GARDNER

Engine Forum

Autumn 2020

www.gardnerengineforum.co.uk

No. 38

GARDNER Engine Forum Membership Application

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Gardner Engine Forum Philosophy

The aims of the Forum are to promote and foster interest in all Gardner engines"

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Electronic Magazine For Sale 20

Advertising Rates:
Free for Members Personnel Ads
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Cover Pictures

Foden PVSC6 Coach with 6LW

Bristol Bus with 6LX

at the Anson Engine Museum Gardner 150th anniversary exhibition opening.

Photo's by S Gray

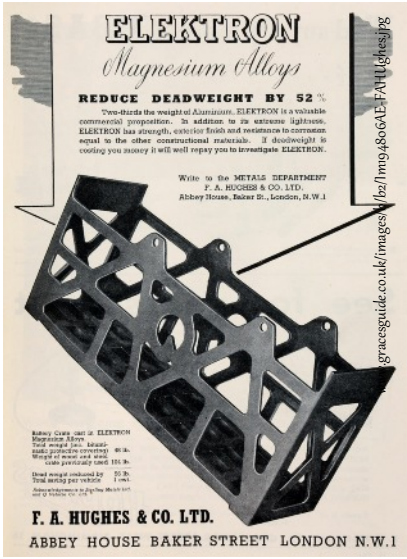
Chairmans Notes

For obvious reasons 2020 will go down in history as a stinker!. It has been a disastrous year for organisations throughout the world, our rally included and the meaning of normal being redefined on an almost daily basis.

I read somewhere that this year has been one of the sunniest since records began in 1956. The sunniest being 1959 which I remember well, as it was extremely hot. Outside our family home, we had a hand pump, not used for many years and as a water shortage was on the cards my father instructed young Naylor to fix it! Albert Slack was the local artesian well man and after a visit to him, some new leathers acquired and fitted we had our own water supply, to this day the people who live in the house can if required still use it.

Moving on I read an interesting article by Peter Freakley in the October 2019 edition of Stationary Engine magazine about restoring the 3L3 that now sits in the Anson Engine Museum. It is an opposite hand build which runs in the normal clockwise direction. The article elicited a letter to the editor in the May 2020 edition from Tony Redshaw. (Tony was one of the 3 original enthusiasts who started the forum.)(Ed) Tony recounts that at a visit to the factory whist it was still operating that he was informed by the Chief Engineer that during the war years that 50 Port Side engines were built, no complimentary Starboard side units were built. They were all built with no external identifying information, so the tappet covers were blank, the engine number was stamped on the flywheel rim, the Lloyds stamp on the crankshaft would be that of their tester/inspector.

This moves me back to the Spring edition of the Forum Newsletter and my mention of the midget x-craft. My grandfather was involved with the batteries and LG & S the production of the lightweight 4 LKs. As you will be aware the LKs made extensive use of a magnesium alloy called "Elektron". This was produced by a company called appropriately "Magnesium Elektron" If you look at the photograph which is a German reconnaissance image from 1941, you can see the factory of Magnesium Electron and the Exide works where the batteries were made. Hence the Germans wanted to bomb them.



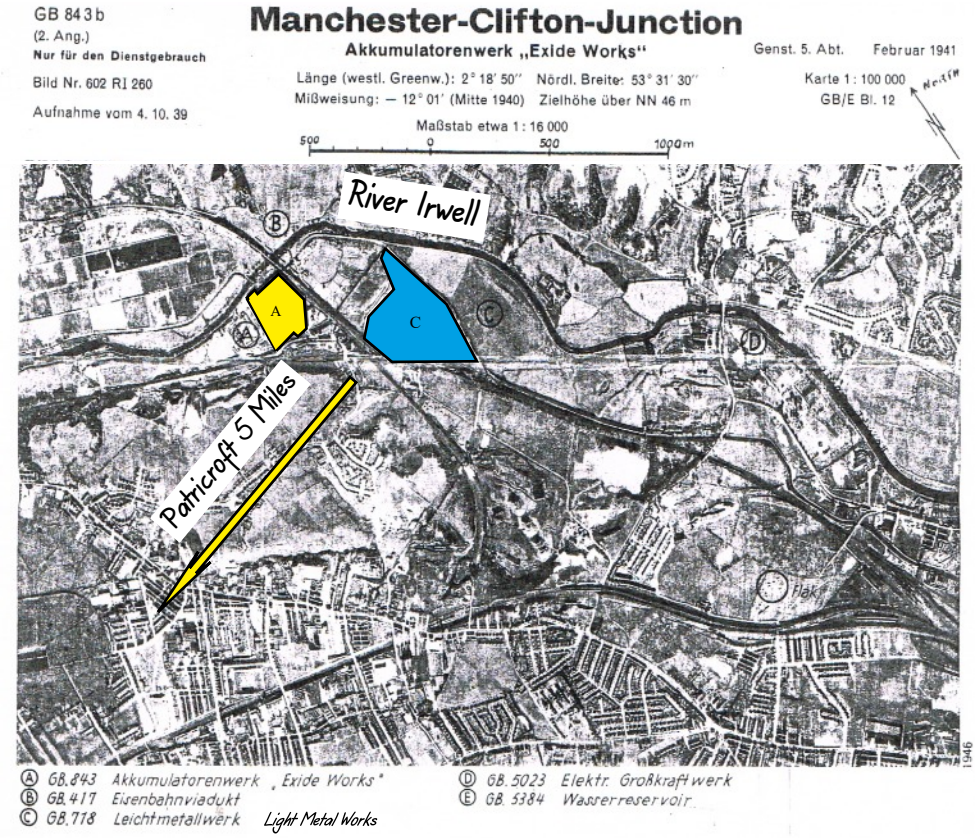
gracesguide.co.uk/images/b/b2/Img480GAE_FAHughes.jpg

When I was an apprentice I machined some LK sumps on I think a Kendal & Gent milling machine. Perhaps more of that another time.

Back to COVID 19, I am well aware that the Industrial Revolution started in Britain, but a leading theory for the origins of modern growth is it started during the Back Death. Like COVID the plague started in China before spreading to Europe.

I hope with the lock down you have managed to work on all the projects you have been putting off.
Next year the LW engine is 90 years old . For our next rally, whenever that may be, lets hope we have a good showing of LW's.

Along with this issue you will have received another small booklet detailing the merchandise that we now supply, usually at rallies and in smaller quantities by post during the year. The variety of items that we now offer has grown and



Magnesium Elektron Ltd (MEL or the Mag) is a British chemical company which produces magnesium and zirconium metals and compounds.
The company was founded in 1934, as the British Magnesium (Elektronmetal) Ltd. and in 1935, Magnesium Elektron Ltd was formed as a joint venture between ICI (48%), I.G. Farbenindustrie (30%) and F.A. Hughes & Co (22%).[1] It started by producing Elektron or Elektronmetall, under licence, first developed in 1908 by Gustav Pistor and Wilhelm Moschel at the Bitterfeld works of Chemische Fabrik Griesheim-Elektron (CFGE or CFG), whose headquarters was in Griesheim am Main, Germany.

In 1936, the company opened a factory on Lumns Lane at Clifton Junction, to the north west of Manchester to produce magnesium metal. During the Second World War, the company made an important contribution to the nation's war effort producing thousands of tons of magnesium metal alloys for the aircraft industry:-(Wikipedia)

cannot all be included into the newsletter without compromising article space. Most items can posted for a cost of £3.50 or less. Christmas is just around the corner so now would be a good time to replace those worn out items.

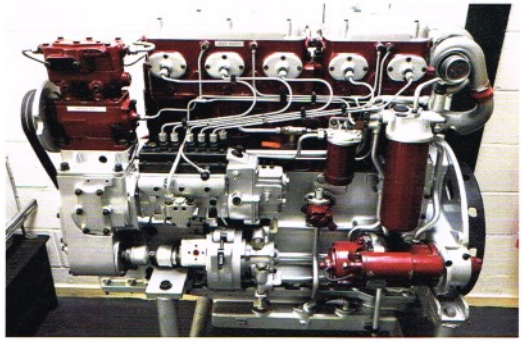
I mentioned the rally that we had to cancel due to Covid 19 and access issues for boats to Bugsworth Basins caused by the issues with Todbrook reservoir, it is likely that these problems will continue into 2021. The committee have discussed the situation (by email and telephone) and concluded that it is unlikely that we will be able to organise an event with any certainty for next year, under normal conditions application forms and risk assessments would be underway by the time you read this, A September rally may be possible if conditions improve but will depend on when the situation has improved sufficently for us to be in contact with operators of suitable sites.

I would like to welcome new members Richard Bateman, Elisabeth Heelin and Per Snarud.
Stay Safe.
John

Gardner Diesels Rise and Demise continued from newsletter 37

In 1935, a higher revving 53-60bhp, four-cylinder, the 4LK, was introduced for lighter trucks and vans. It remained in the catalogue into the 1960s but, being essentially a cheap and cheerful market, it was not a worthy target for a premium quality diesel. The LW series remained in production for five decades. Production exceeded 90,000 units by 1979. This was not far short of Gardner's total output of high-speed diesels by the time production ceased in the wake of the Hawker Siddeley and Perkins takeovers in the 1980s and 1990s.
In the LW'S final ten years or so of production, the higher operating weights and transition to semi-trailer heavies began to cast a lengthening shadow. The Continentals were coming and Cummins had begun UK production. There was an appetite for more power, and Gardner's

▲ '240' 8LXB-engined Atki. By the time the Seddon Atkinson 400 appeared, Gardner was rationing deliveries and losing out to Cummins.



▲ Least known of Gardner's legendary LX series, the mid-range five-cylinder 5LXCT turbo slotted in between the 6s and 8s.

Pochin Construction's Harold Lomas cherishes this 8LXB powered Foden 4x2 tractor, maintained in tip top condition.

bread-and-butter customers - ERF, Foden and Atkinson - were beginning to feel the pinch.

Gardner's answer was the 6LX series, introduced in 1958. Unlike the incremental 'if it 'ain't broke, don't fix it' tweaks applied to the LW over its lifetime, the 6LX was subject to intensive developments and upgrades. The initial '150' spec received massive acclaim. Whilst it kept Gardner in the game, Gardner's more traditional production engineering culture meant that demand increasingly limited its ability to supply, creating an open goal for competitors. The 6LX progressively evolved into the 180bhp 6LXB, 193bhp 6LXC and the turbocharged 220/230bhp 6LXCT that entered production in 1981. (For the bus and coach market, Gardner produced horizontal versions of these engines).

To the world's amazement, in 1970 Gardner answered the demand for even higher outputs with the 240bhp 8LXB straight-eight. With turbocharging, later developments delivered 290-/300bhp at 1,900rpm and 880-lb.ft at 1,400rpm. Cabs were getting longer, so the length of the block was not a problem. Installed under shorter cabs, two pistons were typically in the open, leading to the quip that it had six water-cooled and two air-cooled cylinders. Gardner disliked turbocharging, but could not swim against the tide race of market expecta-

▲ The very first ERF, Gardner powered and immaculately preserved. ERF built more Gardner-engined trucks than any other make.

tions. However, price was increasingly acting against Gardner, not helped by relatively restricted production capacity that extended delivery lead times. Some trucks that were spec'd with Gardner engines were priced at a premium purely to steer operators into choosing alternative makes of engine.

Gardner diehard Harold Lomas, 50 years with Cheshire-based Pochin Construction as driver and head of maintenance has the highest praise for the LX series. The firm has retained a Foden S83 cabbed 4x2 tractor with 8LXB power. "Big, lazy, smooth and bulletproof:" is his summing up. "Superb quality and great to drive" He is equally enamoured with the Foden's similarly immaculate ERF stablemate. One of seven formerly operated by Pochin as placing boom concrete pumpers, it is powered by a turbocharged 6LXCT. It houses a massive 1929 Gardner 3J5 two-stroke, one of a pair that powered a motor yacht formerly owned by the Pochin family

Gardner's swansongs were the turbocharged 6LXDT series and 6LYT, both introduced in 1984. Whereas the 230/275bhp 6LXDT and derivatives were evolved from the LX series, prior to the 6LYT, Gardner had not introduced an all new engine for 30 years. Notably quiet, the 6LYT features included cross-flow cylinder heads and oil-cooled pistons. Outputs were 300/350bhp at 1,800rpm and a potential 400bhp. Maximum torque was 1,140-lb at 1200rpm. The 6LXDT and 6LYT were valiant attempts to save the business but time had run out for both Gardner and the Brits on which it had been reliant.

An excellent history, "Gardner Legendry Engineering Excellence" by Graham Edge is obtainable from various online second hand book suppliers. The Anson Engine Museum has a magnificent collection of Gardner engines from different phases of the firm's history. Altogether the museum has a collection of over 350 engines. Virtually all are in running order, and include the first ever diesel engine built in Britain and only the third in the world. For details visit the The Anson Engine Museum website, enginemuseum.org

▲ Rare classic '320' 6LYT-engined ERF tractor. Introduced in 1984, the turbo-six was the first all-new Gardner for 30 years.

This article was originally published in the August 2019 edition of Heritage Commercials. It has been reproduced by kind permission of the author Ed Burrows and Kelsey Media

British Tank Engines of World War I

Continued from newsletter 37

The 150bhp tank engine development

In October 1916 a meeting was held with potential manufacturers to discuss the proposal for a new tank engine. As a result of the meeting Harry Ricardo was given a mandate to proceed with the detailed design. The target power output was reduced to 150bhp as the original design figure of 200bhp was considered too high for the drive system.

The summary of the key issues to be considered with the new tank engine design were as follows (per Ricardo's own notes):

Load factor

An average load capability of 80% was required for long periods in tank applications compared with a typical load factor of 35-45% for truck and bus applications using similar engines.

Engine speed

Tank engines ran close to the governed maximum speed of 1,250rpm for most of the time with a piston speed of 1,560 feet per minute whereas truck engines averaged about half that figure.

Dust and mud

There were continual problems of dust and mud within the operational environment.

Fuels

Fuels were often inferior.

Service

Engines mostly got unskilled attention in the field.

Operational limits

Engines were often subject to a 35 degree angle when climbing out of trenches.

Design work was undertaken at the offices of Rendel, Palmer and Tritton in London (owned by Ricardo's grandfather). Design and drawing office staff were loaned by Mirrlees Bickerton and Day Ltd, including George E Windeler, Chief Engineer, to assist with the detailed design drawings. The project was given very high priority alongside other tank development work.

In proposing the new engine design, the original plan was to fit the unit into the current Mark IV tank as an interim measure prior to development of the Mark V design being completed. This factor alone placed significant constraints on the new design.

150bhp engine design objectives

The design requirements specified by the Ministry of Munitions included:

Power

The engine had to develop 150bhp

Torque

The engine must maintain a high torque figure across a wide speed range to minimise the risk of tanks stalling in service

Operating conditions

The engine must be capable of operating when tilted at an angle of 45 degrees without losing oil pressure

Smoke

No smoke should be emitted from the exhaust under any operating condition

Endurance

The engine, must be capable of running for 100 hours without requiting any major adjustment or overhaul

Fuel

The engine had to be capable of operating on low grade fuel

Efficiency

The fuel and oil consumption should be as low as possible (no figures were specified)

Dimensions

The engine had to be the same length and width as the existing Daimler unit and to be fully interchangeable with it

Materials

The components had to be designed using mainly cast iron and mild steel (as high tensile steel and aluminium supplies were a priority for aircraft manufacture).

Hence the overall remit was to design an engine producing 42 per cent higher output than the existing design within the same physical dimensions whilst meeting all the other requirements.

Engine design issues

A key challenge was the exhaust smoke requirement as piston rings were not well developed at this time and it was normal for automotive engines to produce blue smoke. Ricardo had previously designed an experimental single cylinder four stroke engine using a cross head piston arrangement. This design had the advantage of keeping the lubricating oil well clear of the combustion space, and the experimental engine exhibited a completely clear exhaust. Hence the cross head design was adopted for the new six-cylinder tank engine. Key features of the original design included:

- 5.625 inch bore and 7.5 inch stroke
- Cylinders were of the non-detachable head design

- Poppet valves were side mounted inlet over exhaust in casings and operated by a side mounted camshaft and pushrods with a crank arrangement for the inlet
- Dry sump design with suction pickup at both ends of the sump
- Two governors — one for maximum speed control and the other for mini mum speed control (400rpm) to minimise risk of stalling and based on Mirrlees design for their diesel engines
- Auxiliaries mounted at the engine ends to meet width restrictions.

The design had a further advantage in that the heat dissipated to the lubricating oil system was much reduced compared with the Daimler Knight design, thus eliminating the requirement for an oilcooler. A Lanchester viscous damper was fitted to minimise vibration. The cylinder design of the experimental engine was retained with a compression ratio of 4.3 to 1, and provision was made for an air start capability but this was never used.

One of the operational problems with the early tanks fitted with the Daimler engine was that these were prone to stalling when changing gear. This was overcome on the Mark V design by using a heavy flywheel on the Ricardo engine combined with a Wilson epicylcic gearbox.

Development timescale

The overall time scale of the new engine development can be summarised as follows:

- October 1916 Authorisation given to proceed with the design
- December 1916 Order confirmed for the production of 700 engines
- January 1916 Manufacturing drawings produced
- February 1917 Initial order doubled to 1,400 engines
- March 1917 First prototype engine produced by Peter Brotherhood
- April 1917 First production engine produced by Mirrlees Bickerton and Day
- June 1917 First Mark V tanks produced with the Ricardo 150bhp engine

Hence the first production engines were manufactured within around 6 months of authorisation to proceed, which was an incredibly short time scale even by today's standards.

The trial evaluation of the prototype engine was completed in an area of rough ground called Foxcovert, adjacent to the Peter Brotherhood works in Peterborough, and the trials proved that the engine met all the specified design parameters such that full scale production could commence.

The Ministry decided shortly after the first engine had been produced that the Ricardo engine would not be fitted to the Mark TV tank as rapid progress had been achieved with the new Mark V tank development (although Mark IV tanks were used for trial evaluation and testing of the new engine). The Ricardo engine was to be used only for the Mark V tank production and hence the strict limitations on the dimensions had not been required after all!

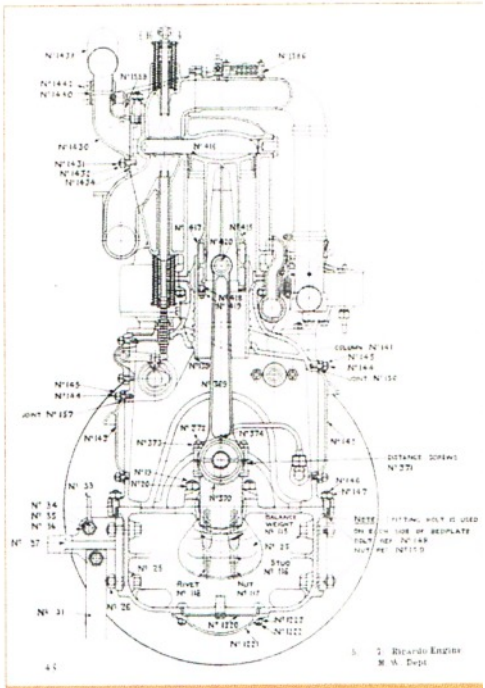


Figure 11 End elevation of the Ricardo 150bhp engine

Testing

The standard works test for the 150bhp engine included:

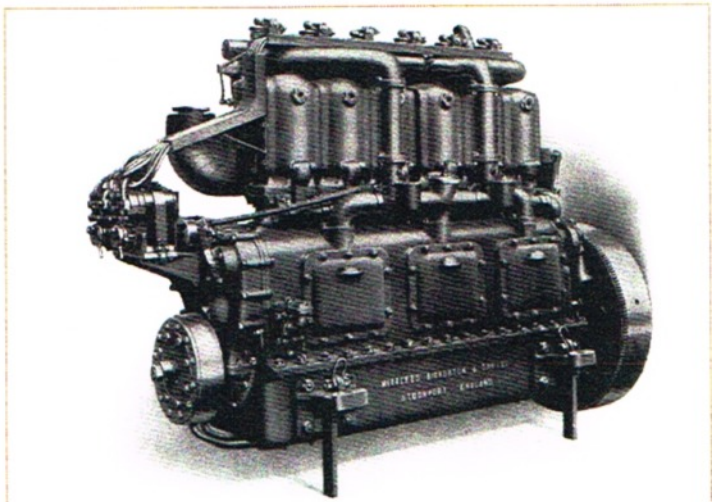
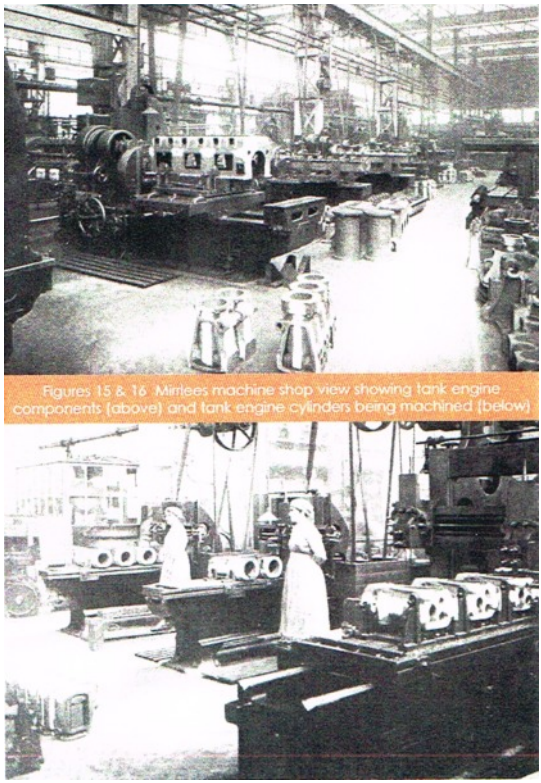


Figure 12 Side view of a Ricardo 150bhp tank engine

- 2 hours at 150bhp and 1,200rpm with fuel and lubricating oil consumption measurements
- 10 minutes at full load at 1,600rpm
- Low speed test of 55bhp at 400rpm
- A special test for the first production engine and then for every 1 in 50 engines included:
- 50 hours continuous running at I 50bhp and I ,200rpm
- 10 minutes running at no load and 400rpm tilted at 35 degrees one way and then the other



Figures 15 & 16 Mirrlees machine shop view showing tank engine components (above) and tank engine cylinders being machined (below)

Service results with the Ricardo 150bhp design

The original concept of 100 hours between overhaul in tank applications was originally considered to be acceptable but Ricardo noted that at least 4 engines achieved over 1,400 hours in service without any attention beyond routine maintenance.

No crankshafts were ever reported as broken in service but problems were reported on engines running for prolonged periods such as those used for power generation purposes and engines used in training tanks (which were in continual rather than occasional use). The combination of small bearing surface area and the soft steel used for the crankshafts resulted in rapid wear requiring the need to regrind crankshafts and to fit new bearings at 500 to 700 hours. This was resolved on all engines other than those destined for fighting tanks by fitting balance weights to the crankshaft thereby reducing the wear rate to less than one third the original figure.

Crankshaft dampers worked well until balance weights were fitted as detailed above causing the dampers to fail within 50 hours. A new design was developed by Gardners using cast iron in place of steel plates resulting in negligible wear after 1,200 hours.

The sand cast aluminium/ copper (88/12%) alloy pistons engines on early engines had porosity problems resulting in failures between the crown and the trunk. This was cured by using pistons cast in dies. Failure of the pistons caused little or no consequential damage.

The exhaust pipes on the 150bhp engines caused too much heat to be emitted for the comfort of the crew and an air cooling system was incorporated using an engine driven fan.

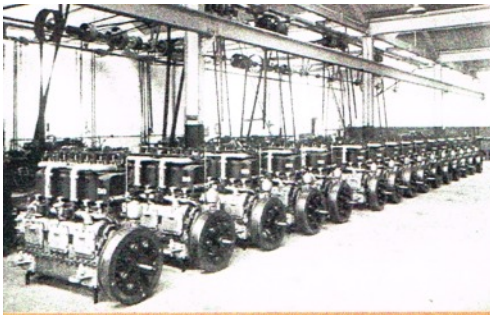


Figure 18. 150bhp engines awaiting despatch from the Mirrlees factory

In some notes written by Ricardo mention is made of a loud and alarming barking dog' noise emitted by individual cylinders on odd occasions with the development engines but with no established pattern. This required some considerable research to establish the cause. It was suggested that piston blow-by along with inadequate piston ring clearance was a possible cause, and one cylinder on a development engine was configured with tight ring clearances. This experiment resulted in the engine making the noise continuously, resulting in broken piston rings. This experiment proved the problem to be one of blow-by when there was not enough piston ring clearance. The side clearance of the piston rings was increased for production engines and no further cases were reported.

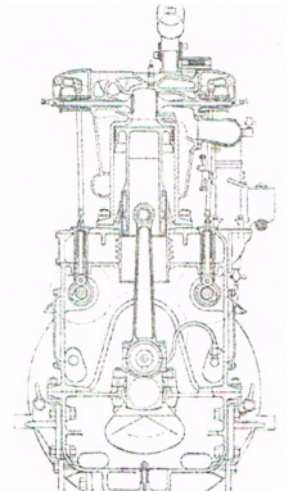


Figure 20. Cross-section of the Ricardo 225bhp engine

225bhp tank engine development

The increase in the overall weight of the later tank due to requirement to increase the armour plating led to a requirement for increased power. Hence after the successful completion of the 150bhp engine design Ricardo was immediately commissioned via Engine Patents Ltd to build a 225bhp engine for the new larger tank designs and also a four cylinder 100bhp version for smaller tanks.

For the 225bhp engine Ricardo increased the piston diameter frçn 5.625 to 6.75 inches whilst retaining the

same stroke of 7.5 inches. The design incorporated four horizontal valves per cylinder which were operated by push rods and bell cranks from a pair of camshafts. The opportunity was taken to correct a problem which had arisen with excessive heat being emitted into the tank from the exhaust system on the 150bhp engine. The exhaust design was improved on the 225bhp engine by running short exhaust pipes upwards from each cylinder head with the manifold being located outside the tank.

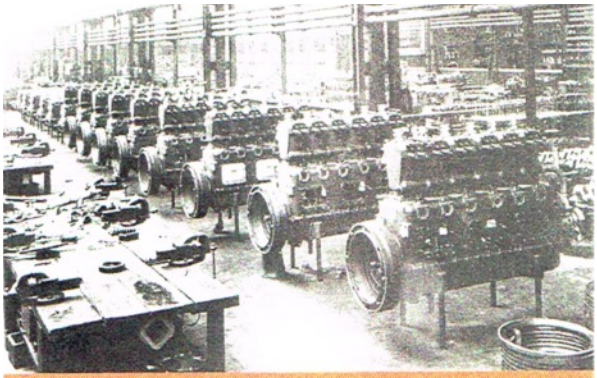


Figure 21 225bhp engines in the assembly bay at the Gardner factory

Larger bearing surfaces were incorporated to provide radically improved bearing and journal life for engines used for power generation purposes. This develop-

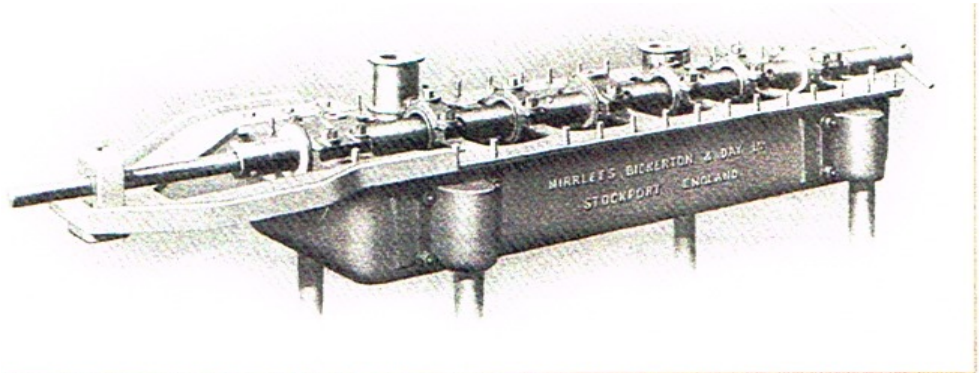


Figure 25 Illustration from the service manual showing reaming of main bearings

ment proved to a good design and the engine was later uprated to 260bhp.

300bhp V12 engine development

A V12 version was developed to give 300bhp but this was not produced in any significant numbers before the war ended. This engine was for use in the Mark VIII tank which did not enter active service before the war ended.

It is believed that 24 were built with the Ricardo engine. A series of hand drawn sketches exist of the Baker Perkins factory which confirm that the V12 was manufactured there along with the 4-cylinder mentioned below.

100bhp 4-cylinder tank engine development

In the later stages of the war a series of new 'Medium' tanks were developed, one of which ('Medium Mark B') required a lighter and lower output engine. This led to a 4-cylinder 100bhp development of the original 1 50bhp 6-cylinder design. The additional engine developments did not reach production until 1918 and thus did not play a significant role in the war.

150bhp 'Light' engine development

The 'Medium Mark B' tank required the 150bhp Ricardo engine in a lighter configuration. A new design was therefore developed to incorporate aluminium bedplates and columns along with various other changes to reduce the weight. The drawings and parts lists were thereafter amended to refer to original cast iron design as 'heavy type' and the new aluminium version was the 'light type' engine. consolidated parts list and service manual covering both types was published by Mirrlees Bickerton and Day in April 1919. The new tank designs were too late to see action.

Manufacture

Manufacture of the engine was undertaken by a group of manufacturers comprising:

- Baker Perkins
- Browett Lindley Ltd
- Crossley Brothers Ltd
- L Gardner and Sons ltd
- Mirrlees Bickerton and Day Ltd
- National Gas and Oil Engine Company Ltd
- Peter Brotherhood Ltd
- Ruston and Hornsby Ltd

George Windeler was appointed as coordinator of manufacturing.

From a historic viewpoint it is fortunate that Mirrlees Bickerton and Day Ltd decided to commission a book to commemorate the end of the war entitled A British Engineering Shop during the War 1914-1918'. This recorded the efforts

made in the overall war effort with copies being made available to all employees. Photographs were taken of the works at a stage when tank engine production was still a dominant part of the activity. Hence very detailed photographs exist of the Ricardo tank engine and its components both in 150 and 225bhp versions. It is also fortunate that MAN Diesel and Turbo UK Ltd decided to commission a reprint of this book in 2011 (with copies made available via the Anson Engine Museum with all proceeds to the Poppy Appeal Fund).

It is believed that the photographs were taken after the war had finished and possibly in early 1918 when the manufacturer appears to be continuing with the wartime contracts to provide work for their employees before normal engine sales and production could resume. Credence is given to this concept by the significant volumes of complete engines awaiting despatch shown in the photographs and also by the high proportion of main components being machined for the 225bhp version rather than the I 50bhp design. It is also unlikely that work would be stopped to allow such photographs to be taken if the country was still at war.

There are a number of interesting hand drawn illustrations concerning the activities of Baker Perkins in manufacturing the Ricardo engines as part of the war effort and these can be seen at wwwestwoodworks.net; illustrations include:

- Assembly of the 4-cylinder 100bhp
- Testing of the 12-cylinder 300bhp \T12 engine
- The test beds showing 4 and 12-cylinder engines on test
- Machining of the crankcase for the V12 300bhp engine

It is also apparent that many of the works involved with tank engine production were substantially expanded and improved to accommodate volume production of smaller engines. In the case of Mirrlees Bickerton and Day the works floor area was four times that of the original 1908 factory by 1920. Also the various works were equipped with a substantial number of new machines designed to handle volume production of tank engine components. There was some specialisation arranged with the various factories in the pool with Gardners for example handling crankshaft production.

Total number of Ricardo tank engines produced

Production of the combined manufacturing group was recorded at 40 engines per week of the 150bhp design in the summer of 1917, rising to in excess of 100 per week by the end of 1917.

The total production of all variants of the Ricardo tank engine was claimed to be around 8,000 in various publications including those written by Ricardo and the number is also listed in the

historical section of the current website of Ricardo plc. The approximate number of tanks produced with Ricardo engines is as follows:

Mark V	1,220	150bhp 6-cylinder heavy type engine
Mark V*	579	150bhp 6-cylinder heavy type engine
Mark V**	25	225bhp 6-cylinder engine
Mark VII	3	225bhp 6-cylinder engine
Mark VIII	125	300bhpV12-cylinder engine Engines
Mark IX	3	150bhp 6-cylinder heavytype engine
Medium Mark B	102	100bhp 4cylinder engine
Medium Mark C	50 1	50bhp 6-cylinder light type engine

It is possible that some Mark IV tanks were fitted with the same engine in addition to the ones used for trial and testing purposes. Allowing for some additional engines being produced to replace those damaged in the field the above list does not total anywhere close to 8,000. One could conclude therefore that substantial numbers were used for other purposes such as power generation for war sites such as airfields, hospitals, workshops etc.

It is also recorded that the Navy used some of the engines. It is also surmised that some manufacturers carried on with production after the war ended and/or used up existing stocks of surplus engines. The photographs taken of the Mirrlees works (presumably taken in 1919) show the works in full production with 150 and 225bhp tank engines.

In some unpublished notes (available via a Cambridge University website) Harry Ricardo is quoted as saying:

"I *have said that the number of engines for Tanks turned out during the years 1917-18 were considerably higher than the number of hulls. These engines were in great demand for a large number of other purposes. Several hundred of the 150bhp engines were used in France for providing power and light to base workshops, hospitals, camps, etc. These engines in many cases were called upon to run for very long spells, sometimes non-stop for several weeks on end. This, of course, was a far more arduous duty than service in the Tanks. Others were in demand for the Navy for propulsion of all kinds of auxiliary craft Others yet again were used in improvised shunting locomotives. The Navy, however preferred the larger 225bhp engine which was uprated to 260bhp."*

There is on-going research into the numbers of engines produced by each factory, but the provisional figures established so far are:

Mirrlees	1451
Gardner	410
Crossley	900
Brotherhood	300

Field service

Major workshops were set up in France to handle repair and replacement of all engine types in service. Large stocks of parts including major assemblies and complete engines were required to keep tanks operational.
The workshop manual for the Ricardo tank engine contains comprehensive instructions on a wide range of repair ' procedures to be undertaken in field workshops using special tools.

Post war engine applications

When peace was declared the engine manufacturers were still fully committed to the wartime production contracts including the Ricardo tank engines. Evidence suggests that wartime production of the engines continued for some time whilst the manufacturers reorganised themselves for normal commercial production- Hence surplus tank engines were used for other purposes and some were probably sold at war surplus sales. The Ricardo tank engines were used for various applications including shunting locomotives, tractors, generating sets, and mobile compressors.
Peter Brotherhood produced a post war brochure showing their range of engines which included both 150 bhp and 300 bhp Ricardo tank engines and other manufacturers may have adopted a similar policy. Peter Brotherhood designed and produced a tractor which incorporated the 150 bhp engine with around 300 being sold mainly to Australia and New Zealand.

Heritage

There are Ricardo tank engines still in existence at various museums including the Tank Museum at Bovington, Dorset (see www.tankmuseum.org). The heritage aspect is continuing to be researched by Geoff Challinor at the Anson Engine Museum with a particular focus on the production side..

Postscript

The experience with the tank engine development established the reputation of Harry Ricardo in engine design and development and his name appeared in the 1920s and 30s associated with the development of engines for various manufac-

turers. A further development was that the royalties received for the tank engine work enabled Ricardo to purchase three acres of land at Shoreham and the Bridge Works Laboratories were developed in 1919 for experimental work on engines and fuels. This site is still is owned by Ricardo plc.

The subsequent development of smaller high speed diesel engines in the 1920s was probably linked to experiences gained with the tank engine development. Standards were probably well established on the bearing surface area of crankshafts and connecting rods as a resultant of the issues with the I 50bhp tank engine development. The trunk piston concept was, however, not carried over as by that time there had been significant improvement in piston, piston ring and liner design and production such that acceptable lubricating oil consumption could be obtained with a conventional crankshaft and connecting rod arrangement.

The debate on sleeve vales versus poppet valves continued into the 1920s but most manufacturers adopted poppet valves for new designs. It was curious to note that Ricardo pursued a single sleeve valve design concept in connection with a high speed diesel engine design for the Air Ministry (which was subsequently aborted) and he continued to promote this valve design for many years. The single sleeve was made to oscillate as well as moving up and down and this solved the problem of inadequate lubrication. The concept was continued when Ricardo developed a series of sleeve valve industrial diesel engines in the mid-1920s which were built under licence by several manufacturers including Peter Brotherhood, Mirrlees Bickerton and Day, and Vickers Armstrong.

Anecdote

The author was privileged to work at the Mirrlees factory alongside R.S (Dick) Bickerton who was one of the last of the original 'company representatives' (with a direct reporting route to the Managing Director on customer related issues) and who was a grandson of Henry Neild Bickerton, one of the founding directors of Mirrlees Bickerton and Day Ltd and also of the National Gas Engine Company.

One of Dick's earliest memories was of being taken to the Mirrlees works by his father and given a ride in a tank across an area of rough land adjacent to the factory in Hazel Grove which subsequently became the company golf course. He confirmed that this tank was being used for testing the engines.Figure 7 shows a Mark IV tank as pictured in the Mirrlees publication 'A British Engineering Shop during the War' and may be the tank used for testing purposes (and possibly used for the ride mentioned in this anecdote). The tank was manufactured by Mirrkes Watson Company Ltd in Glasgow This company under its previous trading name of Mirrlees Watson Yaryan and Company had secured the first licence from Dr

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Diesel in 1897 for the manufacture and sale of diesel engines in Great Britain.

Bilographical Footnotes

Sir Harry Ricarado

Harry Ricardo was born in 1885 and was actively involved with the Diesel Engine Users Association (DEUA) from the earliest days and presented a number of papers. He went on to form a company which ultimately developed into the present Ricardo plc (see www.ricardo.com). He was a regular attendee at the DEUA Annual Luncheon and received a standing ovation on his entrance to the luncheon in later years. The author can remember attending the 1974 DEUA Annual Luncheon when it was announced that he was unfortunately not able to attend this meeting following a fall. He died a few weeks later.

George E Windeler

George Windeler was the Chief Engineer at Mirrlees Bickerton and Day Ltd and went on to publish a number of papers including DEUA Paper 37 in 1919 entitled *A Method of Checking the Alignment of Diesel Engine Shafts and a Means of Proving if a Shaft is actually Bedding in its Bearings'* (available to download via

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This paper was presented by Trevor Owen at the Anson Engine Museum, Poynton on Thursday 24th September as a combined Imarest/IDGTE* event.

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