The Application of Planned Maintenance to Steam Turbine Tankers*

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Organizing and developing a programme for the maintenance of a unit of capital equipment is not new, it is normal procedure in industry.

A maintenance policy may be quite justifiably vague in outline, as for example, the outside painting of a building every five to seven years, or it may be comprehensive and detailed, on an operating time basis, as with aircraft maintenance.

Within the shipping industry, there is a very wide variety of floating equipment, ranging from passenger vessels, through cargo carriers, tankers and speciality carriers, to estuarial craft, tugs and barges. Each is designed for a specific purpose, influenced by operating conditions, and having regulations applicable to the particular trade. For each, a maintenance policy will vary to meet the conditions of service.

This paper is intended as an interim report, on a study covering a plan for the overall maintenance of a fleet of ocean-going, steam turbine driven, crude oil tankers, classed with Lloyd's Register of Shipping. The term "interim" is stressed, as the study is far from complete, particularly in economic terms, and cannot yet be used as a basis for a firm policy.

The tentative conclusions drawn, therefore, apply only to this group of vessels, but the general outline and certain apparent principles could be applicable to other groups of vessels.

Why is such a study considered necessary?

Within the last decade, technological development in the size of these oil carriers, and in the design of equipment, has been significant.

Loss of earnings, due to fall off in speed between drydockings, and time out of service for maintenance repairs, becomes of increasing importance, and is related directly to the increasing size of these vessels.

Shipping in general is passing through a prolonged period of low freight rates and reduced earning potential, and in these highly competitive conditions, the cost factors, within the control of the operator, require more searching analysis.

Lloyd's classification requirements for surveys have been amended, based on operating experience, and this permits greater flexibility in the planning of maintenance.

Initially, this study is intended to examine the optimum period, between drydockings, solely for bottom cleaning and painting. Taken in conjunction with a system of planned maintenance by ship's staff, combined with continuous survey of machinery to meet classification requirements, the objective is to extend the periods between withdrawal of a vessel from service, for shipyard overhaul, possibly to a maximum of 24 months, during the first eight years' life of the vessel.

Thereafter, the time in service between shipyard repair periods will be regulated by boiler survey requirements.

The essential need for detailed ship and machinery performance records is stressed.

Tentative conclusions are drawn, and areas requiring closer investigation are highlighted. This interim study will no doubt provoke some controversy, but it is hoped that the comments and criticisms stimulated by the study will contribute to improvements in the overall operating efficiency.

INTRODUCTION

Reviewing the economic factors which constitute the overall cost of operation of a tanker in service and assuming that continuous employment for the vessel is available, three of these factors can vary appreciably and can be influenced by direct administrative control. These three factors are:

a) Repair costs (including the replacement value of "time out of service" for repairs).
b) Operational efficiency with emphasis on speed and fuel consumption.
c) Manning.

It is the intention to outline work which has been carried out to date, on planning for the overall maintenance of a tanker fleet, but it is emphasized that the pattern of thinking, as set

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out, and the results to date, are more in the nature of an interim report, rather than conclusions which could form the pattern for a firm policy.

The basic factor in the study has been—a) "Repair costs and time out of service", but factors b) and c) are interrelated, and their influence is commented upon at later stages in the paper.

Within the narrow confines of tanker operation, there are wide variations of size, design, and service requirements, ranging from coastal and estuarial vessels, through product and speciality carriers, to the very large crude oil tankers. For the purpose of this paper, therefore, and in order to utilize more specific data, two groups of vessels of 26,650 d.w.t. and 36,000 d.w.t. capacity, operating in the crude oil trade between the Persian Gulf and U.K., have been used. These are all post-war vessels, built and maintained under the classification of Lloyd's Register of Shipping; the earliest delivery in the group dating from 1954.

In effect, this involves a detailed economic study of two classes of vessel operating on a specific trade route, in order to arrive at the principles to be used for evaluation. Having arrived at this point, it may then be possible to apply, or adjust these basic principles to a wider range of vessels in the tanker trade.

Outline of Project

Prior to commencement of this study in 1960, the policy had been to drydock each vessel annually, at which time general maintenance repairs and classification surveys due, or due well prior to the following drydocking, were carried out.

Reduced to fundamental terms, the study now required analysis of two basic factors:

1) What was the deciding factor in determining at what period the cost of withdrawing a vessel from service, and docking, cleaning and painting the bottom, could be offset against the accumulative loss due to reduction in speed resulting from deterioration of the hull underwater surfaces?

and

2) What was the maximum period of time during which a vessel could be maintained in service, between classification and M.o.T. surveys, without loss of efficiency in machinery performance, subject to the maintenance of the equipment being planned in detail?

The optimum economic period between drydockings might not coincide with time out of service required for classification and M.o.T. surveys and, as the loss due to time out of service, or, conversely, the cost of replacing a vessel during repair time out of service, constitutes a substantial part of the "Repair cost" component, it was proposed that each of these "primary considerations" be studied separately.

PERIODICAL DRYDOCKING

Losses due to fall off in speed

Accurate and detailed analysis of the performance of a vessel in service, from log book and other performance data, is difficult, due to the influences of wind, weather and sea conditions, slowing down for policy reasons, perhaps to meet loading and/or discharging dates, or for short periods to suit tidal conditions or a Suez Canal transit. Again, there are machinery defects and breakdowns, inefficient operation of propulsion plant, defective instrumentation and the human errors in recording essential data.

Expenditure on trained technical manpower, both afloat and ashore, and the fitting of more costly but more accurate and reliable instrumentation on individual vessels has been difficult to justify previously, to ensure that such detailed performance data is available.

Basically, however, it is known that performance does deteriorate due to corrosion and roughening of the hull underwater surfaces and the development of marine growth. The loss in speed during a period of 12 months between drydocking and painting, can be appreciable, and the speed loss is not always fully regained on re-entering service after drydocking.

It was decided, therefore, to establish the basic economic principles for periods between drydocking, on a theoretical speed loss curve, based on "scatter charts" for the 26,650-d.w.t. vessels, over several years in service and, then concentrate on refining the analysis of actual performance data, with a view to drawing more positive conclusions.

Mention can be made at this stage that general Company policy has been to operate the main turbine unit of the vessels under consideration, under normal conditions at sea, on a fixed turbine nozzle setting for loaded and ballast voyages, with ahead throttle valve full open, to minimize pressure drop between H.P. steam supply, and H.P. turbine inlet. Assuming relatively constant boiler drum pressure, and superheat temperature, variation in propulsion power output will vary, to a limited extent, but over a period a comparison of performance under similar conditions can be made, and this has assisted in analysis of the "scatter chart" for speed loss.

Reverting now to the theoretical study, it it obvious that from commencement of service after bottom cleaning, the gradual speed loss is an accumulative loss in earnings, as time on voyages increases, and the eventual necessity for drydocking and cleaning entails further direct expenditure on maintenance, plus a period of loss of earnings or, alternatively, the cost of chartering-in a vessel, to balance the "out of service" time of the owned ship.

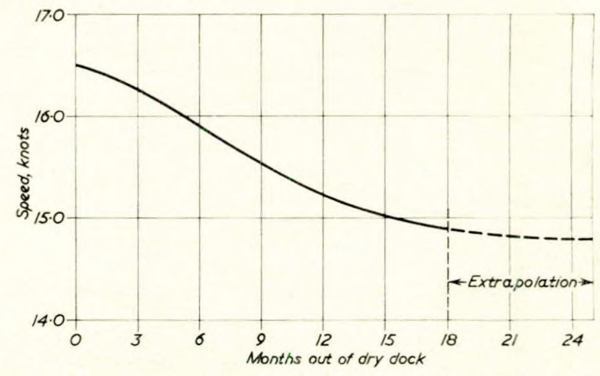


FIG. 1—*Approximate speed fall off curve—26,650 d.w.t. vessels*

Fig. 1 shows a rough curve, derived from the "scatter chart" for the 26,650-d.w.t. tankers, which has been used in an endeavour to show the pattern of the speed loss on these vessels over a period of months between drydocking and this has been extrapolated to cover a full period of 24 months. Speed is shown in knots, and on the basis of a fixed turbine nozzle setting, approximate constant power has been assumed.

Utilizing the rough curve shown in Fig. 1, an estimate can be made, at varying levels of freight rate, of the accumulative losses, either in earning capacity or in the equivalent of "chartered-in" tonnage for replacement on the basis of speed loss, over a period.

The accuracy of this estimate will depend, however, on the accuracy of the actual performance data available from a particular vessel, and as such estimates can influence the whole pattern of planned maintenance for this vessel, the necessity for maintaining and analysing reliable performance data, cannot be over emphasized.

Periodical Drydocking Costs

Generally, the fact of withdrawing a vessel from service, for drydocking and bottom cleaning, entails a loss of time, in deviating from the trade route to arrival at the port of docking, and from this port, back to the trade route. For the purposes of the study, a total period of 24 hours has been allowed for deviation, but this period can be adjusted, when preparing a cost study for a particular vessel.

Again, the charges for tugs, port charges, docking and undocking, dock rent, labour and hull coating materials will vary from port to port, and to some extent, on the type of bottom composition used and the condition of the underwater surfaces. For the purposes of this study, average costs have been used, assuming only hand scraping, brushing and washing down, and the application of conventional materials to boot-topping and bottom areas only.

These conventional coatings are one coat anti-corrosive and one of anti-fouling to the bottom, and one undercoat and one top-coat to the boot-topping.

A total of three days has been allowed, from arrival at the sea-buoy to departure from the sea-buoy, and taking into consideration the 24 hours allowed for deviation, the actual expenditure on drydocking and bottom cleaning is augmented by a total of 4 days cost of replacement tonnage at the level of freight rate obtainable at a particular time.

The three days "sea-buoy to sea-buoy" time includes four tides in dry dock, and it is assumed that gas-freeing for drydocking (access only) has been carried out en route.

Survey Requirements

For classification purposes and excluding docking for a damage survey, vessels in the group under consideration need only be drydocked within a maximum period of 24 months subject to the known condition of the vessel. (Lloyd's Register of Shipping "Additions and Amendments" dated 15.3.62).

Withdrawal of a vessel for machinery survey, or maintenance repairs is being considered independently.

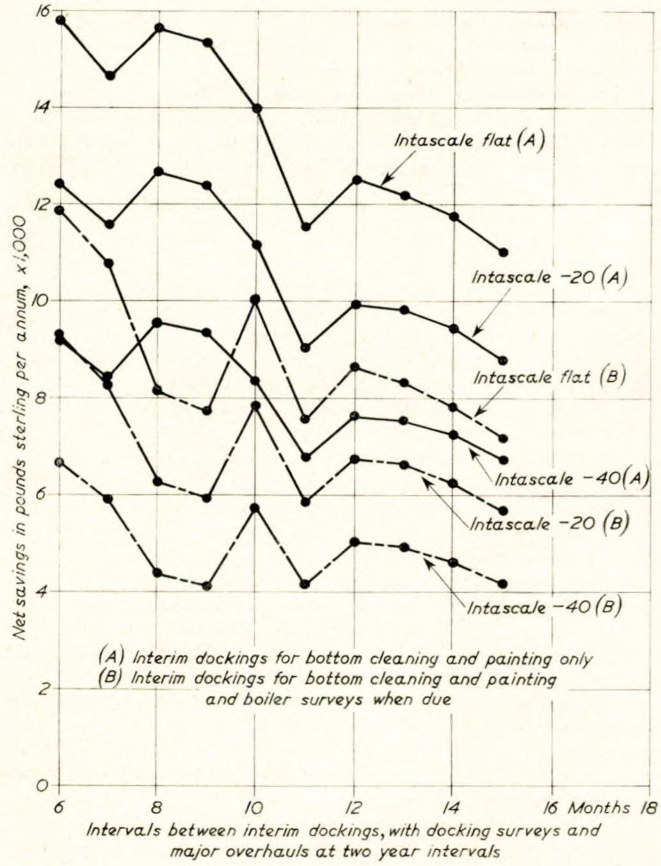
Optimum Drydocking Period

Fig. 2 shows a set of curves of apparent net saving over a period of 24 months, resulting from correction of speed loss, by interim docking for cleaning and painting 26,650-d.w.t. and 36,000-d.w.t. tankers, at fixed intervals of "x" months between docking periods, at a freight rate of Intascale Flat, Intascale −20 per cent and Intascale −40 per cent, based on the speed loss curve shown in Fig. 1 and the authors' estimate of average docking costs. Due allowance has been made for replacement tonnage for "out of service" time, at the appropriate freight rate.

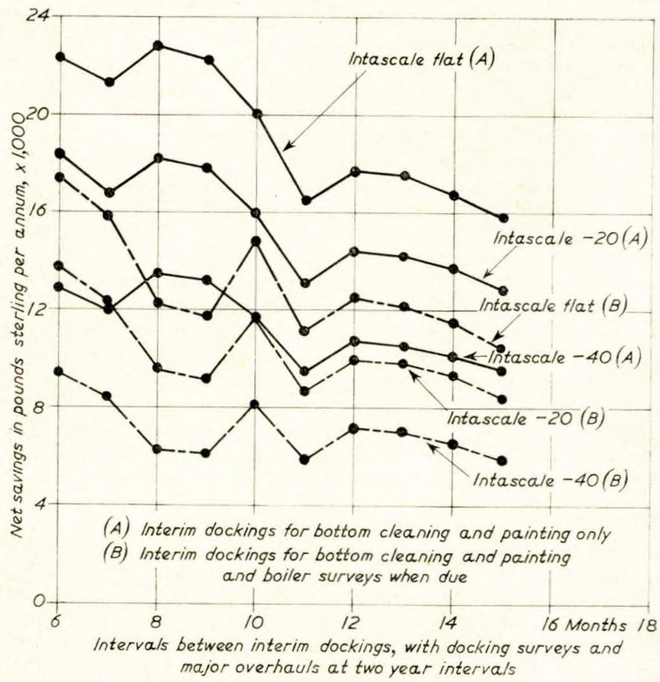
What tentative observations can be made on this accumulated information?

1) The shape of the speed loss curve in Fig. 1, when amended or confirmed by more reliable information, may be similar for the wider range of vessels on this trade route, and may approximate that for other vessels operating under similar trading conditions, but the slope of the curve will vary, depending on the degree of roughness and the extent of fouling of a particular vessel.
2) Curves on the basis of three freight rates only are shown, but the optimum period between drydocking, for a particular vessel in the group under consideration, may not be greatly influenced by the freight rate for replacement tonnage.
3) The weakest component is the assessment of the accumulated loss of earnings for a particular vessel due to drop-off in speed. A new vessel, with well prepared and smooth underwater hull surface, may operate for relatively long periods, initially, between docking, cleaning and coating, but as the underwater surface deteriorates due to corrosion, roughness and paint accumulation, these periods will decrease.
4) Ultimately, the economics of blasting the underwater surfaces to bare metal and recoating to obtain a smooth surface, at a shipyard repair period, may require to be considered, to restore the underwater surfaces to approximately the original condition and reduce the accumulated speed loss.

On the wider aspect, and reviewing the implications of this work, certain factors come to light and warrant further consideration, in an endeavour to improve efficiency and minimize cost.



(a) 26,650 **d.w.t.**



(b) 36,000 d.w.t.

Note: It is assumed that a period of grace not exceeding 3 months outside the boiler survey due date will be accepted by the Classification Society for interim Boiler Surveys.

FIG. 2—*Net savings by interim dockings after deducting all expenses*

Improved instrumentation of selected vessels, and the training of personnel to record and assess data, would establish more factual information on hull efficiency.

The running of short sea trials, at reasonably frequent intervals, on a selected and suitably calibrated area, close to a vessel's trade route, would provide much necessary information, more especially when allied to the improved instrumentation referred to above.

Continued research is required on the development of improved bottom coating materials, and it is suggested that such research may be channelled along two separate lines, i.e. the development of rapid drying coatings more compatible with the wide range of weather conditions experienced in Northern European shipyards, and the development of coatings having the properties of high density to resist deterioration, with a smooth external finish, and giving improved anti-corrosion control. These requirements underline the extent of further research needed in this field.

Dealing now with the direct costs incurred on the interim docking of a vessel, the time spent in deviation from the trade route and return to the trade route, is a loss, the magnitude depending on the total time of deviation and the replacement freight rate.

Again, the actual time in dry dock may possibly be reduced by improved labour organization, and "round the clock" working, on a shift system, with adequate dry dock floodlighting. This may increase direct maintenance costs, but could reduce tonnage replacement costs, for "out of service" time. In this context, it would appear essential for "round the clock" work to be carried out for docking and cleaning of the very large crude oil carriers of 60,000-100,000 d.w.t., if maintenance and replacement tonnage costs are not to become excessive.

Finally, the development of the technique of underwater hull scrubbing, using skin divers for the rapid clearing of marine growth, shows potential. This technique has been used in the Mediterranean area, and could well contribute to reducing speed loss and "out of service" time.

Survey Periods

Let us now turn our attention to consideration of the maximum period of time, during which a vessel could be maintained in service between surveys required for Lloyd's Register of Shipping and the Ministry of Transport.

The main and auxiliary machinery must be submitted for "special survey", every four years, some latitude on this period being permitted at the discretion of the Classification Committee. Owners may apply for approval to operate on "continuous survey" for Lloyd's Machinery Certificate, whereby equipment can be opened up, surveyed, and noted in the records, on an agreed cycle, at convenient intervals extending over the four-yearly period.

The group of vessels under consideration operate on "continuous survey" of machinery. It is suggested that this arrangement is more convenient, and equipment opened up for periodic overhaul at intermediate periods can be submitted for survey, saving time and minimizing cost at the "special survey" period.

Following amendment of the Rules in early 1959, boilers are to be surveyed at two-yearly maximum intervals until they are eight years old, and each year subsequently.

Survey of a single screwshaft, fitted with continuous liner is due every three years, with some latitude at the discretion of the Classification Committee and further comment on this is made later in the paper.

Application may be made to the Classification Committee to operate on "continuous survey" of hull and internal structure, over the four-yearly period between "special surveys" but the authors feel that no advantage is apparent in applying this to the vessels under consideration, at least, during the early years of life. The general requirements for hull "annual survey" can be carried out afloat, subject to the age and known condition of the vessel. The maximum interval between "docking surveys" is two years.

Endorsement of the "load line" certificate is due at 12-monthly intervals from the date of issue, and such endorsement may be carried out afloat, subject to the known condition of the vessel.

Renewal of the "safety equipment" certificate is required at two-yearly intervals, and the survey can be carried out afloat.

It appears, therefore, that subject to maintenance on board being carried out conscientiously, annual survey requirements could be arranged and carried out, with the vessel afloat, during normal loading and discharging periods and the vessel could be retained in service, during the initial eight years of life, for a period of two years between withdrawals, for shipyard repairs. Thereafter, the annual boiler survey requirements would require re-assessment of a maintenance policy.

The three-year period between screwshaft surveys, may be a problem of planning, if the survey does not coincide approximately with a shipyard overhaul. The survey may coincide and could be carried out, with an interim docking for bottom cleaning and painting only, but in these circumstances, time in dry dock may be increased.

It is assumed that dispensation from the Classification Society for deferring the survey for a limited period may be considered, subject to records being available, and to the wear-down being within allowable limits.

In recently constructed vessels, fitted with white metal lined, oil lubricated stern tubes and external and internal mechanical sealing arrangements, it is suggested that consideration could be given, based on operating experience, to extending screwshaft survey periods to four years, subject to more detailed design of keyway and cone end, being specified under classification requirements.

Shipboard Planned Maintenance

Theoretically, these vessels could now be operated in service for 24 months, between withdrawals for docking survey and shipyard repairs, during the initial eight years' life, but practically this entails continuous and detailed attention to maintenance to ensure seaworthiness and operational efficiency.

Undoubtedly, chief engineers and chief officers plan the work of their shipboard staff to ensure these requirements, but within the limits of these intentions, individual ideas differ on planning. There is lack of continuity resulting from frequent changes in staff for leave, or re-assignment, and shipboard planning must be co-ordinated with periodical shipyard repair periods and survey requirements.

The intention of a shipboard planned maintenance programme is to supply the necessary guidance to ships' staff for continuity, and to co-ordinate the efforts of the ships' staff into the overall plan for survey and repair.

Spare Gear Entitlement

The basic requirements for planned maintenance, as distinct from routine operational maintenance, are manpower and adequate replacement parts. It is first proposed to deal with the spare gear entitlement.

These vessels, when delivered from the builders, were furnished with the sub-contractors' "recommended spare parts", for each item of equipment, as detailed in the construction specification. Thereafter, replacements and additional spares have been requisitioned, and supplied, subject to scrutiny by shore staff, based on the experience and intentions of the senior departmental officers on board, and their knowledge of stock remaining on board at that time.

Opinions can differ widely on the efficiency of equipment, allowable rates of wear on components, optimum periods between overhauls, and the stockpiling of components on board as insurance against breakdown, especially when there is a considerable delay between ordering and delivery of spare parts.

The spare gear on board a vessel constitutes an appreciable capital investment and is justified only as an insurance against loss of efficiency, breakdown and delay to a vessel.

It was decided, therefore, that a primary requirement for a shipboard planned maintenance schedule was the preparation of an adequate spare gear entitlement for each vessel, or class of vessels, where equipment is essentially duplicated throughout the class. In effect, such an "entitlement" has been prepared and issued for the vessels under consideration. The preparation required a major effort in time, in stocktaking on board, in analysis of repair records and in pooling of experience to factually assess the minimum essential requirements.

The terms of reference to carry out this project were:

1) To establish a comprehensive spare gear entitlement for each vessel, with a sufficient quantity and range of spares to ensure continuity of the planned maintenance programme.
2) To check and record all spare gear already on board and to note a surplus or augment this stock to the level of entitlement.
3) To review the potential for shore based stockpiling of a limited number of large spare gear components, e.g. cargo pump rotating elements, forced draught fan motors, tailshafts, etc., for a class of vessel rather than carry on board, one spare component per vessel.
4) To review the spare gear storage available on board and to make such alterations as were deemed necessary for ease of handling.
5) To protectively wrap and attach an identification tag to each item of spare gear forming the entitlement.
6) To establish a comprehensive record filing system covering the spare gear entitlement for shipboard use.

Fig. 3 illustrates an example of a card from the spare gear filing system.

It may not be out of place, at this stage, to mention a few facts and some of the difficulties resulting from experience when putting this entitlement into effect:

a) The spare gear entitlement entailed additional capital expenditure, in the order of about £5,000 per vessel.
b) The total spare gear normally included as sub-contractors' "recommended spares" is inadequate for rapid shipboard maintenance. Partly assembled or assembled units, such as rotating elements for pumps, are more economical, providing worn units can be reconditioned ashore at reasonable cost and re-issued.
c) The responsibility for maintaining the entitlement should rest entirely on the ships' staff, but routine checks may be necessary to ensure that this responsibility is fully accepted, and omissions do not occur following staff changes.
d) Human nature being as it is, there may be a tendency to order items in excess of entitlement, "in case it may be needed".
e) Initially, there may be some apparent indiscriminate use of spares during machinery overhauls for the planned maintenance schedule. This could be a natural reaction resulting from the ready availability of spares, and if allowed to continue, could seriously affect the economics of the programme.

   Used spares can be placed ashore at the United Kingdom discharging ports, for examination by the resident engineer superintendent, with a view to reconditioning, where practicable, and return to the vessel or a shore stockpile. Of greater importance, however, is the re-assessment of wear rates on worn parts, resulting in review and probable extension of the time a unit can remain in service, between overhauls.
f) Plastic wrappers are useful for storing certain spares, whilst hot dipping in plastic material is equally satisfactory and protects against atmospheric and minor physical damage.
g) Each spare part in the filing system can be designated by a requisition reference number, which facilitates

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FORCED DRAUGHT FANS MOTORS DATA — INVENTORY PREFIX E2/

VESSEL ESSO — No. OF UNITS	SPARE GEAR				
MANUFACTURER HANSA MOTOREN,	SHIP'S PART No.	MAKER'S PART No.	DESCRIPTION OF PART	No. OFF	WHERE STORED
ADDRESS HAMBURG	E2/1		Set Stator Coils - High Speed	1	
	/2		Set Slot Insulation - High Speed	1	
INSTRUCTION BOOK No. — DRWG. No.	/3		Set Stator Coils - Low Speed	1	
REFER:	/4		Set Slot Insulation - Low Speed	1	
			Bearings, coupling end, SKF 6320		
			Bearings, free end, SKF 6320		
Type: 16.2500 6/4B			Motor Contactor Types :- 121/71-80A,		
H.P.: 70/250			221/121-130A, 300/221-220A & 521/351-380A		
R.P.M.: 1140/1760					
Volts: 440			Motor Starter Type :- 745/59/63/03		
Serial Nos.:-					
			For Ball-Bearing Spares Requirements see		
No. 1:			Chart, Page E.61		
No. 2:			For Motor Starter Spares Requirements see		
No. 3:			following pages		
			(a) CONTACTORS Pages E.57 to E.59		
			(b) MISCELLANEOUS Page E.60		
OPERATING AND MAINTENANCE NOTES					

FIG. 3—*Example of a card from the spare gear filing system*

easy identification in the spare gear section ashore, and simplifies descriptive wording in radio messages from ships afloat.

PLANNED MAINTENANCE SCHEDULE

These schedules fall naturally into two parts, i.e. deck and engine room departments.

The engine room schedule, in particular, is not designed to include routine maintenance and inspection normally practiced on board ship, but rather as an extension of this work, entailing the systematic inspection and reconditioning of equipment at specified intervals.

At the time of writing this paper, the vessels under consideration have been operating on an 18-month period between shipyard overhauls, with an interim drydocking for bottom cleaning, only when the condition of the external underwater surfaces, and assessment of the resultant speed loss, warranted an interim docking. However, the policy is currently under review and the initial planning is in hand to amend the programme to 24 months between shipyard overhauls, with an interim drydocking at 12 months.

Appendix A sets out in detail the planned maintenance schedule for machinery and electrical equipment on a 36,000-d.w.t. tanker based on the 18-month period between shipyard overhauls. It will be appreciated that the schedule can be re-phased, quite simply, to meet a possible change in policy.

Engine Room

Reverting now to Appendix A, some explanation may be required as to its use.

Planned Maintenance Schedule I sets out a general pattern of partial maintenance of various items as distinct from complete overhaul on a basis of time intervals, together with the complete overhaul, at protracted intervals, of units of equipment which are used only spasmodically. Taking for example, the auxiliary condensate pump; the turbo-generators normally exhaust to the main condenser and the auxiliary condenser is used only when the main propulsion unit must be shut down for repairs, or during a lengthy period in port. The actual running time for this pump is therefore limited, and a period of 4½ years between strip down for overhaul is considered adequate.

Planned Maintenance Schedules II-VII cover six three-monthly phases of planned maintenance commitments, for the periodical overhaul of essential equipment. The actual frequency of overhaul of individual units is based on the number of hours of service operation, taking into account the routine change-over from "running" to "standby", for all duplicated machinery.

Then follows a list of the major items which are to be specified in detail for shipyard overhaul, the criterion being that it is impracticable to strip down and service these units, whilst the vessel is in service.

Finally the three phases of continuous survey of main and auxiliary machinery, to classification requirements are set out, each phase covering an 18-month period.

Appendix B is part of a large chart, generally located in the Chief Engineer's office. The complete chart shows the planned maintenance and survey commitments, over the three 18-month periods, and as the symbols are marked off on completion of each commitment, overall progress with the programme can be assessed at a glance.

Finally, a small card index system has been supplied to facilitate the recording of actual work carried out and spare parts used in overhauling each particular unit.

Fig. 4 is an illustration of one of these cards and it will be noted that the use of symbols facilitates description of work done, and requires little in the way of explanation.

Deck Department

A similar pattern applies to the programming of deck maintenance.

The complete cycle is extended over a period of 18 months,

VESSEL S/S ESSO SHIP		RECORD OF REPAIRS, RENEWALS & SURVEYS			UNIT SERIAL No. M 33		
SYMBOLS	DATE	SYMBOLS OF WORK DONE	SPARE PARTS REPLACED, NAME AND QUANTITY	REQ. REF.	SHIP'S PART No.	DATE ORDERED	DATE RECEIVED
A = OPENED	17/5/61	A.K.U.L.O	1 - SHAFT SLEEVE PART Nº 29	27/61	M 33/2	23/5/61	18/7/61
B = CLEANED			1 - IMPELLER " " 4	"	M 33/6	"	"
C = ADJUSTED			2 - WEARING RINGS " " 5	"	M.33/5	"	"
D = VARNISHED			1 - BALL BEARING. S.K.F. 6306 Pt 21	"	M.33/8	"	11/7/61
E = MACHINED			1 - " " S.K.F. 3306 - C4. Pt 20	"	M.33/9	"	"
F = VALVES OVERHAULED							
G = RETUBED	12/1/62	A.E.K.L.O.U.	2 - WEARING RINGS PART Nº 5	1/62	M.33/5	22/1/62	29/4/62
H = REMETALLED							
I = REWOODED							
K = TESTED							
L = PARTS RENEWED							
M = CONDITION GOOD							
N = FUTURE REPAIRS (SHOW ON CARD EDGE)							
O = SHIP'S STAFF							
P = VOYAGE REPAIRS SHORE LABOUR							
Q = ANNUAL REFIT							
R = SEE OPERATING AND MAINTENANCE NOTES							
S = LLOYDS SURVEY							
T ( )= SEE BLUE BOOK ( )= PAGE No							
U = MAINTENANCE SCHEDULE							
V = BREAKDOWN							
WHEN ORDERING SPARES,							
INDICATE ON CARD EDGE							
IN APPROPRIATE MONTH							

SALT WATER EVAPORATOR BRINE PUMP Nº1 — FUT. REP. | 1 | 2 | 3 | 4 | J | F | M | A | MY | J | JY | A | S | O | N | D

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FIG. 4—*Card for recording of actual work carried out and spare parts used (Appendix B)*

but here again, re-phasing to meet a possible change in policy would be quite simple.

The cycle consists of six three-month phases of planned maintenance commitments, and for brevity, the first three-month phase only has been attached as Appendix C. No doubt this first phase will serve to illustrate the outline of the overall plan.

The emphasis is primarily on periodical inspection and maintenance of safety equipment, navigational equipment and the cargo system and systematic scaling and painting of structure.

Appendix D is part of a set of charts, detailing the complete cycle of the programme over an 18-month period, designed to show at a glance progress with commitments.

A small card index system is used to facilitate the recording of actual work carried out and the use of symbols, as illustrated in Fig. 5, minimizes the necessity for explanation.

a vessel in service, the possible savings in time due to anticipation of machinery failures, and to the effect on morale of a well maintained vessel.

Undoubtedly, the periodic inspection and reconditioning of equipment, should contribute to a higher degree of mechanical efficiency, and should assist in anticipating potential machinery failures. It is the authors' opinion that the active planning, co-operation and guidance which has been necessary between ship's staff and shore staff, in preparing the programme has resulted in a fuller appreciation of difficulties on board and a closer understanding of responsibilities.

These factors cannot be assessed on a monetary basis.

CONCLUSIONS

Maintenance and repairs represent a sizable proportion of the total operating cost of marine transportation.

This fact is fully appreciated, and forward estimating and cost control by budget allocation has been normal practice in many shipping companies.

VESSEL: ESSO SHIP. DATE OF LAST SURVEY: 1-3-58

DIMENSIONS/CAPACITY: 5 TONS UNIT SERIAL No.: WELLAND 632 & 633

SYMBOLS	DATE	APPLICABLE SYMBOLS	PARTS OVERHAULED/ REPAIRED/REPLACED, Etc.	PART	TYPE & NUMBER	SIZE/ THREAD, Etc.	DATE FITTED REPLACED
A = D.D. REPAIR	6/4/59	R	GRIPES & RELEASE SPANS	Limit Switches	G.E.C. AS/S/747		
B = RECHARGED	12/4/59	T	LIMIT SWITCHES OPERATING				
C = CLEANED			SATISFACTORILY	Gripes	WIRE	1¾"	
D = SCALED	11/5/59	S	BOWSING TACKLES - TURNED				
E = ADJUSTED			END FOR END	Release Spans	WIRE	1¾"	
F = REFILLED							
I = INSPECTED				Bowsing Tackles	MANILA	2½"	
K = REPACKED					2 DOUBLE-SHEAVE 4¾" GALV. BLOCKS		
L = OIL DRESSED				Tricing Gear	WIRE	1¾"	
O = OVERHAULED							
R = RENEWED				Clamps	NIL		
S = SURVEYED							
T = TESTED				Safety Bolts	T	1"	
V = VARNISHED							
W = WEIGHED							

LOCATION OF UNITS, SPARES, CONTROL POINTS, Etc.

CODE No	UNIT												
S.7	No.3 LIFEBOAT DAVITS	1	2	3	4	5	6	7	8	9	10	11	12

Commence typing here

In order that the Titles be VISIBLE they must be typed between the perforation and the light horizontal line which is ¼" above it—as close to the perforation as possible. After typing front and back, tear off perforated strip.

FIG. 5—*Example of card index system showing symbols used (Appendix D)*

Additional Personnel

It was not intended to assign specific personnel to a ship's staff, solely for the purpose of carrying out planned maintenance, but rather to guide and co-ordinate the effort of the staff on the application of the plan. However, it has been appreciated that assistance may be desirable, to ease the duties of watchkeeping officers, both on deck and in the engine room, and several proposals have been considered and tried. In general terms, the normal crew of a 26,650-d.w.t. and a 36,000-d.w.t. tanker have been augmented by one third engineer officer and one third deck officer, and the duties and responsibilities of carrying out planned maintenance are rotated amongst the officers at this level.

Operational Efficiency

It is relatively simple to assess the efficiency of a propulsion plant, operating on normal service power, by analysis of the fuel consumption and the engine room log book, but it is much more difficult to assess the degree of reliability of

The intention of this study is to analyse the major components which make up the maintenance and repairs cost, for a selected group of vessels, with a view to maintaining or possibly improving operational efficiency, with the maximum time in operational service, at the lowest practical repair expenditure.

Basic principles have been considered for assessing the most economic period between drydocking for bottom cleaning and painting, but these principles could be refined in detail.

Adequate performance data are not generally available to assess accurately the fall-off in speed of an individual vessel and the keeping of more detailed records is proposed. These records could be substantiated by short sea trials, at specified intervals, in a selected and calibrated sea area, close to a vessel's trade route.

Should the basic principles evolved, prove reliable, it is theoretically possible to operate a vessel for a maximum period of 24 months between shipyard overhauls, with one or more interim dockings for bottom cleaning during this period, subject to adequate shipboard maintenance, and the opportunity to carry out annual surveys afloat.

Assuming the speed loss curve, in Fig. 1, to be reasonably accurate, and reverting to the curves of optimum cost saving for docking periods (Fig. 2) there does not appear to be a great monetary incentive for interim docking periods of less than 12 months during the first eight years life of a vessel as long as the freight rate remains close to the present low level. Potential delays in obtaining a gas free certificate and the immediate availability of a dry dock will be borne in mind. However, on a basis of Intascale flat, or above, an interim docking at eight month periods could show some economic advantage.

After the first eight years of life, the 24 months between shipyard overhauls could be maintained. However, the cost of annual boiler survey and the additional "time out of service" to carry out this survey, plus the cost of an interim docking for cleaning and painting, would appear to indicate a combined docking and boiler survey at a 12-month interim.

Further research is indicated, to improve on the techniques of cleaning and preparing the external hull surfaces, and in developing the objective of maintaining these hull surfaces smooth and free from marine growth, thereby minimizing loss of speed over a period in service.

The expenditure on additional manning and in augmenting spare gear to the necessary entitlement is more than offset by repair cost savings together with savings in " time out of service" and in improved operational efficiency. Based on about two years experience the results of planned maintenance by ships' staff are most encouraging.

It is not a programme which can be started in an off-hand way, and later dropped, as considerable prior planning and explanation is required and prior expenditure is incurred.

The emphasis must be on guidance, rather than regimentation and the co-operation by ships' staff is of primary importance.

ACKNOWLEDGEMENTS

The authors appreciate the assistance of Mr. E. Eckert, Manager, Construction and Repairs Division, Esso Tankschiff Reederei, by reference to his primary work on optimum drydocking periods.

Thanks are due also to colleagues in Construction and Repairs Division and Staff of Marine Department, Esso Petroleum Co. Ltd., for their assistance and co-operation in the preparation of the paper.

Appendix A

PLANNED MAINTENANCE SCHEDULE—I
36,040-D.W.T. VESSELS
To operate in conjunction with the Lloyd's Continuous Survey Schedule

Every Voyage	
Cargo stripping pumps, Nos. 1 and 2	Examine suction and delivery valves and clean strainers.
Cargo pump emergency stop	Trip and prove in good order.
Main engine emergency valve	Trip and prove in good order.
Stores hoist	Test and prove in good order prior to storing.
Every Three Months	
Air compressors, S.S. and C.C. Nos. 1 and 2	Examine suction and delivery valves and unloaders. Refit or renew as required. Change oil. Clean air filters. Overhaul starters and pressure switches. Refit or renew contacts. Check all connexions for tightness.
Cargo pumps Nos. 1, 2, 3 and 4 and ballast pump	Examine governor and L.O. trip. Test overspeed trip.
Generators Nos. 1 and 2	Examine and clean all external governor gear. Test overspeed trip. Clean and adjust brush gear. Clean sliprings, etc. Clean air filters.
Forced draught fans Nos. 1, 2 and 3	Examine starters and check operation of all relays.
Steering gear Nos. 1 and 2	Examine starters and automatic change-over relays. Check all connexions for tightness.
Main shaft bearings	Drain off sample of oil and prove free from sludge.
Every Six Months	
Cargo stripping pumps, Nos. 1 and 2	Overhaul bridle gear. Check valve setting.
Air conditioning compressors, Nos. 1, 2 and 3	Examine suction and delivery valves. Check operation of protective devices. Overhaul starters.
Boilers, port and starboard	Water wash from air-heaters down. Inspect air-heaters, casings, refractory. Patch as required. Check air registers, burner fittings, soot blower elements. Remove selected handhole plates for internal examination of headers. Record any defects found.
Bailey controls, port and starboard	Clean Pilotrols and all air filters. Check air reducing valves. Prove draught connexions clear, check F.O. impulse line to fuel/air ratio controller. Examine fuel and feed control valve diaphragms. Repack glands as required. Examine positioners on fuel, feed and fan controllers.
F.D. fans, Nos. 1, 2 and 3	Examine fan bearings and couplings. Inspect vane assemblies. Make good any defects found.
Feed pumps, Nos. 1, 2 and 3	Examine and clean governor gear, check couplings. Test overspeed trip.

Main engine	Inspect gearing. Record anything of note. Check L.O. sprayers and clean filters. Verify axial position indicators. Examine and clean sliding feet.
Salt water evaporators, Nos. 1 and 2	Chemically clean, including brine lines. Pressure test complete units. Make good any leaks.
Make-up feed evaporator	Chemically clean. Pressure test shell and make good any leaks. Overhaul controls, valves, etc.
Steering gear, Nos. 1 and 2	Examine all pins and links in control mechanism. Prove pump locking pawls free.
Lubricating oil service pumps, Nos. 1 and 2	Overhaul starter. Check operation of automatic change-over device.
Main circulating pump	Examine and clean brush gear and sliprings. Overhaul starter and controller.
Air operated reducing valves, air operated level controllers	Examine controllers and air lines. Repack glands as required.
Generators, Nos. 1 and 2	Inspect gearing and couplings. Check axial position of rotor.
Every Nine Months	
Bilge pump, engine room	Examine suction and delivery valves. Refit or renew as required. Overhaul starter.
Butterworth pump	Examine pump and turbine bearings. Inspect L.O. system, gearing and coupling. Examine and clean L.O. cooler.
Cargo pumps, Nos. 1, 2, 3 and 4 and ballast pump	Examine pump and turbine bearings. Inspect L.O. system, gearing and coupling. Examine and clean L.O. cooler.
Generator, Nos. 1 and 2	Examine and clean L.O. cooler.
L.O. cooler pump	Open for examination of impeller, wearing rings, bushes, bearings, etc. Refit or renew parts as required. Overhaul starter.
Sanitary pumps, Nos. 1 and 2	Complete overhaul of pump. Overhaul starter.
S.W. evaporator Nos. 1 and 2 pumps and air ejectors	Complete overhaul of all pumps. Overhaul starters. Examine and clean air ejector nozzles.
Refrigerator compressors, Nos. 1 and 2	Examine suction and delivery valves. Refit or renew as required. Check strainers and driers. Check operation of protective devices. Overhaul starters.
Windlass	Run on test. Adjust bearings as required. Overhaul brake, clutch, and reversing gear.
Capstans, Nos. 1, 2 and 3	Run on test. Adjust bearings as required. Overhaul reversing gear. Clean sump. Change oil.
Engine room vent fans, Nos. 1, 2, 3 and 4	Overhaul starters.
Boiler room vent fans, Nos. 1, 2, 3 and 4	Overhaul starters.
Pump room vent fan	Overhaul starters.
Annulus fan	Overhaul starters.
Accommodation vent fans	Overhaul starters.
Galley vent fans	Overhaul starters.
Air compressors, S.S. and C.C. Nos. 1 and 2	Complete overhaul.
Pump room fan, steam turbine	Run on test. Remedy any defects.
Every Eighteen Months	
Fuel oil transfer pump, E.R.	Complete overhaul of steam and liquid ends. Check adjustment of relief valve.
F.O. service and transfer pump	Complete overhaul of steam and liquid ends. Check adjustment of relief valve.
F.O. transfer pump, forward	Complete overhaul of steam and liquid ends. Check adjustment of relief valve.
Bilge and ballast pump, forward	Complete overhaul of steam and liquid ends. Check adjustment of relief valve.
General service pump	Complete overhaul of steam and liquid ends. Check adjustment of relief valve.
Amidships fresh water transfer pump	Complete overhaul of steam and liquid ends. Check adjustment of relief valve.
Winches, Nos. 1, 2, 3 and 4	Complete overhaul.
Wash water pump, Nos. 1 and 2	Complete overhaul of pump, motor and starter.
Drinking water pumps, Nos. 1 and 2	Complete overhaul of pump, motor and starter.
Boiler compound pump	Complete overhaul of pump, motor and starter.
M.U.F. evaporator feed pump or S.W. evaporator emergency feed pump	Complete overhaul of pump, motor and starter.
Thermotank H.W. pumps, fwd. Nos. 1 and 2; aft Nos. 1 and 2	Complete overhaul of pump, motor and starter.
Hot wash water circulating pump	Complete overhaul of pump, motor and starter.
Air conditioning circulating pumps, Nos. 1 and 2	Complete overhaul of pump. Overhaul starter.
Fire pump	Complete overhaul of pump. Overhaul starter.
Main condensate pumps, Nos. 1 and 2	Complete overhaul of pump. Overhaul starter.
F.O. service pumps, Nos. 1 and 2	Complete overhaul of pump. Overhaul starter.
L.O. purifier, Nos. 1 and 2	Overhaul starter.
Sanitary pumps, Nos. 1 and 2	Open up motor, clean and varnish windings. Renew bearings as required.
S.W. evaporator, Nos. 1 and 2 pumps	Open up motor, clean and varnish windings. Renew bearings as required.

Gland vapour exhaust fan, auxiliary	Overhaul motor and starter.
Gland vapour exhaust fan, main	Overhaul starter.
Cold start feed pump	Overhaul starter.
Cold start fuel pump	Overhaul starter.
Feed pumps, Nos. 1, 2 and 3	Overhaul governor and trip mechanism. Examine pump and turbine bearings and coupling. Inspect L.O. pump and system. Clean L.O. cooler and bearing sumps.
Generator, emergency Diesel	Inspect valve gear, crankcase, bottom ends, etc. Examine all starting and alarm systems. Clean and adjust brush gear, clean sliprings, etc.

Every Four Years (at Completion of C.S. Cycle)

Auxiliary condensate pump	Complete overhaul of pump. Overhaul starter.
Auxiliary circulating pump	Complete overhaul of pump. Overhaul starter.
Cold start F.O. pump	Complete overhaul of pump, motor and starter.
Cold start feed pump	Complete overhaul of pump, motor and starter.
L.O. service pumps, Nos. 1 and 2	Complete overhaul of pump.
F.O. heaters, Nos. 1 and 2	Chemically clean.
F.O. heater drain cooler	Chemically clean.

PLANNED MAINTENANCE SCHEDULE—II
36,040-D.W.T. VESSELS

Work to be Carried Out by Ship's Staff During the First Three-month Period

Unit	*Description of Work*
Air compressor, S.S.	Complete overhaul.
Air compressor, C.C. Nos. 1 and 2	Examine suction and delivery valves and unloaders. Refit or renew as required. Change oil. Clean air filters.
Air conditioning compressor, Nos. 1, 2 and 3	Examine suction and delivery valves. Refit or renew as required. Check operation of protective devices.
Air conditioning circulating pump, No. 1	Complete overhaul.
Air operated reducing valves	Examine controllers and air lines. Repack glands as required.
Bilge pump, E.R.	Examine suction and delivery valves. Refit or renew as required.
Ballast pump, main cargo pumps, Nos. 1, 2, 3 and 4	Examine governor and L.O. trip. Test overspeed trip.
Stripping pumps, Nos. 1 and 2	Examine suction and delivery valves and clean strainers each voyage. Overhaul bridle gear, check valve settings.
S.W. evaporator, Nos. 1 and 2	Chemically clean, including brine lines. Pressure test complete units and make good any leaks.
S.W. evaporator, No. 1, pumps	Overhaul all associated pumps. Examine and clean air ejector nozzle.
F.O. transfer pump, E.R.	Complete overhaul of steam and liquid ends. Check adjustment of relief valve.
Feed pumps, Nos. 1, 2 and 3	Examine and clean external governor gear. Check couplings. Test overspeed trip.
Generator, Nos. 1 and 2	Examine and clean all external governor gear. Inspect gearing and couplings. Check axial position of rotor. Test overspeed trip.
Main engine	Inspect gearing. Record anything of note. Check L.O. sprayers, clean filters. Verify axial position indicators. Examine and clean sliding feet.
Main shaft bearings	Drain off sample of oil. Prove free from sludge.
Main engine emergency valve	Trip each voyage.
Steering gear, Nos. 1 and 2	Examine all pins and links in control mechanism. Prove pump locking pawls free.
Stores hoist	Check for correct operation each voyage before storing.
Windlass	Run on test. Adjust bearings as required. Overhaul brake, clutch and reversing gear.
Capstan, No. 1	Run on test. Adjust bearings as required. Overhaul reversing gear. Clean sump. Change oil.
Pump room fan, steam turbine	Run on test. Remedy any defects.

Electrical—First Three-month Period

Air compressors, S.S. and C.C. Nos. 1 and 2	Overhaul starters and pressure switches.
Air conditioning compressors, Nos. 1, 2 and 3	Overhaul starters.
Air conditioning circulating pump, No. 1	Overhaul starter.
Bilge pump, E.R.	Overhaul starter.
Cargo pump emergency stop	Trip and prove in good order each voyage.
S.W. evaporator No. 1, pumps	Open up all motors. Clean and varnish windings. Renew bearings as required. Overhaul starters.
F.D. fans, Nos. 1, 2 and 3	Examine starters. Check operation of all relays.
Generator, Nos. 1 and 2	Examine, clean and adjust brush gear. Clean sliprings, etc. Clean air filters.
Steering gear, Nos. 1 and 2	Examine starters and automatic change-over relays.
Stores hoist	Check controller. Prove in good order each voyage prior to storing.
E.R. vent fans, Nos. 1, 2, 3 and 4	Overhaul starters.
Pump room vent fan	Overhaul starter.

PLANNED MAINTENANCE SCHEDULE—III
36,040-D.W.T. VESSELS

Work to be Carried Out by Ship's Staff During the Second Three-month Period

Unit	*Description of Work*
Air compressor, C.C. No. 1	Complete overhaul.

Air compressor, S.S. and C.C. No. 2	Examine suction and delivery valves and unloaders. Refit or renew as required. Change oil. Clean air filters.
Air operated level controllers	Examine controllers and air lines. Repack glands as required.
Boilers, port and starboard	Water wash from air-heaters down. Inspect air-heaters, casings, refractory. Patch as required. Check air registers, burner fittings, soot blower elements. Remove selected handhole plates for internal examination of headers. Record any defects found.
Bailey controls, port and starboard	Clean Pilotrols and all air filters. Check air reducing valves. Prove draught connexions clear, check F.O. impulse line to fuel/air ratio controller. Examine fuel and feed control valve diaphragms. Repack glands as required. Examine positioners on fuel, feed and fan controllers.
Bilge and ballast pump, forward	Complete overhaul of steam and liquid ends. Check adjustment of relief valve.
Ballast pump, main cargo pumps, Nos. 1, 2, 3 and 4	Examine governor and L.O. trip. Examine pump and turbine bearings, couplings and gearing. Examine L.O. system. Clean L.O. cooler. Test overspeed trip.
Stripping pumps, Nos. 1 and 2	Examine suction and delivery valves and clean strainers each voyage.
Drinking water pump, No. 1	Complete overhaul.
Main condensate pump, No. 1	Complete overhaul.
M.U.F. evaporator feed pump or S.W. evaporator emergency feed pump	Complete overhaul.
M.U.F. evaporator	Chemically clean. Pressure test shell and make good any leaks. Overhaul controls, valves, etc.
F.D. fans, Nos. 1, 2 and 3	Examine fan bearings and couplings. Examine vane assemblies and make good any defects found.
F.O. service pump, No. 1	Complete overhaul. Check relief valve.
Generator, Nos. 1 and 2	Examine and clean all external governor gear. Test overspeed trip.
Main shaft bearings	Drain off sample of oil. Prove free from sludge.
Main engine emergency valve	Trip each voyage.
L.O. cooler pump	Complete overhaul
Refrigerator compressor, No. 1	Examine suction and delivery valves. Refit or renew as required. Check strainers and driers. Check operation of protective devices.
Sanitary pump, No. 1	Complete overhaul.
Stores hoist	Check for correct operation each voyage before storing.
Wash water pump, No. 1	Complete overhaul.
Winch, No. 1	Complete overhaul. Clean sump. Change oil.
Capstan, No. 2	Run on test. Adjust bearings as required. Overhaul reversing gear. Clean sump. Change oil.

Electrical—Second Three-month Period

Air compressors, S.S. and C.C. Nos. 1 and 2	Overhaul starters and pressure switches.
Cargo pump emergency stop	Trip and prove in good order each voyage.
Drinking water pump, No. 1	Open up motor. Clean and varnish windings. Renew bearings as required. Overhaul starter.
Main circulating pump	Examine and clean brush gear, sliprings, etc. Overhaul starter and controller.
Main condensate pump, No. 1	Overhaul starter.
M.U.F. evaporator feed pump (or S.W. evaporator emergency feed pump)	Open up motor. Clean and varnish windings. Renew bearings as required. Overhaul starter.
F.D. fans, Nos. 1, 2 and 3	Examine starters. Check operation of all relays.
F.O. Service pump, No. 1	Overhaul starter.
Generator, Nos. 1 and 2	Examine, clean and adjust brush gear. Clean sliprings, etc. Clean air filter.
L.O. service pump, Nos. 1 and 2	Overhaul starter. Check operation of automatic change-over device.
L.O. cooler pump	Overhaul starter.
Refrigerator compressor, No. 1	Overhaul starter.
Sanitary pump, No. 1	Overhaul starter.
Steering gear, Nos. 1 and 2	Examine starters and automatic change-over relays.
Stores hoist	Check controller. Prove in good order each voyage before storing.
Wash water pump, No. 1	Open up motor. Clean and varnish windings. Renew bearings as required. Overhaul starter.
B.R. vent fans, Nos. 1, 2, 3 and 4	Overhaul starters.
Annulus fan	Overhaul starter.

Once Only at Four Years (at Completion of C.S. Cycle) During Third Eighteen-month Period

Auxiliary circulating pump	Complete overhaul of pump. Overhaul starter.

PLANNED MAINTENANCE SCHEDULE—IV

36,040-D.W.T. VESSELS

Work to be Carried Out by Ship's Staff During the Third Three-month Period

Unit	*Description of Work*
Air compressor, C.C. No. 2	Complete overhaul.
Air compressor, S.S. and C.C. No. 1	Examine suction and delivery valves and unloaders. Refit or renew as required. Change oil. Clean air filters.

Air conditioning compressor Nos. 1, 2 and 3	Examine suction and delivery valves. Refit or renew as required. Check operation of protective devices.
Air operated reducing valves	Examine controllers and air lines. Repack glands as required.
Butterworth pump	Examine pump and turbine bearings, gearing and coupling. Inspect L.O. system. Examine and clean cooler.
Ballast pump, main cargo pumps Nos. 1, 2, 3 and 4	Examine governor and L.O. trip. Test overspeed trip.
Stripping pumps, Nos. 1 and 2	Examine suction and delivery valves, and clean strainers each voyage. Overhaul bridle gear, check valve settings.
S.W. evaporator, Nos. 1 and 2	Chemically clean, including brine lines, pressure test complete units and make good any leaks.
S.W. evaporator, No. 2 pumps	Overhaul all associated pumps. Examine and clean air ejector nozzle.
F.O. transfer pump, forward	Complete overhaul of steam and liquid ends. Check adjustment of relief valve.
Feed pumps, Nos. 1, 2 and 3	Examine pump and turbine bearings and coupling. Overhaul governor and trip mechanism. Test overspeed trip. Inspect L.O. pump and system. Clean L.O. cooler and bearing sumps.
Fire pump	Complete overhaul.
Generator, Nos. 1 and 2	Examine and clean all external governor gear. Inspect gearing and couplings. Check axial position of rotor. Test overspeed trip. Examine and clean L.O. cooler.
Main engine	Inspect gearing. Record anything of note. Check L.O. sprayers, clean filters. Verify axial position indicators. Examine and clean sliding feet.
Main shaft bearings	Drain off sample of oil. Prove free from sludge.
Main engine emergency valve	Trip each voyage.
Refrigerator compressor, No. 2	Examine suction and delivery valves. Refit or renew as required. Check strainers and driers. Check operation of protective devices.
Sanitary pump, No. 2	Complete overhaul.
Steering gear, Nos. 1 and 2	Examine all pins and links in control mechanism. Prove pump locking pawls free.
Stores hoist	Check for correct operation each voyage before storing.
Thermotank H.W. pumps, fwd. No. 1; aft No. 1	Complete overhaul.
Winch, No. 2	Complete overhaul. Clean sump. Change oil.
Capstan, No. 2	Run on test. Adjust bearings as required. Overhaul reversing gear. Clean sump. Change oil.

Electrical—Third Three-month Period

Air compressors, S.S. and C.C. Nos. 1 and 2	Overhaul starters and pressure switches.
Air conditioning compressors, Nos. 1, 2 and 3	Overhaul starters.
Cargo pump emergency stop	Trip and prove in good order each voyage.
S.W. evaporator, No. 2 pumps	Open up all motors. Clean and varnish windings. Renew bearings as required. Overhaul starters.
F.D. fans, Nos. 1, 2 and 3	Examine starters. Check operation of all relays.
Fire pump	Overhaul starter.
Generator, Nos. 1 and 2	Examine, clean and adjust brush gear. Clean sliprings, etc. Clean air filter.
Refrigerator compressor, No. 2	Overhaul starter.
Sanitary pump, No. 2	Overhaul starter.
Steering gear, Nos. 1 and 2	Examine starter and automatic change-over relays.
Stores hoist	Check controller. Prove in good order each voyage prior to storing.
Thermotank H.W. pump, fwd. No. 1; aft No. 1	Open up motor. Clean and varnish windings. Renew bearings as required. Overhaul starters.
L.O. purifier, No. 1	Overhaul starter.
Accommodation vent fans	Overhaul starters.
Galley vent fans	Overhaul starters.

Once Only at Four Years (at Completion of C.S. Cycle) During Second Eighteen-month Period

L.O. purifier, No. 1	Open up motor. Clean and varnish windings. Renew bearings as required.

PLANNED MAINTENANCE SCHEDULE—V
36,040-D.W.T. VESSELS

Work to be Carried Out by Ship's Staff During the Fourth Three-month Period

Unit	*Description of Work*
Air compressor, S.S.	Complete overhaul.
Air compressor, C.C. Nos. 1 and 2	Examine suction and delivery valves and unloaders. Refit or renew as required. Change oil. Clean air filters.
Air conditioning circulating pump, No. 2	Complete overhaul.
Air operated level controllers	Examine controllers and air lines. Repack glands as required.
Boilers, port and starboard	Water wash from air-heaters down. Inspect air-heaters, casings, refractory. Patch as required. Check air registers, burner fittings, soot blower elements. Remove selected handhole plates for internal examination of headers. Record any defects found.
Bailey controls, port and starboard	Clean Pilotrols and all air filters. Check air reducing valves. Prove draught connexions clear, check F.O. impulse line to fuel/air ratio controller. Examine fuel and feed control valve diaphragms.

	Repack glands as required. Examine positioners on fuel, feed and fan controllers.
Bilge pump, E.R.	Complete overhaul. Check adjustment of relief valve.
Ballast pump, main cargo pumps Nos. 1, 2, 3 and 4	Examine governor and L.O. trip. Test overspeed trip.
Stripping pumps, Nos. 1 and 2	Examine suction and delivery valves and clean strainers each voyage.
S.W. evaporator, No. 1, pumps	Overhaul all associated pumps. Examine and clean air ejector nozzles.
M.U.F. evaporator	Chemically clean. Pressure test shell and make good any leaks. Overhaul controls, valves, etc.
F.D. fans, Nos. 1, 2 and 3	Examine fan bearings and couplings. Examine vane assemblies and make good any defects found.
Generator, Nos. 1 and 2	Examine and clean all external governor gear. Test overspeed trip.
Main shaft bearings	Drain off sample of oil. Prove free from sludge.
Main engine emergency valve	Trip each voyage.
Stores hoist	Check for correct operation each voyage before storing.
Windlass	Run on test. Adjust bearings as required. Overhaul brake, clutch and reversing gear.
Capstan, No. 1	Run on test. Adjust bearings as required. Overhaul reversing gear. Clean sump, change oil.
Pump room fan, steam turbine	Run on test. Remedy any defects.
Amidships F.W. transfer pump	Complete overhaul of steam and liquid ends. Check adjustment of relief valve.
F.O. emergency gear	Test tripping arrangements.

Electrical—Fourth Three-month Period

Air compressors, S.S. and C.C. Nos. 1 and 2	Overhaul starters and pressure switches.
Air conditioning circulating pump, No. 2	Overhaul starter.
Bilge pump, E.R.	Overhaul starter.
Cargo pump emergency stop	Trip and prove in good order each voyage.
Main circulating pump	Examine and clean brush gear, sliprings, etc. Overhaul starter and controller.
S.W. evaporator, No. 1, pumps	Overhaul starters.
F.D. fans, Nos. 1, 2 and 3	Examine starters. Check operation of all relays.
Generator, Nos. 1 and 2	Examine, clean and adjust brush gear. Clean sliprings, etc. Clean air filters.
L.O. service pump, No. 1	Overhaul starter. Check operation of automatic change-over device.
L.O. purifier, No. 2	Overhaul starter.
Steering gear, Nos. 1 and 2	Examine starters and automatic change-over relays.
Stores hoist	Check controller. Prove in good order each voyage prior to storing.
E.R. vent fans, Nos. 1, 2, 3 and 4	Overhaul starters.
Pump room vent fan	Overhaul starter.
Gland vapour exhaust fan, main	Overhaul starter.
Gland vapour exhaust fan, auxiliary	Open up motor. Clean and varnish windings. Overhaul starter.

Once Only at Four Years (at Completion of C.S. Cycle)

During First Eighteen-month Period

L.O. service pump, No. 2	Open up motor. Clean and varnish windings, renew bearings as required.

During Second Eighteen-month Period

L.O. purifier, No. 2	Open up motor. Clean and varnish windings, renew bearings as required.

During Third Eighteen-month Period

L.O. service pump, No. 1	Open up motor. Clean and varnish windings, renew bearings as required.

PLANNED MAINTENANCE SCHEDULE—VI
36,040-D.W.T. VESSELS

Work to be Carried Out by Ship's Staff During the Fifth Three-month Period

Unit	*Description of Work*
Air compressor, C.C. No. 1	Complete overhaul.
Air compressor, S.S. and C.C. No. 2	Examine suction and delivery valves, and unloaders. Refit or renew as required. Change oil. Clean air filters.
Air conditioning compressors, Nos. 1, 2 and 3	Examine suction and delivery valves. Refit or renew as required. Check operation of protective devices.
Air operated reducing valves	Examine controllers and air lines. Repack glands as required.
Boiler compound pump	Complete overhaul.
Ballast pump, main cargo pumps, Nos. 1, 2, 3 and 4	Examine governor and L.O. trip. Examine pump and turbine bearings, couplings and gearing. Examine L.O. system. Clean L.O. cooler. Test overspeed trip.
Stripping pumps, Nos. 1 and 2	Examine suction and delivery valves and clean strainers each voyage. Overhaul bridle gear, check valve settings.
Drinking water pump, No. 2	Complete overhaul.
Main condensate pump, No. 2	Complete overhaul.
General service pump	Complete overhaul of steam and liquid ends. Check adjustment of relief valve.
S.W. evaporator, Nos. 1 and 2	Chemically clean, including brine lines. Pressure test complete units and make good any leaks.
F.O. service pump, No. 2	Complete overhaul.

Feed pumps, Nos. 1, 2 and 3	Examine and clean governor gear. Check couplings. Test overspeed trip.
Generator, Nos. 1 and 2	Examine and clean all external governor gear. Inspect gearing and couplings. Check axial position of rotor. Test overspeed trip.
Main engine	Inspect gearing. Record anything of note. Check L.O. sprayers, clean filters. Verify axial position indicators. Examine and clean sliding feet.
Main shaft bearings	Drain off sample of oil. Prove free from sludge.
Main engine emergency valve	Trip each voyage.
L.O. cooler pump	Complete overhaul.
Refrigerator compressor, No. 1	Examine suction and delivery valves. Refit or renew as required. Check strainers and driers. Check operation of protective devices.
Sanitary pump, No. 1	Complete overhaul.
Steering gear, Nos. 1 and 2	Examine all pins and links in control mechanism. Prove pump pawls free.
Stores hoist	Check for correct operation each voyage before storing.
Wash water pump, No. 2	Complete overhaul.
Winch, No. 3	Complete overhaul. Clean sump, change oil.
Capstan, No. 2	Run on test. Adjust bearings as required. Overhaul reversing gear. Clean sump, change oil.

Electrical—Fifth Three-month Period

Air compressors, S.S. and C.C. Nos. 1 and 2	Overhaul starters and pressure switches.
Air conditioning compressors, Nos. 1, 2 and 3	Overhaul starters.
Cargo pump emergency stop	Trip and prove in good order each voyage.
Boiler compound pump	Open up motor. Clean and varnish windings. Renew bearings as required. Overhaul starter.
Drinking water pump, No. 2	Open up motor. Clean and varnish windings. Renew bearings as required. Overhaul starter.
Main condensate pump, No. 2	Overhaul starter.
F.D. fans, Nos. 1, 2 and 3	Examine starters. Check operation of all relays.
F.O. service pump, No. 2	Overhaul starter.
Generator, Nos. 1 and 2	Examine, clean and adjust brush gear. Clean sliprings, etc. Clean air filter.
L.O. cooler pump	Overhaul starter.
Refrigerator compressor, No. 1	Overhaul starter.
Sanitary pump, No. 1	Open up motor. Clean and varnish windings. Renew bearings as required. Overhaul starter.
Steering gear, Nos. 1 and 2	Examine starters and automatic change-over relays.
Stores hoist	Check controller. Prove in good order each voyage prior to storing.
Wash water pump, No. 2	Open up motor. Clean and varnish windings. Renew bearings as required. Overhaul starter.
B.R. vent fans, Nos. 1, 2, 3 and 4	Overhaul starters.
Annulus fan	Overhaul starter.

Once Only at Four Years (at Completion of C.S. Cycle)

During First Eighteen-month Period

F.O. heater, No. 1	Chemically clean.

During Second Eighteen-month Period

F.O. heater, No. 2	Chemically clean.
F.O. heater drain cooler	Chemically clean.

During Third Eighteen-month Period

Auxiliary condensate pump	Complete overhaul of pump. Overhaul starter.

PLANNED MAINTENANCE SCHEDULE—VII
36,040-D.W.T. VESSELS

Work to be Carried Out by Ship's Staff During the Sixth Three-month Period

Unit	*Description of Work*
Air compressor, C.C. No. 2	Complete overhaul.
Air compressor, S.S. and C.C. No. 1	Examine suction and delivery valves and unloaders. Refit or renew as required. Change oil. Clean air filters.
Air operated level controllers	Examine controllers and air lines. Repack glands as required.
Boilers, port and starboard	Water wash from air-heaters down. Inspect air-heaters, casings, refractory. Patch as required. Check air registers, burner fittings, soot blower elements. Remove selected handhole plates for internal examination of headers. Record any defects found.
Bailey controls, port and starboard	Clean Pilotrols and all air filters. Check air reducing valves. Prove draught connexions clear, check F.O. impulse line to fuel/air ratio controller. Examine fuel and feed control valve diaphragms. Repack glands as required. Examine positioners on fuel, feed and fan controllers.
Butterworth pump	Examine pump and turbine bearings. Inspect L.O. system, gearing and coupling. Examine and clean L.O. cooler.
Ballast pump, main cargo pumps, Nos. 1, 2, 3 and 4	Examine governor and L.O. trip. Test overspeed trip.
Stripping pumps, Nos. 1 and 2	Examine suction and delivery valves, and clean strainers each voyage.
S.W. evaporator, No. 2, pumps	Overhaul all associated pumps. Examine and clean air ejector nozzle.
M.U.F. evaporator	Chemically clean. Pressure test shell and make good all leaks. Overhaul controls, valves, etc.

F.D. fans, Nos. 1, 2 and 3	Examine fan bearings and couplings. Examine vane assemblies and make good any defects found.
F.O. service and transfer pump	Complete overhaul of steam and liquid end. Check adjustment of relief valve.
Generator, Nos. 1 and 2	Examine and clean all external governor gear. Test overspeed trip.
Generator, emergency Diesel	Inspect valve gear, crankcase, bottom ends, etc. Check air starting system.
Main shaft bearings	Drain off sample of oil. Prove free from sludge.
Main engine emergency valve	Trip each voyage.
Refrigerator compressor, No. 2	Examine suction and delivery valves. Refit or renew as required. Check strainers and driers. Check operation of protective devices.
Sanitary pump, No. 2	Complete overhaul.
Stores hoist	Check for correct operation each voyage before storing.
Hot wash water circulating pump	Complete overhaul.
Thermotank H.W. pumps, fwd. No. 2; aft No. 2	Complete overhaul.
Winch, No. 4	Complete overhaul, clean sump, change oil.
Capstan, No. 3	Run on test. Adjust bearings as required. Overhaul reversing gear. Clean sump. Change oil.

Electrical—Sixth Three-month Period

Air compressors, S.S. and C.C. Nos. 1 and 2	Overhaul starters and pressure switches.
Cargo pump emergency stop	Trip and prove in good order each voyage.
Main circulating pump	Examine and clean brush gear and sliprings, etc. Overhaul starter and controller.
S.W. evaporator, No. 2, pumps	Overhaul starters.
F.D. fans, Nos. 1, 2 and 3	Examine starters. Check operation of all relays.
Generator, Nos. 1 and 2	Examine, clean and adjust brush gear, clean sliprings, etc. Clean air filters.
Generator, emergency Diesel	Examine starting and alarm systems. Clean and adjust brush gear. Clean sliprings, etc.
L.O. service pump, Nos. 1 and 2	Overhaul starter. Check operation of automatic changeover device.
Refrigerator compressor, No. 2	Overhaul starter.
Sanitary pump, No. 2	Open up motor. Clean and varnish windings. Renew bearings as required. Overhaul starter.
Steering gear, Nos. 1 and 2	Examine starters and automatic change-over relays.
Stores hoist	Check controller. Prove in good order each voyage prior to storing.
Hot wash water circulating pump	Open up motor. Clean and varnish windings. Renew bearings as required. Overhaul starter.
Thermotank H.W. pumps, fwd. No. 2; aft No. 2	Open up motor. Clean and varnish windings. Renew bearings as required. Overhaul starter.
Accommodation vent fans	Overhaul starters.
Galley vent fans	Overhaul starters.
Cold start pumps	Overhaul starters.

Once Only at Four Years (at Completion of C.S. Cycle)

During First Eighteen-month Period

Cold start fuel pump	Complete overhaul of pump. Check adjustment of relief valve.

During Third Eighteen-month Period

Cold start feed pump	Complete overhaul of pump. Check operation of relief valve.

ITEMS TO BE INCLUDED IN REPAIR SPECIFICATIONS

The following items are to be included in dry dock list, in addition to, or coincidental with, the appended Lloyd's Machinery Continuous Survey schedule.

Every Repair Period

Boilers	Survey of boilers and overhaul of mountings. Overhaul of all soot blower heads.
Main condenser	Open up for inspection and cleaning.
L.O. coolers	Open up water side for inspection and cleaning.
Cargo pumps	Two pumps and turbines to be included for overhaul at each period.
Cargo stripping pumps	Complete overhaul of pumps.
Main circulating pumps	Open up pump, renew worn seals and bearings, check and record clearances. Examine coupling, repack gland.
Air conditioning plant	Complete overhaul of one compressor each period.
Sea connexions	Overhaul each period.

Electrical Equipment

Main circulating pump motor	Complete overhaul of motor and starter.
F.D. fans	Complete overhaul of all motors and starters.
Annulus fan	Complete overhaul of motor.
Generator L.O. starting pump	Complete overhaul of motor.
Gland vapour exhaust fan, main	Complete overhaul of motor.
Air conditioning compressors	Complete overhaul of one motor and starter each period.

Alternate Repair Periods

Ballast pump	Complete overhaul of pump and turbine.

Electrical Equipment

Bilge pump motor	Complete overhaul of motor and starter.
L.O. service pump motors	Complete overhaul of one motor and starter.
F.O. service pumps	Complete overhaul of one motor and starter.
Steering gear motors	Complete overhaul of one motor and starter.

Main condensate pump motors	Complete overhaul of one motor and starter.
Air conditioning circulating pump	Complete overhaul of one motor and starter.

Every Third Period

Refrigerator compressor	Complete overhaul of compressor.

Electrical Equipment

Refrigerator compressor motors	Complete overhaul of motor and starter.
E.R. vent fans	Complete overhaul of motor and starter.
B.R. vent fans	Complete overhaul of motor and starter.

LLOYD'S MACHINERY CONTINUOUS SURVEY 36,040-D.W.T. VESSELS

First Period

Main and Auxiliary Machinery

Main turbine reduction gearing
Auxiliary generator turbine (No. 1)
Feed pump (No. 1)
Feed pump turbine (No. 1)
Main condensate pump (No. 1)
Auxiliary condenser
Auxiliary condensate pump
L.P. heater and drain cooler
Salt water evaporator (No. 1)
Evaporating plant distiller (No. 1)
Evaporating plant air ejector (No. 1)
Salt water evaporator feed circulating pump (Nos. 1 and 2)
Evaporator brine pump (No. 1)
Evaporator distillate pump (No. 1)
Evaporator coil drain pump (No. 1)
Main forced draught fan (No. 1)
Fuel oil transfer pump E.R.
Fuel oil transfer pump (forward pump room)
Lubricating oil cooler (No. 1)
Lubricating oil cooler (No. 2)
Combustion control air compressor (No. 1)
Windlass
Cold start feed pump
Lubricating oil service pump (No. 1)
Auxiliary circulating pump

Electrical Equipment

937·5 KVA alternator (No. 1)
3·5 KW exciter (No. 1)
Main switchboard
Forced draught fan motor (No. 1)
Combustion control air compressor motor (No. 1)
Auxiliary circulating pump motor
Main condensate pump motor (No. 1)
Auxiliary condensate pump motor
S.W. evaporator feed and circulating pump motor (Nos. 1 and 2)
Evaporator brine pump motor (No. 1)
Evaporator distillate pump motor (No. 1)
Evaporator coil drain pump motor (No. 1)
Lighting transformers
Galley transformer
Lubricating oil service pump motor (No. 1)

Second Period

Main and Auxiliary Machinery

H.P. main turbine
Main turbine manœuvring valves
Main steam lines (pressure test)
De-superheater (external)
Main circulating pump
Main feed pump (No. 2)
Main feed pump turbine (No. 2)
Main air ejector
Auxiliary generator turbine (No. 2)
Auxiliary air ejector
Third feed stage heater
Gland steam condenser
Salt water evaporator (No. 2)
Evaporator brine pump (aft) (No. 2)
Evaporator distillate pump (aft) (No. 2)
Evaporator coil drain pump (No. 2)
Sea connexions
Main forced draught fan (No. 2)
Fuel oil service pump (No. 1)
Fuel oil heater (No. 1)
Fuel oil discharge filters
Lubricating oil service pump (No. 2)
Lubricating oil discharge filters
Sanitary and emergency fire pump (No. 1)
Main fire pump
Combustion control air compressor (No. 2)
Air receiver combustion control
Air receiver ship's service
Steering gear pump (No. 1)
Cold start fuel pump
Bilge pump
Bilge system

Electrical Equipment

937·5 KVA alternator (No. 2)
3·5 KW exciter
Forced draught fan motor (No. 2)
Combustion control air compressor motor (No. 2)
Main circulating pump motor
Main fire pump motor
Steering gear pump motor (No. 1)
Lubricating oil service pump motor (No. 2)
Sanitary and emergency fire pump motor (No. 1)
Oil fuel service pump motor (No. 1)
Evaporator brine pump motor (No. 2)
Evaporator distillate pump motor (No. 2)
Evaporator coil drain pump motor (No. 2)
Bilge pump motor
Cold start fuel pump motor

Third Period

Main and Auxiliary Machinery

L.P. turbine (main)
Main thrust block
Shafting and bearings
Main condensate pump (No. 2)
Main feed pump (No. 3)
Main feed pump turbine (No. 3)
Main feed lines (pressure test)
Fourth stage feed heater
De-aerator
Main condenser
M.U.F. evaporator
Main forced draught fan (No. 3)
Sanitary and emergency fire pump (No. 2)
General service pump
Ship's service air compressor
Ballast pump (forward pump room)
Emergency Diesel engine
Emergency Diesel engine air starting bottle
Fuel oil service pump (No. 2)
Fuel oil heater (No. 2)
Fuel oil heater drain cooler
Fuel oil service and transfer pump (E.R.)
Cooling water circulating pump
Fire and Butterworth pump
Fire and Butterworth pump turbine
Steering gear pump (No. 2)

Steering gear telemotor system
Steering gear
Emergency steering gear

Electrical Equipment
Main condensate pump (No. 2)
Emergency Diesel alternator
Emergency Diesel exciter
Main forced draught fan motor (No. 3)
Ship's service air compressor motor
Cold start boiler feed pump motor
Sanitary and emergency fire pump motor (No. 2)
Cooling water circulating pump motor
Steering gear pump motor (No. 2)
Fuel oil service pump motor (No. 2)
Lifeboat davit motors (4)

APPENDIX B

M or m = MECHANICAL MAINTENANCE REQUIRED
E or e = ELECTRICAL MAINTENANCE REQUIRED
(CAPITAL LETTERS INDICATE COMPLETE OVERHAULS)

PLANNED MAINTENANCE & CONTINUOUS SURVEY.
36,040 D.W.T. VESSELS.

MS & ES = MECHANICAL & ELECTRICAL SURVEYS

	18 MONTHS PRECEDING FIRST SURVEY						LLOYDS SURVEY	18 MONTHS PRECEDING SECOND SURVEY						LLOYDS SURVEY	18 MONTHS PRECEDING THIRD SURVEY						LLOYDS SURVEY
AIR COMPRESSOR, C.C. No. 1	m e	M e	m e	m e	M e	m e	MS ES	m e	M e	m e	m e	M e	m e		m e	M e	m e	m e	M e	m e	
AIR COMPRESSOR, C.C. No. 2	m e	m e	M e	m e	m e	M e		m e	m e	M e	m e	m e	M e	MS ES	m e	m e	M e	m e	m e	M e	
AIR COMPRESSOR, S.S.	M e	m e	m e	M e	m e	m e		M e	m e	m e	M e	m e	m e		M e	m e	m e	M e	m e	m e	MS ES
AIR COMPRESSOR, DECK SERVICE																					
AIR CONDIT. COMPRESSOR No. 1	m e		m e		m e			m e		m e		m e			m e		m e		m e		
AIR CONDIT. COMPRESSOR No. 2	m e		m e		m e			m e		m e		m e			m e		m e		m e		
AIR CONDIT. COMPRESSOR No. 3	m e		m e		m e			m e		m e		m e			m e		m e		m e		
AIR CONDIT. CIRC. PUMP No. 1	M e						MS ES	M e							M e						
AIR CONDIT. CIRC. PUMP No. 2				M e							M e							M e			MS ES
AIR CONDIT. H.W. PUMP, FWD. No. 1			M E							M E							M E				
AIR CONDIT. H.W. PUMP, FWD. No. 2						M E							M E							M E	
AIR CONDIT. H.W. PUMP, AFT. No. 1			M E							M E							M E				
AIR CONDIT. H.W. PUMP, AFT. No. 2						M E							M E							M E	
AIR OPERATED REDUCING VALVES	m		m		m			m		m		m			m		m		m		
AIR OPERATED LEVEL CONTROLLERS		m		m		m			m		m		m			m		m		m	
BOILER, PORT		M		M		M			M		M		M			M		M		M	
BOILER, STARBOARD		M		M		M			M		M		M			M		M		M	
BAILEY CONTROLS, PORT		m		m		m			m		m		m			m		m		m	
BAILEY CONTROLS, STARBOARD		m		m		m			m		m		m			m		m		m	
BOILER COMPOUND PUMP					M E							M E							M E		
BUTTERWORTH PUMP			m			m				m			m				m			m	MS
BILGE PUMP	m e			M e				m e			M e			MS ES	m e			M e			
BILGE & BALLAST PUMP, FWD.		M							M							M					MS
BALLAST PUMP, MAIN	m	m	m	m	m	m		m	m	m	m	m	m		m	m	m	m	m	m	
CARGO PUMP No. 1	m	m	m	m	m	m		m	m	m	m	m	m		m	m	m	m	m	m	
CARGO PUMP No. 2	m	m	m	m	m	m		m	m	m	m	m	m		m	m	m	m	m	m	
CARGO PUMP No. 3	m	m	m	m	m	m		m	m	m	m	m	m		m	m	m	m	m	m	
CARGO PUMP No. 4	m	m	m	m	m	m		m	m	m	m	m	m		m	m	m	m	m	m	
CARGO PUMP EMERG. STOP VV.	e	e	e	e	e	e		e	e	e	e	e	e		e	e	e	e	e	e	
CARGO STRIPPING PUMP No. 1	m	m	m	m	m	m		m	m	m	m	m	m		m	m	m	m	m	m	
CARGO STRIPPING PUMP No. 2	m	m	m	m	m	m		m	m	m	m	m	m		m	m	m	m	m	m	
COLD START FEED PUMP						e	MS						e							M e	ES
COLD START FUEL PUMP						M e							e	MS ES						e	
DRINKING WATER PUMP No. 1		M E							M E							M E					
DRINKING WATER PUMP No. 2					M E							M E							M E		
EVAP. BRINE PUMP No. 1	M E			M e			MS ES	M E			M e				M E			M e			
EVAP. BRINE PUMP No. 2			M E			M e				M E			M e	MS ES			M E			M e	
EVAP. DISTILLATE PUMP No. 1.	M E			M e			MS ES	M E			M e				M E			M e			
EVAP. DISTILLATE PUMP No. 2.			M E			M e				M E			M e	MS ES			M E			M e	
EVAP. CIRCULATING PUMP No. 1.	M E			M e			MS ES	M E			M e				M E			M e			
EVAP. CIRCULATING PUMP No. 2.			M E			M e	MS ES			M E			M e				M E			M e	
EVAP. COIL DRAIN PUMP No. 1.	M E			M e			MS ES	M E			M e				M E			M e			

APPENDIX C

DECK PLANNED MAINTENANCE SCHEDULE 36,000-D.W.T. VESSELS
Work to be Carried Out by Ship's Staff
First Three-month Period

Code "S"	*Safety Equipment*	Maintenance Coding
8*	Lifeboat motors	I
9	Lifeboat Fleming gear	O
11	Liferafts	I
12	Lifebuoys and lights	O
14	Fire hoses, nozzles, hose monitor clamps	O
15A*	Fixed foam system	T
16*	Steam smothering	O
24	Emergency equipment (aft)	I
25	Signalling equipment	O
27	Navigation lights (oil)	I
30	Gangways, pilot ladders, extension ladders, accommodation ladder, Jacob's ladders, lifeboat overside ladders	I.O
32	Emergency steering	O
34	Lifejackets	I
Code "C"	*Cargo Equipment**	
4	Ballast lines in tanks	T
5	Ballast lines in pump room	T
6	Ballast lines on deck	T
9	Ballast and bunker lines in for'd pump room	I
10	Bunker lines on deck	I
17	Valves in for'd pump room	T
26	Ullage gauze screens	I
32	Whessoe gauge spares	I
38	Cathodic protection	I
39	Protective coatings	I
Code "M"	*Mooring Equipment*	
5	Insurance wires and reels	I
13	Roller leads and universal chocks	O
15	Anchors and cables	I
16	Spare anchor shackles and connexion links	I

18	Mooring shackles	O
19	Fenders	I
21	Ratguards	I
Code "X"	*Miscellaneous Items*	
2	Automatic door closers	O
3	CO_2 box hinges, etc.	O
4*	Fresh water transfer system	T
8	Lark scaler and pneumatic hammers	O
16	Domestic water tanks	I
20*	Water fountains (coolers)	I
21*	Cabin and pantry refrigerators	I
28	Canvas awnings	I
32	Sludge hoists	O
33	Tarpaulins and wedges	I
34	Catwalk gratings, bolts, wedges, etc.	I
Code "D"	*Deck Fittings*	
5*	Floodlight and deck light fittings	O
6	Hawse and spurling pipe steel covers	I
7	Deck fire hose rack-pins, hinges, etc.	I
8	Portable gate rails, chains, etc	O
9*	Suez searchlight and trolley gear	I
11	Sidelight (navigation) access doors	O
12*	Stores loading hoist	O
14	Gangway and other stowage racks	I
15	Ventilator extended spindles and gearing	O
16*	Whistle hydraulics and hand pulls	I.O
20	Air pipe ball floats and gauzes	I
Code "R"	*Rigging Equipment*	
3	Derrick running gear	I
4	Derrick guy wires	I
5	Derrick guy tackles	I
6	Derrick head and heel blocks	O
7	Derrick lead blocks	O
8	Derrick topping lift blocks	O
9	Cargo hooks and nets	I
14	Davit blocks and running gear	O
16	Funnel hooks, blocks and tackles	O
17	Windsail spans and tackles	O
19	Snatch blocks	O
22	Funnel to boiler room access plate wires	O
Code "W"	*Watertight Fittings*	
10	Bunker tanklids	O

*Indicates that maintenance is to be carried out in joint co-operation with engine room department.

Appendix D

SCHEDULE "S"

PLANNED MAINTENANCE

SAFETY EQUIPMENT SCHEDULES

THIS SPECIMEN IS INCLUDED FOR YOUR GUIDANCE

DRY DOCK DATES 5-30/11/60 — 18 MONTHS RUNNING PERIOD

UNIT	GROUP CODE	[illegible]	1st 3 MONTHS	28-2-61 DATE	2nd 3 MONTHS	30-5-61 DATE	3rd 3 MONTHS	30-8-61 DATE	4th 3 MONTHS	30-11-61 DATE	5th 3 MONTHS	30-2-62 DATE	6th 3 MONTHS	30-5-62 DATE
Lifeboat No. 1	S1	Ir					O							
Lifeboat No. 2	S2	Ir							O					
Lifeboat No. 3	S3	Ir									O			
Lifeboat No. 4	S4	Ir											O	
Lifeboat Davit Winches	S5	Gm			O *	[illegible]					O *			
Lifeboat Falls	S6	Ir			O	[illegible]			O	[illegible]			A	
Lifeboat Davits	S7	Gf.Tf			O	[illegible]			O				O	
Lifeboat Motors	S8	Tw	I *	20-2-61	I *	16-5-61	I *	[illegible]	I *		I *		I *	
Lifeboat Fleming Gear	S9		O	[illegible]			O	[illegible]			O			
Lifeboat Stores	S10	Ir												
Inflatable Life Rafts	S11		I		I		I		I		I		I	
Lifebuoys & Lights (GEC)	S12	Tf	O	[illegible]	O	[illegible]	O	18-7-61	O	[illegible]	O		O	
Fire Extinguishers	S13	Tr												
Fire Hoses/Nozzles/Monitor Clamps	S14	Tr	O	[illegible]	O	[illegible]	O	11-7-61	O	[illegible]	O		O	
Foamite Nozzles & Cans	S15	Tr												
Foam Tank & System	S15A		T *	[illegible]	T *	[illegible]	T *	[illegible]	T *	[illegible]	T *		T *	
Steam Smothering	S16	Tb *	O *	15-12-60	O *	[illegible]	O *	[illegible]	O *	[illegible]	O *		O *	
C. O_2 Battery System	S17				I *	[illegible]					I *			
General Alarm System	S18	Tw												
Fire Flaps in Vents	S19	Gf												
Radio Transmitters-Lifeboat/Emergency	S20	Tw												
Breathing Apparatus (Bloman)	S21	Tr			O	[illegible]			O	[illegible]			O	
Resuscitator "Minuteman"	S22	Tmu												
Explosimeter	S23	Tvu			O	[illegible]			O				O	
Emergency Equipment (AFT)	S24		I	[illegible]	I	[illegible]	I	[illegible]	I	[illegible]	I		I	
Signalling Equipment	S25		O	[illegible]	I	[illegible]	O	7-7-61	I	[illegible]	O		I	
Navigation Lights - Electric	S26	Tu												
Navigation Lights - Oil	S27		I	[illegible]			O	[illegible]	I	[illegible]			O	
Distress Equipment (Bridge)	S28				I	[illegible]					I			
Safety Harness	S29	Tu			I	[illegible]			I				I	
Gangway - Pilot Ladders, Etc	S30		I O	[illegible]	I O	[illegible]	I O	[illegible]	I O	[illegible]	I O		I O	
Auxiliary Steering Gear	S31						I *	4-7-61					I T *	
Emergency Steering Gear	S32	Tv Gu*	O	[illegible]			O	[illegible]			O			
Medicine Chest	S33	Iv												
Life Jackets	S34		I	[illegible]									I	
Stageing - Bo's'ns Chairs	S35	Tu			O	[illegible]			O				O	
Ventilator Plugs & Covers	S36						I	[illegible]					I	
Fire Main - Line & Hydrants	S37	Tv *												
Gangway Lifebuoy	S38	Iv												

MAIN CODING

- I Inspect and/or clean/Check
- O Requires maintenance and/or overhaul
- G Oil and/or grease/Lubricate
- T Test
- A Requires renewing - attention in D.D. - from shore - from C & R.

Insert in col. as required. Refer Colour Symbol on appropriate card.

SUB - CODING

- W Weekly
- f Fortnightly
- m Monthly
- r Rotationally
- v Every voyage
- b Every ballast passage
- u Before use - After use

e.g. Ir = Inspect rotationally
Tu = Test before use
Gfu = Grease fortnightly, before and/or after use.

This chart indicates the minimum attention required during any 18 month period.

Insert date in column provided when unit received attention listed.

N.B. Where any particular unit of equipment requires attention outside the period listed it is to be attended to as soon as opportunity allows.

• This is to be carried out in joint co-operation with the engine room department.

Discussion

CAPTAIN D. CAMPBELL, B.Sc., R.N. (Member) said that the presentation of a paper on planned maintenance applied to merchant ships was a rare and important event, so first he wished to congratulate the authors on an interesting and informative paper and to thank them for making available their methods and experience at a stage when they emphasized that the report was " interim " and the conclusions were still tentative.

He made no claims to be an expert on tanker maintenance but as one concerned in the past with applying planned maintenance to warships and at present to a fleet comprising passenger liners, cargo vessels and tankers, he endorsed the authors' comment that although the paper dealt specifically with tanker maintenance, the general principles were applicable to other groups of vessels. The paper contained much valuable information, so that in commenting on apparent obscurities or omissions the intention was to add to and not detract from its value.

The authors made a splendid psychological impact by including at an early stage an impressive series of graphs with ordinates showing savings in thousands of pounds sterling, well calculated to create interest in shipping boardrooms. It was, therefore, rather disappointing to find that these graphs took no account of the economics of planned maintenance as such. However, he found them extremely interesting, particularly as the authors kindly made available to him the detailed calculations on which they were based, which had been seen briefly in the slides.

His interpretation of these graphs and data was that during the first eight years of life, on a cycle of two years between shipyard overhauls and without a system of planned maintenance, as described in the paper, one intermediate docking showed a saving of about ten days' earnings and two and three intermediate dockings showed a saving of about fourteen days' earnings.

After eight years, when an annual lay-off for boiler survey was obligatory, the savings by one or three intermediate dockings were still greater when the half-way docking was combined with the compulsory boiler survey. In this connexion the graphs were, he suggested, misleading as drawn and the virtual savings after eight years should be increased by the cost of a boiler survey lay-off without docking. Two further factors applied: intermediate dockings allowed maintenance and survey work to be progressed, which in turn should reduce the time and cost of shipyard overhauls, thus further enhancing the savings; more frequent dockings preserved the life and smoothness of the hull, thereby reducing repairs and maintaining earnings. The graphs therefore suggested that in these particular cases the economic docking policy should be, for the first eight years, three or two intermediate dockings spaced as equally as possible, and, after eight years, docking and boiler survey near twelve months with dockings only as near six and eighteen months as possible.

His further suggestion was that with a system of shipboard planned maintenance as described in the paper, which could be progressed at intermediate dockings with or without shore assistance, the savings by these frequent dockings were further enhanced. These conclusions were valid for the authors' assumed data which appeared realistically representative for tanker service. They were shown to apply over a significant range of freight rates, ship tonnage and docking costs per ton. They were unlikely to be altered except by an effective breakthrough to much better hull surface protection than was afforded by present conventional materials.

He had developed these conclusions, although the authors had hesitated to do so, in order to emphasize that the paper demonstrated an elegant method of analysis of ship operation economics which had wider application. If the conclusions were unacceptable it was the data, not the analysis, which was suspect, in particular the curve of speed loss against time out of dock merited continued investigation.

The paper implied that the desirable target was to extend the time between dockings and that shipboard planned maintenance then assumed importance. The graphs, however, indicated that, in the present state of the anti-fouling art, extending the docking interval beyond six to eight months was detrimental to ship earnings and ship upkeep and that planned maintenance, although essential if and when the two year bottom coating became available, had greater savings potential in conjunction with frequent docking by reducing the biennial repair commitment. It would, therefore, be of great value if the authors could state the length of the biennial overhaul for these tankers, and whether they expected a reduction in duration or cost in consequence of planned maintenance.

Those concerned with devising their own maintenance systems would be interested in three aspects of the one described—the maintenance schedule, the maintenance plan and the documentation system.

In producing a maintenance schedule it was necessary to strike a balance between bulk and brevity. In Appendix A, the authors had suceeded in compressing the engineering maintenance schedule for a 36,000-ton ship into less than two pages, plus another page and a half for survey and shipyard overhaul items. The result was a model of concise wording and few would dispute the content as a sound code of maintenance practice. This brevity had mainly been achieved by omitting "routine maintenance and inspection normally practised on board ship" and by lavish use of the word "overhaul". In his opinion it was necessary to direct attention to a good deal of "daily, weekly, monthly" maintenance, particularly with novel equipment, and it was advantageous in many cases to specify the work in greater detail than just "overhaul".

A maintenance plan must be flexible to suit the ship's operations and to deal with unprogrammed repairs. Appendix B gave the impression of a rather rigid 4½ year plan imposed on the ship, but no doubt some flexibility was allowed in its execution. Could the authors state whether a backlog accumulated, and what steps, if any, were taken to catch up?

The advantages of using the same documentation in all ships were self-evident. He also favoured uniformity of documentation between departments in a ship, as much equipment was the subject of joint maintenance between the deck and engine departments and there was also a considerable advantage if deck and engineer officers could be trained in this subject in the same course.

Were there any good reasons why the engine and deck documentation differed so completely and particularly why the cards in Figs. 4 and 5 should not have the same layout and symbols?

With regard to spotlighting unnecessary and excessive maintenance arising from shortcomings in design, material or workmanship by feeding back factual information on defective equipment for the information of designers and manufacturers, did the system make provision for this?

He fully endorsed the authors' final conclusion that co-operation by ships' staff was of primary importance. The successful introduction of planned maintenance was not so much a technical problem as a battle for men's minds. Did the authors agree with him that it was often easier to make converts afloat than ashore?

While it was interesting to discuss the details of the system described he considered that the real importance of the paper was that it revealed that a large tanker operator had deemed it expedient to adopt a system of shipboard planned maintenance and, after some years' experience, was confident that it had proved practical and successful, with a promise of increased operating efficiency and reduced upkeep costs.

MR. J. McAFEE (Member of Council) said that the paper which these two authors had presented might on the surface appear to be a relatively simple contribution to the TRANSACTIONS of the Institute. It contained no revelation of new machinery designs, it used no abstruse mathematics and all it had to convey was comprehensible at a glance. To dismiss it therefore as a minor effort was easy, but this would be a profound mistake because it was concerned with what, in the final analysis, was the only criterion of the success or failure of a machinery installation, that was its ability to pay, to pay not only in terms of fuel economy but in manning, cost of repairs and, above all, availability. It was strange how few issues of the TRANSACTIONS had been concerned with these vital aspects, yet in the end they far outweighed in importance the attraction of a frame space saved by reducing the length of a main engine or a half per cent gain in thermo-dynamic efficiency.

The term "planned maintenance" was coined some years previously to denote the scientific approach to the problem of securing maximum availability by intelligent foresight and anticipation of trouble. The availability required of tankers was greater than for any other class of ship so that the authors were faced with the problem in its most acute form. They had indicated here and there the need to correlate maintenance work and classification society requirements and it would be interesting to know to what extent they found these a help or an encumbrance. Speaking from the other side of the fence, one must point out that classification society rules must be framed on a broad international basis, neither too strict nor too lax, pulling up the indifferent owner who was oblivious to planned maintenance yet recognizing that others—a minority unfortunately—would often go further than the requirements of any official body in ensuring that their machinery was regularly opened up and examined. It would be interesting to have the authors' frank comments on classification society rules, more particularly as regards the continuous survey of machinery. In framing rules a middle course had often to be steered between the sometimes conflicting requirements of national authorities, coupled with the tendency of such authorities to interpret international conventions in different ways.

On screwshaft surveys the authors pointed out, reasonably enough, that because of the three-year period for a single-screw ship it was sometimes difficult to synchronize examinations with the time when the ship was in dock for overhaul. The screwshaft was the most vulnerable part of a ship's machinery installation and it was a sobering thought that over 10 per cent of all screwshafts examined were condemned for one reason or another. It was usual to assume that small wear-down of the bearing could justify an extension between examinations, nevertheless one wondered how wise this was. Did the authors consider from their own records that the interval between examinations of screwshafts in single-screw ships could be extended to four years, as was permitted for twin-screw vessels? If so, what special precautions would they take either in the design and construction of the shaft or the thoroughness of examination in order to obviate failure?

The carrying of a spare screwshaft and propeller was a matter of varied opinion. The variation in the length of voyages, nature of service, etc., between ship and ship was such that some years ago Lloyd's Register decided that the maintenance of machinery spares should be left to the owner's discretion and not be a classification requirement. From a classification point of view the important thing was that a vessel should be able to reach port. The approach therefore was to see that, as far as possible, essential services were duplicated and if a breakdown did occur then, after arrival in port for repairs, it was the owner's concern whether or not spares were available on board. Some owners now positioned their spare propellers, screwshafts, etc., at strategic points ashore, particularly when a number of similar ships was concerned. This meant not only a saving in spare gear but the additional possible freight over the years was not inconsiderable. One gathered that this practice was being pursued by the authors' company; it would be interesting to know to what extent.

Classification rules required duplication of essential services such as feed systems, lubricating oil pumps, etc. Vital amongst these was the electrical generating system. Many tankers and dry cargo ships where the deck or refrigerating installation electrical load was small, were fitted with only two generators, each one capable of taking the entire load. An emergency generator to comply with convention requirements was also fitted but usually had insufficient power to supply current for even the minimum essential services at sea. Such an arrangement was entirely in accordance with the rules but it left nothing in hand if one of the main generators broke down. If this happened in a distant port, a long delay might occur before a new crankshaft, turbine rotor, or perhaps a rewound armature, could be obtained and there was a natural desire for the ship to proceed on one generator only. Generators were unfortunately more fallible than main engines and the owner who knowingly took this risk might well be considered to have failed to exercise due diligence, which was the basis of so much legislation and most insurance. It would be interesting to know how the authors viewed such an eventuality.

DR. A. W. DAVIS (Member) said that he welcomed the opportunity of saying how very refreshing he found the paper. It was particularly interesting to see how the requirements of a well run ship had been integrated with Lloyd's survey requirements with best benefit to economy of operation.

Mr. McAfee had stressed the importance of propeller shaft surveys as measured by the high proportion of shafts found defective. It was perhaps an unhappy reflection upon the builders that a better performance had not been registered but he thought that to some extent this was brought about by the variation in different owners' requirements leading to a combination of features which were sometimes incongruous.

There was for example quite an absurd number of ways of providing for the watertightness of a propeller. Most of them were good and some were very bad. If there could be a degree of standardization of even that single feature it would lead towards greater satisfaction. The shapes of keys and key-ways were legion and some of them were not at all satisfactory. The need did not always seem to be understood for the highest quality of workmanship on key-ways having regard to the critical nature of their design. One tanker company had recently been concentrating on the actual fit of very large propellers and had produced quite conclusive evidence that the force fit of a propeller, as frequently fitted in cold climates, was inadequate when the ship entered tropic waters. The speaker had had his suspicions about this for some years now and very much welcomed a request that steam heating of the boss should be employed when fitting, regardless of any difficulties that might arise in its subsequent removal. A unified approach to this whole problem say under the aegis of the British Ship Research Association, might well lead to the improvement of performance that would be necessary before consideration was likely to be given to extending the periods between surveys, an extension which the authors had clearly shown to be an eagerly anticipated amendment.

With regard to Fig. 2 he did not quite understand what was portrayed. This must surely be a uniform theoretical determination based on the aggregate of a wealth of varying practical experience and he did not see why it should for example be so persistently unsatisfactory to have an 11-month interim period and relatively satisfactory to have 10 or 12-month intervals. He would have thought there would be a turning point and that, according to the authors' evidence, it would have been shown to be most economical to drydock at intervals of about eight or ten months, depending on the freight rate. He would be glad to have this explained in a little more detail.

The information given by the authors on spare gear policy would surely command great interest and attention. This was a subject in which the broadest co-operation between owners and builders could lead to worthwhile economies.

MR. J. E. FENTON thanked the Institute and the authors for the opportunity of making a contribution to the paper. He was privileged on 9th January 1952 to read a paper* on the question of protection of underwater surfaces of shipping, before the Honourable Company of Master Mariners and opened his paper as follows:

"I wonder if the greatest efficiency derivable from anti-corrosive and anti-fouling compositions at present marketed in the U.K. is obtained. Vessels' hulls are often badly cleaned and prepared to receive surface coatings of any kind—good, bad or indifferent—and money in such cases is largely wasted in drydocking and re-painting a ship if docked for the latter purpose only. The standard of work executed, and expected, seems much lower since the termination of hostilities and certainly than it was before the 1914 war. Ships are supposed to be punt scrubbed as the water is pumped out of the dock in a number of our ports, but as likely as not this work is scamped, and when it comes to the flats, in many cases in the U.K. throughout the year the flats are not touched at all unless the plating is covered with very obvious fouling matter of some kind or another. It seems to be forgotten that slime fouling, very often not obvious to the naked eye but noticeable to the touch by its slipperiness, has been proved to be present between successive applications of compositions. There is often a distinct layer of decayed fouling matter obviously preventing the adhesion and functioning of subsequent treatment of either of the surface coatings, and thereby contributing to the future breakdown of the compositions, and to the impossibility of their functioning to their greatest efficiency."

Today the situation was very much as it was then. If owners were prepared to pay for greater efficiency in so far as surface coatings were concerned, they were available to them in this sense, that they thought owners should be prepared to invest in experimentation. As an example, a round trip from Fawley to the Persian Gulf was about 12,000 miles. At a speed of 16½ knots a 36,000-ton tanker would take 33-34 days, allowing for Suez Canal detention.

Assuming an operating cost of £1,000 to £1,100 a day, a loss of speed of 10 per cent could equate a figure of about £3,000. On this line of thought, on, say ten round voyages to the Gulf in a year, a loss was being sustained of £30,000, which over a docking period of 24 months could amount to £60,000.

The question that really arose then was: Could some of this £60,000 be saved by greater attention in so far as the preparation of the bottom was concerned before receiving any surface coating at all and whether, in conjunction with this, more efficient paint could reduce this loss still further.

His organization was of the opinion that on a 24-months' docking period an expenditure of one-sixth of this amount could procure a surface much more free from surface friction than was currently the situation. Thinking on these lines it was essential to begin at the moment a contract for new tonnage was being contemplated with any particular yard and ensure that the plates were free from scale when they were lying in the yard prior to being built into the new ship; not only that they were free from corrosion but that the profile of the metal was no more than one mil. If this could be attained, a basic cause of skin friction, to say nothing of mill scale, was immediately eliminated and it was on this smoothness of surface that subsequent application of surface coatings to maintain this friction-less surface should be considered.

It would be understood, of course, that he was not suggesting perfection because perfection would require a steel surface which Lackenby in his paper† on the resistance of ships had indicated where a deviation in the required lines amounting to only 0·03in. over a length of 10ft. might be sufficient to cancel a favourable gradient for roughness.

His company therefore posed the question to Esso: should they not provide the suppliers of surface coatings with a hull so conditioned to receive protective and anti-fouling compositions as would once again eliminate the basic cause of friction? The standard of smoothness of the plating to be incorporated in the ship must be sustained from the time the plates were rolled through their incorporation in the new hull, either in the builder's shop in sections or on the stocks until they were coated with efficient protectives both from corrosion and fouling in the finished new construction.

With regard now to the operation of the tanker once the high efficiency build-up of the new hull had been put into service, a gradual deterioration of the smoothness of the painted hull would occur no matter what precautions were taken to prevent it. It was a question of degree and it was suggested that at the preliminary docking of 12 months and certainly at the bi-annual dockings of ships a system of cleaning and re-painting, much more efficient than the habitual treatment currently given to ships, was necessary and essential. For example, hulls should be lightly water-blasted at a pressure of about 100lb./sq. in. incorporating grit or fibre as was necessary to eliminate all fouling matter, old and perished paint, etc. and a re-paint treatment should be considered as a standard of efficiency required on the underwater surface of ships.

His company were inclined to think that owners and yards had thought that the painting of the underwater surface of the hull of a ship was the last question that need be considered and even then that consideration of time and efficiency was of little moment. There must be a new thinking on this question in the building yards of this country and owners must give the protection of the surface of their craft, whether above or below water, a far greater priority in so far as efficiency standards were concerned, as a requirement, than ever they had done in years gone by.

If, over a two-year period, the £60,000 that had been suggested as loss could be eliminated to the extent of 50 per cent, i.e. £30,000 and say half of this amount was available for better preparation of surfaces and the usage of more efficient protective coatings, it would still leave a saving to the owners of £15,000.

Such underwater surface coatings as vinyl types were available to shipowners at the present time and this would provide them with such efficiency standards as, combined with preparation of plating incorporating high pressure abrasive washing with non-siliceous grits, were very largely an answer to the question insofar as the efficiency of surface coatings were concerned and what contribution they could make to the questions posed by owners in this paper.

MR. J. R. KING (Associate) said that the authors modestly described their method of calculating the costs of speed losses

* Fenton, J. E. 1952. "Anti-corrosive and Anti-fouling Compositions." Jnl. the Honourable Company of Master Mariners, Vol. 5, No. 49, p. 10.

† Lackenby, H. 1962. The Thirty-fourth Thomas Lowe Gray Lecture—"The Resistance of Ships with Special Reference to Skin Friction and Hull Surface Condition." Proc.I.Mech.E., Vol. 176, p. 981.

as a " theoretical study ". Since it was based on a speed loss curve obtained from a group of tankers over several years of actual service and the figures used for drydocking and painting costs were averages based on experience, it was clear that the values given in Curve II, and later in Table I, represented a close approach to the real costs. Accordingly the authors' figures were of considerably more practical use than the inspired guesses sometimes published. In particular they emphasized the importance of maintaining the bottoms of large tankers in a smooth condition.

So far as the development of improved paint materials for ships' bottoms was concerned, this must be allied to the facilities available in dry docks and to the weather conditions in the major ship repairing areas. Improvements in the methods of surface preparation and paint application had been introduced—for example blast cleaning and airless spraying—but there was a need for new thinking about protection against the weather. For instance, there could surely be some attempt to provide shelter against rain, good lighting under the flats and perhaps also artificial heating, e.g. by infra-red radiant heaters. Heavy duty coatings based on newer types of resins such as vinyls or epoxies were available and these could be applied in thick coats so that good protection could be achieved from two or three coat systems. In general, however, these materials were less tolerant of imperfect surface preparations, dampness and low temperatures at the time of application than were the more conventional types of ships' bottom paints. Paint technologists could modify these coatings to make them less sensitive to cold, damp conditions, but if full advantage were to be taken of their improved performance some attention to obtaining dry, warm conditions was justified. This was particularly so if round-the-clock working was to become regular practice when these large vessels were drydocked. Admittedly the provision of rain shelters, good lighting and radiant heating would be costly, but would be justified by the savings in time and the resulting improvements in performance.

The authors mentioned that continuous research was required on the development of improved bottom coating materials. This work called for experienced scientific staff and was expensive; paint manufacturers would welcome closer co-operation with the technical staffs of shipowners in arranging practical application trials right through the surface preparation and coating operations to facilitate earlier assessment of new products to be made.

Commander E. H. W. Platt, M.B.E. R.N. (Member) said that the authors had done a valuable service to the industry in setting out their practical experience of maintenance planning in a large fleet of steam turbine tankers, thereby illustrating how important this could be to the economic maintenance of such a fleet.

The discussion on the question of the optimum drydocking interval was of particular interest. In the past, the heavy corrosion of tanker steelwork necessitating extensive renewals, often beginning at the second special survey, had created long periods during which major overhauls of machinery had been possible. If tank coatings and other methods of corrosion control achieved perfection these periods should no longer exist, and hence careful maintenance planning would become more and more necessary in order to ensure that the machinery installation was kept in good order and operating in an efficient manner.

Looking at the curves in Fig. 2 it would seem that there was a theoretical optimum drydocking interval of about eight months. This seemed to be confirmed by the more detailed figures shown on the slides. However, later the conclusion was drawn in the paper that the interval should at present be set at 12 months. He had not found the reasoning which led to this quite clear and hoped that the authors would clarify it.

It was clear from the paper that the overall approach to the physical acts of maintenance was similar to that which had become good practice in well managed fleets. The difference lay in the development of a sound and simple method of documentation and the authors were to be congratulated on the way in which they had steered between the Scylla of over-elaborate paper work and the Charybdis of insufficient documentation.

The reference on page 180 to the possible use of skin divers for the rapid clearing of marine growth was most interesting. Would the authors indicate whether a worth while improvement in performance appeared to have been achieved by bottom cleaning by this method and also whether the anti-fouling treatment had continued to be effective after such cleaning had been carried out?

With regard to the question of the relation of running and maintenance experience to the design and selection of machinery for new construction, one valuable end product of maintenance schedules such as those shown in the Appendix should be the feed-back of information to those responsible for the design of new machinery. Were the authors finding benefits of this kind?

Commander L. K. D. Wood, M.B.E., R.N. (Member) said that he thought that planned maintenance of ships and their propulsion equipment dated from about 2,000 years B.C. The ancient Egyptians probably had a word for it. So did the Phoenicians and so did the Greeks.

Over the centuries to this present day men who used the sea in ships had learned by experience how to keep their ships. They had known what maintenance was necessary and had made their individual plans as to when and how to do it. Usually they had passed this experience on to their successors at sea.

Over these same centuries many—by no means all but many—of those men ashore who gained by these ships had been loth to provide the time and the money necessary to keep their ships fit for the hazards of the voyages.

In this day and age responsible deck and engineer officers knew what was needed to enable a little money and " time out of service " for maintenance to prevent the loss of much more money and time for repairs. For those afloat who organized and carried out the work, planned maintenance was little more than a guide to procedure and an assistance to continuity. For those ashore, now probably few, whose almost paramount concern was " earning time ", planned maintenance of the type described should be a mandatory reminder of the old adage of " a stitch in time ".

In some circumstances, like those being discussed, marine and engineer superintendents, who had attained positions of responsibility for fleets of ships, were applying the single ship experience of themselves and others to devise specific plans for organized maintenance of all the ships in their charge. This should bring great benefits in the form of better understanding of all the factors involved, as had been revealed that evening and in acceptance by those in control of the fleets of the need for planned maintenance and the time and facilities to do it.

The United States Navy and later the Royal Navy had realized over recent years that warships could be worn to near scrap by incessant sea time and denied maintenance time. Both these navies now made planned maintenance and the time to do it mandatory under instructions which could not be ignored. From the experience of these two warship navies, the marine and engineer superintendents of merchant fleets might well learn the strategy and tactics which could inspire acceptance of planned maintenance in both superiors and subordinates.

From his own personal experience he wished to give a small warning about spare gear and replacement parts. When spare gear—an individual item, a sub-assembly or even a complete unit—was rushed from ship's store or depot store to be used as a replacement in a time-restricted maintenance period or an emergency repair, it must fit, straight in, first go. This would not happen unless the shipowner, the shipbuilder and the sub-contractor had understood this requirement and attained the fundamental need that such ship and depot spare gear must be exactly dimensionally and functionally interchangeable with the original. This was not automatically attained when spare gear was ordered. To ensure it required careful attention in both ordering and supplying.

In conclusion he wished to add his own congratulations to those already expressed to the authors of this valuable paper.

Mr. A. F. Harrold, B.Sc. (Member) said that he would like to endorse the comments of previous speakers in saying how refreshing it was to find the problems of ship management and operation figuring again in the Institute's proceedings. He found himself in company with Dr. Davis in finding some difficulty in interpreting the discontinuities in the curves showing the optimum length of time between drydockings and would likewise appreciate it if the authors could clarify this.

It had become quite apparent in recent years that the effect of ship size would have a big influence on the optimum period between bottom cleanings. This did not quite come out in the curve shown in the paper. Not only did the larger ship find herself in a higher bracket of docking charge rates per gross registered ton per tide, but in addition the daily cost was directly proportional to her tonnage and the number of tides required to paint the larger ship was also likely to be greater. In practical terms the dock dues themselves on a 65.000-ton vessel were of the order of £1,300 per day as against £220 per day for an 18,000-ton vessel, which suggested a longer optimum period between the dockings for the larger vessels.

The basis on which his company had been experimenting was a period of 16 months between dockings, giving three refits to a survey period instead of four. Various other factors made it attractive to break away from docking periods which were a multiple of 12 months. The tendency hitherto had been to bunch the refit of tankers into the summer months when market replacement rates tended to be at their lowest, but this raised problems of overloading a fixed staff of superintendents in one half of the year which also happened to include the period when the repair yards and indeed, most superintendents, took their annual holiday. In addition, to maintain this seasonal spread in practice meant that ships were on average docking at 11½ monthly intervals. At the same time, when operating on a 12-month cycle there was a tendency for a ship, which initially underwent refit in mid-winter, to continue to do so over a number of years and this was not conducive to a good painting job on the hull, the climate being what it was.

On the question of planned maintenance, most superintendents would no doubt agree with the need for an improved measure of routine. Whether this should be achieved by the introduction of complicated paper forms, however, was open to discussion. Certainly there was no wish to clutter the superintendent's office with more paper work for checking and record keeping. In principle it must remain true that it was the chief engineer's responsibility to care for the machinery under his charge and he should be capable of maintaining a suitable routine with the help of advice from his superintendent and from manufacturers' instructions. In this connexion he noted the emphasis given by the authors to the term " guidance ".

On the question of extra manning, referred to on page 183 of the paper, he thought that many people would feel that the future must point to a reduction in manning scales, it being borne in mind that the wages bill was at present roughly 2-2½ times the repair bill. Even if the present wages bill was acceptable there could be few shipowners today who were not concerned about the availability of both engineer officers and ratings. In these circumstances surely their objective must be towards reduction of the work load on board, with increasing emphasis on a minimum maintenance design philosophy.

The high availability achieved in efficient tanker fleets today bore testimony to the overall reliability which had been reached. Nevertheless, improvements and new procedures must be continually envisaged if competitivity was to be retained, and the authors had given a valuable insight into their own approach to this urgent need.

Mr. H. J. S. Canham said that at B.S.R.A., on the naval architects' side there was particular interest in the authors' Fig. 1, showing the approximate speed loss over the course of 24 months. There was very little information on this available today and, moreover, what information was available tended to be highly conflicting, so that it was almost a case at the moment of "paying your money and taking your choice"; but this only emphasized the difficulties to which the authors referred of obtaining accurate speed loss curves from voyage data. Quite apart from any instrumentation problems there was the problem of the influence of sea state, to which they had referred and many other factors. Also the incidence of roughness on a ship's bottom would differ from ship to ship within the same class unless perhaps they were on identical routes and of the same age and had been painted with identical compositions under identical conditions, but even then he did not think that this was at all certain.

For some years B.S.R.A. had been attempting to use voyage data for obtaining speed loss curves of the type shown in this paper, with the object of providing information useful to an economic study such as had been described in the paper. A small sample of different types of ships had been used and there was no doubt whatever that it was extremely difficult to draw any hard and fast conclusions. One thing had stood out and had been supported by the results of a number of repeat trials carried out on one particular class of vessel: that was that the character of the speed loss curve could change significantly within each successive period between drydocking. This was particularly so if there had been widespread corrosion on the hull during the previous period. Full advantage of the study described in the paper could not be taken, he felt, unless it could be taken as certain that the speed loss curve such as depicted here was in fact true for the great majority of vessels of that class in the fleet and therefore it was essential to try to reduce any variation between ships of the class to the minimum and finally to eliminate such variation and ultimately—as referred to by an earlier speaker—to eliminate the speed loss altogether. Tankers were very sensitive to frictional resistance, as all there knew and the problem was really essentially one of obtaining a hydrodynamically smooth hull while the ship was new and to maintain the hull in such a condition throughout the service of the vessel. Everyone would agree that they were far from this situation today.

He had been thinking in terms principally of the type of roughness which occurred as a result of the onset of corrosion, for their experience had been that fouling was not a great problem in the case of a tanker. This was certainly not the case in dry cargo ships.

It was not accidental that a lot of the attention given to this problem today had been by tanker owners. The problem so far as the dry cargo owner was concerned had been disguised by that of obtaining quicker turn-round. The need to maintain speed at sea in calm water as well as in waves had been largely overshadowed by difficulties in turn-round.

Tankers were ideally suited for trials. They had not the same loading problems as the dry cargo ship and it should be fairly easy to ensure that if accurate trials were carried out from time to time these were in very much the same sort of loading condition. This was a very helpful thing. It was the additional factor of having to cope with a wide variety of loading conditions which made periodic trials on other types of ship less profitable. He felt that if a great deal of effort were put into the tanker side of it, particularly by way of accurate trials at periods during the life of the ship and particularly within a period of successive drydockings, a very much closer understanding would be achieved of the nature of the growth of resistance with the present types of modern treatment and painting and this in turn would lead to a better appreciation of special measures which had been evolved to reduce the incidence of corrosion.

Mr. C. Scorer said that it was interesting to learn how other people had been approaching these problems. The similarity between the authors' conclusions and those of his company was quite marked. For example, for the past two years, his company's Dutch associates had placed a small permanent work-party under an extra third engineer on many of their ships to carry out the type of extra maintenance described in this paper, primarily to reduce the time in dock. On the other hand, their German colleagues had been reducing the complement on their ships and whenever automation was mentioned, a reduction in staff was given as one of the incentives. His company was considering studying in detail the allocation of work among the crew of a tanker at sea so as to be able to base these partly conflicting theories on practiced needs.

As an aid to routine maintenance their French associates used one electric timer for each electrically-driven auxiliary. This timer was basically a little electric clock costing less than £4 which was connected in series with the auxiliary and simply clocked up operating hours.

On the subject of skin divers mentioned on page 180, these had been tried in France to increase the time between dockings. The hull could be cleaned in the time available during discharge and it was not prohibitively expensive, but the improvement was lost within about twelve weeks. However, skin divers were useful in cleaning the underwater surface just before a ship went into dry dock.

His company had recently tried grit-blasting a ship's hull as mentioned at the bottom of page 179. It was too early to be dogmatic, but it was expected that the coating applied after grit-blasting would last much longer than usual. However, to obtain a smooth surface, grit-blasting must not be left until pitting was too far advanced. In two cases, six-year old ships had been grit-blasted at docking, but this proved to be too late for the full benefit to be obtained. The correct time would of course depend, among other things, on where the ship had been trading.

With reference to the subject of hull coatings, mentioned at the top of page 180, the conditions under which paint was applied required probably as much attention as the composition of the paints themselves.

Could the authors please explain the term "short sea trials" at the top of page 180. Did they mean measured mile trials, the use of Decca or the use of land marks? The information in log books was subject to the usual human and mechanical errors, as mentioned in the paper. Measured mile trials were usually accurate enough, but measured distances were seldom close to a vessel's trade route and in any case such trials involved delays. Perhaps statistical analysis of an improved form of log book data might have a future. It should then be possible to make intermediate docking dates more flexible and adjust them according to the power/speed relationship of the ship considered.

Could the authors please give some more details on how the curve in their Fig. 1 was obtained?

The authors put the case perhaps rather mildly when they said that the speed loss was not always regained after docking. The effect of 22 dockings had been investigated, using measured mile trials before and after each docking. Of these dockings, only two brought the ship back to the original condition, and in these cases both ships were only one year old.

Finally, he agreed that instruments and their mounting left very much to be desired. In particular pressure gauges and temperature measuring instruments very often did not last twelve months or developed unacceptable errors. Probably it was necessary to mount them resiliently.

REAR-ADMIRAL R. S. HAWKINS, C.B. (Honorary Vice-President) said that it was a most interesting paper, in which the arguments for planned maintenance and the conclusions reached were akin to those of the Royal Navy. Procedures and application within the Royal Navy were somewhat different from those detailed in the paper, and a short description of the method used might be of interest.

Schedules were in the first place raised by the Design Sections, based on manufacturers' recommendations and past experience. Calendar periodicities were used generally, to facilitate forward planning and the whole of a scheduled volume was designed to conform to the ship's expected operating cycle. All routine maintenance and inspection required for any given equipment was covered by the appropriate schedule. The periodicities of the routines involved varied from daily to a maximum of six years, the whole being designed to keep the equipment operating satisfactorily up to major overhaul/refit. The work involved was split between naval and dockyard staffs, the longer periodicity routines being normally a dockyard commitment. The maintenance load was taken into account when assessing engineering department complements, the numbers allowed being invariably in excess of those required for three watch steaming. At the same time, care was taken that the number of excess maintenance personnel allowed was such that they would not be under-employed whilst the ship was steaming. Any shortfall in maintenance effort on the naval side brought about by this restriction was made good by use of base staffs during a ship's alongside time.

Schedules were made up in departmental volumes for each ship; subsequent amendments were made in the light of feedback information from ships. Control was excercised by means of maintenance cards, there being one for every routine and on which was entered the schedule and routine number, description of equipment, routine to be undertaken and date last maintained/inspected. Each card was contained in a plastic envelope, colour edged, appropriate to its periodicity and the whole was stowed in a filing system, on a periodicity basis. A bring-up system ensured that routines due were brought to notice in good time. Where necessary, the results of inspections or maintenance done were entered in the master record.

Much of the repair work on board was by replacement and, therefore, a fair amount of spare gear had to be carried. The spares on board were backed up by other spares carried in the various support ships, shore bases or stores depots. The initial allowances were decided by the Admiralty and provided to each ship, together with a master list giving entitlement and a full description of each item. Control within the ship was exercised by means of stock ledgers, a separate page being used for each type of item. The pages showed receipts, issues, stock remaining and due in, allowing the maintenance personnel to ascertain at a glance the stock position and the usage rate for any item; this was considered important.

Stores were of two categories, consumable and permanent, the latter generally being those of a reclaimable nature or with high scrap value. Reclamation was invariably done on shore in a dockyard or repair depot. All spares were suitably preserved, packaged and identified prior to issue. Replacements were obtainable from central depots, demands being noted with remains and reasons for demand. Stock audits were easily carried out by means of the stock ledgers and this meant that, in general, spares in excess of allowance were not carried in ships.

Recently two extensions of the planned maintenance system had been under trial. The first was a set of charts similar to that in Appendix D of the paper, designed with the same purpose. The second was a job method card, intended to partner the maintenance cards. The job method cards listed the method to be used to do the routine, tolerances/wear limits, etc. and the tools and materials necessary. It was thought that this procedure would result in work to common standards and also ease the load on the maintenance personnel.

Correspondence

MR. A. R. HINSON (Associate Member) wrote with reference to the first of the two basic factors mentioned on page 178 of the paper:

"What is the deciding factor in determining at what period the cost of withdrawing a vessel from service, and docking, cleaning and painting the bottom, could be offset against the accumulative loss due to the reduction in speed resulting from deterioration of the hull underwater surfaces?"

One criterion which could be used was *distance travelled per year of service.*

From Fig. 1 in the paper it could be shown that the average speed of a vessel was reduced by approximately 1 knot during a 24 month period, i.e. if, when clean the speed was 16·5 knots and, when dirty, 14·8 knots, the average speed of operation for the 24 months was 15·5 knots.

It could also be shown that the reduction in average speed was approximately linear for the first 18 months and that negligible error was introduced in the following argument by assuming linearity for the 24 months.

Hence, average speed $= 16{\cdot}5 - \frac{t}{24}$ knots where t is time out of dry dock in months, i.e. the drydocking period.

Distance travelled per year = time in service × average speed

or S = time function in days $\times (16{\cdot}5 - \frac{t}{24}) \times 24$

Time function = 365-a-b-c-d days

where a = days in port/year.

b = days in dry dock/docking including deviation time.

c = days in service to pay for each drydocking.

d = days in service to pay for replacement tonnage while in dry dock.

Assuming $a = 50$; $b = 4$; $c = 2$; $d = 4$.

$$\text{Time function} = 365 - 50 - \frac{48}{t} - \frac{24}{t} - \frac{48}{t}$$

$$= 315 - \frac{120}{t} \text{ where } t = \text{drydocking period in months.}$$

We have

$$S = (315 - \frac{120}{t})\,(16{\cdot}5 - \frac{t}{24})\ 24 \text{ sea miles} \ldots (1)$$

$$S = 124{,}600 - 315t - \frac{47{,}520}{t} + 120$$

$$\frac{ds}{dt} = -315 + \frac{47{,}520}{t^2}$$

$$= 0 \text{ for a maximum.}$$

$$\therefore t^2 = \frac{47{,}520}{315} = 151$$

$$\therefore t = 12{\cdot}3 \text{ months.}$$

The optimum drydocking period could be estimated by the above method for variations in *a, b, c,* and *d.* Variations in average speed could also be accommodated if the law were roughly established.

It would be ideal if the vessel travelled at 16·5 knots all the time it was not in port. The distance travelled/year would then be 124,600 sea miles. From (1) drydocking every 12·3 months, the distance travelled = 117,000 miles.

$$\text{Maximum drydocking efficiency} = \frac{117{,}000}{124{,}600} = 93{\cdot}8 \text{ per cent.}$$

Suppose drydocking took place every 24 months; then distance travelled = 115,300 miles. and drydocking efficiency = 92·6 per cent.

This represents a loss of approximately 4 days/year.

The foregoing was a much simplified method of ascertaining the maximum drydocking efficiency and one which could be improved by devising a computer programme which would take into account variation in costs over the drydocking period. If the authors' wished, trial runs could be made on the computer operated by Lloyd's Register of Shipping to see if any advantage could be obtained.

Mr. Hinson thanked the authors for a very interesting paper.

Authors' Reply

In reply, the authors felt that during the discussion which followed on the presentation of the paper, it had become apparent that more detailed explanation of Fig. 2—"*Net savings by interim dockings after deducting all expenses*"—was required. A number of slides had been shown, briefly, during the presentation, to illustrate the cost analysis used in the preparation of Fig. 2, and it was now proposed to include tables from these slides in the reply.

maintenance work, certain operating expenses were not incurred, or were considerably reduced, and an estimate of the net loss of earning capacity per day (making due allowance for these items) at the three specified freight rates, was shown at the top of Table III. Underneath was shown the cost of replacement tonnage, allowing for 333 earning days per annum.

This table also showed the average estimates of direct and indirect cost incurred, resulting from withdrawal of a vessel at

TABLE I.—NET VALUES OF AVOIDED SPEED LOSSES AFTER ALLOWING FOR COSTS, INTERIM DOCKINGS AND REPLACEMENT TONNAGE

NOTE:—It is assumed a maximum three months grace would be accepted on boiler survey due dates

Interim docking interval, months	Number of interim dockings in 2 years	Bottom clean only allowed for, net savings per annum						Bottom clean and boiler survey allowed when due, net savings per annum						Number of interim boiler surveys allowed
		26,650 dwt.			36,000 dwt.			26,650 dwt.			36,000 dwt.			
		At scale	−20	−40	At scale	−20	−40	At scale	−20	−40	At scale	−20	−40	
		£	£	£	£	£	£	£	£	£	£	£	£	
6	3	15,740	12,490	9,200	22,830	18,210	12,950	11,890	9,720	6,600	17,540	13,780	9,400	1 (12th. month)
7	3	14,630	11,590	8,450	21,280	16,910	11,950	10,790	8,270	5,850	15,990	12,450	8,400	1 (14th. month)
8	2	15,820	12,660	9,550	22,820	18,390	13,450	8,140	6,220	4,350	12,240	9,530	6,350	2 (8th. & 16th.)
9	2	15,445	12,410	9,325	22,320	17,990	13,150	7,765	5,970	4,125	11,740	9,130	6,050	2 (9th. & 18th.)
10	2	13,920	11,110	8,350	20,120	16,140	11,675	10,080	7,890	5,750	14,830	11,710	8,125	1 (10th.)
11	2	11,420	9,060	6,725	16,470	13,190	9,450	7,580	5,840	4,125	11,180	8,760	5,900	1 (11 th.)
12	1	12,500	9,930	7,600	17,710	14,420	10,700	8,670	6,710	5,000	12,420	9,990	7,150	1 (12 th.)
13	1	12,160	9,830	7,525	17,460	14,245	10,550	8,320	6,610	4,925	12,170	9,815	7,000	1 (13 th.)
14	1	11,710	9,480	7,235	16,810	13,720	10,150	7,870	6,260	4,625	11,520	9,290	6,600	1 (14 th.)
15	1	11,010	8,880	6,775	15,860	12,870	9,500	7,170	5,660	4,175	10,570	8,440	5,950	1 (15 th.)

NOTE:— All values assume (a) that vessels have periodical docking for major repairs at 24 months.
(b) that interim dockings are done precisely at the stated intervals
(c) that hull condition is fully restored at each docking, i.e. no allowance is made for any progressive deterioration of hulls due to aging

Table I was the summation of the detailed cost factors considered for both the 26,650 d.w.t. and 36,000 d.w.t. class vessels under review, and showed on one hand the net value of savings per annum arrived at during the first eight years' life of a vessel, with scheduled interim drydocking for bottom cleaning only, at varying periods, in months, and boiler survey at the shipyard overhaul every 24 months. On the other hand, similar net values were shown, after the eighth year of life, on the same scheduled interim drydockings, but with boiler survey carried out at one of these interim periods and again at the shipyard overhaul period every 24 months.

These values were on the basis of three Charter Rates and were, in effect, the values plotted in Fig. 2.

Referring now to Fig. 1, "*Approximate speed fall-off curve*", Table II illustrated the accumulative effect of this speed loss on a unit basis of a single vessel in operation for one month, assuming the vessel remained in service without drydocking for bottom cleaning for the whole 24-month period, the accumulated loss amounting to 1·5834 ship/months over this period.

The value of this loss, in terms of replacement tonnage required, on the basis of three freight rates, Mina-al-Ahmadi/U.K., allowing 333 earning days for a 12-month period, was shown at the bottom of the table.

During the time a vessel was withdrawn from service for

TABLE II

Months out of Dry Dock	Accumulated Speed loss in knots from 16·5 (see speed curve)	Average speed during the month (knots)	Average underspeed in the month (knots)	% of underspeed in the month over 16·5 %	Accumulative % loss to date (Area over speed curve) % ship/months
1	·07	16·465	·035	·21	·21
2	·16	16·385	·115	·70	·91
3	·25	16·295	·205	1·24	2·15
4	·36	16·195	·305	1·85	4·00
5	·48	16·08	·42	2·54	6·54
6	·60	15·96	·54	3·27	9·81
7	·72	15·84	·66	4·00	13·81
8	·88	15·70	·80	4·85	18·66
9	·95	15·585	·915	5·55	24·21
10	1·06	15·495	1·005	6·07	30·28
11	1·18	15·38	1·12	6·79	37·07
12	1·30	15·26	1·24	7·52	44·59
13	1·39	15·155	1·345	8·15	52·74
14	1·45	15·08	1·42	8·60	61·34
15	1·50	15·025	1·475	8·95	70·29
16	1·55	14·975	1·525	9·25	79·54
17	1·58	14·935	1·565	9·49	89·03
18	1·60	14·91	1·59	9·64	98·67
19	1·62	14·89	1·61	9·75	108·42
20	1·64	14·87	1·63	9·87	118·29
21	1·655	14·85	1·65	10·00	128·29
22	1·67	14·837	1·663	10·01	138·30
23	1·685	14·82	1·68	10·02	148·32
24	1·70	14·807	1·693	10·02	158·34 *

* Values of 158·34 % ship/months at the REPLACEMENT tonnage rates Table III					
26,650 dwt			36,000 dwt		
Intascale	−20	−40	Intascale	−20	−40
£76,000	£62,500	£48,800	£108,700	£89,500	£68,500

TABLE III

ECONOMICS OF SPEED LOSSES OVER TWO YEARS WITH INTERIM DOCKINGS FOR BOTTOM CLEANING / PAINTING

SHIPS EARNING CAPACITIES

26,650 dwt.			36,000 dwt.		
at Intascale	at scale - 20	at scale - 40	at Intascale	at scale - 20	at scale - 40
£1170 per day	£860 per day	£550 per day	£1770 per day	£1340 per day	£900 per day

REPLACEMENT TONNAGE COSTS (allowing for Bunkers and Port Charges)

	26,650 dwt.			36,000 dwt.		
	at Intascale	at scale - 20	at scale - 40	at Intascale	at scale - 20	at scale - 40
	£1730 per day	£1420 per day	£1110 per day	£2470 per day	£2040 per day	£1600 per day
*	£48000 per month	£39400 per month	£30800 per month	£68600 per month	£56600 per month	£43450 per month

* allowing 333 earning days per 12 months

INCLUSIVE COSTS OF INTERIM DOCKINGS — allowing for deviation and bunkers, Port dues, Dock rents, Materials and Labour

26,650 dwt					
			scale flat	-20	-40
Bottom Clean Only	Docking etc.		3900	3900	3900
	4 days tonnage		4680	3440	2200
		Total	£8,580	£7,340	£6,100
Bottom Clean and Boiler Survey	Docking etc		6900	6900	6900
	8 days tonnage		9360	6880	4400
		Total	£16,260	£13,780	£11,300
36,000 dwt					
			scale flat	-20	-40
Bottom Clean Only	Docking etc.		5000	5000	5000
	4 days tonnage		7080	5360	3600
		Total	£12,080	£10,360	£8,600
Bottom Clean and Boiler Survey	Docking etc.		8500	8500	8500
	8 days tonnage		14160	10720	7200
		Total	£22,660	£19,220	£15,700

the interim periods, the extent of work invoived and the time required, being taken into consideration.

Assuming now that interim dockings for bottom cleaning only were contemplated, and considering varying periods in months between these interim dockings, some loss of speed would occur while in service, but the overall loss would be reduced, in relation to the accumulated loss illustrated in Table II, i.e. over a 24-month period. Utilizing the replacement values shown in this tab!e, the equivalent values of speed losses avoided, due to these interim drydockings, was shown in Table IV, but

TABLE IV

Interim Docking Interval (Months)	% Ship/months loss sustained	% Ship/months loss Avoided	No. of Interim Dockings	EQUIVALENT VALUES OF SPEED LOSSES AVOIDED BY INTERIM DOCKINGS OVER TWO YEARS BEFORE DEDUCTING DOCKING COSTS ETC.					
				26,650 dwt.			36,000 dwt		
				at scale	at - 20	at - 40	at scale	at - 20	at - 40
6	39·24	119·1	3	£57,200	£47,000	£36,700	£81,900	£67,500	£51,700
7	43·576	114·76	3	55,000	45,200	35,200	78,800	64,900	49,700
8	56·577	101·76	2	48,800	40,000	31,300	69,800	57,500	44,100
9	58·227	100·11	2	48,050	39,500	30,850	68,800	56,700	43,500
10	64·557	93·78	2	45,000	36,900	28,900	64,400	53,000	40,550
11	75·047	83·29	2	40,000	32,800	25,650	57,100	47,100	36,100
12	89·178	69·16	1	33,600	27,200	21,300	47,500	39,200	30,000
13	89·808	68·53	1	32,900	27,000	21,150	47,000	38,850	29,700
14	91·618	66·72	1	32,000	26,300	20,570	45,700	37,800	28,900
15	94·498	63·84	1	30,600	25,100	19,650	43,800	36,100	27,600

without taking into account the direct and indirect costs incurred.

Finally, the net value of avoided speed loss, after allowing for the cost of interim drydockings, and replacement tonnage for time out of service, was shown in Table I and plotted on Fig. 2.

Captain Campbell had commented on much of the detail now shown in these tables, and undoubtedly the theoretical estimates would indicate an economic advantage in carrying out more than one interim drydocking during the 24 months. However, having in mind the difficulty of guaranteed dry dock availability, the arrival of a large tanker at a repair port, the operational problems associated with changes in orders for discharging ports, the unscheduled incidents in service which could result in delay, and the relatively small differential in cost saving involved between one 12-monthly interim, as against two or three at shorter intervals, practical considerations tended to sway the decision to maximum time in service with the minimum of interim withdrawals.

Fleet vessels were now operating on a policy of one 12-month interim with a shipyard overhaul at about 24 months, and at the commencement it was thought that some increase, in the order of 20 per cent, could be expected, in the amount of shipyard repair work required and in the time taken for this work, after 24 months in service. In practice, to date, based on a relatively short period of experience, cost and time were about the same as that previously incurred at each 12-monthly shipyard overhaul, and this most satisfactory result undoubtedly stemmed from the planned maintenance work, carried out conscientiously and efficiently, by the ships' staff.

On occasion, mechanical failures, or other troubles, had occurred in service, at which times, planned maintenance work due for attention had been deferred, but to date no trouble had been reported with regard to catching up on commitments, when conditions aboard had returned to normal, but should difficulty be experienced, there was no doubt that a small increase in shipboard personnel, for a limited period, would soon enable any backlog of work to be handled.

The suggestion that work record cards, Figs. 4 and 5, could be more closely standardized in layout and symbols, was very constructive and this matter was now under review. These record cards did highlight excessive maintenance on specific units of equipment arising from design defects, or unsuitable material and the importance of this aspect was worth highlighting. In general, it had been found that manufacturers were most receptive to comments on design detail and proposals for alternative materials.

Mr. McAfee had reviewed the proposals contained in the paper, relative to Lloyd's ru'es and regulations for classification. Of necessity, these rules must be framed on a broad international basis, to cover a most complex range of vessels operating in diverse trades, and at the same time they must be practicable and able to be interpreted with reasonable ease.

Undoubtedly, this broad concept had been achieved, but where interpretation had been at issue a reasoned opinion on any specific case was forthcoming promptly.

As regards continuous survey of machinery, the current rules were flexible. The timing of much of the planned maintenance of auxiliary machinery was co-ordinated, such that surveyors' inspection of units stripped down, could be carried out at a cargo discharge, and the co-operation received was acknowledged.

Dealing now with screwshaft surveys, it was agreed that the screwshaft was the most vulnerable part of the machinery installation on a single-screw vessel. There had been a rapid increase in propulsion power transmitted through a single propeller at low r.p.m. for very large tankers and bulk carriers, and these large propellers could be in the order of 28 to 35 tons in weight. Where the conventional lignum vitæ lined stern tube was used, it was doubtful if a reasoned case could be put forward for extending the present three-year period between screwshaft surveys and in fact it would appear essential to facilitate the checking of after end wear-down readings at every convenient occasion between surveys, due to the potential "bell-mouthing" effect caused by the bending moment of the heavy propeller.

The white metal lined, oil lubricated stern tube, with reduced clearance and mechanical seals, was rapidly gaining in acceptance for these large single-screw vessels, however, and subject to more detailed specification of design of the cone end and the keyway of the screwshaft, and to detailed review of service results over a period of the next few years, it was suggested that extension of screwshaft survey to four years on these installations could be worthy of consideration.

The necessity to carry a spare screwshaft and propeller on board each vessel was a matter of opinion. The 36,000 d.w.t. tankers referred to in the paper operated primarily to European ports, and drydocking took place in this area. A total of twelve vessels was constructed, and the service screwshaft and propeller of each was finished to suit a "master" cone gauge.

It was possible to reduce the number of spares, for this group of vessels, to four, machined to the "master" gauge, these spare sets of screwshaft and propeller being stored at stragetic location in Europe. They were relatively handy for any dry dock location and the arrangement permitted an appreciable saving in capital cost. Similar arrangements had been made for groups of larger tankers, of a class, now in service or under construction.

However, on single vessels operating on international trade routes, where drydocking might be at any convenient port, the carriage of spares on board would appear fully justifiable to save transportation costs and time in the event of replacement being required.

The question of the number and capacity of electrical generating units installed on a vessel related primarily to cargo ships, tankers and bulk carriers operating on international voyages, as the passenger ship, speaking generally, had considerable generating capacity to meet the heavy "hotel" loading. It could be argued, in the circumstances quoted, that where a vessel had two main generators, each capable of taking the entire sea load, the vessel could be considered seaworthy, when one main generator was out of action, providing the emergency generator, installed to meet convention requirements, was capable of starting and supplying the auxiliaries essential to operate the vessel at reduced navigable speed, in the event of failure of the second main generator at sea.

However, current thinking on large steam turbine machinery installations was to install one turbo-generator and one Diesel generator, each capable of taking the entire sea load, the Diesel unit being located outside the main engine room and being considered as covering also the emergency generator requirement.

In this case, the energy source, either steam or Diesel fuel, was separate. One could point to cases where vessels had been towed in, due to failure of the steam generating plant, where both turbo-generators were fully serviceable, and the alternative of the large Diesel generator would have saved the situation. Again, considering the case of duplicate main generators, even in the event of one generator being out of action, the failure of the other unit could generally be overcome by interchangeability of parts and a little hard work to obtain one serviceable unit.

Dr. Davis had requested clarification of the basic economics relating to the optimum period between drydocking for bottom cleaning, and no doubt the tables now published and the explanation given would clarify this point.

Mr. Fenton had passed much valid comment on cleaning and application procedures for bottom preparation and coating of the underwater surfaces of a vessel during construction and in service, and posed a theoretical question on surface preparation. Undoubtedly, much technical research was now being undertaken to enhance the performance of the improved coatings which were available.

Commander Platt had highlighted the very considerable developments which had taken place on corrosion control and which should result in an appreciable reduction in structural steel renewals and time out of service required, for bulk oil tankers, at the later "hull special surveys". It was agreed that where the principle of continuous survey of machinery was not used, the time available for "special survey" of machinery would be very much less at these particular hull surveys.

He had requested, together with Mr. Harrold, further clarification of Fig. 2. The basic economic factors and the reasoning applied to arrive at the proposal for interim drydocking at 12-monthly intervals were now given in the reply, but the opportunity was again taken to stress the relatively small differential in savings, between operating on, say, two interim dockings at eight-monthly periods and one at 12-months. In the end, the aim was to maintain a vessel in service for the maximum period, between shipyard overhauls, with the minimum loss of hull efficiency and as unscheduled delays could occur more frequently, when planning a drydocking, the 12-monthly period was thought more practicable.

Experience to date on the use of skin divers to clear underwater hull growth had been obtained only on vessels just prior to entering dry-dock for painting. A certain amount of loose scale and paint, and the surface of the anti-fouling paint, was removed by this method and some doubt was felt as to the effect of returning a vessel to service, after cleaning by skin divers, without docking and re-coating at least the sides and after end of the hull.

Very little growth was found on the flat of bottom of these tankers, possibly due to lack of light and skin divers would not work under the hull of a large vessel.

Mention had also been made by Captain Campbell on the side benefits of a follow-up on design of components and assessment of alternative materials, stemming from the planned maintenance reports, and these benefits were utilized to improve equipment reliability and increase service periods between overhauls.

Mr. Scorer had asked for further information on the reference to "short sea trials". The ocean fleet vessels referred to in the paper were engaged primarily in the crude oil trade between the Middle East and European ports, and the "measured mile" area off Malta, using posts and lights, entailed a minor deviation, on this trade route, on loaded passage. Considerable advice and assistance had been obtained from B.S.R.A. in laying down a suitable programme and in analysing results.

Mr. Hinson had proposed a mathematical analysis of the optimum period between interim drydockings based on Fig. 1—"*Approximate speed fall off curve*" and the distance travelled in service. The primary factor in this analysis was dependent on the accuracy of Fig. 1, and as stated in the paper, this had been arrived at from a "scatter" chart covering service operation of a number of 26,650 d.w.t. tankers over a period of years. In practice, the "hull roughness" factor of these vessels probably varied considerably and additionally, the authors had found that following an enforced delay in a Mediterranean port, say, for emergency repairs, a hull would foul rapidly due to marine growth with a marked fall off in performance on return to service.

For the present, it seemed necessary to keep detailed performance records of each individual ship and to assess drydocking requirements based on analysis of these records.

However, with the development of shot blasting techniques, and with more advanced hull compositions, no doubt reliable analysis would be carried out in the future with the aid of a computer.

In conclusion, the authors were conscious that the speakers had each contributed much of their knowledge to the general discussion, and in fact it could be said that the results had been a valuable interchange of experience and information.

INSTITUTE ACTIVITIES

Minutes of Proceedings of the Ordinary Meeting held at The Memorial Building on Tuesday, 22nd January 1963

An Ordinary Meeting was held by the Institute on Tuesday, 22nd January 1963, when a paper entitled "The Application of Planned Maintenance to Steam Turbine Tankers" by J. Scott, D.S.C. (Member) and H. Vickerstaff (Member), was presented by the authors and discussed. This paper was a contribution by the Institute to the National Productivity Year.

Vice-Admiral Sir Frank Mason, K.C.B. (Chairman of Council) presided at the meeting which was attended by 135 members and guests.

In the discussion which followed ten speakers took part.

The Chairman proposed a vote of thanks to the authors which was greeted by prolonged acclamation.

The meeting ended at 7.30 p.m.

Section Meetings

Bombay

Annual Report

The number of members registered with the Section on 31st December 1962, was 201 compared with 188 at the close of the previous year. Twenty-two new members were enrolled and nine members were removed from the list due to transfer or loss of contact. Members are requested to notify the Honorary Secretary of the Section of changes of address as in most cases the only indication of any change is when successive letters addressed to members concerned, are returned.

During the year three technical meetings were held jointly with the Institution of Marine Technologists, as follows:

29th June	Symposium on Existing Ship Repair Facilities in Bombay and the Scope for Improvement; the following papers were read: "Types of Repairs and Various Customs and Port Formalities" by C. S. Sundaram, A.M.R.I.N.A., A.M.I.E.S. (Member). "Dry Docking" by B. S. Sood, M.I.E. (India), M.I.Mech.E., A.M.I.E. (Member). "Ship Repairs" by E. John Cyriac. "Material for Ship Repairing in Bombay" by W. A. Raghavan (Associate).
17th July	"Electrical Engineering in the Navy" by Cdr. L. D. Tewari, I.N.
19th November	"Theory of Centrifugal Separation and Means of Comparing two Centrifuges of Different Dimensions with Each Other" by Bjarne Zachariassen, Mech.E. and "Centrifugal Separation of Marine Fuel and Lubricating Oils" by Lars Norling, Mech.E.

The Section was invited to a talk and a film show on the new French Line flagship *France*. While not strictly a technical meeting, the proceedings provided a stimulating insight into the future of giant luxury liners.

Three Committee meetings were held during the year at which discussions centred mainly on the scope for intensifying the activities of the Section. Acknowledgements were due to Rear-Admiral T. B. Bose, B.Sc., I.N. (Vice-President for India) for making available, a room in which to conduct the meetings.

Owing to the state of emergency prevailing in the country, unfortunately, the Annual Dinner had to be cancelled.

Requests for books from the Division library were received not only from members, but other interested parties as well. The need for greater reference facilities in an important centre such as Bombay, cannot be overstated and various schemes to provide these were considered.

D. Dyer (*Honorary Secretary*)

Annual General Meeting

The Annual General Meeting of the Section was held on Wednesday, 27th February, 1963, at the Nautical and Engineering College, Bombay 1.

Rear-Admiral T. B. Bose, B.Sc., I.N. (Vice-President for India) was in the Chair and thirteen Corporate Members were present.

The annual report, which had been previously circulated, and the financial statement, were presented and approved.

The scrutineers, Mr. M. K. Jagtianie and Mr. H. L. Sethi, gave the results of the ballot to the Chairman who announced that the following members had been elected to serve on the Committee: Mr. B. Ananda, Mr. A. N. Mukherjee and Mr. R. S. Rawal, who will replace Cdr. W. P. Bapat, I.N., Mr. E. J. D'Sa and Mr. S. Kasthuri.

The Committee for 1963 is constituted as follows:

Vice-President: Rear-Admiral T. B. Bose, B.Sc., I.N.
Chairman: *To be appointed*
Committee: B. Ananda
E. R. Dastoor
R. C. Mohan
A. N. Mukherjee
K. Parthasarathy
S. Ratra
R. S. Rawal
K. S. Subramaniam, B.Sc.
Honorary Secretary: D. Dyer
Honorary Treasurer: C. S. Sundaram

After thanking the scrutineers for their services the Chairman said that the reason for the poor attendance at the meeting was probably due to the fact that members were working late owing to the emergency. He said that the report clearly indicated that the level of activities was being maintained.

The Chairman said that it was the tendency abroad these days to have joint councils with other institutions, for instance in Britain, the Institute was represented on a joint council with the Institution of Mechanical Engineers and the Institution of Electrical Engineers among others. It was to be hoped that in view of potentialities, similar steps would be taken in Bombay.

The Chairman mentioned that a new approach for the training of marine engineers was being tried out in which there were two branches. One branch would be composed of higher theoretical education and the other of people with a predominantly practical approach.

Admiral Bose said he was sure that members would join in expressing appreciation for the services performed by the retiring Committee Members. He welcomed the newly elected members of Committee.

In conclusion he appealed to the members for their support for the activities of the Section.

Mr. T. M. Sanghavi, B.E. (Secretary, Indian Division) said that since the inception of the Division, papers read at the Shipping Conference had been published in the Indian Supplement. These were, however, running out and there was an urgent need for more material. He hoped that members would give a serious thought to the writing of papers.

Calcutta

The Annual General Meeting of the Section was held on Thursday, 28th February 1963, at the British Council, 5 Theatre Road, Calcutta, 16.

Mr. B. Hill (Local Vice-President) was in the Chair and thirty-two members were present.

The adoption of the financial statement for 1962 was proposed by Mr. P. D'Abreo and seconded by Mr. H. Allen. This was unanimously approved.

The following members were elected to serve on the Committee:

Local Vice-President: B. Hill
Chairman: T. K. T. Srisailam
Committee: P. D'Abreo
J. E. D'Souza
S. K. Paul
V. R. Rajagopalan
K. Ramakrishna
C. Tye
B. D. Wadia
Honorary Secretary: K. S. Chetty
Honorary Treasurer: A. Krishnan

North Midlands

A meeting of the Section was held on Wednesday, 3rd April 1963, at the British Iron and Steel Research Association Building, Hoyle Street, Sheffield, at 7.15 p.m.

Mr. J. W. Batey (Chairman of the Section) presided at the meeting and after welcoming the thirty-five members and visitors introduced the speaker, Dr. J. E. Garside, M.Sc. and invited him to present his paper entitled "Metallurgy in Marine Engineering".

The paper, illustrated with slides, was most interesting and stimulating and moved the audience to ask many questions, all of which were adequately and courteously dealt with by Dr. Garside.

A vote of thanks to the author, proposed by Mr. H. V. Campbell (Member), was carried by acclamation and the Chairman closed the meeting at 9.15 p.m.

South East England

A meeting of the Section was held on Tuesday, 19th March 1963, at the Clarendon Royal Hotel, Gravesend, when a paper entitled "Heat Exchangers—Design aspects to avoid Corrosion" was presented by Mr. C. H. Pattman, Technical Director of Serck Tubes Limited.

Mr. G. F. Forsdike (Chairman of the Section) was in the Chair and fifty members and guests attended.

The paper, which was liberally illustrated by colour slides, was received with great attention and those present kept both Mr. Pattman and his colleague, Mr. Fowler, very busy answering numerous pertinent questions on the subject.

Mr. Pattman and Mr. Fowler were thanked most heartily for their presentation of a subject on which they obviously had a great fund of knowledge and experience.

Before closing the meeting, the Chairman gave details of a visit which the Section was planning to make, to Bradwell Nuclear Power Station, on Sunday, 23rd June, for which numbers were restricted. Any member not present at the meeting on 19th March, who wished to join the party was asked to contact the Honorary Secretary, Mr. J. Haddock.

Election of Members

Elected on the 15th May 1963

MEMBERS

Edward Burnett, Lt. Cdr., R.C.N.
Donald Clark
Broan John Cobham
Peter Constas
John E. Crellin
William Macdonald Davidson
Gerard Anthony John Fuchter, Eng. Lieut., D.S.M., R.N.
Frederick Charles Richard Lush, Eng. Lt. Cdr., R.N.
Eric Dermott Mackie
Thomas Rodger MacLean
Rodolfo Muller
John Frederick Pellatt, Eng. Lt. Cdr., R.N.
Gordon Victor Stacey
Carlo Starc
Geoffrey Collingridge Valder
Alexander Buchanan Williams

ASSOCIATE MEMBERS

Lubin Cyril Aarons
Dinesh Chandra Agnihotri
Mohammad Athar Ayub
Louis Alexander Bee
Balla Narayan Bhat
Gaetano Bucchieri
Alan Lindsay Budd
Pierre P. Chausse
Erach Jamshedji Contractor
John Michael Corker
Roger Keith Cunningham
Ian Roger Driver
David John Endicott
Harihara Iyer Ganapathy
Gordon Roger Green
Brian Harris
Frank Ernest Higgins
David John Hill
Oswald Philip Horrobin
Richard Kelso
Mohamed Samir Osman
Harold Reay
Harish Prasad Saxena
Bhagwan Singh
Brian George Smith
Edward Mitchelson Smith
Michael Geoffrey Carlisle Tanner, Lieut., R.N.
Alexander John Todd, Eng. Lieut., R.N.
Thomas Edwin Tonkiss

ASSOCIATES

Robert Paul Bernhardt
George John Jailler
Donald Fraser Masson
Arne Pedersen
George Ratchford
Felix Paul Mark Scott
Ross James Smith

GRADUATES

Peter Fredrick Anthony
Robert Charles Bale
Sunit Kumar Bhattacharjee
Victor Buchanan
Gordon Reginald Burgomaster
John Ramage Campbell
Kenneth Challice
William Henry Dixon
Bernard Jones
Barry Desmond Margetts, B.Eng. (McGill University)
Robert Stephen Milligan
Albert Andrew Dennis Pickles
Brian Clifford Spenceley

STUDENTS

George Frank Allinson
Terence John Godden

Zafar Hameed Ismail
Albert Kar-Luen Tam

PROBATIONER STUDENT
Peter John McSweeney

TRANSFERRED FROM ASSOCIATE MEMBER TO MEMBER
Thomas Alexander Beaton
Alan Beattie
John McPherson Cook

TRANSFERRED FROM ASSOCIATE TO ASSOCIATE MEMBER
William Thomas Jordan, Eng. Lieut., R.N.
John Mathew, Sub. Lieut., I.N.
Anthony Conrad Palin

TRANSFERRED FROM GRADUATE TO ASSOCIATE MEMBER
Peter Joseph Adolph
Ian Fredrick George Beard
Khwaja Mahmood Hasan, Lieut., P.N.
David Michael Haywood
Godfrey Julian Hoare
Philip Henry Inman
Eric William Ivimey
David Hugh Shallis
Francis James Thomas, B.Sc.
David McGoun Tree
Joseph Benedict Walker

TRANSFERRED FROM GRADUATE TO ASSOCIATE
John Geoffrey Hurn

TRANSFERRED FROM STUDENT TO ASSOCIATE MEMBER
Richard Howard Chadburn
Devi Prasad Mohanty
Dennis Grantham Pearson

TRANSFERRED FROM STUDENT TO GRADUATE
Alfred John D'Souza
Jack Gregson
Frank David Peach
Robert Dennis Terry
Alexander Duncan Tosh
Gordon William Whitehead

TRANSFERRED FROM PROBATIONER STUDENT TO ASSOCIATE MEMBER
Alexander Gibb Troup Tosh

TRANSFERRED FROM PROBATIONER STUDENT TO GRADUATE
Richard John Christie-Gammie

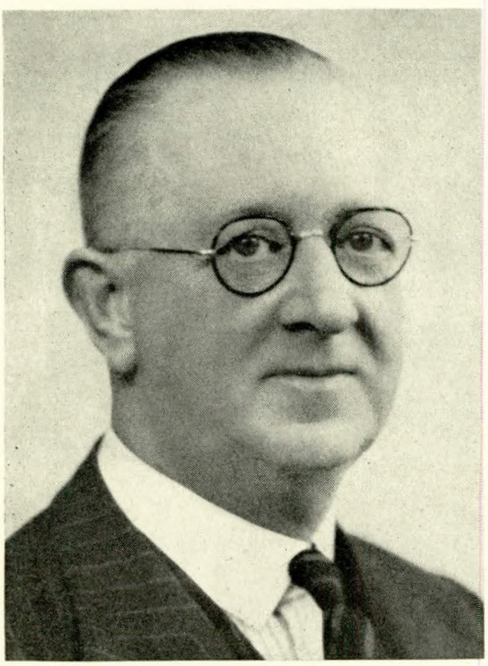
TRANSFERRED FROM PROBATIONER STUDENT TO STUDENT
Derek Alan Horrocks
Robert Andrew Murray
John Edmund Richmond
Johann Ludwig Schubert

OBITUARY

SIR SUMMERS HUNTER, J.P. (Member 2710), a well known marine engineer and an Honorary Vice-President of this Institute, died at his home in Newcastle upon Tyne on 26th March 1963.

Born on 26th July 1890, the son of the late Summers Hunter, C.B.E., he was educated at Oundle School, after which he served an apprenticeship with the North Eastern Marine Engineering Co. Ltd., Parsons Marine Steam Turbine Co. Ltd., Yarrow and Co. Ltd. and Scott's of Greenock, in conjunction with training at Armstrong College (now King's College) Newcastle upon Tyne.

In the First World War he was a temporary engineer officer in the Royal Navy and served, under the late Lord Fisher, as



an assistant secretary to the Board of Invention and Research at the Admiralty.

He joined the North Eastern Marine Engineering Co. Ltd. in 1919, being appointed assistant to his father who was then managing director and later chairman of the company. In 1921 Sir Summers was himself appointed a director of the company and, seven years later, succeeded his father as managing director. When, in 1938, N.E.M. and George Clark (Sunderland) Ltd. amalgamated with Richardsons, Westgarth and Co. Ltd., he was appointed managing director of the group.

During the Second World War he undertook the duties of regional director of merchant shipbuilding and repairs for the North East Coast area and was created a Knight Bachelor in the New Year Honours List of 1943.

Sir Summers, who was elected a Member of the Institute on 19th December 1912, will be well remembered for his services as Vice-President for Newcastle, an office that he held for several terms, and also as an Honorary Vice-President of the Institute since 1956. In addition, he was a fellow of the North East Coast Institution of Engineers and Shipbuilders and president from 1944 to 1946, an honorary vice-president of the Royal Institution of Naval Architects and a member of the Institution of Mechanical Engineers and of the Institution of Engineers and Shipbuilders in Scotland. He was also a founder member and first chairman of the National Association of Marine Engine-builders.

Sir Summers retired from executive duties with the Richardsons, Westgarth Group in 1955 and was elected president of N.E.M., an honorary position he held until his death.

He leaves a widow and three sons.

JOHN BELL PARKER, O.B.E. (Member 6912) died on 2nd November 1962, at the age of 56 years.

His apprenticeship was served, first with the Blackburn Aeroplane and Motor Co. Ltd. and then with John Lynn and Co. Ltd., after which, in 1927 he commenced his lengthy sea-going career. In 1930 he joined the Blue Star Line, as fourth engineer, thus beginning a thirty-two year association with that company. He was chief engineer in various ships of the Blue Star fleet from 1942 onwards, including the *Uruguay Star, Brasil Star, Paraguay Star* and *Tasmanian Star*. He held a First Class Board of Trade Steam Certificate with Motor Endorsement.

Mr. Parker was awarded the O.B.E. in October 1943, for outstanding courage and devotion to duty whilst serving as chief engineer in m.v. *Empire Glade*. The vessel was sailing alone when she was attacked with shell fire by an enemy submarine. Although considerable damage was sustained, the *Empire Glade* put up a successful defence and shook off her attacker. Mr. Parker had remained below with the second engineer throughout the attack despite damage caused by shell fire which penetrated the engine room. After emergency repairs had been effected the vessel was kept on her way and arrived safely at her destination.

Mr. Parker was first elected an Associate Member of the Institute on 5th October 1931 and was transferred to full membership on 12th June 1933.

He leaves a widow.

FREDERICK ERNEST PULL (Associate 19035), an Associate of the Institute since 19th June 1957, died on 3rd November 1962, at the age of 61 years.

After serving an apprenticeship with the Aston Construction Co. Ltd., he embarked upon a career as an engineering draughtsman and designer. In that capacity he was employed by the Ministry of Supply in the Services section, during the Second World War, after which he spent two years on various short term engagements. In 1948 he became senior draughtsman concerned with plant layout to the British Oxygen Co. Ltd. and later became section leader in that company's instrument section.