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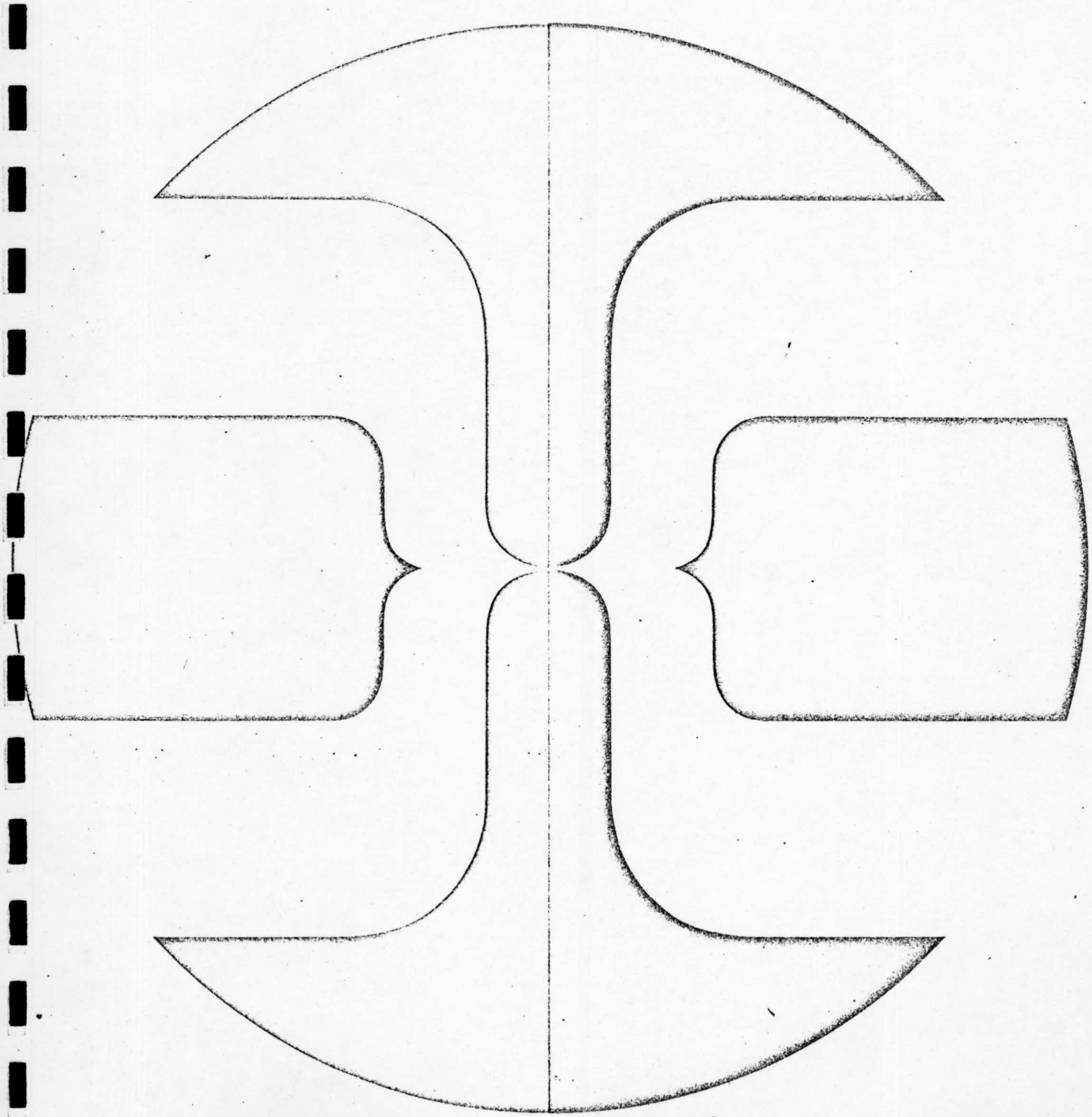
WAVEPOWER LIMITED

COCKERELL LP RAFTS IN STEEL



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COCKERELL LP RAFTS IN STEEL

Comments Made by Rendell, Palmer & Tritton
on 24th October, 1979

1: What is the validity of using foreign man hour productivity related to heavy capital investment, for predicting UK costs? Two UK industries which already have intensive mass production - the car industry and BSC - continue to have man hour productivity a long way below comparable firms overseas. BSC have not found greenfield sites to be any answer to the problem. I am not seeking to criticise the idea, but to ask you to give some solid grounds why the idea should be accepted.

2: The man hours per ton appear to be very low compared with the simplest mass production steel now available anywhere in the world. Could APA please consider the selling price of steel piles, which are the simplest form of fabricated steel one can imagine and which are made on highly automated production lines in very large tonnages. The man hours to complete fully assembled stiffened plate barge structures must clearly be very much more.

3: Has proper allowance been made for the disruptive effects of NDT of plates and welds - that is the distruptive effects on line production of the rogue element.

4: Are APA satisfied that when the raft is fully analysed and detailed, the number of "specials" - elements reinforced for local forces, cut outs, etc., will not severely upset the predicted man hours. (I think it will be very helpful to have some sample detail drawings showing reinforcement, man joints, cut outs, etc., and also calculations relating to some of these areas).

5: I would like to see figures for the Swedish yards quoted on the basis of man hours per square metre of stiffened "skin", and compared with the figures for the rafts. I have a feeling that costs are at least as much related to this parameter as to simple tonnage.

6: What is the quantitative reasoning by which it is concluded that these rafts are inherently simpler than a large oil tanker.

7: Comment - it seems to me that mass production is a potential benefit to be ascribed to many of the wave power devices.

In concluding, may I say that I am very sympathetic to the idea of mass produced fabricated steel, and we are following all the lines we can have to find out:

a) What should be the bench mark for best achievable man hours now in 1979, based on proved performance anywhere in the world.

b) What further evidence exists to substantiate the extrapolation of existing technology by which APA are making.

Summers 1967 Cost estimates as predictors of actual costs

p 140 first paragraph, – unreliable estimates
p 142 after 'A superficial ... wildly inaccurate'
p 146 bottom 'consequences' of inaccuracies
p 144-145 bottom p145 – degree of technical advance sought
p 147 The answer is not always "No" – practical results
p148 Errors in non-military cost estimates . some good examples
p149 – five goals of a development prog. – performance held to tenaciously – why costs of major articles can be looked at alone p150

p 151 Raw F = "Actual cost of major article / Estimated cost of the " "

152 table of mean errors etc.
153 adjustments :– quantity procured, + price levels.
154 – timing of estimates within dev't programme .
estimates better as dev't proceeds.
155 hypothesis 1) late cost estimates likely to be close to final costs
2) early cost estimates lower – as prog goes on this weakens
156 Timing within programme t
Development programme : early 1/3 medium 1/3 late 1/3
157 Technological advance A – subjective to dev't engineers
p158 time & tech advance chart 
p160 length of dev't programme L
161 calendar date T
162 the formula . $F = Ke^{(\ldots)}$
164 hypothesis what happens to F with changes in t, A etc.
165 top. more on Technical advance.
167 – change of estimates over time – graphs. High tech advance still the problem.
169 inaccuracies due to estimator or contractor?
175 learning during development. IMP

PTO

Summers 1967

p176/7 'Changing configuration hypothesis'
usually base costs on physical item not on performance
estimate OK — it is change in configuration which occurs &c
Spec's stay the same.
'Conscious underbidding hypothesis
'policing of development programme by others

p179 "In choosing between 2 systems } important
"failure to debias the major article
cost will cause the new system to appear relatively
better than it should (of a follow-on devt).
p180-181 probability of cheaper article (in early estimates)
ending up more expensive
– suggests relative magnitude of costs necessary
for confident prediction that cheaper system will stay
cheaper
cost effectiveness
p184 case studies: would conclusions change
if 1) debiased cost estimates
2) taken account of uncertainties
significant difference in case study I "

REPLY TO COMMENTS

General

The points raised refer to a discussion of the project held on the 9th October at APA, Killingworth, at which two RPT representatives were present, rather than the report written by APA and sent to Wavepower Limited on the 2nd October. The report deals with problems of:

a) Raft Design:
- For Operation
- For Production
- Durability of Structural Material
- Production Characteristics

b) Facility Design:
- Output and Throughput
- Philosophy of Facility
- Welding and Manipulation
- Equipment List
- Person Power Requirements

c) Financial and Energy Projections:
- Capital Cost
- Operating Cost
- Raft Unit Cost
- Material Selection on Energy Grounds

The meeting on the 9th October presented all of these problem areas for discussion and it is a little surprising that after 14 days consideration the RPT written comments have such an undue emphasis on the bottom line calculation of forecast productivity at the end of the section on Person Power Requirements alone. Possibly this means that all of the other problem areas and solutions are agreed with, so let us consider only this question of productivity and how far it may be relevant to the project.

Productivity

Foreign manhour productivity related to heavy capital investment was not used to predict the UK costs given in the report and nowhere is the question of foreign or any other industrial productivity even raised in the text.

The nature of advanced rather than imitative projects calls for a predictive assessment of what and who is required to do the job based upon analysis, which results at the bottom line in the ratio of output to input known as productivity. The input has to be in various forms including materials, equipment, facilities, person power and money for the ratio to have meaning and usefulness. The integration of these component forms into a single index has taxed the minds of researchers but not yet been resolved.

The tendency for imitative projects is to single out person power as an easy component form of input and to use a measure of it (person hours) against output (steel tonnes). The errors are to then assume that this also applies to overall productivity and to use it in working back to determine output/throughput rates and manning levels.

Another danger of the imitative approach is acceptance of the present level of productivity, whatever that may be, as the starting point perhaps for improvement. This is done without ever knowing what the productivity level ought to be or the size of the gap to be closed. Maybe in an established industrial situation one could sympathise with, though not condone, such an approach but in an entirely new industrial situation (for example, a wave raft factory) there can be no excuse for anything other than the analytical approach. No form of inhibition, pseudo-social or political, should be permitted to influence the calculations of what is humanly acceptable, technically possible and presenting the best economic opportunity.

From the foregoing it will be appreciated that APA try as far as possible to avoid approaches based on comparability in all of their studies but especially in one of the wave energy type. For this project the most significant aspect is the huge requirement of annual output, far in excess of other marine industries. The cycle times in each work station would be so short that the work processes would have to be extensively mechanised and automated to cope. Therefore person power is not a realistic indicator of productivity anyway. The calculations on cycle time and manning level for the wave factory were made unrelated to location and ought to apply anywhere; there is really no difference in the capability of the worker in Britain, Sweden, Japan or anywhere else. This is not to say that there is no difference in the inhibiting factors that result in different levels of productivity. What is technically possible in one country is technically possible in another and no effort should be spared to make it so. Surely it is not too optimistic to expect that British industry can get it together soon and certainly by the time a wave raft factory comes into operation, in spite of present experiences by the car and steel industries.

Comparability

During the discussion on the 9th October, APA was asked to compare the resulting person power productivity predicted in the report with performances achieved already. Accordingly a statement was produced and sent to Wavepower Limited on the 12th October. A copy is enclosed with this document for completeness. Reading the statement makes it clear that it was never postulated that wave rafts are inherently simpler than a large oil tanker. However, if one must engage in comparability studies then it is in the activities of the tanker factories of Sweden and Japan that one will find the closest relationship to a proposed wave raft factory.

One has to remember that there can be very few reasons why engineers and managers of the foreign tanker factories should divulge to prospective competitors detailed information on their own performances. One reason might be close personal friendship and respect and APA is fortunate in enjoying a measure of these from major facilities in Scandinavia and the Far East. Even then the information is overall rather than detailed and interpretation is for us to do, not them, and therefore may not be completely accurate. The suggestion that a better parameter might be man hours per square metre of stiffened skin may be true but we do not have the information to check it completely.

In fact, APA adopt in analysis work the parameter person hours per metre of joint length according to type of structure and we find this works quite well. The rates of accomplishing joint length are obtained from overall returns from actual processes so that these take account of the disruptive effects of the rogue element.

It is difficult to see any possibility of comparability between wave rafts and steel piles. Consideration of the selling price of piles would not tell us anything about the cost of producing them and the man hours expended in the process. However, in such a high volume, automated and mechanised process it is probable that the person power productivity will be a lot less than 1 person hour per tonne and approaching nil.

Design Level

All design activity is a process of successive assumptions and calculations on relevant factors, spiralling through each more than once at increasing level of detail and hopefully converging on the best solution. In the steel wave raft project there are two separate designs which are, however, inter-dependent. These are the design of the raft and the design of the production facility. It is necessary to go round the first loop in each design at the same level to see whether the project as a whole is likely to spiral to convergence or divergence. The criterion is usually the economic one so that design of both types at the first loop should be taken only to the point where an order of cost can be assessed.

This is the status of the steel raft study as described in the report dated 2nd October, 1979, i.e. at the end of the first loop of the spiral. Most design spirals for established products pass through three loops and one for a new product, such as a wave raft, may be expected to require at least four loops. There is a long way to go yet and one could not pretend to have prepared third and fourth loop details of design at the first level of study. This applies to both raft design and production facility design.

There may be differing views on the degree of optimism or pessimism to apply to the assumptions in the first loop. One has to be reasonably realistic, so far as technology and time will allow, but the view of APA is that at the first loop for a novel project one should be erring on the side of optimism in each assumption giving benefit to the novelty. Then as the first loop concludes one can learn whether the second loop is worth embarking upon. If the novel project does not appear viable then it may be confidently dropped as if it could not work under very favourable circumstances then it would be unlikely to do so under more realistic and certainly more pessimistic circumstances. If the novel project does appear to be viable then further effort is justified to increasing level of detail.

The study by APA has erred on the side of optimism without losing touch with the reality known to the experience of the naval architects and shipbuilding engineers employed on the project. Calculations have been made pertaining to the designs of both the raft and the production facility and at this first level of study APA is satisfied that both are of the right order.

Assessment of Costs

There is no doubt that every technical project is judged mainly on its prospective economics and discussion usually starts and revolves on this topic. The study on the steel raft seems to indicate encouraging economics which on the one hand could justify further work but on the other hand brings down anxieties about validity.

Validity is questioned mostly because the consequential "productivity" is very much less than is generally publicised. It is therefore appropriate to investigate the economic results for its sensitivity to changes in "productivity" - in particular person power productivity resulting from the numbers to be employed. Table A1 shows the effect on net cost per tonne of steelwork per raft.

It will be appreciated that if the whole steelwork of a large oil tanker could be constructed for less than 12 man hours per tonne using the technology of 4/5 years ago then it can be anticipated that for technology of, say, 5 years time a fully designed wave raft in large numbers should be constructed for considerably less. Therefore, the net cost per tonne is very unlikely to be greaten than £350 (commercial basis) and quite possibly less than £250 (national basis).

Mass Production

The techniques can be applied whenever there is to be quantity production of identical articles. The benefits can be obtained however only when the article is designed for simplicity of production. Some wave power devices may not lend themselves to this treatment to the same extent as others.

WP/JAT/31OCT79
jms

TABLE A1

SENSITIVITY OF PRODUCTION COST TO CHANGES IN NUMBERS EMPLOYED

% Variation	Total Production Persons	Total Person Power	Productivity of Production Persons ph/tonne	Annual Operating Cost 1979 Prices 80 Rafts per Year £ million	Estimated Cost per Tonne of Steelwork - Net After Allowing for Scrap	
					"Commercial" basis £	"National" basis £
- 75	213	375	0.9	254	269	224
- 50	425	750	1.7	257	277	232
0	850	1,500	3.4	262	290	245
+ 100	1,700	3,000	6.8	273	327	282
+ 300	3,400	6,000	13.6	295	376	331

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STEELWORKING PRODUCTIVITY ACHIEVEMENTS

During the early 1970s the boom in shipbuilding for the construction of very large tankers up to 500,000 tons dwt resulted in the introduction of new, highly mechanised steelworking assembly plants. For very large tankers above 250,000 tons dwt some two-thirds of the hull structure may be made up from flat panel blocks. It is this portion of the hull which has been the centre of development for high productivity shipbuilding.

Figure 1 shows a typical cross-section in way of a tanker. The hull structure is normally broken down into a number of natural panel blocks, such as the side structure, longitudinal bulkhead, centre tank deck, etc. Figure 2 shows how these panel blocks may be brought together either on the slipway or in the building dock to make up the hull tank structure.

Figure 3 shows a typical cross-section for a 400,000 ton dwt tanker. This ship has a beam of some 64 metres and a depth of 29 metres. Figure 4 shows the block breakdown for the 400,000 ton tanker design. The cargo tank portion of the ship has been made up of some 13 plate lengths, each being in the order of 21.5 metres.

The maximum annual output from any shipyard concentrating on the production of very large tankers was achieved by Mitsubishi's Koyagi Nagasaki shipyard. In this case, eight 250,000 ton dwt tankers were produced annually. Each ship has a steelweight just over 30,000 tons and so the annual steelwork output was in the order of 250,000 tons. The cargo tank hull structure was assembled using a mechanised assembly line capable of processing panels up to 45 metres long, 30 metres wide and with a maximum weight of 600 tons. It is understood that the Koyagi shipyard operated below 15 manhours per ton for all the steelworking requirements in the construction of the 250,000 tonners. The fabrication of panel blocks up to 600 tons was achieved with a productivity rate of less than 2 manhours per ton.

Possibly the shipyard which developed the highest level of technology for the construction of large tankers was Kockums in Sweden. In this case, the annual output achieved was six 250,000 ton tankers per year and the total steelworking productivity was less than 12 manhours per ton. The new production facilities at Kockums feature a 1,500 ton capacity goliath crane which is capable of transferring blocks from an undercover final assembly workshop into the 500,000 ton capacity building dock. Panel blocks up to some 700 tons may be processed on a panel assembly line capable of building up panels 25 metres long and 30 metres wide.

It should be appreciated that the production manhours involved in the series production of large panel blocks for large tankers represents only some 15-18% of the total steelworking manhours required for the construction of ships in this class. In the case of the proposed facility for the series production of rafts, virtually the complete production operations would be concentrated on the production of the simplest type of steel structure. APA believe it is not unreasonable to anticipate levels of steelworking productivity for this type of structure being compatible, if not better than those already achieved some 4-5 years ago for the construction of ships up to 500,000 tons dwt.

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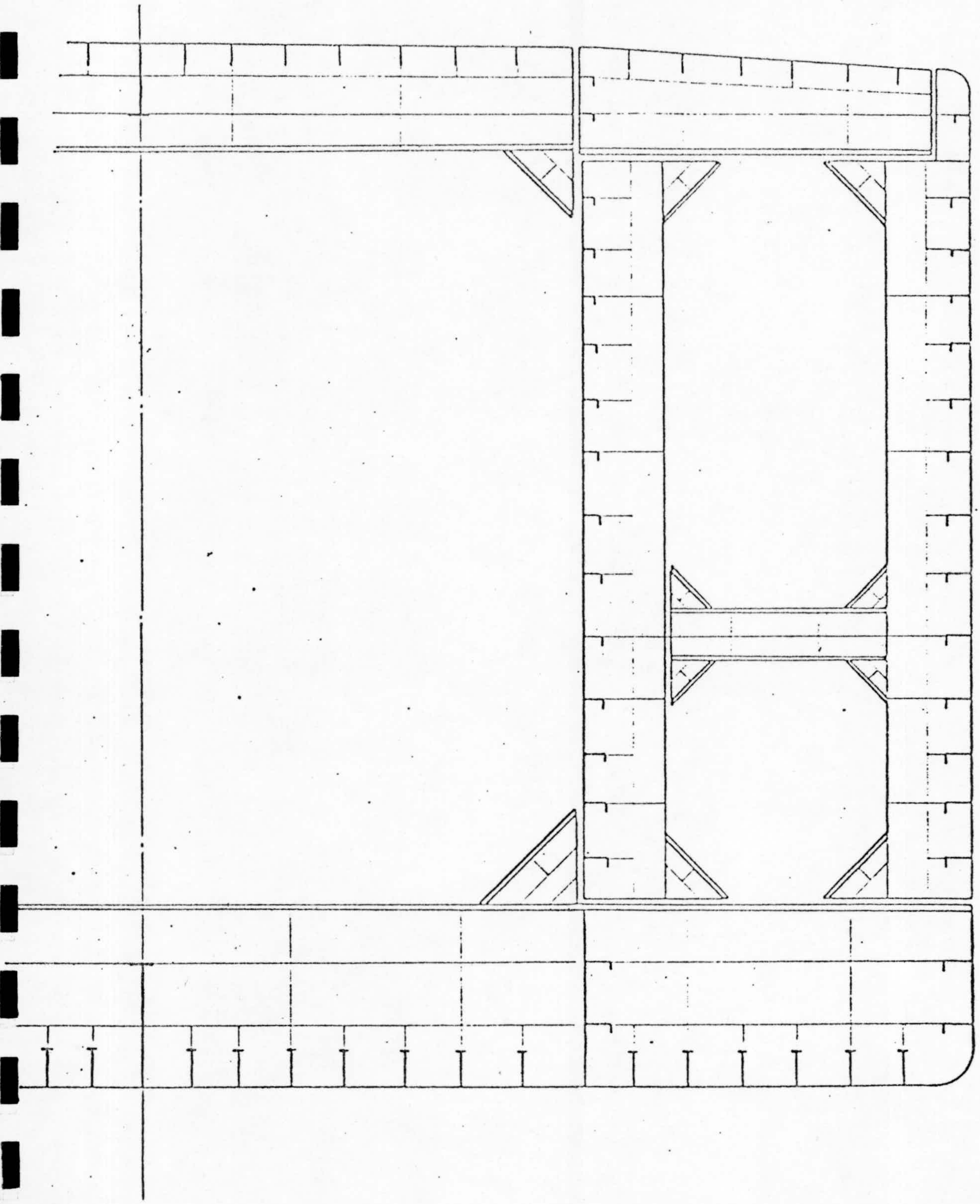


TANKER MIDBODY BLOCK BREAKDOWN

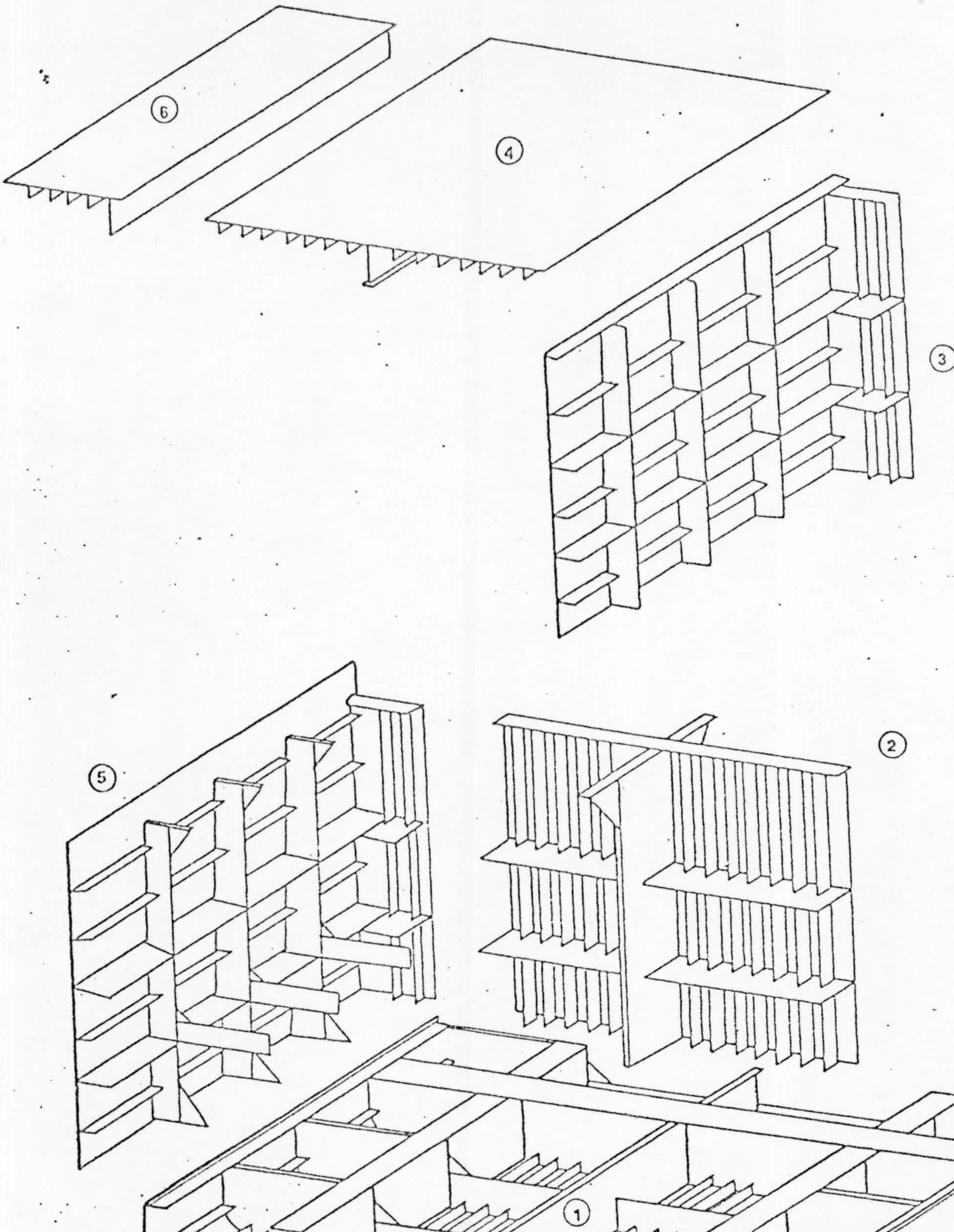
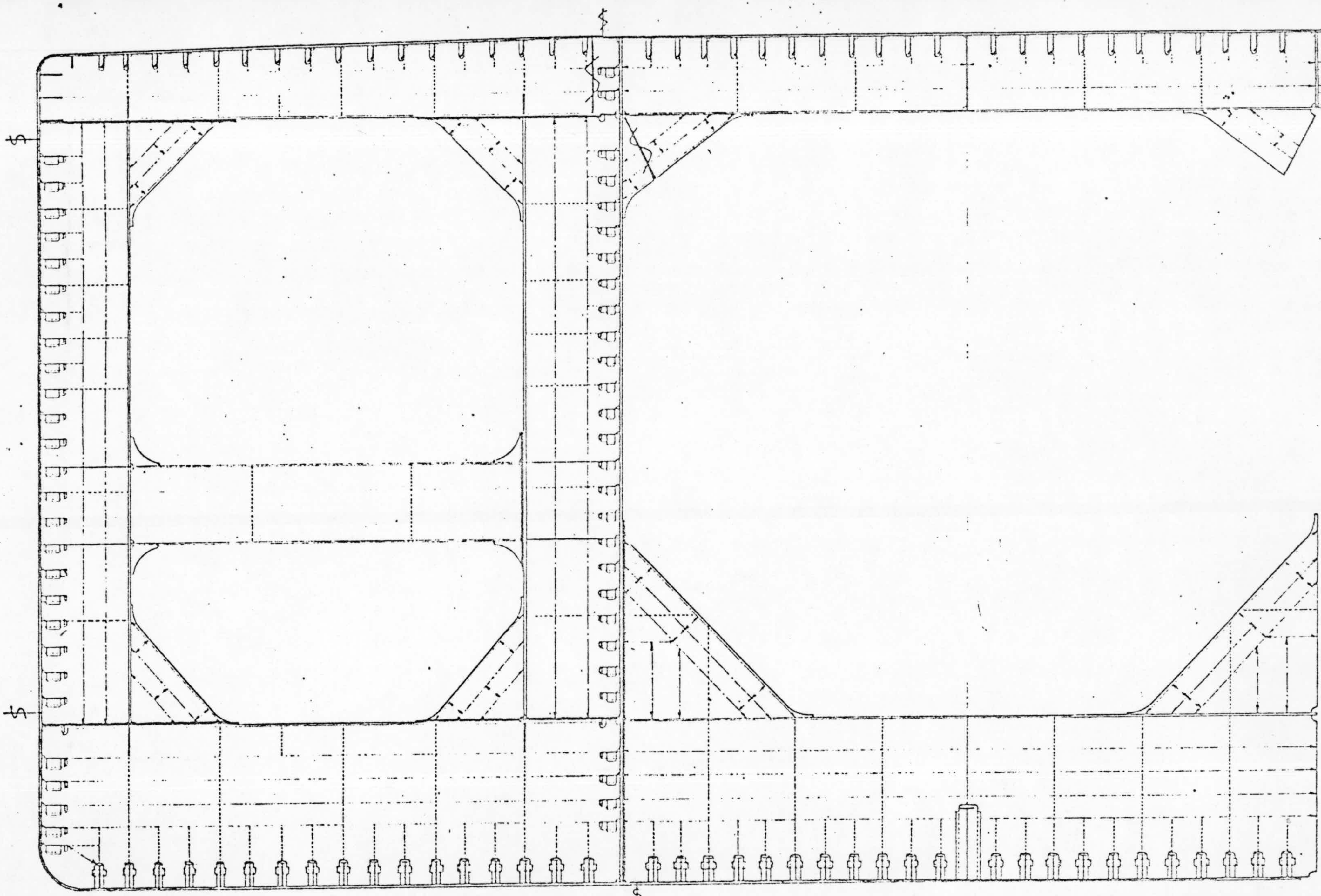
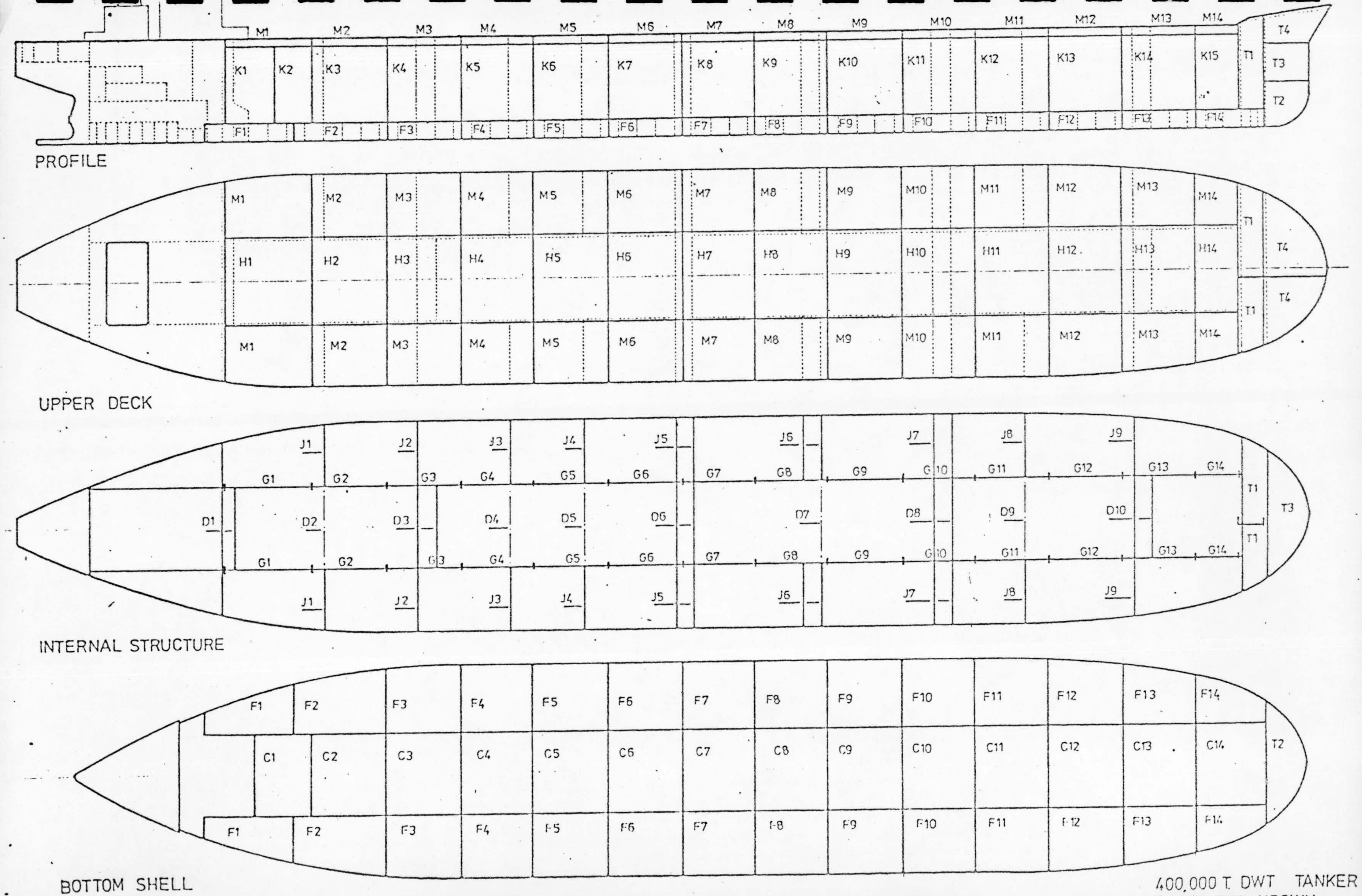


fig 6.2



400,000 T DWT TANKER
MIDSHIP SECTION

SCALE 1:125



400,000 T. DWT TANKER
BLOCK BREAKDOWN