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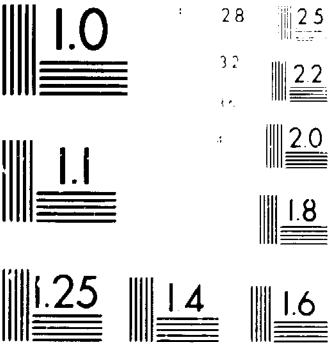

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SHIPBUILDING AND SHIPREPAIRING INDUSTRY IN SINGAPORE*

prepared by

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1. INTRODUCTION

Within a short span of two decades, Singapore has emerged as one of the newly industrialised countries in the Asian Pacific region. The successful development of the shiprepairing and shipbuilding industry has a tremendous contribution towards this industrialisation process not only in terms of visible economic earnings but in providing the resources and opportunities for massive manpower training in various technological skills and managerial expertise vital to the continuous growth of the industrialisation process. Moreover, as a heavy engineering and "global" industry, it has a large linkage and "gravitational" effect and has attracted the development of other related industries such as shipping, iron and steel, machine, electric, electronic and chemical industries. It has brought about the upgrading of a host of supporting industries like marine equipment, corrosion control, quality machining and automation engineering. It has stimulated the further improvement of essential infrastructure such as global communication, banking, marine inspection and surveying services, port services, industrial training facilities and research.

This paper attempts to present the salient aspects of the status and the development of this vital industry and it is hoped that the Singapore experience will prove a useful reference for others engaged in the similar process of industrialisation.

A broad survey of the marine industry will first be presented largely compiled from published sources of information, followed by a close-up view of the various aspects of shiprepairing and shipbuilding. The writer will draw from his own experience and knowledge in a major shipyard in which he spends his working career. The views and observations expressed are therefore personal but coming from an angle within the industry itself. They hope to have some relevance to the topic of discussion for which this Group Meeting has been called.

The current problems facing the Singapore Marine Industry and the countermeasures being undertaken are next high-lighted. Finally the proposals for co-operation among developing countries are presented.

2. BROAD SURVEY OF THE MARINE INDUSTRY OF SINGAPORE

Singapore's marine industry consists of 3 main sectors: Shiprepairing, shipbuilding and oil rig construction. The growth of the industry is reflected in the revenue breakdown of the industry by sector between 1972 and 1982 as shown in Exhibit 1.

The industry employs some 30,000 workers and is a significant foreign exchange earner contributing some 6% share of total GDP towards the Singapore economy in the peak year of 1981.

2.1 Shiprepairing

The shiprepairing sector was and still is the backbone of the industry. Presently, there are 21 drydocks of which 2 are 400,000 dwt in size, 1 of 330,000 dwt and another 2 of 300,000 dwt capacity each. 6 others can accommodate vessels between 90,000 dwt and 250,000 dwt. Exhibit 2 shows the statistics of drydocks and slipways in Singapore as at 30th June, 1983.

Along with the growth in scale, the repair technology has further developed beyond routine surveys and damage repairs to ship conversions and major modifications. Conversions undertaken included those of cargo vessels to livestock carriers, cargo vessels to fully cellular containerships, tankers to multi-petroleum product carrier and storage vessels, bulk carrier to drillships, drillships to drilling tenders, cargo vessels to cement carriers, whale ships and floating fish factories. Major modifications included retrofitting of crude oil washing and inert gas systems on tankers, upgrading modifications of LNG/LPG carriers and re-engine works.

Supported by a well-developed infrastructure comprising specialist contractors, mechanical, electronics and electrical workshops and suppliers, the range of repair services is also extended to offshore structures, underwater cleaning and maintenance, marine electronics, communications and automation.

2.2 Shipbuilding

The shipbuilding sector accounted for 28% of the total revenue in 1982. The types and number of vessels built between 1978 and 1982 are shown in Exhibit 3.

The biggest of the shipbuilders has a 200,000 dwt building dock and has built in the 70's large ocean going vessels up to 90,000 dwt. Other newbuilding facilities include a 10,000 dwt syncrolift dock, various slipways and some 50 building berths.

2.3 Oil rig construction

The oil rig construction sector accounted for 34% of the total revenue in 1982. In the peak year of 1981, Singapore was the world's leading builder of Jack-ups and second only to the U.S. in oil rig construction. Exhibit 4 shows the varieties and number of oil rig construction between 1970 to 1982.

Apart from rigs, the yards also construct allied offshore structures. These comprise production platforms, accommodation modules, pressure vessels, water injection platforms and single buoy mooring systems.

3. CLOSE-UP ON THE VARIOUS ASPECTS OF SHIPREPAIRING AND SHIPBUILDING

The writer will now take the liberty to use Jurong Shipyard as a reference shipyard to relate the various aspects of shiprepairing and shipbuilding.

3.1 Brief history of Jurong Shipyard

The history of Jurong Shipyard typifies the growth of the shiprepairing and shipbuilding industry in Singapore. Founded on 25th April, 1963 as a joint venture between the Singapore Government and the Ishikawajima-Harima Heavy Industries Company Limited (IHI) of Japan, it was the first major shipyard established in Singapore after the war as part of the industrialisation drive in the early 60's. When it first started, the island called Pulau Samulun on which the shipyard was located was a Malay Fishing Village transformed for industrial use.

Though Jurong Shipyard Ltd (JSL) was set up primarily as a shiprepairing yard in the pioneering days of the 60's, it also undertook shipbuilding of small vessels such as tugs, coastal tankers and vessels up to 5,000 dwt. The main purpose being to expose the workforce to systematic rounds of training on shipbuilding technology which would help upgrade their skills and maintain work stability.

This paved the way for the establishment of the Newship Division in 1971 (then known as the Jurong Shipbuilders Pte Ltd) which began by building a 14,800 dwt Freedom class multi-purpose dry cargo vessel and since then has built numerous similar vessels, three 91,600 dwt tankers, the world largest offshore tin mining dredger, three 10,000 cargo vessels and undertaken numerous interesting conversions.

In the meantime the shiprepairing facilities further expanded with the extension of the No. 2 repairing drydock to reach 300,000 dwt capacity and the provision of new mooring quay facilities at Tanjong Kling. Parallel with the development programme, the workforce increased from an initial number of 466 to 2,092 in 1975, reaching a peak of 2,555 in 1981. Owing to the world recession the workforce has been reduced to some 2,000.

The layout and facilities of both the Newship and Repairship Divisions are shown in Exhibit 5.

3.2 The nature of shiprepairing

The kind of facilities, technology and management style required of a successful shiprepairing industry has a lot to do with the nature of the industry itself. Exhibit 6 is an attempt to analyse the nature of shiprepairing in a commercial environment and identify key areas to which attention must be paid in order to be successful. Seen in this overall perspective, strategic location, facilities and technology only form part of the ingredients for a successful commercial enterprise. The various aspects will now be discussed.

3.2.1 Complexity of systems involved

A ship is an embodiment of complex systems and structures. While some systems and structural arrangements are common to all ships, different ship types are characterised by different specialised systems and structural peculiarities. The complexity is thus multiplied.

Exhibit 7 shows the different types of vessels repaired in JSL in the year 1980.

The range and types of facilities required to undertake such diversities and volume of repair can be gauged from the Exhibit showing the layout and facilities of JSL.

It is impossible to relate the different skills involved to meet the wide ranging repair and maintenance requirements. Suffice to say that it is equally impossible for any individual to be trained in all the skills involved and therefore effective transfer of knowledge and technology must take place at all levels of the workforce through training as well as on the job experience. Technology is therefore a shared and collective asset vested in the workforce.

The transfer of technology in JSL has taken some 10 to 15 years as can be seen from Exhibit 8 showing the reduction of Japanese seconded personnel from the parent company over the years.

The training and development of employees, however, goes on with greater emphasis on job enlargement, managerial and supervisory skills, improvement of work attitudes and teamwork. For it has been recognised that the human factor, more than anything else is the most crucial element and that people are the most important asset of the company.

The kind of organisational structure must be adequate to cope with complexities but at the same time 'trim' enough to response quickly to changing and unexpected situations characteristic of shiprepairing. The structure must be such that a clear and quick communication line can be effectively established for all parties concerned and the various activities well co-ordinated at all times.

The organisation chart of JSL is as shown in Exhibit 9.

Exhibit 10 takes a closer look at the organisation of the Repairship Division.

It is seen that under the Shipyard Manager, there are six "shop" Sections and one shiprepair Managers' office. The division of the facilities and workforce into 6 "shop" Sections is to cope with the whole range of shiprepairing which can be categorised as follows:-

1.	Hull Construction	:	Hull and steel repair
2.	Outfitting	:	Hull fitting repair such as various hull piping systems, deck machinery, living quarters, etc.
3.	Machinery Fitting	:	Machinery overhauling and repair, shafting and boilers, etc.

4.	Electrical Fitting	:	All electrical and electronic repairs
5.	Painting	:	Cleaning, shotblasting and painting works.
6.	Dock	:	Docking and mooring operations, staging and rigging works.

The Shop Sections are responsible for the control of equipment and facilities, allocation of manpower and overall planning of the activities under their respective areas.

On the other hand, the Shiprepair Managers' office plays the very important role of control, co-ordination and communication on a vessel to vessel basis. Each shiprepair manager is the centre of control, co-ordination and communication for a particular vessel under his charge. He is responsible for the total planning, scheduling, control and safety of the appointed vessel. He is the counterpart of the vessel's chief repair superintendent and deals with the Classification Society's surveyors and all external contacts. In this way, clear and quick communication, effective co-ordination within and without are achieved.

3.2.2 Heavy Engineering

The sheer size of the hull, machinery to be serviced/handled means that safe, efficient material/transportation and handling system and techniques are keys to successful operation.

This has a number of implications:

(1) In planning or in reviewing a shipyard's layout the main aim is to achieve a logical flow of material and to minimise distances of transportation among workshops, warehouses, docks, quays, etc. unless unavoidable owing to geographical reasons.

(2) In planning or reviewing shipyard's facilities, the choice of crane capacity, their numbers, types and locations is decisive as to the potential capabilities of the yard in terms of production. Therefore the choice of craneage must be commensurate with the production capability planned and future capability envisaged.

Experience has proved the point that the larger the units (be it steel blocks or machinery units) that can be assembled on the ground, the more economical will be the production cost. It means greater crane capacity and engineering planning to achieve the maximum possible pre-assembled units.

Exhibit 11 shows the data of steel work efficiency against amount of steel repaired for various vessels. A detailed analysis revealed that the drastic improvement in efficiency of steel repair with increasing steel weight was largely attributed to the adoption of bigger block construction technique as the frequencies of its use increased with bigger amount of steel renewal.

(3) It is of utmost importance that workers must be educated and trained in the safe and efficient handling of the material/equipment. In JSL the needs for upgrading this particular aspect was realised in the early 1970's both for safety and productivity reasons. As a result workers/supervisors were trained for safe material handling methods and techniques and only workers/supervisors who passed the standard test were allowed to handle material/equipment.

(4) A preventive maintenance program of all lifting facilities is essential from both safety and

production points of view. In JSL, all cranes are subject to regular checking and maintenance.

Other lifting appliances such as chain blocks are subject to regular tests. All lifting wires are checked monthly and colour coded for a particular month.

(5) Greater engineering planning must be encouraged for the full utilisation of existing lifting facilities to increase production efficiency.

To illustrate the possibility of the use of big blocks for steel repair, a recent example of bottom damage repair will be outlined.

A 80,000 dwt tanker, sustained heavy bottom damage due to grounding. The extent of the damage amounted to 1,700 tons and stretched almost the entire length of the vessel. To repair the vessel in a conventional way of removal and refitting piece by piece will be a long labourious and uneconomical process. It was decided that block construction technique be adopted. The problem was then reduced to one of scrap removal and block insertion.

The extent of damage and the number of bottom blocks planned are shown in Exhibit 12. The maximum block weight is about 90 tons. The average block dimensions are 18m x 5m.

The method used for the removal and installation of steel blocks was by means of portable wooden skid beams arranged transversely at the dock bottom as shown in Exhibit 12. Top surface of the skid beams was coated with tallow and wax. Between the steel block and the skid beams (two transverse ring of block) wooden blocks to a height of 200mm were arranged.

The block to be installed was slided into position by the pulling of the crane through wire. Once in position, the block was lifted up by crane through vertical wire ropes. This was made possible by cutting small butterworth size openings on deck at suitable locations to allow passage of wire ropes. The use of a lifting spreader ensured that the lifting wires remained vertical. Wooden blocks were then arranged underneath the lifted block for support.

The removal of scrapped blocks maximum about 60 tons was done in the reverse procedure.

Scrap removal process was done in two stages. During the first stage as much damaged steel as could be removed without endangering the ship and dock bottoms strengths was removed. The dock wooden blocks were pre-arranged to leave unobstructed those areas where first stage cutting was to be carried out. Additional blocks being arranged to support other parts of the hull unaffected by the first cutting. After the installation of new blocks which were then supported by the wooden blocks, the cutting of the remaining damaged area was allowed to proceed.

Heating coils, piping and other fittings were installed at the block stage and thus the efficiency of outfitting work was also greatly increased.

3.2.3 Cyclical fluctuation of job volumes

Shiprepairing is subject to great fluctuation of job volumes. There is always the element of unpredictability. The impact of this fluctuation can be absorbed to a large extent by the use of subcontract labour. During the boom times, the number of subcontractors could be as high as 60% of the shipyard's own workforce.

However, the heavy reliance on subcontract labour has its own drawbacks as experienced by the Singapore yards:-

(1) During the boom times, the subcontract workers demand and often get unreasonably higher wages and more generous employment terms than the permanent workers. This leads to job hopping among the permanent workers to join sub-contractors.

(2) The subcontract workers often lack discipline and display their worst job attitudes when they are needed most.

(3) Because of their mobility, subcontract workers often receive little or no formal training from their transient employers. Employers are also unwilling to invest in employees who are not on their permanent payrolls. Such a situation retards productivity improvement.

While the subcontracting system cannot be totally eliminated for economic reasons, the extent of reliance on subcontractors can be minimised by better planning and greater utilisation of own permanent workers. This is the direction currently being followed by the major yards in Singapore. Workers are being systematically trained to equip them for multi-skills capability.

3.2.4 Short duration of repair and constant change of job specifications

Shiprepairing is characterised by short repair schedules. Most routine and normal repairs seldom exceed two weeks. Those exceeding one month will most probably be classified as major repairs or conversions. The repair specifications are often subject to constant changes as new items are added to the list. To deal with such changes quickly and to complete the repairs in time, the ship repair manager system is probably best.

However, this must be complemented by strong front-line supervisory personnel who are able to carry out the instructions, delegate and supervise works properly and have accurate daily feedback of the job progress.

In a constantly changing situation such as shiprepairing, simple but effective scheduling technique such as bar charts is probably best. On the higher level the ship repair manager will prepare his overall schedule with broad manpower planning to be followed by the various sections concerned.

This overall schedule is subject to daily review to assess job progress and to detect likely delays. In line with the overall schedule, the various sections in turn will have their own detailed schedules and manpower planning to meet the various datelines.

The overall dock and quay schedule which decides the critical events of each vessel's movement such as arrival, docking in, docking out, mooring, unmooring and delivery, is prepared by the yard manager who has to keep up to date the overall perspective.

The important thing is not the form and technique of scheduling but the judgement and thought behind it. In this respect there is no substitute for knowledge and experience to arrive at sound judgement.

Although in shiprepairing, material accounts for about 25% of the total cost, the availability of material in stock or quick procurement from the local market (sometimes overseas) is important on account of the short schedule.

Adequate stocks should be kept of basic materials such as steel plates and sections, welding electrodes, pipes, valves, flanges, etc. Care should be taken in selecting the kinds and quantities of material so that they represent the most commonly used standard materials to avoid creating non-moving stock. The tendency of "stockpiling" should also be discouraged. In other words, only keep minimum stock commensurate with smooth operation.

3.2.5 Global competition and service oriented industry

Shipping is very much an international business and so is commercial shiprepairing. So good communication infrastructure such as efficient international telephone and telex facilities is indispensible. Overseas marketing offices or agencies in key areas for business contacts and apportunities are essential.

To the shipowners, ships are too costly an investment to be spent idling. So not only the cost of repair but the time taken and the quality of the repair are all important factors for the owner's evaluation. All things being nearly equal, the owner is likely to award his repair contract to the yard he is most comfortable with, in other words to the yard who has established a good working relationship and won his confidence. Therefore good and consistent marketing and business attitude is just as important as good marketing and business strategy.

It is important to impart to the staff and employee this service oriented philosophy.

Incidentally, the quality control sector of JSL is placed under the direct control of the Production Controller intending to ensure that good and impartial standard of quality can be maintained.

3.2.6 Potential Hazards

Last but not least, the importance of safety cannot be overemphasized. The shiprepairing yards in Singapore have gone a long way to arrive at the present level of safety consciousness and environment. Still there is much room for further improvement. Of particular importance is the prevention of fire and explosion in hazardous and confined areas onboard ships and elsewhere. It is now a legal requirement to strictly implement a safe code for gas freeing and hot work procedure. Such a procedure is shown in the co-ordination chart and the checking system illustrated in Exhibit 14.

The procedure is to establish a system of clear communication and co-ordination where hot work (of open flame or spark producing nature) is involved in hazardous areas such as a cargo oil tank, even though the tank has been certified gas free. (It is a legal requirement for all ships coming for shore repair to be certified gas freed by the Govt. Chemist before port entry can be granted). The following is a brief description of the procedure.

1. Ship's Job Specification and General Arrangement

The Business Section after receiving confirmation of the job specifications from the owner of the vessel shall provide a copy of the specification to the Safety Section. The shiprepair manager who also receives copies of the specification from the Business Section shall indicate on the General Arrangement Plan for the vessel when hot work shall be carried out. A copy of this general plan shall then be given to the Safety Section.

The Safety Section shall then ensure the necessary requirement in the specification are strictly adhered to.

2. Cleaning of area for hot work

The shiprepair manager shall be responsible to arrange the cleaning of the area where hot work is to be carried out.

3. <u>Government Chemist - Hot Work/Gas Free Certificate</u>

When it is judged that the cleaning is adequately done, the shiprepair manager shall contact the Government Chemist for inspection to obtain the hot work certificate.

4. <u>Certificate Distribution</u>

The copies of the hot work certificate shall be distributed to the section concerned (the section who will be carrying out the hot work) and the Safety Section respectively.

5. <u>Location and Time of Hot Work</u>

The section concerned shall inform the Safety Section of the location and time of hot work everyday.

The engineer or foreman of the section concerned who will carry out hot work in the area will have to inform the shiprepair manager before the starting of hot work or oily works such as opening of pipes and overhauling of valves.

6. Safety Section

After receipt of copies of hot work and gas free certificate, the Safety Section shall then despatch a safety promoter to the vessel to verify that the area for hot work is safe. A daily check by a safety promoter shall be made of the area where hot work is carried out.

The daily gas checking report (supplement) should be submitted by the safety promoter to the shiprepair manager, the captain of the vessel and the section managers of the various sections once or twice a day.

If the safety promoter finds the area to be unsafe he is authorised to stop the hot work immediately and inform the section manager or engineer-in-charge of the dangers. The area shall then be cleaned and all unsafe acts removed before hot work can commence. The safety promoter shall at the same time inform the Safety Officer.

3.3 The Nature of Shipbuilding

Shipbuilding is a step up the technological ladder compared with shiprepairing. Many fundamental aspects of shiprepairing are equally applicable to shipbuilding. However, there are also distinct differences between the two which call for different considerations.

Exhibit 15 "Differences between shiprepairing and shipbuilding industries" highlights the differences between shipbuilding and shiprepairing.

3.3.1 Sporadic works versus assembly flow line

One of the marked differences between shiprepairing and shipbuilding is that shipbuilding lends itself readily to the modern concept of assembly line production. Infact modern shipyards are planned along an assembly line production sequence in which there is a logical flow of materials to assembly areas and an orderly flow of assemblies to the building site. As the larger the units that can be assembled, the more economical will be the production, the crane capacity is usually much larger than is required for a purely shiprepairing yard. Mechanisation and rationalisation of process can be readily introduced at the various work stations along the flow line. Thus, while shiprepairing is rather limited in the extent of mechanization due to its sporadic work nature, shipbuilding has almost unlimited mechanisation possibilities. However, over-mechanisation which means high capital investment can also run into economic difficulties if there is no sustained production demand to match the production capacities. Therefore the desired degree of mechanisation is not only a question of technology but of economy.

Exhibit 16 illustrates the work flow for newbuilding and conversion at Newship Division. Exhibit 17 gives the physical locations of the various stages. The production flow will now be briefly explained.

1. Steel Material Storage (Bay No. 1)

Steel material falls into two categories:
Steel plates and sections. They are usually unloaded directly from ships which come alongside the unloading quay (North Quay). Each shipment may be up to 5000 tons. the unloading is carried out using the shore 20T jig crane onto a conveyor system which transports most of the material into the covered storage area (Bay No. 1) and the rest to the open storage areas. The material is arranged into piles of about 200 tons each according to the types of fabrication to be undergone. It is usual to arrange them in "block" units and in a pattern which will suit the shotblasting and fabrication sequence. As the material has to be handled frequently

and quickly, two overhead cranes of 20t and 10t are installed. Exhibit 18 shows the overhead cranes facilities of the various hull shops.

2. Surface Treatment (Bay No. 1)

For better anti-corrosion protection and coating effect, the material is then gone through the shot-blasting and painting machine installed in the storage area to remove dust, mill scale and other particles and coated with suitable shop primer. The maximum plate width which can be accommodated by the machine is 4m. Low lying sections where the height does not exceed 200mm can also be treated by the machine in batches.

3. Fabrication (Bay No. 2 and No. 3)

Steel material is transported through a transverse conveyor to the fabrication shops (Bay No. 2 and Bay No. 3) next to Bay No. 1. There are several lines of fabrication process as outlined in Exhibit 19.

Line No. 1 is primarily for the fabrication of skin plates. Gas cutting and edge preparation for submerged arc joining process is normally done by flame planner in Bay No. 2 for speed and accuracy. Where plates are required to be bent, they are transferred to the bending and press area in Bay No. 3 through transverse conveyor for presswork and line heating. The fabricated plates are then transferred to their respective storage areas. The flame planner has a rail span of 7m and length of 35m. It is equipped with 4 sets of multi-nozzle gas cutters for edge preparation and 10 sets of cutting torches for flat bar cutting.

Line No. 2 is primarily for the fabrication of internals. Marking is done on a conveyor chain line installed in Bay No. 2 leading to a stationary gas cutting station equipped with semi-automatic cutting machines. The speed of the conveyor regulates the speed of the marking and cutting process. Cut pieces are then cleared away and sorted into orderly piles. Unwanted scraps fall automatically into a scrap pit for periodic clearing. Pieces such as flanged brackets, face plates which require bending work are sent to Bay No. 3.

Line No. 3 in Bay 3 is for the marking and gas cutting of curved plates and sections in stationary beds. The cut pieces are cleared away and sorted into orderly piles, where bending work is required, the pieces are sent to the bending bay for treatment. All markings are done manually by means of full scale moulds and tapes prepared by the mould loft which also issues the nesting plans (cutting plans) for maximum utilisation of materials.

4. Bending (Bay No. 3)

As described earlier, plates and sections which require bending are sent to the bending and press station in Bay No. 3.

Plates for bending are usually treated by the vertical oil hydraulic press of 500t capacity. For more complicated bending, finishing is done by line heating to attain the desired curvature.

Flanged brackets are pressed by the hydraulic press while sections and face plates by a horizontal flame bender. Finishing is done by line heating.

The wooden bending moulds required for the bending process are prepared by the mould loft.

5. Sub-Assembly (Bay No. 2 and No. 3)

Between the assembly and fabrication stages, it is generally considered to be more efficient to introduce another intermediate stage where smaller units, panels, built-ups, etc can be pre-assembled before reaching the assembly area. Hence the sub-assembly stage.

In the process of sub-assembly, larger members such as web plates, panels are usually laid horizontally and smaller pieces such as stiffeners, brackets and face plates are arranged, fitted and welded onto the larger members. The assembled units are then overturned onto a raised open jig platform where welding distortion is eliminated by line heating and the pieces for the reverse side are then fitted and welded. Each unit so assembled is usually less than 20 tons. They are then stored on the pallets for easy storage and transportation.

Exhibit 20 illustrates a typical process of sub-assembly.

The sub-assembly plans are prepared by the mould loft.

6. Submerged Arc Welding Station (Bay No. 2)

This is the area when joining of flat skin plates are carried out by the submerged arc welding process. The plating is usually overturned for submerged arc welding on the reverse side. Therefore high headroom is necessary for the overturning process.

The welded panel which is the full extent of an assembly block is then marked as a whole by "finished marking tapes" prepared by the mould loft.

7. Assembly (Bay No. 2 and No. 3)

This is the heart of the entire assembly line process. The assembly blocks can be classified into the following broad categories:-

1. Flat block (e.g. parallel parts).
2. Semi-flat block (e.g. engine room double bottom block).
3. Curved block (e.g. side shell blocks).
4. Cubic block (e.g. fore and aft parts).

The aim being to assemble the largest possible units subject only to handling and space limitations.

Different processes of assembly are chosen to suit the different categories.

Exhibit 21 - illustrates the different methods which can be adopted for assembling flat blocks.

Exhibit 22 - illustrates one method of assembling semi-flat blocks.

Exhibit 23 - illustrates one method of assembling curved blocks.

Exhibit 24 - illustrates one method of assembling cubic blocks.

The assembled blocks are then transported out to the block storage area by trailers o a hydraulic jacking and buggy system which has a carrying capacity of 300 tons and is linked via rails to the erection site adjacent to the building dock.

8. Pre-erection (Outdoor)

This stage may or may not be required depending on the building circumstances. This is an intermediate stage between assembly and erection whereby two or more assembly blocks are combined together into yet bigger units so that the erection work and schedule can be reduced. Another advantage of this system is that surplus labour which is brought about from the early and later stages of erection can be utilised for the pre-erection work.

9. Advanced Outfitting System

Along with the hull construction flow, outfitting is also organised according to the sequence of assembly blocks production so that pipe pieces fittings and equipment that go into a particular block can be palleted and fitted on the assembled blocks on the ground before reaching the erection stage.

Large items such as main engine, boilers and windlasses are handled as unit items. But pipe pieces, fittings and the like are handled in bulk. This bulk is called a pallet. But a pallet here need not mean a physical container. It is the term given to a collection of fitting materials needed for a particular block. In practice, the item may be contained in a pallet as in the case of pipe pieces, or the item may be picked up from the storage area and palleted while loading onto the transportation vehicles.

Palleting is therefore a highly organised activity. It is aided by the so called MLF Lists prepared by the Design Department. A MLF list gives a breakdown of the items required for a particular block's outfitting requirement. The MLF list serves as an important control document as far as outfitting activities are concerned.

Fittings that cannot be done at the assembly stage are palleted for the erection stage in a similar manner.

10. Painting

When an assembled block is completed and inspected, surface cleaning and preparation is carried out and the block painted accordingly to the Painting Specifications. The erection joints and areas that need to be protected from painting are suitably covered.

This process reduces considerable amount of painting work that needs to be carried out at the erection stage.

11. Erection

The erection of the assembled blocks is carried out on a building dock. Before the commencement of fabrication, the block erection sequence must be decided, for this is the basis on which assembly blocks sequence, sub-assembly and fabrication sequence are planned. The supporting wooden blocks are also arranged to bear the weight of the assembled blocks to be loaded.

Prior to block erection, lifting eye pieces, scaffolding, fittings must be arranged for the convenience of the erection process. The blocks are then lifted by the level luffing cranes (80t and 150t capacities) installed on each side of the building dock. Heavier blocks will need the combination of both cranes for lifting and loading on the actual locations on the building dock.

After loading, the block is adjusted and fitted to the adjacent block. The welding of the erection joints follows closely after.

The so-called semi-tandem system of building was adopted when freedom series were constructed. In this method of building, the first ship and the aft half of the second ship are built at the time in the single building dock of 335m x 56m x 11m. The aft half of the second ship which contains the engine room is being built next to the foreside of the first ship. When the first ship is launched the aft half of the second ship is shifted to the same position previously occupied by the aft half of the first ship and the rest is built. At the same time the aft half of the third ship is built next to the second ship. In this way proper balance of outfitting work and hull construction work is maintained leading to higher operational efficiency.

12. Afloat Outfitting

When the erection work is completed, the ship is floated out of the building dock and transferred to the outfitting quay. Remaining outfitting works and accommodation works continue until completion.

3.3.2 Short schedule versus long schedule

Shiprepairing is characterised by short schedule during which there is a great concentration of manpower and activities to finish the repair in the shortest possible time. This sense of urgency has a self motivating effect on the workforce and helps to keep the schedule in check. At the same time there are periods of relative slackness when the work tension is eased.

As shipbuilding works to a schedule of several months or longer for each new vessel, this psychological sense of urgency is less except perhaps towards the end of the building process when the ship is about to be launched or delivered. Added to this is a monotonous work routine as apposed to varieties in shiprepairing. There is therefore less motivation and a tendency for the workforce to slack until the last moment. On the other hand a long schedule has the advantage of flexibility in planning to even out the workload.

Two other major factors, namely, the drawings and the materials/equipment have a direct bearing on the overall schedule as well.

Therefore an effective scheduling and control system must take into consideration the above mentioned factors. Usually the scheduling and control techniques should follow the op down system as follows:-

First, the Master Building Schedule must be decided by the top production executive such as the General Manager or the Yard Manager. This serves as the blue plan for the entire production operation. This master building schedule is necessarily brief and contains only the major principal events for the ships to be built such as contract signing, the commencement of fabrication, keel laying, launching and delivery of each vessel.

Although the master building schedule consists of the barest outlines, it is based on past performance and on appropriate production parameters determined from a long-range viewpoint. It has taken into account the production capacity of the facilities, the capacity of the workforce, the shipowner's requirement, the time needed for the preparation of drawings and material procurement, etc.

Second, based on the principal dates of the master building schedule, the block erection schedule is next established (in other words the dates and loading sequence of the assembled units on the building dock) by the hull erection.

This then serves as the basis for the preparation forward of onboard outfitting schedule, and backwards of block assembly schedule, sub-assembly schedule, fabrication schedule, drawing schedule and on block outfitting schedule by the individual sections concerned. All schedules being geared towards meeting the target dates as stated in the Master Building Schedule.

Next, other minor detailed schedules such as the daily crane usage schedule, pipe fabrication schedule may then be drawn up for daily and weekly control.

In this system of top-down Scheduling Control, a system is established by which the schedules are drawn up, beginning with the major schedules and then the minor schedules, When drawing up minor schedules, the major schedules are not to be altered.

In order to monitor the work progress at various stages, weekly check should be made against the respective schedules and countermeasures taken to rectify delay. Apart from scheduling other production monitoring yardsticks can be used to monitor progress and efficiency such as production weight per month, the man-hour achieved per ton of production. The establishment of such tangible targets such as the production weight per month and the man-hour per ton help to challenge the workforce and instil a sense of motivation.

.3.3.3 Labour Cost Versus Material Cost

Although shipbuilding is also labour intensive the cost of the material/machinery components that go into making the ship is by far the larger cost component. The cost of the material portion is in the region of 70% - 80% as compared to some 15% - 20% in shiprepairing. Therefore material cost is the added element the control of which is of paramount importance. The successful shipyard must incorporate into its production control system an effective means of material control.

Material cost control should be exercised throughout the entire shipbuilding cycle starting with the basic design of the vessel.

The material cost control strategies should include the following:-

1. Material cost (Production cost) - oriented design
   e.g. Optimum choice of basic materials/machinery

leading to saving in cost without sacrificing functions intended. Simplication of systems. Rationalisation of structural system.

2. Setting up a production design stage between key design and production to rationalise production in terms of material and labour.
   e.g. Rationalisation of piping and fitting arrangement.

3. Setting up of a material cost budget and monitoring system.

4. Material saving measures during production such as reducing material scrap percentage, welding electrodes wastage.

5. Development of a strong procurement department.

6. Towards material standardisation.

The long-term cost control strategy however must involve the development of a strong local ships components supporting industry in order to cut down the imported content of the materials and equipment.

3.3.4 **Design is an essential element**

As the normal routine in shiprepairing is overhauling or replacement, little design activity is involved. In most cases a few staff who are also part of an inspection group will suffice for producing repair plans. Steel repair can also be adequately handled by the mould loft.

For shipbuilding and for major conversions, a design capability is essential from both marketing and production points of view.

There are 3 levels of design activities:-

1. Basic Design
2. Key Plan Design
3. Production Design

1. **Basic Design**

This is the highest level of design activities which deals with feasibility studies, economic parameters, initial cost estimation, the determination of basic ship types, principal dimensions, basic arrangement and configuration, powering requirements, etc.

In other words, the fundamentals of ship design.

Basic design has 3 phases namely Conceptual, Preliminary and Contractual.

The conceptual phase is largely exploratory, translating the mission requirements into naval architectual and engineering alternatives and possibilities. Essentially it deals with technical feasibility studies to determine such fundamental elements of the proposed ship as the principal dimensions, powering, basic arrangement or alternative sets of characteristics, all of which meet the required speed, cargo cubic and deadweight. The initial cost estimates follow to enable the most economical solution to be chosen. This phase is usually summarised into a brief outline specification and an outline general arrangement or specifications (where there are alternatives) in which only the most fundamental and cost influencing elements will be reflected. They are accompanied by initial cost estimates for the various alternatives.

Once a particular concept design is selected, the preliminary design phase carries the study a step further to confirm and further refine the major ship characteristics affecting cost and performance. For example, the preliminary hull form is now defined to enable speed, trim and stability, capacities etc. to be checked. The general arrangement will now incorporate more features. The structural Midship Section and Steel Scantling Plan and profile will take shape. This phase of the design is usually summarised by a preliminary specification which provide a precise definition of the vessel. It may also be accompanied by supplementary drawings and calculations such as the Midship Section, steel scantling plan and profile, preliminary trim and stability booklet, power and speed prediction, capacity plan and selected piping diagrams.

The preliminary design forms the basis for serious cost estimation on the part of the shipyard and further evaluation on the part of the ship owner. As successful bid will lead to be contractual design phase in which a further refinement is made on the preliminary design loop and slight modifications made to incorporate comments arising from the latest evaluation. The specification and general arrangement which develop will now form an integral part of the ship contract document.

Basic design requires design know-how, a wealth of data, research and high calibre staff with innovative ideas who are capable of sound theoretical analysis and have been exposed to a wide range of fundamental design problems.

This is an area of expertise which represents the last "stronghold" of technology transfer and the acquisition of which is an invaluable asset and will put the shipyard on an independant footing and enhance its flexibility as to the range of ship types that can be marketed and built.

However, most developing shipyards are usually limited by the experience and resources in developing a credible basic design capability within a relatively short time. For the initial stages, it is therefore necessary to rely on foreign or imported basic design or enter into a technical tie-up with some consultant firms.

Every attempt however must be made to enter into the realm of basic design for the development of which holds the key to greater engineering capabilities.

2. Key Plan Design

Key plan design works within the framework of the basic design. The design parameters determined in the basic design process are not altered.

Key plan design has the following functions:-

1. Further refinement of the basic design loop in the light of design development. The amount of refinement to be done depends largely on the quality of the basic design. This process of refinement is brought to its completion at the completion of the vessel when the inclining experiment and deadweight measurement is carried out and when the performance of the vessel is tested at the sea trial. The final results are analysed, documented and used to produce the final trim and stability booklet.

2. Study into the technical and functional aspects of the various systems and sub-systems not covered by the Basic Design. Preparation of basic arrangements and Schematic drawings for piping, ventilation, electrical cabling, etc. not covered by the Basic Design.

3. Purchase ordering specifications for raw materials, equipment and machinery items.

The key plan design process involves on the one hand external parties such as the owner, the Classification Society and the equipment manufacturers and on the other hand internal parties such as the production and purchasing departments. For this reason, it is strongly recommended that the key plan design be handled by the shipyard's design team who know the shipyard's production and purchasing requirements and therefore are in a better position to preparo production-oriented drawings and co-ordinate with external bodies.

3. Production Design

Production design has been termed detailed design. But it is infact more than detailed design. It is design for production. Therefore production design convey a better meaning. For an assembly flow line type of production, production design (or yard plans) is indispensible. Production design embodies the technological aspect of design, "how to build". It must take account of the shipyard's facilities and building system and explore the best way of building. For an assembly flow line system, the fundamental decision is the way in which the ship is to be assembled. This is then reflected in the assembly block arrangement drawing indicating how the ship is to be divided into assembly units and the block loading sequence at the erection stage. Hull construction drawings are then produced to suit the block divisions and construction techniques (e.g. sub-divisions of an assembly block to suit sub-assembly units). Piping and fitting arrangement drawings are produced to suit the block construction technique, so that advanced outfitting can be done at the assembly stage following after the assembly blocks production sequence. For this purpose pipe piece drawings, fabrication drawings of fittings and the MLF lists are produced in advance to suit the production schedules.

Good and timely production drawings lead to a smooth flow of production and results in considerable saving in material and labour costs. Therefore design should be treated as part of the production process. In the Plan-Do-See cycle, Design is the "Plan" stage, production is the "Do" stage and review and feedback is the "See" stage. Constant co-ordination and review between the production and design will result in better design which in turn lead to better production.

4. CURRENT PROBLEMS AND COUNTERMEASURES

The phenomenal growth of the marine industry in Singapore is not without its shortcomings and with the present world-wide economic recession there are challenges to be surmounted.

4.1 Current Problems

Some of the shortcomings can be identified as follows:-

1. The decade of rapid growth has led to an over-expansion of shiprepairing facilities. On the other hand, the sharp increases in crude oil prices in 1973 and 1978 and the sluggish economic growth has triggered irrevocable structural changes in the shipping industry. For example, there is an absolute decline in the tanker repair market from a permanent reduction in worldwide oil consumption. In other words there is an over-supply and shrinking demand situation as far as shiprepairing is concerned.

2. The rapid economic growth has led to escalating wages and at the same time the heavy nature of the industry leads to increasing difficulties in

attracting fresh employees as there are more and more other employment opportunities elsewhere.

3. In the course of rapid progress, there was less time and attention spent on review, gathering and compilation of data, setting up of yard's standards, etc. which are needed in order to consolidate the technical base. There is still a lack in basic design and engineering capability which limits the scope of operations.

4.2 Counter Measures

The countermeasures being taken seriously by the marine industry in Singapore as a whole are mainly directed towards the above weaknesses.

They accordingly can be summarised into a 3-prong strategy:-

1. Towards diversification
2. Towards higher productivity
3. Towards greater design capability

4.2.1 Towards diversification

To make full use of facilities and manpower, many yards have diversified or are in the process of diversifying their operations into related steel fabrication and engineering activities e.g. onshore and offshore steel structures, offshore production and accommodation modules, fabrication of crane structures, marine terminals.

4.2.2 Towards greater productivity through human resource development and mechanisation

To combat escalating wages and scarce human resources, there are only two possibilities, namely more efficient use of the human resource and mechanisation.

As was pointed out earlier, shiprepairing is labour-intensive and has limited mechanisation possibilities. Though shipbuilding process can be highly mechanised the level of mechanisation should be synchronised with the wage and efficiency level of the labour force to achieve cost effectiveness. Therefore the human resource remains the key factor. This is the area that has been given the most attention by the shipyards in Singapore.

The Singapore Government has actively encouraged the upgrading and training of employees through the Skill Development Fund which was set up specifically for the promotion of such trainings which lead to the upgrading of skills of the employees. The shipyards have been able to utilise this Fund for the development of multi-skill workforce (job enlargement), supervisory and managerial skills of the managerial staff. The Quality Control Circles movement which has had tremendous success in Japan is being experimented here as well. This is potentially a powerful movement which if implemented with success will lead to self-motivation of employees towards higher quality and productivity.

On the aspect of mechanisation, the present level of mechanisation is considered adequate for shiprepairing. Even in shipbuilding substantial mechanisation as a total system is not anticipated in the near future since the ships to be built are likely to be small and medium, specialised and varied. Therefore the growth strategy is in minor mechanisation measures to

a) Increase work efficiency by means of better tools, equipment.

   e.g. Gravity welders, co2 welding, submerged arc welding, jigs & fixtures for in-situ machining work. Flame Planner.

b) Improve safety and working environment.

e.g. Steel scaffolding, travelling stages for painting in drydock.

4.2.3 Towards Greater Design Capability

As pointed out earlier the design capability is essential from both marketing and production view points for shipbuilding and conversions. The marketing capability of a shipyard will be greatly enhanced if it can assist shipowners in feasibility studies and offer projects on a turn-key basis. The productivity will be greatly enhanced with improved production design capability. The short-turn strategy calls for the followings:-

a) in-house training of existing staff to upgrade their skills.

b) the recruitment of high calibre staff (local and foreign).

c) the setting up of the yard's internal standards of materials, quality, etc.

d) technical tie-up with consultants, higher institutions.

The long-term strategy will involve the industry as a whole in collective and co-ordinated efforts to develop a technology and research centre. A Marine Development Centre has actually been conceived and proposed as joint effort in this direction. The proposed scheme outlined the following as the main functions:-

1. <u>Information</u>

a) To set up and maintain a computerised technical data bank. Input will come from shipyards, other local sources and may even be purchased from abroad. It will include information on ship and rig designs, building and repair techniques, and marine and offshore equipment and machinery.

b) To set up a technical library with lending and reference facilities. At present, this basic facility is lacking.

c) To assist the industry to keep abreast of technological advances and arrange for the disemination of such information through technical bulletins, seminars, talks, films and demonstrations.

2. Design Service

a) To undertake design projects for the industry and assist yards in developing new ship types to suit specific trade/route requirements. This will include feasibility studies.

b) To assist shiprepairers in undertaking conversion and modification projects on a turn-key basis e.g. re-engining of ships.

3. Productivity Services

a) To determine how productivity may be measured and improved and set realistic targets for the industry.

b) To assist shipyards in identifying shipbuilding and rig construction processes where improvements are possible. These will include yard layout, organisation flow, planning and scheduling and quality control.

5. PROPOSALS FOR CO-OPERATION AMONG DEVELOPING COUNTRIES

The foregoing is an attempt to present the Singapore experience in the development of its shiprepairing and shipbuilding industry. It is hoped that the experience itself will prove a useful reference for other developing countries engaged in the similar process of industrialisation.

Singapore has benefitted from the technology transfer of shiprepairing and shipbuilding expertise from developed countries. Especially in shiprepairing, the technology and facilities are well developed and established. Such transfer of technology was invariably achieved through joint ventures with the developed countries. In a similar manner Singapore can inturn transfer its technology through joint ventures to other developing countries. The case for technology transfer from a developing economy to another is stronger since the technology has already undergone an adaptation process to suit an developing environment.

Short of a joint venture there are other possibilities through which the Singapore experience can be shared such as:-

1. Technical and management consultancy and assistance in the setting up and operation of a shiprepairing and shipbuilding yards.

2. On the job training in management, supervisory and other skills at established yards in Singapore.

3. Study team to investigate the relevant aspects of the Singapore Marine Industry.

4. The proposed Marine Department Centre could be extended to provide design and engineering services on a regional level.

The development of the shiprepairing and shipbuilding industry on an international scale cannot be viewed in isolation of other economic and social factors. Regional balance must also be considered to avoid the situation of duplication of facilities to the detriment of all parties involved. There is therefore a need for complementary regional development rather than independent development.

A comprehensive survey of the domestic market demands of the countries concerned and future trends of regional shipping will be required before a complementary strategy can be mapped out.

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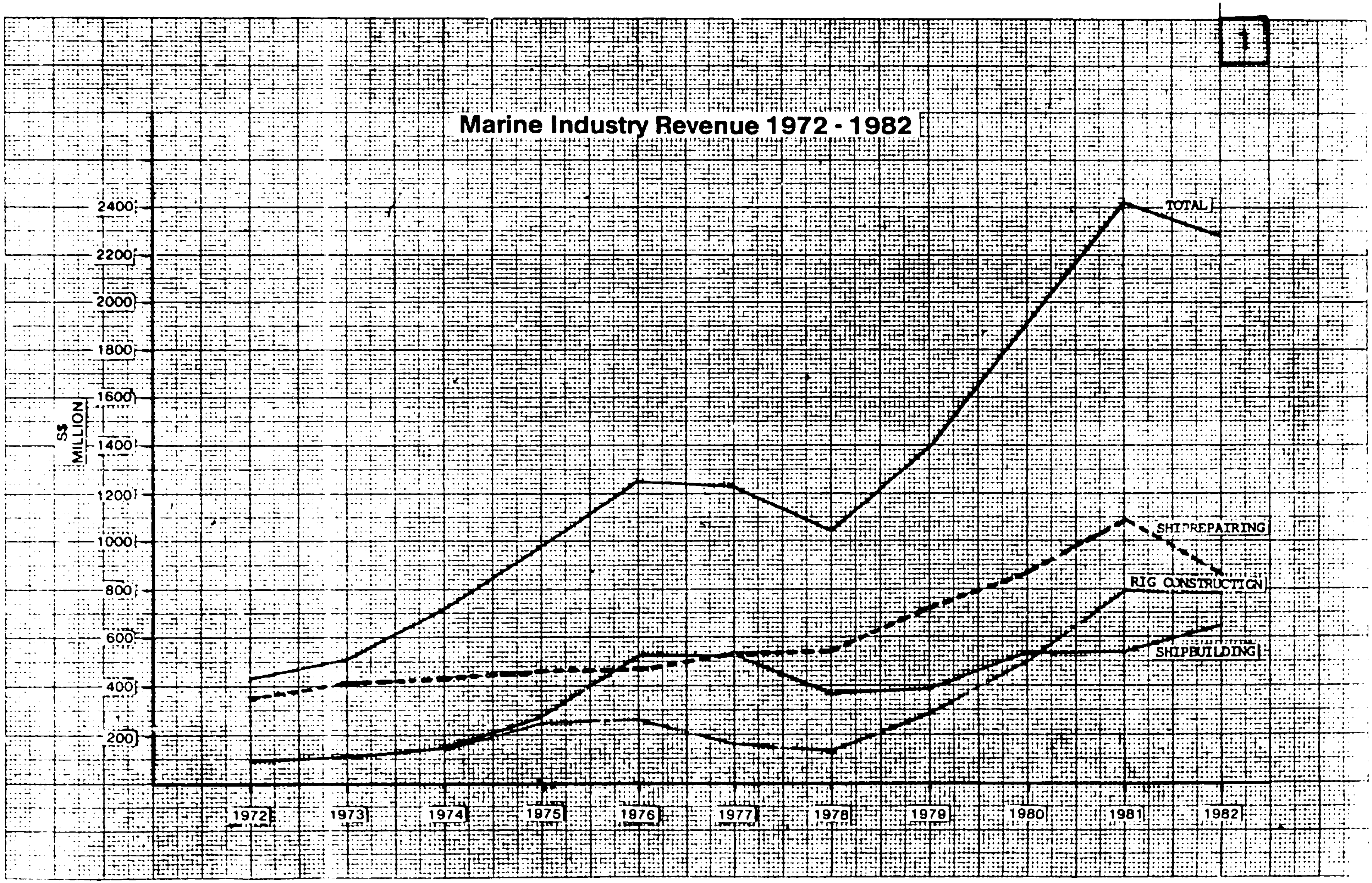
EXHIBITS


Marine Industry Revenue 1972 - 1982
S$ MILLION
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
TOTAL
SHIPREPAIRING
RIG CONSTRUCTION
SHIPBUILDING
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982

STATISTICS OF SLIPWAYS

SLIPWAYS IN SINGAPORE AS AT 30 JUNE 1983		
CAPACITY (TONNES)	NO.	TOTAL TONNAGE
Below 199	5	680
200 - 399	3	800
400 - 599	7	3,300
600 - 799	1	600
800 - 999	3	2,400
1,000 - 1,199	-	-
1,200 - 1,399	5	6.250
1,400 - 1,599	3	4,400
1,600 - 1,799	-	-
1,800 - 1,999	1	1,800
2,000 and above	6	42,000*
TOTAL	34	62,230

*Note: *2 units of 2000 dwt each for new building.*

2

AND DRYDOCKS AS AT JUNE 1983

DRYDOCKS IN SINGAPORE AS AT 30 JUNE 1983			
DWT	NO.	TOTAL DWT	REMARKS
Below 5,000	1	4,000	
5,000 - 29,999	6	43,000	One 10,000 DWT (F)* One 10,000 DWT (S)*
30,000 - 49,999	4	140,000	One 30,000 DWT (F)* One 40,000 DWT (F)*
50,000 - 99,999	1	90,000	
100,000 - 149,999	1	100,000	
150,000 - 199,999	3	470,000	One 150,000 DWT (F)*
200,000 - 399,999	4	1,180,000	
400,000 and above	2	800,000	
TOTAL	22	2,827,000	

Note : *F* : Floating dock*
S : Syncrolift*

STATISTICS OF SHIPBUILDING (1978-1982)

VESSELS LAUNCHED: 1978 - 1982

Type of Vessel	1978		1979		1980		1981		1982	
	No.	Total GRT	No.	Total GRT	No.	Total GRT	No.	Total GRT	No.	Total GRT
Barges	98	71,753	125	69,943	317	172,604	315	211,226	229	163,298
Tugs	40	3,603	24	2,419	32	6,716	40	9,054	41	9,925
Cargo Vessels	21	41,786	9	20,172	6	13,619	10	13,848	6	16,629
Tankers	3	31,080	2	1,087	3	1,854	2	4,487	-	-
Supply/Utility Vessels	15	3,006	9	3,096	14	5,830	17	9,441	29	16,965
Patrol Craft	4	700	5	.291	3	274	1	-	1	492
Landing Craft and Dredgers	17	10,422	8	4,902	12	2,233	6	3,400	13	5,231
Ferries/Launches/ Others	15	1,674	12	2,248	18	9,047	11	6,086	12	2,762
TOTAL	213	164,024	194	104,158	405	212,177	402	257,542	331	215,302

STATISTICS OF OIL RIG CONSTRUCTION (1970 - 1982)

OIL RIG CONSTRUCTION — **YEAR 1970 TO 1982**

TYPE	70	71	72	73	74	75	76	77	78	79	80	81	82	TOTAL
Jack-up	1	1	3	2	4	7	8	4	2	9	11	15	16	83
Drilling Tender	-	1	1	-	1	2	1	-	1	-	1	3	2	13
Drill Barge	-	-	-	1	-	1	-	-	-	-	-	-	-	2
Submersible	-	-	-	1	-	-	-	-	-	-	-	-	-	1
Semi-Submersible	-	-	-	-	2	-	-	1	-	-	-	-	-	3
Drill Ship	-	-	-	-	-	1	2	1	-	-	-	-	1*	5
Semi-Submersible Accommodation Unit	-	-	-	-	-	-	-	-	-	-	-	-	1	1
TOTAL	1	2	4	4	7	11	11	6	3	9	12	18	20	108

**Conversion from a bulk carrier to a drillship.*

Layout and Facilities

Repairship Division (RSD) (Pulau Samulun)

Dock

	Size	Capacities
No 1	270 M x 40 M x 10 M	90,000 DWT
No 2	300 M x 56 M x 13 M	300,000 DWT

Quay

South Quay	470 M Max. Draft — 30'
East Quay	110 M Max. Draft — 15'
West Quay	270 M Max. Draft — 18'

Crane

Capacity	Location	Reach (Radius/Ton)	Nos.
80 T	Dock Side	58M x 40T 30M x 80T	1
45 T	Dock Side	45M x 30T 28M x 45T	1
15 T	Slipway S/O	38M x 7.5T 27M x 15T	1
10 T	W/O	50M x 5T 25M x 10T	1
10 T	W/O	32M x 5T 15M x 10T	1
10 T	Dock Side S/O E	50M x 5T 28M x 10T	2
5 T	S/O W	30M x 2.5T 24M x 5T	1

12 OHC of various capacities in shops and 1 Gantry Crane in fitting area

Compressor

Capacities	Locations	Nos.
27.8m³/min. at 7kg/cm²	South Quay	1
56.2m³/min. at 7kg/cm²	South Quay	1
27.8m³/min. at 7kg/cm²	Berth M/Loft	2

Machine Shop

Dynamic Balancing M/C - 2,500 mm x 13 Ton

Dynamic Balancing M/C - 1,800 mm x 1 Ton

Shaft Lathe - 3,000 mm x 15,000 mm

Shaft Lathe - 1,200 mm x 8,000 mm

Horizontal Boring Machine - Spindle Dia — 110 mm

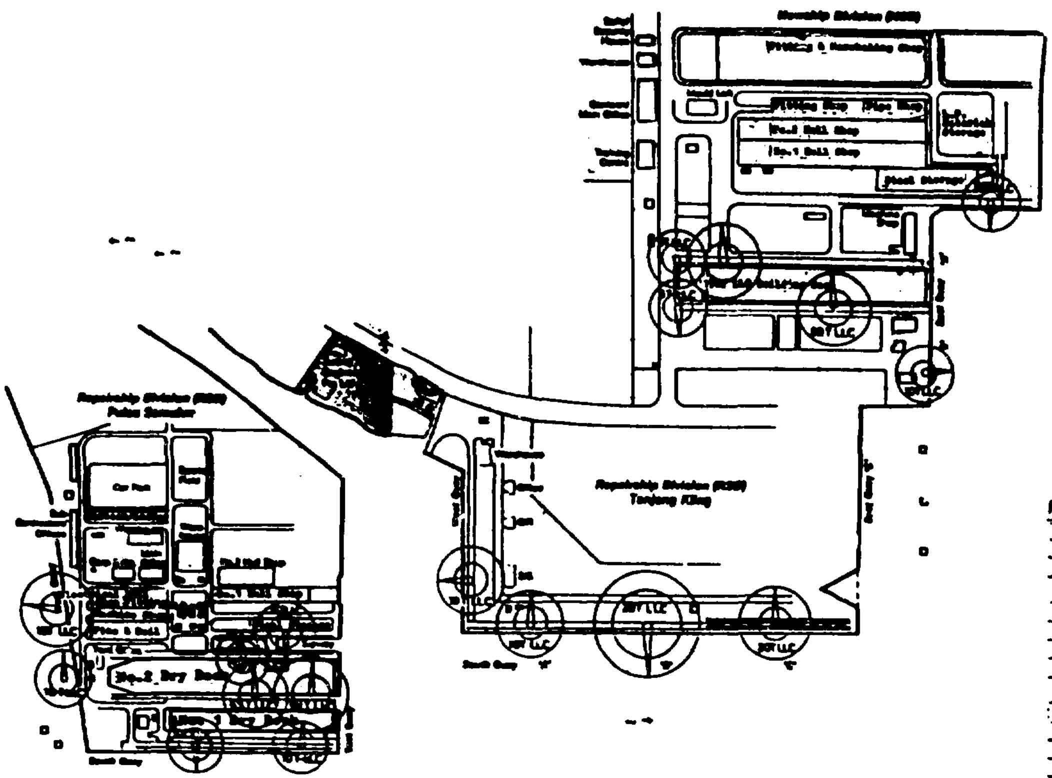
Rewinding Shop

Motor Generator

Capacity	Location	Purpose
500 KVA	Sub-Stn 'A'	Shore Supply
300 KVA	Sub-Stn 'A'	Shore Supply
500 KVA x 2	Sub-Stn 'E'	Shore Supply
500 KVA	Sub-Stn 'D'	Shore Supply

Water Pump

Capacity	Head(m)	Motor Output	Location	Nos.	Type of Liquid
800 T/H	70	300 HP	P/H (RSD)	1	Sea Water
500 T/H	40	110 KW	P/H (RSD)	1	Sea Water
300 T/H	70	150 HP	T.K. S/O 'C'	1	Sea Water
200 T/H Booster	70	100 HP	In front of No. 2 Dock	1	Fresh Water
200 T/H	45	30 KW	P/H (RSD)	2	Sea Water
150 T/H	50	40 HP	W/O (RSD)	2	Industrial Water
100 T/H	50	30 KW	S/O (RSD)	1	Sea Water
100 T/H	50	30 KW	T.K. W/O T.K. S/O 'A'	2	Sea Water
100 T/H	50	22 HP	W/O (RSD)	1	Sea Water
For Fire Fighting					
200 T/H	80	60 HP	Comp. Rm (RSD) Comp. Rm (T.K.)	2	Fresh Water
200 T/H	40	30 KW	Comp. Rm (RSD)	1	Fresh Water
150 T/H	40	30 KW	Comp. Rm (T.K.)	1	Fresh Water



Repairship Division (RSD) (Tanjong Kling)

Quay

South Quay A, B, C	650 M	Max. Draft: 30'
West Quay	240 M	Max. Draft: 18'
East Quay 'C'	366 M	(Future Expansion)

Crane

Capacity	Location	Reach (Radius/Ton)	Nos.
20 T	S/O 'B', 'C'	60M x 10T 42M x 20T	1
20 T	S/O 'B', 'C'	70M x 10T 50M x 20T	1
10 T	S/O 'A'	50M x 5T 28M x 10T	1
10 T	W/O	50M x 5T 28M x 10T	1

Motor Generator

Capacity	Location	Purpose
500 KVA x 2	Sub-Stn. 'A'	Shore
1000 KVA	Sub-Stn. 'B'	Supply

Newship Division (NSD)

Building Dock

Capacity	Size
335M x 56M x 11M	200 000 DWT

Quay

North Quay — 129M — Max. Draft — 17'

East Quay 'A' — 95M — Max. Draft — 17'

East Quay 'B' — 110M — Max. Draft — 17'

Crane

Capacity	Location	Reach (Radius/Ton)	Nos
150 T	Dock Side	60M x 75T 36M x 150T	1
80 T	Dock Side	56M x 40T 30M x 80T	1
20 T	N/Quay	38M x 10T 15M x 20T	1
10 T	E/O 'B'	40M x 5T 25M x 10T	1
5 T	Dock Side	35M x 1.5T 15M x 5T	2

16 OHC of various capacities in shop

8 Gantry Cranes of various capacities in storage & fitting areas.

Compressor

Capacities	No. of Sets
55.2m³/min. at 7kg/cm²	3 Sets

Motor Generator

Capacities	Locations	Purpose
180 KVA	Sub-Stn E-2	Shore
500 KVA	Sub-Stn. K	Supply

Water Pump

Capacity	Head(M)	Location	Nos.	Type of Liquid
180 T/H	30 M	Comp. Rm	2	Fresh Water
110 T/H	32 M	No. 2 Gate	1	Industrial Water

6

THE NATURE OF SHIPREPAIRING

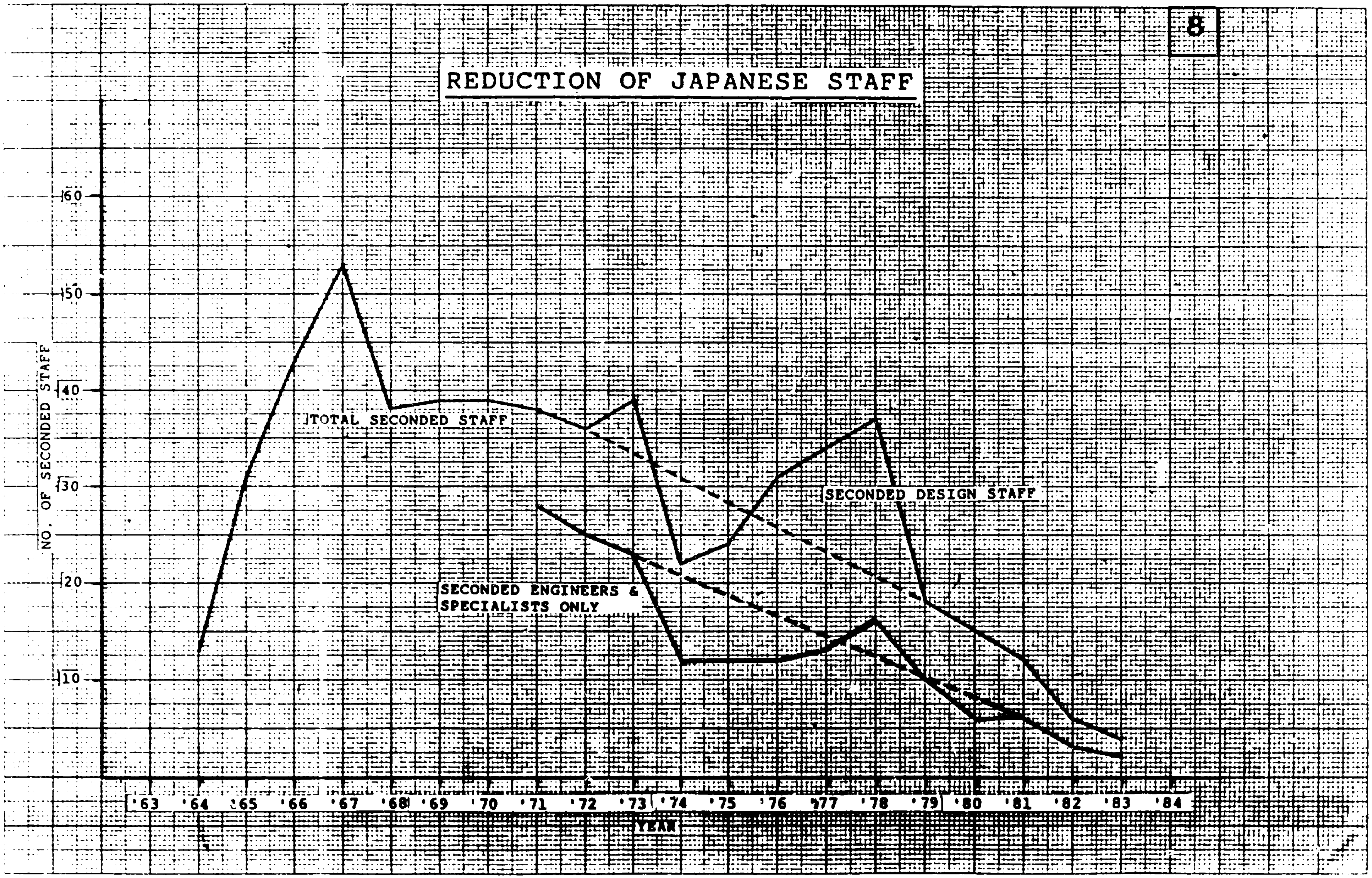
NATURE OF SHIPREPAIRING	KEY AREA INFLUENCED BY SUCH NATURE
(1)COMPLEXITY OF SYSTEM INVOLVED	1. RANGE OF FACILITIES 2. PROJECT MANAGEMENT MUST SUIT COMPLEXITY 3. MANPOWER SKILLS TRAINING AND UTILISATION 4. COMMUNICATION AND CO-ORDINATION 5. SUPPORTING SERVICES AND SPECIALISED SERVICES 6. RANGE OF MATERIAL (PROCUREMENT AND STOCK)
(2)HEAVY ENGINEERING INVOLVING HEAVY COMPONENTS	1. LAYOUT AND FACILITIES 2. TECHNOLOGY OF MATERIAL/EQUIPMENT HANDLING 3. SAFETY
(3)CYCLICAL FLUCTUATION OF JOB VOLUMES	1. MANPOWER PLANNING AND UTILISATION 2. SUBCONTRACTING SYSTEM 3. DIVERSIFICATION
(4)SHORT DURATION OF REPAIR & CONSTANT CHANGES OF JOB SPECIFICATIONS	1. PROJECT MANAGEMENT MUST SUIT FLEXIBILITY AND EFFECTIVE FEEDBACK 2. STRONG FRONTLINE SUPERVISORY PC.. AND CONTROL 3. COMMUNICATION AND CO-ORDINATION 4. AVAILABILITY OF MATER.. ROCUREMENT AND STOCK
(5)GLOBAL COMPETITION & SERVICE-ORIENTED INDUSTRY	1. MARKETING AND BUSINESS STRADEGY AND PHILOSOPHY 2. COST, QUALITY AND TIME OF REPAIR 3. COMMUNICATION 4. SERVICE INFRASTRUCTURE
(6)POTENTIAL HAZARDS	1. SAFETY AND HEALTH

7

TOTAL NUMBER AND TYPES OF VESSELS REPAIRED IN JSL (1980)

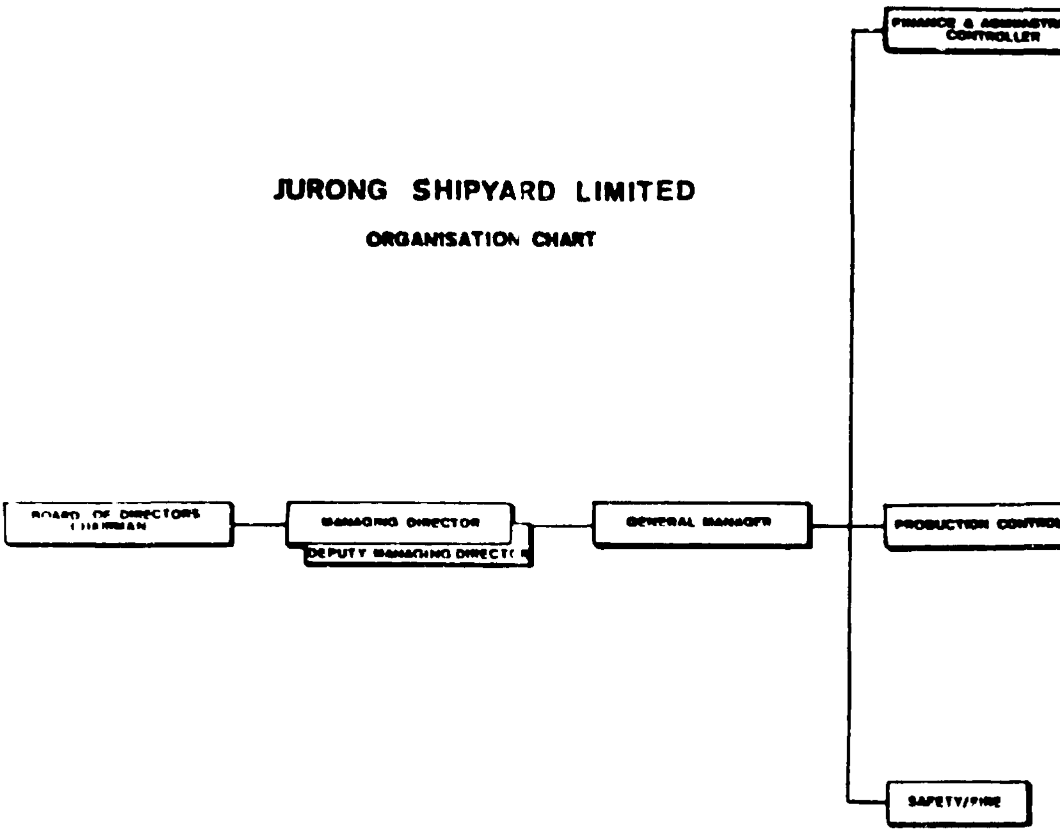
TYPE OF VESSEL	GROSS TONNAGE	NO. OF VESSEL REPAIRED
1. TANKERS	ABOVE 100,000	14 (1)
	50,000-100,000	27 (8)
	20,000- 50,000	30 (8)
	BELOW 20,000	14 (2)
2. BULK CARRIER	20,000- 50,000	12 (1)
	BELOW 20,000	9
3. CARGO VESSELS	BELOW 20,000	44 (5)
4. LNG CARRIER	50,000-100,000	3 (5)
5. CAR CARRIER	17,612	1
6. TUG	2,970	1
7. DRILLING VESSEL	6,134	1
8. FLOATING CRANE	6,443	1
9. FLOATING DOCK	3,500	1
10. FISHING BOAT	934 (TOTAL)	2
11. BARGE	8,751 (TOTAL)	7
TOTAL	7,6[illegible],855	167 (30)

( ) INDICATES REPAIR AT ANCHORAGE

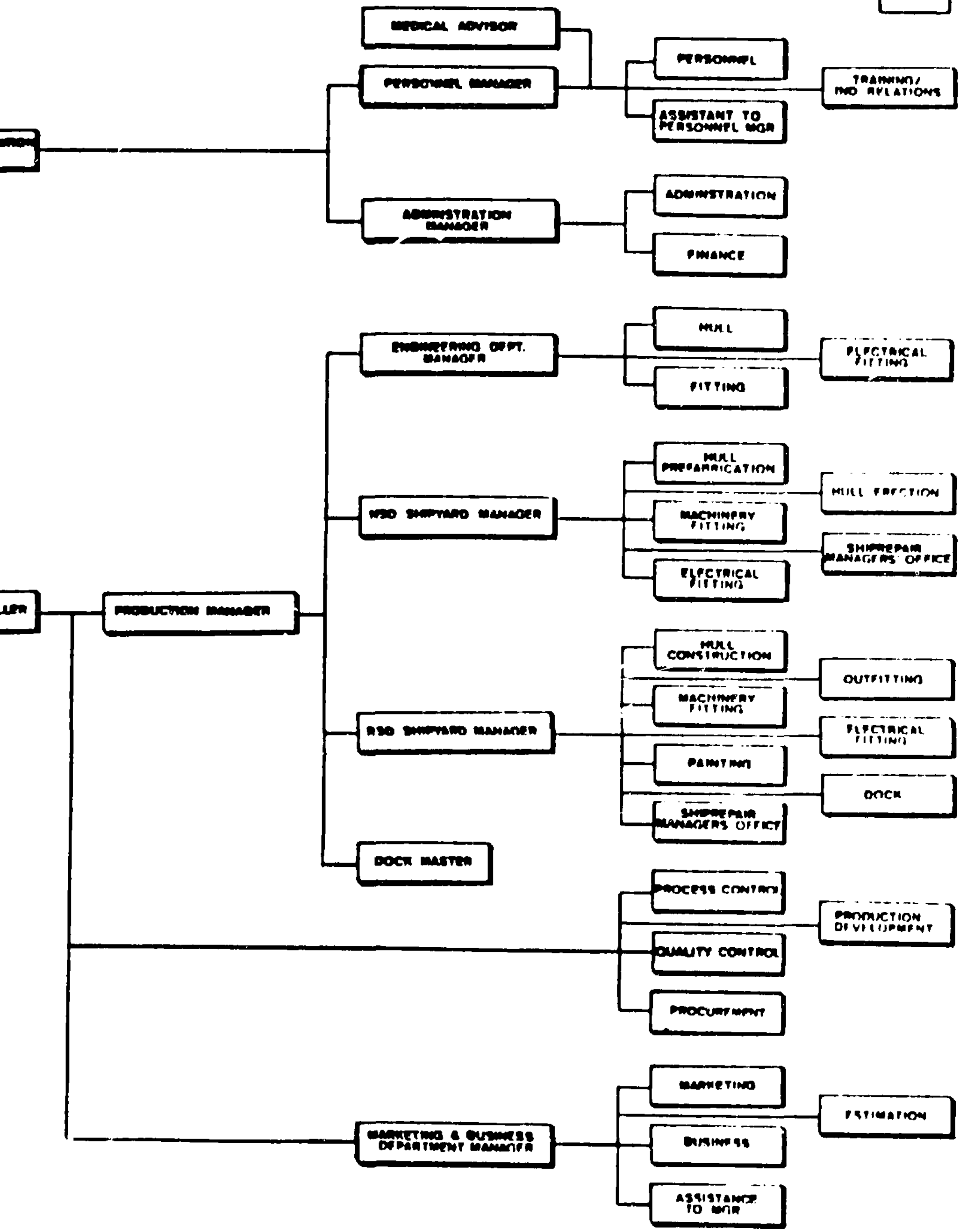

8
REDUCTION OF JAPANESE STAFF
NO. OF SECONDED STAFF
60
50
40
30
20
10
TOTAL SECONDED STAFF
SECONDED DESIGN STAFF
SECONDED ENGINEERS &
SPECIALISTS ONLY
'63
'64
'65
'66
'67
'68
'69
'70
'71
'72
'73
'74
'75
'76
'77
'78
'79
'80
'81
'82
'83
'84
YEAR

JURONG SHIPYARD LIMITED

ORGANISATION CHART



9


MEDICAL ADVISOR
PERSONNEL MANAGER
PERSONNEL
ASSISTANT TO PERSONNEL MGR
TRAINING / IND RELATIONS
ADMINISTRATION MANAGER
ADMINISTRATION
FINANCE
ENGINEERING DEPT. MANAGER
HULL
FITTING
ELECTRICAL FITTING
NSD SHIPYARD MANAGER
HULL PREFABRICATION
HULL ERECTION
MACHINERY FITTING
SHIPREPAIR MANAGERS OFFICE
ELECTRICAL FITTING
PRODUCTION MANAGER
RSD SHIPYARD MANAGER
HULL CONSTRUCTION
OUTFITTING
MACHINERY FITTING
ELECTRICAL FITTING
PAINTING
DOCK
SHIPREPAIR MANAGERS OFFICE
DOCK MASTER
PROCESS CONTROL
PRODUCTION DEVELOPMENT
QUALITY CONTROL
PROCUREMENT
MARKETING & BUSINESS DEPARTMENT MANAGER
MARKETING
ESTIMATION
BUSINESS
ASSISTANCE TO MGR

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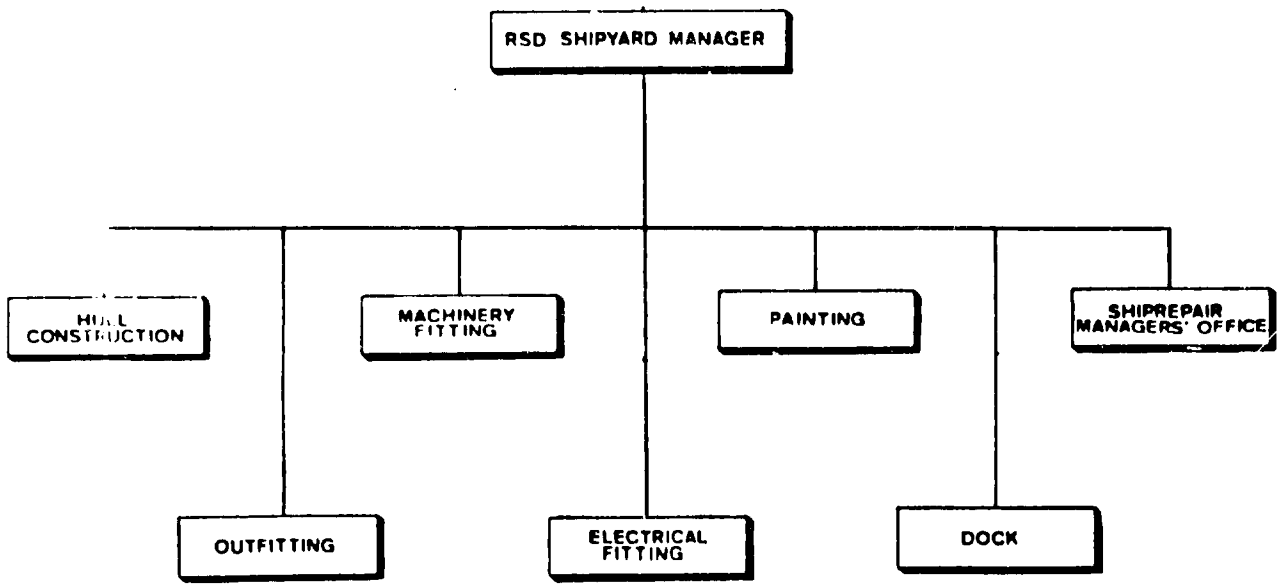
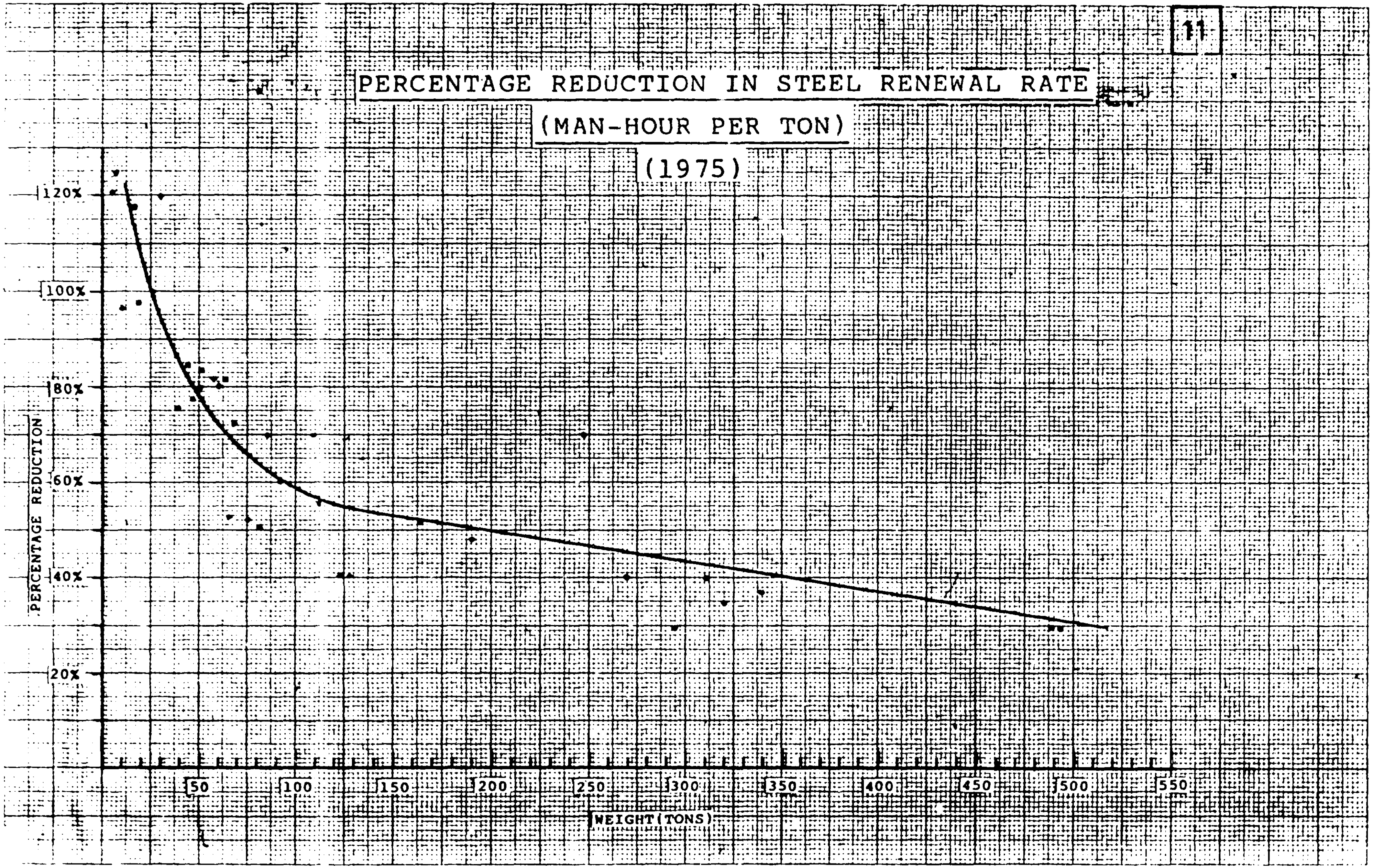
REPAIRSHIP DIVISION

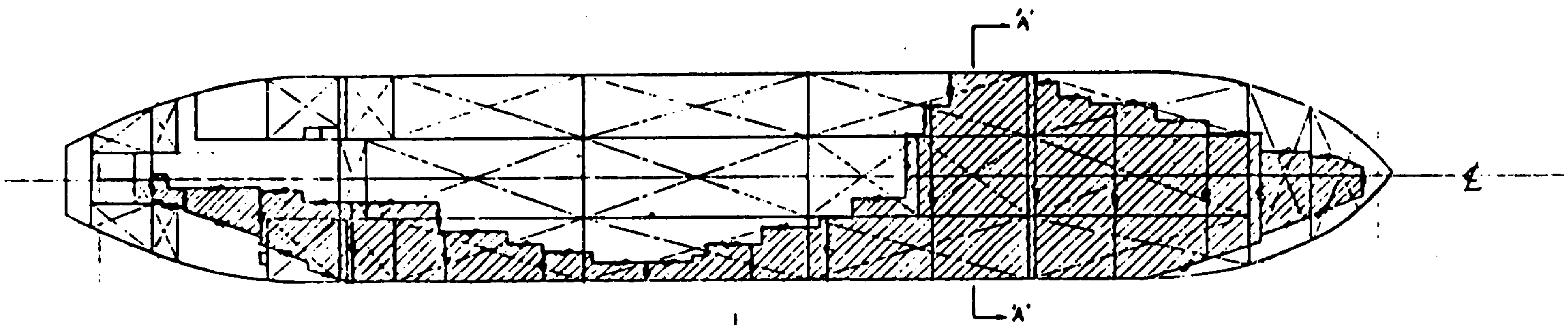


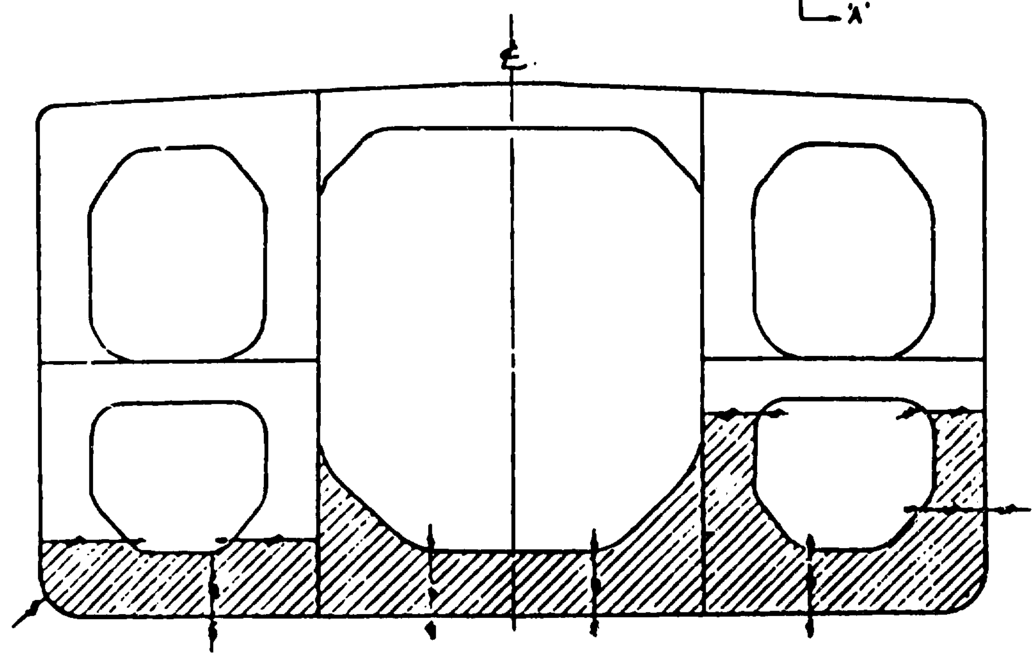


11
PERCENTAGE REDUCTION IN STEEL RENEWAL RATE
(MAN-HOUR PER TON)
(1975)
120%
100%
80%
60%
40%
20%
PERCENTAGE REDUCTION
50
100
150
200
250
300
350
400
450
500
550
WEIGHT (TONS)

12

80,000 DWT TANKER BOTTOM DAMAGE REPAIR PLAN





'A'-'A' ~ SECTION

SHADED PORTION SHOWS RENEWED BLOCKS

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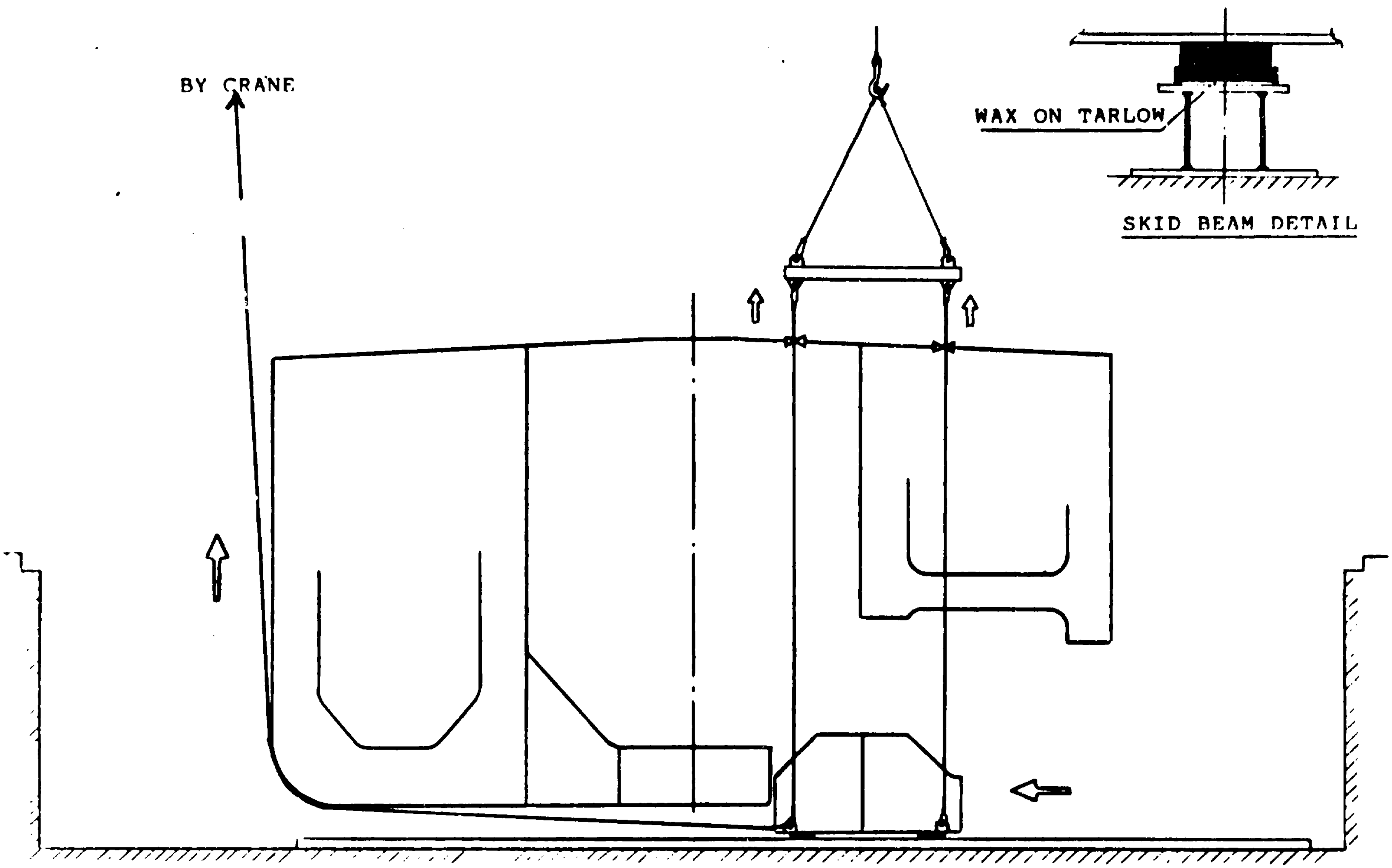
BLOCK INSTALLATION TECHNIQUE FOR 80,000 DWT TANKER BOTTOM DAMAGE REPAIR



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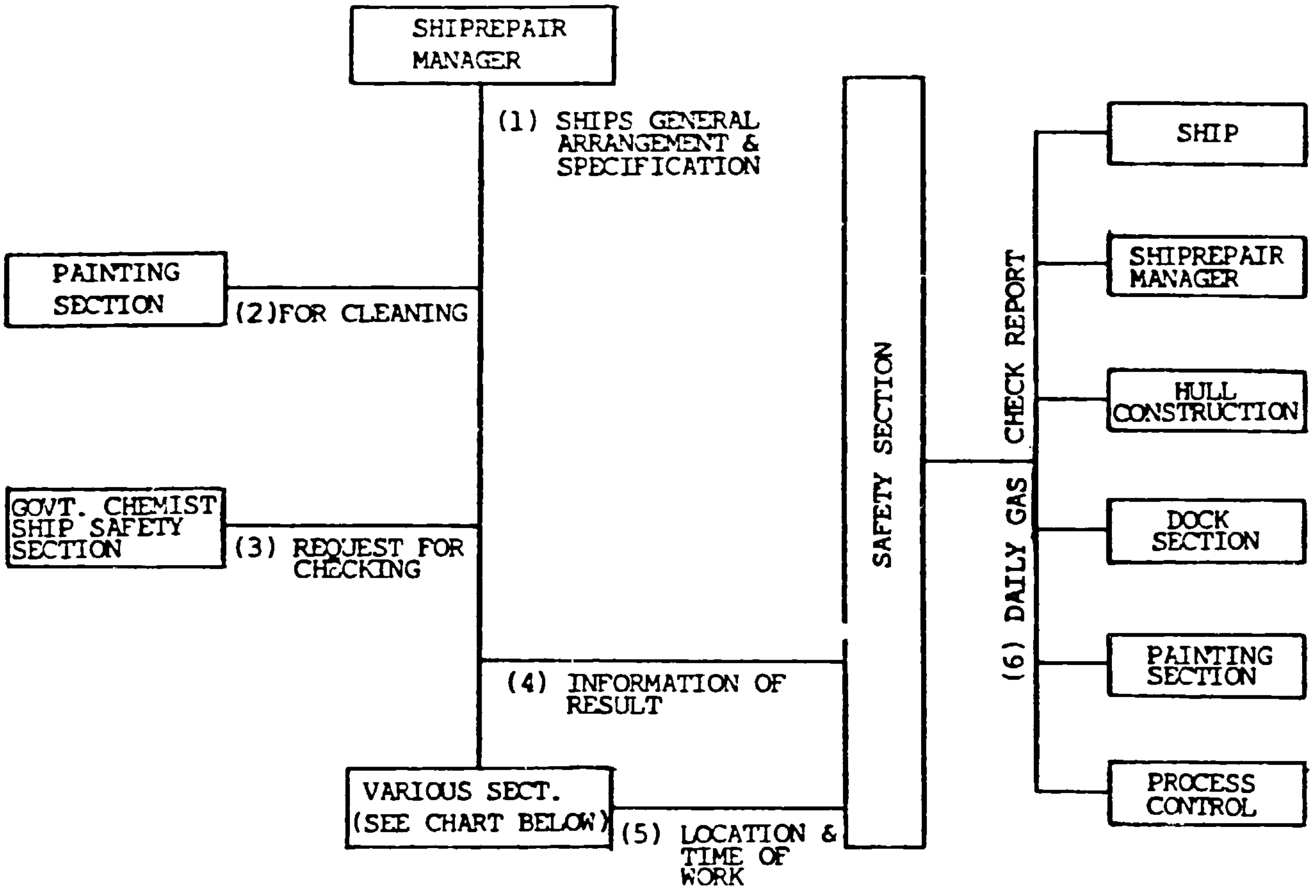
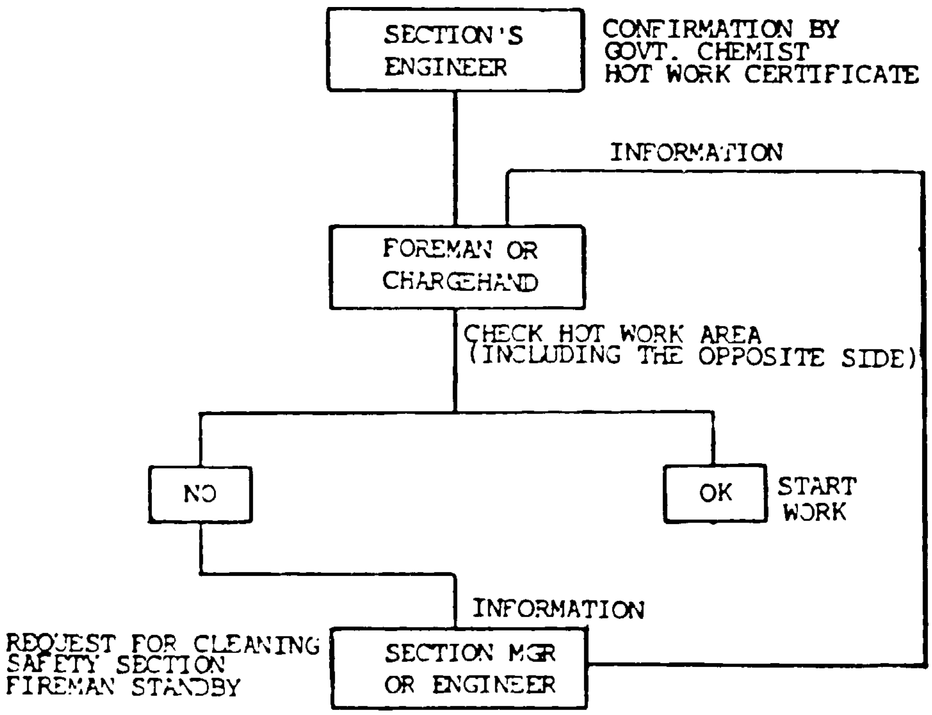
CO-ORDINATION CHART FOR HOT WORK



VARIOUS SECTION'S CHECKING SYSTEM



DIFFERENCES BETWEEN SHIPREPAIRING AND SHIPBUILDING INDUSTRIES

SHIPREPAIRING	SHIPBUILDING
1. Sporadic works carried out simultaneously (limited degree of mechanisation)	1. Assembly flow line concept (high degree of mechanisation possibility)
2. Short schedule per repaired vessel	2. Long schedule per building vessel
3. Labour is the main cost component	3. Material is the main cost component
4. No or little design involvement	4. Design is an essential element

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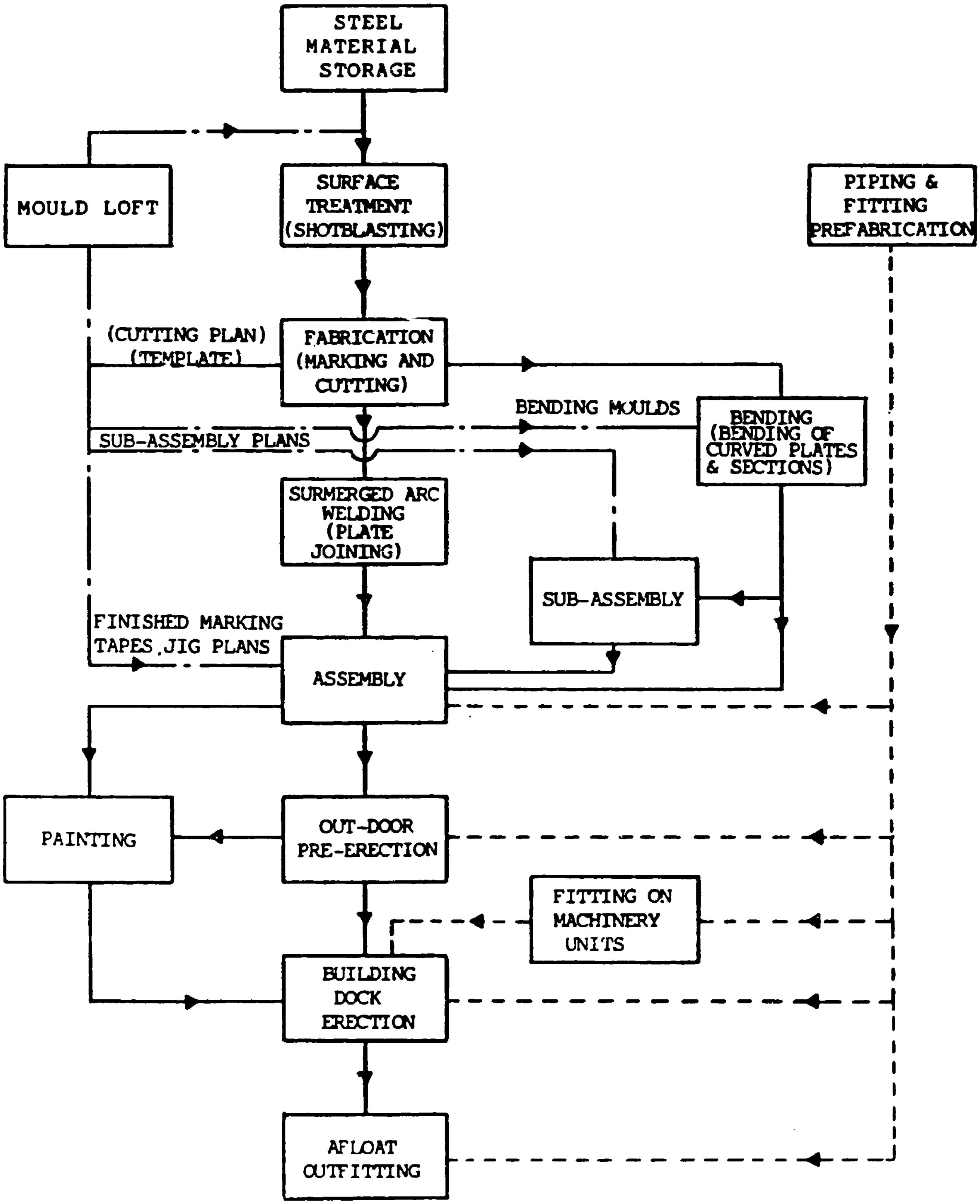
WORK FLOW OF SHIPBUILDING PROCESS



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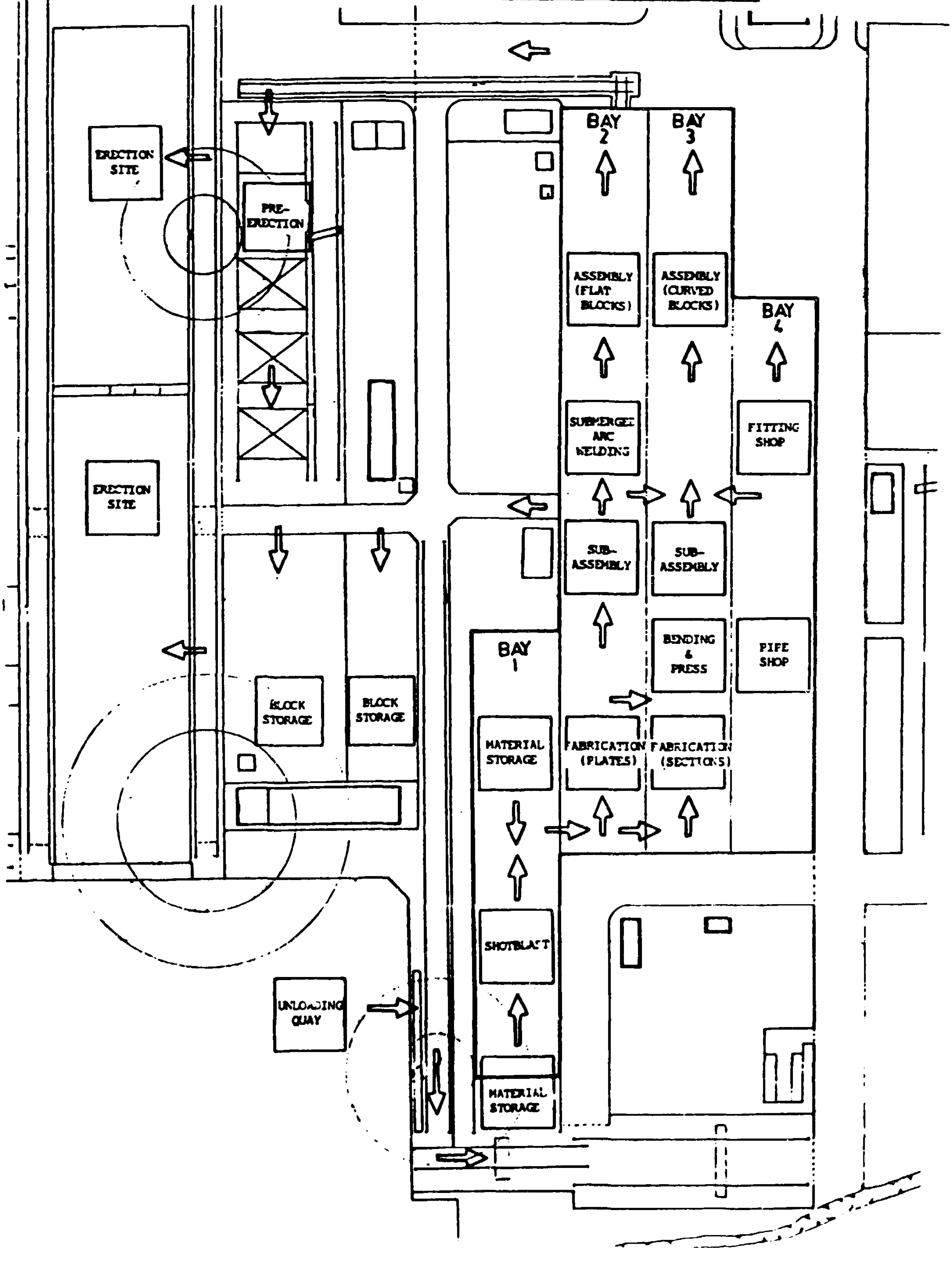
PHYSICAL FLOW PLAN OF SHIPBUILDING PROCESS IN NEWSHIP DIVISION OF JSL

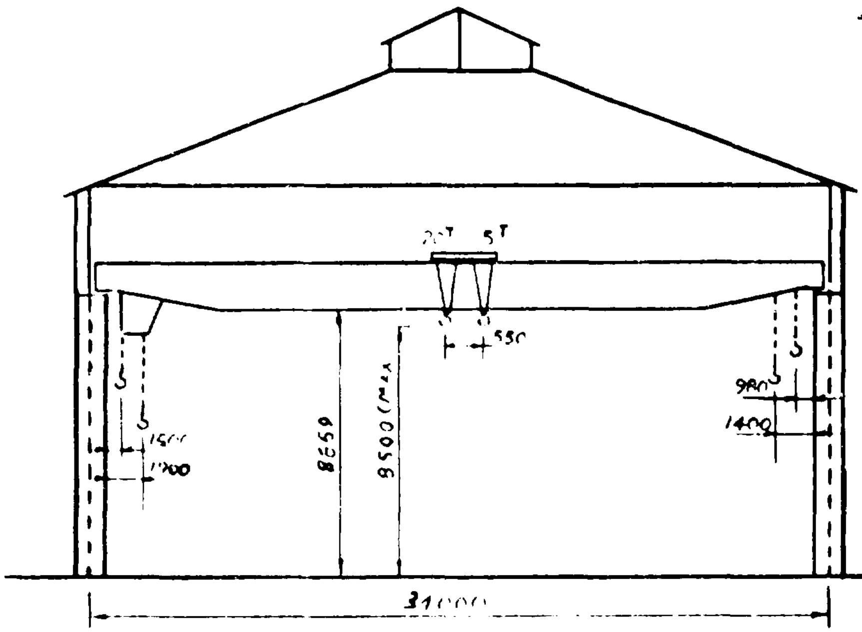


NSD FACILITIES - HULL SHOP OVERHEAD CRANES

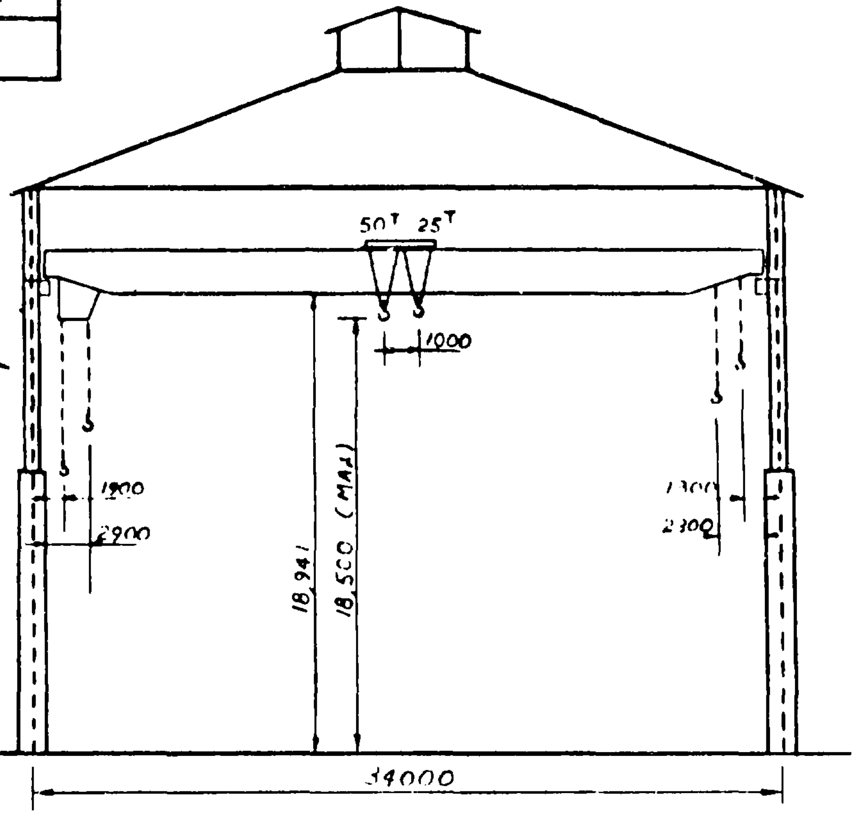
LOCATION	TYPE OF WORK	NO. OF OVERHEAD CRANE 10 T	20/5 T	50/25 T
BAY NO. 1	MATERIAL STORAGE	1	1	
BAY NO. 2 (FABRICATION)	FABRICATION SUB-ASSEMBLY	2		
BAY NO. 2 (ASSEMBLY)	SUBMERGED ARC WELDING	1		1
BAY NO. 3 (FABRICATION)	FAB., BENDING SUB-ASSEMBLY	1	1	
BAY NO. 3 (ASSEMBLY)	ASSEMBLY			2
BAY NO. 4	OUTFITTING	2		

SPECIFICATION OF SPEED

	50 T	25 T	20 T	5 T
HOISTING	4 M/MIN	6 M/MIN	6 M/MIN	12 M/MIN
TRANVERSING	30 M/MIN	30 M/MIN	35 M/MIN	35 M/MIN
TRAVELLING	90 M/MIN	90 M/MIN	100 M/MIN	100M/MIN



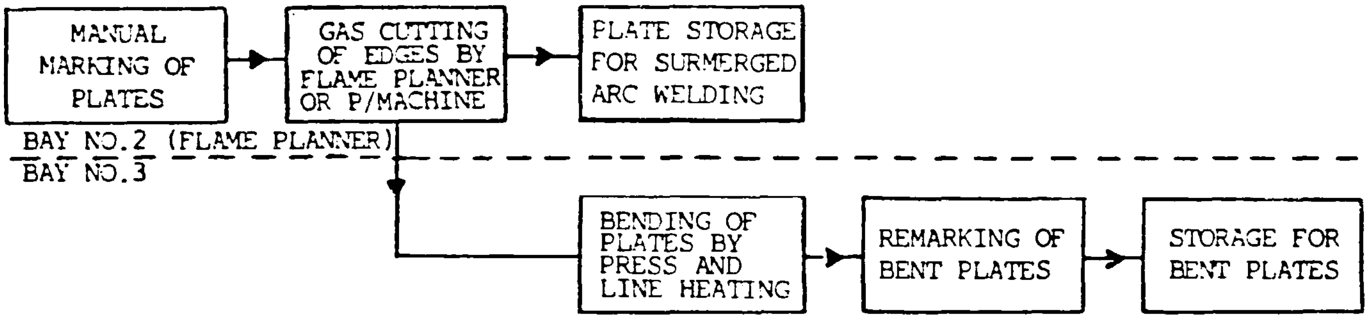
20T/5T CRANE



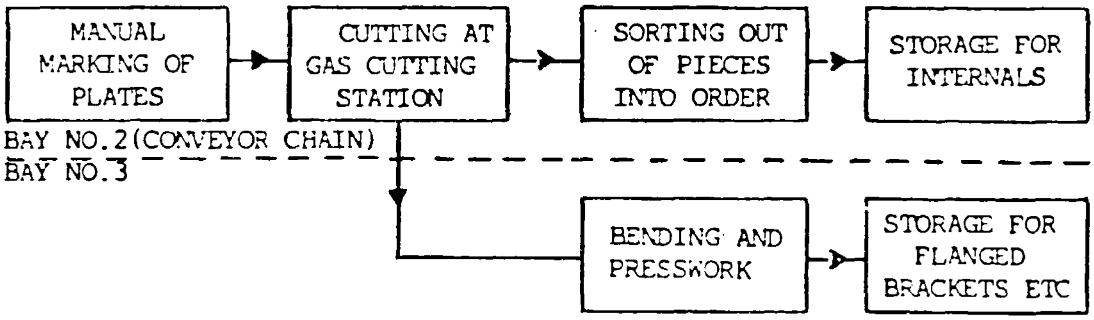
50T/25T CRANE

DIFFERENT LINES OF FABRICATION PROCESS

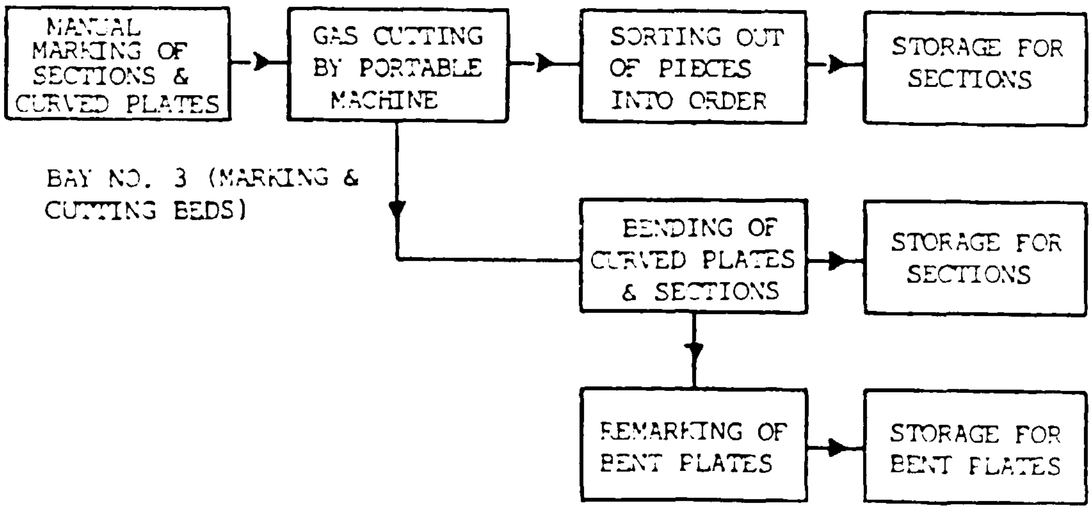
1 FLAME PLANNER LINE



2 GAS CUTTING CONVEYOR LINE



3 SECTIONS & CURVED PLATES CUTTING LINE



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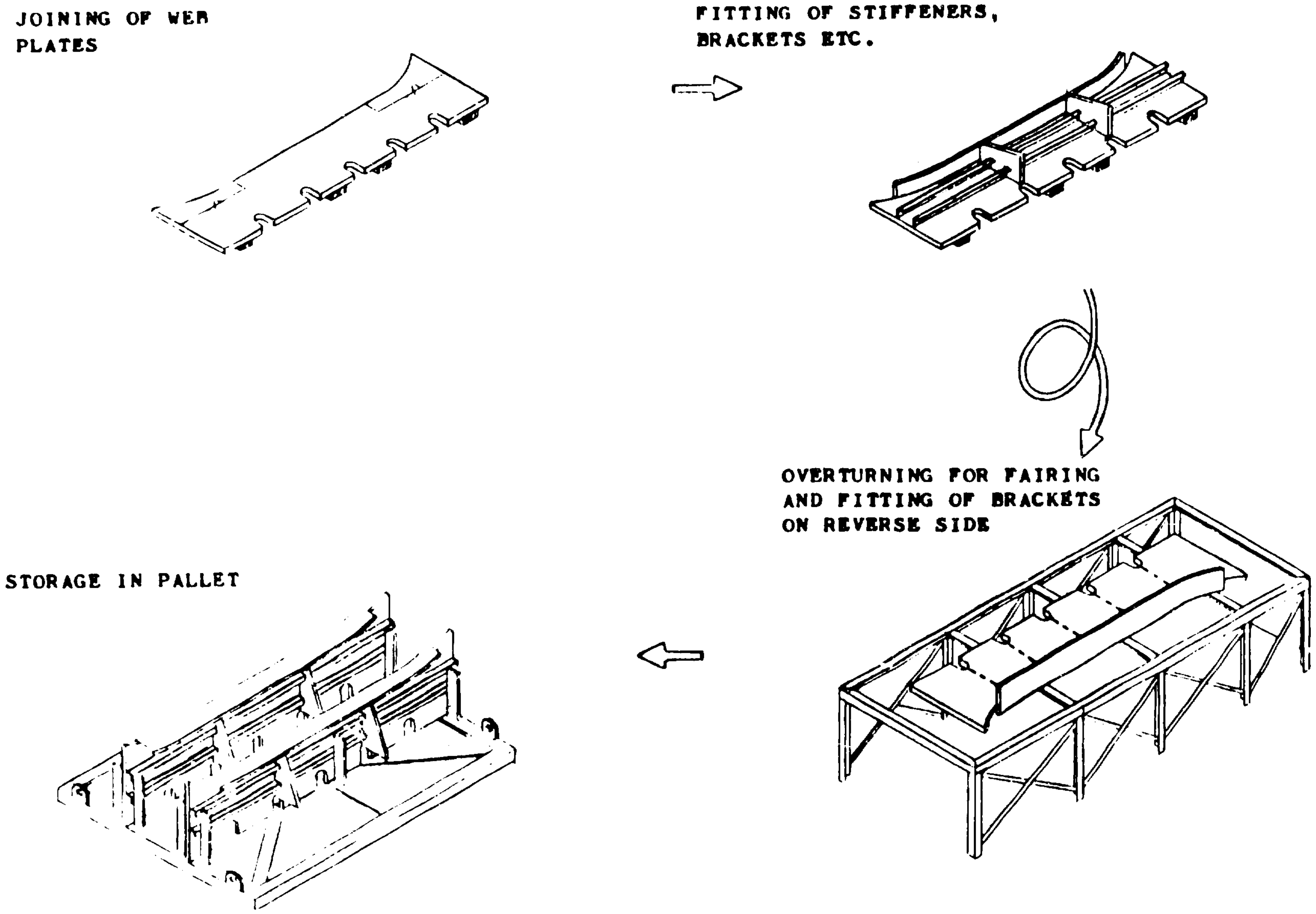
TYPICAL SUB-ASSEMBLY SEQUENCE



ASSEMBLY OF FLAT BLOCK (EXAMPLE)

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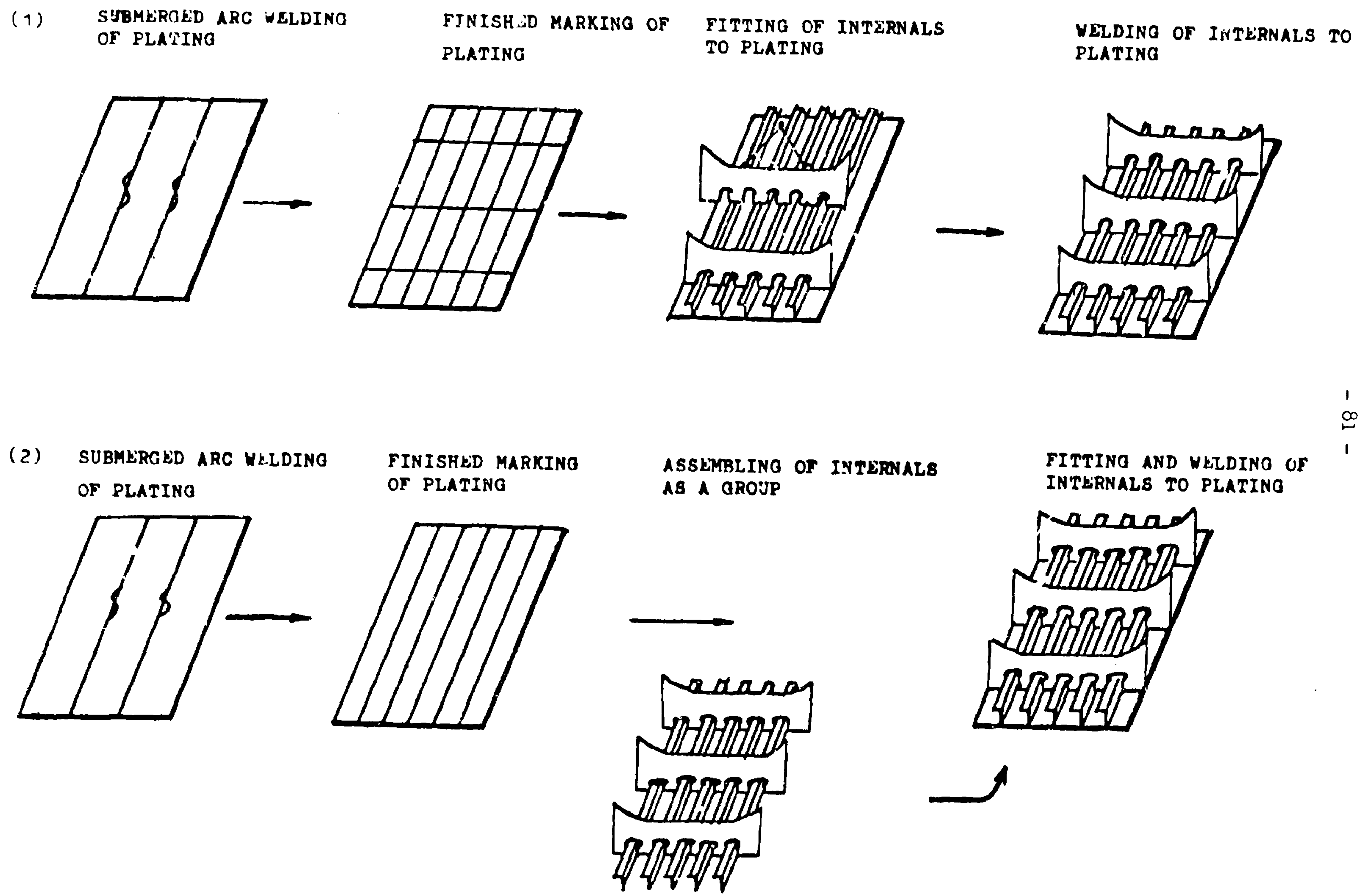
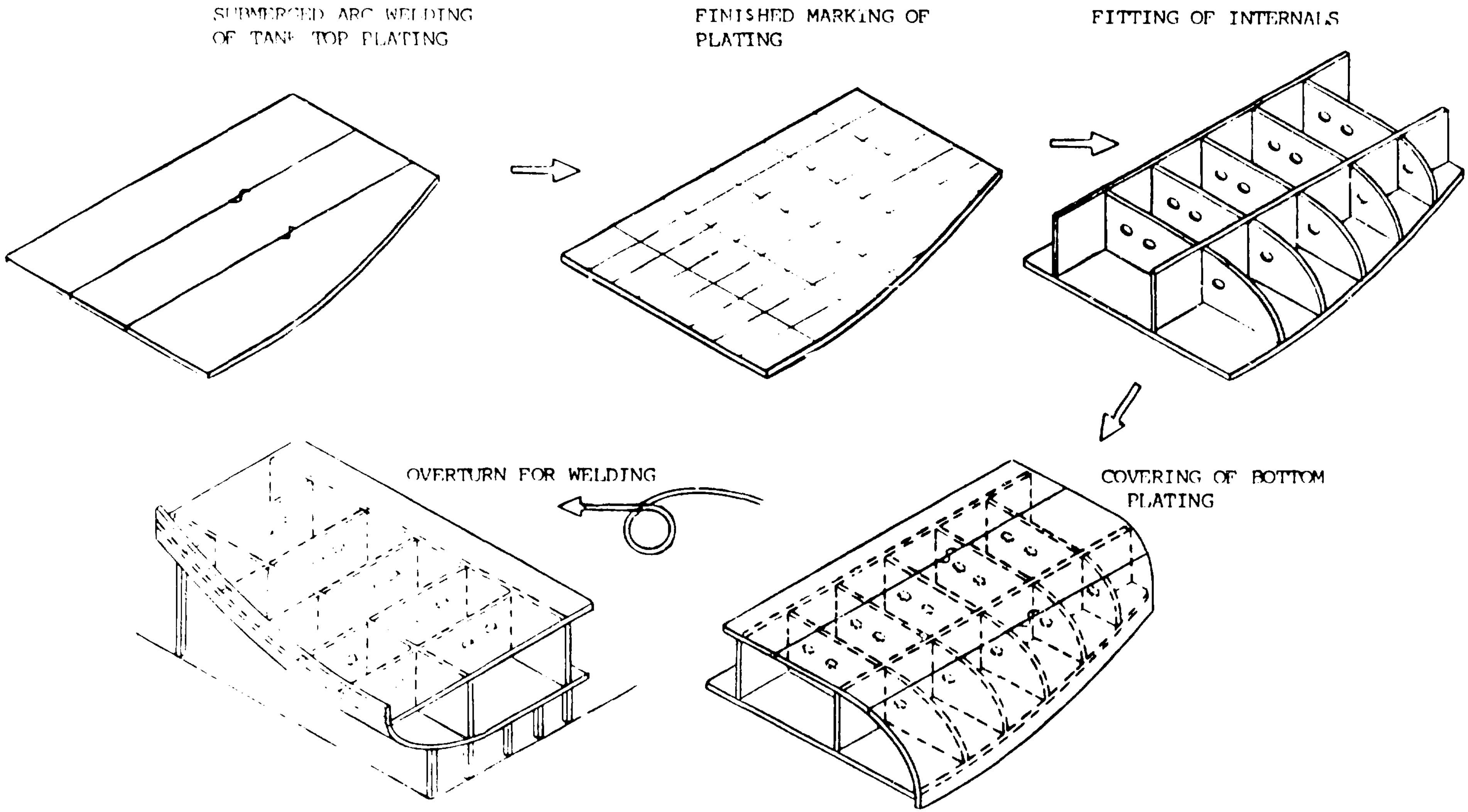


ASSEMBLY OF SEMI-FLAT BLOCK (EXAMPLE)

22



ASSEMBLY OF CURVED BLOCK(EXAMPLE)

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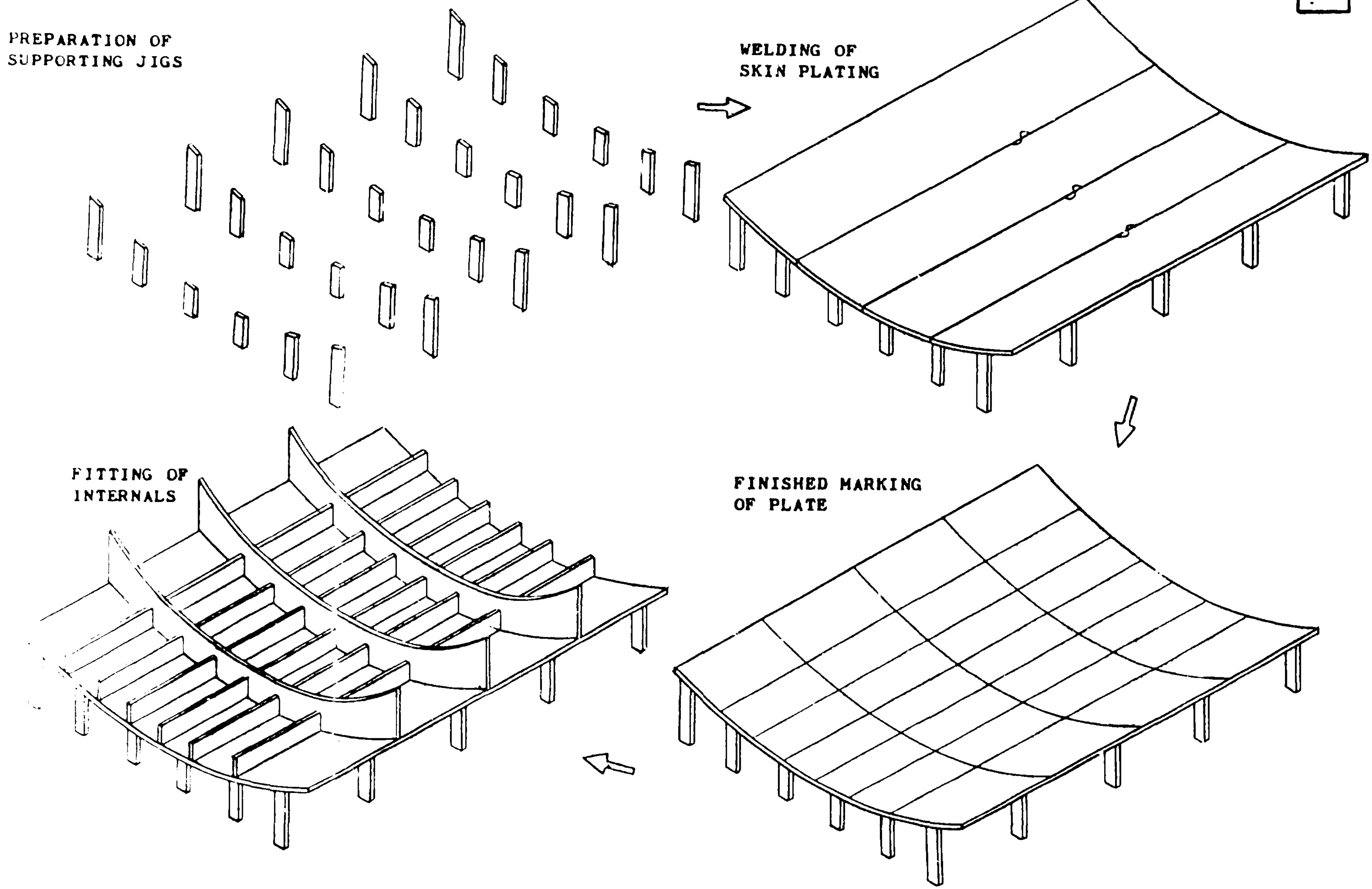

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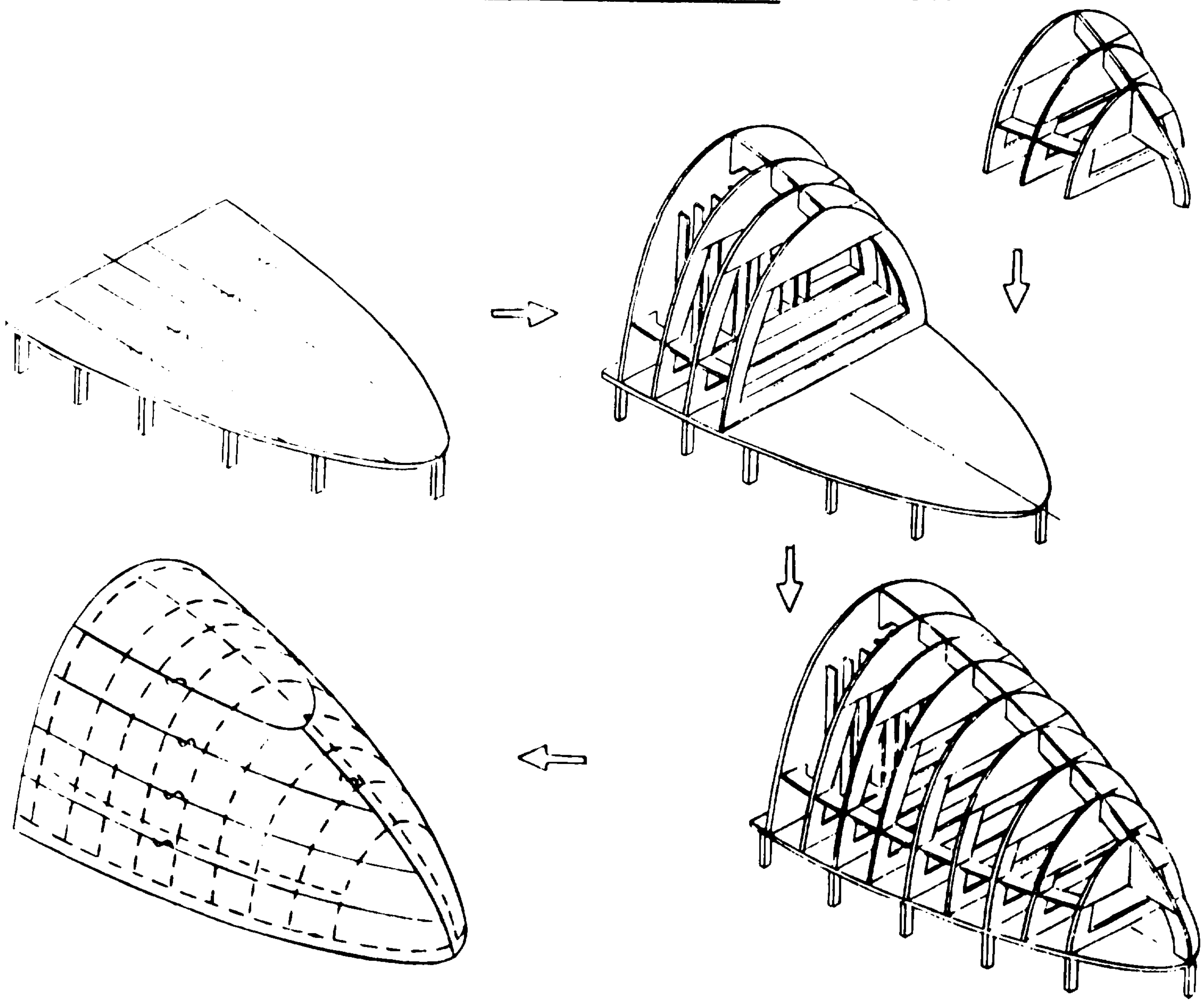
ASSEMBLY OF CUBIC BLOCK (EXAMPLE)



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