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RUNNING AND MAINTENANCE OF A FLEET OF BULK CARRIERS AND GENERAL CARGO CARRIERS

T. W. Major, C.Eng., F.I.Mar.E.

SYNOPSIS

The Paper compares a Fleet Budget for a Financial Year with actual expenditure. Ways of controlling and minimising costs are discussed. A simple Planned Maintenance System is dealt with and from this a question is raised whether present Classification methods for ships in service are as good or efficient as they might be. New sources of oil and improving refinery techniques is putting a heavy burden on machinery and engine maintenance. The high daily cost of fuel suggests a need for a computer programme to monitor ship and machinery performance. Operating figures for different types of engines are given with a passing reference to bad engineering. Mechanical and electrical engineering problems are discussed. A final plea asks whether through G.C.B.S. there could be as much co-operating on cost figures, as there presently is with general information, so that we could have some yardstick to gauge our efficiency.

OPERATIONAL CONSIDERATIONS

The Fleet described consists of thirteen owned vessels and six managed vessels. These range from 15,000 tonne, 14.5 knot general cargo ships, to 72,000 tonne Panamax type vessels, including one 45,000 tonne car carrier. Annual operating hours vary from 8,000 to 3,600. Main Engines are all slow speed diesels of up to 144 r.p.m. except the "CORNISH CITY" and "WELSH CITY" which had medium speed 500 r.p.m. Pielstick PC 2 - 5 Engines.

The greater proportion of this Fleet trades continuously away from the U.K. Generally, the vessels are only seen at Drydockings, or at irregular intervals when Superintendents are in the vicinity and call in for a check up visit. In the case of a particular vessel, she never returned to the UK/Continent from the time she was completed at the Builders Yard on the Clyde, until being eventually sold. A second vessel was seen in Europe only once from commissioning to sale, when it was brought back to Europe for car decks to be fitted. It therefore follows that

* Director. Sir William Reardon Smith & Sons Ltd.

MECHANICAL STOPPAGES OF OWNED AND MANAGED VESSELS

BETWEEN 1ST APRIL, 1976 AND 31ST MARCH, 1977

Included in these figures are stoppages at sea, vessels held for machinery damages and a proportion of drydocking time used for engineering repairs. Excluded are hull damages, stevedore repairs and capital modifications.

OWNED VESSELS

	M.V. "CARDIFF CITY"	3 Days	-	0 Hours
	M.V. "CORNISH CITY"	1 Day	-	7 Hours
	M.V. "DEVON CITY"	4 Days	-	0 Hours
*	M.V. "EASTERN CITY" (New Ship)	3 Days	-	1 Hour
	M.V. "FRESNO CITY"	2 Days	-	16 Hours
	M.V. "INDIAN CITY"	5 Days	-	9 Hours
	M.V. "NEW WESTMINSTER CITY"	5 Days	-	0 Hours
	M.V. "PORT ALBERNI CITY"	6 Days	-	10 Hours
	M.V. "PRINCE RUPERT CITY"	8 Days	-	11 Hours
	M.V. "TACOMA CITY"	4 Days	-	5 Hours
**	M.V. "VANCOUVER CITY"	22 Days	-	20 Hours
	M.V. "VICTORIA CITY"	-		20 Hours
	M.V. "WELSH CITY"	5 Days	-	18 Hours

* This figure includes 17 days main engine re-chocking.

** Severe Damage to Generator.

MANAGED VESSELS

	Vessel "A"	6 Days	-	6 Hours
	Vessel "B"	5 Days	-	23 Hours
	Vessel "C"	6 Days	-	1 Hour
	Vessel "D"	5 Days	-	9 Hours
*	Vessel "E"	4 Days	-	15 Hours
	Vessel "F"	1 Day	-	12 Hours

* Vessel had further 8 days docking due cracked Tailshaft Liner.

FIGURE 1

operating vessels which are rarely seen, requires a fair degree of sophistication in systems, if vessels are to be operated efficiently.

Off Hire Time

We prepared a list showing the total number of hours each vessel spent off-hire, for other than commercial reasons. This was found to be meaningless, as in two cases vessels were off hire when they grounded in the centre of a buoyed channel, with a Pilot on board. Another case involved serious damage to a vessel struck by a barge whilst anchored in the Mississippi, with a similar incident repeated at Singapore. We have therefore extracted the mechanical stoppages as itemised in FIGURE (1) and look upon these as being a more useful guide.

Periods Between Drydockings

Despite having utilised a wide variety of underwater paint specifications, we find that as long as a vessel keeps moving, she does not foul up readily, and 15 to 18 month periods out of dock are quite possible without a significant increase in slip. It is a different story where vessels are spending long periods discharging and loading, particularly in warm water ports. In this case they foul up quickly, and only 9 to 12 months between dockings is practicable without incuring the penalty which goes with high slip.

Under water scrubbing can usefully prolong a drydocking interval, but the success depends on the quality of the Contractor and his equipment. It is essential that the vessel keeps moving there-after, as subsequent stops in warm water ports will promote worse fouling than was originally the case.

OPERATING COSTS

At the start of each Financial Year, there is prepared a Fleet Budget, or an Anticipated Expenditure for the following 12 months. This is based on historical costs, known drydockings and damages, plus an allowance for inflation. Also included is a £10,000 insurance franchise for each of our owned vessels. For 1976-77 our first Budget was as shown in FIGURE (2).

Originally the Budget was prepared by a Superintendent and this, plus monitoring of subsequent expenditure, was carried out on a part time basis. As expenditure increased, inflation rates changed world-wide, and currency fluctuations could change from month to month, we found it necessary to employ professionally trained engineering estimators, who readily adapted to all these conditions, and a separate section of the Superintendents Department now deals with Budget, Specifications, and Contracts.

Control of Expenditure is carried out at different levels, which are detailed as follows:-

Urgent Repairs

Are obviously carried out as and when necessary at the port where the emergency arises. A Superintendent is flown out if heavy expenditure is likely to be incurred, or if the work is particularly complex. This factor, however, is not a significant factor in our expenditure.

Voyage Repairs

Include such items as wasted pipes, tanks and plating, where immediate repair is not essential. Vessels submit a "Shore Repair Form", as indicated in FIGURE (3), from which a reasonably accurate idea of cost can be made.

Over the years we have acquired a good working relationship with a number of small Repair Firms in various parts of the world, whose quality of workmanship and charges we are well acquainted with. If a vessel has only recently completed its periodic drydocking, but has a number of voyage repairs to put in hand, we contact one of these Firms and get them to carry out the repairs in conjunction with the ships' staff. This is particularly the case where the damaged items have a "nuisance" value to operations.

Anticipated Expenditure 1976/77

	Cornish City	Indian City	Welsh City	Vancouver City	Prince Rupert City	Victoria City	Fresno City	New West'ster City	Tacoma City	Port Alberni City	Cardiff City	Devon City	Eastern City	Orient City	Total
Voyage Repairs	20 000	35 000	20 000	30 000	30 000	30 000	30 000	25 000	25 000	20 000	20 000	20 000	10 000	5 000	320 000
Surveys	4 000	4 000	4 000	4 000	7 500	4 000	4 000	7 500	7 500	7 500	3 000	3 000	1 000		61 000
Drydocking		58 000	40 000	21 000	50 000	50 000		45 000	40 000	40 000		50 000			394 000
Paint (D.D.)		5 600	4 600	9 600	8 000	8 000		8 000	8 000	8 000		8 000			67 800
Improvements	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500	1 500		19 500
Radio	2 500	2 500	2 500	2 500	2 500	2 500	2 500	2 500	2 500	2 500	2 500	2 500	2 500		32 500
Maintenance Spares	35 000	50 000	35 000	45 000	45 000	40 000	40 000	35 000	35 000	30 000	15 000	15 000	15 000	25 000	460 000
Sub Total	63 000	156 600	107 600	113 600	144 500	136 000	78 000	124 500	119 500	109 500	42 000	100 000	30 000	30 000	1 354 800
Insurance Franchise	10 000	10 000	10 000	10 000	10 000	10 000	10 000	10 000	10 000	10 000	10 000	10 000	10 000	10 000	140 000
Total	73 000	166 600	117 600	123 600	154 500	146 000	88 000	134 500	129 500	119 500	52 000	110 000	40 000	40 000	1 494 800
Drydock	July 77	May 76	May 76	May 76	May 76	Mar 77	June 77	Dec 76	Feb 77	Jan 77	June 77	Aug 76	Dec 77	MARGIN	25 200
														TOTAL	£1,520,000

FIGURE 2

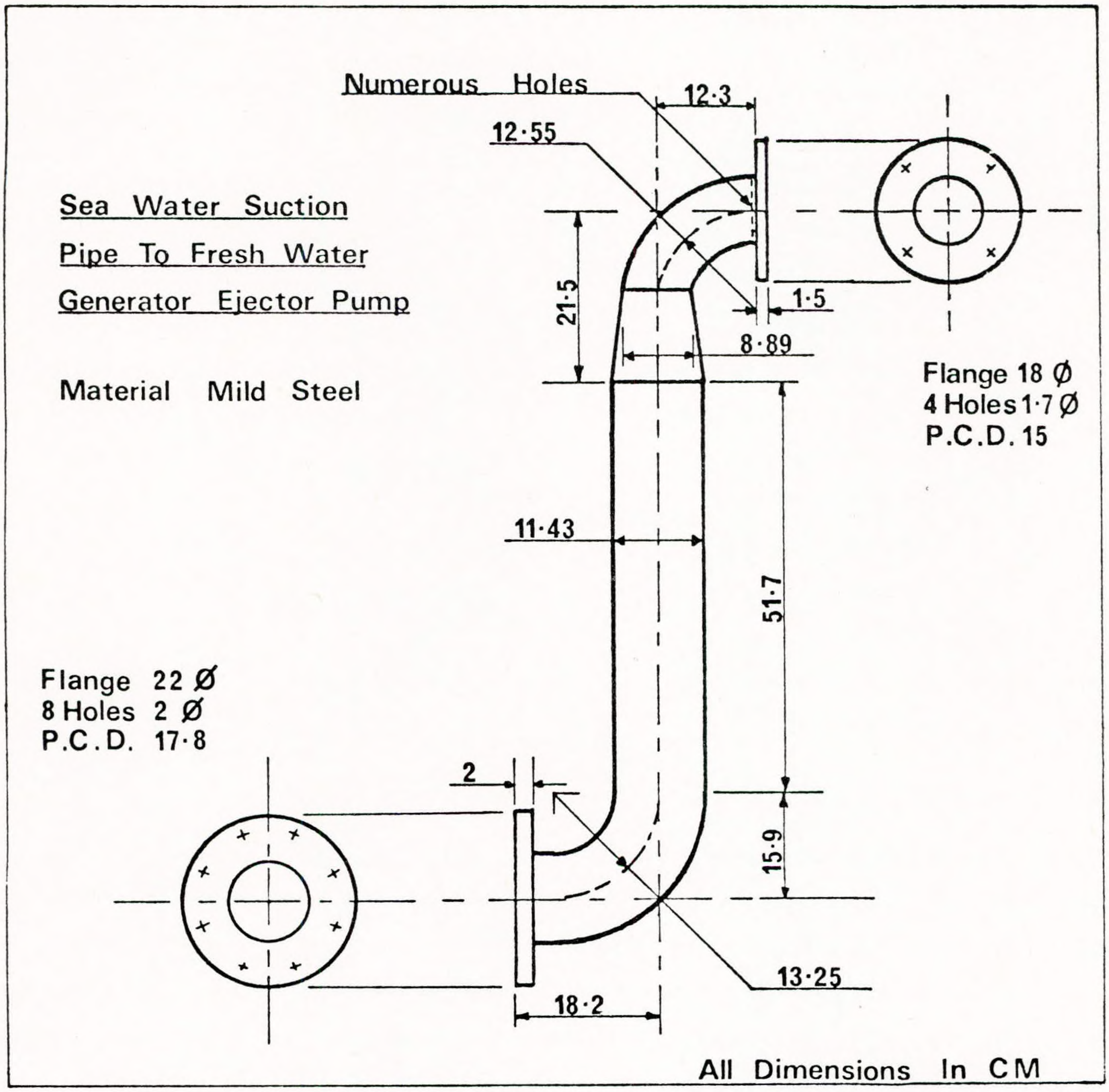
SHORE REPAIR FORM

M V Fresno City

Code No E 2

Date 20 - 2 - 77

Port Durban



Access Requirements :- One Section Platforming on Two Stanchions

Staging Requirements :- Approx 5 M Double Plank Staging

Coating Requirements :- Galvanised

Special Requirements / Remarks :-
Pipe Can Be Removed & New Pipe Fitted By Ships Staff

Signed ____________

Rank ____________

FIGURE 3

Please quote the following general expenses and also indicate port rates for tugs and pilot where these are not directly employed by you, also additional costs involved in drydocking/undocking outside normal working hours, or at week-ends. Advise whether any holidays fall due during the anticipated period of repair:-

G2	a	Tugs
	b	Pilot
	c	Mooring and Unmooring
G8	a	Fire Precaution
	b	Connect and Disconnect Hose
G9	a	Shore Power
	b	Connect and Disconnect Cable
G10		Refuse Disposal
G12	a	Refrig. Cooling Water
	b	Connect and Disconnect Hose
G14		Stores Crane
G28	a	Port Dues, if any
	b	Dock Dues, if any
G31		Telephone

Also quote any other general service expenses, associated with drydocking and repairs, applicable to your Yard.

Please also quote the following rates:-

G50 Charging out labour rate for day work, shift work and overtime.

G51 Rate per metre for ½" fillet welding.

G52 Rate per metre for vee-ing out ½" fillet weld.

G53 Rate per kilogram for general replacement, small steelwork up to 500 kilograms.

G54 Rate for staging (2 plank, 3 plank and 4 plank) per metre in length or your standard.

G55 Price for removing and refitting bolted manhole covers including supplying and refitting new jointing.

G56 Price for removing and refitting screwed drain plugs, at base of ballast tanks, in drydock if required.

G57 Price for checking only tightness of ballast tank drain in drydock prior to undocking.

G58 Rate for cleaning ballast tanks if required.

G59 Rate for cleaning and gas freeing fuel tanks if required.

FIGURE 4

If, however, periodic drydocking is soon due, the Shore Repair Form is sent forward with the Drydock Specification and included in the price.

Tendering

Each Shipping Company, no doubt, has its own Standard Forms which are used when inviting Tenders for Drydockings. Set out in FIGURE (4) is a part of our Standard Form which is designed to highlight the principal items of expenditure, plus those which can often be "hidden extras". It is also essential, particularly for managed vessels, that Terms of Payment are fully agreed.

Particular points for attention are as follows:-

Tugs

If these are owned by the Yard, or by a Company with an Operating Agreement with the Yard, then this can lead to a substantial cost difference. If work is expected to finish on a Sunday evening, it may be more economic to defer sailing until one minute after midnight, to avoid being charged full week-end overtime.

Port and Dock Dues

In certain areas there are only part charges, or even no charges at all, if a vessel enters a port solely for drydocking and repairs. Time of arrival at the yard is important because the cost of overtime for tugs, boatmen and the Yard personnel can nearly double the cost of Docking and Undocking, and with this extra cost readily available, the Superintendent can decide whether it is economic, or not, to incur the additional expense.

Shore Power

We have been involved in so many disputes over charges for shore power, that an investment of £50 in a Kilowatt hours meter for each ship has proved well worthwhile.

Salvage

Comprehensive lists which include all the information required by Underwriters also expedites settlement of Insurance Claims, and makes it easier to obtain payments on account. With the cost of repairs escalating so heavily payments on account, and early settlement, can have a dramatic effect on cash flow, and outstanding debts in Average Accounts.

Painting

There can be wide discrepancies in areas of paintwork sand or shot blasted, and also areas of paintwork touched up. We find it pays to agree these areas as they are dealt with to prevent 100 square metres being claimed as 1,000 square metres, as has actually happened.

An analysis of Tenders for two different types of work comes out as shown in FIGURES (5) and (6).

In the case of the Tender in FIGURE (5), we accepted Continental Yard "C" Tender at £37,000. The work, plus some extras, was completed in 7½ days.

In the case of the Tender in FIGURE (6), which occured several years ago, we accepted Continental Yard "D" Tender at £215,000 at 48 days. The completed work came out at slightly more than this due to extra work and took 3 days longer.

In the first case, allowing off hire charges and loss of earnings at £3,000 per day, the best British Tender at £40,000 and 14 days would be more than £24,000 greater than their Continental competitors.

In the second case, on the same basis, the differential would be over £100,000.

It is quite tragic that with £1 Sterling almost halved against the stronger Continental currencies, the British are still not able to compete. If one looks at the illustrated Tenders, it is apparent that if work could be double shifted, so that time taken was brought into line with Continental and Far Eastern competitors the drydock charges would come down,

26,000 Ton Bulk Carrier

	Continental Yards						British Yards		
	A	B	C	D	E	F	G	H	I
GENERAL SERVICES, DRYDOCKING & REPAIRS INCLUDING PORT DUES, TUGS & MOORING	41 725	36 753	30 272	40 544	39 608	38 381	32 583	28 813	38 682
TUGS, PILOT & PORT DUES IN/OUT DISCHARGING PORT	4 944	4 944	4 944			4 944	4 944	4 944	4 944
STEAMING COSTS/OFF-HIRE EARNINGS TO REPAIR PORT. FUEL COSTS.	6 887	3 708	1 666			5 416	6 526	6 526	6 526
Totals £	53 556	45 405	36 882	40 544	39 608	48 741	44 053	40 283	50 152
Time	10 DAYS	9 DAYS	7 DAYS	$7\frac{1}{2}$ DAYS	6 DAYS	9 DAYS	18 DAYS	14 DAYS	12 DAYS

FIGURE 5

26,000 Ton Bulk Carrier

Grounding Damage Repair Tenders

Repairs as Specified 380 Tons Steel

Continental Yards					British Yards	
A	B	C	D	E	F	G
317,066	312,000	283,000	215,000	358,000	246,000	260,000
50 DAYS	37 DAYS	53 DAYS	48 DAYS	60 DAYS	72-75 DAYS	70 DAYS

ALL PRICES POUNDS STERLING

FIGURE 6

management charges would come down, and highly competitive tenders would result. It would be necessary to ensure sufficient volume of work through the Yard to justify this.

Maintenance Spares:

This is a subject to which a complete Paper could be devoted on its own, but for brevity it splits up into four main elements.

(a) A careful examination of incoming orders is necessary to check exactly what is being ordered, as against what is required. Orders received of the style:

6 off part No.1234 XYZ. Drawing No.67890/AB.

- can lead to the ordering of whole sub-assemblies where only one component would have been necessary. In an extreme example of this, a 3 ins thermostatically controlled valve which was sent complete with the control gear cost £1,350, when only the valve was required, cost about £80. Another example of this pitfall is as follows:

A set of main engine piston rod scraper segments complete for one rod ordered to, say, Spare Part No. 123 XYZ, costs £1,570. Usually all that is required is a set of HECO rings, cost £50.

(b) This item is largely complementary to (a), and requires the careful examination of incoming invoices to monitor high value items, or lower value items coming through in volume. Then a check is made on maintenance schedules, or basic engineering concepts, to see if this can be reduced.

As an example it was noted that after relatively short periods of service, complete hatch jacks or their rams and seals, were being ordered in wholesale quantities. The cost of a complete jack came out at £65, a ram £22 and a seal £13. The cause of failure appeared to be penetration of the ground chromium surface of the ram by salt

penetration of the ground chromium surface of the ram by salt air with consequent peeling of the chromium plating. This was assisted by a "grinding paste" made up of iron ore or grain dust, mixed into the oil film. There was a high nuisance value and substantial maintenance cost to the ships' staff, apart from actual cost.

It was arranged to manufacture rams in stainless steel at a cost of £18 each, and a U.K. metric seal was obtained costing £5. Additionally a bellows type gaiter was fitted over the ram to keep out cargo dust deposits. Since there are 50 rams per ship, and a number of ships, the saving is substantial.

A control box for an exhaust valve grinding machine was ordered to Part No. 1234, Cost £120. When checked, it was found that an internal spring had failed. The replacement cost was 30 pence.

Main engine exhaust bellows had been failing regularly after approximately 10,000 hours service. On the failed units it was noted that the internal sleeve had ruptured exposing the convoluted bellows sections to the full blast of the exhaust gases. When the manufacturer was persuaded to fit an internal sleeve three times the original thickness, the problem disappeared.

(c) With the sharp rise in the cost of spare gear, reconditioning which was previously scarcely worthwhile, is now an economical proposition.

For Example:

Pump impeller and spindle assemblies which cost now about £1,000, can be reconditioned at under £250, with a special coating being applied to the impeller which appears to give it a life in excess of the original product.

Final Expenditure 1976/77

	Cornish City	Indian City	Walsh City	Vancouver City	Prince Rupert City	Victoria City	Fresno City	New West'ster City	Tacoma City	Port Alberni City	Cardiff City	Devon City	Eastern City	Orient City	Summary of Totals
Voyage Repairs	11 935	26 687	10 660	60 979	16 037	13 277	24 706	14 851	12 629	14 680	4 693	8 086	5 739		224 959
Surveys	3 860	2 077	2 140	4 445	6 641	2 008	2 970	7 809	12 654	8 742	1 477	1 921	89		56 833
Drydocking	11 291	57 136	57 755	17 319	55 970			68 724	55 000	16 148	17 165	56 226			412 734
Paint (D.D.)		4 737	4 28	9 576	7 962			7 584	7 296	7 367	7 980	9 157			65 943
Improvements	2 259	285	1 395	2 882		1 969	2 520	47	245	34	2 006	329	79		14 050
Radio	1 009	2 274	1 463	2 866	2 768	393	2 472	−235	1 863	1 724	1 250	4 107	3 400		25 354
Maintenance Spares	33 847	39 988	32 925	28 388	17 309	35 911	31 163	27 081	28 905	27 939	12 309	10 557	18 635	25 000	369 957
Sub Total	64 201	133 184	110 622	126 455	106 687	53 558	63 831	125 861	118 592	76 634	46 880	90 383	27 942	25 000	1 169 830
Non Recoverable Damage & Repairs Including Franchise			10 119	12 500	1 568				12 445	17 332	1 177				55 141
Recoverable Damage Repairs			40 637	11 182					28 750	37 518					118 087
Total	64 201	133 184	161 378	150 137	108 255	53 558	63 831	125 861	159 787	131 484	48 057	90 383	27 942	25 000	1 343 058
Postponed D.D. Estimate Allowed for Victoria															60 500
															£1,403,558

FIGURE 7

Main engine cylinder covers are probably better units with the latest reconditioning techniques, than they were when new.

A scuffed piston rod can be brought back to standard size by re-chroming, and grinding at a cost of £800, as against £3,200 for a new rod.

The scope for such cost/engineering savings seems unending.

(d) There is a wide area of spares supply items where a careful check of alternatives is very worthwhile.

When asked to quote for the supply of a rudder bearing bush to Owners drawing and B.S. materials prices varying between £1,260 and £600 were obtained.

An intricate clamping device for hatches in stainless steel costs £180 from the Suppliers, £30 from a local Engineering Co.

A standard H.D. contactor bought for £92 from the equipment supplier, was obtainable at £36 direct from the manufacturer.

Air filtration materials quoted at £34 were available at £7 from an alternative, local supplier.

The variation in cost between different Companies for reconditioning a piston head to a standard specification is up to £500, and a piston ring price can treble from different sources.

These smaller items of expenditure might not seem very important but when multiplied by the number of instances per ship, and then by the number of ships, the total saving is significant.

The final costs for the year are shown in FIGURE (7), and show a balance of £116,000 inside estimates. This was a good year when maintenance, damages, and costs were much more stable than expected, but the swings in each direction can be violent, and it is possible to be as much out "above the line", as below it. However, we check "raw" expenditure totals at three monthly intervals, so that by the 31st March, our figures are reasonably accurate.

Surveys

Usually, we only keep vessels between 10 and 15 years. Steelwork is to full scantlings (i.e. non-corrosion control), with double bottoms and other ballast tanks coated with grease paint, which enables us to "run through" the 5th and 10th year Survey almost without cost. Life Saving Appliance (L.S.A.) Surveys, which used to be a costly item, are now handled on a "Planned Maintenance" basis, by Second and Third Officers, with little or no cost accruing when actually surveyed.

Mechanical and Electrical Surveys are carried out on a Planned Maintenance System, and again little cost is involved. The only exception to this can be on the very hardest run of our vessels, where shore assistance may be necessary, from time to time.

It was formerly our practice to code items of expenditure under approximately 40 different headings, but it was found that general clerks found difficulty in coding such a number of headings correctly. Similarly when the print-out for 18 ships under 40 headings came through, the task of checking was a mammoth one. Furthermore, discrepancies were historical, and the necessary corrective action may have been taken months before. As a result of all this, we now code under only 8 to 10 items, as this number is easily monitored.

A few years ago, when examining the value of the Section of three people checking and taking action on these costs, we noted an accrued saving over a twelve month period to be in excess of £150,000 for the Fleet of 18 ships.

This figure excluded all Contract and Standard price work, which could be an equal amount, and with money at 15% the expeditous rendering of accurate Average Accounts also represents a substantial sum.

PLANNED MAINTENANCE

This system was originally a Kalamazoo system, which involved Chief Engineers in moving strips around in their Record Books when a particular item of maintenance was done outside its planned schedule. With ships that are rarely seen, we found that the strip index could get totally out of hand. Furthermore, when operational experience showed that overhaul intervals required lengthening or shortening, a major effort was necessary to get all the Kalamazoo strips changed.

Several years ago, to overcome these shortcomings, we changed the system and transferred all the maintenance to a Computer. This now enables us to give a Chief Engineer a printout of all the items which will fall due during his tour of duty on a vessel. Included are all Survey Items. Also Main Engine crankcase, generator and tailshaft lub oil tests, piston and jacket water samples for analysis, and boiler water tests.

FIGURES (8) and (9) indicate part of the print out. Before a Chief Engineer joins a vessel, he comes to Head Office for a briefing on the recent history of the vessel and any special circumstances that might prevail. He is given two copies of the full planned maintenance print out, one for the engine room and one for himself.

When on the vessel, the Chief Engineer is required to enter all details of maintenance carried out, on a Maintenance Summary Sheet (M.S.S.) with any relevent calibrations shown on the reverse side of the sheet. Examples of a typical M.S.S. with calibrations are given in FIGURES(10) and (11). A duplicate copy of the M.S.S. is kept on the vessel.

The Maintenance Summary Sheet is forwarded to Head Office, where it is scrutinised by a Fleet Superintendent and also the Planned Maintenance Superintendent, before being passed on for processing. This input is then used to update the Records.

Each vessel has details of the particular requirements for each schedule, giving general details and working instructions for the machine in question. These are bound in cellophane covers for easy handling in the engine room. An example of a typical schedule instruction sheet is given in FIGURE (12).

The input to the Computer enables a wide range of operational information to be available promptly, as follows:

Planned Maintenance Schedule
Shows the maintenance work which is overdue on a ship, and that which is due to be done in the next 6 months or 5000 hours.

Outstanding Maintenance Report
Lists those items of Planned Maintenance which should have been completed by the selected date or engine hours, but which have not been reported as having been done.

Breakdown Comparison Report
Compares the number of breakdowns over a specified period which have occurred on each unit across ships of one class.

Machinery Breakdown Analysis
Provides a more detailed look at those units appearing on the above Report which have an unsatisfactory history of failure over the given period of time (usually 2 years).

Breakdown Warning Report
Unlike the other breakdown reports, this report is produced as soon as possible after a unit has

REPORT PRODUCED - 18 APR 77
INCLUDES WORK UP TO: 30 OCT 77
LAST MSS REF: 323E 25 MAR 77

PLANNED MAINTENANCE SYSTEM

SHIP - ATLANTIC
01

PLANNED MAINTENANCE SCHEDULE NO. 4

REPORT - PM 10 PAGE 1

CHIEF ENGINEER: MR. D. HARRISON
JOINED: 30 APR 77
LEFT:

STANDING INSTRUCTIONS TO CHIEF ENGINEERS

As soon as possible after commencing his Tour of Duty on board, the Chief Engineer is to make sure that all staff are fully instructed in the following safety precautions and actions:-

1. Precautions to be taken in the event of fire - how to raise the alarm in the event of accident or fire in the engine room or elsewhere on board.

2. The location of all fire-fighting equipment and its particular use - how to start and operate each unit.

3. The location - description - operation of all quick closing valves and remote stops - closing of all ventilators - skylights.

4. The correct procedure and frequency for blowing down and testing of boiler water level gauges and correct interpretation of the *pulsation* of the water level in the glass as a guide to its accuracy.

5. The location, understanding and operation of ship's side valves in the event of sudden inrush of water into the engine room these valves to be test opened and closed every month, this action to be noted in the engine room log.

6. The understanding - the significance, and the method of operation of the bilge injection with its associated pump as an S.O.S. measure in case of flooding of the engine room. The Chief Engineer to test this valve at commencement of Tour of Duty.

7. An understanding that, in the event of malfunction to the automatic boiler fuel burning installation, it is possible oil will accumulate in the furnace - this must be cleared and the furnace vented before attempting to restart the fire.

The Chief Engineer is to make certain the following "M" Notices are readily available and fully understood by all Engineering Staff:-

	M 750	Prevention of Fires in Machinery Spaces
	M 707	Fires Involving Low Pressure Oil Fuel Pipes
	M 651	Fires Involving Lubricating Oil
OIL POLLUTION:	M 589	Discharge of Oil into United Kingdom Territorial Waters.
	M 656	Discharge of Oil from U.K. Ships and Requirements to Keep Oil Records.
	M 680	Disposal of Oily Bilge Water Accumulated while in Port.
MISCELLANEOUS:	M 467	Precautions to be taken before entering tanks and other Enclosed Spaces.
	M 752	Electric Shock Hazard in the Use of Electric Arc Welding Plant.

FIGURE 8

REPORT PRODUCED - 18 APR 77
INCLUDES WORK UP TO: 30 OCT 77
55426 HOURS

LAST MSS REF: 323E 25 MAR 77

PLANNED MAINTENANCE SYSTEM

SHIP - ATLANTIC
01

PLANNED MAINTENANCE SCHEDULE NO. 4

REPORT - PM 10 PAGE 9

CHIEF ENGINEER: MR. D. HARRISON
JOINED: 30 APR 77
LEFT:

DONE	HOURS OR DATE DUE	SURVEY BEFORE	UNIT NUMBER & NAME		SCHEDULED WORK	ENTER ON MSS	JOB CARD NO.	SCHEDULE FREQUENCY	CHIEF ENGINEER'S COMMENTS
	53761		074 7	Main Engine Fuel Pump Cams Cams and Rollers.	Sched. A	SA		2000 Hrs.	
	53761	Mar 81	081 2	Main Engine Turbo Blower No. 2.	Sched. A	SA		1000 Hrs.	
	53896		008 2	Main Engine Exhaust Valve No. 2.	Sched. A	SA		6000 Hrs.	
	54046	Aug 79	005 4	Main Engine Unit No. 5 and P.C.W. Glands.	Sched. A	SA		8000 Hrs.	
	54046		017 3	Main Engine Piston Rod Diaphragm Gland No. 5.	Sched. A	SA		8000 Hrs.	
	54150	Oct 76	091 6	Main Engine Crankcase Explosion Devices.	Sched. A	SA		5000 Hrs.	
	54252	Aug 78	006 7	Main Engine Unit. No. 6 and P.C.W. Glands.	Sched. B	SB		16000 Hrs.	
	54252		018 6	Main Engine Piston Rod Diaphragm Gland No. 6.	Sched. B	SB		16000 Hrs.	
	54252		118 0	Main Engine No. 6 Cylinder Liner.	Sched. A	SA		16000 Hrs.	
	54425		070 6	Main Engine Crankshaft Deflections.	Sched. A	SA		2000 Hrs.	

FIGURE 9

MAINTENANCE SUMMARY SHEET

SHIP NAME	"VICTORIA CITY"	PORT SENT FROM
FROM: 07.07.76.	TO: 14.07.76	
TYPE: 1 9	SHIP No.: 1 3	CHECK LETTERS: V 1
SHEET No.: 2 5 1		

Date	Total Running Hours	Break-down / Schedule	CAUSE OF FAULT AND ACTION TAKEN	Spare Gear used Part No. or Code	No. Remaining	Ship Order Number	Ref. Let	Unit Name	Unit Number	Check
070776	29710	S A	Schedule "A" Carried Out. Suction Valve Replaced with Overhauled Spare.	4 - "O" Rings 5084 2 - Copper Washers 3115	34 Nil		A	Main Engine Fuel Pump No. 1	0 2 5	1
080776		S B	Schedule "B" Carried Out. Machine found to be in good order. Machine cleaned and reassembled and run o.k.	1 - Seal R/R 71350 1 - Seal R/R 14238 1 - Seal R/R 67587 1 - Seal R/R 38259	10 10 11 14		B	L.O. Purifier.	2 1 8	5
100776		B S A	Schedule "A" Carried Out. Pointer sticking on stb bridge wing telegraph. Fault: Bearing tight on extension spindle, bearing cleaned, re-greased. Telegraph now in good working order.				C	Telegraph	3 6 9	0
110776		S A	Schedule "A" Carried Out. All found in good condition. Megger Readings Motor - INF Starter - INF				D	L.O. Purifier	3 1 8	X
120776		S A	Schedule "A" Carried Out. All found in good condition. Megger Readings: Motor INF Starter INF				E	Piston Rod Drain Pump M. & S.	3 4 9	3
120776		S A	Schedule "A" Carried Out also Pump Surveyed. Machine found to be in good condition.	1 Gear Cover Joint 4 Crankshaft Bush Joints 2 Suc. Valve Joints 2 Disc. Valve Joints	Nil Four Nil Nil		F	Boiler Feed Pump (Aft)	2 2 1	X
130776	29734	S A	Schedule "A" Carried out also Bearing Surveyed at Buenos Aires. Weardown from Original Figure 0.001.	Nil			G	M.E. Main Bearin No. 1	0 4 3	3
130776	29734	S A	Schedule "A" carried out also Bearing Surveyed at Buenos Aires. Weardown from Original Figure 0.003.	Nil			H	M.E. Main Bearin No. 2.	0 4 4	6
130776		S A	Schedule "A" carried out. All found in good condition. Megger reading 100 M	Nil			I	Piston Rod Drain Tk High Alarm.	3 4 9 A	5
130776	29734	S A	Schedule "A" carried out. Unit opened for cleaning etc. All joint faces lapped in. All ring gaps within limits. Unit found in good condition.				J	M.E. Unit No. 4.	0 0 4	1
130776	29734	S A	Schedule "A" carried out. Valve replaced with overhauled spare. Bush clearance Top 0.460 mm Bottom 0.460mm	2 - "O" Ring 6065 1 - "O" Ring 2049 Metalastic bush 7044	29 56 42		K	M.E. Exhaust Vv. No. 1	0 1 0	4
140776		S A	Schedule "A" carried out. All found in good condition. Motor 50 M Starter INF.				L	M.E. F.V.C. Pump Port	3 2 3	X
140776		S A	Schedule "A" carried out. All found in good condition.	Crane Packing CE Fibre Bush	Nil Nil		M	Fire & Bilge Pun	2 0 4	0

Input Type	Ship Number	Check Letters	Date: Day	Date: Month	Date: Year	Hours: Main Engine	Hours: Generator 1	Readings: Generator 2	Readings: Generator 3	Enter E if end of Tour	Initials, If Report Required	Super / Clerk / COMPUTER
07	1 3	V 1	1 8	0 8	7 6	30480	20721	18715	16554	E		

FORM No. M103

Chief Engineer ____________________

FIGURE 10

NO. 4 M. E. UNIT

LINER CALIBRATION IN M.M.

POSITION	A	B	C	D	E	F
F & A	740.74	740.78	740.68	740.60	740.60	740.43
P & S	740.78	740.72	740.63	740.72	740.51	740.45

IN MM

HOURS RUN SINCE LAST READING	WEAR RATE PER 1000 HRS SINCE LAST READING	HOURS RUN SINCE NEW	WEAR RATE PER 1000 HOURS SINCE NEW
9962	0.026	29734	0.027

PISTON

VERTICAL CLEARANCE ON NEW RING. 0.001"

	FIRING	NO. 2	NO. 3	NO. 4	NO. 5	OIL RING
A	0.020	0.022	0.016	0.016	0.018	0.014

ALL RINGS FOUND IN GOOD CONDITION. ALL FREE.

FULL SET NEW RINGS FITTED.

LINER AND PISTON IN GOOD CONDITION.

LITTLE BUILD UP OF CARBON.

ALL CYLINDER LUBRICATOR POINTS TESTED AND IN GOOD CONDITION.

SPARES USED:

PISTON RING	PART NO. 0544	NO. USED 2	NO. REMAINING 39
PISTON RING	PART NO. 0633	NO. USED 1	NO. REMAINING 33
EXHAUST BELLOWS JOINT		NO. USED 1	NO. REMAINING 25

FIGURE 11

PURIFIER SCHEDULES

MAPX 210	-	Heavy Fuel Oil
MAPX 207	-	Lubricating Diesel Oil

SCHEDULE A	-	2 Months
SCHEDULE B	-	6 Months
SCHEDULE C	-	12 Months

Machine Code Nos:-	216 X	217 2
	218 5	218B 9
	219 8	

SCHEDULE A:

Change oil in Gear Case. Check worm and worm wheel, check bottom nut tightness on Main Vertical Spindle. Clean suction strainer. Check clutch friction pads. Remove bowl hood lock ring, smear thread with castor oil and refit.

SCHEDULE B:

Carry out as "A" above and additionally strip down to and including paring disc, and thoroughly clean. Renew "O" rings and seals. Check sealing water flow to paring disc via control valve.

SCHEDULE C:

Overhaul machine completely. Remove, dismantle vertical and horizontal shafts. Renew ball races and oil seals. Clean suction strainer. Check sealing water flow to paring disc via control valve.

FIGURE 12

broken down for the second (or subsequent) time since the last Planned Maintenance work was done. It is thus intended as a warning to Superintendents of possible problems.

Enquiry Report

There are two main types of enquiry which are available in the system - one looks at individual units while the other looks at the same unit across different ships. The report shows the output format of an enquiry on individual units. The units can be on any ship, although details of units on a particular ship will be grouped together on the same page.

Enquiry Report (Multiple Ship)

This report is intended to be used for comparing the history of the same unit on a number of ships.

Index of Units on File

Shows a list of all units on the computer file for a given ship.

Survey Report

Here is shown the Survey position on every unit on a particular ship, with the next survey date listed.

File Update Report - Unit

This report shows the details held on the computer Master File for a particular unit. These details can be updated on request, should alterations be made to the unit.

History Report

Available is a full listing, since the commencement of computerised records, of all maintenance entries against a specific unit.

With the Printout and M.S. Sheets being the only documents exchanged between Head Office and ship, the scheme is as simple as could be devised, and only one Superintendent is required to oversee 15 vessels. The other three vessels are old and will probably be shortly disposed of.

Classification

As vessels become larger, Classification Surveyors work more and more closely with Quality Control Departments of Shipyards and by so doing have a greater influence on the finished product, than did the old tank by tank, hold by hold inspection of former years.

We feel some similar requirement is long overdue in the Classification Surveys of ships in service. Any good Owner has stiffer requirements for the maintenance of his Fleet than is called for by the Society. Below are some examples of the frequency of inspection for our own maintenance Schedules:

Main Engine Piston and Liner
Approx 3½ x Class Requirements

Alternator Engine
Approx 2½ x Class Requirements

Sea Water and Ballast Pumps
Approx 5 x Class Requirements

Main Engine Bearings (Poker Gauge)
Approx 5 x Class Requirements

Fuel Injectors
Approx 10 x Class Requirements

Megger Readings
Approx 12 x Class Requirements

Feed Pump
Approx 10 x Class Requirements

Auxiliary Condenser
Approx 5 x Class Requirements

Air Compressor
Approx 5 x Class Requirements

Turbo Blowers
Approx 5 x Class Requirements

Lub Oil and J.W. Heat Exchangers
Approx 5 x Class Requirements

Fresh Water Generator
Approx 5 x Class Requirements

Purifier Heaters
Approx 2½ x Class Requirements

Main Engine Crankshaft Deflections are taken at least 10 times during a 5 year cycle, although they are not a Class Requirement, but are a vital check on the principal component of the main engine.

Accordingly we are running an exercise with a Classification Society to see how practicable it is, for Classification to be carried out via the Planned Maintenance Scheme. This has now been running for over twelve months, with no problems arising.

There are difficulties for the Society, but if these can be overcome as with a Quality Control Department, then they will obtain better control of ship operation than is now possible. With a wide variety of Surveyors, of different nationalities, surveying odd bits of machinery in different parts of the World, the collation of Reports is a major headache and a source of error.

For the Owner, there would be great benefits, particularly for ships which are run very hard. We would prefer to work with our Local Classification Office. Responsibility for the condition of the ship would be concentrated, and the ultimate users of the Society - the Ship Owner and the Underwriter - would be better served.

MAIN MACHINERY PERFORMANCE

It is incredible that a main engine, built to run on heavy fuel oil, is run on the test bed at most of the principal manufacturers on diesel oil only. The standard excuse for this from the manufacturers is that they must have a fuel of known characteristics. This excuse seems rather feeble, and one feels that they are obliged to use a "souped up" fuel, to ensure that their engine will safely deliver its power. They then recommend you only run at 85% of this power. Every credit must be given to the few manufacturers who will test their engines on heavy oil.

As a result of the above, Superintendents are faced with receiving from the Engine Builder original Data Sheets which are unreliable as a guide to checking performance under normal sea-going conditions.

The Fleet described probably uses £7 - £10 million of fuel per year. The time has now come with the development of new sources of crude oils, coupled with the improvements in refinery techniques, for another "John Lamb" exercise in the burning of heavy fuels in Marine Diesel Engines. Again, a whole Paper could be devoted to this subject, but here are some points from our experiences:

(a) We witnessed a most comprehensive testing of fuel oil centrifuging and settlement in an Engine Works in Japan. This consisted of centrifuging the oil and allowing it to settle for twelve hours. At different times during this period, oil samples were drawn off at different levels and subjected to a spectrographic analysis. This showed that there was considerable stratification of the oil in the tank. As a result of these observations, when we re-engined two medium speed engined vessels, we adopted a re-circulating system in the daily service tank, and limited the viscosity of fuel burnt in the engine to 1000 seconds Redwood No. 1. This gave tolerably good results.

(b) American Refinery techniques, or their supply requirements, are such that they are able to take out of the fuel most of the worthwhile constituents, so that the remaining residual oil is not much better than a liquid bitumen of low quality. Refinery practice in Europe leaves a greater percentage of residual fuel, and therefore a better quality product. Recent figures quoted to us stated that American Refineries ended up with 10% residuals, European Refineries 40% residuals.

(c) Having regard to the above mentioned refinery techniques, an Owner bunkering fuel oils from worldwide sources is probably heading for trouble if he opts for a fuel oil with a greater viscosity than 1500 seconds Redwood No. 1. This is not to say that heavier fuels cannot be burnt successfully, but one needs to know in advance a great deal about the make up of the fuel before using it. In particular when vessels are on Charter, where the usual procedure is for the Charterer to supply the fuel, one is usually able to obtain only minimal information about the fuel being bunkered. In several cases, even its specific gravity was not available.

(d) South American fuels have a high Vanadium content and this can have a disastrous effect on medium speed exhaust valves. When trading in areas where only high Vanadium fuels are obtainable, then you have problems. By limiting viscosities to 1000 seconds Redwood No. 1 and restricting exhaust temperatures after the turboblowers to 410°C, these effects can be minimised. This means keeping blowers and air coolers in good condition, but it is essential when burning such fuels that exhaust temperatures are kept low. With two types of medium speed engines, we have never found a valve rotator which would operate trouble-free for long periods, but we found that if the valve did keep rotating slightly, then its life was longer than valves where the rotators have failed fairly soon after overhaul. The problem can also be overcome metallurgically by the use of Nimonic steels for the exhaust valves, but these are extremely costly. FIGURE (13) gives a breakdown of fuel characteristics from worldwide sources.

(e) In considering what quality and viscosity of fuel to burn, one must have in mind a requirement of present-day shipping that from time to time it is necessary to proceed at "economic speed", which for most Companies will mean not less than 50% m.c.r. While you can blank off one injector, or fit special slow speed steaming injectors, this is not usually very practicable, and it is therefore important that the fuel be capable of igniting and burning under generally poor combustion conditions. Whilst on the subject of economic steaming, our general experience is that greater problems arise in running at low powers with loop scavenged engines than with through scavenged engines.

(f) Fuel oil centrifuges should be of ample capacity, so that through-put can be reduced to preferably 50-60% of the Manufacturer's claimed figure, as the "dwell time" of the fuel oil in the centrifuge seems to be the critical factor. Our own practice is to double-centrifuge all oil on a 24 hour day basis, re-circulating the oil when the tank is full, so as to minimise stratification.

Most Companies run their main machinery at between 80-90% of full power. To stay at this output for long operating periods requires the blowers and air coolers to be in first class condition. We water-wash blowers on the air side with a detergent daily, and for 10 years have water-washed the gas side of the blowers every five days. However we have found that where there is only a short distance between exhaust and blower, the blower casings rapidly deteriorate and the replacement of casings has become an expensive item. For this reason we have recently stopped water-washing the exhaust gas side, and are stripping the blowers at more frequent intervals. However, in supplying a new casing to a vessel recently we took the precaution of ultrasonically testing the thickness of the casing as delivered from the Manufacturers and found that the casing as delivered, in fact had thicknesses which were close to the point of failure. This is the situation at the time of writing this Paper so that the fault may not in fact lie with the water-washing, but rather with some change in manufacturing or casting techniques.

PROPERTIES OF LIGHT FUEL OIL 1500 FROM PRINCIPAL CRUDE OILS

CRUDE OIL SOURCE	DENSITY 15 °C	POUR POINT (UPPER) °F	°C	NICKEL PPM	VANADIUM PPM	CARBON RESIDUE (CCR) % wt	SULPHUR % wt
VENEZUELA							
Bachaquero	0·959	10	-12	48	335	9·6	2·3
Lagunillas	0·952	0	-18	30	210	10·5	2·1
Tia Juana Medium	0·943	5	-15	28	240	9·2	2·0
Barinas	0·952	55	13	84	210	10·7	1·7
AFRICA							
Hassi Messaoud	0·930	75	24	<1	2	4·0	0·36
Brega	0·924	105	41	9	<1	5·3	0·41
Amal / Nafoora	0·904	100	38	10	2	5·7	0·25
Sirtica	0·927	105	41	27	12	5·7	0·7
Nigerian	0·937	110	43	8	3	3·7	0·33
MIDDLE EAST							
Murban	0·933	90	32	<1	<1	4·6	1·6
Agha Jari	0·946	75	24	22	75	7·4	2·4
Gach Saran	0·949	60	16	50	170	8·4	2·3
Basrah	0·946	60	16	9	28	7·4	3·4
Kirkuk	0·952	50	10	28	57	7·0	3·2
Kuwait	0·949	45	7	10	43	8·5	3·8
Aramco	0·952	55	13	10	26	7·9	3·1
Safiniya	0·952	25	-4	27	100	9·4	3·9
FAR EAST							
Minas	0·895	120	49	<1	<1	4·8	0·12

FIGURE 13

Wax In Diesel Oil

A mystifying occasional shut-down of a diesel alternator - usually in port - on a number of vessels was traced to waxing up of the fuel filter cartridges, when the engine room temperature fell to 65^{o}F. We were not aware that wax can be a constituent of a distillate fuel, but now understand that in some areas residual fuel is blended with gas oil to provide the necessary 55^{o} viscosity, hence the wax. This problem can simply be overcome, by wrapping electric heating tapes around the diesel supply pipe. (Note the pour point of fuels in FIGURE 14).

Water in Fuel

Two vessels in very good condition, purchased from a reputable Owner, with over 12,000 running hours, and having low liner wear, experienced a sharp increase in liner wear when operated regularly on a fuel containing 2% water. Two other vessels using the same fuel had no problems. Months of investigation seemed to isolate the cause as being due to the first two vessels having only a single clean fuel service tank in which the odd 5% - 10% water not removed by the centrifuge, was drawn in to the main engine supply line and via fuel pumps and injectors to the cylinders. There was only single stage purification.

By increasing the centrifuge dam ring to draw off a larger percentage of fuel/water interface and reducing through-put to a minimum, the situation has been contained.

On the second pair of vessels, using the same fuel, two clean Fuel Service Tanks and two stage purification allows time for the small percentage of water to settle out, and be drawn off, prior to changing over a tank to the supply line.

Earlier reference was made to the problems with the quality of fuel oil and we have found that with decreasing quality, it pays to advance the fuel pump timing about 3 or 4^{o} over Manufacturer's recommended settings, when an immediate drop in exhaust temperatures is noted, and the same R.P.M. are attained with perhaps a notch, or a notch and a half reduction in the fuel control lever. Checks on maximum pressures show very little differences from Test Bed readings.

This slight advancement may not seem important, but if you pick up a batch of fuel of poor quality, the poor ignition qualities, and poor flame propagation in the combustion space, leads in turn to "after burning" with port blockage, and ring trap fouling, taking place.

For a medium speed engine where the combustion time is less than half that of a big engine (allowing the engine is a fourstroke) the ignition and flame propagation qualities of the fuel are critical, and as fuel continues to worsen it will become more so. A single cylinder takes almost as long to overhaul as the big engine, and even if a pair in a V - bank are overhauled together, the total for the engine is much higher. Add to this a multiplicity of exhaust and inlet valves, fuel pumps and injectors, couplings and gearing, then the work load on engineering staff becomes excessive !

The emphasis on fuel may seem excessive, but with fuel oil costs forming probably £2,000 a day, or upwards, of ones operating costs, and with the quality - on a world wide basis - so vague, the penalties to the Owner, in the form of extra maintenance for port blockage, piston ring trap blockage, blower and air cooler fouling, is so high that the emphasis is justified. It is hoped that the present G.C.B.S. investigation into fuels will throw further light on this.

We have looked at the practice of sending in a "Chief Engineer's Abstract Sheet" at the end of each passage to see if paperwork could be cut down by abolishing it. We find that the information is so valuable in checking engine performance, that we are so far unable to do this.

Little importance is attached to indicator cards except for maximum pressure readings, but when you consider the cost of fuel, plus the time and effort that goes into keeping main engines in good condition, investment in a torsionmeter is well worthwhile. Reasonably maintained, they give power developed to within 5% of actual output, and together with other instrument readings give the best sort of guide to engine operation - 24 hours a day, in fine weather and foul, also at reduced power and "economic steaming".

The other readings required:

- Draft.
- Controls Settings.
- R.P.M.
- Fuel Consumption.
- Slip.
- Weather.
- Cylinder Exhaust Temperatures.
- Exhaust Temperatures After Blowers.
- Air Temperature After Coolers.
- Scavenge Pressure.
- Blower R.P.M.
- Sea and Engine Room Temperatures.
- Fuel Temperature at Engine.

Some Engine Builders offer an engine data analysis service, which we know little about, but in view of the cost significance of good engine performance when using say £2,000 of fuel per day for each vessel in a Fleet, it seems a worthwhile area of investigation for a computer programme. It could accept this basic information, and give a diagnostic printout which might be related to the engine itself, or the condition of the hull.

Great attention is paid by the Fleet Superintendent to this data. With Chief Engineers being changed at 5 month intervals it is surprising how often a Fleet Superintendent picks up a slow deterioration in performance, as against ships staff, who, in fairness, have many day-to-day problems with which to concern themselves.

Four items are outstanding in maintaining performance. First and foremost turboblower condition, with the air filters being regularly cleaned, as well as daily impeller cleaning. This daily cleaning also helps air coolers, but it is hard to say what additional running hours of the cooler can be attributed to this. On the gas side, we are having second thoughts on our standard water washing practice of the last 10 years.

Second, in situ cleaning of air coolers is now standard, but from time to time, if this cleaning does not last, it pays to remove the unit complete, and properly degrease in a carbon solvent. High pressure spraying of the tube nest may be necessary to remove solidified oil, and in this respect a recent suggestion that an aperture be provided in the centre of the tube bundle for the use of a high pressure lance seems a good idea.

Third, engine fuel injection timing which has already been discussed.

Fourth, injectors themselves. Although high quality Servicing Companies exist throughout the World, none test the completed injector on hot, thick residual oil, so that the subsequent performance of injectors is often unsatisfactory. Hot testing of injectors would show the proper tolerance required in the needle, if subsequent operation with a hot fuel is not to result in some degree of binding in service.

Keeping Fuel Valve Cooling at 80°C also seems to give better atomisation, whether this is because it keeps the fuel hot, or it prevents sluggish operation of the needle is not clear.

The injector test equipment supplied to the ship is usually quite crude (again with an honourable exception). It is important that a good (preferably paper) filter is fitted and scrupulous cleanliness observed, with all connecting pipes and unions, otherwise a good injector can be damaged on the ship, prior to fitting. There are good proprietary Test Kits on the market, but our experience of these is too recent for comment.

Cylinder liner and piston ring wear is not a problem and it appears that on wear figures alone, Cylinder liners will last the life of the ship. An exception is the R.N.D. 68's, but these are not long out of guarantee, and we shortly hope to improve matters by altering the timing.

Wear Figures

K 74 EF B & W (42 cylinders) 27 - 33,000 hours.
Liner Wear .03 mm/1000 hours.
Cylinder oil cons. 0.46 gms/B.H.P./hr.

RD. 76 and RD. 90 (24 cylinders) 50,000 hours.
Liner Wear .05 mm/1000 hours.
Cylinder oil cons. 0.65 gms/B.H.P./hr.

R.N.D. 68, (14 cylinders) 10,000 hours.
Liner Wear .09 mm/1000 hours.
Cylinder oil cons. 0.81 gms/B.H.P./hr.

B. & W. engines run on cylinder overhauls of 10,000 hours, RD's on 6-8,000 hours. As engines get older we find it necessary to lift RD liners at 12-16,000 hour intervals to renew rubber rings. This is not experienced with the B. & W. but the face to face joint of the cylinder cover is a nuisance, and if one leaks, grinding in is tedious and time consuming. Specially made 1 m.m. thick joints will shortly be tried on these cylinder covers to see if we can overcome this problem.

One common problem is that as liners wear, then the original radius of scavenge and exhaust ports is lost. It is important that this be restored, particularly in the corners, otherwise broken piston rings can result. We have a number of instances of radii being incomplete on new liners so that within a few thousand hours broken rings were found.

ENGINEERING

When the Author became a Superintendent more than 25 years ago the standard manning of an engine room was Chief, Second, Third, Fourth, three Juniors, and an Electrician. Since then engine powers have soared, turbo chargers and intercoolers have been added, alternators similarly, larger pumps and pipe systems requiring automatic or servo control plus large hotel systems, air conditioning, refrigeration, sewage and constant pressure water systems. On deck huge windlasses and automatic self tensioning winches are overshadowed by hatches automatically lifted and opened, plus very complex cranes of large lifting capacity. There is the same manning now, as then. If it is accepted that the three Junior Engineers are largely "trainees" then 4 Engineers and an Electrical Officer run and maintain this large engineering and electrical complex. Occasionally £100,000 of gadgetry is added so that the vessel is U.M.S. and all can sleep in their beds at night - or can they ? Try to find any similar complex ashore, where the environment is infinitely less hostile, run and maintained by so few men, then you will fail, for none such exists.

It may be concluded that the ability of so few men to run this complex is due to built-in reliability and this may be partly true but there is still too much bad engineering in our industry, and some of it is just crude. A simple example of this is the cylinder liner and cover joint. In 40 ship/years operation we have had virtually no trouble with one manufacturers head fitted with a jointed cover. In the same period, with another manufacturers design, endless hours have been spent grinding in face to face joints. Totally unnecessary work for the ships staff caused by bad design.

Operations Manuals

For a number of years pipe line diagrams have been provided, mounted so that they could be flipped over for easy reference. The Builders diagrammatic arrangements are not usually suitable for this, as often they do not relate to positioning of actual units and valves, so special layout plans were produced related to actual arrangements in the engine room.

However as engine rooms get more complex, something more than this is required and in later vessels an Operations Manual has been produced, which expands on the above arrangement, but includes automatic systems and controls, and as the heading implies, advises how to operate the engine room. Specialist firms are available who do this very well, but they are expensive. If you do this yourself, with the staff standing by a new ship, then with the amendments they find necessary when the ship goes into service, it is a very useful document. A copy should be kept at Head Office so that new staff going to the vessel, can read it.

U.S. Coastguard Regulations in any case require this for the handling of fuel oil, but ballasting and de-ballasting can equally penalise the vessel if there is any lost time.

While discussing Operations Manuals it may be appropriate to mention Instruction Books, where with vessels purchased abroad, or having non-British equipment fitted, the technical instructions may be misleading or inadequate. Non-British drawings and electrical diagrams may well have layout and symbols quite different to U.K. practice, and in such cases the Instructions should be completely re-written or re-drawn.

We have in mind a particularly complex piece of equipment, where after a number of problems and complaints from Staff, the Book was largely re-written with new drawings and fault finding Charts, the copywright of which was subsequently purchased by the overseas manufacturer .

Piping and Control Systems

Shipbuilders say that depending on the Owner, requirements vary from the basic simple to the highly complex, so that when planning a "standard" series of vessels they aim somewhere between the two. Our experience is, that the simpler the layout the better. The special change-over connection for some unusual failure, rarely is used, because ships staff do not know it exists. If they do not know it exists, then your better off without it. We have standard vessels with piping arrangements so complicated, that when, in a few years time pipework begins to fail, we shall have to shut down the ship completely to gain access to lower pipes in a "rats nest" of pipes, since so many systems are involved. This degree of complexity also tends to spill over and obstruct access to the tank-top, access to manholes and access to holding down bolts. This may seem unimportant, but it can put your ship "off hire" if something needs to be done in a hurry.

Control Engineering has become a separate and specialised branch of industry where one gets the impression that the controllers tell the Marine Engineers what they should have rather than vice-versa.

We find that by controlling on the salt water side only, with a dump valve regulating pressure in the salt water main, an extremely simple and reliable arrangement results. It has the advantage that when stopped or steaming slowly in estuarial waters, valves are almost shut, so that harbour debris is excluded from your heat exchangers, and fault finding is easy.

For diesel engines, upper and lower limits can be much wider than Control Engineers allow, $\pm$ 5% gives a simpler, cheaper, and more reliable valve than a $\pm$ 1% valve, to no purpose. If for example your particular engine has J.W. outlet temperatures of 150^{o}F, and you are able to pull up, in an emergency stop at sea, holding your J.W. temperatures to 143^{o}F - does it matter ? What does matter, is that the valve operates reliably.

In the past 10 years we have used simple rubber diaphragm operated valves for controlling, and with perhaps some 100 valves in use, there is about 99% reliability, and nil maintenance cost. Regrettably as engines get more powerful, and system piping gets bigger, we are having to move away from this type of valve.

5 NODE 2ND ORDER VIBRATION 240 CYCLES per MIN

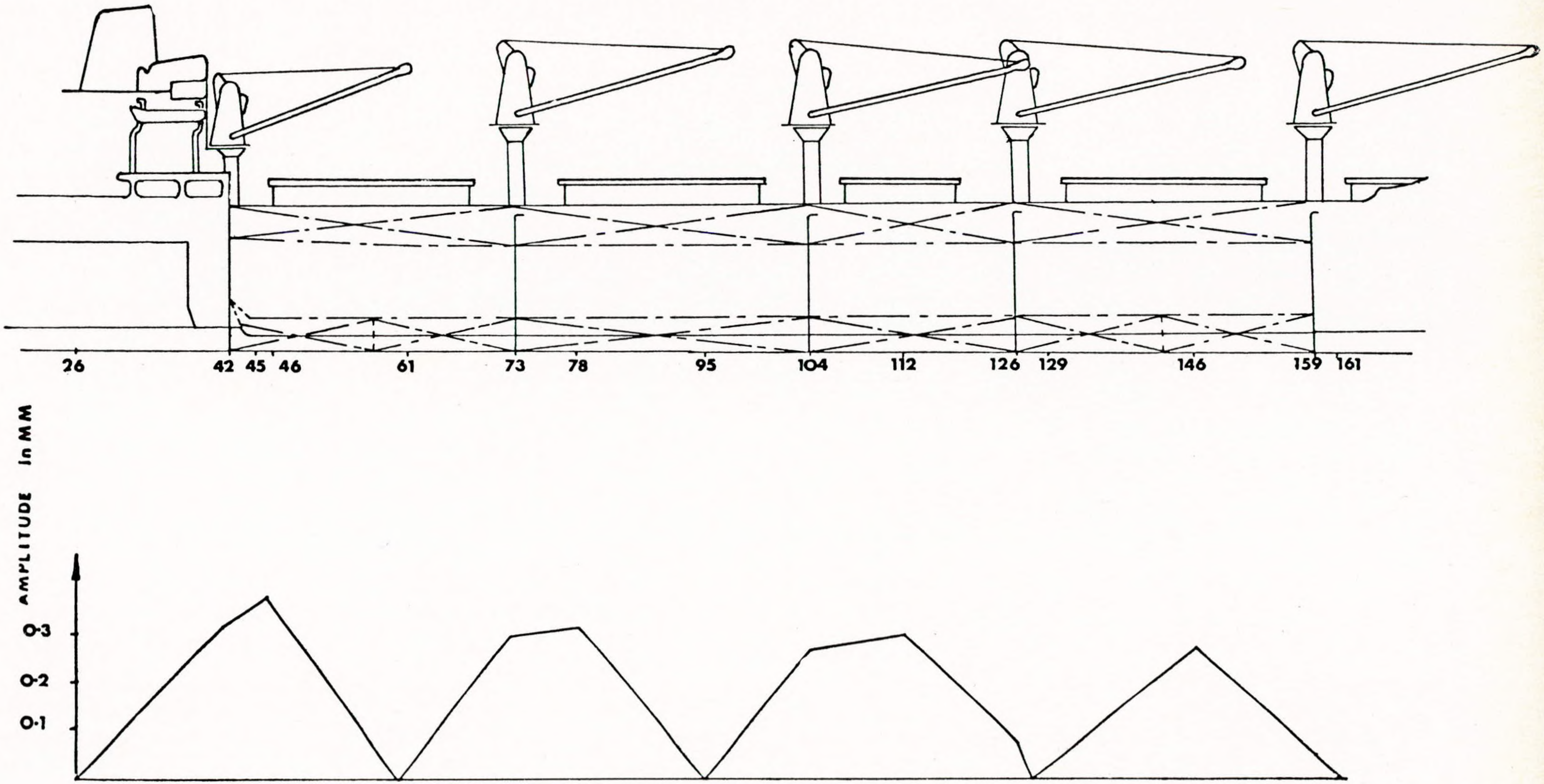


FIGURE 14

Ballasting and Deballasting

As shore loading appliances increase their capacity, it is essential that bulk carriers be capable of deballasting rapidly, and with the minimum of skilled attention. In most instances the position is still unsatisfactory.

The ballast pipes should have their centres not more than 2 ft from the bottom and should run parallel to the bottom into the engine room terminating in a small totally enclosed tank, with the ballast pump recessed into the tank for minimum lift. Control Priming Systems or ejectors should draw from both tank and pump so that full volume is retained until changed to the stripping mode.

Operationally, a surprising number of ships staff have not worked out that a 16" ballast main requires 6 - 7" tank valves open to keep it supplied, and certainly younger Engineers do not appear to appreciate this point. The trick with 6 valves open is to know when one draws air. Despite all the claims for modern instrumentation, the failure rate for double bottom tank gauges is high. This can only be attributed to severe sloshing forces from loose water in the tanks, which with many thousands of rolls in a single passage moves the gauges from zero to maximum (possibly against the stop) until they fail.

We do not yet have an installation which has operated for a few years with only a reasonable maintenance requirement. But the same equipment on tall narrow fuel service tanks where there are limited sloshing effects, works quite satisfactorily.

You then have recourse to a sounding rod, and the information from the Deck on tank soundings is vital.

The general procedure on de-ballasting should be discussed at a Management Meeting prior to docking, so that as de-ballasting and loading proceeds the critical trim of the ship will be retained even if loading has to be stopped or changed to other holds.

When ballast systems are poorly laid out, you have problems, but by bringing these up at Ship Staff Meetings at Head Office and with a Circular Letter for guidance, these can be largely overcome. With the larger ships it should be borne in mind that to maintain a satisfactory keel inclination can mean a proportionally greater trim. For instance, if a 2½ ft trim by the stern is adequate on a 500 ft long vessel, then 3¾ ft trim will be required for similar results on a 750 ft. vessel.

Vibration

While engine builders are fully aware of the out-of-balance in their engines, so long as these do not raise stresses in crankshaft, to which Classification will object, then all is well. But installed in the ship all sorts of problems arise.

Six cylinder slow speed engines, for example of 10,000 - 12,000 BHP have an out of balance secondary force of over 100 tons metres (except Doxford) which can have unpleasant - and serious effects on the hull. It can excite accommodation so that rooms are unpleasant to live in, it will tear a crane seating from the deck and will "brinell" roller races in engine room machinery, deck machinery, and cranes to the point of failure.

If the Superintendent has any say in the machinery to be installed, this should be borne in mind. At the same time a study of the longitudinal natural frequency of the hull will show where this exciting force will be greatest and some re-arrangement may be possible, a balancer fitted, or a different number of cylinders chosen. FIGURE No. 14 shows a diagram of a vessel fitted with such an engine where continuous trouble is experiençed with the fore end of the engine, and Nos. 3, 4 and 5 cranes all of which lie on the peaks or flanks of high amplitude vibrations.

Floodable Holds

Slack water in the older type deep tank often lead to serious damage. When floodable holds were introduced, it was clear that sloshing forces of a very high order would be generated due to the larger free surface. A float arrangement with a read-out and alarm in both wheelhouse and engine room, was fitted so that if any ballast line valves leaked a warning came up, for action to be taken. With this arrangement no damage has been suffered from slack water.

Piston Rod Glands

Higher scavenge pressures, and increased blowpast from higher maximum pressures, is giving greater problems with piston rod glands. Higher garter spring pressures on the scraper segments easily damages the rods. When this occurs, sludge can harden in the glands and crankcase oil can become fouled. As a consequence, crankcase lub oil losses are high.

More frequent stripdowns are a necessity, and due to the care and attention required for the correct re-assembly of these glands, instruction sheets suitably enclosed in cellophane packets are provided for use in the crankcase. Surprisingly, garter spring lengths and ratings are often incorrect from the Manufacturers, and should always be carefully checked before use. Scuffed piston rods must be re-chromed and ground, but despite all this attention to the glands on our part, some Manufacturers designs have not kept pace with service conditions, throwing additional burdens on Engineering Staff.

In a number of instances in our Fleet, normal 24 hours/day centrifuging of fouled crankcase oil failed to adequately clean it. Two years ago, as an experiment, we stopped using alkaline reserve crankcase oils on two ships, reverting to straight mineral crankcase oil. A specially designed high pressure hot water spray device was fitted, spraying directly into the lub oil system, and this has very effectively cleaned up the crankcases to the point where the film coating is a light golden brown colour, which was certainly not the case previously. We have no indication of any crankcase corrosion since dropping the alkaline oil, and in fact the only occasion in the last 15 years when we have had crankcase corrosion, was when using such an oil.

General Points

Continuous uprating of machinery is placing ever increasing strains on engineering staff, who are still being called on to overcome very ordinary problems, some of which have been outlined in the foregoing. Automation is no panacea, and if there is enough of it, then it creates its own problems. But in the engineering problems which arise daily in running a Fleet some are hard to explain, or overcome. The standard oil lubricated tailshaft with a header tank 3 metres above the Load Water Line, will allow water to pass into the oil, if the seal becomes damaged, against all principles of logic.

A fuel heater tube bundle tested to 2½ times working pressure with hot water, shows no sign of leakage, yet replaced in the heater leaks freely.

Rubber seals and rings of most types deteriorate under fluorescent light, so that unsuspectingly a new seal is fitted which fails after a short period in service.

How does one locate a fracture in some part of the combustion area of a main engine, when the fault only shows up at 115 R.P.M. ?

ELECTRICAL

With the increasing cost of electrical repairs, and lost time resulting from out of service units, or fault finding, the efficiency of the Electrical Department is as important as engineering, some points of interest are as follows:

(1) It is often the case that air cooling for alternators flows the wrong way. Carbon dust from brushes is blown into windings, which with the higher voltages commonly in use easily tracks current to earth.

(2) Slip rings and brush composition are still a problem. It is still necessary to experiment with slip ring brushes on new alternators to prevent damage, and we have had to adapt commercially manufactured equipment quite regularly to machine slip rings, in place.

(3) Present day motor and alternator insulating materials appear hygroscopic, possibly because of minute cracks in the material. The fact remains that a motor or alternator will run for a whole passage quite satisfactorily, then when meggered prior to starting, be found down to earth. The only satisfactory solution is to fit pencil heaters or tapes with a small ammeter in series (an indicating light is no good) which comes in automatically when the unit is stopped. Size of the heater can only be found by trial and error, but this works well.

(4) Filtration: Powerful engine room ventilation systems carry dirt (often from the cargo) to every part of the engine room. A local Company manufactured filter boxes, with cheap renewable filter elements. By fitting these to all principal motors, maintenance cleaning has been cut down sharply.

(5) Recorded extensive meggering of all circuits on a 4 - 5 month basis has sharply cut system failures, and is well worthwhile even though meggering itself is time consuming.

(6) The quality of electrical servicing, particularly cleaning and stoving windings, is not reliable in many parts of the World. It is therefore worth considering doing your own. Effective carbon separation and flushing fluids are available, which used with good spray gear, and dried out with heaters and insulating blankets, will usually bring up most units to good insulation readings.

(7) It was earlier mentioned that "gadgetry" could bring its own problems. One well known diesel engine had a complex essential systems monitoring and shut down arrangement which proved troublesome, and where functions could be inoperable, with no warning to the engine room staff. It was possible to design a replacement unit, with half the number of parts, which was easily understood, and tested by ships staff. Its cost was just over £100.

(8) Printed Circuit Cards are expensive and it is essential to know if failure is in the system, or on the card. A low cost test box can be constructed which will check the card out, making diagnosis easier.

(9) Alternator breaker operation is important and in the usual way, difficult to test. It is possible to construct test equipment at a reasonable cost, which will inject variable overload current in the breaker relay logic, which will knock off preference trips, then the breaker itself, to show the unit is functioning correctly.

THE GENERAL COUNCIL OF BRITISH SHIPPING

In the U.K. Shipping Industry, we are largely competing with other Countries. In his professional life, the Author gets immense assistance from Superintendents of other Companies, who give help and advice freely, and will discuss shortcomings in machinery and equipment in a most frank manner, which it is not possible to do in a Paper such as this.

Attempts have been made to translate this sort of co-operation into more formalised operating-costs comparisons by the GCBS. All our efforts are directed towards building and operating vessels in the most economical manner but following the recent GCBS decision to drop its Operating Costs Inquiry because of lack of interest, we have few adequate yardsticks to measure efficiency. The Norwegians, on the other hand, have for many years run a scheme where, quite anonymously, all the costs of running say a 30,000 ton bulk carrier are recorded, and from this is issued a Summary showing "high cost" "low cost" and a medium band cost, and this in turn can be broken down into different departments to show the sort of figures given at the start of this Paper.

ACKNOWLEDGEMENT

Much of what is said in the foregoing is "stating the obvious" but it will be interesting to see which items are of interest to Members of the Institute.

The Author would like to thank all his Technical Staff whose views and constructive ideas form the main basis of this Paper.

DISCUSSION

MR. J.H. AUBREY, M.I.Mar.E., said that Mr. Major had raised a number of issues concerning fuels and fuel treatment which would bear further examination in that whereas engine development had reached a peak of output per cylinder and sophistication in design, fuels were on the downward slope in combustion quality and cleanliness. As he rightly had stated, it could no longer be acceptable for engine designers to run their engines on light clean fuel on the test bed when they were supposed to run on the generally available bunker fuels which were by no means uniform in character, let alone clean. He had had recent correspondence with a major engine designer who suggested that the maximum abrasive particle size allowable within the cylinder of their engines was 1/10 micron which surely suggested that they were not living in the real world of ship operation.

Although purifiers might well be capable of removing solids down to that level from a light fuel under test conditions, it was by no means certain that particles smaller than 5 micron could generally be removed from heavy dirty fuels under conditions of operation at sea. He wondered if Mr. Major would like to say a few words about his own experience of this aspect of purifier operation ? As long ago as 1963 BSRA published results of tests indicating that a surprisingly small percentage of ash was removed by purifiers and surely at sea one could not expect results as good as those from land based tests. The Table (Fig. 15) showed a precis of the BSRA results.

The wide variation in bunker fuels available today surely pointed to the fact that a treatment was required that would render the combustibility of fuels more uniform in order to ensure complete combustion. If the asphaltene agglomerates and bituminous matter were broken down into particle sizes at least approaching that of the lighter fuel used to cut back the residual, then a number of advantages would result:

1) The fineness of atomisation in the cylinder will not be dependent on the percentage of residual in the fuel.
2) Because of more complete combustion fouling of injectors and exhaust systems will be reduced.
3) With smaller droplet size and complete combustion, the resulting vanadium compounds will be less likely to adhere to exhaust valve seats and exhaust systems.

Mr. Major clearly stated the fears of all shipowners when he referred to the desirability of bunkering fuel of less than 1500 sec. The trouble was that bunker fuel viscosities would tend to rise in the coming decade. Specific gravities were already so high in some cases that purifiers could not effectively remove water except by prolonged operation at low flow rates and this could only exacerbate the maintenance costs of these machines and increase the percentage of fuel lost. Regarding water in fuel one noticed a tendency for Marine Superintendents to be most adamant that any quantity of water in fuel was harmful to the engine whereas from the combustion and fouling rate point of view up to 10 per cent water could be beneficial. Trouble arose only when the water was present in discrete slugs so that the injectors sprayed almost pure water from time to time which was not evaporated before the droplets hit the piston crown and cylinder wall. If, on the other hand, water was uniformly dispersed in the fuel with droplet sizes not more than 10 micron, which meant that they evaporated in the cylinder along with the full droplet, fuel consumption rate at part load would actually improve due to the improved atomisation of fuel. He was glad to say that shortly a research programme would commence that would go a long way to indicate the practical effects resulting from the positive addition of water to fuel.

An experience mentioned by Mr. Major relating to full stratification was rapidly becoming a general one. In the same context one might mention the variation in viscosity of bunker available at various points of call, all of which indicated a need for blending capability that was more effective than a simple pumped circulation system. It was not generally realised that the energy required to blend fuels adequately to achieve uniform combustion was very considerable.

Now all the factors mentioned in Mr. Major's paper and those ee had touched on suggested that a new look was required for heavy fuel systems with the emphasis on Uniformity of Combustion Quality rather than removal of unwanted solids and water. His company had given much thought to this aspect over the last seven years and the result has been the Vickers Homogenising Machine.

The Vickers Fuel Oil Homogeniser comprised three sets of discs which exerted 150 g loading on to the wall of the tyre as the whole rotating assembly was driven at 1200 rev/min. This combined grinding, shear, and mixing action was applied to the fuel as it passed through the Homogeniser.

The rotor was directly driven and was vertically mounted with its motor alongside the buffer drain tank and, with its associated control instruments, formed a compact fuel treatment module. Maintenance of the unit was cnnfined to three-monthly greasing and a servicing at 10,000 running hour intervals.

One advantage of homogenising fuel instead of purifying was that it allowed a simple once-through fuel system which might also be arranged for fuel blending and the thorough dispersion of additives metered into the fuel.

BARROW ENGINEERING WORKS

THE EFFECT OF CENTRIFUGING THE FUEL ON ENGINE-CYLINDER WEAR

ASH LEVELS OF FUELS

THIS TABLE WAS EXTRACTED FROM THE BSRA REPORT NS. 18 (1963)

FUEL REFERENCE NO.	2	10	11	12	13	14	15
DESIGNATION	1500 SECS	MIDDLE EAST	FAR EAST	WESTERN	WESTERN	LAS PALMAS	DOXFORD
ASH, PER CENT WT	0.042	0.030	0.031	0.128	0.068	0.137	0.132
MEASURED ASH AFTER CENTRIFUGING,PER CENT WT.		0.028	0.020	0.108	0.043	0.117	0.085
PERCENTAGE INITIAL ASH REMOVED BY BOTH CENTRIFUGING	16.6	23.4	16.2	7.0	17.7	11.0	38.6
VISCOSITY REDWOOD NO 1 SEC AT 38°C(100°F)	1440	1080	795	1500	625	3000	3600

FIGURE 15

MR. B. TAYLOR, B.Sc., M.I.Mar.E., said that first of all he would like to refer to the budget figures given in Fig. 2 with particular reference to the cost of maintenance spares. It would be of interest if the author could give some indication of the proportion of these costs which was accounted for by main engine maintenance spares. In another part of the paper reference was made to the difficulties experienced when costs were divided into a great number of categories, but he presumed that costs were split down in somewhat greater detail than that shown in the table. There was one particular figure that caught his attention and that was the estimated expenditure on the "Orient City" for maintenance spares of £25,000. For a new ship was this not rather high ?

On the question of reconditioning of worn parts the author pointed out that great savings could be made but for this arrangement to work successfully additional spares had to be carried or held by the owners in a central store. Another alternative was for the engine builders to hold a stock of reconditioned spares, but this also introduced problems because a reconditioned part supplied on an exchange basis might have seen longer service than the part which was sent in for reconditioning. Such parts could not be guaranteed in the same way as new components. Costs of reconditioning could vary widely and the price at which a reconditioned spare could be supplied would obviously depend on the condition of the part for which it was exchanged.

The planned maintenance system described by Mr. Major appeared to have the merit of simplicity and also had the advantage of giving the chief engineer a reasonable degree of responsibility in deciding when the work should be done. As with most of planned maintenance systems, however, there was a risk that overhauling might be done unnecessarily.

On the question of running main engine test bed trials on heavy fuel, he agreed with the views of the author. It had been his company's practice for many years to use heavy fuel on the test bed, but the viscosity was limited to about 1,000 sec Redwood No. 1 as heavier fuel was not readily available. As well as testing the engine under conditions nearly approaching those in service, they found there was less risk of liner scuffing during the early stages of running-in the engine if heavy fuel was used. On the question of test bed trials he would be interested to have the author's opinion as to the necessity of carrying out such trials on every engine. At least one continental engine builder had dispensed with routine test bed trials and performance data sheets were produced from comprehensive trials of the prototype engine of each type.

As mentioned by the author it was not uncommon under present-day conditions for main engines to be operated for prolonged periods at little more than 50 per cent m.c.r. In all pulse pressure-charged engines this introduced the risk of fouling of the turbocharging and fuel systems resulting from inefficient combustion. In this respect the common-rail fuel system which allowed the fuel pressure to be controlled at any speed of the engine had advantages. It was good practice under these conditions to run the engine up to normal service power for half an hour in every twelve hours to clear the exhaust system and burn off carbon trumpets which might have formed in the fuel injectors.

In his reference to fuel oil treatment the author did not mention the use of homogenizers. Their limited experience so far with this type of equipment was satisfactory and it had the advantage of eliminating problems of sludge disposal. To maintain satisfactory operating conditions required the turbochargers to be kept in the best condition possible and he therefore thought perhaps it was a mistake to discontinue entirely the water washing of the exhaust gas side of turbochargers, particularly if the fuel used had a high vanadium content such as the south American fuels listed in Fig. 13. In this connection he agreed it was an advantage to advance the fuel injection timing as the performance of the turbocharger and cooler fell off, to reduce exhaust temperatures and maintain maximum cylinder pressure. One important point not mentioned by the author was that of fuel temperature.

Although it was not usual to test injectors using heated heavy fuel, they had done tests under these conditions. Providing the nozzle temperature was not allowed to fall below about 90°C, the performance of the injector had been found to be equal to that when tested with diesel fuel as long as the heavy fuel was heated to a viscosity of less than 100 sec Redwood No. 1.

Another point worthy of consideration was the use of electronic monitoring equipment, which now appeared to be reaching the point where it was fairly reliable, to enable routine checks to be taken on fuel injection timing and cylinder pressure diagrams.

MR. J. CHRISTENSEN said that he had studied with great interest Mr. Major's paper regarding ways of controlling and minimising operating costs.

He had noticed that the fleet was operated strictly according to a planned maintenance system controlled by a computer, and thought this planned maintenance system was very temptating specially with rapid crew changes, but he had the impression that for some items a combination with condition-based overhaul could save time and money. The very low wear rate of cylinder liner and piston rings mentioned in the paper could call for piston withdrawal based on an inspection of the liner, piston and piston ring condition through the scavenging air ports. Thereby this inspection could be decisive for whether pistons shall be drawn. When one looked at the present wear rate, running intervals up to 30,000 hours, which some owners really obtained, should be a realistic goal. Further cleaning of turboblowers, air coolers, air filters etc, could preferably be executed as condition based maintenances.

The author enquired about a diagnostic printout of engine performance which Mr. Christensen - to save time - could answer by referring to the paper, which Mr. T. Bakke read at the Institute on 15 April 1975: "Diesel Engine Design with a View to Reduced Maintenance Costs".

In this paper their two Condition Check Systems, CC1 and CC10, were briefly described: CC1 for systematic reporting to a central EDP plant on shore; CC10 for transmission to a digital computer on board, programmed to evaluate the results and to give direct diagnosis, advice for maintenance or alarm. Both CC1 and CC10 were based on their manual synopsis system which for many years had been included in their instruction books.

Mr. Major's paper discussed the risk of corrosion attack on the turboblower gas side from excessive water washing. His company had, in co-operation with a Danish shipowner and with promising results, tested a "dry cleaning" method on a number of ships. A small receiver was needed for filling-up cleaning agent which could consist of crushed nutshells or the like. The injection o' the cleaning agent was by means of compressed air and could be done without reducing the engine rpm.

The paper gave some information on fuel valves. He noticed that good results had been obtained by cooling fuel valves to 80°C which was somewhat higher than his company has previously recommended. This corresponded to their experience, which had lead them to the adoptation on the GF engines of uncolled fuel valves, which also gave other disadvantages, for example, a much simpler installation This new type of fuel valve had greatly increased the intervals between overhauls; normally they recommended a pressure test only once a year and replacement of the spindle unit once every second year. This type of valve could also be fitted to older type engines by changing the bushings on the cylinder cover.

The author had recommended workshop testing on heavy fuel. Mr. Christensen was sorry to have to repeat the standard "excuse" for running on a diesel oil with well known characteristics, on the testbed.

He thought it was well proven over many years service that engines were able to run on many different kinds of heavy fuels and, for the customer and themselves, he thought it was more important to control that the engine was correctly adjusted and its performance fully in accordance with other engines of the same type tested under the same conditions, including fuel brands.

If the test on testbed should be on heavy fuel, should it then be a USA West Coast fuel, a South American, a Middle East fuel etc, and how much running time would be necessary to control the engine for any bad influence on fouling of the gas systems ?

Of course, for prototype testing it was very important that different kinds of heavy fuels were tested and their influence on combustion conditions and internal material temperatures in the heat loaded parts. He thought all engine designers were doing these tests.

The author had mentioned hull vibrations. Four, five and six cylinder engines had all relatively big 2nd order free moments which were able to excite hull vibrations in case of reasonance.

In his company's K-GF size they could therefore offer these engines fitted with moment compensators driven from the camshaft. Because of the limited dimensions of the moment compensators and their high position on the engine, it was also unnecessary to increase the length of the engine room.

As it was normally difficult for the shipbuilder to decide beforehand if a compensator was necessary or not, there was furthermore the possibility of preparing the engine for later adaption if the vibration conditions of the hull should prove it necessary after the ship had entered service.

As to grinding-in the face joint between the cylinder cover and liner, it was a little astonishing to hear about the difficulties in keeping the joint gastight on the K-EF engines, as up to now his company had recorded very few complaints. If burning marks appeared, he fully agreed that hand grinding of the seats could be rather time consuming. However, to facilitate this work they had, together with a Swedish machine tool firm, developed a special milling and grinding machine for this purpose.

MR. T. BAKKE said that it was obvious that control of costs of maintenance was an important part of the operational budget.

When the paper dealt with a comparison between different ships, it must be remarked that different types of ships with different service hours, which in the operational considerations were given as ranging from 3,600 hours up to 8,000 hours and with different demands on the ships and of the engines gave different costs for each ship.

Differences in the working loads on the engines would also give different costs for the running and maintenance of each ship, and in the budget with an indication of the service results of the different ships. The actual working load and hours of service should be an integral part of the budget and taken into account to give a fair judgement of the costs of spares and maintenance.

As these values were not available in the tables in the paper the comparison between the ships was difficult, if not impossible.

He was very keen to learn if the budget analysis was based upon the actual demand of the ships rather than a yearly account.

Costs, Repair and Maintenance

Clear specification of wanted repair, benefitted the budget and an analysis made by the Norwegian Shipresearch Association (NFSI) a couple of years ago covering a number of ships, gave a clear indication that the duration and cost of a drydocking could be reduced as much as up to 20 - 30 per cent when good preparations were made.

Mr. Major had indicated that he sent out standard forms when inviting quotations but Mr. Bakke would like to know what the following-up procedure was, as his company found that considerable benefit could be attained by checking the items delivered and also by carrying out a close follow-up of the actual work done, in situ.

As they themselves had a world-wide service organization with their own service centres in 19 major ports around the world, they had had the opportunity to see the unfavourable results of repairs and maintenance done in the absence of qualified people representing the company.

Therefore, he was a little surprised at the policy put forward that docking etc, was based upon supervision and control as a desk job. He would like to have this elaborated as they had found that it was of great importance that somebody personally took care of the valuable installation rather than basing judgement on computerized historical data.

Price of Spares, etc.

When the author gave an indication in the paper that comparing the prices of spare parts was of great value and that big savings could be achieved when the crew was able to indicate exactly what was needed for the repair rather than ordering complete units, it must also be mentioned that this work involved qualified personnel who could also take advantage of the existing instructionsand spare part manuals.

When looking at the price of spare parts it must be realized that the initial cost of the part itself is only one part of the cost. The work itself had a great influence on the cost and it very often exceeded the cost of spare parts.

It must also be mentioned that, if the repair had to be repeated after a short time in service due to break-down of cheap parts, such a policy could not be reckoned as cost consciousness.

When mentioning cheap parts, he meant price-wise and quality-wise, as it was often proved that low quality cost more on the budget in the longer run due to the increase of off-hire and excessive time for repair and maintenance. He would like to hear the author's experience regarding the split-up of costs for parts and for the actual work done and if such cost analyses were the basis for reviewing the budget.

When looking at the price of spare parts, it was mentioned by Mr. Taylor from Doxford's that reconditioned parts on an exchange service basis was not a solution which could be recommended. Mr. Bakke's company, however, for a couple of years had an exchange service of some of the most common parts of the engine such as fuel valves, pistons, cylinder covers, exhaust valve spindles, and seats.

Instead of sending such components for repair or reconditioning, the exchange service gave quick delivery, fixed costs and approved quality as B&W gave the same guarantee for the exchanged parts as for new parts.

When reconditioning the parts in their works, the component itself was carefully checked for failure in material, loss of shape, dimensions, etc, before starting a reconditioning procedure.

After repair and reconditioning the parts were carefully checked and a quality report written in the same way as for a new spare part component.

Exchange service was available from major ports all over the world, for instance Copenhagen, Singapore, Hong Kong, South Africa, Sydney, etc, which gave a quick and qualified service. The price for exchange service parts would be around 50 - 70 per cent of the price of a new part and a relative saving could thus be achieved in a safe manner, rather than by using low quality and cheap parts.

Another point which could be mentioned was that today it was possible to improve the existing performance of the engine by modernizing it with new components and systems taken from the newly designed engines and fitted to the existing engines. Such modernization could consist of fitting uncooled fuel valves in the cylinder cover of the K74EF engine, which gave the benefit of better saving in fuel for the engines and lower maintenance costs. By modernizing the fuel system it had been shown that savings of up to 75 per cent of the running costs for the fuel valves had been achieved.

Another type of modernization was fitting a new spring system for exhaust valves to ease the maintenance and reduce the cost of breakdowns on springs etc.

MR. D. ROYLE, M.I.Mar.E., said that the author had quite rightly mentioned the high vanadium content of certain Western Hemisphere fuels but then suggested that restricting the viscosity to 1000 sec Redwood No. 1 at 100°F helped to minimise the effect of vanadium. A typical vanadium content for certain Western Hemisphere bunker fuels of 4000 sec Redwood No. 1 at 100°F was 550 ppm, but when the fuel was reduced in viscosity to 1000 sec seconds, the vanadium content has only dropped to 450 ppm, not a very significant reduction. Even a 200 seconds fuel made from the same bunker fuel had a vanadium content of 275 ppm.

The author had mentioned wax in diesel fuel and made the observation that this came about due to the addition of residual fuel to meet a 55 seconds viscosity (presumably Redwood No. 1 at 100°F). Most marine diesel fuels were now distillates and had been for many years. A distillate marine diesel would have a low Conradson carbon content of less than 0.15 per cent and consequently could not contain a residual fuel component. However, distillate marine diesel fuel made from many crudes in order to have a reasonable viscosity, say 37 sec Redwood No. 1 at 100°F, would contain appreciable amounts of wax.

The pour point was kept under control by pour depressants but these did not influence the cloud point or the wax formation temperatures. Especially in winter time it was important that marine diesel fuel should not be centrifugal or filtered below its wax formation point of about 10°C.

The author had talked about water inaa clean service ice tank of 5 to 10 per cent. These figures were exceptionally high and one wondered if the decimal points had been omitted. If the figures were correct, surely there must have been some fault in the operation of the centrifuge.

Finally, he was pleased to see that the author had mentioned advancing the fuel pump timing to accommodate the slow burning portion of some residual fuels. This had been advocated in the past, but was probably forgotten on many occasions and was well worth repeating.

MR. S.N. CLAYTON, F.I.Mar.E., in a contribution read by Mr. Leach, I.Mar.E., said that Mr. Major's paper covered the whole gambit of running and maintenance with an emphasis on efficiency both in the engineering and financial fields. He would, however, confine his remarks to the section dealing with classification.

It was agreed that effective Planned Maintenance should bring benefit to an owner, particularly where the periods between surveys as required by the classification Society could be incorporated in to the owner's scheme. In cases where these periods did not entirely coincide there should be no serious difficulty in effecting a compromise.

The crux of the problem for the Classification Society lay in the setting of Rules to cover the inefficient, as well as the efficient, operator. With the latter, it was possible to build up a level of confidence to allow flexibility, always provided this did not involve delegation to the extent of an abrogation of responsibility.

In this respect, as had been pointed out by Mr. Major, there was a comparison between the Quality Control System operated in certain shipyards and an acceptable Planned Maintenance Scheme for ships machinery. Both have the underlying necessity for a moderate degree of delegation coupled with building up a level of confidence that the required standards are being maintained.

It must be remembered that a classification survey often formed the basis for the issuance of a SAFCON Certificate on behalf of a national authority and therefore statutory requirements must be kept in mind when considering alternative survey arrangements. This however only served to emphasise the advantage of a Planned Maintenance Scheme which dovetailed completely into the Classification Society requirements.

The use of a Breakdown Warning Report was a very commendable innovation. The supply of such reports to the Classification Society could be a valuable supplement to the reports received from its own Surveyors. He suggested that this could be investigated.

The desire of an owner to work with the local office of the Classification Society was fully appreciated and should not cause problems provided that the information exchange was in such form that the Classification Society's centralised records could be readily updated. It was worth noting that with the equipment Lloyd's Register had installed in its local offices all classification information stored on the main computer in Headquarters was now readily to hand.

MR. B.C. TONKIN, F.I.Mar.E., said that this was a timely paper giving good information on the operation and cost of running ships in these difficult times. The example of estimating the expenditure for a fleet was well set out but he was a little puzzled by some of the figures stated for Drydock Painting. Taking the "Indian City" which was believed to be a vessel of 43,000 deadweight tonnes built 1967, a figure of £5,600 was shown as the anticipated cost of drydock painting for 1976/1977 whereas the seven ships of 26/28,000 deadweight tonnes of more recent date of build had a figure varying from £8,000 to £9,000 per annum. The final expenditure table (Fig. 7) gave £4,737 for "Indian City" compared with £7,500 to £9,500 for the seven smaller and more recent vessels. Could Mr. Major please clarify ?

Turning to tenders for drydocking and repairs his company's experience of prices and time of British yards compared with Continental ones was very similar to the author's. With the cost of British labour approximately half the Continental rate the British yards should be in the position of turning away work rather than looking for it.

Most present would agree that the double shift work should materially reduce the time factor. Of equal importance for good results was for the Management/Labour relationship to be improved in some of the yards. They had all seen work held up by silly demarcation disputes and other peccadillos. It was well illustrated in this paper, what could be done by a competent staff in reducing costs by strict control of spares, stores and sensible repair of parts instead of a complete renewal.

The author had made a good suggestion regarding the exchange of operating cost figures through the medium of the General Council of British Shipping, but whilst there was certainly a "Freemasonry" amongst the Superintendents of the various companies it was quite likely that this did not extend to the commercial side of these companies. Consideration could perhaps be given to reconvene the Senior Superintendents meetings which were held at the Institute some years ago and which many of them found useful for the exchange of experiences and information which ultimately led to the benefit of the Shipping Industry.

Correspondence

MR. J. GALLOIS wrote that it was the first time his company had seen such interesting comments on the maintenance process of a fleet and figures on its cost.

As engine designers and particularly medium speed engine designers, it was the first time that they could read precise information about comparisons between ships propelled with slow speed engines and medium speed.

The main problem in this comparison was the reliability of the engines, i.e. availability and maintenance costs.

1) In this respect, it would be very interesting to know the feeling of Mr. Major about the comparison of the availability of the medium speed PC 2-5 engines and that of the slow speed engine he was using. It was of interest to mention that:

"Welsh City" and "Cornish City" were propelled by one 16 PC 2-5 each since they had been re-designed, so they could be directly compared with the other ships also equipped with only one engine

the PC 2-5 engines of these ships were the first of this new PC series

Fig. 1 showed off-hire time of 1 day and 7 hours for "Cornish City" and 5 days 18 hours for "Welsh City", which were to be compared with an average of 6 days and 1 hour for the 11 other ships

Could Mr. Major comment on this point and say what part on the main engine and the gearbox contributed to this off-hire time ?

2) It would also be appreciated if Mr. Major could split up the expenses for repairs, drydocking and spares under at least two headings:

the main engine
others

It would be very interesting to have this figure as if one looked at the general aspects of the maintenance cost of the ships for 1976-1977, there was no clear difference between those propelled with slow speed engines and the two ships propelled by PC 2-5 engines: the average cost for the ships (if we except the "Orient City") was about £88,000 a year, for all the ships, and the average was £87,000 for the two ships propelled by PC 2-5 engines.

It was necessary to take into account that some ships were submitted to a complete drydocking, whereas some others were not.

3) Mr. Major mentioned later in his paper that to get good combustion quality in the engines, he used only 1,000 sec Redwood fuel in the PC 2-5 instead of 1,500 for slow speed engines.

This limitation seemed to them to be absolutely unjustified. The good combustion quality of these engines was demonstrated by the low specific combustion rate and also by the very low rate of wear of the cylinder liner and of the piston ring, as could be seen in Fig. 16. It was possible to see in this figure that today more than 25 per cent of their engines running on heavy fuel were using one with a viscosity of between 1,500 and 3,500 sec Redwood.

The only problem regarding medium speed engines and high viscosity fuel was the vanadium content which created some difficulties with exhaust valves.

It should be noted that in the case of "Welsh City" and "Cornish City", the exhaust valve design was the first one with water cooled cages and solid valves coated with stellite 20.

Since that time, they developed new valves with Nimonic, which give a much better result as mentioned by Mr. Major and which would reduce the number of failures and also the maintenance cost because they would be used for a much longer time.

Would it be possible to know if Mr. Major agreed with him as they installed some of these valves in "Welsh City" ?

Fortunately also, technological improvements were continuously going on and they now had available much more reliable rotators than some years ago, which allowed him to give an optimistic answer to one point raised by Mr. Major and which had improved the behaviour of the exhaust valves a lot.

It had also to be added that the difference between 1,500 and 1,000 sec Redwood fuel was obtained with an addition of less than 5 per cent of diesel oil in the considered fuel. This explained why the difference was so small.

4) They would also be very interested to know the position of Mr. Major about the maintenance cost of their engines compared with the slow-speed engine, taking into account that, for them, the piston overhauls would be done at much longer intervals than on the two-stroke engines.

On this point, the two engines installed on "Welsh City" and "Cornish City" were equipped with the very first design of cylinder liner with bore cooling and the cooling effect was in fact too strong. So, they showed a high rate of wear which did not allow using completely the advantages of the medium speed engines. Some new liners had been installed on "Welsh City" for demonstration purposes two or three years ago.

He would be very interested if Mr. Major could say whether the results foreseen were confirmed by his experience or not.

The experience obtained on the other PC 2-5 engines with the final design of the liners, was that it was not necessary to overhaul pistons before 12,000, 15,000 or even 18,000 running hours because the chromium plating of the first ring was not yet worn.

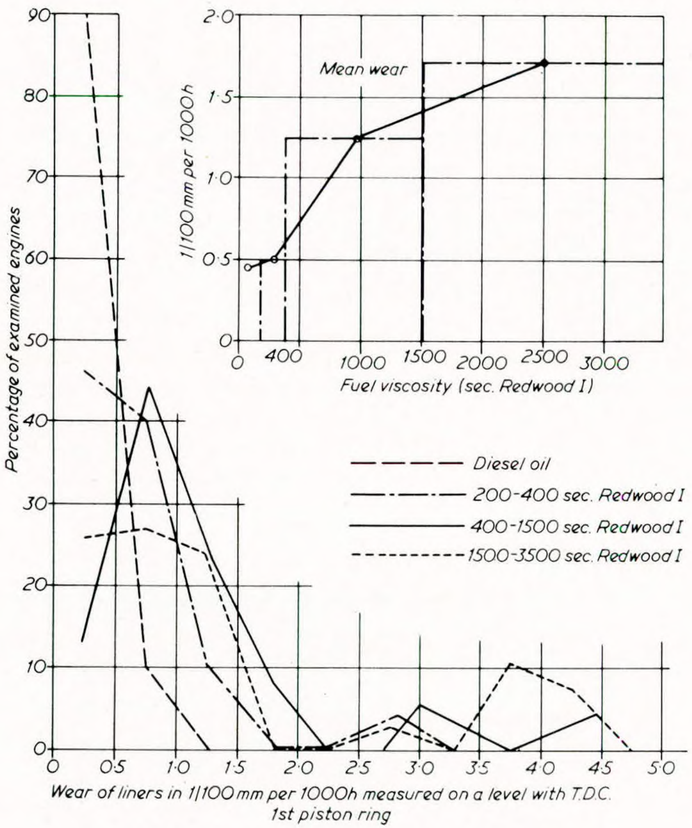


Fig. 16(a) – Wear of liners for PC 2 engines in regard to the viscosity of fuels used

Liner	Piston		Piston rings						Valves			
									Exhaust		Inlet	
	1st groove	2nd groove	Top		1st compression		Upper scraper	Lower scraper	Lower bush	Stem (bottom)	Lower bush	Stem (bottom)
Bore	Height	Height	Radial thickness	Thickness	Radial thickness	Thickness	Radial thickness	Radial thickness	Bore	Dia.	Bore	Dia.
0·70	1·35	1·40	3·3	0·44	3·7	0·35	3·8	1·35	4·0	0·8	2·7	0·6
(0·45)*	(0·56)*	(0·16)*										

Crankshaft		Main bearing	Big-end bearing	Small-end bush	Piston pin
Crankpin	Crank journal				
Dia.	Dia.	Bore	Bore	Bore	Dia.
<0·2	<0·2	<0·3	<0·3	0·1	<0·1

*Wear of engines burning diesel oil

Fig. 16 (b) – PC 2 engine. Medium speed on heavy fuel merchant ships (110 engines)

Fuel	Number of installations	Diametral wear	Wear in height	Radial wear	
		Liner	Top ring groove	Top ring	Scraper ring
Diesel oil	30	0·48	0·73	1·30	2·02
200-600 sec. Redwood No.1	28	0·77	1·11	3·07	4·21
600-1500 sec. Redwood No.1	58	0·87	1·09	3·56	4·07
1500-3500 sec. Redwood No.1	20	1·56	1·64	3·71	3·43

The above figures are given in 1/100 mm per 1000 running hours

Fig. 16(c) – PC 2 engine. Average wear of main parts

This would compensate for the greater number of cylinders which could be less important also if the necessary care was taken to have an engine room installation and environment really designed for the maintenance of the main engine. With such precautions, the overhaul time for a PC 2-5 piston should be one half of that for a slow speed engine.

5) His final point concerned the lubricating oil consumption.

On their side, his company had followed regularly the figures measured on "Welsh City" and the average after 10,000 running hours was 0.85g/hph, the power taken in consideration for that calculation being the service power.

Could Mr. Major give a comparison of the lubricating oil consumption and generally speaking, the lubricating oil cost between the PC 2-5 engines he had used, and that of his last slow speed engines in operation ?

MR. K.V. TAYLOR, F.I.Mar.E., wrote that in the paper the author had mentioned problems associated with engines with significant secondary unbalance. This had been a major problem for many years. Historically the first vibration problems affecting the hull resulted from primary unbalance, but this was relatively easy to cure and engine manufacturers were soon producing engines which had all primary forces and moments balanced out. However, this was achieved sometimes at the expense of secondary unbalance which, if undue vibration of the ship occurred, was more difficult to cure owing to the balance weight having to be rotated at twice shaft speed.

To explain the mechanism of excitation, any out-of-balance force would input energy into the vibrating system if the force was applied to a point on the hull which had movement. A force applied at a node in the mode profile i.e. Fr. 26 in Fig. 14 would not input energy and would not cause vibration. On the other hand, an out-of-balance couple from the engine would only require a change of slope of the mode profile in order to input energy and as could be seen from that figure, such a condition was fully satisfied.

It would be appreciated that there would always be a substantial slope variation until near the second anti-node position was reached i.e. about Fr. 42 in Fig. 14. Therefore, any large secondary couple in a ship with engine room aft was bound to produce significant vibration. In practice, of course, the magnitudes of vibration would be determined by the proximity of the excitation frequency (twice running speed) with one or other of the vertical hull mode responses (the 5-node mode being illustrated in the example in the paper). For a ship, resonant frequencies were load dependent and it was not unusual for more than one mode form to be associated with vibration between light ballast and fully loaded conditions. In any of these mode forms the differences in mode profiles in the vicinity of the engine was relatively small.

Prediction of the vibration in the design stage was possible and Lloyd's Register had the facility to do this. Although calculation of natural frequencies of the lower hull girder modes was possible to accuracies within a low percent, prediction of response could only be qualitatively assessed. In view of the latter uncertainty some owners or builders neglected to take advantage of these calculation procedures in the hope that serious vibration would not occur. The prudent designer would always commission these relatively inexpensive calculations in cases where a significant out-of-balance force or moment was associated with a possible choice of engine. The risk of hull girder vibration could then be considered in perspective with other design parameters in the final selection of main engine. If the choice of main engine was restricted to one having a significant secondary out-of-balance couple then provision for fitting balance wrights could be considered at an early design stage along with any other practical remedial action. If the risk of unacceptable vibration was not considered excessive then the decision actually to fit the balancing system could be deferred until the vibration had been assessed on sea-trials. It should be noted that the fitting of secondary balancing systems to some given machinery arrangements might prove difficult unless considered as a possibility at the design stage.

He was also interested in the author's comments on the failure of tank gauges which he attributed to severe sloshing pressures.

Lloyd's Register of Shipping had recently made a comprehensive study of sloshing in tanks and had developed a computer program for predicting the natural frequencies of sloshing and the pressures likely to occur. Apart from damage to gauges, a prolonged period with slack tanks under resonant conditions could produce significant damage to the ship structure. To prevent this occurring it would be prudent to ensure that the tank was never filled to a depth at which severe motions could take place i.e. have a barred range.

MR. A.F. WHITE wrote that in this very informative and comprehensive paper one was given a small insight into the operation of an extremely efficient shipping company, with a modern approach to technical management.

The wealth of detail contained therein, coupled with evidence of systematic cost control monitoring procedures, was an example which many similar companies must seek to emulate.

In his experience, Reardon Smith had over many years demonstrated an ability to select auxiliary machinery which was sized and suited for the task it had to perform and, having done so, they then had the advantage of firstly controlling expenditure on maintenance, and secondly, they were in a position to eliminate the possibly undesirable side effects of incorporating untried and unproven products which could occur in associated machinery, including the main engine; a fundamental principal one might observe, but one which in the present economic climate was not so easy to achieve.

The fuel and lubricating oil purification system on any ship was perhaps the most vital process, as without adequate and effective treatment, the entire operation must grind to a halt. The author had clearly identified his awareness and concern for this area and, in consequence, had instituted well formulated maintenance schedules which had paid off over the years, hence the lack of any detailed reference to major centrifuge failures.

On the occasions where centrifuges were mentioned, the author highlighted problems such as high water content in fuels and then provided the solution, this being correct assembly and operation of the machine. He also recognised that for certain applications a greater dwell time in the bowl for the fuel oil during purification could be beneficial, and concluded that another John Lamb exercise was overdue; a point which the writer could only agree to, as there had been much progress in centrifuge techniques since John Lamb proved his point and indeed, even since the BSRA did some research along similar lines some years ago.

For quite some considerable time, the industry had been investigating alternative methods to the centrifuge for treating both fuel oil and lubricating oil and they had witnessed the spate of claims from filter manufacturers that the filter would eventually replace the centrifuge, but experience had shown that the inability of the filter to select and remove water continuously, coupled with the high cost of the element replacement, made the filter at best a follow-up for a centrifuge.

The latest challenger to the centrifuge, the homogeniser, which was of course restricted to only fuel oil treatment, had been undergoing trials for a number of years and now the industry was being asked to consider the merits of the "crusher" homogeniser as a replacement for the centrifuge.

It was one thing to attempt to crush undesirable particulate material in the fuel oil, always assuming that the particle was crushable, and did in fact arrive at the crushing point and not pass directly through the body of the crusher, but quite another to contemplate homogenising saline water with the fuel oil, where the sodium component entrained in the mixture was known to act as a flux between the hot surfaces in the combustion space, including the exhaust valves referred to in the paper and vanadium present in varying quantities in heavy fuel oil which was also referred to in this paper. The disastrous effects of vanadium were of course well known to most experienced operators.

A further interesting possibility was to imagine the effect of homogenising a biologically degraded mixture of fuel oil and water for combustion in a diesel engine. The damage resulting from the effect of biologically degraded lubricating oil in engines was already well documented, but so far, due to heating and centrifuging techniques, there were no reports of similar damage to the sensitive fuel distribution system, associated with marine engines.

One must also consider the confusion which could be created in a situation which was not so uncommon, in which stratification in fuel tanks allowed for a continuous feed of water and sludge to a homogeniser, a possibility which was dealt with adequately during the normal course of events, using a centrifuge.

Only certain marine engines known to have pretty rugged characteristics might be suited for conversion to what might be described as rotary incinerators, using such a system, and it was understood that in common with the author's comments, no testing had been undertaken on the test bed involving homogenisers with the heaviest grades of fuel oil now specified.

In conclusion, it must be stressed that centrifuge manufacturers had not been stagnant over the years and had in fact worked very closely with oil companies, shipowners, engine builders and shipyards, to produce highly efficient machinery, serving over 95 per cent of the world's tonnage. The latest innovation was the Alfax controlled discharge centrifuge which had the advantage of drastically reducing the sludge handling problem, while eliminating oil losses entirely during the cleaning cycle. Many shipowners were now very attracted to this system, both for new construction and for retrofitting ships employing the more familiar total discharge separator characteristics.

The CHAIRMAN (Mr. G. McNee, B.Sc., President, I.Mar.E.) said that he must comment on Mr. Taylor's reference to £25,000 for maintenance spares being too high for one ship and he would like to support Mr. Major's reply.

It entirely depended on the owner's policy and there were few owners who did not, in the first year, provide additional spares to enable them to run the ship efficiently.

AUTHOR's REPLY

Mr. Major answered Mr. J.H. Aubrey by saying that the paper had suggested that a "John Lamb" exercise on the burning of heavy fuels in diesel engines where specific gravity, viscosity, stratification, inclusion of asphaltenes bituminous matter, and even water could be investigated. If the proposed homogeniser would effectively render the separate constituents into a homogenous fluid then it would be well worth considering, but where exactly it should be placed in the treatment system needed further thought in view of the "stratification" experiment. It was suggested it would be an adjunct to, not a replacement of, the centrifuges.

Mr. Major then replied to Mr. B. Taylor stating that the £25,000 shown for the maintenance spares on the "Orient City" came about when arrangements were made for "the initial outfit" of spare gear to be purchased gradually over the first months of the vessel's operation, rather than ordering it with the initial Contract of the ship.

It was allowable to set this off as "a cost item" instead of an annual running cost.

Doxford tested their engines on heavy fuel and were one of the few honourable exceptions to the quite disgraceful practice of testing on diesel oil. Every credit to them for this excellent engineering practice.

The Author agreed that the common rail fuel system had great merits, and his company's experience with the latest products of other manufacturers gave the impression that with a jerk pump system, cam and roller were reaching the limit of loading for long reliable service, and with the necessity for flexible steaming, it was a system which could well be adopted by other engine manufacturers to get better combustion over a wide range of powers.

To Mr. Christensen he replied that the Planned Maintenance programme was based on the time which, experience had showed, it was wise to run the units; but it was found that after some years of running, 10,000 hours was a sensible limit, to check the radius on ports, the vertical clearance of piston rings, that lubricators were delivering correctly, and even to pick up the odd fractured liner.

The comments on performance monitoring were intended to refer to a ship/engine performance, with all the variables this entailed, rather than machinery performance alone.

Cleaning a turbocharger with a ground shell powder was interesting, and the company were looking into this.

The G.F. fuel valves certainly were a great improvement on the KEF valves, and the company now had over 12,000 hours very satisfactory operation of these valves with only occasional cleaning found necessary. However, the capital cost of changing tc the new design valves was not acceptable in present conditions in our Industry.

Deteriorating quality of fuel was a serious problem, and while it might be unreasonable to ask the engine builder to test his engine on a U.S.W.C. oil, it did not seem unreasonable to ask him to test with locally available heavy fuels which would would at least bear more resemblance to U.S.W.C. oil than diesel oil.

The intention of the comments about engine induced vibration was to suggest to Superintendents that if they were experiencing continuous trouble with some machinery item - say, a crane - then they should perhaps look out for this. The tendency now to go for smaller bore 7 cylinder engines, rather than larger bore 6 cylinder engines, had been noted.

As maximum pressures continued to rise the author felt that the jointless cylinder cover would give more and more trouble. Jointed covers had been found totally reliable and trouble-free in service. The company had also been able to fit an extra cylinder cover stud in the KEF engine where it was presently missed out, in way of the air start valve, which is where it was found that cover leakage took place. The modification plus joint, had now run about 7,000 hours, with no trouble experienced, so the company were now in process of converting all 42 cylinders to this arrangement.

Mr. Major thought that Mr. Bakke was right in commenting on the wide difference in running hours of the ships in the paper. The company did, of course, take into account the difference in these running hours when comparing operating costs of each type of engine.

The analysis of the Norwegian Ship Research Association, giving an estimate that a well prepared Drydocking and Periodic Overhaul Specification could save up to 20 to 30 per cent was in line with his company's findings. They did not regard the supervision of these repairs as a "desk job", only putting together the Specification.

The author agreed that "cheap" spares might not be cheap if they have to be renewed after only a short period of service. At the same time many suppliers had realised they had a "captive" customer, and had raised prices to a level whic. did not reflect a fair manufacturing cost, plus allowance for exchange, or shelf life, plus a reasonable profit. Certain items were charged at hugely inflated prices, and in such instances it was only fair that the shipowner should be allowed to protect himself by seeking alternative suppliers.

It was agreed that modernisation of badly designed or troublesome parts could be well worthwhile, but as mentioned with fuel valves, the cost of the change had to be set out against its potential saving.

Mr. Royle was, of course, right in saying that restricting the fuel viscosity to 1000 secs Redwood No. 1 would have little effect on the vanadium content. The author's intention was to indicate that with vanadium present it was more than ever essential to have a good burning fuel. Mr. Royle's explanation that many distillate marine diesel fuels did have a wax content was very interesting. The water content in the fuel was given as 2 per cent with a guess that perhaps 5 to 10 per cent (i.e. 0.1 per cent to 0.2 per cent), of this would remain after centrifuging.

Replying to Mr. Clayton it was agreed that what the author proposed might involve considerable problems for the Classification Society. However, this should not bar them from trying to improve their own operations so that they would be of benefit to the underwriter, and to the shipowner - this being the sole reason for the Classification Societies' existence.

A study of the various Classification Rules showed that the effort devoted to requirements for building ships, was disproportionate to the requirements for running ships. Highly sophisticated computer systems monitor Classification Survey requirements, but the point made in the paper was that the requirements themselves bear little relationship to the necessity of maintaining equipment in good order, and in the extreme case of the crankshaft deflections the absence of Survey requirements was a hazard to basic surveillance.

MR. Tonkin had picked up a good point from the company's figures. The "Indian City" had very complex car deck hoisting, lowering and stowage arrangements, with holds full in each direction. It was, therefore, necessary to stop for a few days each year for necessary maintenance. The vessel was, therefore, on twelve months drydocking period and used conventional paints, which on that particular drydocking had a higher "spread" rate than the manufacturer's recommendation (this probably meant that the paint had been heavily "thinned", a practice which the company tried to stop but were not always successful). The 26,000 ton vessels were on 18 months drydocking period and had sophisticated paint systems, which usually came out at about half the paint manufacturer's stated spread rate.

The problem with senior superintendents' meetings was being able to get together a group of men who were constantly moving around. The G.C.B.S. cost exercise might be more valuable in that it would highlight high cost areas of one anonymous company against another, which would enable necessary remedial action to be taken.

To Mr. Taylor the author replied that it required an expert to fully understand the more esoteric reaches of ship vibration. As stated in the reply to Mr. Christensen, the author's intention was to draw superintendents' attention to this phenomenon as a possible cause of inexplicable continuous machinery failure in equipment otherwise known to be reliable.

It was worthwhile knowing that Lloyd's Register of Shipping could reasonably predict the sort of vibration which would cause this trouble, and superintendents should ask shipyards whether this has been done. It would be worthwhile not only from the point of view of machinery damage, but in some cases from having cabins which were unusable.

There seemed to have been little discussion of sloshing forces, but these could generate very high loads and as highlighted by Mr. Taylor these could cause serious damage to hull structure, with complete bulkheads being torn apart if proper care was not paid to this matter.

Mr. White's comments were constructive. The author was not aware of the special advantages which their latest machines might have, but would stress that with the degradation of the fuel oil, and in particular with its increase in specific gravity, a considerable responsibility would lie with the ability of centrifuge manufacturers to effectively purify the degraded products which were now more and more being put forward as marine fuel.

The author answered Mr. Gallois by stating that the main stoppages on the main machinery were due to having to drill out broken cylinder head studs, broken by improper use of the hydraulic tensioning gear, turbo charger overhaul, and modifications to the air supply system by fitting a centrifugal fan in the trunking, to pressurise the turbo chargers and improve their output - which it did.

The company had had no trouble with gearboxes or couplings. Both vessels were on general cargo runs, spending only about 4,500 hours a year at sea which allowed them easily to keep up with main engine maintenance. Had they been spending 6 to 7,000 hours at sea, which many of the other vessels did, then the multitude of cylinders, heads, valves, fuel pumps and injectors, would have made it difficult to keep up with the maintenance programme without stoppages.

Split up of maintenance spares was approximately one-third to main engine, two-thirds to remaining equipment. That was between £10,000 to £11,000 per ship for the main engines and this was roughly in line with slow speed engines although the latter had longer running hours each year.

The point about using only a 1,000 sec fuel, was to ensure the fuel was of reasonable quality. The author was aware of a number of incidents of serious engine breakdown or failure due to vessels, unknowingly, bunkering low grade fuel. Then when this new fuel was used at sea, there were centrifuging difficulties, causing problems of overheating in cylinders and turbo charger fouling. A number of fleets previously using 3,500 sec fuel, had had so many problems that they had reverted to 1,500 sec fuel. It was in this context that the company had restricted their medium speed engine fuel to 1,000 secs, as with only a quarter of time available to inject, ignite, and propagate the flame, the above-mentioned difficulties could have even more serious consequences. The 5 per cent of diesel oil necessary to convert a 1,500 sec fuel to a 1,000 sec fuel might make a valuable contribution to its ignition qualities.

The Nimonic valves went a long way towards eliminating the problems of high vanadium content fuels, but due to the lack of sufficient operating hours on this type of fuel it was not possible to say that these were trouble-free.

The maintenance cost of the PC 2 was similar to that of slow speed engines, but the operating hours of the PC were low, and those of the slow speed engines quite high. It was thought that had the medium speed engined vessels been on severe bulk carrier runs, with high operating hours, then its maintenance cost would have been higher.

It was agreed that the first liners were over-cooled, but the company had only two of the later liners. The original liners had a low wear rate of approximately 0.035 mm/1,000 hours, at the point of maximum wear, but it must be remembered that it was necessary to renew the liner when it had only 2 mm of wear.

Liners and pistons of any engine could go for very long periods without overhaul when pistons and liners were new, but as liners began to wear, and vertical clearances of ring grooves rose, then excessive time between overhauls should be avoided, and 10,000 hours was long enough to go before checking what was happening to the unit.

The company could not agree that with full knowledge and use of the proper overhauling gear, the time for the overhaul of a PC 2-5 unit was half that of a slow speed engine.

For a crosshead engine one had to add crankcase lubricating oil losses to cylinder oil consumed to arrive at a total figure of oil used, and therefore the daily cost.

In the case of the PC 2-5 engines, allowing some losses from the crankcase, system, and centrifuging, allowing that the crankcase oil lubricates the cylinders, then it had always been felt the oil was too low. It was estimated to work out at 0.4 gms/bhp/h. The low consumption was no doubt due to the efficiency of the scraper rings, but the low rate of make-up meant that on one occasion it had been necessary to renew a complete sump charge, due to the t.b.n. falling so low.