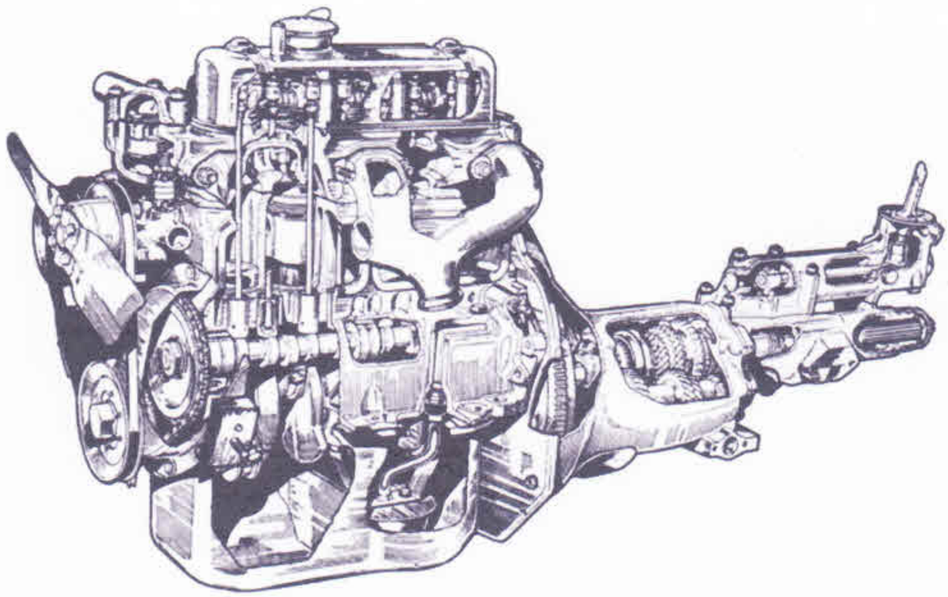
THE B.M.C. 'A' SERIES ENGINE - part 1

Originally A.35 and Morris Minor and later Minis, 1100s, 1300s, MG Midgets and many other developments.

This paper was written by W.V. (Bill) Appelby who was the Chief Designer – Power Units, British Motor Corporation in 1964 and presented to a symposium on small mass produced engines.

This engine was first introduced in 803 cc form in 1952, and the paper traces its subsequent design history, culminating (at the time the paper was written) in the 1098 cc version for transverse installation. The 1275cc size engine (both Mini Cooper S and 'production' versions) came after the paper was written (although possibly the 1275cc Cooper S engine did exist at least in prototype form by this time?).

Originally designed for the post-war Austin 7 saloon, this engine was reclassified as the 'A' series unit at the time of the formation of the British Motor Corporation. It was then decided that this unit and its derivatives would power all the smaller range of B.M.C. cars. Of particular relevance to MGCC members are the MG Midgets (other than the last Midget 1500's with the Triumph origin engine) and the MG1100 and MG1300 saloons with 'A' series engines. Later on also MG Metros had a further developed 'A Plus' engine.



Murray Meyer was prompted to search out this article because he is hoping to shortly get an Australian Morris Mini K with an 1100cc 'A' Series engine that originally belonged to his mother back on the road after being in storage since 2005. Murray could remember the article from his mechanical engineering studies in the 1960s (when things like digitally controlled fuel injection etc were years in the future and the SU carburetor was considered to be a precision instrument not able to be improved and that the efficiency of the 'modern' engine at that time was about as good that it would ever be) but has learned/ remembered quite a bit about 'A' series engines from the Mini K project to date. In particular it seems that the Australian engines were assembled in Australia from UK sourced components but also with a degree of local manufacture and with differences that make life interesting when trying to obtain the right parts. The story of BMC Australia given that some MGs were assembled, there could be another story sometime.

Murray realizes of course that his MG Midget 1500 with its Triumph engine rather than the 'A' series is not a 'proper' Midget and also that this year's budget may require provision for work on its Triumph engine, but the weaknesses of the Triumph engine is also another story.

Ed.—Apologies for the quality of the drawings and graphs. We have enhanced them the best we could.

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The immediate post-war demand for the medium-size car had been substantially filled when the directors of the Austin Motor Company decided, in 1950, to introduce a modern version of the Austin 7-hp car, the original of which, introduced in 1923, had contributed so much, both nationally and internationally, to the reputation of the Company.

It was decided to build a four-seater saloon car weighing approximately 13cwt, the engine to be a push rod overhead-valve type of 800 cc (actually 803 cc) capacity, to develop 30 bhp at 4800 rev/min (Fig 1.1). This car was called the Austin A30.

When Austin and Nuffield merged to form the British Motor Corporation in 1952, this engine was also fitted to the Morris Minor which, however, weighed 15 ½ cwt.

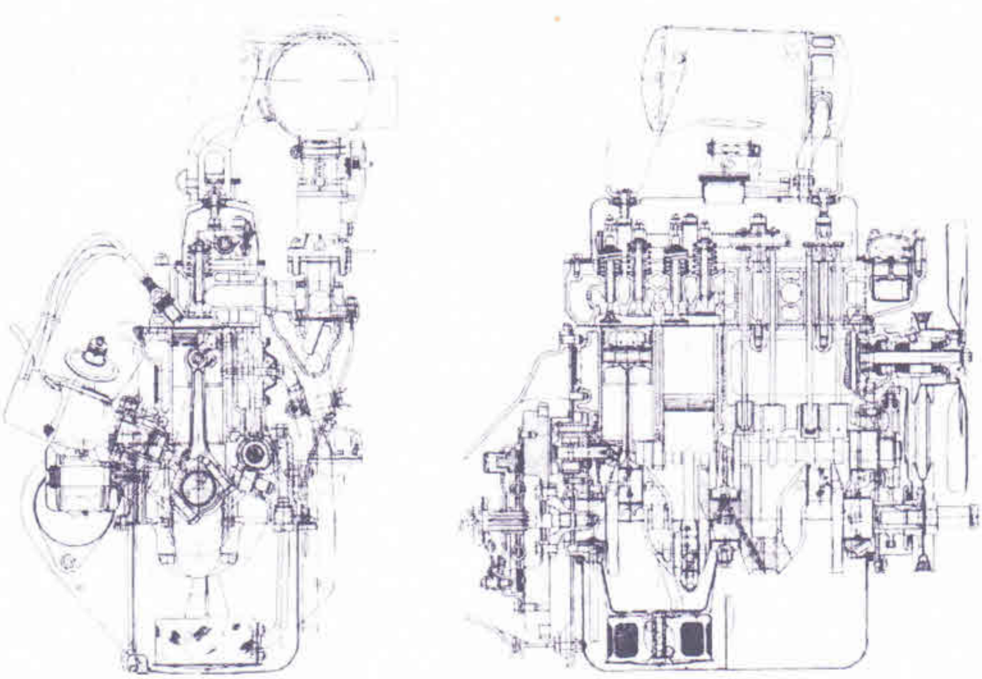


Fig. 1.1 Arrangement of 800 cm³ engine: longitudinal and cross sections

The first decision to be made when designing a new engine is the stroke/bore ratio. The engine designed prior to the proposed new one was the 1200 cc four cylinder engine, which had a bore and stroke of 65.6 mm x 89 mm, a ratio of 1.3:1. This engine had been a great success, over half a million cars having been sold. We could see no point, therefore, in changing this ratio which was maintained on the new engine with a bore of 58 mm and a stroke of 76 mm. In any case, since the stroke was shorter, piston speed would be reduced by about 14 per cent for the same number of revolutions, and it is really the actual piston speed which matters, not the stroke/bore ratio, providing the latter is not extreme.

As this paper forms part of a symposium on small mass-produced engines, the author proposes to dwell on those features of construction which are different to those of our competitors and to give the reasons for these differences.

In the first place, the camshaft and push rods are on the right-hand side of the engine looking from the front, and are on the same side as the inlet and exhaust ports. Thus construction was adopted to avoid the fitting of tubes in the cylinder head to enable the push rods to pass the spark plugs, which would have been necessary if the camshaft had been on the other side of the engine.

It was considered that the tubes could be a source of oil and water leaks, and as production of the engine was likely to be several thousand per week, a small percentage of leaks could create a serious service problem.

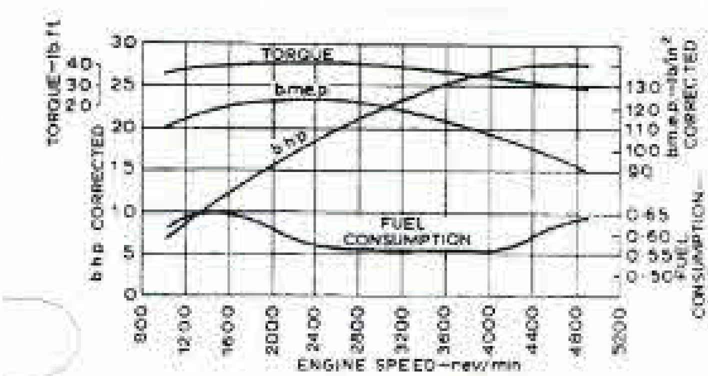
This construction does, however, compel one to use siamezed inlet ports and a centre siamezed exhaust port. We have never found any disadvantage from using a siamezed inlet port; in fact it appears to have an advantage in that the volume of the induction system is less than that of separate ports and therefore there can be a quicker response to any demand from the accelerator. A siamezed exhaust port, however, is not desirable, and its disadvantages can only be overcome by using first-class exhaust valve materials. We now use 21-4N as our standard exhaust valve material.

Another feature of B.M.C. engine design is to put all the electrical equipment on the side of the engine away from the carburetor and the inlet and exhaust manifold. This is done to prevent any petrol drip from the carburetor or heat from the exhaust manifold affecting the electrical components.

This meant that the drive from the camshaft to the distributer had to be taken across the engine. To eliminate another gear and to reduce cost the oil pump was driven from the rear end of the camshaft. This meant that the pump was comparatively high up, above the oil level in the sump, and that means for priming the pump would have to be provided.

The inlet and outlet ports were arranged so that, when once primed, the pump would be at least half full of oil so that priming would not be required again unless the engine was stripped and rebuilt.

Another feature which we insist on is engine flexibility over a wide speed range, including good pulling power at low rev/min. This we secure by using large valves, a low valve lift, a conservative valve timing and a comparatively heavy flywheel. Our standard valve timing is: inlet opens 5 deg BTDC, inlet closes 45 deg PBDC, exhaust opens 40 deg BBDC, exhaust closed 10 deg PTDC, the valve opening period being only 230 deg. A study of the power curve (Fig 1.2) shows that maximum torque is developed at 2200 rev/min, which is just over 30 mph and that the torque curve is fairly flat.



Four cylinders: bore 2·280 in, stroke 3·000 in.
Capacity 800 cm³.
Carburettor—Zenith 26JS.
Camshaft 2A82.
Compression ratio (nominal) 7·2:1.
Choke 18 mm.
S.R. jet 40.
S.R. bleed 80.
Main jet 95.
Main air jet 160.

Fig. 1.2. Power curve for AS3 engine (production)

Another B.M.C. feature that is different is that we employ four rings per piston, whereas it is more usual to fit three. We do this to ensure consistently good oil consumption from one engine to another. We find also that our blow-by figures are lower than those of most other engines, and as air pollution is coming much more to the fore, it is a feature we are likely to retain.

The radial depth of the piston rings was D/26, a plain parallel sided top ring being used with two taper-faced rings and a slotted oil control ring, all to B.S.S. 5004 Material Specification. The maximum blow-by figure on this particular engine was 15 ft^3/h under full load running, which is less than ½ per cent of the displaced volume.

All our crankshafts and connecting-rods are made from 55-ton alloy steel stampings, whereas a 40-ton steel is more generally used. This, of course means, that our die life is shorter. Although this costs the Company a great deal of money, it means that these moving parts can be lighter and the length of the engine can be kept to a minimum. We also use a hardened-steel camshaft with chilled -iron tappets, and this combination has been exceptionally free from trouble.

The combustion chamber design is covered by Weslake patents and is unusual in that it is heart shaped in plan view, with the spark plug at the apex. The combustion chamber wall is brought in between the valves to form a peak, which acts as a deflector to direct the incoming charge towards the plug, this having being found effective in reducing ignition advance, particularly on part loads. Altogether the combustion chamber is very compact.

As only Pool petrol was available in Great Britain, 7.2:1 was the highest compression ratio we could use.

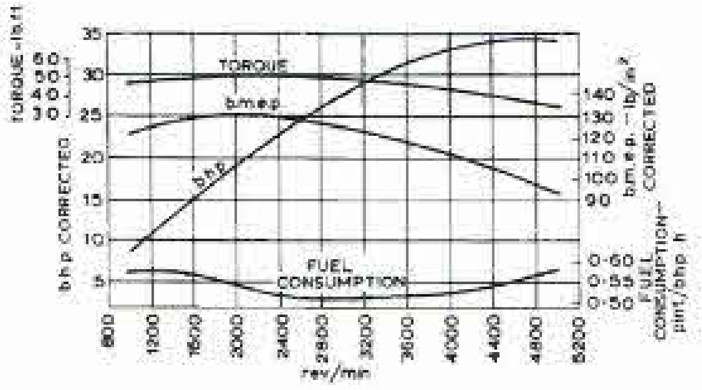
The engine was built in two forms; one using a Zenith down-draught carburetor for the Austin A30 and the other using an SU carburetor for the Morris Minor. The opinion of the road test drivers was that the use of the constant-vacuum as opposed to the fixed-jet carburetor smoothed out many of the induction troubles.

Another B.M.C. feature is the use of a gudgeon pin clamped in the connecting-rod. Although this construction is condemned by piston suppliers and racing enthusiasts, it has a lot to commend it from the manufacturer's point of view. It can be smaller in diameter than the full-floating pin, thus reducing the reciprocating weight and the big-end loading. Any grade size of gudgeon pin will fit the small-eng bore, thus easing the servicing problem.

There are no circlips to cause trouble and there is complete freedom from small-end knocks. It is not surprising that the Americans have turned away from the full-floating pin to pursue the pressed-in pin.

A.35, A.40 and Morris Minor 1000

After building 556000 of the 803 cc engine it was decided to increase the cubic capacity in order to increase the demand for the cars into which they were fitted. The bore was therefore increased to 62.9 mm, the stroke remaining at 76 mm to give a capacity of 950 cc (948cc).



Four cylinders: bore 2·478 in, stroke 3·000 in.
Capacity 948 cm³.
Compression ratio 8·3:1.
Carburettor—Zenith 26 V.M.E. with 22 mm choke.
Camshaft 2A82.
Cylinder head 2A629.

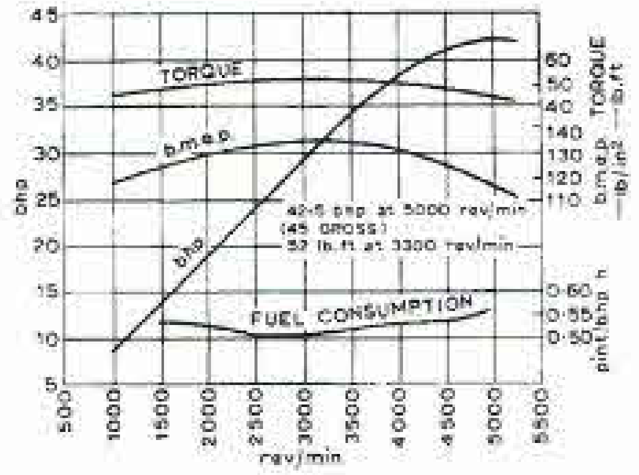
Fig. 1.3. Power curve for 950 cm³ AS5 high-compression engine

As Premium petrol had become available it was possible to raise the compression ratio to 8.3:1. This had the effect of raising the power to 34 bhp in the Austin version and 37 bhp in the Morris Minor 1000. The torque was also raised from 40 to 50 lb.ft (Fig 1.3).

The diameter of the big-end journals was increased from 1-7/16 to 1-5/8 inches and the material of the big-end bearings changed to lead-indium.

With lead-indium bearings it was necessary to fit a full-flow oil filter in place of a by-pass filter and this was done.

One of the disadvantages, as we then thought, of increasing the bore and retaining the same cylinder centres was that the cylinders had to be siamezed in pairs. When we built the first engines we were dismayed to find we had excessive bore distortion which we, at first, ascribed to the siamezing. We eventually traced the cause of this to a thick copper and asbestos cylinder head gasket which had replaced a thin steel gasket used on the 803 cc engine and which was not entirely trouble free. We then adopted a copper-asbestos gasket 1/32 inch thick and we eventually finished up with a maximum bore distortion of 0.0009 inch.



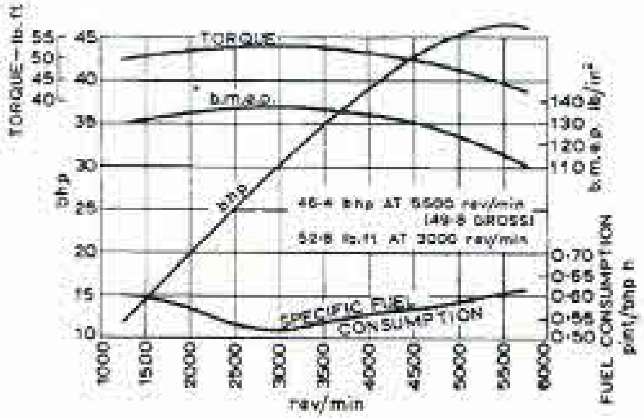
Four cylinders: bore 2·478 in, stroke 3·000 in.
Capacity 948 cm³.
Compression ratio 8·3 : 1.
Carburettors—twin S.U. H1 fitted with G.G. needle, jet 0·090 in d.

Fig. 1.4. Power curve for Austin-Healey Sprite

During the life of this engine we wanted to increase the bore life by fitting a chromium-plated top ring, but when we tried it out we found our oil consumption increased very considerably. After many experiments we increased the radial depth of the rings to D/24, making the top and bottom rings of D.T.D. 485 material. These rings gave very good results on oil consumption, and service complaints in this respect virtually ceased.

Our method of machining our cylinder bores is also different from those of our competitors. We prefer a surface finish of from 25 to 60 micro-inches, which we obtain by first boring with a single point tool, wire-brushing and then rolling.

Austin-Healey Sprite and MG Midget
In May 1958 the Austin-Healey Sprite was introduced as a completely new and inexpensive sports car. The engine used was the 948 cc and using twin carburetors and a compression ratio of 8.3:1. This engine developed 42.5 bhp at 5500 rpm with a maximum torque of 52 lb.ft at 3300 rpm (Fig 1.4).



Four cylinders: bore 2·478 in, stroke 3·000 in.
Capacity 948 cm³.
Compression ratio 9·0 : 1.
Carburettors—twin S.U. HS2 fitted with V3 needles, Blue Springs.

Fig. 1.5. Standard power curve for ADO. 41/47 (uprated Sprite and Midget)

In June 1961 the Sprite Mark II, with various body improvements, and the MG Midget were introduced, and it was felt that an increase of engine power would help to increase demand. A new cylinder head with a compression-ratio increase to 9:1 and with larger valves was accordingly designed and the power increased to 46.6 bhp at 5500 rpm (Fig 1.5).

Austin and Morris Mini Car
During the life of the 948 cc engine, Alec Issigonis had his great inspiration for the Mini Cars, fitted with a transverse power unit driving the front wheels.

Some consideration was given to the use of two-stroke, air-cooled and water-cooled four stroke twin-cylinder engines, but all were discarded in favour of the four-cylinder, four-stroke, water-cooled engine which we considered had the minimum degree of refinement acceptable to the greatest number of motorists. This decision was precisely the same as the one arrived at by Sir Herbert Austin in 1923.

The Mini Car weighed only 11 ½ cwt and it was felt that, if the 948cc engine was fitted, the car would be too fast for many people. For the Mini, therefore, the stroke was reduced to 68.26 mm, but the same cylinder block, cylinder head, valve gear and timing gear as for the 948 cc engine were used (Fig 1.6).

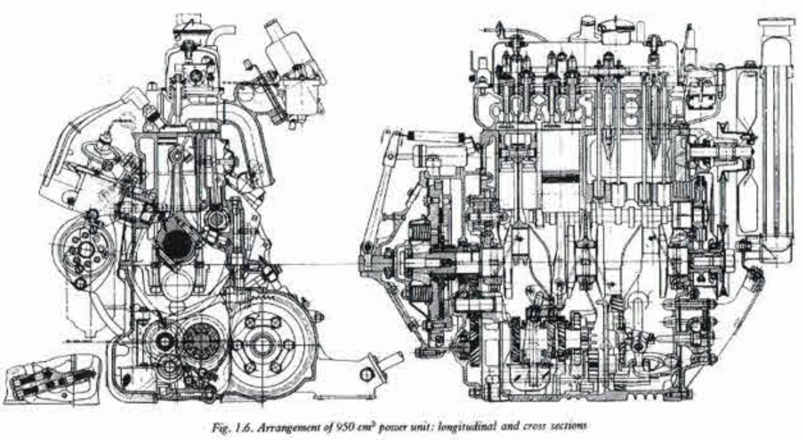
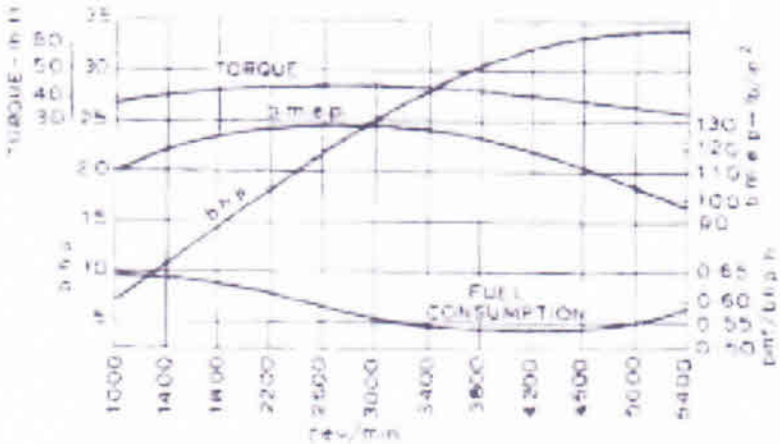


Fig. 1.6. Arrangement of 950 cm³ power unit: longitudinal and cross sections

In consequence, the engine developed the same power as the single carburetor 948 cc engine, but at higher revolutions and with a reduced torque of 44 lb.ft.



Four cylinders: bore 2·478 in, stroke 2·690 in.
Capacity 848 cm³.
Compression ratio 8·3:1
Carburettor—S.U. HS2, Red Spring EB needle.
2A896 manifold, Cooper's paper element cleaner. Power taken direct off flywheel.
44 lb.ft torque at 2900 (45 gross).
34 bhp at 5500 (37 gross).

Fig. 1.7. Standard power curve for 848 cm³ ADO. 15 high-compression engine

When we were well on the way to production we discovered that Dr Giacosa of Fiat had patented a similar layout of transverse power unit in 1947 but had abandoned it two years later.

For the first time we used the same compression ratio engine (8.3:1) for use with both Regular and Premium petrol, varying only the distributor characteristics and the ignition timing. This was a great help in production, since it was possible to change an engine from one type to the other at the last moment, after installation in a vehicle, merely by making an external alteration.

The transverse engine has a primary gear and the clutch between the rear main bearing and the flywheel. This means that the torsional frequency of the crankshaft is much lower than that of a similar crankshaft in a fore and aft engine. The figures are 24300 c/min for the mini and 29400 c/min for the 948cc. Fortunately the amplitudes of vibration were too low to justify the use of a damper, being of the order of +/- 0.4 deg (sixth order) at 4000 rpm (Fig 1.7).

Part two of this article continues in the next issue of the Canterbury MaG.