Some Aspects of the Application of Planned Maintenance to Marine Engineering

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"Planned maintenance", as the name implies, aims at the improvement in reliability and reduction in costs. Both are desirable objectives and repay handsomely the additional trouble and expense of adequate record keeping.

The approach to the resolution of engineering problems is continually undergoing changes. More modern machinery requires not so much the "improvization" approach as the "renewal". This in turn engenders reliability which is the requirement planned maintenance sets out to provide. Guaranteed availability is a valuable commodity and cannot be simply obtained by building a ship with a much higher rating than a normal service requires.

A simple example of planned maintenance operating at its minimum efficiency is in recording the rates of liner wear in Diesel engines. If carried out systematically, the impact of extensive renewals during one overhaul is avoided, together with the engineering hazards of running on excessively worn liners.

How is this to be done? Clearly it cannot be escaped that additional manpower is required to keep records and records are of no use unless kept up to date. There is a case for creating a special responsibility rather than to have it regarded as just another administrative chore.

In this way the schedule once established assumes a prime responsibility and can provide besides information on performance a basis for cost estimation for managerial guidance.

INTRODUCTION

Marine engineers have long prided themselves on being able to "keep the job going". They accomplished this task very successfully and established a tradition of improvization that was, and still is, an invaluable part of the experience of the young engineer.

It is well known that ships have been sold after thirty years' life with some of their outfit of original spare gear unused in the boxes or on the bulkheads. This was possible because of the large tolerances in the strength of working parts which allowed, for example, rods to be machined and refitted to the pump many times. The spare was in many instances only fitted on failure of the working unit, an action which was regarded with regret as a reflection on the craftsman's ability to repair the original working part.

Modern marine engineering, because of improvements in design and economy trends, attempts to reduce these tolerances and has in any case changed from a predominantly reciprocating plant to a predominantly rotary one with higher speeds, but the full implication of these changes is only just beginning to influence maintenance practice. It is demonstrated by the American propensity for renewing rather than repairing.

TYPICAL INSTALLATIONS

A recapitulation of modern usage takes the following form: —

Motor Ship

The main propulsion unit usually consists of a single engine driving the propeller directly, although twin engine installations coupled to a single propeller through reduction gears are not uncommon. In larger ships two-stroke engines are practically universal and the majority of current designs are single acting. There is also an increasing number of exhaust gas turbochargers being fitted to these engines.

The majority of the pumps are electrically driven rotary machines. The electricity is usually generated by Diesel-driven direct current generators. In the tramp ship, relatively few of which have been built since the war, the auxiliaries may be steam driven from a large donkey boiler which can be fired with either exhaust gas or fuel oil.

Steam Ship

The main engine is normally a steam turbine driving the propeller through double reduction gearing and the boilers are usually of the watertube design. The auxiliary pumps are generally of a similar type to those in the motor ship, but the electricity is generated by turbo-generators, Diesel generators or a combination of both.

WHAT ARE THE REQUIREMENTS OF PLANNED MAINTENANCE?

As in all applications of planned maintenance, the fundamental requirement is the elimination, so far as humanly possible, of the risks of a breakdown during a service period. With single-screw ships, and with the reduction of duplication of plant, this is becoming a paramount need to ensure the safety of the ship. It is in fact equivalent in importance to the failure of part of a continuous manufacturing process in which a breakdown of a component hazards the safety of the entire plant with the added risk that perhaps £1,000,000 worth of somebody else's property is also at stake.

THE PROVISION FOR MACHINERY MAINTENANCE

Ship operation is a widely varying business. The main types of ocean going ships are passenger liners, cargo liners, oil tankers and tramps. The operational requirements of these types vary. Passenger traffic is usually a seasonal business so that these liners are required to operate at high availability for, say, nine months of the year, and then at a lower level of

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availability for the remaining time. During the three months off-season, by increasing the availability of the ship in service, one or more can be taken out of service for annual overhaul, so that the prime need is for twelve months' complete reliability following an overhaul period.

Cargo liners, on the other hand, are providing a regular scheduled service for cargo. The flow of cargo is fairly constant at a level determined by the aggregate of world trade conditions. The time taken for handling cargo is considerably greater than that for handling passengers and their baggage so that it is possible to combine routine maintenance with cargo handling. Not all companies, however, adopt this procedure.

Tankers are normally operated on continuous service and annual overhaul basis, while tramps are subject to wide variations and conditions. When charter rates are high, the latter are required to run with the regularity of cargo liners, but they may be laid off service when rates are low. There is no sure pattern for charter rates, influenced as they are by world factors of an unforeseeable kind.

With the possible exception of the tramp ship, maintenance is never required to be on a basis of longer than twelve months between overhauls.

EFFECT OF OVERHAUL TIME ON ECONOMY OF SHIP OPERATION

A day's availability lost during overhaul, excluding depreciation, can be taken as equal to between £400 and £5,000 loss, depending upon the size of the ship. In some cases the loss may be much greater if passengers have to be put ashore and accommodated in hotels or if cargo has to be discharged and reloaded.

It is readily apparent, therefore, that guaranteed availability is a valuable commodity. Many shipowners set out to achieve this by building ships that are not an economic ideal. For example, a ship may have a margin of power greatly in excess of its need, with the result that the vessel is running away from its optimum efficiency for the most of its life or the steam pressure and temperature may be well below current established practice.

There is a strong belief that such a practice produces more reliable plant, but as—in the author's experience—most breakdowns are due to causes of an entirely different nature, it is considered that this is just a fallacy resulting from inadequate appreciation of the technical problems involved.

SETTING ABOUT PLANNED MAINTENANCE

Planned maintenance infers the coalescence and analysis of all relevant information followed by the formulation of a policy or plan which can be economically applied by the existing administration. It should also aim at the preservation of continuity and the elimination of duplicated effort.

The requirements of the survey by the Ministry of Transport and Lloyd's Register of Shipping automatically involve opening up much of the machinery, but unfortunately in many cases the information so readily available is not recorded in the manner needed to ensure that it can be used for forward planning.

The main liners of a main propulsion Diesel engine serve as a useful example in this connexion. The rate of wear of the liner is determined from direct measurement of the bore at a number of preselected points whenever the opportunity arises. The difficulties inherent in this type of measurement are such that accuracy is extremely difficult to obtain. In fact, unless one man is employed for this work, the readings are only comparable within fairly wide limits. However, one should not altogether discount unscheduled checks, even although there is a risk that they might deviate from the wear pattern, for in estimating liner consumption, it is only the total life that is of interest.

Liner wear patterns vary between engine types; Baker[3] indicated that in one engine type the wear pattern had three distinct phases. Initially there is a rapid wearing of the surface associated with a process akin to "running in" on a motor car, followed by a smaller rate of wear which extends over about 85 per cent of the life of the liner. Towards the end of the life of the liner, there is a second phase of rapid wear, which is probably due to lateral movement of the piston coupled with an increase in blowby of the products of combustion and resulting loss of efficient lubrication.

It will be found that the wear rates of all liners in the same engine or type are not identical (Figs. 1 and 2), and that, if a sufficiently large sample can be collected, a statistical pattern may be built up. An inspection routine must envisage an examination at periods of not more than the minimum life of an individual unit if 100 per cent reliability is to be guaranteed; subsequent inspection of the liner must be gauged in relation to the wear pattern found.

Taking a hypothetical case of a liner which has worn 50 per cent of its allowable figure up to the end of the first inspection period, then it will probably last until the next inspection. However, if it has worn 75 per cent, it will not last until the next inspection and must therefore be renewed which, of course, implies that the maximum possible wear of a liner does not occur and that a large portion may be wasted, but this loss must be weighed against the cost of failing to keep complete reliability. In general it will be found that possible losses on the commercial side are greater than certain losses on engine components.

Fortunately, routine examinations can be conveniently arranged at much shorter intervals, e.g. at the end of each voyage. These may occur at intervals which are as little as 25 per cent of the minimum life of an individual component. Clearly, then, the amount wasted can be greatly reduced and a schedule of maintenance drawn up so that the work can be spread over a number of voyages.

The principle may be applied to practically all the components that require routine maintenance, adjustment or renewal. As new materials and new techniques are introduced, certain artifices evolve which, when integrated into the main-

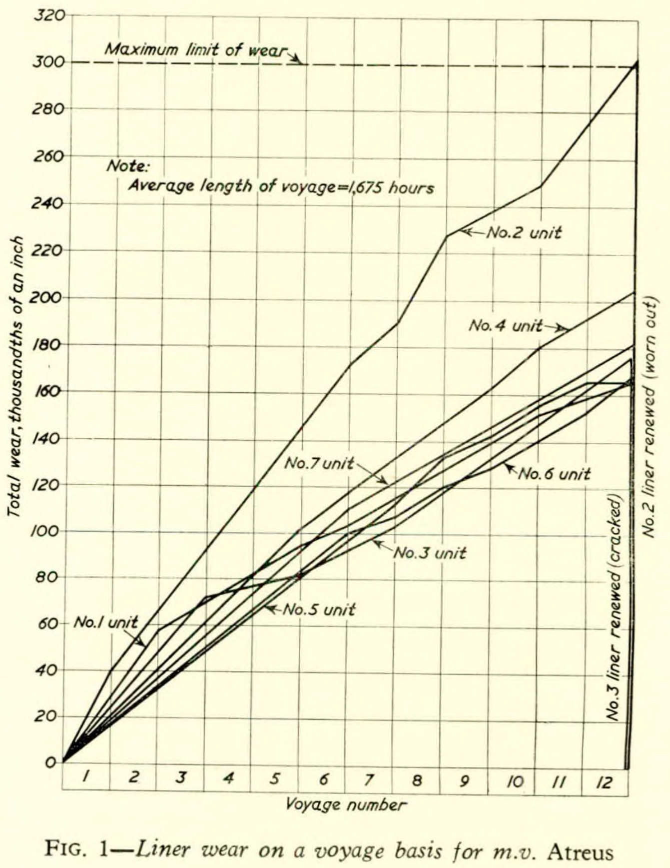


FIG. 1—*Liner wear on a voyage basis for m.v.* Atreus

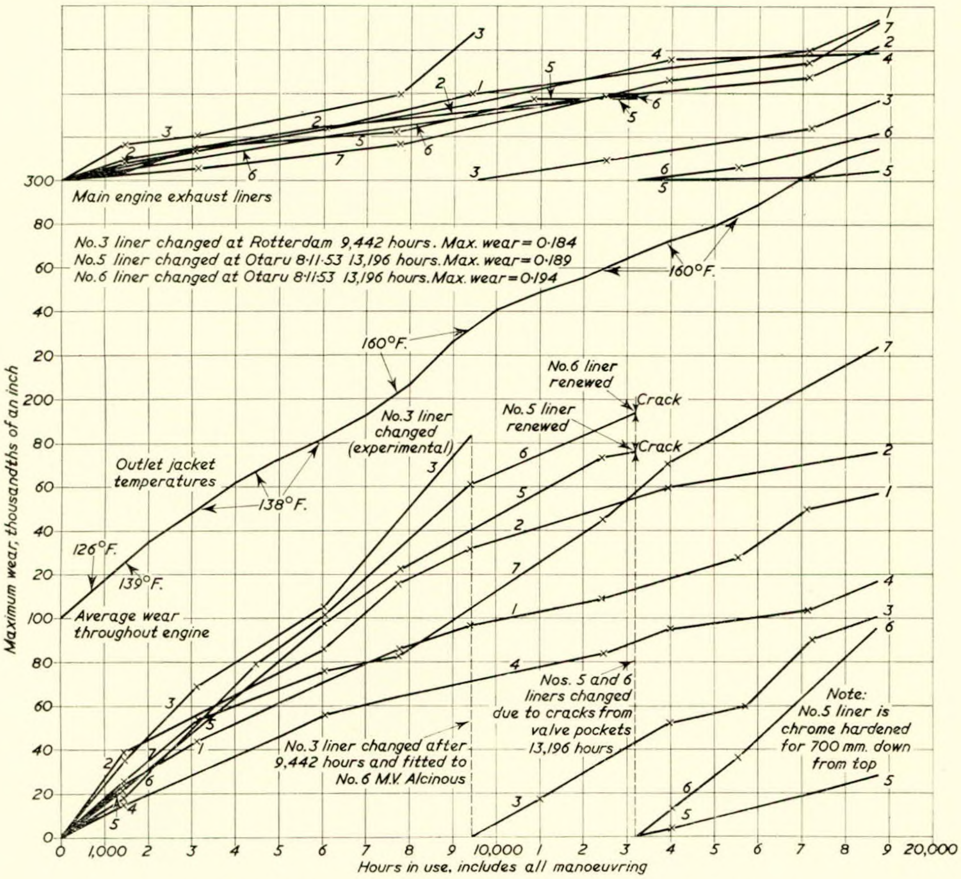


FIG. 2—*Main engine liner wear chart for m.v.* Bellerophon

tenance plan, considerably extend component life. Fig. 3 illustrates the point, liners A and B were considered to have a rather high rate of wear and when fitted with chrome-faced rings this rate was reduced to a very acceptable figure. C, on the other hand, was fitted with the chrome-faced type initially and produced wear rates which indicates that the artifice works equally well on both worn and unworn liners. This has subsequently been borne out in practice.

MAINTENANCE SCHEDULES

Whether maintenance is planned on an annual refit basis or arranged concurrently with cargo handling, the function of the maintenance schedule is the same. It should provide for regular examination, servicing and maintenance of each piece of machinery. The schedule must envisage instructions as to when each operation should be executed. A maintenance policy incorporating such a schedule will only be effective so long as each part is examined after its scheduled number of running hours have been reached and that the wear tolerances laid down are adhered to even although there is every indication that the machine is running satisfactorily. Mechanical wear is not the only consideration which determines the interval between examinations; under certain conditions chemical decomposition, corrosion and erosion may be taking place during the interval and if allowed to progress unchecked, will result in a failure. The initial running time is based on an acceptable minimum but as time goes on statistical analysis of representative samples will indicate whether or not the interval can be increased or should be decreased to improve reliability.

Before commencing to compile a preventive maintenance schedule, the components of each machine or item liable to wear or misalignment must be studied in a comprehensive manner in order to assess the frequency of examination or the maintenance required. Where cargo liners are concerned, schedules can be compiled with some considerable degree of accuracy and corrected by practical experience fairly promptly. The task is further simplified when a number of similar vessels are involved. In this type of vessel there is normally a considerable amount of useful basic information available in defect lists and record books, etc. The former are submitted about fourteen days before the end of each voyage to facilitate the planning of repairs. Unfortunately, much of this is in non-standard forms and the rationalization of data from such a source assumes formidable proportions. Therefore, the extent to which this information can be used is limited by the labour made available for analysing and investigation purposes.

There is little doubt that machinery maintenance can be made more effective when routine maintenance on board ship is planned as part of the general maintenance organization. Standard practice once established avoids foolish maintenance which leads to greater repairs. The concise maintenance report which is a feature of this type of organization should include the time taken to service or overhaul the unit. Provision should also be made for abstracting the defects.

The author has always thought that records of this nature should have been in more general use in the past, for it is the logical conclusion to what has been standard practice for many years with main propelling machinery. It is of considerable importance to the owners to know how long it will take to effect a repair to the main propelling machinery in the event of a failure.

RECORDING INFORMATION

To enable a planned maintenance schedule to be drawn up, it will be clear that careful documentation is necessary to be able to co-ordinate the knowledge obtained from surveys. In building up experience on the basis of which forecasts may be made, it is equally necessary to record all data that may be

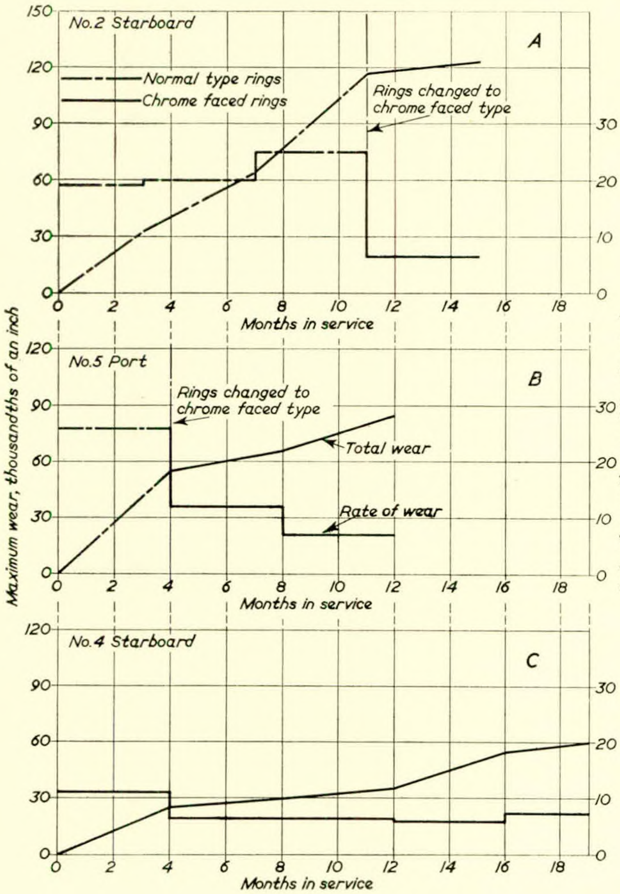


FIG. 3—*Main engine liner wear in m.v.* Glenorchy

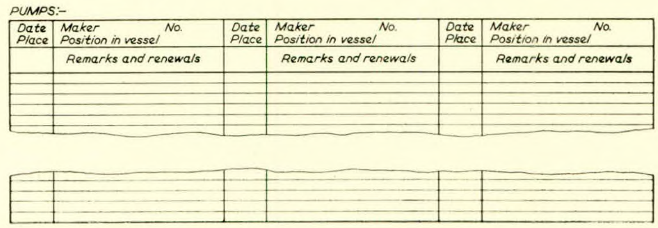


FIG. 4—*A typical auxiliary record sheet*

unit, is shown in Fig. 1. Fig. 2 illustrates what has proved to be the most useful type of plot associated with liner wear. One tenth of an inch squared paper is normally used, the ordinate being marked off at 20/1,000 inch per inch, while the abscissa is marked off at 1,000 hours per inch.

Another form of plotting data is shown in Fig. 5. This produces above and below the axis a double histogram of the frequency of two types of occurrence to the same part, i.e. piston rings being found broken. Whilst a given set of engine

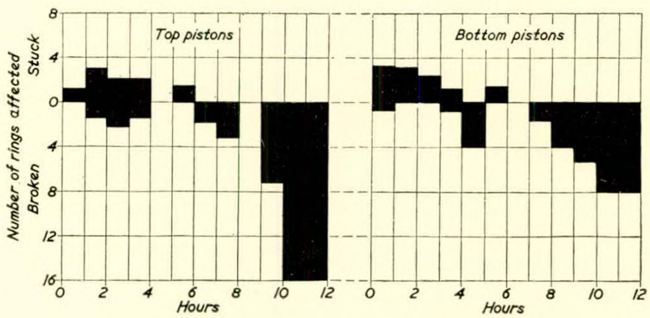


FIG. 5—*Summary of ring condition and breakages*

relevant, as in the initial stages it is not known which particular wear rate will be the dominant one in determining the life of the component or assembly.

To assist the inspecting engineer in tabulating all the data required, it is essential to draw up record sheets in such a form that no one can fail to realize when a record is not complete. Complicated forms are to be avoided whenever possible as they only lead to misunderstandings and errors follow. Some typical designs of record sheets are given in the appendices, but it is suggested that this is more properly the function of the engine or master builder, provided that there is some standardization of the format so that collection, collation and filing present no problem. They could, with advantage, be issued as a supplement to the maintenance and instruction manual.

One company of engine builders did in fact issue such sheets before the war, as they found that the information they required could be more easily obtained when the customer was supplied initially with a standard data sheet.

COLLATION OF DATA

The collation, presentation and interpretation of the data requires as much attention as does the collection. Each individual case requires consideration on its own merits. In the case of one pump per ship it is probably enough to keep a plot for the unit, or, alternatively, a data sheet as shown in Fig. 4 will be found to be adequate; whereas with, say, main engine liners it will be necessary to keep a plot for each ship and possibly subsidiary grouped plots and histograms after correction for the variation in service condition between different ships. A quick reference plot, where the basis may be an unconventional unit of time, but nevertheless a very practical

conditions may cause firstly sticky and then broken rings, it is probably true in general that the causes are different for each type of failure.

Another method of presenting data is shown in Fig. 6. Unfortunately this type of analysis requires rather an unproportionately large amount of manpower to keep a complete set of records up to date.

PERFORMANCE TESTING

In safeguarding against loss of reliability the development of a routine of performance testing can be efficacious. Units such as refrigerating machinery or auxiliary generators have been developed to the point at which the life of their components is in general greatly in excess of normal overhaul periods. As time proceeds, however, the chances of breakdown due to adventitious circumstances must be increased.

A routine of testing such as full load trials, governing trials, cooling down tests, etc., will do much to give warning of falling off in performance considerably in advance of breakdown. Bearings, of course, cylinder head valves, etc., indicate their failure in their own ways, but in many cases insufficient attention would appear to be paid to the ability to develop the designed full load. In older ships a tradition often grows up that a particular unit is incapable of developing its full duty, simply because it was either originally overrated and/or has been subsequently neglected in the finer points of detail.

This procedure is customarily adopted for main propulsion Diesel engines but for no other form of propulsion. In such cases where such techniques are *not* applied to Diesel engines, the reliability suffers and serious disasters not infrequently happen. Steam turbines on the other hand were not without some reliability but at a greatly reduced efficiency.

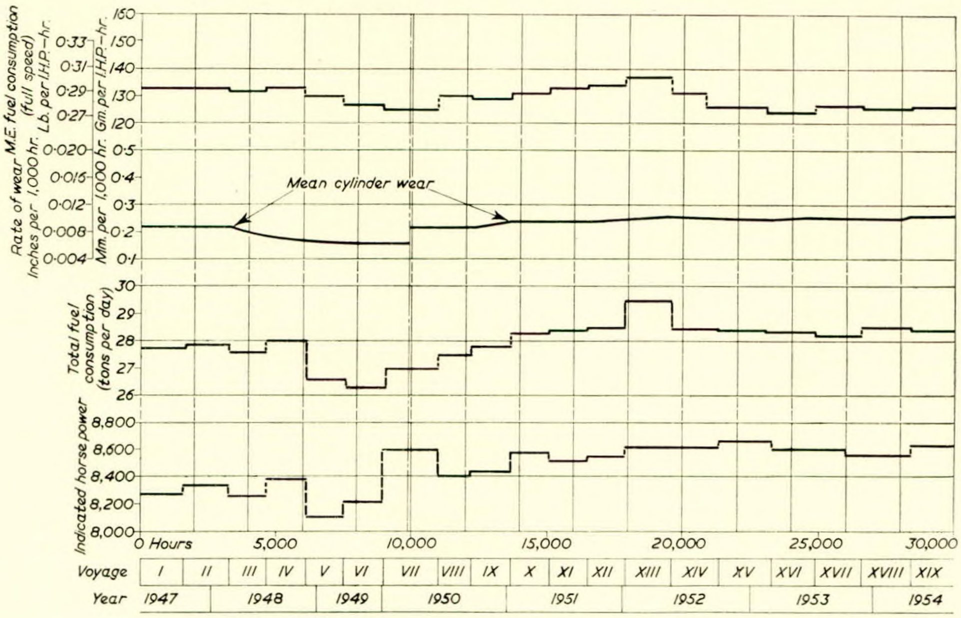


FIG. 6—*Power, consumption and liner wear analysis for a typical "A" Class vessel*

Boilers

The "wear and waste test" procedures developed by the Admiralty in the past aimed at regular testing of the boilers to determine systematically the amounts of internal and external wastage. The results obtained were used in assessing a probable life for the boiler. If the life were less than the normal interval between tests, the interval was correspondingly reduced. In the case of superheater tubes, experience had shown a minimum life of two years and instead of routine testing superheaters were retubed automatically after this interval.

This procedure would appear to be unwarranted for merchant ship boilers of the watertube type, provided that:

(1) The design eliminates pockets where damp soot can collect.

(2) The boiler water is subject to a closely supervised water treatment system involving at least a strict control of the salinity and alkalinity.

The principal factors affecting the falling off of the efficiency are accumulations of soot and air casing leakages. Unfortunately the intervals between cleaning operations is still too small. If water washing could be adopted in all types of boilers instead of in only a very few designs, the steaming time could be very much increased. The cleaning operation would be much quicker and more thorough as bonded and acid deposits in otherwise inaccessible places would be removed.

Internally the picture is satisfactory; experience would indicate that periods in excess of the present interval between thorough internal boiler cleanings are possible and perfectly safe.

Auxiliary Machinery

Units such as coolers and condensers have been developed to a point where maintenance is almost exclusively confined to routine cleaning and chemical descaling. Tube failures, although rare, can be a serious embarrassment.

When portable non-destructive inspection equipment developed for this type of work is used at regular intervals to eliminate defective tubes, the incidence of tube failures assumes negligible proportions. Hydraulic tests only reveal tubes that have actually failed.

The defective tubes should not only be examined for the nature and cause of the defect but whenever practicable a sample length of the tube should be tested to determine the effect of scale on the heat transfer coefficient of the material.

The rotary auxiliary has practically displaced its reciprocating counterpart with the result that fortuitous failures rarely occur, due largely to the decrease in the number of working parts, and can be relied upon to run with the minimum of attention between widely spaced examinations. Expendable components which restore the unit's performance are usually fitted at these examinations. It is suggested that as time goes on rotary units will become practically universal because of their simplicity. Where more extensive repairs are necessary, the removal and replacement of a complete unit is now quite usual.

THE INFLUENCE OF DESIGN ON MAINTENANCE AND STANDARDIZATION

Although design and maintenance are interdependent, the latter should not impose restrictions which retard progress. The ever-present need for reductions in the power/weight ratio and for improvements in reliability and performance postulates higher steam conditions, greater degrees of pressure charging, standardization of equipment and true interchangeability of parts. This, in time, will change existing maintenance policies as it entails the introduction of new materials and the adoption of new techniques which are not susceptible to traditional maintenance methods.

This does not mean that the general engineering shop is no longer necessary. On the contrary, the majority of repairs will still be carried out by such establishments, if for no other reason than that there are many ships in service which are likely to remain in service for many years to come. However, it does mean that as time goes on, many new items of equipment and new designs will be introduced that cannot be repaired by normal methods and will of necessity, therefore, be replaced by new or reconditioned components or sub-assemblies.

The principle of standardization applies to both steam and internal combustion engines. Where a considerable number of vessels have to maintain a high standard of efficiency, the advantages of standardization become apparent and must be recognized when new construction is being contemplated. Some companies considerably simplify their future maintenance problems by adopting a standard design for a number of vessels. Although more than one design may be under construction or consideration at the same time, auxiliaries common to both steam and motor vessels are very often standardized. This type of policy does not retard progress for if changes are made intelligently a considerable degree of interchangeability can be achieved. Because of the large number of items of machinery that go to make up a modern installation, new ideas and designs are being constantly introduced. A more detailed study of the problem would indicate that a class or unit of less than three requires as many base spares and as much organization as a class of twice as many. It can be more uneconomical to hold too few spares than it is to hold too many.

The marine industry has not, in general, adopted toleranced drawings with a satisfactory system of limits and fits and still largely depends on the skill of its craftsmen to achieve the performance sought. More progressive firms have successfully introduced satisfactory systems and the author is of the opinion that they will eventually achieve such a degree of dimensional accuracy that full dimensional inspection will be considered to be a routine matter and not a requirement of a particular customer. It is also thought that this desirable state of affairs will evolve as a result of improvements in design and workshop technology, a greater use of automation and the influence of the ever-increasing cost of labour. If for no other reason the latter will accelerate the introduction of unit replacement as the cost of overhauling complicated pieces of machinery by skilled labour *in situ* becomes prohibitive. In fact, there are now a number of cases on record where the cost of overhauling and repairing a particular unit has been greatly in excess of the cost of a completely new replacement.

One authority which investigated the number of man hours spent in refitting one of the more common items of machinery indicated that, over a specified twenty-year interval, there was a 65 per cent increase in the man hours required and, recognizing that the human element entered into it, attributed this to more complicated machinery. In the author's experience this is probably true of some types of machines, more particularly the smaller auxiliaries; but it should also be borne in mind that improvements in performance can only be achieved at the expense of a more complicated design and while appreciating that this involves an increase in overhauling time, it is also true to say that the interval between overhauls has been very much improved. Of main engines and auxiliary Diesels, it can be said that the man hours required per horse power have been considerably reduced, due largely to improvements in design. It is evident that a maintenance load is built into a vessel when designed and that this load never decreases during the life of the vessel.

AIDS TO PLANNING

Effective planning is based upon knowing the time required to execute repairs and to carry out preventive maintenance. Estimates are based on the practical experience of the individuals concerned in these matters. At present cargo handling schedules do not impose any great strains on port repair facilities, but if trade conditions allow a quicker turn round, the various types of planning schedules discussed will assume greater importance. Where large variations in the nature of the job can occur, for example in boiler cleaning, the introduction of special equipment has done much to reduce the time required as well as to reduce the effect of varying conditions. Tools such as tungsten carbide tipped rock drills and industrial vacuum cleaners have done much to make an objectionable job, such as the cleaning of air heaters, a routine affair which does not now call for special mention.

In Diesel engines the story is similar. The trueing-up of crankshafts by hand has been largely superseded by power driven portable lapping and superfinishing machines; both require equally skilful operators but the latter are quicker and require less effort, with possibly a greater degree of accuracy.

Portable non-destructive testing equipment provides extremely useful tools; pieces of equipment in common use, such as magnetic crack detectors, probologues, and ultrasonic crack detectors, together with microstructure examinations *in situ,* all contribute to the control of material in service. Techniques in their use require to be developed. Fig. 7 shows a piston which was hydraulically tight and outwardly flawless, although the detector clearly indicated a crack. When broken up, it will be observed in Fig. 7 (c) that a ligament of solid metal obscured the fatigue crack.

There are a number of such aids to planning but prob-

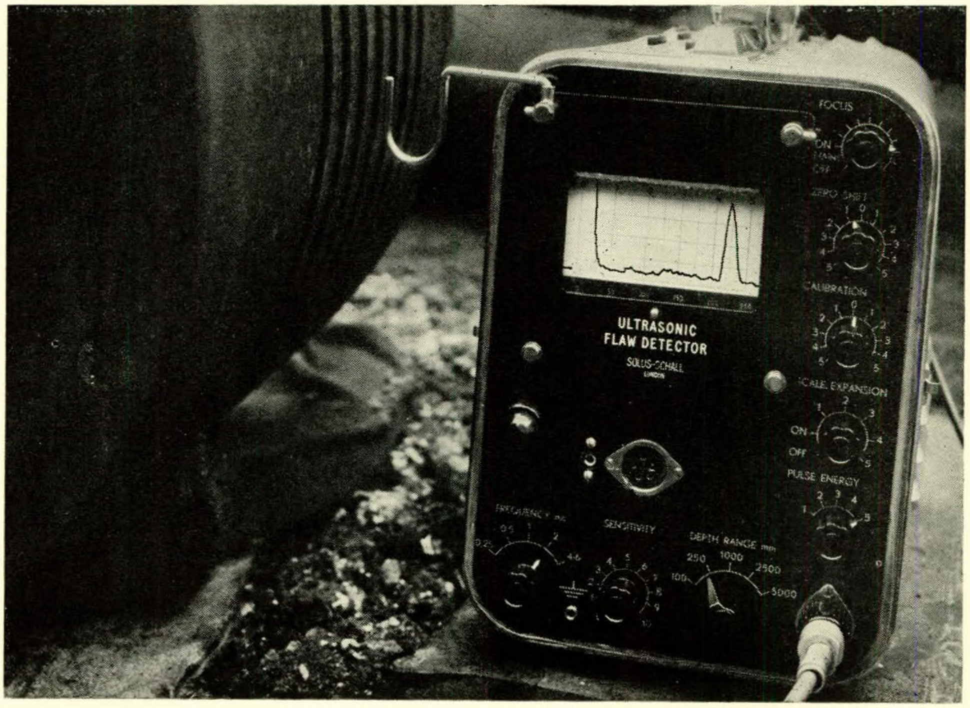


FIG. 7(a)—*Flaw detector with quartz crystal probe (transceiver) on sound portion of piston: initial response due to interface echo followed by echo at about 240 mm. deep, i.e. the ring groove*

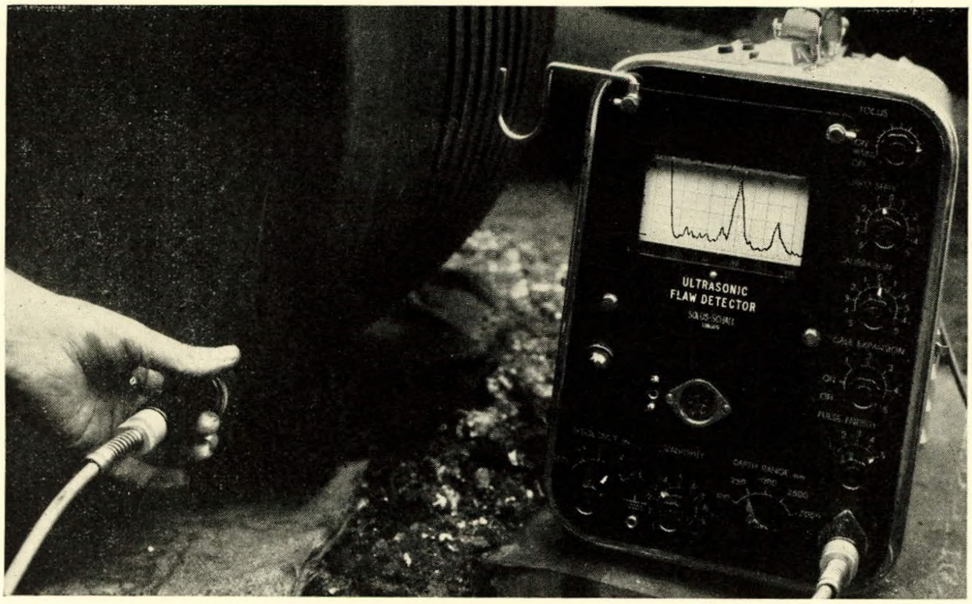


FIG. 7(b)—*Flaw detector with quartz crystal probe (transceiver) in line with suspected flaw: initial response due to interface echo followed by echo of flaw at 150 mm.*

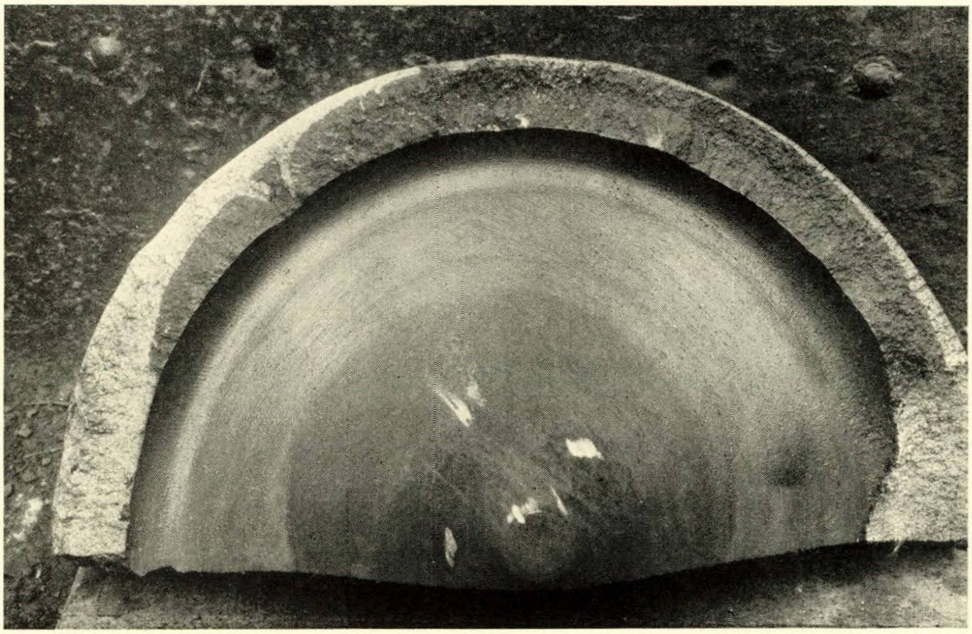


FIG. 7(c)—*Crack that was subsequently revealed on breaking up piston*

ably the most useful one of all is the services of an independent chemical and metallurgical laboratory. The large organization will find it worth while to employ their own specialists, who are free from the day-to-day problems of running a fleet and who can not only investigate defects and failures but devise means of controlling and avoiding them in the future. Material analysis figures rather largely in such a scheme and apart from checking against the original specification, new specifications are drawn up which ensure that the same type of failure or defect will be avoided in new construction.

Where an independent laboratory has functioned for a very long time, differences of opinion based on experience not infrequently arise and may result in long term investigations into different materials. The investigation into the effect of water-soluble oil corrosion inhibitors on the fatigue strength of mild steel is a typical example of this[1].

ANCILLARY SERVICES

These services are essential features of any maintenance organization and should incorporate a reliable spares supply system, which not only includes the supply of new spares but also reconditioned sub-assemblies. In addition to the fairly comprehensive supply of spares carried in each vessel, large items such as propellers and tailshafts must be stored at a number of strategic ports on the general trade routes, together with other items which experience shows can be, with advantage, placed there.

Observing that many consumable items of machinery have

FIG. 8(a)—*Thong-secured visible index binder showing method of assembly (the survey record book)*

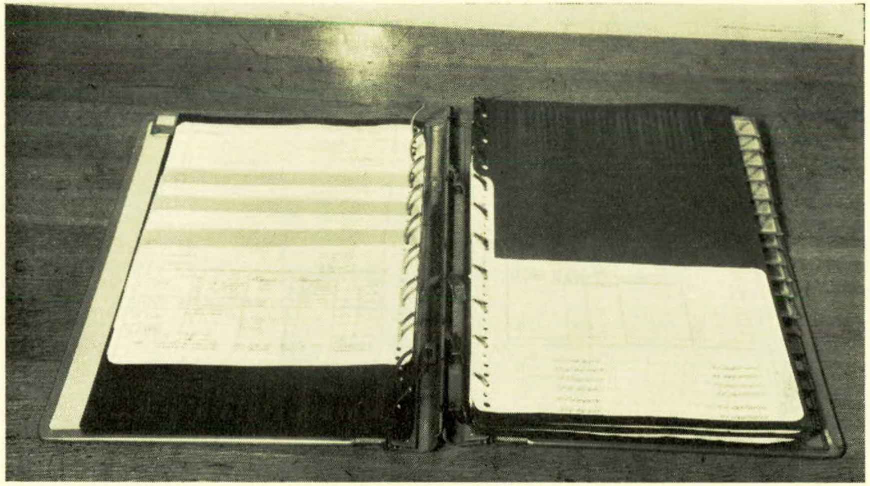
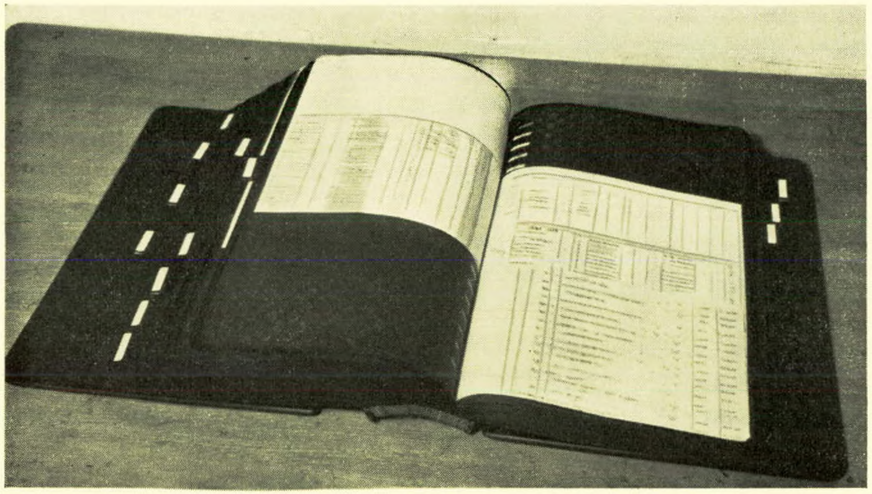
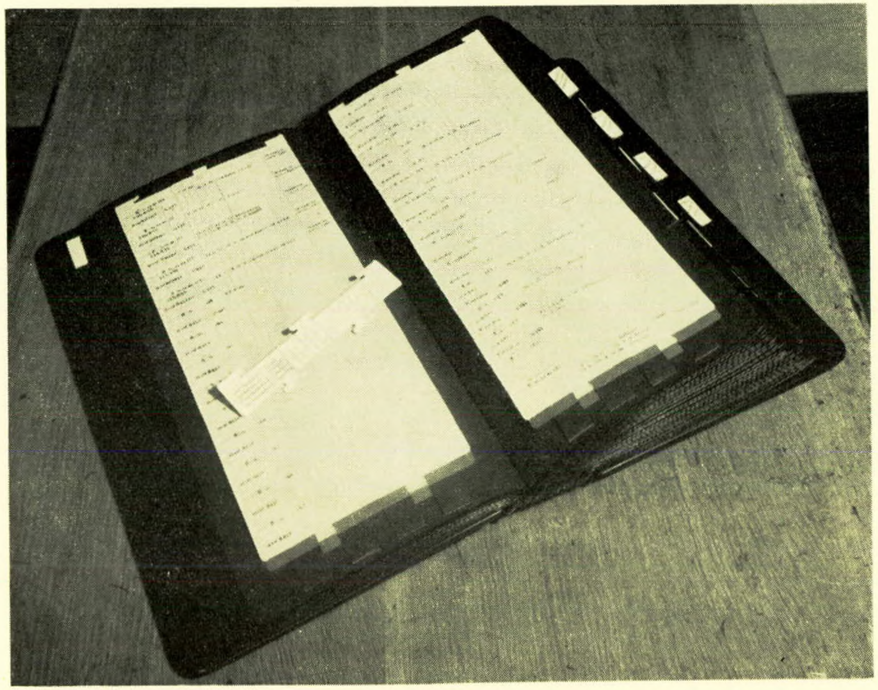


FIG. 8(b)—*Ring-secured visible index binder showing method of assembly (gauging record book)*

FIG. 8(c) (below)—*Visible index binder (buying and price record and stores control)*

FIG. 8(d) (bottom right)—*Strip-index binder (book of code numbers)*





a considerable manufacturing life of perhaps several hundred hours, it is very important that forward planning should include the forecasting and ordering of such capital goods so that they are provided at a constant rate which is approximately that of the rate of consumption. A buffer supply is also essential to cover unexpected contingencies such as strikes and temporary shortages of material. To this end it is advantageous to have the customer's representative either resident at or visiting the manufacturers regularly to smooth out problems which inevitably arise and to inspect the work in progress.

The actual control of the physical stock, equipment and material on order can be very conveniently carried out by using one of the proprietary types of visible index binders illustrated in the appendix (see Fig. 8). It should be noted that fairly simple stock control record sheets suffice for most of the material that is normally required.

Where components have to be moved, a reliable system of identification has proved to be extremely useful. The strip index system illustrated has proved to be a simple and efficient method of tracking down individual items. Redundant units are removed from the register.

The staff engaged on fleet maintenance have very little time to meditate and naturally welcome any device that will enable them to do their job more thoroughly.

CONCLUSION

Preventive maintenance has always been a feature of the author's company's maintenance policy. Repair by replacement has already been introduced to a limited extent and will undoubtedly grow. It is suggested that as new designs, free from the restriction of current maintenance practice, are introduced, the subject will assume greater importance if the inflated cost of repairs continues. The reason for, and effect of, planned maintenance is reliability. It can also be claimed that an additional effect is economy, demonstrated in costs both estimated and actual. Planned maintenance provides information for estimated costs necessary for managerial guidance and helps to reduce additional and unexpected costs of engineering hazards.

To initiate a comprehensive scheme requires a small staff of specialists who understand the problems involved. However, a modest degree of control can be achieved by a very small staff on a part-time basis.

It is recognized that the paper constitutes a rather brief review of a subject which could with advantage be treated in greater detail. The author's observations and remarks have been confined to some of those aspects with which he is personally acquainted, and if the paper stimulates some interest in the subject, he will be satisfied.

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(5) WARREN, W. J. 1954. "Probolog—An Application of Eddy Current Techniques to Non-Destructive Testing". Tenth Annual Conference, National Association of Corrosion Engineers, Kansas City Mo.

Appendix

Some Notes on Data Sheets

Particulars of the data required must first be collected and classified before the actual design of the sheet can be considered. Classification should be looked upon as a tool, which enables more intensive concentration upon particular lines of thought by setting up an arbitrary framework to limit and/or subdivide the field.

Generally, two distinct types of form will suffice, the first seeking a little information about numerous identical and associated components and the second much information about more complicated assemblies. Both are illustrated in Figs. 9, 10 and 11.

Before deciding on the format of the sheet, the available standard sizes of sheets should be studied, together with the method of filing which is to be adopted.

The two main types of filing are:

(a) Loose sheets which can be conveniently kept in a folio.

(b) Precision printed sheets which are normally contained in a special binder.

Fig. 11 (a) to (e) shows examples of the former which are generally looked upon as short term records, the more important aspects of which are set up in some other more consumable form. The precision printed sheet is a more permanent and comprehensive form of record, where more detailed information is of importance, and where all information of the same type is to be kept together.

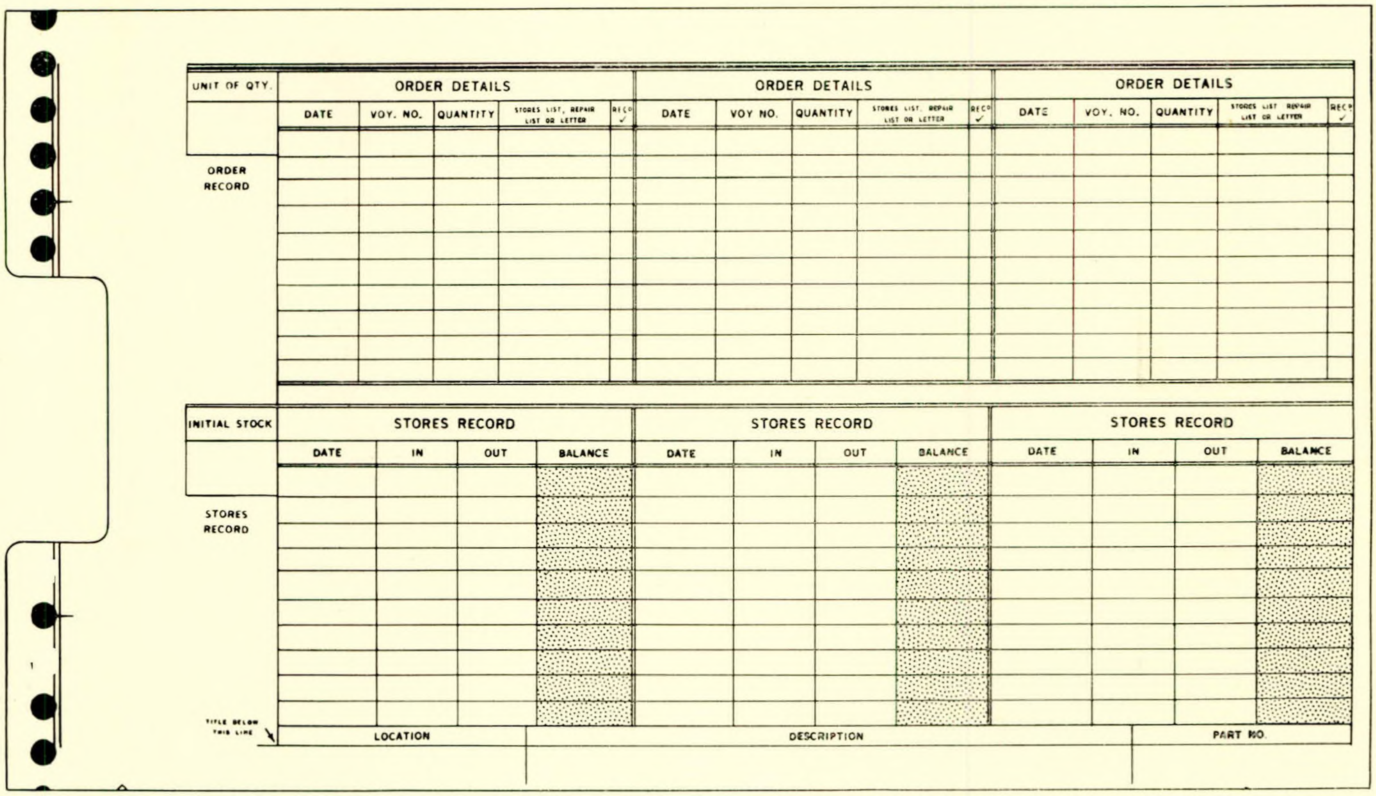

FIG. 9(a)—*Stores control insert as used on board ship*

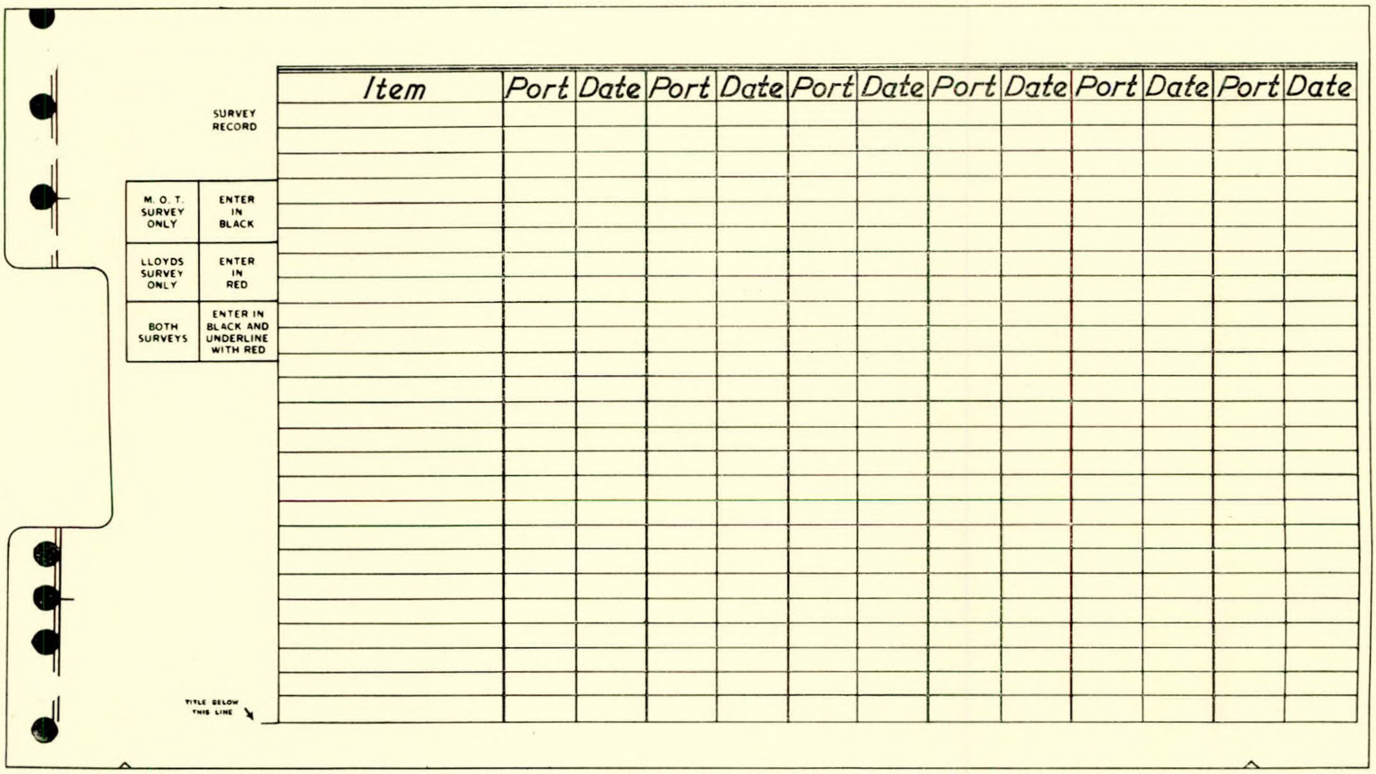

FIG. 9(b)—*Survey record sheet*

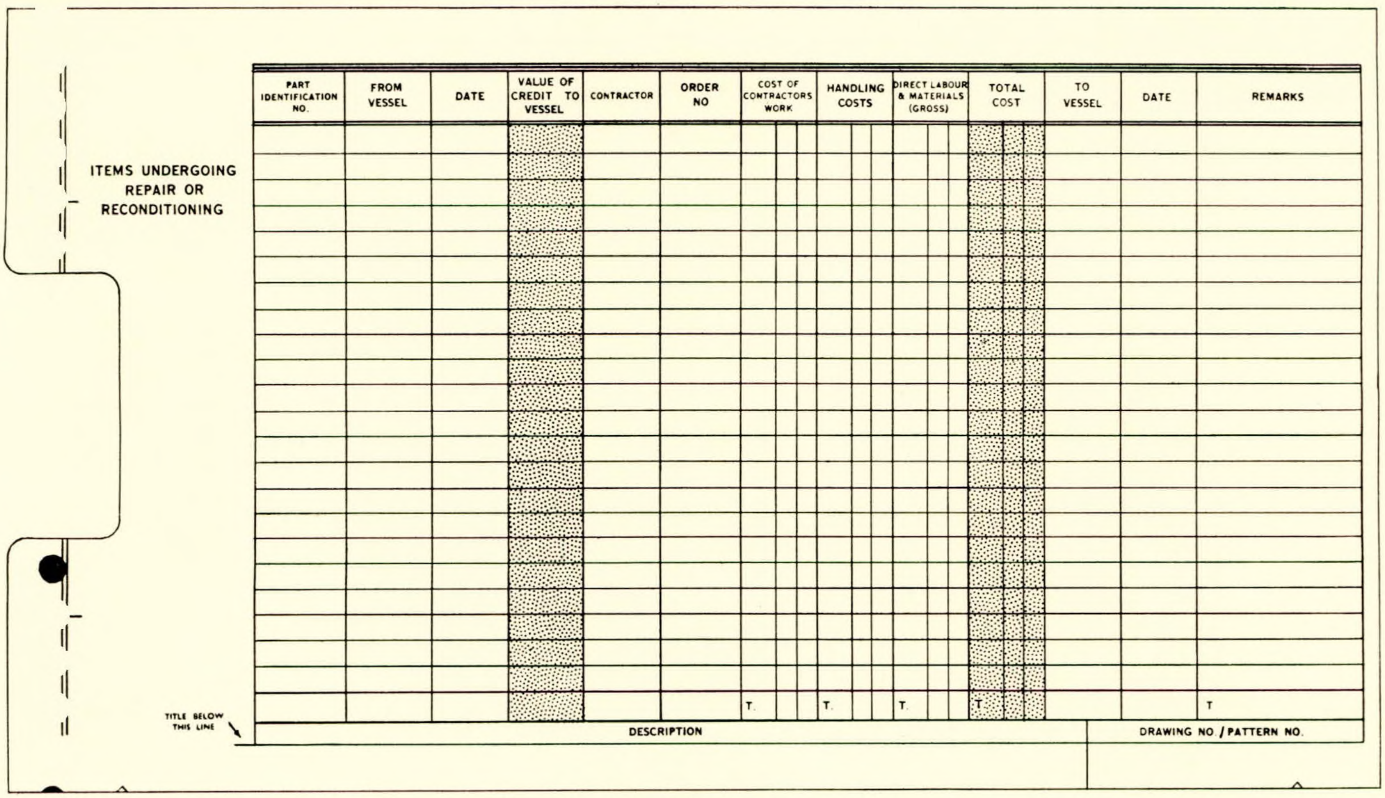

FIG. 9(c)—*Reconditioning record insert*

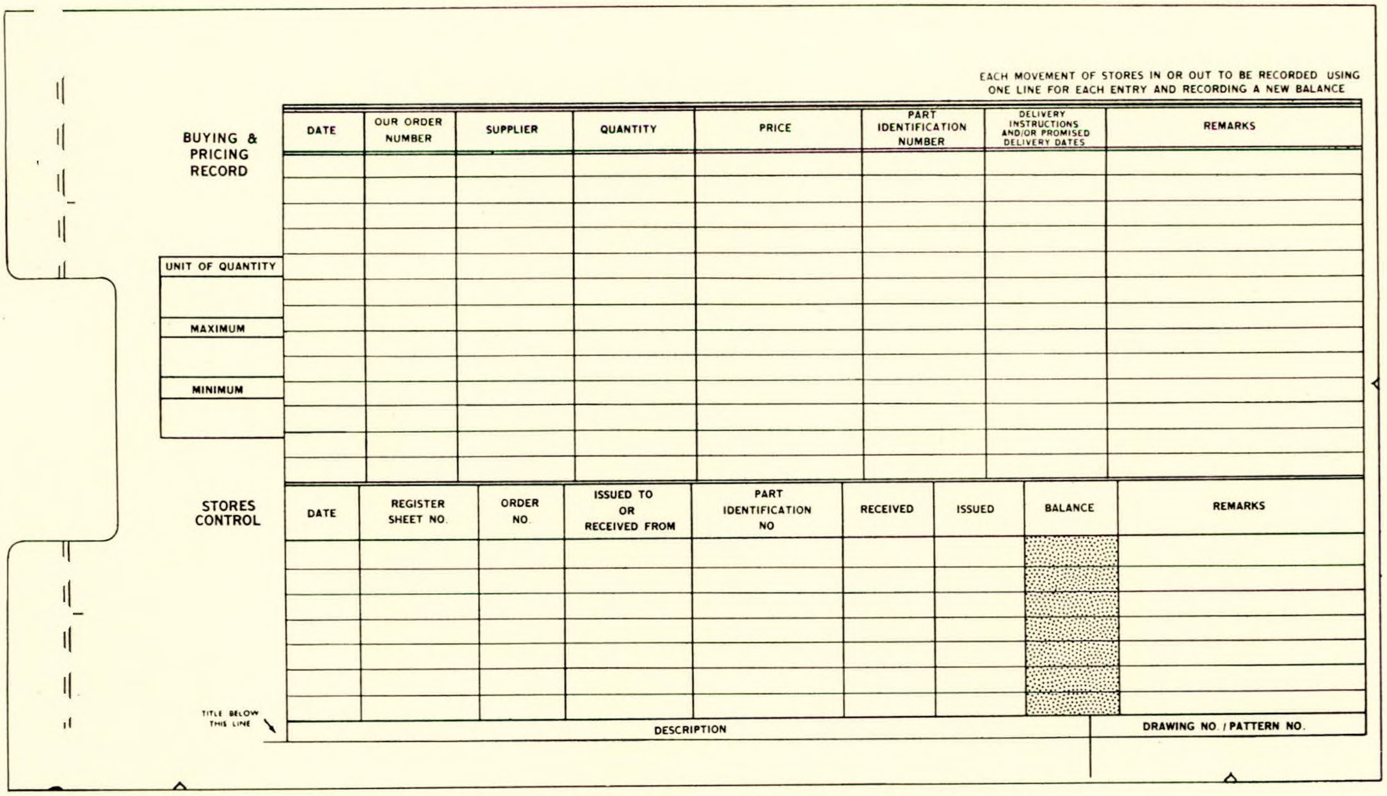

FIG. 9(d)—*Buying and pricing record and stores control insert*

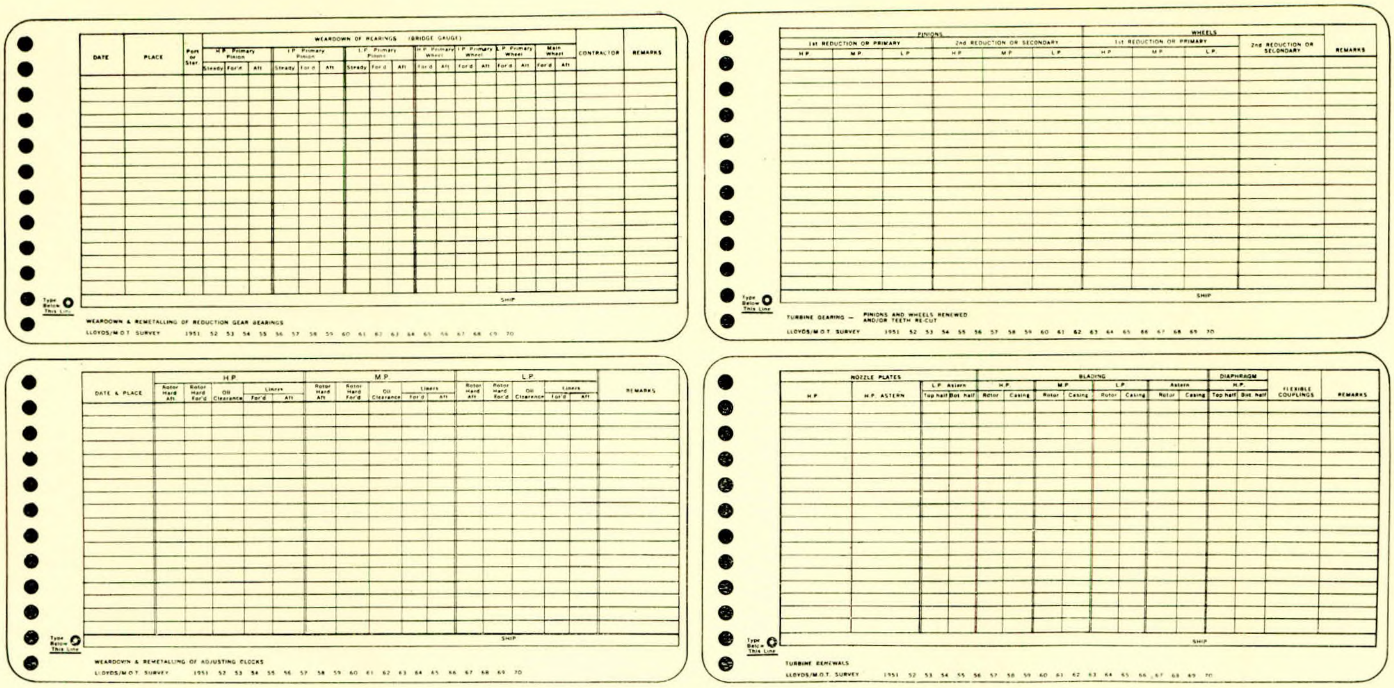

FIG. 10(a)—*Some typical examples of gauging record sheets*

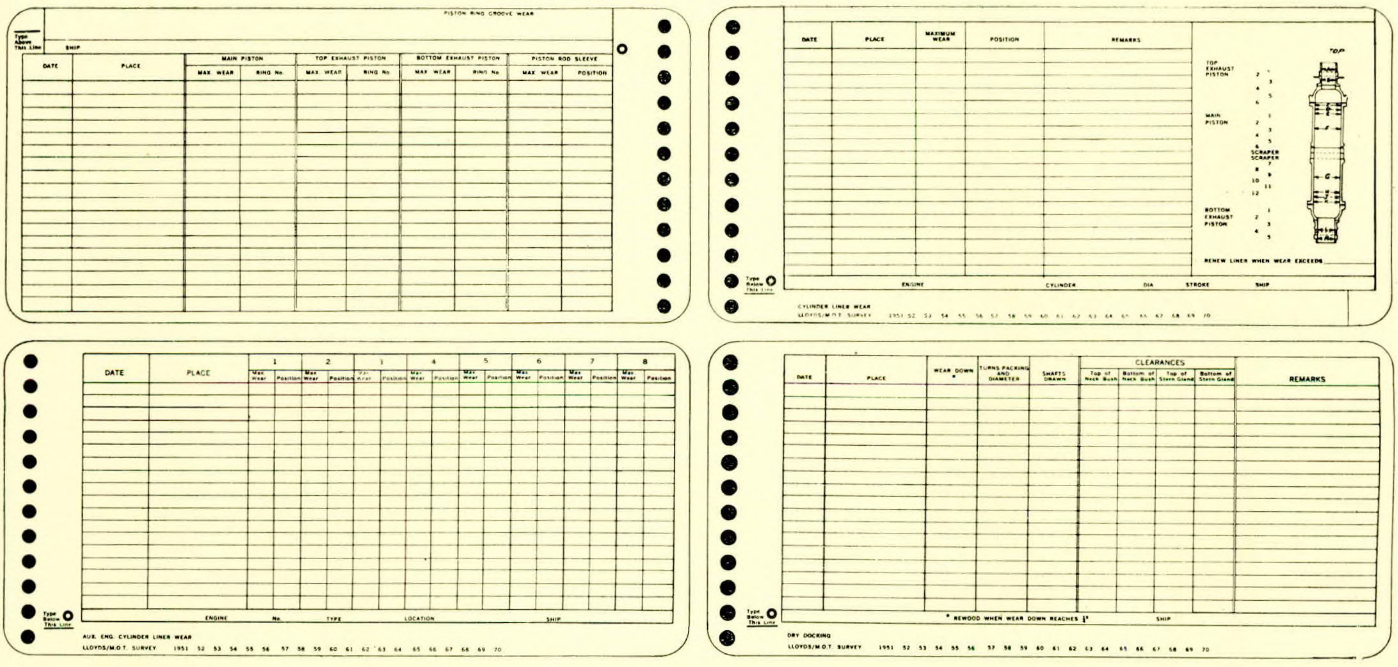

FIG. 10(b)—*Some typical examples of gauging record inserts*

550/1400 CAMSHAFT, FUEL PUMP AND VALVES DATA SHEET

M.V. ______________ VOYAGE NO. ______________

DATE	PORT	ASSISTANT SUPT.	CHIEF ENG.

H.P. FUEL PUMP

BEARING	1	2	3	4	5	6	7	8
CLEARANCE								
RE-METALLED								
TOP CHANGED ..								
BOTT. CHANGED ..								

FUEL VALVES

UNIT NO.	1		2		3		4		5		6		7		8	
	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S
TOP																
BOTT.																

STARTING AIR VALVES

TOP								
BOTT.								

CAMSHAFT CENTRE PART

EXAMINED							
	FOR'D		SPROCKET WHEEL SLEEVE		AFT THRUST BEARING		
BEARING	FOR'D	AFT	FOR'D	AFT	FOR'D	AFT	FORE & AFT
CLEARANCE ..							
RE-METALLED ..							

OIL BAFFLES

		EXAMINED	CONDITION	RENEWED
FOR'D BEARING ..	FOR'D			
	AFT			
AFT THRUST BEARING ..	FOR'D			
	AFT			

SPROCKET WHEELS AND CHAIN

CRANKSHAFT			
LOWER INTERMEDIATE ..			
UPPER INTERMEDIATE			
CAMSHAFT			
TIGHTENING			
CHAIN			
REVERSE CLUTCH SCROLL ..			
REVERSE CLUTCH			

SCAVENGE BELT

EXAMINED		CLEANED	

NOTE:—ENTER IN BLUE—MERSEYSIDE
ENTER IN RED—GLASGOW
ENTER IN GREEN—BRISTOL CH. LONDON AND CONTINENT

Ref. E.D.O. I.

TWO CYCLE ENGINES CRANKCASE SHEET

M. V. ______________ VOYAGE NO. ______________

SURVEY	
DATE	
PORT	
SURVEYORS ..	
ASST. SUP'T ENG.	
CHIEF ENG. ..	

CRANK SHAFT DEFLECTIONS

CRANK	1	2	3	4	5	6	7	8
ZERO AT T.D.C. ..								

MAIN BEARING WEAR DOWN

BEARING NO. ..	1	2	3	4	5	6	7	8	9	10
BRIDGE GAUGE ..										
CLEARANCE ..										
LINERS OUT ..										
RE-METALLED ..										

BOTTOM END BEARINGS

CYLINDER NO. ..	1	2	3	4	5	6	7	8
CODE No. /BEB								
CRANKPIN SIZE ..								
CLEARANCE ..								
LINERS OUT ..								
RE-METALLED ..								
CRANKPIN LAP'D								

ECCENTRIC STRAP CLEARANCES

CYLINDER NO. ..	1		2		3		4		5		6		7		8	
	F	A	F	A	F	A	F	A	F	A	F	A	F	A	F	A
CODE No. /E																
CLEARANCE ..																
LINERS OUT ..																
RE-METALLED ..																

ECCENTRIC TOP END BEARINGS

CYLINDER NO. ..	1		2		3		4		5		6		7		8	
	F	A	F	A	F	A	F	A	F	A	F	A	F	A	F	A
CLEARANCE ..																
LINERS OUT ..																
RE-METALLED ..																

CONNECTING ROD TOP END BEARINGS

CYLINDER NO. ..	1		2		3		4		5		6		7		8	
	F	A	F	A	F	A	F	A	F	A	F	A	F	A	F	A
CLEARANCE ..																
LINERS OUT ..																
RE-METALLED ..																

NOTE:—ENTER IN BLUE—MERSEYSIDE
ENTER IN RED—GLASGOW
ENTER IN GREEN—BRISTOL CH. LONDON & CONTINENT

Ref. E.D.O. I.

FIG. 11(a)—*Typical maintenance data sheets for main engines*

550/1400 BLOWER DATA SHEET

M.V. __________ VOYAGE __________

SURVEY	DATE	PORT	SURVEYOR	ASST. SUP'T	CHIEF ENG.
M.O.T.					
LLOYDS					

BLOWER

FOR'ARD __________ AFT __________

BEARINGS

	DRIVE END		FREE END			
	TOP BRG.	BOTT. BRG.	TOP BRG.	TOP BRG. F. & A.	BOTT. BRG.	BOTT. BRG. F. & A.
CLEARANCE						
RE-METALLED						

DRIVE SHAFT BEARINGS

	BEARING FREE END	THRUST BEARING		
		FOR'ARD	AFT	THRUST
CLEARANCE				
RE-METALLED				

ROTOR TIP AND CASING CLEARANCE

	TOP OR BOTTOM	INBOARD SIDE	OUTBOARD SIDE
TOP ROTOR			
BOTTOM ROTOR ...			

MESHING CLEARANCE BETWEEN ROTORS

ROTOR GEARWHEELS

EXAMINED	CONDITION	TOOTH CLEARANCE	RENEWED

OIL BAFFLES

	EXAMINED	CONDITION	RENEWED
TOP FREE END 260 M/M ...			
BOTTOM FREE END 260 M/M			
TOP DRIVE END 260 M/M ...			
BOTT. DRIVE END 260 M/M ...			
BOTT. DRIVE END 170 M/M			
SCRAPER RING 170 M/M ...			

CHAINWHEELS AND CHAIN

CRANKSHAFT			
CHAIN TIGHTENING ...			
BLOWER DRIVE SHAFT ...			
INTERMEDIATE			
CHAIN			

FLEXIBLE COUPLING

RUBBER BUSHES ...			
SPRINGS			
SPRING SHOES			

NOTE :—ENTER IN BLUE—MERSEYSIDE
ENTER IN RED—GLASGOW
ENTER IN GREEN—BRISTOL CH. LONDON AND CONTINENT

Ref. E.D.O. I.

FIG. 11(b)—*Typical chain driven blower maintenance sheet*

M.V. __________ VOY. NO. __________ | CYL. NO. __________ DATE __________

SURVEY	DATE	PORT	SURVEYOR	ASST. SUPT.	CH. ENGR.
M. O. T.					
LLOYDS					

TOP EXHAUST PISTON NO. C/T.E.P.
CONDITION OF PISTON RINGS

No.	RING GAUGINGS	RINGS RENEWED	RINGS FREE
1			
2			
3			
4			
5			
6			

CROWN EROSION __________

CROWN WELDED __________

CONDITION OF COOLING OIL SPACES __________

PRESSURE TESTED __________

MAIN PISTON NO. C/T.M.P. **NO. C/B.M.P.** **NO. C/PR.**
CONDITION OF PISTON RINGS

NO.	RING GAUGINGS	RINGS RENEWED	RINGS FREE
1			
2			
3			
4			
5			
6			
5			
5			
7			
8			
9			
10			
11			
12			

PRESSURE TESTED __________

PISTON ROD SLEEVE GAUG'S MAX. __________

PISTON ROD SLEEVE MACH'D __________

PISTON ROD SLEEVE RENEWED __________

BOTTOM EXHAUST PISTON NO. C/B.E.P.
CONDITION OF PISTON RINGS

NO.	RING GAUGINGS	RINGS RENEWED	RINGS FREE
1			
2			
3			
4			
5			
6			

CROWN EROSION __________

CROWN WELDED __________

PRESSURE TESTED __________
GLAND BOX CHANGED __________
DIAPHRAGM PACKING __________

LINER
LINER RENEWED

NEW LINER	C/TL.	C/CP.	C/BL.	C/EP.
OLD LINER	C/TL.	C/CP.	C/BL.	C/EP.

GENERAL CONDITION OF LINER __________
CONDITION OF TOP EXHAUST PORTS __________
CONDITION OF BOTTOM EXHAUST PORTS __________

LINER GAUGINGS

	A	B	C	D	E	F	G	H	J	K	L	M	N	
F & A														F & A
ATH														ATH

	TOP EXHAUST PISTON	MAIN PISTON	BOTT. EXHAUST PISTON
CHANGED			
NUMBER OF PISTON REMOVED	C/T.E.P.	C/TMP. C/BMP. C/PR.	C/B.E.P.

TOP EXHAUST PISTON SCRAPER RING EXAMINED __________
BOTT. " " " " " __________

Ref. EDO I. L.P. 1/56 G 80059

FIG. 11(c)—*Typical maintenance sheet suitable for a complete double acting opposed piston cylinder unit*

AUXILIARY ENGINE DATA SHEET

M.V.____________________ VOYAGE NO.____________

SURVEY	DATE	PORT	SURVEYOR	ASST. SUPT.	CHIEF ENGINEER
M.O.T.					
LLOYDS					

CRANKSHAFT DEFLECTIONS

CRANK	1	2	3	4	5	6	7	8
ZERO AT T.D.C.								

MAIN BEARING

BEARING NO.	1	2	3	4	5	6	7	8	9
CLEARANCE									
REMETALLED									
CROWN THICKNESS									

BOTTOM END BEARING

CYLINDER NO. ...	1	2	3	4	5	6	7	8
CRANKPIN SIZE ...								
CLEARANCE								
LINERS OUT								
REMETALLED								
CRANKPIN LAPPED ...								

TOP END BEARING

BEARING NO.	1	2	3	4	5	6	7	8
GUDGEON PIN SIZE								
CLEARANCE PIN & BUSH ...								
BUSH RENEWED								
CLEARANCE PIN & PISTON ...								
PIN RENEWED								
PISTON RENEWED								

LINER GAUGINGS

LINER NO. ...	1		2		3		4		5		6		7		8	
	FORD.	AFT	FORD.	AFT	FORD.	AFT	FORD.	AFT	FORD.	AFT	FORD.	AFT	FORD.	AFT	FORD.	AFT
TOP																
MIDDLE																
BOTTOM ...																
LINERS RENEWED																

CYLINDER HEADS

CYLINDER HEAD NO.	1	2	3	4	5	6	7	8
EXAMINED								
RENEWED								

MAKER'S ENG. NO.__________

SHIP ENGINE NO.__________

POSITION IN VESSEL__________

ENTER IN BLUE — MERSEYSIDE

ENTER IN RED — GLASGOW

ENTER IN GREEN — BRISTOL CH. LONDON AND CONTINENT

Ref. E.D.O. I.

FIG. 11(d)—*Typical maintenance data sheet for auxiliary engines*

Discussion

MR. W. MCCLIMONT, B.Sc. (Member) said that the subject of the paper was one of great interest to all sides of the industry, and they were indebted to Mr. Falconer for a thought-provoking paper.

There was increasing evidence that shipowners were realizing that the trend of design of marine machinery called for some modification of the traditional methods of maintenance. Design and maintenance methods had always been interdependent, and, as the pressure of demand for improvements in power/weight ratio and specific fuel consumption forced the designer to reduce his factors of safety (or of ignorance), so the approach to maintenance must follow this development. His own understanding of the traditional approach referred to by the author was that in design it meant trying to ensure that all components were built to last for ever and in maintenance it meant improvising to cover up the fact that the designer had not fully attained his objective.

Whether one approved of the change or not, the tradition of aiming at unlimited life had had its day. Other fields of engineering where high performance and light weight had great advantages had produced a "limited life and replacement" philosophy which had seeped steadily into the marine field and would do so at an increasing rate. The process would be hastened by the growing problems of maintaining adequate staffs of really efficient seagoing engineers which would tend to transfer more and more of the maintenance of a ship to the "base workshop", and that preferably in its home port. These developments undoubtedly called for a high standard of planning of fleet maintenance and Mr. Falconer had shown in his paper the thought that was being put into meeting this challenge.

The design of marine machinery in recent years had made steady progress in providing the economic advantages arising from increased speed, increased payload and reduced fuel consumption; maintenance costs must of necessity be higher; that was the price of the advantages that had been gained and the true objective should be to carry the efficiency of maintenance methods to such a high standard that the price was not too high and in the overall picture one was left with a sizeable credit balance. It might have been noticed that he had not mentioned reliability. He did not like the suggestion, so often made, that reliability must be improved. He preferred to think that the aim should be to maintain the wonderful tradition of reliability that British marine engineers had inherited from those who went before them.

Looking in detail at some of the planning proposals that Mr. Falconer had made, he felt a little disappointed that he had not developed the best part of his paper, which was rather tucked away in a condensed form at the end. It was difficult to comment on his planning methods without more of the all-important details, and one could not differ with him on the general principles he set forth on organization. The only observation which might not be redundant was to draw attention to or underline once again the danger that statistics might be improperly used to prove anything. If a small staff on a part-time basis was to be employed, which was suggested as a possibility, it was desirable to avoid histograms unless it could be etablished that the small staff could really read them and understand them.

He would like to stress the value of the sifting and tabulation of service information to those who had to investigate the causes of the ills that beset ships. They were much indebted to Mr. Falconer, to his colleagues and to all who adopted similar methods for the assistance they received in the investigation of difficulties. The high degree of control of maintenance which was practised by forward-thinking people like that enabled them to get quickly and accurately the information on the performance and life of present designs which was the true starting point of future development.

Mr. Falconer, he was afraid, erred considerably at one point when he suggested that the preparation of record sheets was more properly the function of the engine builder. Firstly, with all due respect, he suggested that a competent progressive superintendent engineer knew better than the engine builder. Secondly, no engine builder, however honest, could be expected to suggest all the things that might go wrong with his product. However, it was certainly true that close collaboration was desirable between manufacturer and operator on all matters arising from "limited life" designs, and more could probably be done by engine builders to indicate to the operator the life expectancy of components and to discuss with him the economic suitability of design of this kind. Such collaboration would probably eliminate much misunderstanding and recrimination.

In the middle of his paper the author dangled some tempting bait in the form of observations on details of the design of boilers and auxiliaries. He would only rise to one of these to observe that the only apparatus and technique available in this country which would give an accurate determination of the effect of scale on the heat transfer through the walls of a condenser tube was being operated by the British Shipbuilding Research Association on a research programme. It was a finicky business which he would not recommend to any superintendent engineer as standard equipment.

He would like once again to thank Mr. Falconer for an interesting paper.

COMMANDER H. T. MEADOWS, D.S.C., R.D., R.N.R. (Member) said that being a typical marine engineer, trained in the hard school of the British India Steam Navigation Co., Ltd., where all machinery, boilers and valves were opened up in careful rotation, quite apart from any classification survey requirements, he remembered the second engineers of those days, those stalwarts who without rule book or guidance or forms or reports kept their jobs running efficiently without breakdown and with the minimum assistance from shore labour and, indeed, with the minimum engine stores.

Later on, he prided himself on doing likewise for a number of years as a chief engineer. But by this time there were fewer stalwart seconds. With this background, then, he was most sceptical when, earlier in the year, he was introduced to planned maintenance. He imagined it to be some product of the modern age, some necessity due to present standards and, in fact, some sort of reflection on the capabilities of chief engineers. He thought how hostile he would have been to it had he still been at sea.

His only reason for speaking was to inform them of this and to tell them how wrong he was and how easily and quickly he was initiated. Unfortunately, this initiation had taken place while he was undergoing naval training and not being sure of the security regulations in this matter he hoped that a representative of the Admiralty might be allowed to enlighten them as to the great success planned maintenance had proved in Her Majesty's Navy.

It seemed to him that in an already well-run ship the real benefit of planned maintenance was to the shipowner and to the superintendent and this benefit could be achieved with little extra work on the part of the chief engineer. In due course, the ship's staff would benefit when, over a period, records which were at present kept on the ship or in someone's head were collated and the fact that certain pieces of machinery, valves, equipment and so on were of inherently bad design, or which were perhaps inaccessible, would become apparent by excessive cost in man-hours or spares.

On the other hand, if there were any badly run or inefficient ships, the offenders could easily be traced, and the old cry of "Oh, that pump has never worked, sir", would never be heard again.

He suggested that trouble should be taken to show the engine room staff how planned maintenance would work and what immense value it could be not only to the administration but to themselves in that the installation in future of troublesome machinery and fittings could be avoided.

To his mind the author summed up planned maintenance in his paragraph on page 39, which said:

"There is little doubt that machinery maintenance can be made more effective when routine maintenance on board ship is planned as part of the general maintenance organization. Standard practice once established avoids foolish maintenance which leads to greater repairs. The concise maintenance report which is a feature of this type of organization should include the time taken to service or overhaul the unit. Provision should also be made for abstracting the defects".

Then he would like to take one of Mr. Falconer's phrases out of its context, if he might, and say that planned maintenance was, to use the author's own words, "the logical conclusion to what has been standard practice for many years with main propelling machinery".

If he might make a constructive criticism, he would suggest that the scope of planned maintenance should be widened immensely to cover not only the engine room but also the rest of the ship. Why not cover the hull, tanks, electrical machinery, everything in the ship? There in the office would be a complete record which must be of great use to the shipowner in estimating renewals probably necessary at survey and thus allow him to budget not only for cost but for time out of service.

Finally, he congratulated the author on having the courage to bring to the notice of the Institute this most important aspect of the work of the profession.

MR. J. MCAFEE (Member) said that so far as he was aware this was the first occasion on which a paper of this type had been presented to the Institute. He hoped, therefore, that since the subject was of such interest to all concerned with the intelligent operation of machinery it would arouse the discussion it deserved.

The author had defined his terms of reference by stating

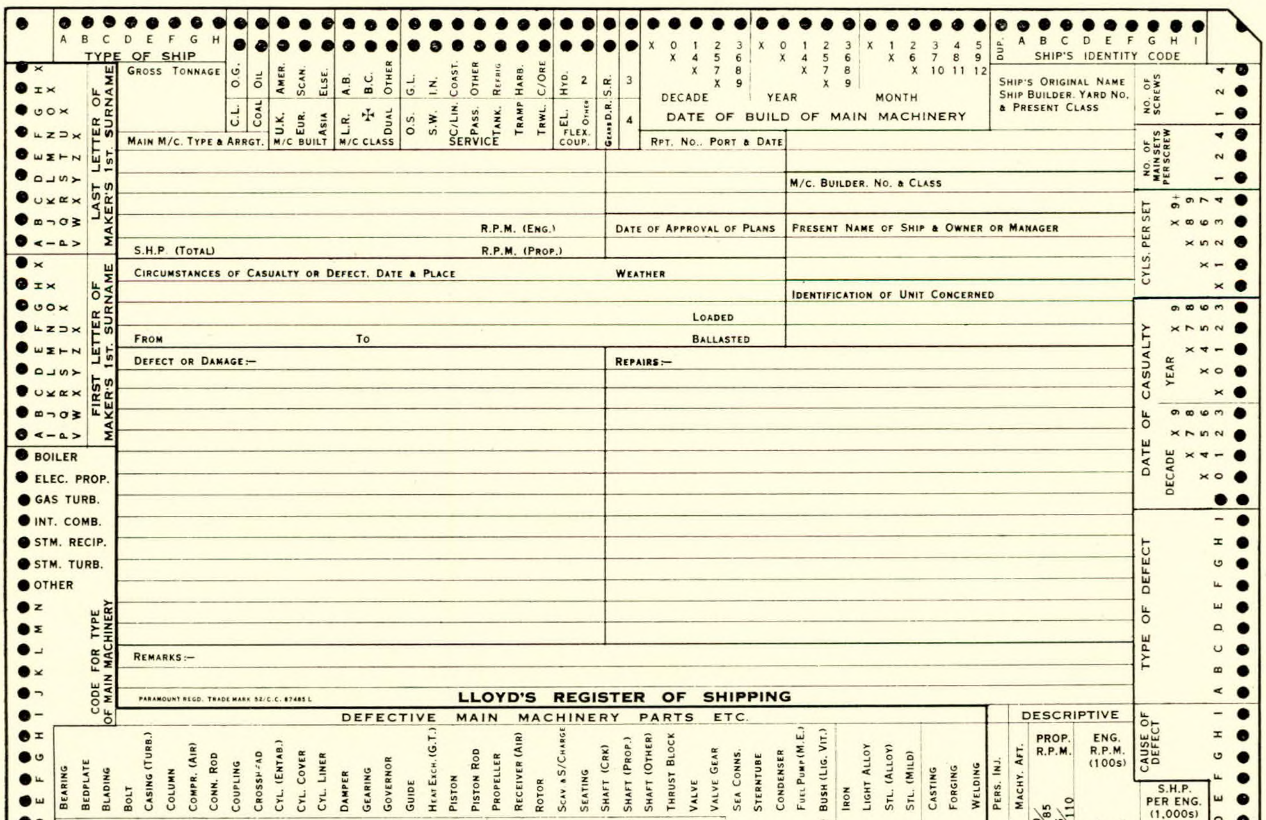

FIG. 12

that the object of planned maintenance was to avoid, as far as possible, the risk of breakdown in service, and no one would disagree with that. On studying the paper, however, it seemed that instead of pursuing this aspect, he was largely concerned with methods for analysing and recording cylinder liner and piston ring wear in internal combustion engines. One would not dispute for a moment the advisability of recording such data, and so planning in good time when and where renewals were to be effected. What was surprising was the implication that this was an important factor in obtaining the freedom from trouble which was postulated as the object of planned maintenance. Wear of liners or rings usually produced various undesirable consequences but nothing so catastrophic as a breakdown.

When considering pistons or liners incipient cracks were the most dangerous factor. Crack detectors were briefly mentioned in the paper but would the author say if any drill had been laid down for their regular use when parts were opened up for inspection? A cracked piston was illustrated which outwardly had appeared flawless. Did this discovery, for example, lead to a regular practice of ultrasonic testing of all pistons of this type?

Many breakdowns were due to the failure of the engine room staff to make periodical inspection of bolts and other fastenings inside crankcases, particularly on moving parts. Had the author any system for ensuring that this was carried out regularly? Bottom end bolts, more so in auxiliary engines, were another well-known source of trouble, and it would be interesting to learn if these had given rise to any special routine.

The author stated that the survey requirements of Lloyd's Register "automatically involve opening up much of the machinery, but unfortunately in many cases the information so readily available is not recorded in the manner needed to ensure that it can be used for forward planning". This seemed strange since one would have assumed that any planned opening up for maintenance purposes would be linked to the periodical opening up required for survey purposes. Perhaps, however, the author would enlarge on this point and say to what extent survey requirements were of assistance to his planning. Did he consider that these requirements were too exacting in his particular service, or not exacting enough?

Classification Survey Rules must be framed on a broad basis owing to the wide variation in types of machinery, nature of service, and, to some extent, the standard of maintenance. Nevertheless, these Rules were framed with the same object in view as planned maintenance, namely, the avoidance of breakdown in service. In complying with the Rules, the individual surveyor would tend, in the absence of precise instructions, to interpret them in his own way, and to look more closely at one item than at another. His outlook would be conditioned, as in other walks of life, by his own particular experience, and by what he himself had seen fail. In Lloyd's Register it had been the practice, therefore, for many years to supplement the Rules by circular letters to surveyors emphasizing the importance of details which the records suggested were not receiving sufficient attention. Within recent years this system had been much improved by setting up at Headquarters a special department for card indexing all reported defects. The type of punched card used for this purpose was illustrated in Fig. 12.

Each hole around the card was coded to a particular feature so that there was a complete coverage of engine and boiler types, builders, nationalities and, of course, the types of defects themselves. As each report was received a fresh card was filled in with brief particulars of the defect, the name of the ship and type of machinery, and the appropriate holes were then clipped free. When these cards were subsequently stacked together, a long needle could be inserted through the hole related, say, to crankshafts, and another needle through the hole for oil engines over a certain bore. When the cards were then lifted only those giving defects with crankshafts of the size in question would fall out.

The information thus recorded was periodically analysed so that surveyors could be advised of recurrent defects, or in extreme cases amendments made to the Survey Rules. One might suggest, therefore, that this was a contribution to planned maintenance.

Over 10,000 ships were classed with Lloyd's Register and this procedure therefore represented the accurate recording of the service failures of a vast floating laboratory. The work involved prevented the system from being operated until comparatively recently so that the full value of the records would only be obtained with the march of time. The information then to be harvested should help them all in their common aim of avoiding breakdown.

MR. H. CASSIDY (Member) said that Mr. Falconer's paper was full of progressive ideas but the title was somewhat abbreviated and should have read "Some Aspects of the Application *and Execution* of Planned Maintenance to Marine Engineering". No amount of planning alone would in itself produce the required results which, as Mr. Falconer rightly said, were reliability and reduction of costs.

There were one or two operations in his mind by which he might illustrate this point. When a piston was drawn from a cylinder of any motor ship, it was the usual practice for the engineer to be told and to make sure the lubricator holes were cleared. Many engineers pumped the cylinder lubricator and when they saw the oil was going through the lubricator holes into the cylinder, said they were clear. Possibly after a week's running, however, those holes were not clear and the correct procedure was to drill the hole out each time the piston was taken out and ensure maximum bore at the beginning of the voyage.

Similarly, in the case of scavenge and exhaust ports, it was important to radius scavenge ports and exhaust ports every time a piston was withdrawn, whether or not one had planned to radius them. If the radiusing was not done correctly the planning fell apart. Many practical operations were essential to reliability which, he would contend, could not be put on paper and could only be achieved by educating the operating staff, by discussing with and explaining to them what could happen if certain operations were not carried out. In ports where major operations and major overhauls were going on, it was essential for a reliable engineer to be present to see that all the detail for which the planning asked was carried out.

Mr. Falconer was fortunate that his present cargo turnround give him plenty of time to carry out all his engine repairs. His own time, on the other hand, was limited and he could not afford to take all the cylinder gauge readings recommended on page 48. The conditions imposed the maximum readings which, in his opinion, were the governinig consideration in deciding whether to change a liner or to carry on. Similarly, it was an expensive luxury to have fitters standing by after a piston had been cleaned, gauging all the grooves individually. A reading of the wear in the two top grooves would give a fair indication of the essential information.

With reference to the gauging of liners, the ship's engineer was quite capable of doing this; and no specialist was required, provided again that the engineer was educated to compare his readings with the previous readings and satisfy himself that there was nothing exceptional which must be investigated. The graph in itself very quickly indicated the discrepancies, and instead of accepting the idea of a specialist gauger, he would suggest that there should be more emphasis on a simple gauge for gauging liner wear which anyone could operate.

Many experiments were carried out in motor ships to reduce liner wear. To use one or two cylinders on an engine as an experiment was not very satisfactory. He had proved that it was essential to experiment on at least 50 per cent of the cylinders or better still on the entire engine—and for a reasonable time—as more than one operation of the engine could affect liner wear.

He completely agreed with Mr. Falconer when he said in his paragraph on performance testing that the auxiliary engines should be at all times capable of taking their full load. However, the full load of the chief engineer in some cases was more accurate than that of the builders. Many a superintendent, including himself, had grey hairs trying to disprove this statement.

One aspect of planned maintenance which was not mentioned in the paper was the difficulty of ascertaining the true voyage costs. For example, suppose a piston were taken out of a large double acting engine and all that was wrong with it was that the sleeve was worn and required machining. Time was not available for this so a spare piston was drawn from the store. This piston might be entirely new material, and the cost plus assembling all this material together might be £1,000. A credit was given to the piston taken out but everyone knew that secondhand value deteriorated very rapidly. If a credit of £500 were given for the piston that was taken out, there was then a discrepancy of £500 with which the ship was charged on that particular voyage, while, had there been time, possibly £30 would have covered the machining of the sleeve and putting the piston back in the ship again. Therefore, with planned maintenance, operation costing should not be done principally on voyages but over a much longer time.

He congratulated Mr. Falconer on his excellent paper and agreed with possibly eighty per cent of what he had said. He hoped all the initiative would not be taken away from the marine engineer, however, and that he would not have to spend his time in his room filling up forms while something not on the schedule sheet was breaking down.

MR. B. ROGERS (Member) said that he had awaited the production of the paper with some anxiety. He was a little afraid until he had investigated that the author of the paper might be an efficiency expert from one of the time study organizations, who was coming along to instruct marine engineers on how to maintain machinery.

He had had some experience during the war with this type of management genius, when he and other colleague engineers were inflicted with planned maintenance for factories. They were supplied with wonderful charts, coloured crayons, and so on, but the skilled labour available amounted to 1·6 per cent out of a total of engineering personnel—at the factory at which he served—of 1,850; this figure applied to the total for all trades, building, woodworking, electrical, boilermaking, pipefitting, machine shops, transport servicing and repair, etc., and maintenance of machinery.

There were some 7,000 different machine tools in the factory—presses, mixers, hydraulic pumps, power plant and other important machinery. What they were up against in carrying out planned maintenance, therefore, was a lack of skilled labour. It meant that the junior supervisors were drawn away from their ordinary duties to plan the work or the number of operations, or the times in a year when the plant would be opened up for observation and consequent recording of data. In other words they had to work to plan and not to necessity. It was not always possible to work to such a scheme, especially with restricted conditions, inadequate material supplies, and lack of properly skilled labour.

Mr. Rogers said that in his own profession, the science of marine engineering—they were engineers working with engineers for engineers—and that this aspect did not apply to such an extent.

He could agree with the author that now was the time to consider, in an effort to reduce the repair or maintenance cost of ship management, the introduction of schemes similar to that outlined in the paper. There was plenty of support for that contention, and most of the previous speakers had touched on this so he would not enlarge on it. He would warn Mr. Falconer and other superintendent engineers, however, that if they were not careful the compiling of statistics could get out of hand and proper maintenance would suffer.

In addition, he would go on to mention another aspect sometimes embodied in planned maintenance, and that was incentive bonus payments to shipyard and shiprepair workers.

With planned maintenance, i.e. periodic opening up of machinery for inspection purposes, with possible extension of the set time planned for the operation, because of say, necessary renewal or repair, if the operation were linked with a time study control of payment for the operation, there was a danger of scamping, both of the inspection and of any necessary renewal or repair, due to the introduction of this bonus factor. Which meant, therefore, that unless rigid and efficient inspections were made by an inspector—who must be a qualified person—to see that the mechanical part of the work was carried out efficiently, such inspections might be recorded on charts, without necessarily being of any real value, and it was to be recommended that planned maintenance should be entirely divorced from incentive bonus systems or any other system of rate fixing.

CDR. O. J. F. L. ST. JOHN, R.N., said that five planned maintenance organizations had recently been set up in the Royal Navy and of those organizations he was the engineer officer from the one at Chatham.

Great stress had been laid on the necessity for considering a ship as an entity, and care had been taken to see that the maintenance schedules for all departments fitted in one with another. It was considered that hull and deck maintenance was of equal importance with maintenance in the engineering and electrical departments. With Commander Meadows he was interested to see that no mention was made of planned maintenance in departments other than engineering.

The first step that was taken was the introduction of the maintenance schedule itself, and reports back had been received for about eighteen months now. These it had been possible to analyse to see if the periodicity of the maintenance routines which were put out to the Fleet was correct. It was early days to say whether this was so or not, but one thing could most definitely be said: that defects were dropping. As the maintenance was done to the schedule, fewer defects were being reported back.

It was important to establish for reasons of economy exactly how much maintenance was required. In fact, too much could be as bad as too little. Unless machinery was being regularly used, it was thought to be unwise to stick too rigidly to running hours as a basis for examination, as chemical decomposition was more often a function of time. It might be necessary in some cases—and this had been found in the Navy—to stipulate a calendar as opposed to a running hour periodicity between examinations.

A distinction was made between block and running maintenance. Block maintenance meant that maintenance must be done during a specified maintenance period, whilst running maintenance—which concerned mostly items of a low periodicity—could be carried out at short notice or at sea.

It would be interesting to know whether any maintenance schedules had been provided for such things as deck winches and other deck machinery which might be looked at whilst at sea.

He entirely agreed that it was essential to have the necessary tools for the job, and much could be done to lessen maintenance time by the use of such items as flaw detectors and vacuum cleaners. In this connexion, an impassioned letter was received from a commanding officer quite recently, pointing out that a vacuum cleaner should certainly be part of his equipment. His wife was getting fed up with lending hers, and it was going backwards and forwards every day in his motor car. Could the Admiralty please provide one?

To be effective, planned maintenance must save work, and this was the aim. There was a need, therefore, for method study—not time study—by experts in the class of ship, who would promulgate the sequence of operations in that class. Time study for its own sake, he considered, would never be necessary. If a job could be done in this, that and the next way rather than in some other sequence, time study might be used as a means to establishing this end, but the best way of getting average times was from sea experience. Conditions of service varied in temperate and tropical climates; and time study would only be misleading, if used.

The Royal Navy was going over to the type of binder described by Mr. Falconer. In that binder, for each piece of equipment, there would be a top card showing what the equipment was, another card showing alterations or modifications of the equipment, a wear card, a spare gear card and a history card, one behind the other.

Finally, the Navy had seen the need—as mentioned by one speaker—of indoctrinating the ship's officers. At Chatham and other places as well steps were being taken to that end. For instance, before a commanding officer went to a coastal minesweeper, he now spent a day at Chatham where he was introduced to his engines and to his machinery generally. He then came to him (Cdr. St. John) and was shown what the planned maintenance organization was.

Correspondence

DR. H. T. ANGUS thought Mr. Falconer's paper was of particular interest in the manner in which it set out the details of the methods employed to obtain data relating to the running operation of marine Diesels. The British Cast Iron Research Association had been interested for some years in the problem of the wear resistance of cast iron. It had been their experience that it was difficult, if not impossible, to correlate the results of laboratory wear tests with the results which were obtained in service. Laboratory wear tests essentially endeavoured to limit the variables in the process, and in the hands of a single operator they could give valuable assistance when combined with the operator's own experience. It was, however, very difficult to compare results from such equipment produced in different laboratories by different operators and to draw universal service experience from them.

In the field of cylinder liner wear, particularly in the marine field, although a good deal of information had been published, the number of examples which had been reported in which the operating conditions had been directly comparable was very small indeed.

This paper followed as a natural sequence from that by Mr. A. G. Arnold published in July 1956*. One of the difficulties in estimating the wear of cylinder liners in the past had been that work had been mainly carried out by engineeers whose knowledge of the metallurgy of cast iron had been limited, and where the wear investigations had been carried out by metallurgists many of the engineering factors had been overlooked. The papers by Mr. Arnold and Mr. Falconer had been able to provide much more closely detailed engineering information of a large number of marine Diesel engines, operating under one centralized control and comparatively uniform conditions under which the effect of variables could be much more clearly ascertained, and, at the same time, the metallurgical examination was being carried out in their own laboratories by Mr. Todd in conjunction with their own organization. This combination of close engineering control with full metallurgical examination had been made possible solely by the system of planned maintenance which had been outlined by Mr. Falconer, and they anticipated that as a result of this their understanding of the conditions which caused wear might be markedly improved.

MR. L. BAKER, D.S.C. (Member) wrote that he was very sorry not to be able to attend the presentation of this unusual paper in marine circles.

Mr. Falconer's contribution to the successful introduction of some measure of planned maintenance was very much greater than could be inferred from the modest statement included in the text, and it would not be wrong to say that the superintendent engineers actually responsible for the planned maintenance made a very real contribution to its success.

Fundamentally, there was nothing new in the subject of planned maintenance. The requirements of survey and of the periodic examinations of the Royal Navy were all aimed, be it unwittingly, at planned maintenance, but the operation of ships had, nevertheless, seldom been so organized that controlled planned maintenance could in fact be carried out. This was due to two causes: firstly, the variety of ship operational factors, into the operation of which it was necessary to fit maintenance; secondly, a complete absence of reliable documentation and information.

The techniques which had been introduced and which were outlined in the paper, gave some indication of what could be done by the shipowner. There was, however, one facet of planned maintenance which was perhaps even more neglected and to which Mr. Falconer did not refer. This was the supply of basic maintenance information by the manufacturers on which reliance could be placed. It was quite common for some of the major items such as cylinder liner wear to be limited by the maker's instruction handbook, but it was less common for the maximum allowable clearance of, say, a bearing of an indicator system, or even a steam turbine, to be so tabulated that there was no room for doubt in the engineer's mind.

In Mr. Baker's experience, one of the classic cases was of a feed regulator, the only really critical dimension of which was not toleranced on the drawing issued to the ship, so that the engineer had no reason at all to suppose that its dimension was important.

The change in character of marine engineering would inevitably place more responsibility on the shore going staff than on the sea going. It was far better to spend a little more money on maintenance by using intelligent forecasting than it was to have a ship break down at sea and lose precious time.

CDR. H. BOTT, R.N.(ret.) (Member) felt that the title of Mr. Falconer's paper was somewhat misleading. As he understood it, what Mr. Falconer described was cyclic repair, not planned maintenance. In his own view planned maintenance included three essential features or phases which Mr. Falconer did not mention.

First, assessment of the maintenance workload likely to be required for the unit concerned in a given period (usually, for convenience, a year).

Second, a decision when, where and how that work was to be carried out. In the case of ships, some work must obviously be carried out during certain clearly defined periods, the three most obvious being (a) in dry dock, (b) alongside or at moorings at extended notice for main engines, and (c) at sea.

Again, obviously plans would be made to carry out during the first period in dry dock (a) all routine maintenance work on propellers, shafts, rudders, underwater fittings and other equipment which required the ship to be in dry dock for normal access. The necessary spares, materials, tools, etc., would be mustered and checked for correctness and serviceability and conveniently located in readiness for use; maintenance staff would be detailed and briefed on their duties and so on.

During the second period, extended notice (b) the sort of jobs described by Mr. Falconer could be carried out and the steering gear, stabilizers and all other machinery and equipment required only at sea would be dealt with.

* Arnold, A. G. 1956. "Some Experiences in Vessels Equipped with Two-stroke Cycle Harland and Wolff Opposed Piston Diesel Engines Using Boiler Oil". Trans.I.Mar.E., Vol. 68, p. 201.

In the third period, at sea (c) the routine maintenance of winches (weather permitting!), other cargo handling equipment, power boats (whilst maintaining the required life saving capacity in readiness for use), spare gear generally and special tools and equipment, etc., could be carried out with the relatively few engineers and maintenance staff available for day work at sea.

Third, the detailing and instruction of all the engineers and other members of the maintenance staff on and for their duties in connexion with the routine planned maintenance of not only the ship's main and auxiliary machinery, but also the hull and all fittings, fixtures and equipment in the ship that require and normally receive preventive maintenance to keep them serviceable for as long as it may be economically practicable, ensuring, as far as possible, that each individual gets his fair share of work according to his qualifications and authority.

None of these requirements of a planned maintenance organization was dealt with by Mr. Falconer in his paper which was, he felt, very much more concerned with cyclic repairs of main engines and their recording than with planned maintenance.

MR. E. C. B. CORLETT, M.A., Ph.D. (Associate Member) wrote that, while the bulk of the paper was of a specialist nature, he would like to comment on two particular points.

A certain amount of misunderstanding had arisen in some cases as to desirable values for power margins, especially in Diesel ships, and also as to how these margins should be applied. In point of fact, if a large power margin were available in a Diesel ship, but if this were mainly in the form of revolutions, under certain conditions, the margin might not be available at all, or only in part, without reaching excessive temperatures and pressures. No propeller was designed normally so that the margin was available purely in this way, but very often the margin was predominantly in the form of revolutions and normal operating temperatures and pressures were then such that the torque increase called for in bad weather was not sufficient to produce an increase in revolutions and hence make available the larger part of the margin. Smaller margins, more modest trial speed: service speed ratios and more of the margin made available as torque, might well lead to better overhaul times and reduced liner wear.

The piston illustrated in Fig. 7 was most interesting. One would not normally perhaps anticipate such a well disguised crack, but to detect a defect of this type before the plant was used was clearly of major importance and detail inspection should prove much less expensive than dealing with the consequences of a failure.

MR. R. M. MURRAY (Member) considered that the author was to be commended for the clear and concise manner in which he had presented his paper, which indicated that the services of additional staff recruited for the sole purpose of chemical and metallurgical research, collection and collation of wear and other data should, with the wholehearted collaboration of the chief engineer and his staff, pay dividends to the shipowner who was sufficiently far seeing to sanction the necessary and costly increase of personnel.

Although various types of ocean going vessels were mentioned in the paper, it was noticed that no account was taken of the large, fast passenger liner designed to carry refrigerated and general cargo. This class was well represented on Commonwealth routes where perhaps rigid adherence to a mail schedule called for continuous service year in and year out and where some economic factor precluded the annual lay up, so that all repair, survey and maintenance work must be undertaken during the two to three weeks' stay in the home port between voyages of, say, six to eight weeks' duration.

Was it implied that ships of this type could not be maintained in a fully efficient condition without periodical lay up?

With reference to preventive maintenance of Diesel machinery, did Mr. Falconer favour renewal at regular intervals of large bolts subject to fluctuating stresses, even though the use of electro-magnetic or ultrasonic crack detectors indicated freedom from defect?

The writer would like to express an opinion formed by personal experience that standardization might well be extended to some electrical equipment.

The predominant method of driving marine pumps was by the extremely vulnerable electric motor, the armature of which might be easily damaged seriously by access of sea water or other fluid. The failure in this manner of a pump essential for operation of main machinery might immobilize a vessel and delay could be considerably reduced were the transposition of a motor complete with entablature with a similar motor performing a less vital service possible. Apart from failures by accident or negligence it was not unknown for serious defects to appear in windings of comparatively new motors.

MR. E. PERRY (Member) thanked Mr. Falconer for a most interesting paper on a subject which had hitherto not been widely discussed. Having had several years' experience in endeavouring to institute a planned maintenance scheme, he would like to make a few personal observations.

To carry out planned maintenance the most essential requirement was an adequate supply of suitable labour familiar with the type of machinery fitted to the company's vessels. If the majority of the work was carried out at regular intervals at a small number of ports, an efficient body of technicians who were assured of permanent employment could be readily available as and when required. This was most essential where the concise maintenance reports mentioned by Mr. Falconer showing the time taken to carry out the work were used. All too often, where repair work was seasonal, the most efficient labour transferred to more attractive employment where permanency was assured. The technicians familiar with the maintenance of machinery were also ready for the job that all too frequently did not run according to plan. Great care should be taken that only sufficient data be recorded for the planning of future maintenance otherwise the system became bogged down with paper work. The amount required could only be decided upon by experience. Another difficulty was the training of staff to fill in record sheets of examinations carried out by ships' personnel abroad. This was probably due to the continuous change in seagoing personnel.

Was the engine builder in a position to draw up data sheets as Mr. Falconer suggested? Some of the sheets issued prewar were undoubtedly a useful guide to the operating staff just taking over a new type of machinery, but, after operating the plant for several years, experience showed that quite a number of components did not require to be so frequently examined while others required more attention than recommended. Did the engine builder know the type of personnel maintaining the plant? This had a very important bearing on the amount of maintenance required. He suggested that the engine builders were quite often out of touch with the performance of their products in actual service. He knew of defects reported to the manufacturers of machinery who stated that they were the only people having this trouble. Comparing notes with users of similar machinery, it was discovered that they were experiencing similar difficulties. He suggested that the shipping company's technical staff should arrange its own overhauling schedule.

The "repair by replacement" had proved a very worth while innovation. However, it would be necessary to design engine room layouts much more intelligently to allow the various units to be removed from the vessel without the dismantling of major items such as large sections of pipe work, gratings, engine room platforms, etc. From personal experience, he had found that the cost of removal of some of these items could exceed the saving achieved by changing the unit.

PROFESSOR K. J. SHONE, M.A. (Member) thought that Mr. Falconer rightly stressed that records were a prerequisite to planned maintenance, and without detail records more imaginatively analysed, planned maintenance could never achieve its proper goals.

Some of the burden of record keeping was likely to fall on seagoing staffs, and he felt that a reference to the part they could play in a scheme of planned maintenance was worth amplification, if only because those seagoing staffs, if well enough trained, were in a place to reduce the need for maintenance and assist forecast when it became desirable. In his time at sea, a decade ago (so he hoped to be well out-of-date now) little use was made of junior or some of the senior engineers to analyse the performance and maintenance of the machinery in their care. There were no past records of performance or any useful details of repairs kept in the ship to assist these men, and after a few voyages they transferred to other ships and their experience, too, was lost to their successors. This practice made one self-sufficient and quick to learn by experience—virtues which were costly in personal time and occasionally to the company in delays, and always in setting up to do repairs aboard ship.

He would like to see a two-way communication system established, so that all seagoing engineers were expected to write reports on the performance, operation, and repair of the auxiliaries and equipment under their special care. Such reports should be typed and copies circulated so as to provide (1) a record of useful information for future engineers joining the ship, (2) a commentary on performance which could be useful to shore staff if they were wise enough to realize the value of the occasional inspiration which comes to the young, (3) a copy, annotated by the superintendent engineer's office for the writer of the report, so that he knew his good ideas had been noted by his superior.

Such a system, he thought, would go a long way to assisting young men really to examine their personal experience and make subsequent "ticket" hunting easier. At the same time, it could mitigate the effect of labour turnover in the ships and give men a sense of belonging to the company, and shore staffs a better idea of the problems on which they could give guidance and help to those sailing in the ships.

(The author's reply to this discussion will be published in a later issue)

INSTITUTE ACTIVITIES

Minutes of Proceedings of the Ordinary Meeting Held at the Institute on Tuesday, 11th December 1956

An Ordinary Meeting was held at the Institute on Tuesday, 11th December 1956, at 5.30 p.m., when a paper entitled "Some Aspects of the Application of Planned Maintenance to Marine Engineering", by W. H. Falconer (Associate Member), was presented and discussed. Mr. T. W. Longmuir (Chairman of Council) was in the Chair and seventy members and visitors were present. Six speakers took part in the discussion.

A vote of thanks to the author, proposed by the Chairman, was accorded by acclamation. The meeting ended at 7.20 p.m.

Annual Conversazione

The Annual Conversazione was held at Grosvenor House on Friday, 7th December 1956. The President, Sir Donald Anderson, and Lady Anderson received the 1,560 guests.

After dinner Sydney Jerome's Ballroom Orchestra played for dancing until 2 a.m., except for two interludes: during the Cabaret Wally Fryer presented his 1956 Version of "Champions of the Ballroom" and was followed by Johnny and Suma Lamonte; later there was a Floor Show with Warren, Devine and Sparkes, the Four Gitsom Sisters, and Gene Detroy and the Marquis Family.

Section Meetings

Kingston upon Hull and East Midlands

A meeting of the Kingston upon Hull Section was held on Thursday, 13th December 1956 at 7.30 p.m. at the Royal Station Hotel, Kingston upon Hull. Mr. J. G. Charlton (Vice-Chairman of the Section Committee) took the Chair and there were thirty-three members and visitors present.

The lecture by Mr. G. H. Clark (Member) on "Marine Lubrication" had had to be cancelled at short notice as the result of a bereavement in the author's family but Mr. F. J. Mayor (Member) travelled from London to present his paper entitled "Diesel Hydraulic Propulsion". The paper was illustrated by lantern slides and a short film and was followed by discussion. Mr. Bryan Taylor proposed a vote of thanks to to the author which was seconded by Mr. A. E. Walker, expressing the gratitude that was felt for Mr. Mayor's prompt helpfulness in the emergency and for his interesting lecture.

A meeting of the Section was held on Thursday, 17th January 1957 at 7.30 p.m., at the Royal Station Hotel, Kingston upon Hull, when Mr. A. R. Kenworthy presented the film, "Ocean Highways". The film was lent by Crossley Bros., Ltd., and dealt with marine practice and installations.

Mr. F. C. M. Heath (Vice-President) was in the Chair and there was an attendance of ninety-six. A vote of thanks to Mr. Kenworthy was proposed by Mr. H. F. Hesketh and seconded by Mr. C. Kling.

Scottish

A joint meeting of the Scottish Section was held with the Institution of Engineers and Shipbuilders in Scotland on 12th December 1956. Capt. N. J. H. D'Arcy, R.N.(ret.), Chairman of the Section, presided and eighty-five members and visitors were present. Mr. A. W. Davis, B.Sc. (Member) gave a most interesting paper on "Reheating as a Contribution to the Economy of the Marine Steam Turbine with Special Reference to the Installation in T.S.S. *Empress of Britain*", and some twelve speakers took part in the subsequent discussion. The meeting terminated at 9.15 p.m. with a hearty vote of thanks to the author on the proposal of Professor Small, Vice-President of the Institution of Engineers and Shipbuilders in Scotland.

A general meeting was held at the Institution of Engineers and Shipbuilders in Scotland, Glasgow, on 9th January 1957, the Chair being taken by Capt. N. J. H. D'Arcy, R.N.(ret.) (Chairman of the Section).

Mr. E. M. Currie gave his paper on "Cast Irons in Marine Engineering", illustrated by lantern slides, before an audience of seventy-five. Six speakers took part in the discussion that followed.

The meeting terminated at 9.15 p.m. with a hearty vote of thanks to the author for his excellent paper, on the proposal of Mr. D. W. Low.

Junior Section

Cardiff

A Junior Meeting was held at Cardiff College of Technology and Commerce on Wednesday, 16th January 1957, at 7.15 p.m., when Mr. A. G. Arnold presented his paper entitled "Some Experiences in Vessels Equipped with Harland and Wolff Opposed Piston Engines Using Boiler Oil". The Principal of the College, Dr. A. Harvey, B.Sc., F.Inst.P., was in the Chair and there was an attendance of seventy-five. The Chairman, in introducing Mr. Arnold, referred to the valuable work the Institute was doing in arranging for lectures to students by authors of his eminence in the engineering profession.

Mr. Arnold presented his paper in a simple talk which was interesting and understandable to all, which he illustrated by recounting many amusing experiences. It was a most successful evening for both the senior and junior members of the audience.

A vote of thanks to the author was proposed and seconded by students, Messrs. H. J. Rapson and D. J. Turner respectively, and was carried by acclamation.

The Chairman of the South Wales Section, Mr. H. G. Wickett, M.B.E., then presented the Institute awards for the Ordinary National Diploma Course to the best first year and the best second year students of the College, Mr. D. J. Turner and Mr. A. Scott.

Student Section

A meeting of the Student Section was held at 85, Minories, London, E.C.3, on Monday, 3rd December 1956, at 6.30 p.m., when a paper entitled "Sulzer Engines" was read by Mr. R. Shillington.

Twenty-five members and visitors were present and ten speakers took part in the discussion.

A vote of thanks proposed by the Chairman was accorded by acclamation. The meeting ended at 8.0 p.m.

Sir Donald Anderson (President) and Lady Anderson

Mr. James Calderwood, M.Sc. (Honorary Treasurer and Vice-President) and Mrs. Calderwood, Sir Donald Anderson and Mr. Stewart Hogg (Member of Council)

Annual Conversazione, 1956

Sir Donald and Lady Anderson, Mr. T. W. Longmuir (Chairman of Council) and Mrs. Longmuir at the reception

Sir Donald and Lady Anderson, Mrs. Longmuir, Mr. Longmuir, Mrs. Hogg and Mr. Hogg

Annual Conversazione, 1956

Election of Members

Elected 4th February 1957

MEMBERS

Foster Brown Andrews
William Frederick James Brading, Cdr., R.N.
Stanley Graham Brown
Leonard Frederick Clark, Eng. Lieut., R.N.
John Swanson Clyne
Arie De Jong
Peter Du Cane, Cdr., R.N.(ret.)
James Herbert Lewin
Kenneth McKenzie
Charles Ritchie Walker Marsh
Francis John Powell
Henry Barrell Prentis
William Henry Sampson
Charles Roy Skinner
Charles Smith
Adam John Thomson
Christopher Wappett

ASSOCIATE MEMBERS

Maurice Crowe Armstrong
Peter Johnson Beaman
Robert James Burnett-Godfree
William Maxwell Clements
Peter Henry Rivers Cripps
Alan Mason
Alexander Miller
Richard Povey
John Wedgwood Stangen
Arthur Doran Walker
Thomas Wylam Welch
Alan Wilson

COMPANION

James Robertson Mackay

ASSOCIATES

Ronald Davis Cooke
Leonard Court
Edward Gillon
William Lynn Nelson, Jnr.
William James Pitts
Mark Thornton, Cdr., D.S.O., D.S.C.
Maurice Walter Wood

GRADUATES

Henry Arthur Curnow
Kenneth James Davison
John Clement Evans
John Tickle Hilton
Subramaniam Kalidas, Lieut., I.N.
Joseph Patrick Lobo
Maung Sein Maung
Christopher David Monks
Robert Russell Pike
Stephen John Radway
Joseph Albert Rodrigues
Raymond John Southwell

STUDENTS

Barry David Jones
Colin Denis Nealon
John James Waugh

PROBATIONER STUDENTS

James Aldred Bambrough
Richard Wallace Carrick
Robert Jackson Gill
Graham Brierly David Milne
Robert Preston
Alexander Duncan Tosh
Robert Lambert Wilson

TRANSFER FROM ASSOCIATE MEMBER TO MEMBER

Frederick Henry Evans
Walter Ellis Fotheringham
William Millar Lawson, B.Sc.(Belfast)
Tom Salter

TRANSFER FROM ASSOCIATE TO ASSOCIATE MEMBER

Norbert Dienes
Douglas Gray
Malcolm Francis Heslop
Henry George Jarvis
Panchanan Majumdar, Lieut., I.N.
James Brennan Neilson

TRANSFER FROM GRADUATE TO ASSOCIATE MEMBER

David Seymour Aris
John Graydon Kellett
Panagiotis Anthony Lemos, B.Sc.(Durham)
James Joseph Shields

TRANSFER FROM PROBATIONER STUDENT TO STUDENT

Peter Jon Calder
James Myles Barry Dinsdale
Brian Jameson
Howard Lloyd
Carl Christopher Peterson
Richard Dudley Payne

OBITUARY

JAMES BROADLEY (Member 9299) was born in 1901. He served an apprenticeship with William Beardmore and Co., Ltd., Glasgow, from 1917/22, and after a further year or two ashore he went to sea, sailing for the best part of the next eleven years with the Clan Line Steamships, Ltd. He obtained a First Class Board of Trade Certificate and came ashore as foreman engineer for William Beardmore and Company, holding this position for the next twelve years. In 1947, however, he was appointed resident inspector to W. J. Fraser and Co., Ltd., Barnsley, being promoted production manager in 1949, the position he held at the time of his death on 10th December 1955. Mr. Broadley had been a Member of the Institute since 1941.

ANDREW JOHN BROWN (Member 4705) was born in 1897. He served an apprenticeship with Scott's Shipbuilding and Engineering Co., Ltd., and after a short period as lieutenant in the marine section of the Royal Air Force in 1918/19 he spent a year or so at sea as fourth engineer in the Glen Line. He was an engineer in the Diesel engine department of William Beardmore and Co., Ltd., for the next three years and was employed for a short time with Richardsons, Westgarth and Co., Ltd., before joining Lloyd's Register of Shipping as a surveyor in 1925, a connexion which was maintained until his death on 2nd August 1956. He was in Liverpool from 1927/30, in Split, Jugoslavia, from 1930/37 and the rest of the time in Glasgow.

Mr. Brown was elected to Membership of the Institute in 1923. In 1923 he was awarded the Denny Gold Medal for his paper entitled "The Marine Diesel Engine, Its Reliability in Service".

JOHN ALEXANDER CRAIGIE (Member 14095) was born in 1898. He served an apprenticeship with Brigham and Cowan, Ltd., South Shields, before joining Andrew Weir and Co., Ltd., in 1920 as fourth engineer. In 1923 he transferred to Ellerman and Bucknall, Ltd., and remained with the company as third engineer until he came ashore to study for an Extra First Class Certificate, which he obtained in January 1929. For the next two years he was a draughtsman with Richardsons, Westgarth and Co., Ltd., then an engineer surveyor from 1931/33 with the British Engine Boilers Electrical Insurance Co., Ltd., then draughtsman with Brigham and Cowan, Ltd., until 1936. After a short period with J. Samuel White and Co., Ltd., as oil fuel draughtsman Mr. Craigie returned to sea for a year with the Ellerman Hall Line but joined the Anglo-Iranian Oil Co., Ltd., as a draughtsman in 1938, serving them in Abadan and Tembi until 1940, when he was promoted plant inspector. He returned to England when the company left Iran in 1952. From that time until his death on 16th October 1956 he was an estimator draughtsman with Foster Wheeler, Ltd.

Mr. Craigie had been a Member of the Institute since 1953.

WILLIAM DALEY (Associate 12905) received his initial training in the Royal Navy at the mechanical training establishments at Chatham and Devonport from 1936/42 and qualified as chief mechanician in 1944. Between 1936 and 1949 he served in H.M. Ships *Arethusa, Achates, Euralus, Unicorn, Pioneer, London* and *Wren.* On leaving the Navy he was appointed assistant engineer to Luke, Thomas and Co., Ltd., Aden, holding later appointments with Gliksten's at Awasa on the Gold Coast and as Diesel engineer in charge of Pepel Island power station. Finally, he joined the staff of Marconi Wireless and Telegraph Co., Ltd., in September 1956, and worked as a mechanical engineer in Nigeria until his sudden death on 30th November 1956 at the age of forty-three. Mr. Daley had been a member of the Institute since 1950.

FRANK HOOD EDWARDS (Member 5391) was apprenticed with Doust and Company of Gravesend from 1915/19. Then for the next five years he sailed as fourth and third engineer in various steamships until in 1925 he obtained a First Class Board of Trade Certificate. He came ashore to join Henley's Telegraph Works at Gravesend as foreman maintenance engineer and was employed by this company until his sudden death on 23rd June 1956. Mr. Edwards was elected to Associate Membership of the Institute in 1925 and transferred to full Membership in 1926.

JOHN F. GIRDWOOD (Member 451), who was born on 17th August 1868, died aged eighty-eight on 18th December 1956. He served an apprenticeship with S. and H. Morton, engineers of Leith, from 1883/88 and joined the British India Steam Navigation Co., Ltd., in 1890 as fourth engineer of the s.s. *India.* He was promoted second engineer of the s.s *Chupra* in August 1899 and chief engineer of the *Zibenghla* in June 1908. He retired in March 1924. In July 1956 Mr. Girdwood was elected an Honorary Life Member of the Institute in recognition of his membership of the Institute for over fifty years; he was elected a Member on 28th February 1891.

ROBERT GRAY (Member 14854) died on 25th December 1956, aged sixty. He was apprenticed to David Rowan and Co., Ltd., Glasgow, attended the Royal Technical College, Glasgow, from 1912/14, and from 1914/19 he served as engine room artificer in the Royal Navy. After the First World War he returned to David Rowan and Company as foreman in their engine erecting shops and in 1942 was promoted head foreman; the following year he was appointed assistant to the works manager and in 1949 he became works manager over the entire works producing steam turbine and oil engine machinery, cylindrical and watertube boilers. Mr. Gray also taught marine engineering at evening classes in the Kent Road School, Glasgow, and at Stow College. He was elected to Membership of the Institute in 1954.

ERIC BARNBY IRWIN (Member 1713) was born in 1882. He was educated at Dulwich College and was apprenticed to John Brown and Co., Ltd., Glasgow. From 1910/14 he served with the Argentine Navy and obtained a First Class Board of Trade Certificate, returning home to join the Army in motor transport at the end of 1914. He served in France from February 1915 until recalled to join the Ministry of Munitions in 1916, where he remained until the end of the war; he was awarded an M.B.E. for his services. From

1919/21 he was in India in charge of a mill, returning to England to take over the business of John A. Bremner and Company, oil distributors, on the death of his father. This was followed by the purchase of an oil blending plant in Manchester which was formed into a private company, the business having been established in 1842.

During the 1939/45 war Mr. Irwin was chairman of the National Lubricating Oil and Grease Association and was a member of the Lubricating Oil Committee concerned with quotas for the trade. In December 1949 he disposed of his interest in the company but carried on business as a marine engineer until his death on 15th October 1956.

Mr. Irwin had been associated with the Institute since 1904 when he was elected a Graduate, being transferred to Associateship in 1906 and to full Membership in 1909.

DONALD McINTYRE (Member 13696) was born in 1902. He served an apprenticeship with James Howden and Co., Ltd., Glasgow, from 1918/23 and then joined the British India Steam Navigation Co., Ltd., sailing with them until 1935; he obtained a First Class Steam Board of Trade Certificate in 1933. For the next six years he was works foreman in charge of hull and engine repairs to river steamers and from 1941/47 deputy assistant director, Inland Water Transport Unit, in charge of slipways and workshops. From 1948/51 he was assistant manager, then manager with Mollers Shipbuilding and Engine Works, Ltd., but returned to sea for nine months as chief engineer of the s.s. *Bembridge Hill,* owned by Andrew Crawford and Co., Ltd. He then obtained the necessary experience to enter for the examination for a Motor Endorsement by sailing as third engineer in the m.v. *Cilicia,* David MacBrayne, Ltd., passing the examination in September 1952. Subsequently, he served as chief engineer with Maclay, McIntyre, Ltd., Stone and Rolfe, MacAndrews and Co., Ltd., and finally with the Power Steamship Co., Ltd. In October 1956 he was admitted to hospital, having already suffered serious ill health during the previous year, and he died at his home on 7th December 1956. Mr. McIntyre had been a Member of the Institute since 1952.

EDWIN JOHN MOYSE (Associate 11053), who was born in 1910, was apprenticed from 1926/31 with Camper and Nicholsons, Gosport; during the same period he attended the Municipal College, Portsmouth, having been awarded a part-time scholarship by the Hampshire Educational Authorities. For the next two years he was a marine engine fitter with the same company and was then employed by the Royal Naval Armament Depot at Gosport as a gun repair and emplacement specialist. He was engineer of the motor yacht *Rhodora* from 1933/34 and then spent two years as research workshop machinist in the Experimental Mining Establishment H.M.S. *Vernon,* being later employed there as a draughtsman. From that time until his death on 16th July 1956 Mr. Moyse was employed in Admiralty establishments, at first as second class and later as leading draughtsman. He was first associated with the Institute when he was elected a Student Graduate in 1930; he transferred to Associateship in 1935 and although his membership lapsed during the 1939/45 war he rejoined as an Associate in 1946.

FRANK JOHN PICKTHALL (Member 3025) was born in 1882. He served an apprenticeship with the Vauxhall Ironworks Co., Ltd., London, S.W., an engineering firm which specialized at that time in marine engines, pumps, etc., and later made the first Vauxhall motor car, in the construction of which Mr. Pickthall assisted. The car had a horizontal single cylinder engine in the boot behind the driver and the steering was by tiller, connecting with a steering pillar on the right of the driver. From 1904/13 he was at sea and obtained an Extra First Class Board of Trade Certificate; he was then appointed chief assistant surveyor to Esplen, Swainston and Wilson, consulting engineers, stationed first at Buenos Aires and later at Montevideo where he later established himself as a consulting engineer. He was appointed non-exclusive surveyor to Norwegian Veritas in 1933, to the American Bureau of Shipping in 1944, and to the British Corporation Register in 1947, retaining these appointments until his retirement in 1949. He died in April 1956. Mr. Pickthall was elected a Member of the Institute in 1915.

ANDREW BAXTER RAE (Member 7077) served an apprenticeship with the N.S.W. Government Railways and then sailed in ships owned by the Austral China Navigation Company, Andrew Weir and Co., Ltd., and the Asiatic Steamship Co. (India), Ltd. He obtained a First Class Board of Trade Steam and Motor Certificate and was promoted chief engineer. In 1941 he joined the Department of Labour and Industry, New South Wales, and was responsible for the drafting of the Boiler and Pressure Vessel Regulations which came into force in 1945. He was acting superintending inspector of boilers from 1942/45 during the temporary absence of the then superintending inspector and in 1949 was appointed to the position of superintending inspector of boilers. Mr. Rae was chairman of the Boiler and Pressure Vessels Sectional Committee of the Standards Association of Australia. He died on 18th August 1956, aged fifty years. He had been a Member of the Institute since 1932.

EDWARD ALEC SMITH (Associate Member 4344), marine superintendent of the Great Yarmouth Shipping Company until his retirement through illness in 1954, died on 24th December 1956, aged fifty-six. He served an apprenticeship with J. W. Brooke and Co., Ltd., Lowestoft. In 1917 he joined the Royal Navy as an electrician-artificer and served until the end of the First World War, returning to Lowestoft to complete his apprenticeship. In 1920 he joined the Anglo-American Oil Co., Ltd., as a junior engineer in the s.s. *Cadillac* and the following year transferred to the m.v. *Marragansett,* obtaining a First Class Motor Endorsement to his steam certificate. He left the sea in 1926 when he was appointed an engineer surveyor to the Lowestoft Mutual Insurance Company; later he was engineer surveyor with the Norwich and Continental Shipping Company and the Hull Shipping Company. When the two companies were amalgamated in 1931 with the General Steam Navigation Co., Ltd., under the name of the Great Yarmouth Shipping Company, he became the marine superintendent.

Mr. Smith was an Associate Member of the Institution of Naval Architects and had been an Associate Member of the Institute since 1921.

HAROLD BERTRAM TOSTEVIN (Member 7418) died at Gosport on 6th December 1956, aged seventy-two. He received his engineering training as a boy in the Royal Naval Dockyard at Portsmouth and was awarded the "Newman" Memorial Prize and three Admiralty prizes upon passing out to the Royal Naval Engineering College, Keyham. He was engaged at the Royal Naval College, Greenwich, as instructor in applied mechanics from 1907/10. He served at the Battle of Jutland in the fleet minelayer *Abdiel* in 1916, when he was mentioned in despatches and decorated with the D.S.O. In 1922 he was appointed for three years as superintendent of the Admiralty Engineering Laboratory and for the following six years he was professor of marine engineering at the Royal Naval College, Greenwich; at the end of this period he was placed on the retired list, on 31st October 1933.

Engineer Captain Tostevin thereupon took an appointment as chief engineer of the marine department with the Vacuum Oil Co., Ltd., in London. Six years later, in 1939, he was appointed Admiralty engineer overseer at the works of Cammell Laird and Co., Ltd., Birkenhead, where he remained throughout the war and left to serve one year in the Engineer-in-Chief's department at the Admiralty, Bath, before he retired.

Captain Tostevin was a Member of the Institution of Naval Architects and the Institute of Metals and had been a Member of the Institute of Marine Engineers since 1933. In 1920 he received the Gold Medal of the Institution of Naval Architects for a paper on warship reduction gearing.