Piston Rings, their Design, Functions and Manufacture*

W. A. HARRINGTON†

INTRODUCTION

In the early days, when the metallic piston ring was first brought into vogue by Ramsbottom, the design was to a great extent left to the whim of a draughtsman.

When the development of the internal combustion engine was in progress it was realized that the efficient functioning of piston rings was a vital factor governing power output, and scientific research in the able hands of Mr. Ricardo, Professor Unwin and others led to the adoption of certain formulæ by the British Engineering Standards Association (now the British Standards Institution).

One of the most important was a formula for finding the E_n, that is the elasticity value of the material, which is calculated from the closing load.

$$E_n = \frac{5 \cdot 37 \left(\frac{d}{t} - 1\right)^3 P}{b\, c}$$

Where E_n = elasticity value in lb. per sq. in.
P = diametral load to close ring
d = diameter in inches
t = radial thickness in inches
b = width of ring in inches
c = change of gap in inches
Minimum = 14,000,000lb. per sq. in.

The next test is for tensile strength, obtained by pulling the ring to destruction; this formula gives the ultimate stress in tons per sq. in.

$$S = \frac{P\, D}{1{,}200\, b\, t^2}$$

Where S = stress in tons per sq. in.
D = external diameter of ring, in inches
P = load in lb. to break ring
b = width of ring in inches
t = radial thickness in inches
Minimum = 16 tons per sq. in.

In the formula for wall pressure it should be noted that the ratio between diameter and radial thickness is of vital importance as the cube of that ratio is involved, as follows:—

$$\text{Wall pressure: } P = \frac{E_n\, C}{7 \cdot 07\, d \left(\frac{d}{t} - 1\right)^3}$$

Where P = wall pressure in lb. per sq. in.
C = length of free gap in inches
d = diameter of ring in inches
t = radial thickness in inches
E_n = elasticity value in lb. per sq. in.

Example:

Ring diameter	20 inches
Free gap	2½ inches
E_n value	14,000,000lb. per sq. in.

	Radial thickness, inch	Wall pressure, lb. per sq. in.
	0·6	7·3
Inc. 12½ per cent	0·675	10·45
Inc. 25 per cent	0·75	14·6
Inc. 33 per cent	0·8	17·8

An important point that must be considered is the stress set up in springing the ring on to the piston (not into the groove) which creates a gap of about eight times the radial thickness, so that to install the ring with a R.T. of 0·8 inch, the gap would open 6·4 inches, whereas the ring with a R.T. of 0·6 inch would open only 4·8 inches. The former, with a gap of 6·4 inches may stress the material beyond its elastic limit and cause distortion.

Another formula for the calculation of the theoretical stress set up on installing the ring, reveals that the ring with a R.T. of 0·6 inch would stress the material a little over 6 tons per sq. in., whereas the ring with a R.T. of 0·8 inch would be stressed to about 14 tons per sq. in., which is very close to the ultimate stress of 16 tons per sq. in. allowable under the B.S.I. specification. It is therefore better to reduce radial thickness than the free gap to obtain a desired wall pressure.

DESIGN

From the foregoing formulæ, sufficient data is obtainable to design piston rings to almost any desired physical specification.

The free gap given to piston rings is generally 3½ times the radial thickness. This gap is such that the stress set up on installing the ring does not stretch the material beyond its elastic limit and is approximately equal to the stress on the ring in its closed position in the cylinder.

It is strongly emphasized that the quality of a ring, or the service it will render, cannot be judged by overstraining it either sideways or outwards as a test of elasticity and freedom from permanent set. If it is desired to check this feature, first measure the free gap, then spring the ring on to the piston (not into the groove); it will be noted that the gap will extend to about eight times the R.T., as before mentioned. Remove the ring and press it into the cylinder. On removal, check the free gap with the original measurement; if there is practically no change in free gap, the physical quality of the ring should be satisfactory.

CORNERS

Another matter in design is the question of sharp or radiused corners; small diameter units usually have sharp corners, whereas large marine units generally have radiused corners. The rounding of the outer corners produces a better distribution of the lubricating oil, and acts as a lead-in to maintain an oil film between the ring and liner. It is advisable to make the radius of such dimension that, even after considerable wear, some of the radius remains to assist lubrication;

* Presented at a meeting of the Sydney Section on 30th April 1953.

† Managing Director, W. A. Harrington Pty. Ltd., Lidcombe, N.S.W., Australia.

it should be noted, however, that radiused corners reduce the area of contact and, therefore, increase the wall pressure, as with a given closing load the wall pressure is relative to the area in contact.

WIDTH

There is no hard and fast rule governing the relation between diameter and width of rings, but modern practice has proved that it is more efficient to install a number of narrow rings in preference to a few wide rings. Narrow rings more readily adapt themselves to the cylinder, and cause less groove wear, as owing to being of less weight they have less inertia on reciprocation.

JOINTS OF RINGS

There are several types (Fig. 1) of ring joints, namely:

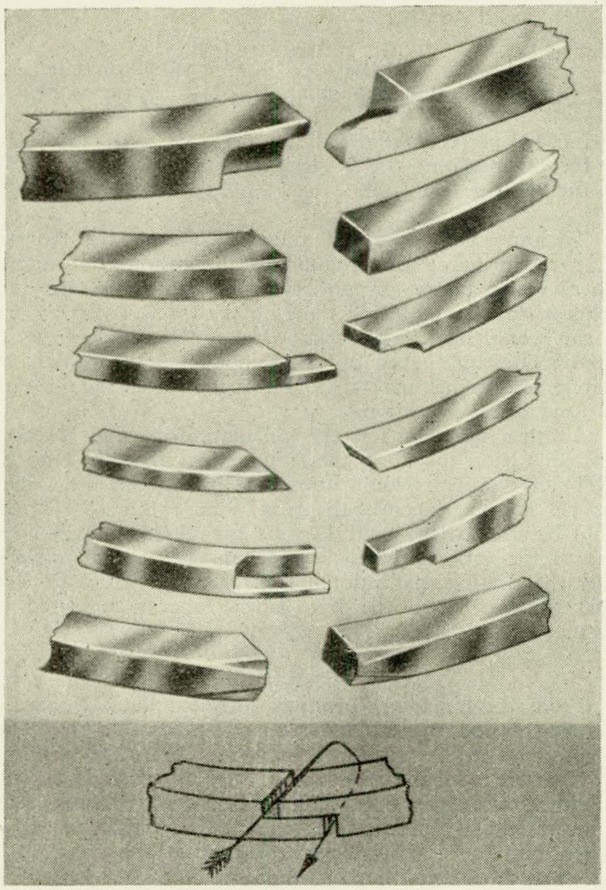


FIG. 1—*The joints illustrated, reading from the top, are: concave convex, straight cut, step cut, mitre cut, shrouded step or S joint, and ring with chamfered points for ported liners; the bottom illustration shows the passage for gas in a plain step jointed ring*

straight cut, mitre cut, step cut, concave convex and the shrouded step cut or S joint. The three latter were designed to avoid gas passing at the joint. This feature is obtained with the S and concave convex joint but the plain step joint has no advantage over the straight or mitre cut as gas can enter the gap at the top of the ring pass behind and escape at the gap at the bottom.

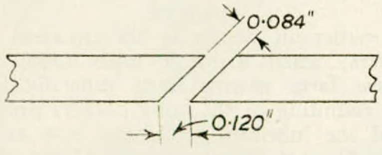


FIG. 2—*Showing the advantage in joint clearance of mitre cut against a straight cut*

The mitre joint has a slight advantage over the straight cut because less gap is required to produce the same peripheral clearance; for example, a 30-in. ring straight cut with a joint clearance of 0·004 inch per inch diameter = 0·120 inch, whereas a mitre cut ring to give the same peripheral clearance would only require 0·120 inch × 0·7 = 0·084 inch; 0·7 being the sine of an angle of 45 degrees (Fig. 2).

FANCY TYPES

It should be mentioned that all fancy joints are costly to manufacture and if applied to narrow rings, which are now generally adopted, the fragile points frequently break off, and not only is their object defeated but damage may result.

RINGS FOR INTERNAL COMBUSTION ENGINES AND COMPRESSORS

It must be recognized that the efficiency of internal combustion engines, steam engines, compressors and the like is vitally controlled by the piston rings maintaining a complete seal, contacting at equal radial pressure the surface of the cylinder, as well as the sides of the groove in the piston.

Another important function of piston rings for internal combustion engines is the transfer of heat from the piston to the water cooled cylinder walls, particularly so with uncooled pistons. There is probably no power unit more dependent on the efficient functioning of the piston rings than the Diesel. Failure of the rings to hold maximum and uniform pressures in the combustion chambers will result in insufficient heated air being generated to burn effectively the full charge of fuel oil, thereby decreasing the power output and causing the formation of carbon on the piston and cylinder heads; further, if blowby occurs through bad ring contact, excess heat is transferred to the skirt of the piston, causing increased expansion with probable distortion, and the abnormal temperature may set up carbonization of the lubricating oil.

Owing to the widely varying conditions existing in Diesels, it is necessary to design the rings to suit each individual unit; for example, in a small bore Diesel at 2,500 r.p.m. the piston changes direction 5,000 times a minute, whereas a large marine Diesel at 110 r.p.m. only changes direction 220 times a minute. Rings designed for the latter on the same basis as the former would be quite unsuitable; the small unit may require a wall pressure of 15 to 18lb. per sq. in., whereas 4 to 6lb. per sq. in. may suffice for the large unit.

Wedge section ring

In recent years piston rings varying from the plain Ramsbottom ring have come into use, one being the wedge section ring which was introduced to eliminate ring sticking; this type usually has an angle of 5 degrees on each side, the groove in the piston being formed with an included angle of 10 degrees to accommodate it. One detracting feature of this type is that as wear takes place on the periphery, slight increase in side clearance must result.

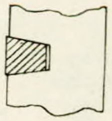


FIG. 3—*Wedge section ring*

FIG. 4—*Cornish ring*

Cornish ring

Another type of compression ring which seems to be gaining popularity is the Cornish ring (Fig. 4), which is made in two pieces, one side of each being faced on the diagonal so that when the two are assembled they form a rectangular ring. When installing, the wide face of the ring must be placed uppermost.

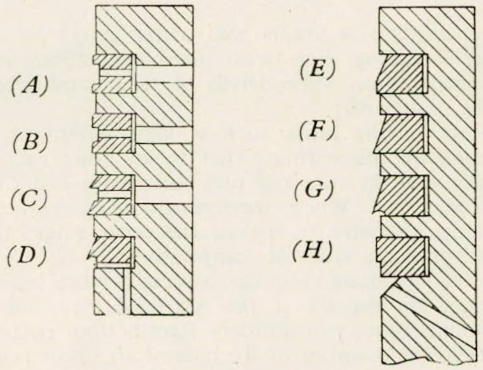
Double or triple seal ring

The double or triple seal ring has also come into vogue and although in some cases they are used as original equipment they are more generally installed in worn liners. Double or triple seal rings, of which there are several types, are expensive to manufacture, but judging by the large number called for in recent years they must have proved efficient and economical.

Rings for oil control

An important factor in piston ring equipment is oil control and in this field there are two distinct cases to be dealt with, namely, the trunk piston with gudgeon pin, and the type where the piston is connected to a crosshead.

In the case of the trunk piston an excess of lubricating oil is generally present and is taken care of by various types of scraper ring, the most common type being the grooved and slotted ring, which is installed in the bottom groove immediately above the gudgeon pin. They may also be fitted in grooves provided at the lower end of the skirt; holes are drilled through the piston at the bottom of the groove, the excess oil passing through its slots in the ring and the holes to the inside of the piston and thence to the crankcase.



FIGS. 5 and 6—*Stepped and bevel scrapers*
(A) Slotted with square lands; (B) slotted bevel with small lands; (C) slotted bevel with knife edges; (D) bevel lip with bottom oil relief; (E) bevel scraper with narrow land; (F) bevel scraper with knife edge; (G) bevel scraper with undercut lip; (H) stepped scraper

The profile of the face of the slot oil ring is generally parallel but further economy can be obtained by bevelling the upper lands, leaving a narrow land in contact with the cylinder, and still further by making them with a knife edge.

Both stepped and bevel scrapers (Figs. 5 and 6) are also popular and vary in profile according to the oil control desired. In some cases the bottom face of the groove is bevelled and holes drilled to the inner part of the piston to permit excess oil to return to the crankcase.

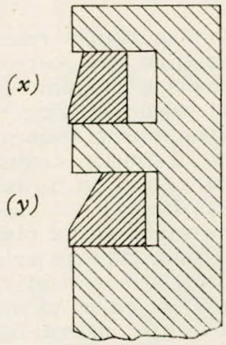


FIG. 7*(x)—Shows light section bevel scraper with seven-degree angle for crosshead type piston. (y)—shows heavy section bevel scraper for trunk type piston*

When the piston is connected to a crosshead, the lubrication is supplied by means of a pump which delivers oil to a series of holes drilled round the liner, so arranged that oil is supplied to the land between the two upper rings at the bottom of the stroke. Although the pump can be adjusted to fine limits, it is usual to fit one or two bevel scrapers in the lower grooves. In this case the bevel scraper should be of light section and low wall pressure with a rather acute angle, about 7 degrees (Fig. 7(x)), so that on the up stroke it can ride over the oil film left on the cylinder wall and scrape off the excess oil on the down stroke.

If a bevel scraper with a heavy wall pressure, and obtuse angle as used on the trunk piston were installed (Fig. 7(y)), it would fail to ride over the existing oil film. In several cases where change of angle has been made on scraper rings for crosshead types of pistons, considerable economies of lubricating oil have been effected.

Contracting rings

Another type of ring that is installed in Diesel engines is the contracting ring, for which there are a number of applications and a variety of types.

For main engine pistons they are one-piece rings hammered on the periphery to cause a closing effect to keep the inner face of the ring in contact with the piston skirt; to obtain roundness and equal radial pressure the ring is hammered on the periphery with blows of varying intensity, the maximum being opposite the joint, and tapering off to the points. After hammering, the ring is expanded into a jig with the desired joint clearance and precision-bored to the skirt diameter of the piston; the profile of the inner face may be parallel, bevel, or of bevel lip form according to the oil control desired. There are usually two of these contracting rings installed in a carrier at the lower end of the liner.

Contracting rings are also used in packing boxes for the piston rods of double-acting Diesel engines, the latest design being an outer ring hammered on the periphery as before described, with two inner rings half the width of the outer ring, each of which is cut into three segments, locating pins being used so that the joints of the inner rings are staggered. This type has the advantage that the inner rings can be replaced by dropping the packing box, and does not require the removal of the piston rod, which was a disability in some of the earlier designs. These contracting rings, of which there may be six or eight in a box, are installed in carriers, and when assembled are provided with sufficient side clearance, usually 0·003 to 0·004 inch to ensure that the rings float freely.

Some packing rings are plain rings precision bored to piston or piston rod diameter, the periphery being grooved to accommodate a garter spring, and are cut into two or more segments. It is essential that where a packing box is built up with carriers that all faces are flat and parallel, because if they are not a precision job blowby is certain to occur.

The design of piston rings for compressors follows closely that for Diesels, but owing to operating conditions being much less severe, the side clearance in the groove and the joint clearance can be considerably reduced.

WEAR OF RINGS

It is generally noted that the wear of rings is relative to the position they occupy on the piston, the wear being greatest on the top ring and gradually lessening to the bottom ring; the explanation is evident from the fact that the upper rings deal with higher pressures and temperatures than the lower rings, which only have to care for gases passing the upper rings.

Another factor is that gas is more likely to get behind the upper rings, causing excessive wall pressure and creating increased wear on both the rings and the upper end of the liner. This is particularly noticeable when new rings are fitted to badly worn liners, as the joint clearance must be allowed at the least worn part of the ring travel in the liner; therefore, excessive joint clearance will occur at that part of the liner with the greatest wear.

Excessive wear on the upper rings and the upper end of the liner can also be caused by lack of lubrication. Where this condition exists it may be overcome by installing an inverted oil ring in the second or third groove, at the same time excessive lubrication must be avoided to prevent carbonization of the lubricating oil with its known disabilities.

When fitting rings to new liners, it is advisable to give the two upper rings more joint clearance than the lower rings owing to the higher temperature. On two-cycle units this is important as the rings are kept as near to the top of the piston as is practicable for the purpose of controlling opening and cut off to the ported liners; they therefore operate at higher temperatures than the four-cycle, and for that reason rings on two-cycle units should be given more joint and side clearance than the four-cycle.

It is essential that when checking joint clearance that the ring is absolutely square in the liner, and with mitre-cut rings particularly that the points are held flat at the joint, otherwise considerable error may result.

It is strongly recommended that a fitting jig be provided; it is not only a great time saver but ensures accuracy, especially with mitre joints; it is advisable to make the jig double ended, one end to standard bore, the other oversize according to the size of rings being handled (Fig. 8).

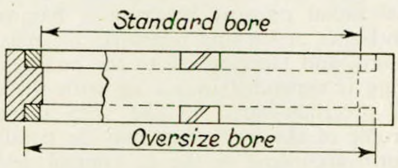


FIG. 8—*Jig for checking joint clearance in standard and oversize bores, with windows for viewing joint*

In a number of cases where new rings have been installed in badly worn grooves, they have failed to function satisfactorily, but on remachining the grooves and fitting oversize rings in width, excellent performance has been attained.

When regrooving pistons it is recommended that the grooves be made uniform in width, so that spare rings can be stocked. Care should be taken that the grooves are square with the piston with as good a finish as possible on the sides: this can best be accomplished by making a tool of the desired width which ensures uniformity; if each side of the groove is machined separately it is extremely difficult to get a precision job.

With large pistons it is advisable to undercut the bottom of the groove. It should be sufficiently wide so that the inner corners of the ring slightly overlap the undercut; this operation will ensure a good seating for the ring and no ridges are worn in the groove, and new rings can be installed for a considerable time without further regrooving.

Rings for two-cycle engines are generally provided with some form of stop to prevent rotation in the groove, thus ensuring that the points pass over a land between the ports; in small units it is usual to fit a steel pin in the piston groove, a recess being provided in the ring to accommodate it. This recess should be at the joint to avoid weakening the ring.

On large units, a ring known as the anchor type is more usual; the upper part of the ring is machined away to leave the anchor an integral part of the ring, the anchor being opposite the joint, and a slot is cut in the top of the groove to suit.

To avoid machining to leave the anchor integral, which is a costly operation, rings with the anchor housed and riveted were tried out but failed to stand up.

If the ports in the liner are reasonably narrow and no form of stop is provided, it is advisable to chamfer the outer corners of the ring on each side near the joint.

When steel piston heads are used, it is usual to fit a cast iron wearing ring to the bottom side of the groove; there are various types, one being of L section which is fitted into an undercut at the bottom of the groove and caulked in position.

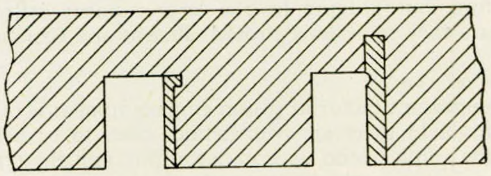


FIG. 9—*Two methods for installing cast iron wearing rings in steel pistons*

Another type is a plain ring with a concentric groove on one side; a reasonably deep recess is cut into the lower end at the bottom of the groove to leave a press fit for the insert ring, the ring being retained by caulking into the groove (Fig. 9).

RINGS FOR STEAM AND OTHER UNITS

As the foregoing deals with internal combustion engine and compressor rings, some details of steam and other rings will now be dealt with.

For slow moving units, such as Weir pumps, it is quite usual to use three piece rings; that is, an inner ring to give the necessary wall pressure and two outer rings half the width of the inner ring. When replacements are required, it is generally only necessary to replace the outer rings; this type is also used on some types of compressors.

Rings for h.p. steam cylinders, especially when using superheated steam, are usually of the restricted type, one of the simplest designs being two ordinary Ramsbottom rings stepped on one side to the diameter of the bore of an uncut ring which restricts the rings when in contact with the step (Fig. 10); it is usual to allow a small tolerance on the outside diameter to allow the rings to wear into the cylinder face before coming in contact with the restrictor ring.

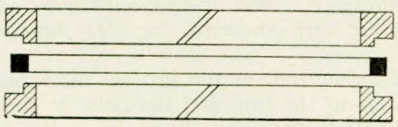


FIG. 10—*Assembly for simple type restriction ring*

It is apparent that restricted rings, of which there are a number of designs, can only be used on built-up pistons. For reasonable efficiency it is necessary for the cylinder to be parallel; with cylinders worn either barrel or of hour-glass contour, it is obvious that the restrictor prevents ring contact in the worn sections, therefore it is useless to fit this type to badly worn cylinders.

In cases where plain Ramsbottom rings have been used in h.p. cylinders and have given very poor service, the trouble has been overcome by grooving and drilling the ring. This permits steam that passes behind the ring to escape through the holes and, to a certain extent, counterbalance the wall pressure; although the area of contact is reduced by the grooving, thus reducing the wearing area on the periphery; this type of ring has proved very satisfactory.

In one instance where several sets of plain h.p. rings were used on a voyage from England, and were replaced with grooved and drilled rings in Sydney, a number of voyages have been made to and from England on one set of rings. At the same time it may be mentioned that the material may have had some bearing on the results obtained in this particular case.

The Belliss and Morcom steam units, with their world-wide reputation, have adopted bronze restriction rings on their h.p. pistons. These are fitted with housed cod pieces at the joints, corrugated springs are used behind the rings to create radial pressure and a wave spring is installed between the rings for lateral pressure. If the spring pressures, both radial and lateral, are correct, they render years of satisfactory service.

The l.p. rings on the Belliss and Morcom units are of cast iron fitted with bronze cod pieces, and have similar spring equipment to the h.p.

The well-known Lockwood and Carlyle rings are fitted in pairs; they are of L section with a contour on the inner face to accommodate a spring of special design that can be adjusted to give the desired radial and lateral pressure, and the joints are fitted with bronze cod pieces. The h.p. Lockwood and Carlyle rings are provided with restriction plates, so arranged that when the rings have been run in they are restrained from further expansion and act almost as a solid piston.

The water end of pumps, which generally have bronze pistons, usually have non-metallic rings, such as woodite, vulcanite or novasteen. It is necessary to allow considerable side and joint clearance with these materials, especially when used on high temperature water for boiler feed.

MANUFACTURE

Materials

In dealing with the manufacture of piston rings, the first consideration is the material, cast iron being universally adopted; the features desired are that the castings shall produce rings that have sufficient elasticity to be installed without undue distortion, that they retain their elasticity under severe working temperatures and pressures, and that they are highly resistant to wear.

Leading metallurgists are agreed that castings with very high physical qualities are comparatively easy to produce, whereas castings with reasonably good physical strength, together with high resistance to wear, are considerably more complex; it has been proved that neither tensile strength nor hardness of cast iron has any relation to wear as applied to piston ring performance.

3, which is in the same Brinell range as item ex 1, has nearly seven times the wear value.

From personal research and the following of technical work in other countries, it has been established that grain size and microstructure of the cast iron for piston rings are the predominating factors controlling piston ring performance.

It has been found that a totally pearlitic structure with large flake graphite, total absence of free ferrite, and a reasonable grain size is most desirable.

Pearlite derives its name from its lamellar structure and is made up of alternate layers of ferrite and cementite (carbide of iron), which is an extremely hard substance; this particular microstructure lends itself to work hardening, forming a skin that is highly resistant to wear even when lubrication is on the lean side.

Castings of the same analysis can have widely varying characteristics, and the method of melting, pouring temperature, mould temperature, rate of solidification and cooling, all play their part in the microstructure and grain size of the casting; a casting 1½ inches thick poured from the same ladle as a casting ½ inch thick will differ considerably in structure and grain size owing to the rate of freezing and cooling in each case.

In substantiation of the importance of grain size and microstructure, a recent investigation on rings from a Diesel power station that practically wore out in fifty hours revealed that, although the physical qualities were well within desired limits, a short run wear test showed 14 to 1 against their standard material. If the test could have been prolonged, it would have shown a considerable increase as the first reading was 3 to 1, the second 7 to 1, the third 14 to 1. It was noted that his company's material almost ceased to wear whilst the other continued to wear.

Another investigation, on a marine job, where the rings utterly failed after forty-eight hours and had to be replaced at sea, revealed very similar characteristics to the former case; the lack of correct microstructure and extremely small grain

TABLE 1

Piston No.	Make of rings	Brinell No.	Hours in service	Radial mean wear, mm.	Mean wear 1,000 hours, mm.
1	V1	168	1,704	0·376	0·221
2	W1	180–210	10,612	4·150	0·391
3	X1	196	1,704	0·247	0·145
4	V2	168	1,704	0·603	0·354
5	V3	168	12,140	4·440	0·362
6	X2	—	6,900	2·170	0·310
7	V4	168	10,612	2·510	0·236
8	Y1	210–275	10,612	3·540	0·312
ex 1	Z1	190–220	6,929	6·680	0·964
ex 3	V5	230	12,015	3·100	0·258

While on the subject of Brinell hardness, this is purely a test of resistance to penetration, and as an iron casting suitable for piston rings is not of uniform structure such as steel, a small indentor will give a multiplicity of readings.

A more reliable Brinell test can be achieved by using a 10 mm. ball, with a 3,000 kilo load, but the section of most piston rings is insufficient to carry this test.

In support of the contention that there is no relation between hardness and wear resistance, reference should be made to Table 3 of the paper* by Mr. Lamb, published in the TRANSACTIONS in June 1950, which fully substantiates what the author has expounded for a number of years.

Referring to the table, which co-relates Brinell hardness with wear, it is noted that items 1 and 7, with a Brinell of 168, has over four times the wear value of item ex 1 with a Brinell 190-220, and item ex 3 with a Brinell of 230 has nearly four times the wear value of ex 1 with 190-220 Brinell. Item

* Lamb, J. 1950. "Further Developments in the Burning of Boiler Fuels in Marine Diesel Engines", Trans.I.Mar.E., Vol. LXII, pp. 217-256.

size was the cause of the failure, and it had been possible to estimate the wear value from the micro.

To produce castings of the desired quality for piston rings entails the analysis of the pig iron, covering the determination of carbon, silicon, phosphorus, and manganese, the sulphur content being ignored as Australian pig iron is of low sulphur content.

Should the pig iron available be deficient or in excess of any of the constituents, calculations are made to bring the melt within the desired analysis.

The melting is done in a cupola which feeds into an oil fired receiver, a weir being provided to take care of the slag, and on each tapping of the receiver into a bull ladle a sample is taken for analysis.

Green sand open top moulds are used, the moulding boxes being quite unorthodox, as each box is built up of a series of rings placed one on another to the desired height; this method permits very easy removal of the casting.

Each casting on removal is weighed and numbered and can readily be identified with the sample taken for analysis.

Apart from the analysis of each day's cast, periodic laboratory tests are made for elasticity, ultimate stress, microstructure and wear value.

Some time back it was quite usual to have to discard the mid section of the heavy castings as, although they showed perfect on both the inside and outside when machined, on being parted into rings a certain amount of porosity was evident; this was caused by shrinkage owing to the slow cooling rate and the trouble was overcome by casting cooling fins on the mid section, which accelerated the cooling.

Machining operations

Before proceeding with a description of the machining operations, the author stressed that a concentric ring made by cutting a piece out for free gap cannot be satisfactory; the form of the ring when closed is high at the points and even if double turned cannot create equal radial pressure. The eccentric ring was evolved in an attempt to overcome this disability but only succeeded to a very small degree and, further, the eccentric ring causes excessive and uneven wear in the piston groove.

On the machining side, a work card giving full particulars and instructions is issued, and when the castings have been selected their numbers are entered on the card, thus providing a record for future reference.

The first operation is to machine the top face of the casting, then drill and tap four holes for studs; the casting is then secured on the false table with which the vertical boring mill is provided.

This method of chucking avoids any distortion of the casting and only a very small part of the casting is lost.

A rough and finishing cut on the inside and out, at the same time, are carried out with tipped tools; for parting into rings the castings are remounted in the same manner, tipped parting tools operating from both inside and out, which not only reduces the time of the operation, but avoids broken edges.

The sides of the rings are then rough ground, leaving a tolerance for finishing; they are then placed in a special purpose machine which bevels both inner corners at one operation, and removes the grinding burrs on the outer edges.

Another special purpose machine is used for splitting, a $\frac{1}{16}$-inch saw being used; the machine can be set to cut straight or right- or left-hand mitre.

The next operation is that of heat forming, which is now recognized as the most scientific method of ensuring equal radial pressure. For this operation a cast iron ring of reasonable length is selected with a diameter in excess of the diameter of the rings to be treated, the upper face is ground flat and a flat piece of steel the width of the free gap desired is secured vertically on the jig, and the rings sprung into position; rings with mitre cut are retained by holding-down plates to prevent winding (Fig. 11).

The jig with the rings is then placed in an oil fired furnace which is equippel with a rotary table to ensure absolutely uniform heating and brought to the desired temperature, which must be high enough to make sure that, on cooling, the rings retain their free gap and at the same time low enough to avoid change of microstructure.

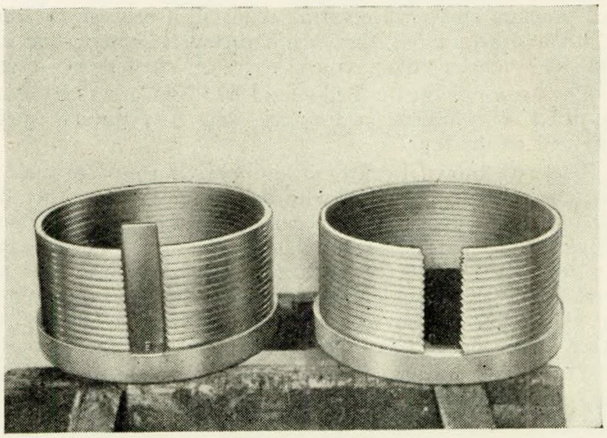


FIG. 11—*Rings before and after heat forming*

The rings are then sprung into a jig ring slightly narrower than the finished size, and fine finish-ground to width to a tolerance of 0·0005 inch.

The last operation is that of finish turning, which is done by closing the ring in a flexible band, mounting and clamping on a jig and finishing to the required diameter with a diamond lapped tipped tool.

As most rings are required for replacements in worn liners, the usual practice is to finish the rings with the joints butted, but if the desired joint clearance is stated, a spacing strip is inserted in the joint before finishing.

It may be mentioned that the accuracy of the heat forming is such that when the ring is closed in a flexible band it is practically dead round, and a finishing cut of only 0·010 inch is allowed for on a 30-in. ring.

Special gear and set-ups too numerous to mention in detail have been developed to ensure the economic production of the various types of double seal, oil control and other special types of piston rings.

After final inspection the rings are washed in spirit and treated with rust-proof oil.

There is a very old saying that you do not learn much from doing things right, you learn most from doing things wrongly, and this certainly applies to the development of the manufacture of piston rings.

ACKNOWLEDGEMENT

The author thanked the many engineers who, by their tolerance and co-operation over a period of thirty years, had contributed to the progress and success of the manufacture in Australia of the modern piston ring of today. He also thanked the technical and research staff of Broken Hill Pty. Co., Ltd., for their very valuable assistance in the metallurgical field.

INSTITUTE ACTIVITIES

Minutes of Proceedings of the Ordinary Meeting Held at the Institute on Tuesday, 28th September 1954

An Ordinary Meeting was held at the Institute on Tuesday, 28th September 1954, at 5.30 p.m. Mr. J. P. Campbell (Chairman of Council) was in the Chair, supported by Mr. W. J. Ferguson, M.Eng. (Vice-Chairman of Council) and Mr. A. Robertson, C.C. (Honorary Treasurer); sixty members and visitors were present.

The CHAIRMAN opened the meeting as follows:—

It is our privilege to have with us this evening our President for this year, and in accordance with procedure I have formally to introduce him to you. I do not think it likely that anyone here does not know the President. He has been a member of this Institute for longer than a good many here this evening.

Our President is Mr. H. A. J. Silley. He is a marine engineer and he has been a member of this Institute for more than twenty-five years. I was going to say "for more than a quarter of a century", but the President takes exception to that remark! He has been a Member of Council, he has been a Vice-President for London, and he has now honoured us by accepting the Presidency for this year. He is the second generation of a very famous engineering family to honour us by accepting the Presidency.

In addition, he is a very generous donor to the Institute funds. I do not know the right superlative to describe his generosity. He is one of this country's big industrialists and, amongst his very many business activities, is an eminent ship repairer. There is quite a lot more I could say about his business activities but I will leave it at that and call upon him to give us his Address.

The PRESIDENT then delivered his Address (*see November 1954* TRANSACTIONS, *p. 281*).

The CHAIRMAN: It is my privilege to thank the President for his very interesting Address. Coming, as it does, from a gentleman of our President's eminence and great experience of the ship repairing industry, we can accept it as a reflection of the present situation. It is apparent to all of us that the work involved in preparing this Address has been considerable. It must have received great thought from the author, involving very considerable research.

It has covered a very wide field and our President has touched on many controversial subjects, such as foreign competition, and taxation relief in connexion with possible large financial projects such as new drydocks and their ancillaries.

From statistics published it is evident that shipowners are building larger and beamier ships than pre-war, and this is especially noticeable in the oil industry where each new tanker built is of greater tonnage and beam than heretofore. In consequence of this, it would appear that larger and possibly more drydocks are essential. Many drydocks throughout the country have on very many occasions been enlarged already, and I do not know quite where the end will come unless the repairer can get the owner to tell him what the final demands will be for the years to come. As a resident of the County of Hampshire, with a business connexion in the Port of Southampton, I was extremely interested in the reference to the first recorded effort with a drydock in that port, which is alleged to have cost 40s. 6d. Knowing, as I do, today's ship repairing costs in the Port of Southampton, I feel reasonably certain that that 40s. 6d. mentioned by the President included the cost of the underwater work and the voyage repairs of the ship!

As a matter of interest—and the President mentioned Southampton first, so I do not want to be accused of advertising!—the last drydock built in that port cost approximately £1¾ million and today's cost would be in excess of £5 million.

It gives me very great pleasure, on behalf of the members, to propose a vote of thanks to our President for his extremely interesting, informative and concise Address.

MR. W. J. FERGUSON: You will all agree that tonight we have had a Presidential Address which merits the greatest publicity throughout the country. Mr. Silley has told us the action which is necessary if our great ship repairing industry is to continue to play its vital part in our national economy It may be that our Papers Committee should consider a Paper on the technical problems which he has mentioned, but I suggest that the twin problems of taxation and demarcation should be referred to Westminster and Scarborough without delay and with all the vigour the Press can command. I have great pleasure in seconding this vote of thanks.

The vote of thanks was carried by acclamation.

The PRESIDENT replied suitably to the vote of thanks and the meeting ended at 6.30 p.m.

Minutes of Proceedings of the Ordinary Meeting Held at the Institute on Tuesday, 12th October 1954

An Ordinary Meeting was held at the Institute on 12th October 1954, at 5.30 p.m., when a paper entitled "Some Fuel Injection Problems", by W. P. Mansfield, Ph.D.(Eng.), was presented and discussed. Mr. W. J. Ferguson, M.Eng. (Vice-Chairman of Council) was in the Chair. Eighty members and visitors were present and ten 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 8 p.m.

Local Sections

Scottish

At the general meeting held in Glasgow on the 10th November 1954, the Chairman of the Section, Mr. D. W. Low, O.B.E., presided and seventy-five members and guests were present.

The Institute prizes for apprentices training under the Alternative Scheme in Stow College were won this year by R. Findlay, second year student, and W. D. Cherry, first year student. As Mr. Findlay was now at sea, only Mr. Cherry was present to receive his prize. Both students were accorded hearty congratulations.

Following this brief ceremony, a paper on "Marine Refrigeration" was read by Mr. T. P. G. Brown on behalf of the author, Mr. D. A. Coull, who was unfortunately prevented from attending through illness. After a lively discussion, the

Vice-Chairman, Mr. G. J. Thomas, expressed the appreciation of the Section of Mr. Coull's instructive and interesting paper and his proposal of thanks to the author and to Mr. Brown, who had undertaken to read the paper at very short notice, was heartily accorded.

Joint Meeting with the Greenock Association of Engineers and Shipbuilders

Eighty members of the Greenock Association (including members of the Institute) attended the lecture on "Diesel Hydraulic Propulsion", given by Mr. F. J. Mayor (Member) at the Lorne, Greenock, on Tuesday, 16th November 1954. Mr. E. H. Lochhead, President of the Greenock Association, was in the Chair, and Mr. Murdoch McAffer (Local Vice-President) represented the Institute.

It was obvious throughout the lecture that the author had a very intimate knowledge of his subject, which dealt mainly with the history of the Thames tugboat *Tom Jay* brought up-to-date. The many searching questions he had to deal with during the discussion emphasized the care taken by the designers over the selection of each component to produce a transmission acceptable to Mr. Mayor.

During the evening, Mr. McAffer, as Principal of the Watt Memorial School, presented the Watt Medal for the best engineering student in the evening continuation classes (S3 National Certificate standard) and the Institute of Marine Engineers' Prize for the best student in the Heat Engines Class (S3 standard) between the ages of eighteen and twenty-one years.

A vote of thanks to Mr. Mayor was proposed by Mr. W. T. Riddell and this was warmly acclaimed.

South Wales

Appointment of New Honorary Secretary

Mr. W. Gracey (Member) has been compelled, on taking an appointment in London, to relinquish his position as Honorary Secretary to the South Wales Section. The new Honorary Secretary is Mr. R. G. Turnbull (Member) of 29, Cwm Barry Way, Barry, Glamorgan, and Mr. G. S. Taylor (Member), "Greenshutters", Lower Westbourne Road, Penarth, Glamorgan, will continue to act as Assistant Honorary Secretary.

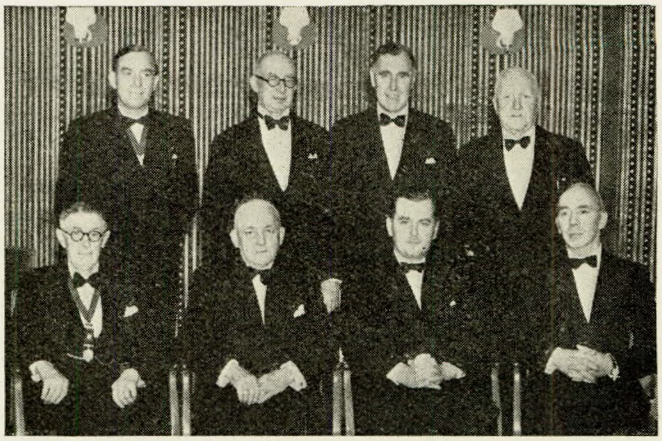
Sixth Annual Dinner

The very successful Sixth Annual Dinner of the Section was held on 12th November 1954, at the Royal Hotel, Cardiff, there being 207 members and guests present. The Chairman of the Section, Mr. J. H. Evans, M.B.E., was in the Chair.

The following officers, members of the Institute Council, and principal guests were present: —

David Skae (Vice-President, Cardiff); H. S. W. Jones (Vice-Chairman of the Section); and T. G. Thomas (Dinner Secretary). J. P. Campbell (Chairman of Council of the Institute); A. Robertson, C.C. (Honorary Treasurer of the Institute); Stewart Hogg (Past Chairman of Council); and Messrs. W. J. Brown, J. E. Church, R. W. Cromarty and B. P. Ingamells, C.B.E. (Members of Council). Councillor Llewellyn Jenkins, B.A. (Deputy Lord Mayor of Cardiff); David Llewellyn (Member of Parliament for Cardiff North); and A. J. Reardon Smith (Chairman, Cardiff and District Incorporated Shipowners' Association).

The toast to the Queen was proposed by the Chairman. Then "The City of Cardiff" was proposed by Mr. David Llewellyn who, in a very witty manner, recounted the history of the port and its rise to prominence; the response was made by Councillor Llewellyn Jenkins who, amongst other things, stressed the wonderful advantage of Cardiff as a technical centre, with colleges that could not be bettered. "The Shipping Industry" was proposed by Mr. David Skae, who pointed out the advantage of shipping to the country and deplored its struggle against increasing taxation; the response was made by Mr. A. J. Reardon Smith, who also referred to the crippling effect of taxation but hoped that they, like their forefathers, would face the future with vision and tenacity.



Sixth Annual Dinner of the South Wales Section
Standing *(left to right): A. J. Reardon Smith (Chairman, Cardiff and District Incorporated Shipowners' Association); A. Robertson, C.C. (Honorary Treasurer); J. P. Campbell (Chairman of Council); and T. George Thomas (Dinner Secretary)*
Seated *(left to right): Llewellyn Jenkins, B.A. (Deputy Lord Mayor of Cardiff); J. H. Evans, M.B.E. (Chairman, South Wales Section); David Llewellyn, M.P.; and David Skae (Vice-President)*

The toast to the South Wales Section of the Institute of Marine Engineers was proposed by Mr. J. P. Campbell, who first paid tribute to the President, who was doing a wonderful job, and then outlined some of the improvements which were being inaugurated by the Institute. He praised the work of the South Wales Section, and looked forward to its continued success. Mr. J. H. Evans replied suitably and welcomed, on behalf of the Section, many of the important guests present. He also paid tribute to Mr. T. G. Thomas, on whom the arrangements and success of the dinner largely depended.

November Meeting

On 29th November 1954, the first lecture of the season entitled "Marine Machinery of the Immediate Future from a Ship Owner's Point of View, with Special Reference to Cost", was given by Mr. J. E. Church (Member of Council) at the South Wales Institute of Engineers before a large audience. Many questions were asked and ably dealt with by the lecturer during the discussion, the subject having aroused much interest.

A vote of thanks to Mr. Church was proposed by Mr. J. Wormald, B.A., seconded by Mr. S. Sedgwick.

Sydney

The annual dinner of the Sydney Section was held on 4th November 1954, at the Wentworth Hotel, Sydney. There was an attendance of eighty, comprising forty-six members and thirty-four guests. The official guests included Messrs. R. W. Mackay (Vice-President, Institution of Engineers, Australia), H. L. Barnard (Chairman, The Institution of Engineers, Australia, Sydney Division), A. Denning (Director of Technical Education, New South Wales), F. Westhorp (Honorary Secretary, Institution of Naval Architects, Australian Branch), W. R. Evans (Chief Technical Officer, Shell Company of Australia, Ltd.), N. H. Hicks (Manager of Research and Development, Electric Control and Engineering Co., Ltd.), and L. Bateman (Marine Engineering Department, Sydney Technical College).

Eng. Capt. G. I. D. Hutcheson, R.A.N.(ret.) (Local Vice-President) presided at the Dinner and conveyed to members a message of goodwill from Mr. H. A. Garnett, who had returned to England in June.

After the Loyal Toast, the Toast of the Institute of Marine Engineers was proposed by His Honour, Mr. Justice Ross Philp, and was replied to by Mr. A. P. Quarrell. The Toast of "The Guests" was proposed by Mr. F. J. Ward and was replied to by Capt.(E) J. W. N. Bull, who had recently returned to Sydney from London.

The Dinner, which was well supported by members of the Section, was again a most successful one.

West Midlands

A general meeting of the West Midlands Section was held at the Imperial Hotel, Birmingham, at 7.0 p.m. on Thursday, 11th November 1954. Mr. H. E. Upton, O.B.E., was in the Chair, and twenty members and visitors were present.

Owing to the ill health of Dr. J. D. Morgan, the paper on "Patents for Inventions" was ably presented by the co-author, Mr. A. R. Bowen. He commenced by describing the inception of patents and continued by explaining patent rights and law. Present-day patent procedure with regard to inventions was explained. Nine members took part in the ensuing discussion.

The Chairman thanked Mr. Bowen for his most interesting paper, and the meeting ended at 8.45 p.m.

Junior Meeting

A Junior General Meeting was held at the Imperial Hotel, Birmingham, at 7.0 p.m. on Thursday, 9th December 1954; Mr. R. J. Welsh was in the Chair and one hundred members and visitors were present.

Films entitled "As Old as the Hills", "Distillation", and "Atomization" were presented by Shell Mex and B.P., Ltd., and "The Houseman Service", which dealt with the necessity of boiler water treatment, was shown by Houseman and Thompson, Ltd. An informal discussion took place and the Chairman thanked the representatives of both firms for arranging such an interesting and enjoyable evening.

The meeting ended at 9.30 p.m.

West of England Section

A meeting was held at the Royal Hotel, Bristol, on Thursday, 18th November 1954, at 7.30 p.m., for the purpose of inaugurating the West of England Section of the Institute. Mr. D. W. Gelling (Local Vice-President) took the Chair in opening the meeting, supported by Mr. J. P. Campbell (Chairman of Council) and Mr. J. S. Robinson (Secretary). Ninety-eight members and visitors were present and apologies for absence were received from several members. Mr. Gelling opened the proceedings by extending a welcome to Mr. Campbell and Mr. Robinson, who had come from London to attend the meeting.

Mr. Campbell then took the Chair and introduced the formal business by explaining the Council's policy on local Sections and by referring to the success of those already formed, giving a brief résumé of the manner in which they were conducted. He formally requested the meeting's opinion as to whether a Section should be formed or not and it was unanimously agreed that the West of England Section should be inaugurated forthwith.

Mr. Campbell then asked for nominations for the committee members, pointing out that in accordance with the rules in operation at the moment Mr. Gelling would automatically become a member of the committee. The following members* were then formally nominated and elected:—

- Capt.(E) T. T. Brandreth, R.N. (Member)
- A. J. A. Davies (Associate)
- T. A. Fawcett (Member)
- S. Jones-Frank (Member)
- Capt.(E) W. F. B. Lane, D.S.C., R.N. (Member)
- A. Nelson (Member)
- R. L. G. Paynter (Member)
- R. J. Richards (Associate)
- C. N. Thomas (Member)
- R. C. Thomas (Associate)
- F. C. Tottle (Member)
- J. H. Vassie (Associate Member)
- O. Watson (Member)

Mr. Campbell called for nominations for (*i*) the Chairman; (*ii*) the Honorary Secretary; and (*iii*) the Honorary Treasurer, to which offices Messrs. F. C. Tottle, S. Jones-Frank, and A. J. A. Davies respectively were proposed, seconded and elected.

Mr. Campbell then handed over the Chairmanship of the meeting to Mr. Tottle who voiced his pleasure at the honour which had been conferred on him.

It was agreed that Monday evenings would be most suitable for Section meetings. Other points raised concerned the advisability of holding an annual dinner, the equal division of the activities of the Section between Bristol and Bath, and the help that would be available from the Institute's headquarters (i.e. clerical assistance), etc.

The Chairman referred to the arrangements made by Mr. Gelling for the meeting, which had been so very well supported. Mr. C. N. Thomas proposed a vote of thanks, which was unanimously accorded, to the Chairman of Council and the Secretary for attending the meeting.

The meeting ended at 8.30 p.m.

**Appointment of Vice-Chairman*

At the first meeting of the Committee of the West of England Section, Cdr.(E) L. J. F. Howard-Mercer, R.N.(ret.) (Member) was co-opted to serve on the Committee and will act as Vice-Chairman, looking after the Bath members in particular.

Junior Section

Falmouth

A meeting of the Junior Section was held at Falmouth Technical College, on 16th November 1954, when Mr. W. G. Vigar (Member) presented his paper on "Marine Watertube Boilers". Engineer Captain Kelly was the Chairman and approximately eighty students and twenty members and visitors were present.

The author explained broadly the types and operation of Babcock and Wilcox watertube boilers and then showed two films; the first was an American film in which the construction of the boilers was demonstrated in stages, and the second, British film, illustrated the various processes and types of welding utilized in their manufacture. To judge by the questions that followed, the lecture was very well received and enjoyed.

Mr. W. Walton Lund (Member), representing the Institute, thanked the author and his company for making the lecture available to a Falmouth audience.

South East London

A lecture on "The Construction of a Ship" was given by Mr. G. Ridley Watson (Member), at the South East London Technical College on Monday, 15th November 1954, at 8.0 p.m. The meeting was well attended, the Head of the Mechanical Engineering Department, Mr. H. McQueen, B.Sc.(Eng.), the secretary of the college Mechanical Engineering and Building Society, Mr. H. R. S. Lake, B.Sc.(Eng.), and about eighty students and members of staff being present.

The Chairman, Mr. F. H. Reid, B.Sc. (Member), formerly principal of the college, introduced the author to the meeting and, representing the Council of the Institute, spoke briefly on the advantages of membership of the Institute.

Close attention to the lecture, which was well illustrated by films and slides, was shown by students and staff. Mr. Lake proposed a vote of thanks to the author, which was accorded by acclamation.

West Ham

A lecture entitled "Marine Diesel Engines", was given by Mr. A. G. Arnold (Member) at West Ham College of Technology on Thursday, 21st October 1954, at 7.0 p.m. Dr. E. A. Rudge, Principal of the College, was in the Chair. The lecture was very well attended by day and evening students numbering over 130.

Mr. Arnold illustrated his talk with slides and a film showing the development and operation of marine Diesel engines, which was followed by a period of questions.

At the close of the meeting, Mr. H. C. Oliver, Head of the

Mechanical Engineering Department, proposed a vote of thanks to Mr. Arnold which was carried with acclamation. Mr. Oliver also expressed appreciation to the Institute for bringing the lectures to the students and stressed the value to them of membership of the Institute.

Student Lecture Programme

The opening meeting of the 1954/55 Student Lecture Programme was held at the Institute on Monday, 18th October 1954, at 6.30 p.m. Mr. H. C. Gibson (Associate Member) gave a lecture on "Watchkeeping and Sea-going Practice". Mr. F. D. Clark (Associate Member), Convener of the Junior Section Committee, was in the Chair and a lively interest was shown in the subject by over ninety students and apprentices who were present.

Mr. Gibson dealt extensively with the duties of junior engineers at sea, after briefly outlining the duties of other members of the engine department with whom a junior would have to work. A number of questions were asked by the audience after the lecture, all of which were exhaustively answered by Mr. Gibson.

At the close of the meeting the Chairman proposed a vote of thanks to Mr. Gibson for his able handling of the lecture and questions, which was heartily supported by those present.

Membership Elections

Elected 7th December 1954

MEMBERS

John Edward Attfield
Robert Beattie
Albert Edward Bell
Ernest Charles Ogilvie Bird
John Robert Clarke, Lieut.-Cdr.(E), R.N.
Robert Gifford Connell
John Rochester Darnell
Leslie Murray Evans, Lieut.(E), R.C.N.
Norman Clifford Hart
Herman Lameris, Ir.
Richard Warwick Marshall, Capt.(E), R.N.
Robert Marshall
Cyril William Grierson Martin
Frank Ernest Monk
Donaldson Murray
Albert James Nettleton
Arthur James Norman
William Paterson
Cyril Peters, Lieut.-Cdr.(E), R.N.
Reginald Vincent Raine
Joseph Robert Riley
Douglas Gordon Thompson, Cdr.(E), R.N.
George Robert Thomson
Claude Francis Tyzack, Lieut.-Cdr.(E), R.N.
William Kerr Wallace

ASSOCIATE MEMBERS

Adriaan Pieter Bliek
Alan Cameron
Donald John Carmichael
Charles George Cooper
William George Fraser
Maurice Reginald Clyde Hanson
Alan Hopper
John Hurworth, Lieut.(E), R.N.
Subrahmanya Venkateswara Iyer, Lieut.(E), I.N.
John Reginald Jaques
Frank Kyle
John George Lathan
Edward Alison McKenzie
William McQuillan
Hugh Meek Oliver
Gordon Gregor Pennie
Dermot Beadon Valentine Pereira
Geoffrey Michael Quick
Maurice Robinson
David Royle, B.Sc.(Eng.)
Shrikrishna Dattatray Sohoni
Robert Valentine Thompson
Nicholas Antonios Vlassopulos
John Raymond Warne

ASSOCIATES

Ronald Shorthouse Collins
Archibald William McKinnon
Frederick Roberts Marshall
James Reginald Parton
Arthur Robinson
William Snowdon
Ernest George Taylor
Patrick Joseph Tye
Douglas George Unthank
Maurice Pursall Whitmore

GRADUATES

Rollo Charles Wheldon Aisbitt
Clifford Brettle
John Berry Brown
Alexander Henry Darling
Peter Victor Donnison, M.Sc.(Eng.)
Francis Hugh Ferguson
James Hogarth Holroyd
Nurul Huda
John Geoffrey Hurn
C. S. Khuman, Lieut.(E), I.N.
Ian Kilpatrick
Peter Kirkup
Stanley Cooper Machin
Homi Navroji Marolia
Richard Wyn Parry
Albert Edward Pitchford
John Vivian Roberts
Thomas Albert Taylor
Rodney Irving Waters
Royden John Whyte
Archibald George Wilson

STUDENTS

Alfred Roy Croft
Edward Michael Davis
Chamrun Dulyanant
Harold Robert English
Ian James Fairley
Frederick Herbert Holmes
Ralph Edward Jenkins
Leslie David Maunders
John Howell Morgans
Gordon William Pinhey
William Edward Powell
Terance James Roberts
Colin John Stacey
Hugh Martin Charles Syrett
Harry Thomas
Paul Stuart Tindall
David McGoun Tree

PROBATIONER STUDENTS

Brian Gilbert Attwood
John Benton
Stuart Wilson Blythe
Joseph Godfrey Carroll
Donald Thomas Clark
Joseph Barry Cull
Leonard Elves
James Finnie
John Duncan Gibb
Geoffrey Roy Halliwell
Peter Harper

Steven George Hattrick
Kenneth Jackson
David Michael Jones
Ian Jones
Michael John Lund
Bryan McLean
Percy George Munn
Trevor Arthur Needham
Kenneth James Overton
William Peel
Brian Price
Brian Waring Ramsden
Douglas Robson
James Leon Russett
Neil Simpson
Alexander McEwan Stevenson
Robert Stanley Symon
Michael Raymond Temple
Alexander Gibb Troup Tosh
Christopher George Turnham
Michael John Wolstencroft
Michael James Thomas Wright

TRANSFER FROM ASSOCIATE MEMBER TO MEMBER
John George Alexander Robertson

TRANSFER FROM ASSOCIATE TO MEMBER
James Randall Elliott Clark
Ernest Howey
John Alan Watt

TRANSFER FROM ASSOCIATE TO ASSOCIATE MEMBER
Robert Leslie Bailey
Burnendu Kumar Banerji
David Henry Barrow
Alfred Leon Rodney Bligh
Patrick Joe Bryant
Cecil Arthur Creber
Arthur Ernest Fitton
Ernest Gabriel Frankel, B.Sc.(Eng.)
John Gilbert Gibson
Desmond John Haley
John Hamilton
Keith Stenson Harvey
Thomas Aidan Kiernan
Alexander Mackenzie
George Richmond Matthews
John Hanson May
Daya Krishan Mital
Thomas Edward Morrison
Eardley Erroll Rockwell Newman
Thomas Louis Ryan O'Hare
Cyril William Josiah Stow
Hilary James Tuttle
John Walter Veal
Neville C. Williams

TRANSFER FROM GRADUATE TO ASSOCIATE MEMBER
Dennis John Brown
James Francis Tobin, B.Sc.(Durham)

TRANSFER FROM STUDENT TO GRADUATE
Constantine Philippou, B.Sc.(Glasgow)

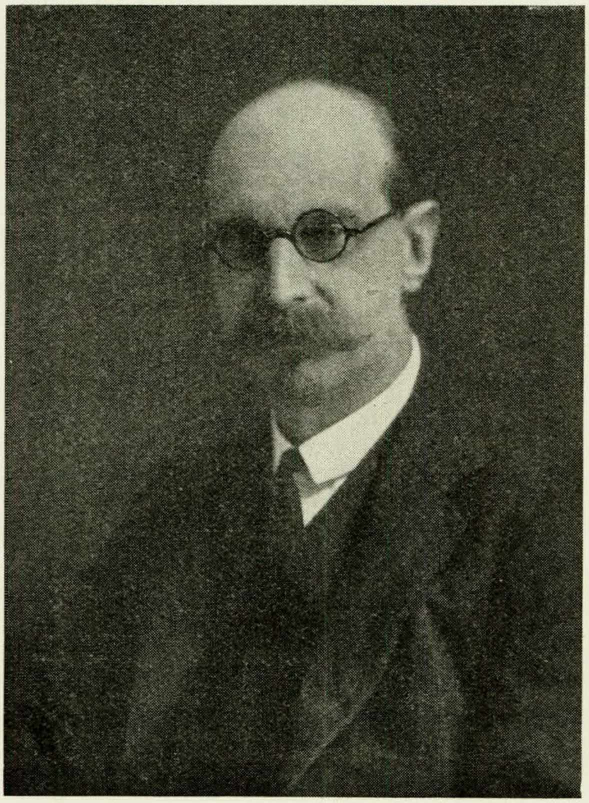
TRANSFER FROM PROBATIONER STUDENT TO STUDENT
David Richard Cusdin

OBITUARY

Ernest Albert Garratt

Ernest Albert Garratt, O.B.E. (Member 4245), who died on 27th November 1954, was chairman of Jacobs, Barringer and Garratt, Ltd., consulting engineers and naval architects, until his retirement in 1952, after more than fifty years with the firm.

He was born at Clapton, North London, on the 15th June 1874, and was educated at St. Johns-at-Hackney Grammar School, London. He served an apprenticeship at the Brighton Works of the London, Brighton and South Coast Railway, from 1890 to 1894. He then went to sea and from 1894 to 1899 served in vessels of Messrs. Pyman and the China Mutual Shipping Company. During this period, he served in all capacities from junior engineer to chief engineer, obtaining his First Class Board of Trade Certificate in 1898, at the age of twenty-four.



In 1900 he left the sea, and for a few months was assistant engineer at a London Electric Power Station. His next appointment was as outside representative for the engineering department of Messrs. Coubro Scruttons. On 1st January 1901 Mr. Garratt joined the firm of Jacobs and Barringer—later, Jacobs, Barringer and Garratt—becoming a director in 1914 and chairman in 1931.

At the outbreak of war in 1914 he joined the Royal Naval Volunteer Reserve and served in the anti-aircraft section in various searchlight stations in London, carrying on this work at night in addition to his normal duties until he was sent to America in 1917. In 1916 he was appointed to the Ministry of Munitions as chief inspector for the Railway Materials Branch and in 1917 he went to the U.S.A. as representative of the Ministry of Shipping, and was supervisor of shipbuilding at Philadelphia for vessels building to British Government account, being responsible for both hull and engine departments. When these vessels were taken over by the American Government on the entry of the U.S.A. into the war, he was recalled to England and appointed to the Ship Management Branch of the Ministry of Shipping, London. In 1919 he was appointed assistant to Lord Inchcape, supervizing the taking over of enemy vessels by the British Government, and their sale to private owners. He was responsible in this way for many well-known vessels, including the *Imperator* (later the *Berengaria*), the *Bismark* (later the *Majestic*), the *Tirpitz* (later the *Empress of Australia*), etc. In 1921 he was awarded the O.B.E. for his various war services, and rejoined his firm in the same year.

Mr. Garratt was recognized as a leading authority on the design and maintenance of oil tankers, and had been responsible for the design of a great number of vessels of this type. He had also carried out a great deal of civil engineering, had often given expert evidence in legal cases, and was the inventor of several successful patents. He had designed many oil storage installations, and had travelled extensively in Europe inspecting oil field equipment. He made a tour of the U.S.A. and Canada in 1910 for the same business, and in 1921 he visited Egypt and carried out a survey of the condition of transport on the River Nile.

Mr. Garratt was the patentee of the first successful interlocking steel sheet piling, known as the "Universal" system of piling. He invented several devices during the 1914-1918 war, including the hydraulic-operated land torpedo. Another successful patent was a form of thread protector for use on oil well casing.

Mr. Garratt was a Member of the American Society of Mechanical Engineers, the Institution of Mechanical Engineers, the Institute of Petroleum, the Institution of Naval Architects, the North East Coast Institution of Engineers and Shipbuilders, and the American Society of Naval Architects and Marine Engineers.

He was elected a Member of the Institute in 1921 and served as Member of Council from 1943-46.

Fred Warwick (Member 8801) died on 15th October 1954, aged eighty-one years, after a short illness. He was a native of West Hartlepool and served an apprenticeship there from 1889-1894 with William Gray and Company; he was at sea from 1894-06 during which time he obtained a First Class Board of Trade Certificate and sailed for six years as chief engineer for Furness Withy and Co., Ltd. He went to America in 1906 where he was an underwriter surveyor for the next ten years, when he was appointed superintendent engineer, adding two years later the responsibilities of marine superintendent and stevedoring superintendent, for Furness, Withy and Co., Ltd.

In 1924 Mr. Warwick returned to England to become assistant to the late Sir John Larking of A. and R. Brown, Ltd. He was appointed general manager of the company in 1931 and managing director in 1944.

He had been a Member of the Institute since 1939.