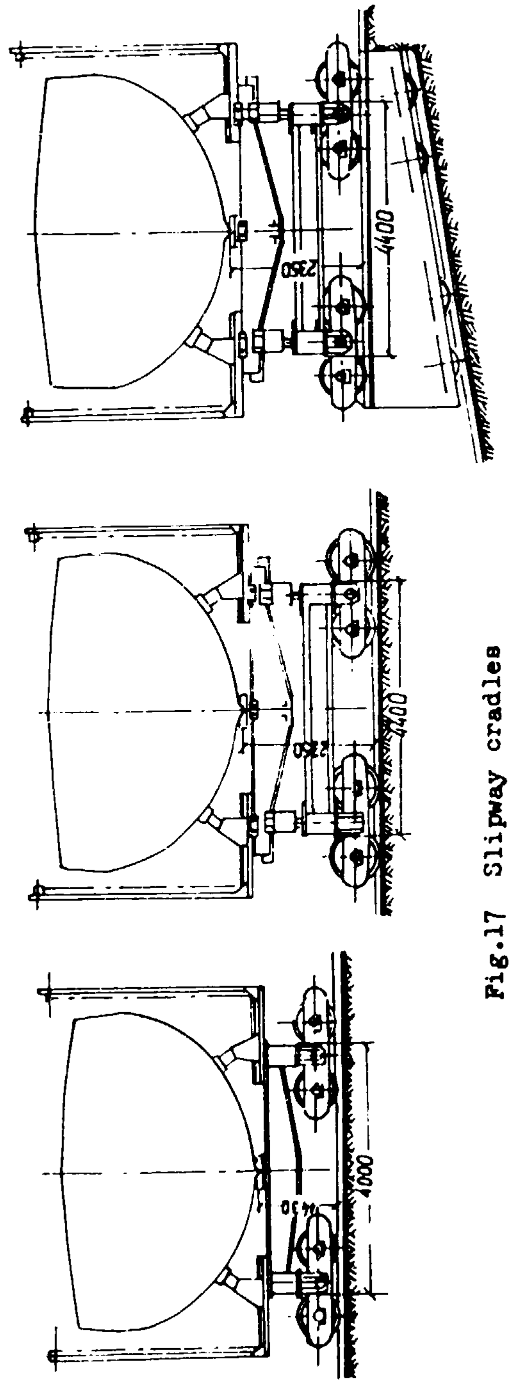


Fig.17 Slipway cradles

lowered by means of winding gear.

Slipways are either of the end-on or broadside pattern, according to whether the vessel is hauled clear of the water in the direction of its length or normal to this direction.

A much more elaborate carriage is required for an end-on slipway than for a broadside slipway if it is necessary that the vessel shall be maintained in a level position. On the other hand, if the vessel can be hauled up in an inclined position, much longer haulage will be required. An end-on slipway, on the other hand, requires considerably less quay space than a broadside slipway, which may be an important consideration. The end-on pattern requires a space equal to only about three times the beam of the ship being dealt with, whereas the broadside pattern requires about 10% more than the length of the ship.

A transfer system can be added to a basic slipway by providing railroads on the adjacent land area. The rails are arranged so that a transfer cradle, with a ship on it, can be rolled to the land area when the slipway cradle is at the yard elevation. The onshore transfer system, similar to the one proposed for lifts, can be designed in such a way that movement in both directions is permitted.

The cradles are of steel and built as one, two or three level cradles. This allows the ship to be transferred from the inclined operation area to the transfer area and repair or building berthis. Movable bilge blocks are provided on the cradle to support the ship.

The hauling gear usually consists of powerful winches worked by electricity which wind up the cradles by wire ropes.

Broadside slipways are suitable in narrow rivers where there is no room for the length of structure required for an end-on slipway. In a broadside slipway there are a number of sets of rails parallel to each other and a number of cradles. The hauling arrangements must be synchronized so that all the cradles rise or descend at the same rate. The cradles may be from 3 to 6 m apart, according to the weight of the vessel to be supported.

Slipways require good foundations of uniform bearing power, since any disparity may cause damage to the vessel on the slip, and may also render the slipway unworkable.

In most cases, as the lower end of a slipway is under water a cofferdam is necessary for its construction. On the other hand, as the weight to be supported on the cradles over the underwater portion of the slipway diminishes as the ways get deeper until finally the ship is afloat, such heavy foundations are not needed in the lower part compared to those required where the full weight of the cradles and ship must be supported. Recently the structure of the railways /beams or frames/ has been of prefabricated, prestressed concrete units which are placed under water on a specially prepared bed.
In the case of insufficient bearing capacity of the soil the frames may be supported on piles driven to the necessary depth and finished with pile caps constructed in underwater concrete. The proper solution depends on the type of slipway and the size and weight of vessel to be supported.

The inclination of slipways varies from 1:15 to 1:30. The power required to work them depends not only on the inclination but also on the state of lubrication, the presence of mud on the ways, and the speed of working, although the latter consideration must necessarily be kept low. The friction in slipway varies within a wide range, and it is towards the elimination of as much as possible of this friction that the efforts of designers should be directed. In situations where mud is freely thrown down by the water and the slipways are not often used accumulations of mud may substantially increase the power required therefore a considerable reserve of power is advisable.

In comparison with the lifts presented in chapter 3 it should be noted that slipways must have ways or tracks extended from the shore to where the water is deep enough for drydocking the vessel. The drydocking takes place in the harbour, /actually 150 to 240 m from shore/, where there is exposure to currents, wind and other natural weather elements. Foundation requirements are high and the underwater maintenance of tracks, pilings, rollers and hauling gear create problems inasmuch as these parts are not visible. Constant surveillance by divers is needed to ensure proper operation. Periodic surveys are required to verify the gradient and allingment of the ways. To replace worn rails or plates on the track requires long shutdown periods. When the vessel is pulled up the inclined ways it comes to rest at the shipyard still on an incline unless more levels and wedge cradles are used. Once this is done the tracks, their foundation, the rollers and the rope or chain gear must be extended underwater to obtain the required depth for drydocking the vessel.

As has already been stated, the size of the slipway is dependant upon the weight of the vessel. Vessels up to 1.000 tons weight are drydocked by using slipways. This means that these structures are mainly used for small ships.

5. SHIPWAYS

Shipways /Fig. 18 to 22/ may be used only for building new ships and thus are recommended only in building shipyards or as the building part of a building and repair shipyard. They are very simple structures and may be made in areas lacking equipment and placed directly on shore. This is very important for shipyards which may be built, for example, for erection of timber vessels of small size.

Shipways consist of inclined launching ways of timber running up from a sufficient depth of water to the requisite height above high water level upon which the building of the vessel takes place. The launching ways may be placed directly on a crushed stone /macadam/ bed, or as a concrete slab laid directly on the macadam bed or supported on piles of timber or concrete.

Shipways are either of the end-on or broadside pattern, according to whether the vessel is launched in the direction of its length or normal to this direction. It should be noted that for large vessels the longitudinal shipway should be closed by side-walls and shipway gates thus limiting the total length of the shipway and its height above ground level.

The ship is built on keelblocks. When the ship is ready for launching the sliding ways /bilge ways/ are placed on the launching way whilst a layer of grease is introduced between them to lessen the friction thus allowing for a smooth launching.

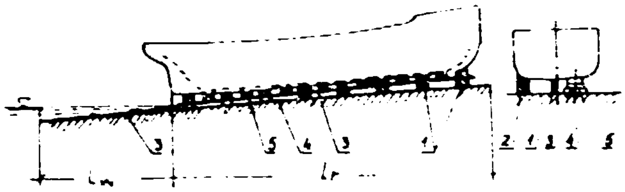


Fig. 18

The ship on a longitudinal shipway: 1-keel blocks, 2-side supports, 3-launching ways, 4-sliding ways /bilge ways/, 5-beams and wedges of sliding ways

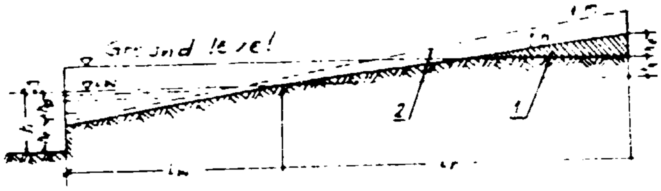


Fig. 19

Dimensions of a longi-tudinal shipway: 1-trestle 2-launching ways

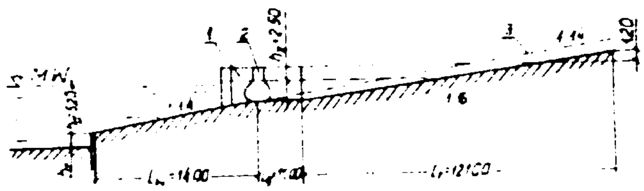


Fig. 20

Dimensions of a closed longitudinal shipway: 1-shipway head, 2-gate, 3-launching way

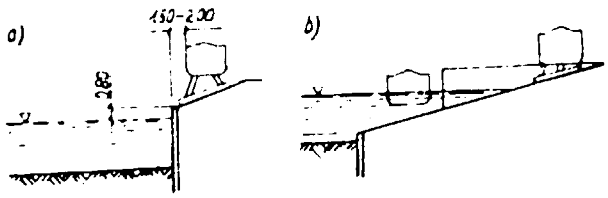


Fig. 21

Broadside shipway: a/with the sill above the water level, b/with the sill under the water level

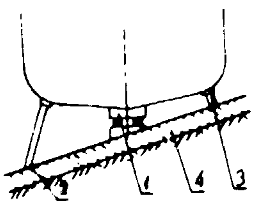


Fig. 22

Supports of the ship on a broadside shipway: 1-keel block, 2-seat, 3-side support, 4-shipway

Between the sliding ways and the hull wedges of timber are introduced which allow the keelblocks to be taken away when the vessel is heaved. This procedure is very simple, particularly if the ship weighs very little.

Usually one ship may be built on shipway. It is possible, however, to use special carriages which allow transfer of sections from the assembly area to the shipway where they will be connected. In all cases, however, the transposition of the hull from the keelblocks to the launching ways is necessary.

The broadside shipways, which may be constructed in narrow rivers or harbour basins where there is no room for longitudinal shipways, have more than two launching ways e.g. 6 to 15. The launching ways may be from 3 to 6 m apart according to the length of vessel to be built and launched.

The inclination of shipways varies: a/ longitudinal shipway: for small ships from 1:8 to 1:16, and for large ships from 1:14 to 1:30, b/ broadside shipway from 1:5 to 1:8. The depth to which the launching ways are placed under the water depends on the inclination of the shipways and on the draught of the vessel during launching /the draught of the bow for longitudinal shipway and the maximum draught of the ship for broadside shipways/. The minimum depth on the sill for a longitudinal shipway is usually 2 to 4 m whilst the depth at the sill should be about 2 m larger. The sill of the broadside shipway may be placed under or above the water level. In the first instance, the vessel will jump its water during launching, whilst in the second instance the launching will be similar to the of the longitudinal shipway. The depth at the sill is usually larger mainly because the structure made as a wall may also be used as a quay wall for mooring of ships.

The shipways should be equipped with stoppers which keep the ship on the launching ways until the moment when launching is intended. These stoppers, made of timber /carpenter stopper/, or steel /mechanical stopper/ are connected to the shipway and released by a hammer or mechanical device.

The length of the shipway above the water level is equal to the length of the supported ship. The length of the underwater part of the open longitudinal shipway depends on the depth of sill and inclination of sill and inclination of the launching ways. This depth is the function of the draught of the bow during launching /e.g. for a draught of 2 m, inclination 1:20, the length should be 40 m/. The determination of the shipway's geometrical parameters is very easy when the dimensions of the ship under consideration are given. In the case of a closed longitudinal shipway the length of the shipway is equal to the largest ship which is to be built on it.

The solution to the structure of the shipway depends on the soil conditions and the size of the ship. It can consists of two timber beams connected by transverse beams laid down on prepared substrata or supported by timber piles. For larger vessels the timber launching ways will be supported on concrete beams or slabs placed directly on to soil or on to piled foundation. The construction may take place behind a cofferdam /earth embankment/ or underwater using divers. This is particularly relevent to timber structures which may be prefabricated, towed and set down on the shore.

6. FLOATING DOCKS /FLOATING DRY DOCKS/

Floating dock /Fig. 23/ is a structure or an equipment in a floating state which allows the docking and launching of ships. The floating dock structure is essentially in two major parts: the pontoons and the wings.

The pontoons are the prime supporting body which must displace the weight of ship and dock and must withstand the transverse bending caused by the ship's along the centerline opposed by water pressure from beneath. The pontoons have their exterior hull fully wetted at all times; and the interior partly, and offen fully wet, with highly humid salty atmosphere above. These conditions are very destructive to steel or iron, but do not affect timber or concrete; hence, pontoons of timber or conerete are the most durable in sea water.

The floating dock wings serve as longitudinal girders to provide longitudnial stiffness. They also provide stability while the pontoons are submerged and afford a means of holding and centering ships. The wings provide space for equipment, and space for ballast water which is needed for sinking and controlling the depth of submergence of the dock.

Generally the wings are dry both inside and outside, except for the damp atmosphere found in the wing ballast tanks. The control of stability and dock submergence require the wings to be watertight. Timber wings usually dry out and lose their caulking. The upper timbers are subject to decay from fresh rain water. All-timber floating docks must have their wings completely filled with water for sinking to full draft, hence no equipment can be installed in the wings.

Fig.23.General view of floating docks

Steel docks are costly to paint and to maintain when constantly exposed to sea water both inside and outside. For this reason, concrete has been used for smaller one piece docks. The maintenance record for these docks is very good. Low maintenance costs, however, are offset by the relatively large first cost and greater operating costs because of the heavy dead weight of the structure.

Composite construction, using steel wings and pontoons of either timber or concrete, actually provides the best and most durable materials selection. There are many docks using steel wings on timber pontoons. Commercially this is a logical choice.

Floating docks which must be towed in the open sea and which must have the greatest strength possible, cannot be built with timber; hence, in this category we find either all steel, or all concrete, or a combination of these, being used.

The heavier submerged weight of steel or concrete also provides much more usable wing space for the quantities of equipment, electrical and steam generators, and fuel and water supplies if necessary.

In wood floating docks, it is necessary to provide weight to sink the dock to full draft. This has usually been by using permanent rock or concrete ballast which consumes about ten per cent of the lifting capacity. To overcome this disadvantage, water ballast is used which is pumped into the dock by reversing the pumps. This results in maximum lifting capacity with minimum displacement and draft.

Floating docks require less real estate than dry docks and are not subject to tidal restrictions. They are more efficient, in that the amount of water to be removed depends on the draft of vessel to be docked, compared to a dry dock, where the amount of water is constant, varying only by the * vessel. The floating dock is fast operating and can handle a vessel with a list or drag, which is beneficial for damaged or unevenly loaded vessels. The dock can be trimmed for and aft allowing, by differential flooding or pumping, for any fore and aft trim of the ship to be docked.

Stability of any floating structure is a measure of its ability to return to its original position after being tilted by some outside force. Adaquate stability of floating docks is essential to their safe operation. The dock designer must provide this stability under the most severe docking conditions which a capacity ship may have. The dockmaster should verify beforehand that for any ship to be lifted, the floating ock will be stabls.

Stability is measured by the distance from the combined center of gravity of the ship and dock to the metacenter. As a floating dock is flooded down to receive a ship and then pumped up with the ship, its stability is constantly changing. It is very important that the dockmaster be awere when minimum stability exists, what the stability is at that time and when to expect a large change in stability.

The internal compartmentation of floating dock pontoons by watertight and non-watertight bulkheads serves to reduce the moment of inertia of the internal free surfaces and thereby, to give stability of the dock.

* amount of water displaced by the

When the dock takes a list because of outside forces, each bulkhead breaks the internal water plane forcing the water within each compartment to act independently from the other tanks. If the list is held, the water will flow from high to low tanks wherever there is only a swash bulkhead separating them, then, only the watertight bulkhed will break up the water plane. A properly operated floating dock will be stable for any length of time at all stages of submergence.

Floating docks may be classified as pump controlled or valve controlled. In the former, each ballast compartment has its own dewatering pump and in the latter, each pump must dewater a number of separate ballast compartments by means of pipes or waterways which may be closed by valves or sluice gates.

The pump controlled dock must use a larger number of small high speed pumps. These may be of the mixed flow, or propeller type, having the bell mouth down close to the bottom of the pontoon where almost all interior water can be removed. No piping manifolds or priming systems are required. The pump valves and flooding valves, which are opened and closed only once in the docking cycle, can be hand operated. The rate of dewatering is controlled by starting and stopping the pumps as needed. Back flow is prevented by a check or flap valve at the discharge side of each pump. If one pump fails, the pump in the adjacent compartment can be used to dewater the two tanks by opening an emergency cross connection valve.

The valve controlled dock may have only a single pump on each side of the dock with piping connecting all the compartments of one side. For proper control, the valves of the dock should be power operated by either electric gear drives or air drives in order to get rapid response. These are costly in comparison with manually operated valves. The valve controlled dock lends itself very well to diesel driven pumps, since the speed of the pump may be varied to suit the actual number of compartments being dewatered.

The prime method of cradling a ship on floating docks is the use of sliding or fixed bilge blocks. The sliding blocks requires the use of a slide from 5 do 30 cm above the pontoon deck, making the longitudinal transport of material difficult. For this reason, many yards have preferred to use fixed blocks without any slides. This is satisfactory when docking vessels of known deadrise in undamaged condition. Sliding blocks permit the cradling of vessels of unknown deadrise without overstress of either dock or ship.

To overcome the disadvantage of the fixed block and, at the same time, maintain flexibility, hydraulically raised blocks have been used with great success. The prime improvement lies in the ability to fit ships having a wide range of deadrise and widths, so that no labor or time is expended between the undocking of one ship and the docking of a second vessel.

Floating docks are customarily moored alongside a pier, quaywall or dolphins, in reasonable proximity to the repair shops in order to provide ready access for men and materials and thus expedite repairs to vessels in dock.

When inadequate depth of water exists close to shore, the dock must be located some distance away and held there by anchors and cables, or by mooring dolphins of some type.

Crane service to ships in a floating dock is an absolute necessity for handling heavy materials and equipment. Where docks are moored to a pier or quay wall, a shore gantry crane with a long boom to reach beyond the center of the dock serves very well to handle materials, both on the dock and ashore. This is particularly convenient and economical when two docks are moored to the same pier, with one or more pier cranes to serve both docks.

When the dock is moored away from shore, one or two wing mounted cranes are needed. These captive cranes must be supplemented by other cranes to transport loads from the dock to the shops on shore.

With flush deck docks having a ramp access ashore, fork trucks, rubber tired cranes and other mobile vehicles can transport material under and around the ship with ease. This approach to materials handling is being used more and more, especially since it serves areas underneath the ship where the crane hook cannot reach.

Floating docks are used mainly for ship repair works, but they can also be used for launching new ships especially in conjunction with a transverse transportation system of ships from the assembly yard to supports on floating dock. The capacity of floating docks is between 1 and 900 MN and there are no technical limitations in that capacity range. In modern layouts, floating docks are also equipped with gantry cranes ensuring greater flexibility during repair or exchange of large parts of the ship under repair.

There are two basic types of floating docks: rigid or one-piece docks and sectional /Fig. 24 and 25/. The sectional floating dock provide means for self-docking. Following types of sectional floating docks are distinguished:

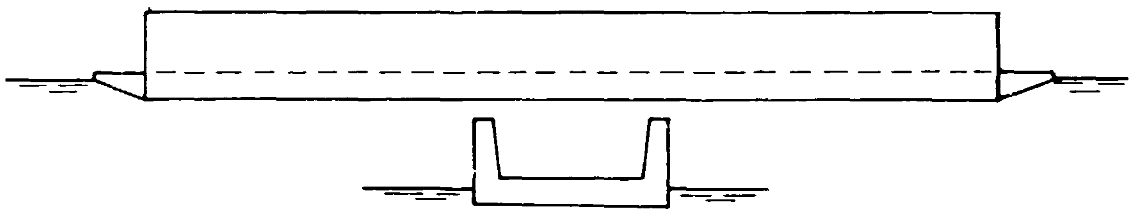
a/ Loose sectional type floating dock consisting of several independent sections, each of which may be dry docked on the others.

b/ Continuous wing-sectional ponton floating dock /Rennie type/ consisting of continuous wings supported on and fastened to a number of separate pontoons. The wings provide longitudinal rigidity and any pontoon may be disconnected and dry docked on the others.

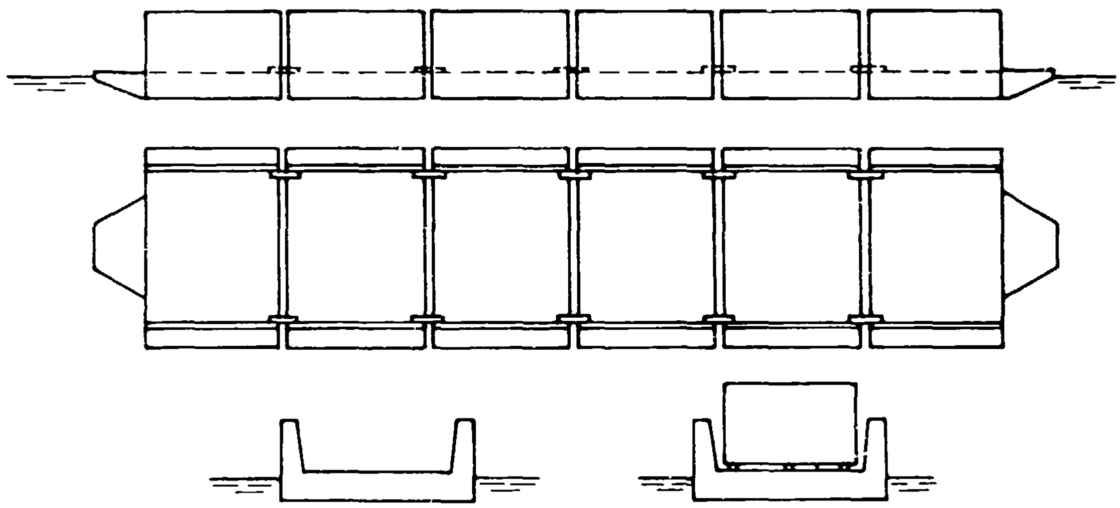
c/ Continuous wing-sectional pontoon floating dock /Clark type/ having greater rigidity due to continuous wings for the full depth to the bottom of the dock. The three pontoons between wings are bolted to them. The end pontoons may be disconnected and dry docked, one at a time, on the center one; or the center pontoon may be moved to a higher position and lifted clear of the water, supported by the end ones. The submerged portion of the wings are made accessible by careening.

d/ Bolted sectional floating dock consisting of three or more sections bolted together around the periphery to form a rigid unit.

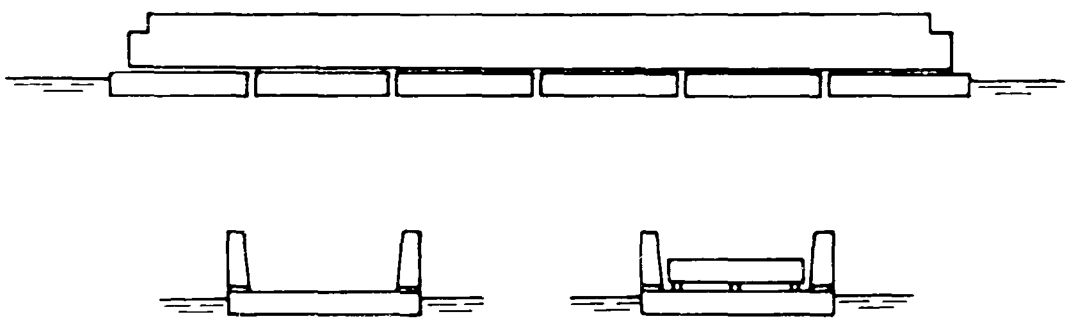
e/ Trussed sectional floating dock developed primarily for wood construction, but adapted also for steel wings and wood pontoons or all-steel. In these, the panel of a truss is incorporated in the wing of each section with steel castings at the panel points, top and bottom. When these are connected by pins through the adjacent castings, the docks is formed into a relatively rugid unit. Any section can be disconnected by removing the joining pins and then be dry docked on the others.



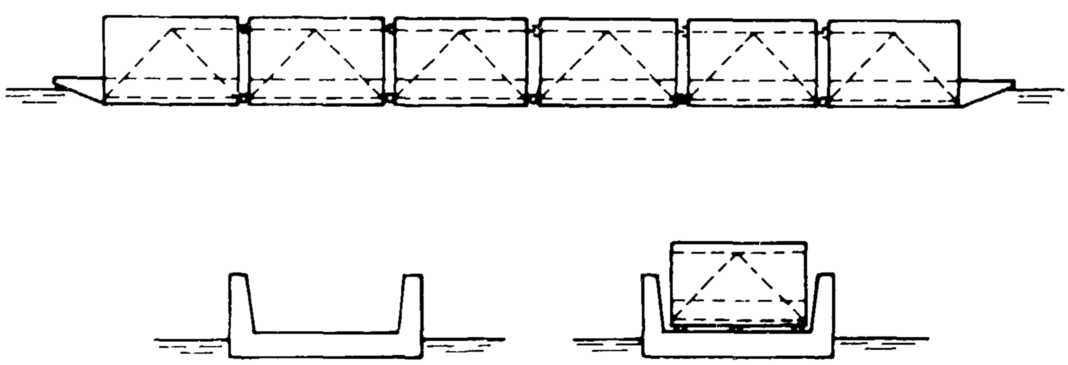
Solid dock type - not self docking



Loose sectional dock

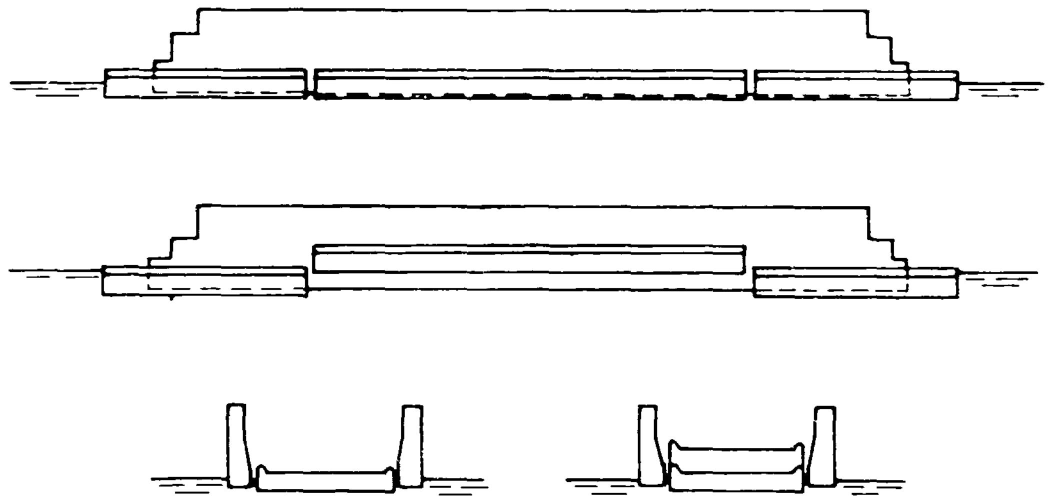


Continuous wing - sectional pontoon floating dock

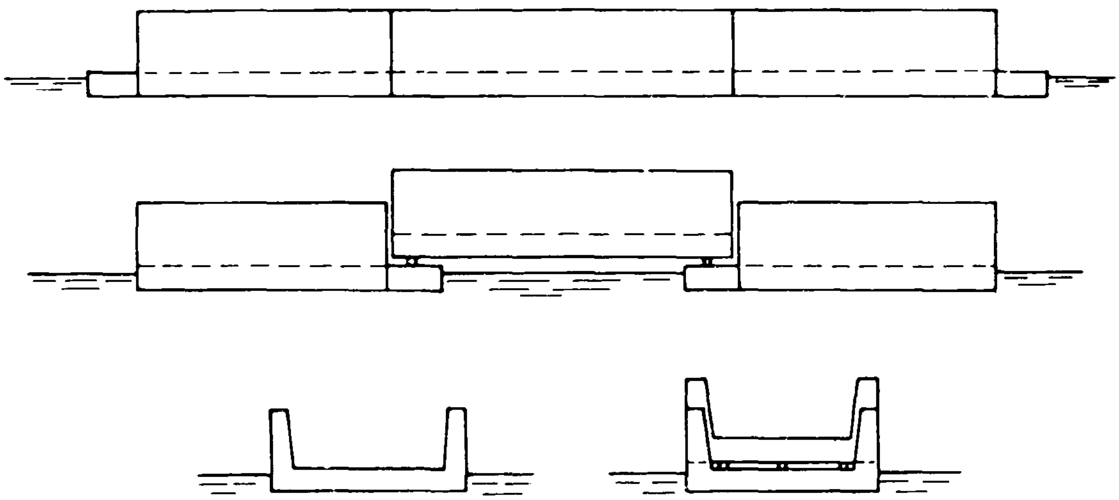


Trussed sectional floating dock

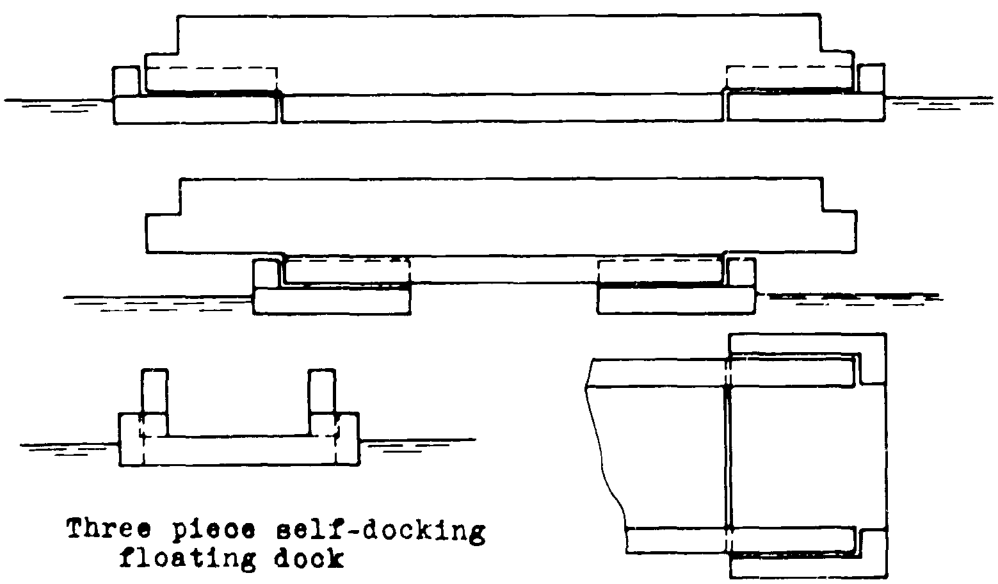
Fig.24



Continuous wing-sectional pontoon floating dock (Clark type)



Bolted sectional floating dock



Three piece self-docking
floating dock

Fig.25

f/ Three piece self-docking floating dock /Dewey type/ with continuous wings integral with the pontoon along the mid-portion. At each end, the wings are cut at the deck level and removable pontoons bolted to them. These end pontoons are made of such length and width that each could be turned and dry docked on the center sections or the two could be placed under the center section to lift the rest of the dock clear of the water.

7. DRY DOCKS /GRAVING DOCKS/

Dry dock /Fig. 26/ is a shipyard main structure permitting the assembly of the ship of each size and its launching or docking for repair. They are divided in following four groups:

a/ Emergency dry docks for docking ships with or without cargo but of greater than normal draught resulting from serious hull damage.

b/ Repair and maintenance docks for docking ships without cargo.

c/ Building docks mainly for ship construction with sufficient depth for undocking an empty or partly equipped hull.

d/ Building and repair docks for ship construction with sufficient depth of sill for docking ships for repair work.

The dry dock permits both launching aud repairing of ship of practically unlimited size and it ensures a horizontal position of the ship during building and launching. This is important when using the block or section methods of construction.

A dry dock does not require the docking depth of a floating dock or a special stretch of water for reducing speed at launch as with longitudinal slipways. Also it does not require a greater depth than the draught of the ship that has been built or repaired, for instance, with side slipways and marine railways.

A dry dock is, generally speaking, a chamber or basin separated from the adjacent harbour waters by a dock gate /Fig. 27/. Its basic structure comprises a floor, side walls, head wall and dock gate which define the dock chamber.

The part of the dock structure located at the entrance, called the dock head, is the support for the dock gate and for all auxiliary devices necessary for docking a ship. The floor of the dock in that part is construted as a sill and the side walls as vertical faces for the dock gate.

Flooding and dewatering of the dock is carried out by means of pumps and other installations usually located in a pumping station.

When the gate is open, the water level in the dry dock is the same as in the harbour basin. It is then possible to bring in the ship, i.e., to dock it, or to float it out of the dock, i.e., to undock it. If the gate is closed, the water level in the dock can be lowered by pumping out the water so that the docked ship can settle on supports placed on the dock floor. Their number and spacing depend on the type and size of the docked ship.

Docks of great length can be partitioned off by inner gates, while in some cases a dry dock may have two entrances. The second entrance is especially useful when the dock has an

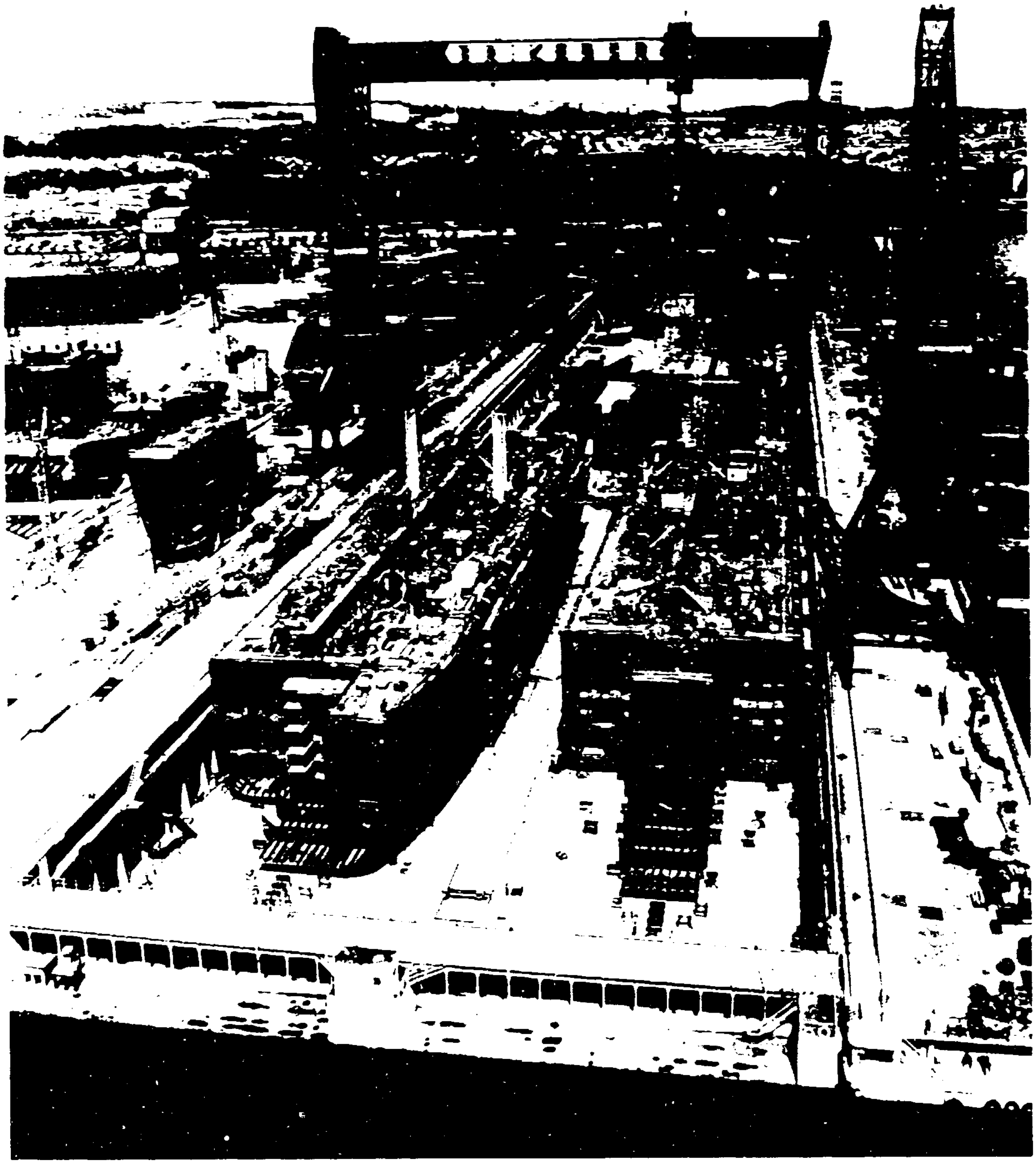


Fig.26.General view of a dry dock

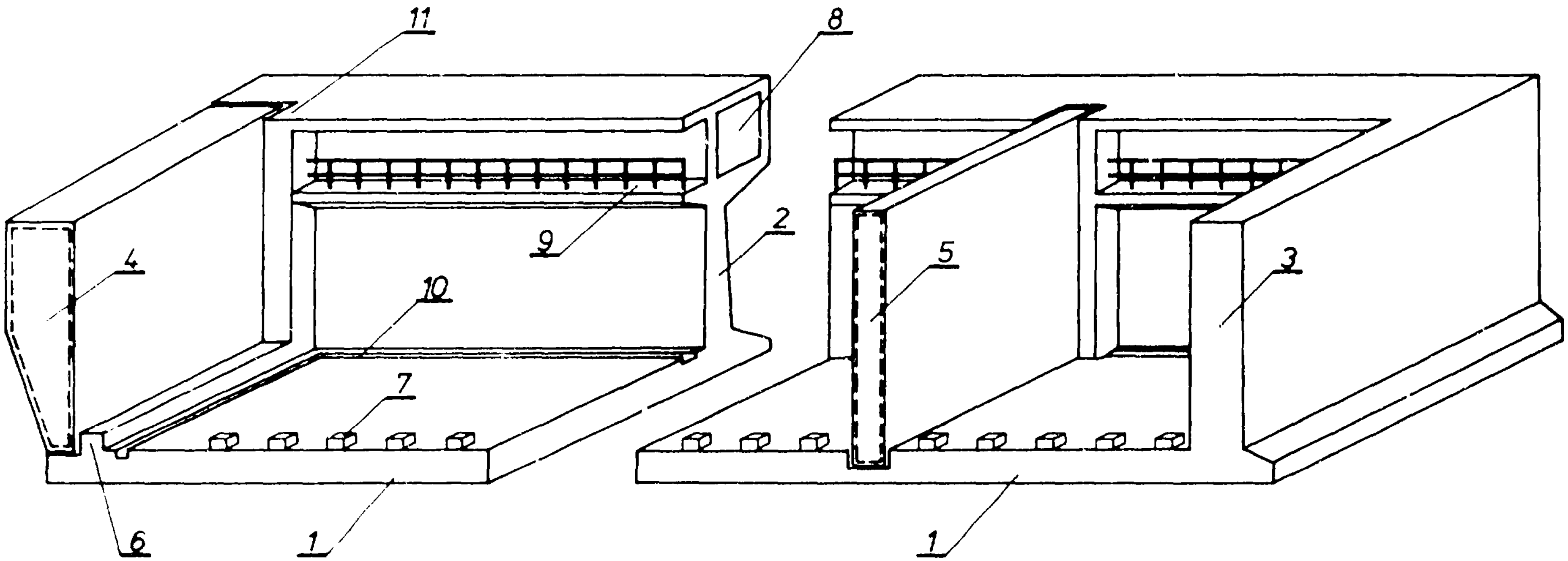


Fig. 27. General scheme of a dry dock: 1 - dock floor, 2 - side wall, 3 - head wall, 4 - dock gate, 5 - inner gate, 6 - sill, 7 - keel blocks, 8 - culvert, 9 - barriers, 10 - dewatering channel, 11 - gate supports

inner gate.

Docking of a ship is the most difficult and dangerous operation carried out in a dry dock. It requires meticulous preparation of the ship and dock. The factor determining the safety of docking a ship is her stability, especially during the initial stage, when she settles on keel blocks. To achieve stability, the exact position of the ship in the dock is determined, and properly designed and prepared supports are distributed on the dock flor.

When the ship and its supports are properly prepared, the dry dock is filled with water and the dock gate is opened. Then the ship is brought in, moored and positioned. Once the ship is positioned corectly, the dock gate is closed and the water pumped out of the dry dock.

On completion of the required repair or building work and the necessary checks, the undocking operation starts. The launching of the ship is effected by raising the water level. The dry dock is gradually filled with water until the ship floats freely, Once the water level in the dry dock and the harbour basin is equalized, the dock gate is opened and the ship is towed out of the dock.

Each dry dock is characterized by physical dimensions which define the size of ships that can be built or repaired in it. These data relate to the following /Fig. 28/:

a/ Total length of the dock structure, L_d

b/ Effeetive length of the dock, L_u

c/ Total width of the dock structure, S_d

d/ Effective width od the dock, S_u

e/ The width of the dry dock at coping level, S_t

f/ The width of the dry dock at the dock floor, S_b

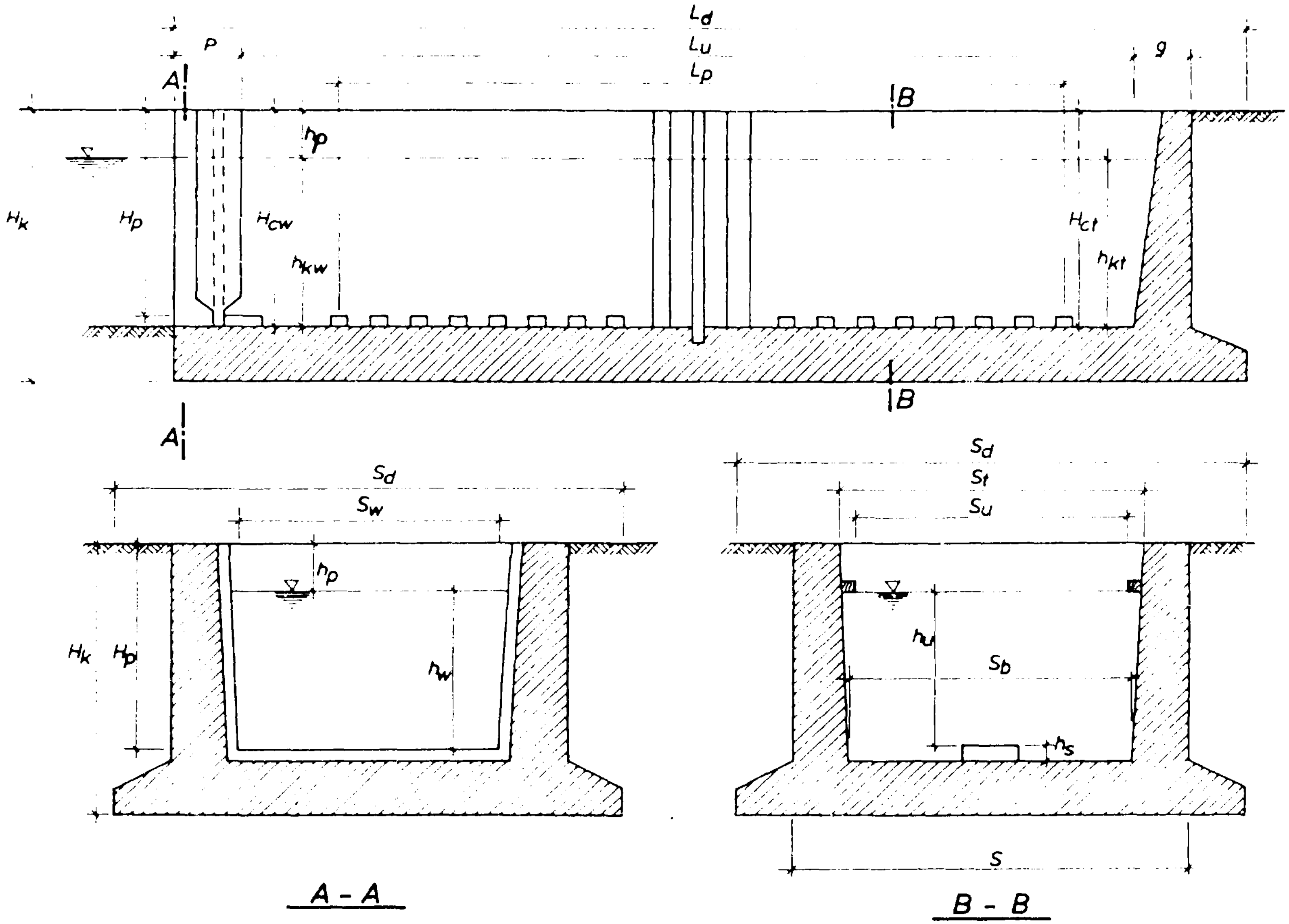


Fig. 28. Main dimensions of a dry dock

g/ The width of the dry dock, S_k, i.e., the average distance between the side walls equal to

$$S_k = 0,5 /S_t + S_b/$$

h/ The width at entrance, S_w

i/ The depth of entrance, h_w

j/ The depth of dry dock at the entrance, h_{kw}

k/ The depth of dry dock at the head wall, h_{kt}

l/ The depth of the dry dock, h_k, equal to

$$h_k = 0,5 /h_{kw} + h_{kt}/$$

m/ The effective dry dock depth, h_u

n/ The height of the coping edge, h_p

o/ The height of the dock structure, H_k

p/ The height of the dock walls at the entrance, H_{cw}

q/ The height of the dock walls at the wall, H_{ct}

r/ The height of the dock walls at the sill, H_p

s/ Dock volume, V:

$$V = L_u \cdot h_k \cdot S_k$$

t/ The factor of dock capacity, W_p

$$W_p = \frac{W}{V}$$

Where W = displacement of the greatest ship possible for docking.

The structural solution of dry docks differs first of all in the method of counteracting hydrostatic uplift. Accordingly docks may be divided into three basic categories:

a/ Heavy or gravity docks, in which the permanent loads are larger than the largest hydrostatic uplift.

b/ Anchored docks, in which the largest hydrostatic uplift is totally balanced by the permanent weight of the dock structure and by a proper anchorage in the ground.

c/ Drainage docks in which the hydrostatic uplift is reduced by a proper drainage system under the dock floor.

The three categories of docks can be further subdivided into:

a/ Heavy dock /Fig. 29/:

- with separate floor slab and side walls which, however, interact in transferring the hydrostatic uplift:

- with heavy floor slab balancing the whole hydrostatic uplift with its own weight;

- with monolithic frame structure of floor slab and walls,

b/ Anchored docks /Fig. 30/:

- with piles,

- with anchoring plates,

- with ground anchors.

c/ Drainage docks /Fig. 31/:

- fully drained,

- partly drained,

- on impervious subsoil.

The introduced design is determined by the local conditions pointed out by the contractor, equipment available and economic considerations as well as ground and water conditions.

Throughout their different stages of operation dry dock structures are subjected to varying loads over very short periods of time. Particularly rapid changes of load can occur during dock flooding and dewatering.

The dry dock loads occur during three main phases:

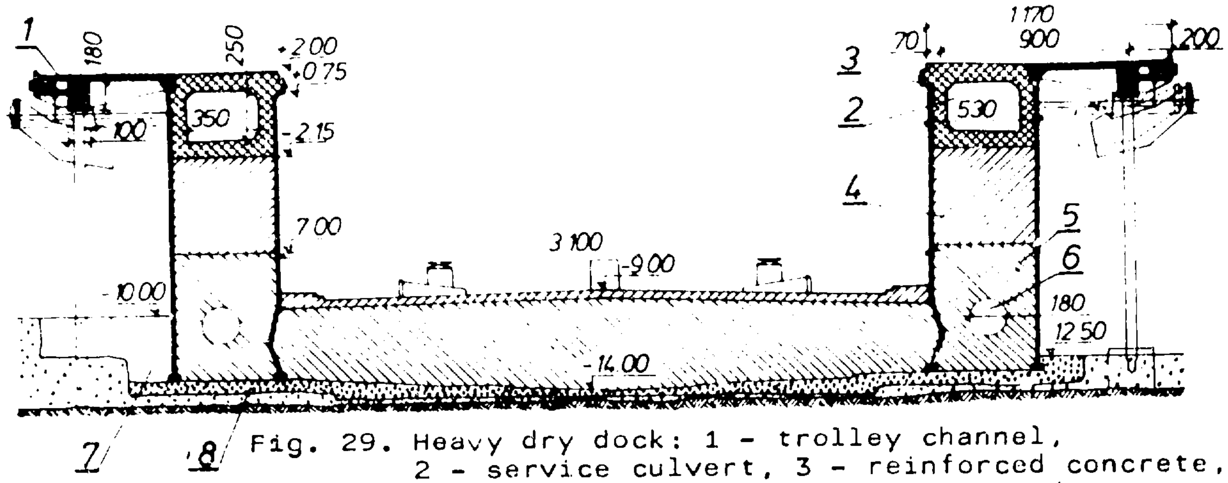


Fig. 29. Heavy dry dock: 1 - trolley channel, 2 - service culvert, 3 - reinforced concrete, 4 - concrete filling in dry, 5 - underwater concrete, 6 - oil container, 7 - sand fill, 8 - gravel bed

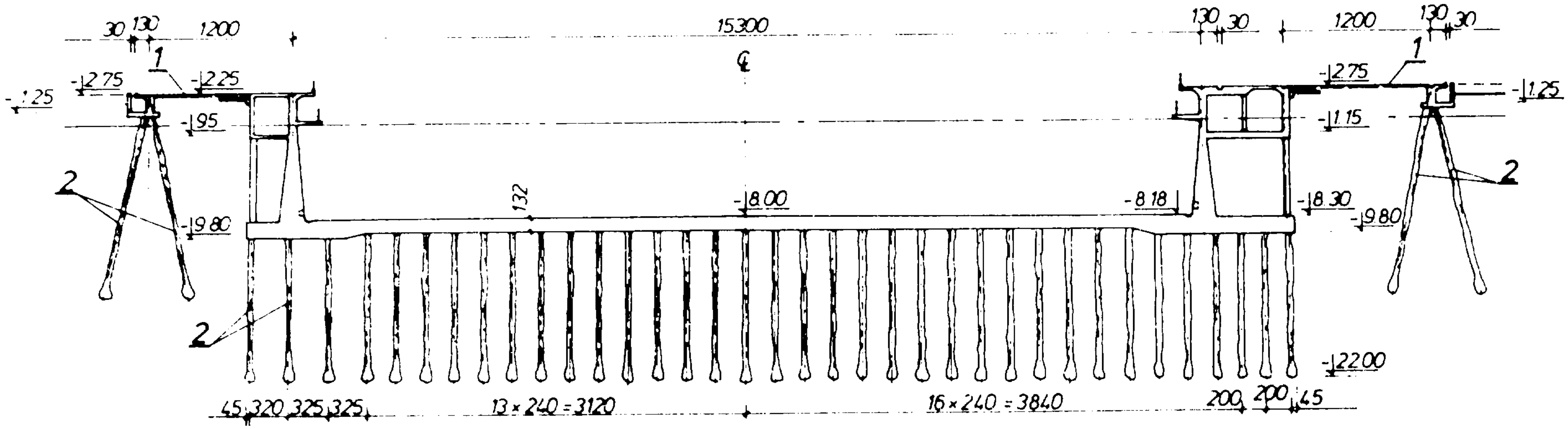


Fig. 30. Anchored dry dock: 1 - pavement, 2 - Franki piles 520 mm dia/800 mm dia

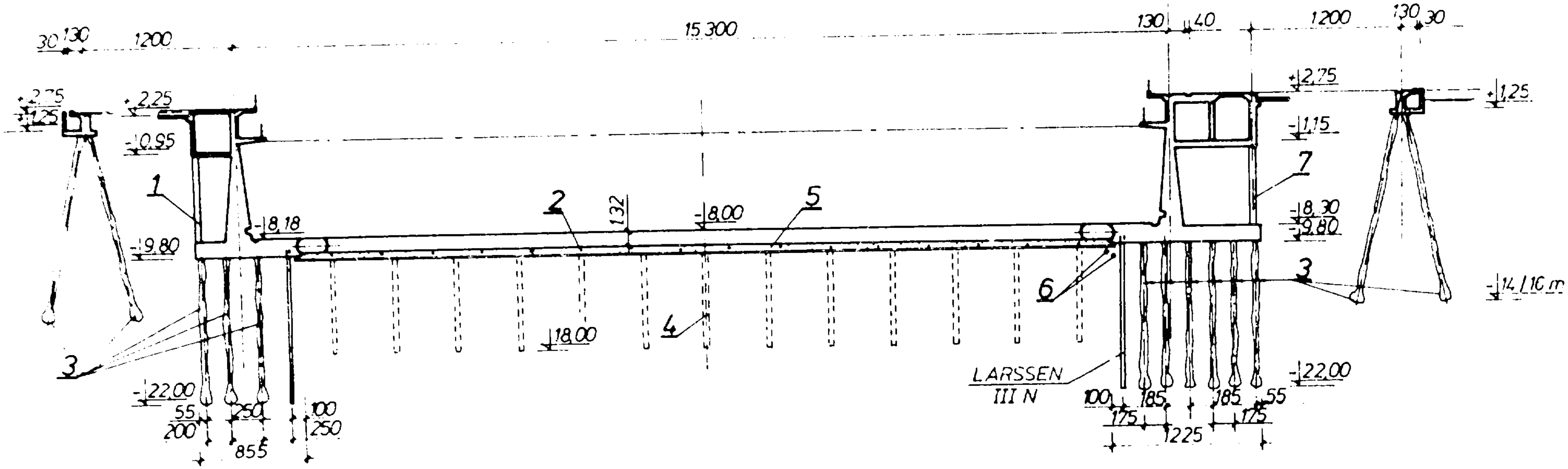


Fig. 31. Drainage dry dock: 1 - concrete columns 500 mm dia at 4,4 m ctrs
2 - P.V.C. drain pipes 90 mm dia at 4 m ctrs, 3 - Franki piles
520 rm dia/800 mm dia, 4 - vertical sand drains 300 mm dia,
5 - graded filter 500 + 200 mm thick, 6 - discharge pipes,
7 - concrete column 500x700 mm at 2,2 m ctrs

Phase I - dry dock dewatered during periods of dock repair or cleaning. The dock walls may be loaded, independent of their deadweight, by soil and water pressures and by the reaction of the dock floor. The dock floo: is loaded, apart from its deadweight, by hydrostatic uplift and the reaction of the subsoil and walls.

Phase II - dry dock dewatered but with a ship resting on the dock floor. The outside loads may be the same as in phase I, but the weight of the ship must be added.

Phase III - dry dock flooded. The hydrostatic pressures on the dock floor and dock walls are added to the loads occuring in phase I.

Among the most important installations in shipyard equipped with a dry dock are the cranes /Fig. 32/. Following types are used for the dry dock service:

a/ Jib cranes,

b/ Gantry cranes,

c/ Mobile cranes,

d/ Floating cranes.

Gantry cranes are used mainly in building dock while the other cranes can be found in every type of dock. Apart from the gantry cranes and the different kinds of jib cranes, various other auxiliary lifting devices are used, such as fork-lift trucks, hydraulic lifts, pneumatic lifts and mobile platforms.

Two basic states of a dry dock can be recognized, namely: filled with water and empty. The change from one state to the other must not be rapid or uncontrolled, which means that the flooding of the dry dock must not cause either big waves in

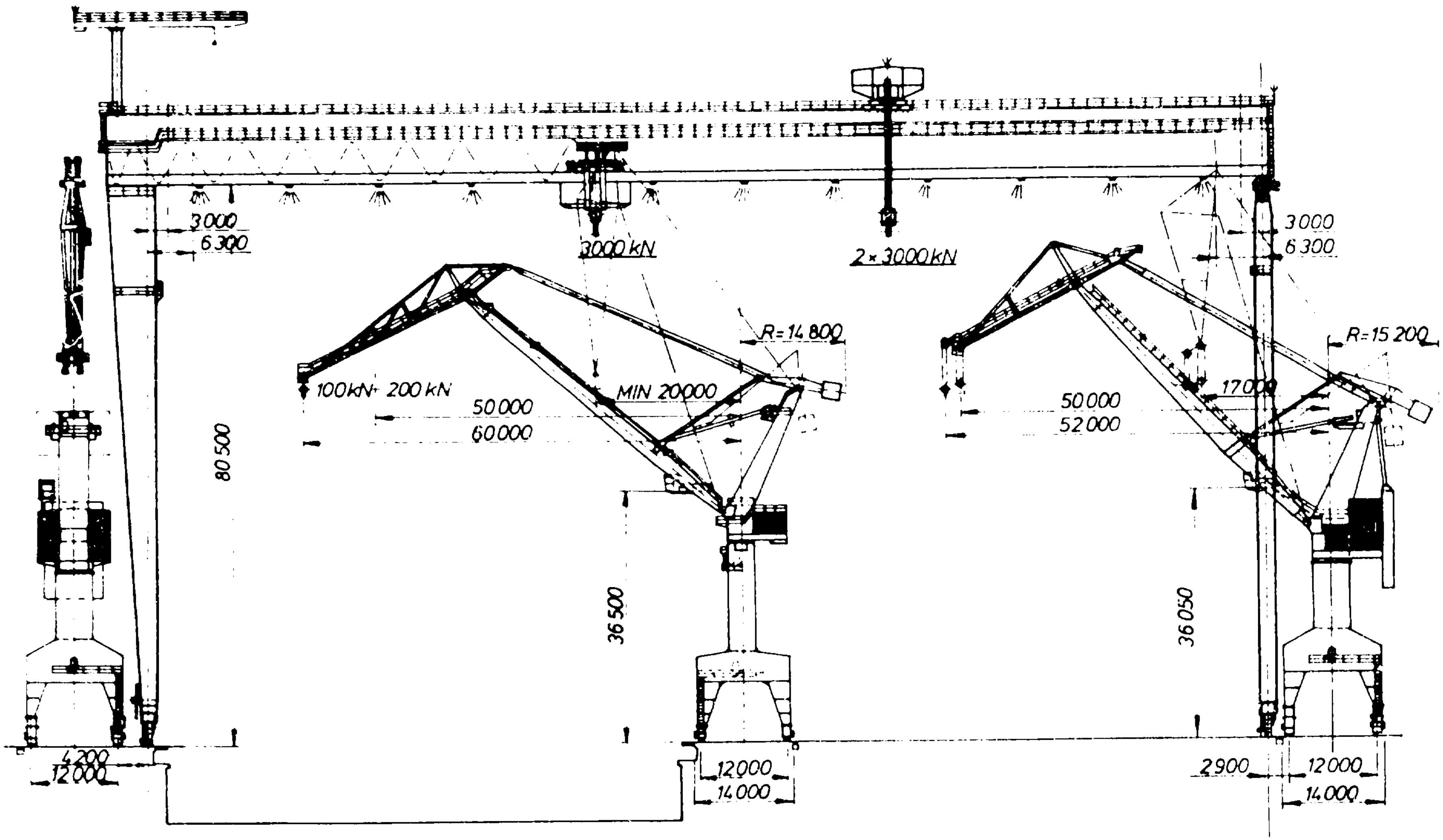


Fig. 32. Arrangement of shipyard cranes around a dry dock and assembly areas

the dry dock or a sudden impact of water on the ship supports, or on the undocked ship itself. The dewatering of the dock should allow a controlled settling of the ship on the supports.

Special equipment is provided for dock flooding and dewatering and this is generally installed in a separate building or chamber known as the pumping station. The amount and type of this equipment depends upon the flooding and dewatering system used in the dry dock. The flooding system /Fig. 33/ usually consists of an inlet culvert, flooding valve and flooding channel, whereas the dewatering system /Fig. 34/ comprises an inlet culvert, suction chamber, suction pipes, pumps, discharge pipes and outlet culvert.

The pumping stations are generally located near the dock entrance because the dock floor normally has an inclination in the direction of the dock entrance that considerably reduces the length of the inflow culverts.

The best location for the pumping station is in the dock wall, because then no special structure or building for the pumping station is needed. In the pumping station /Fig. 35/ following pumps are distinguished:

a/ Main pumps for dewatering the dock

b/ Auxiliary dewatering or seepage pumps for rain water, ballast water, water from hull watertigthtness tests and water seeping into the dock from leaks around the gate.

c/ Sludge pumps removing any water seeping into the pumping station.

d/ Ballast pumps to supply water to ballast the ship tanks, watertightness tests, etc.

e/ Fire pumps

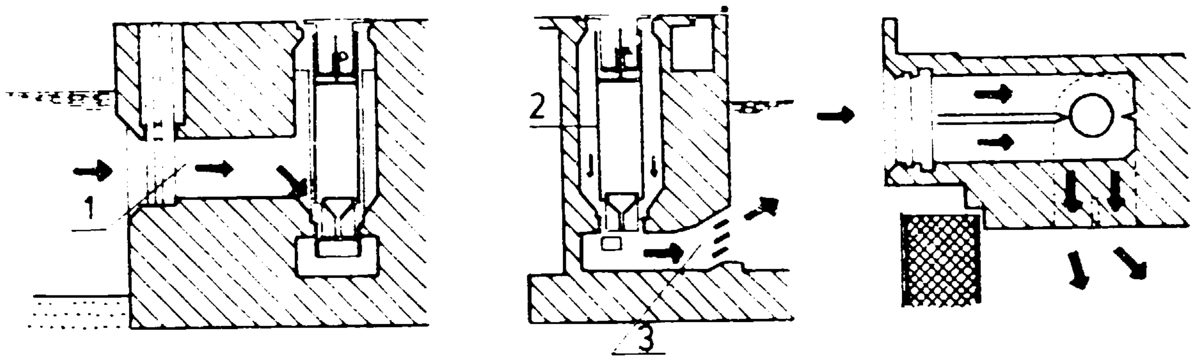


Fig. 33. Flooding system: 1 - inlet culvert, 2 - flooding valve, 3 - flooding channel

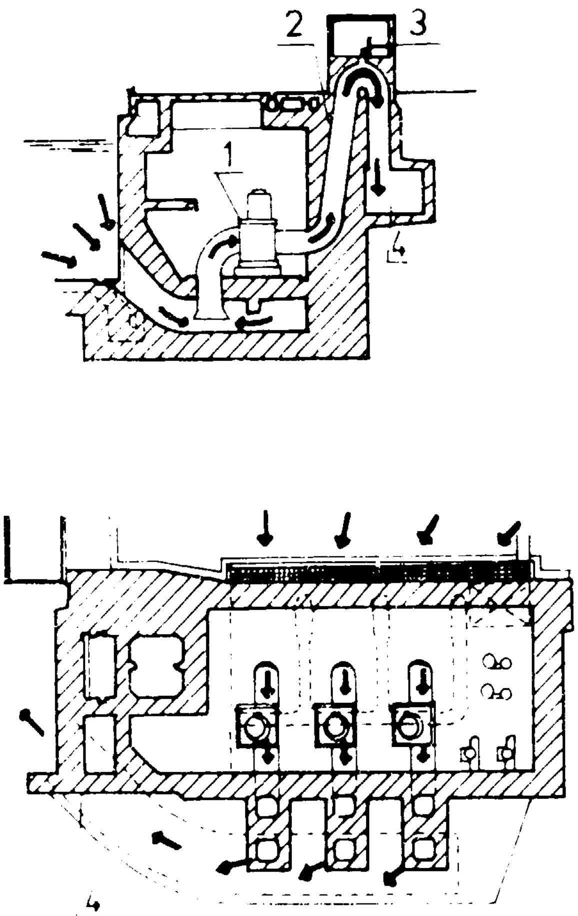


Fig. 34. Dewatering system: 1 - pump, 2 - discharge pipe, 3 - breaking valve, 4 - outlet culvert

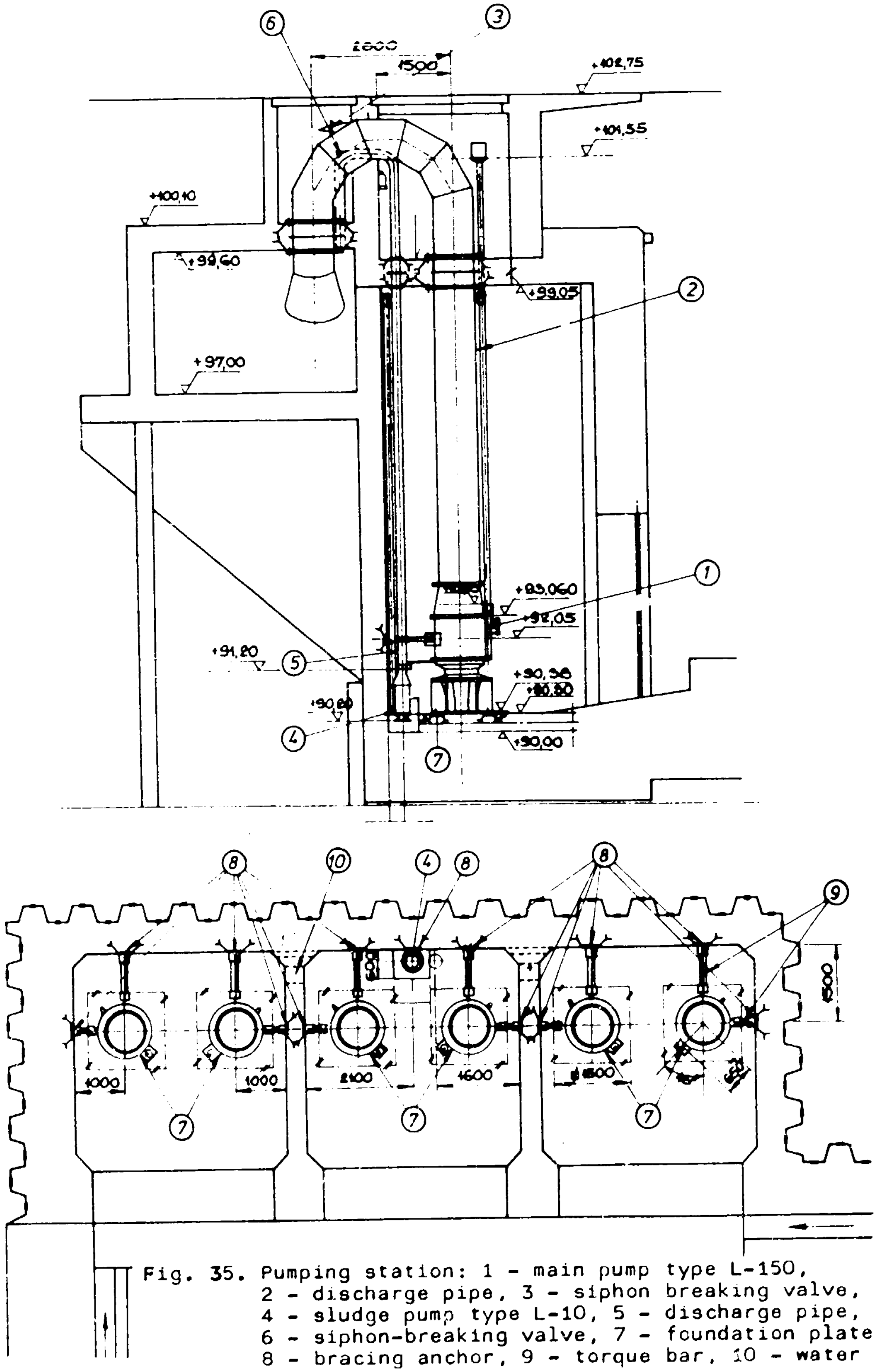


Fig. 35. Pumping station: 1 - main pump type L-150, 2 - discharge pipe, 3 - siphon breaking valve, 4 - sludge pump type L-10, 5 - discharge pipe, 6 - siphon-breaking valve, 7 - foundation plate, 8 - bracing anchor, 9 - torque bar, 10 - water connection

f/ Drainage pumps discharging water from the drainage dry dock.

g/ Cooling pumps used to pump cooling water for auxiliary machinery which is kept running while the ship is in the dry dock.

h/ Sewage pumps for discharging sewage from the ship and special pumps provided in the dry dock structure, for instance in walls or near power stations.

The number of pumps is dependent on the assumed dewatering time of the dry dock and on the efficiency of a single pump. The main pumps are constructed with capacity up to 50,000 m^3/h.

Dewatering of the dry dock takes place after setting the dock gate /Fig. 36/ which permits full closing at the highest predicted water level, and opening at least at the mean level. Dock gates should fulfil the following objectives:

a/ Great tightness for all possible loading cases

b/ Short opening and closing times

c/ Easy servicing and maintenance

d/ Mechanical reliability

e/ Monitoring of the gete position during opening and closing.

f/ Minimum operation and maintenance costs.

When designing a dry dock following types of dock gates may be taken into consideration:

a/ Floating gates built of steel, reinforced or prestressed concrete.

b/ Sliding getes in the form of floating steel or concrete pontoons and caissons.

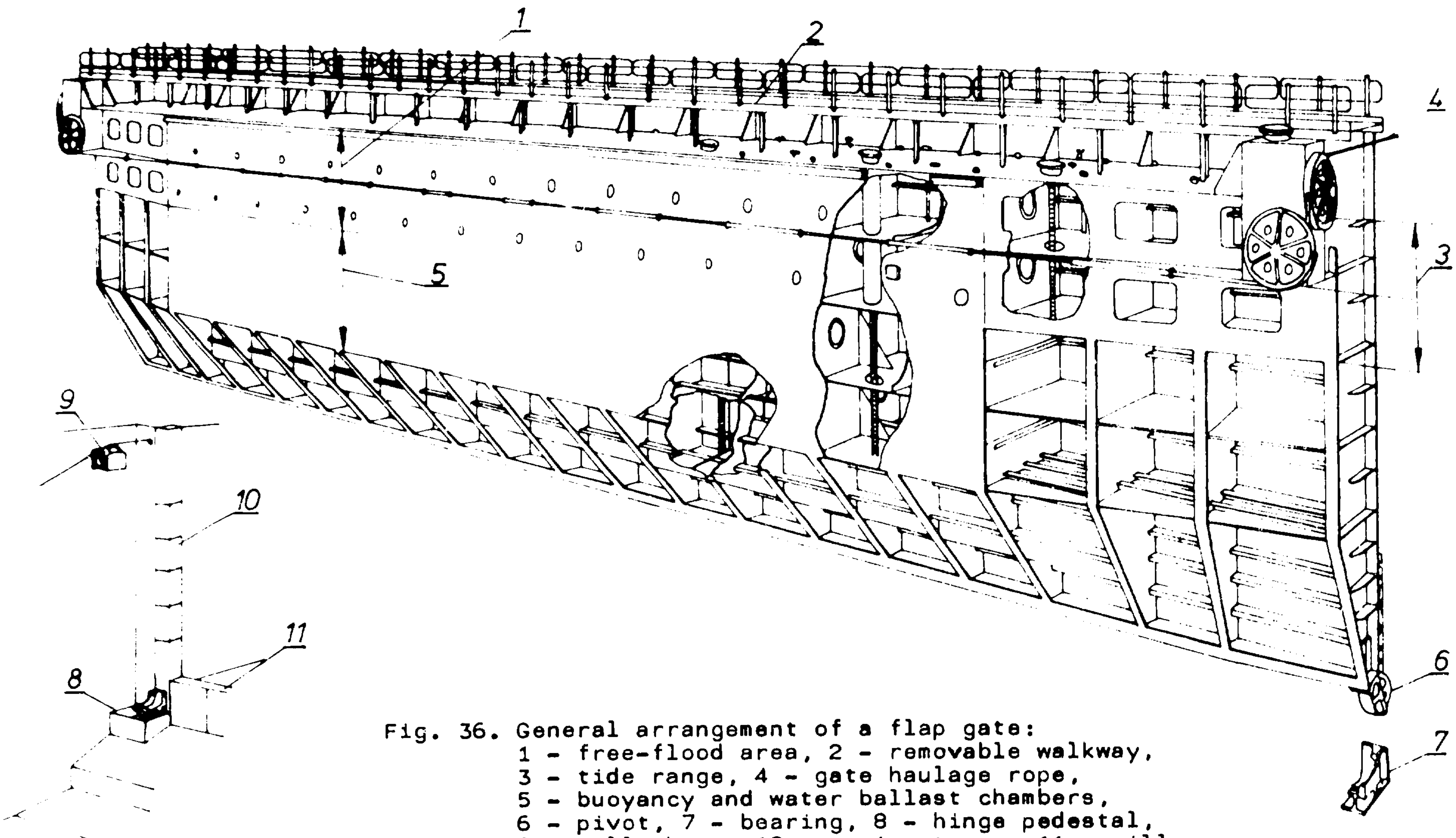


Fig. 36. General arrangement of a flap gate:
1 - free-flood area, 2 - removable walkway,
3 - tide range, 4 - gate haulage rope,
5 - buoyancy and water ballast chambers,
6 - pivot, 7 - bearing, 8 - hinge pedestal,
9 - wall shave, 10 - quoin stones, 11 - sill stones

c/ Mitre and hinge gates made as steel or timber structures.

d/ Flap gates /falling-leaf type gates/.

When selecting a gate type it is important to determine the nature of the traffic, whether rail, road or pedestrian, on the coping of the closed gate. The design of the dock entrance and the construction of the dock head also depend on the type of gate used.

With all types of gates it is necessary to seal the gate joints with the dock head. Defferent kinds of wood and hard rubber are used as sealing materials. The seal should correct any unevennes of the concrete surfaces which could not be eliminated by methods such as grinding.

Common to every type of gate is the problem of protection against corrosion. Steel gates are normally protected by galvanizing the corrosion stress surfaces and coating them with several coats of waterproof paint. The protection of concrete gates against corrosion calls for highly impervious concrete.

8. MATERIALS AND PRODUCTION TECHNOLOGY FOR SMALL SHIPS

In the production of large ships as the main material steel is applied. For small ships a difference exists, namely, the application of many other materials and technologies take place. At the time being in the production of small ships following basic materials for the hull are in use:

a/ wood - required are sorts of high strength and durability whilst the quality of timber has to be the highest, b/ waterproof plywood - its quality depends on the kind of glue and sort of wood whilst application concerns small boats,

c/ coldmoulded wooden shell plating glued from many layers of facing boards /possible due to the introduction of modern glues as Kaskofen or West Epoxy System/,

d/ ship steels, weldable, of normal or increased strength,

e/ light aluminium alloys e.g. duraluminium in many different alloy sorts and strength improvements,

f/ polyester-fiberglass laminates being the products of the modern chemistry; this materials are introduced mainly in high economical developed countries,

g/ ferrocement, material, notwithstanding of its advantages, is not commonly used, whilst the production technology is not wide known.

The comparison of the above mentioned materials from the point of view of their physical and maintenance properties is presented in the Table "Comparison of physical and maintenace properties of hull material". This comparison does not include the prices because they differ considerably for the above listed materials in different countries. Here the relativity of the assumed criterions and estimations, included in the above comparison, has to be stressed. These were determined by the expert method.

For the further considerations of the selection problem of materials and technologies for building of small ships it is necessary to compare the structures of the basic hull types and the connected materials and technology requirements.

COMPARISON OF PHYSICAL AND MAINTENANCE PROPERTIES OF SHIP HULL

No.	Feature / Material of hull	Mass density g/m3	Tonsile strength MPa	Characteristic swell xx	Heat conductivity W/m.K	Vibration dumping & sound absorption	Appearance	Material's resistance on: Sea environment	Marine fauna	Mechanical damage /local/	Fire	Repair of shell plating	Maintenance of hull
1.	Timber	0,47–0,7	60–100 x	pleasant	very low 0,14–04	good	very good	good	bad	good	bad	often complicated high skilled workers required	difficult and expensive
2.	Plywood shell plating	0,6–0,8	30–50 x	pleasant	very low 0,2–0,3	good	good	worse than timber	bad	good	bad	easy enough average skilled workers required	difficult and expensive, durability worse than timber
3.	Coldmoulded shell plating several facing boards glued diagonal	0,6–0,8	40–80 x	pleasant	very low 0,2–0,3	good	very good	better than timber	better than timber	better than timber	bad	easy low skilled workers can perform the job	easier and less expensive than timber
4.	Steel	7,85	370–520	without swell	high 58	bad	good	bad	perfect	good	good	easy; can be done by average skilled workers	easy but expensive
5.	Alluminium alloy	2,5–2,9	160–335	without swell	very high 175	bad	good	very good	perfect	worse than timber	good enough	difficult, high skilled workers required	easy and not expensive, but high requirement of electrolyte protection
6.	Polyester fibre-glass laminate	1,6–1,9	80–270	unpleasant	very low 0,12–0,25	good enough	very good	very good	perfect	bad	bad	easy; low skilled workers required	easy and cheap
7.	Ferrocement	2,3–2,5		without swell	low 7	good enough	good enough	good	perfect	bad	very good	easy; low skilled workers required	easy and cheap

x Items 1,2 and 3: bending strength
xx Swell depends on the sort of paints

COMPARISON OF SMALL SHIP'S HULL STRUCTURES

No	Type of hull construction	Shell plating	Framing and fasteing	Inside spaces and insulation	Main technological requirements	Optimum range of hull's overall length
1.	wood, traditional	- carvel planking - clinker planking - strip planking - diagonal and longitudinal planking	- wood - cooper alloy boat rivets - anticorrosive protected steel bolts and ferrules - antirust fastenings (alloys of metals) - waterproof glues	- wood - zinc coated steel sheets - non ferrous metal sheets - cork	- woodworking mach. - steam bending eq. for planks & ribs - cold-gluing moulds for framing	less than 20 m
2.	plywood	waterproof plywood	as item 1	as item 1	- woodworking mach. - cold-gluing moulds for framing	less than 10 m
3.	composite	as item 1	- wood - steel sections - as item 1	as item 1	- woodworking mach. - cutting, bending, welding & galvanizing eq. for steel	10-30 m
4.	coldmoulded	several facing boards glued diagonal	as item 1	as item 1	- as item 2 - hull mould or special construction of hull framing	less than 20 m
5.	coldmoulded-composite	as item 4	as item 3	as item 1	- as item 3 & 4	15-35 m
6.	steel	plates	- sections-stiffeners - brackets - welding	- as item 1 - steel plates - plastics	- as item 3 - jigs and wolding positioners	more than 10 m
7.	aluminium alloy	plates	- sections-stiffeners - brackets - welding - rivetting	- wood - plastics - alu. alloy sheets	- woodworking mach. - cutting, bending, welding and rivetting eq.for alu. alloy - jigs and welding positioners (for a serial product.)	4-30 m

COMPARISON OF SMALL SHIP'S HULL STRUCTURES
(continued)

No.	Type of hull construction	Shell plating	Framing anf fastening	Inside spaces and insulation	Main technological requirements	Optimum range of hull's overall length
8.	polyester-fiberglass laminate (single skin)	- several fiberglass mats and cloths bonded by polyester resin	- laminated as a skin using plastic foams or balsa	- laminate - plastics - wood - antirust metal sheets	- moulds for hull, deck and inside compartments - laminating positioners (in a serial production) - resin mixers - equipment for building inside spaces	less than 35 m
9.	polyester-fiberglass (sandwich)	- as item 8 - inside and outside skin filled with plastic foams or balsa	- as item 8	- as item 8	- moulds for in- and outside skin or for one skin - mould for deck and inside compartments - as item 8	less than 35 m
10.	ferrocement	- wire frame covered by cement mortar	- steel sections & brackets - reinforcement covered by cement mortar - welding for steel constructions	- as item 6	- cutting, bending and welding equ. for steel - concrete mixer - a special construction for hull framing - equipment for building inside spaces	15–40 m

COMPARISON OF TECHNOLOGICAL REQUIREMENTS FOR BUILDING OF SMALL SHIPS

No.	Materials of the hull	Materials for the inside spaces and insulations	Paint consumption	Electric energy consumption	Technical gases consumption	Machine tools	Transportation units & cranes	Assembling moulds		Labour	
								individual production	serial production	individual production	serial production
1.	- wooden boards - metal fastening materials - waterproof glue	- wooden boards - anticorrosive protected metal sheets - cork - metal fastening materials	high	medium	not necessary	- woodworking machines - hand tools - steam bending eq. - coldgluing moulds for framing	necessary for bigger ships	not needed	essential for framing	very high skilled	very high skilled
2.	- waterproof ply wood sheets - and as item 1	- plywood - and as item 1	high	low	not necessary	as item 1	as item 1	not needed	essential for framing	average skilled	average skilled
3.	- as item 1 - steel sections and plates	as item 2	high	medium	low	- as item 1 - cutting, bending, welding and galvanizing eq. for steel framing	as item 1	not needed	essential for framing	high skilled	average skilled
4.	- wooden facing boards - and as item 1	as item 2	high	low	not necessary	as item 1	as item 1	essential	essential	average skilled	unskilled
5.	as items 3 & 4	as item 2	high	medium	low	as item 3	as item 1	as item 4	as item 4	as item 4	as item 4
6.	steel sections and plates	- steel plates - and as item 2	high	high	high	- cutting, bending, welding & galvanizing eq. for steel framing - hand tools - woodworking machines	necessary	not needed	essential	high skilled	average skilled
7.	aluminium alloy plates and sections	- wooden boards - plywood sheets - plastics - alu. alloy sheets	low	high	high (argon)	- as item 6 - and revetting eq. for alu. alloy	as item 1	not needed	essential	high skilled	average skilled

COMPARISON OF TECHNOLOGICAL REQUIREMENTS FOR BUILDING OF SMALL SHIPS (continued)

No.	Materials for the hull	Materials for inside spaces and insulation	Paint consumption	Electric energy consumption	Technical gases consumption	Machine tools	Transportation units & cranes	Assembling moulds		Labour	
								individual production	serial production	individual production	serial production
8.	- fiberglass mats and cloths - polyester resin - plastic foams - balsa	- as raw materials - and as item 2	very low	low	not necessary	- resin mixer - hand tools - woodworking machines - fan installation	as item 1	essential	essential	average skilled	unskilled
9.	as item 8	as item 8	very low	low	not necessary	as item 8	as item 1	essential	essential	average skilled	unskilled
10.	- steel sections and plates - steel net - cement - sand - water	- as raw materials - and as item 2	low	low	low	- cutting, bending & welding eq. - hand tools - concrete-mixer - woodworking machines	as item 1	not needed	essential	average skilled	unskilled

The comparison is presented in the two following tables:
"Comparison of small ships hull structures".
"Comparison of technological requirements for building of small ships".

In the analyses the ship launching and transfering arrangements are neglected. The technical characteristics of these arrangements are more or less independent on the hull material. Analogically as in the first Table also in the second and third one the relativity of assumed criterions and estimations has to be stressed, mainly because of lack of exact technical data. The extensive description presented in the above tables seems to characterize sufficiently the basic hull structures and erection technologies.

The selection of the optimum material and technology for building of small ships can be made when taking into consideration a number of criterions from which a certain amount concerns the limited possibilities of the maintenance system of the yard. The developed countries which have a very strong economy and a developed industry have no problems to maintain the shipyard industry. In the case of certain shortages they can import raw materials, equipment, technology and also labour force. It may be stated that in the developed countries the development of several industry domains is particularly dependent on the possibilities of their maintenance systems.

On the basis of many designs and literature studies the following list of criterions is prepared, which should be taken into consideration during the selection of material and technology for building of small ships hulls, namely:

a/ Structural usability of materials from the point of view of ships´size and type.

b/ Operational properties of material for given climatic conditions appearing during water transport.

c/ Cheapness and accessibility of materials on the local market.

d/ Accessibility of imported materials.

e/ Sale possibility of the produced units and the possibility of introduction of serial production.

f/ Usability of the material for serial production.

g/ Kind and scope of necessary technological process.

h/ Energy consumption during production.

i/ Consumption of technical gasses

j/ Labour consumption during production

k/ Qualification requirements for workers and accessibility of labour forces.

l/ Type, number and costs of necessary machines and production equipment.

m/ Elimination possibilities of high skilled works.

n/ Eliminations possibilities of heavy works harmful for health of workers.

o/ Investment costs of shipyard building /erection/ together with costs of shipyard starting and staff education.

p/ Operational costs of the shipyard.

q/ Tradition of the local boatbuilding and existing ship building.

r/ Shipyard location possibilities.

s/ Civil engineering and installation works possibilities of the designed shipyard.

t/ Scope and kind of repair services performed next to new production, u/ Export possibilities of ships to neighbour countries.

Analysing the above list one may observe that:

- the optimization analysis of the selection of materials and technologies for shipbuilding has to be made from the point of view of many criterions,

- in actual conditions the several criterions have the character of limits, which are changing with time,

- a part of the presented criterions can't be quantitatively expressed and requires a subjective estimation.

Taking the above into consideration it may be stated that the estimation of the way of selection of materials and technologies for shipbuilding in a considered country is very difficult and requires for each case a separate analysis and feasibility study.

On the basis of the presented considerations it may be stated that it is impossible to determine such a recommendations in the field of selection of materials and technologies for building of ships which could be the optimum for all countries. However, following recommendations concerning the technology and material for building of small ships may be presented:

Type No.1 - technicaly outdated, too expensive in execution, not suitable for serial production - should not be recommended in governmental programmes.

Type No.2 - limited application mainly for small size vessels - can be recommended only in specific conditions.

Type No.3 - can be recommended for production of large size vessels when the requisition is small and concerns cold climatic zones /lack of shipworms - toredo/.

Type No.4 - is particularly recommended for production of small and middle size ships for all countries rich in wood.

Type No.5 - can be recommended for big size ships in all countries rich in wood.

Type No.6 - can be recommended for production of middle and large ships particularly in countries which have no wood.

Type No.7 - because of very high technological and operational requirements it is not recommended for ships production in developing countries.

Type No.8 and 9 - because of their advantages they are recommended particularly for production of small and middle size ships for countries which in the balance of foreign trade can allow for a large import.

Type No.10 - particularly recommended for building of all types of ships in countries which have no wood and which have small import possibilities.

9. CONCLUSIONS

The above general description of hoist lifts, slipways, shipways, floating docks and dry docks shows that for the building and repairing of ships a set of structures exist which can be easily erected, taking into consideration the local conditions. When choosing a solution one should take into account the soil conditions, the available materials: timber, steel, concrete, /cast in-place, precast, prestressed/, the available building equipment, /driving rigs, batching plants etc./, the available labour forces, /skilled labour/, and the proposed shipbuilding activities, /building of timber, steel, concrete and ferrocement ships, repair of these ships/. Having all this data available means that a construction may be recommended bearing in mind the above statements. At this point it may be advisable to contact a specialist in shipyard design and construction to avoid mistakes occuring in the determination of the data to be used as a basis for recommending the shipyard structure.