

THE LIGHTWEIGHT ENGINE.

A Technical Analysis by John Allen

Introduction

This note gives general details on the post-war AMC lightweight engines which were used in AJS 14 and 8 models and Matchless G2 and G5 models. It covers all models.

The 250cc AJS 14 and Matchless G2 were introduced in the early summer of 1958 to complement AMC's existing range of bikes. They were better than most of the 250cc machines available but suffered from a weak engine bottom end and poor telescopic front forks. Although not particularly light, they were called 'Lightweights.' During 1960, 1961 and 1962, 350cc models (the 8 and G5) were sold with a stronger crankpin, duplex primary chain and 1 1/8 inch diameter 'Teledraulic' forks. Similarly, sports and scrambler versions of the 250cc models, the 14S and G2S and 14CS and G2CS, were sold. 250cc CSR models were built with Teledraulic forks, a more substantial crankpin and duplex primary chain, and became available in the summer of 1962, remaining in production until the demise of AMC in the late summer of 1966. The 250cc engine has ten fins on the barrel while the 350cc has twelve.

The Lightweight models have suffered from a 'poor relation' attitude, being used by either those who could not get a Heavyweight single or a twin or those who were simply masochistic. This isn't fair. They remain an affordable introduction to the marques and can be made to go reliably and quickly. For the smaller models, the later ones are better (try to avoid the ghastly Francis-Barnett forks).

Manuals and parts lists

Bruce Main-Smith Ltd, 1 Featherby Drive, Glen Parva, Leicester LE2 9NZ, can supply photocopies of instruction manuals and parts lists for most models. However, they were not published yearly and it appears that there are no parts lists for 250cc models after 1962. The instruction manuals were quite comprehensive but did not give details about work on the bottom end of the engine.

Lodgemark Press publishes a manual, written by an ex-service manager at AMC - Fred Neill, with details of the post-1963 engines. This covers all post-1956 singles (both Heavyweight and Lightweight but it does contain some mistakes, although usually these are obvious. The main problem with it is that its layout is extremely poor and there is no index. I believe that it can be obtained from the Spares Scheme.

At autojumbles, you may find a true AMC service manual, about A4 size with a red cover. This is essentially the same as the Lodgemark book, although some do not have details of later 250cc CSR models.

Roy Bacon has written a couple of books about AMC models. These have some very good pictures, are better written than Neill's works and have some, at least, of the errors corrected. However, I feel that they do not go to such a depth as Neill's books (I would not rely on them when building an engine, for example).

Haycraft's book, in the Pitman series, has no information on Lightweights whatsoever, although there is a picture of one on the cover.

Historical summary

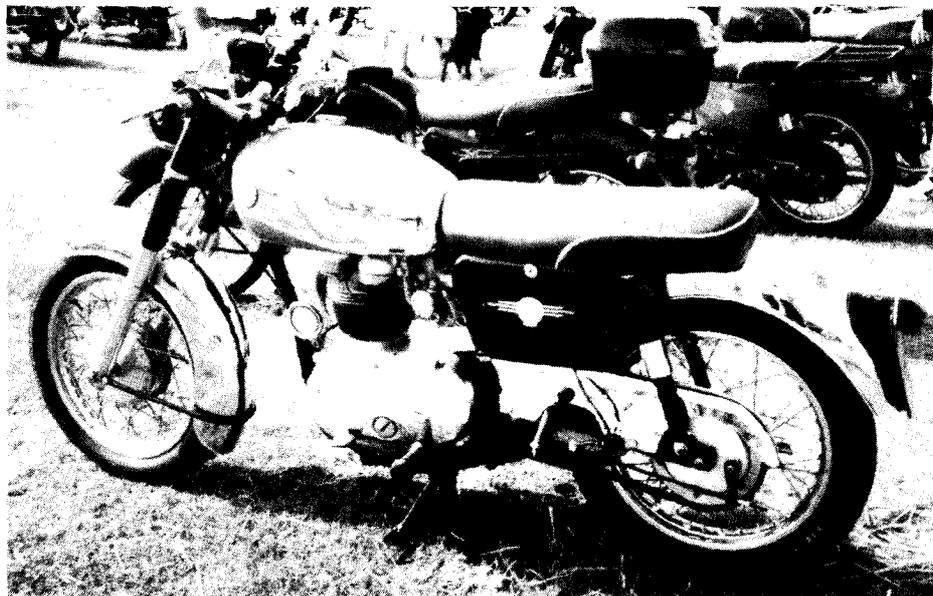
When introduced in May 1958 the main features of the 250cc light-weight engine were:

- Unit-construction appearance with the gearbox apparently integral with the engine castings (it was not, the gearbox, clutch and primary drive were hidden by bulbous side casings).
- Offset (or désaxé cast iron cylinder (to reduce wear) with a bore and stroke of 69.85mm and 64.84mm.
- Oil tank bolted on to the timing side crankcase with a felt oil filter in the drive side crankcase (dry sump). No external oil pipes.
- Crankshaft supported by two ball bearings, with a timed crankcase breather between them, in the drive side crankcase, and a bronze bush for the timing side bearing.
- Reciprocating plunger oil pump driven by a worm on the timing side axle (similar to the heavy-weight single engine).
- Single camshaft, carrying two cams, driven from timing pinion on timing side axle. The nose of the camshaft drove the ignition contact breaker through a centrifugal advance and retard mechanism.
- Pushrods, enclosed in the barrel casting, activated by pivoted cam followers.
- Wire wound piston.
- Cylinder head and rocker box similar to the Heavyweight single with hair pin valve springs. However the head was rotated 21° compared with the crankshaft. The head had secondary finning to encourage air over the spark plug.
- Ignition was from a coil with an alternator providing the electricity.

Changes:

- **1960 [350cc Light-weight introduced with a bore and stroke of 72mm and 85.5mm, duplex primary chain].**
- **1962 - New clutch and chaincase introduced in December 1961 (after engine number c11500).**
 - Hard chromed cam followers used on engines after engine number 12128 (including CSRs).
 - CSRs introduced in May (engine numbers 12128 to 12673). These had steel flywheels, large diameter crankpin, larger inlet valve, new timing side covers and chaincases, a repositioned oil hole in the timing chest and a duplex primary chain.
- **1963 [Only the CSRs remained in production] (engine numbers from 12828)**
 - Long stroke oil pump fitted with direct feed to cam followers.
 - Change in crankcase oil ways.
 - Oil metering plugs deleted from rocker box.
- **1965 (engine numbers from 13965)**
 - High compression pistons fitted, ignition timing 24 degrees BTDC (advanced).
 - Coil valve springs with collars to suit.
 - Oil control screw in cylinder head deleted.
- **1966 (engine numbers from 14757 to 15506)**
 - Ignition timing 27 degrees BTDC (advanced 1).
 - Low compression piston offered using a timing of 34 degrees BTDC (advanced).
 - Direct oil feed to cam followers deleted.

The 250 CSRs. This is a 1963 AJS 14CSR, with distinctive tank, Teledraulic forks and chromed steel mudguards. (photo: Tony Head)



This is a final year's Matchless G2CSR (toting a supply of 'Watson's' Matchless Cleaner!). Note the alloy guards - the silencer and badging are not standard, but the rest is. And very nice it is too



Potential problems

Crankpin -The early engines suffered from crankpin breakages. AMC redesigned the crankpin and conrod a number of times and the final large diameter pin is available as a pattern part from Alpha Bearings to order - if you can get a late conrod.

Crankcases are interchangeable between early and late models. However, the chaincase was wider on duplex primary chain models. The alternator was also set further into this chaincase.

The main bearing arrangement which used two ball bearings had a short life. The inboard bearing, next to the drive side flywheel, should be replaced by a roller bearing. This will also ease assembly.

Valve gear wear - The contact between the hairpin valve spring and collar wears, and to a much lesser extent the spring tangs and valve spring tray.

Inlet valve sticking - Carbon from the valve stem oiling can stop the valve from closing. This sticking is often a problem if the bike has not been used for some time.

Piston cracking - Pistons can crack either across the dome or around the top ring groove. This is usually associated with pattern pistons and a large right hand. Less serious, in the short term, is skirt cracking from expansion slots on some pattern pistons.

Automatic advance and retard unit - This was a Wipac part and appears to be more robust than its Lucas equivalent. However, there is no way of lubricating it. They can break up. A special tool is needed to remove it.

Rocker box gasket - Some pattern gaskets destroy themselves due to the movement between head and rocker box.

Cast iron exhaust valve seats can become loose; later engines used bronze seats. Likewise the exhaust valve guide can work loose since it is too short for the job.

Pattern cylinder head gaskets can give problems; use copper ones instead.

Oil pump - The oil pump is almost foolproof. However, the long stroke oil pump cannot be fitted to early engines.

The engine can suffer from bad oil leaks. Porous castings have been blamed, particularly for barrel oil leaks. However, before going to the bother of sleeving the oil passage to the cylinder head check that the small breather hole between the oil tank to the crankcase cavity is not blocked.

Availability of parts

Very, very few of the parts used in the lightweight engine and gearbox were interchangeable with heavyweight parts. Rocker box bolts and a main bearing are common.

Most wearing engine parts are readily available from either the Club Spares Scheme or the London shops. However, do not expect them to be cheaper than other new parts. The 250cc piston had either a circular or steeply ramped crown while the 350cc one was flat. Over-weight pistons should be avoided since the loads on the crankpin are increased, giving a short crankpin life, and vibration will be worse. On the 350cc engine, an AMC 600cc piston can be used. This will give a higher compression ratio.

Castings are very easy to obtain. The crankcases must match and the threads for the oil filler cap and oil filter should be in good condition. This also applies to the internal oil tank.

The 250cc CSR cylinder head will fit the 350cc engine.

The CSR exhaust valve is noticeably small. However, its stem diameter is 8.5mm compared with the standard exhaust valve diameter of 8mm. The inlet valve has a 7mm diameter stem.

The coil ignition automatic advance and retard units are no longer available and you are very unlikely to find a good one. This is a major problem. The options seem to be:

Fix the unit to one position and time the ignition to fully advanced or slightly retarded and accept that the engine may kick back during starting.

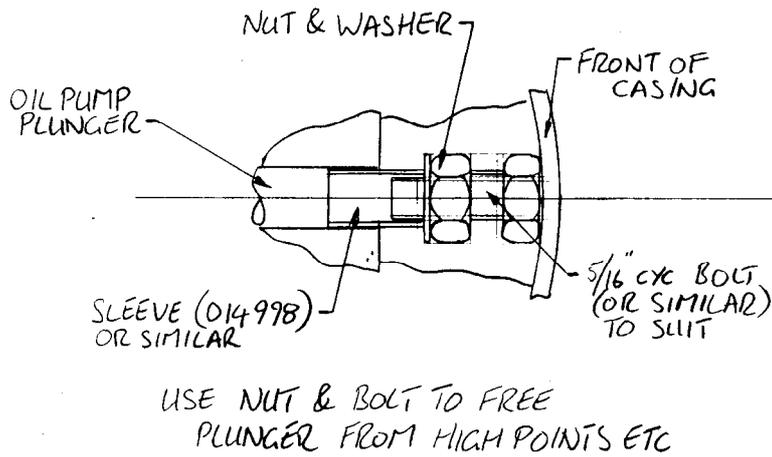
Convert the electrics to 12 volts and use an electronic ignition system that incorporates an advance and retard operation.

Dismantling and assembly advice

NB Any work should be done using an instruction manual. All you have here is advice.

The bottom channel of the frame is removed with the engine. Since it carries the centre stand do not take the engine and gearbox assembly out of the frame with the bike on the centre stand. Either stand the bike on blocks instead of the stand or make sure it is kept upright by rope from the handlebars to the ceiling of the workshop. The frame should be lifted clear of the bottom channel, engine and gearbox. There are six screws securing the rear portion of the chaincase (not three as in Neill).

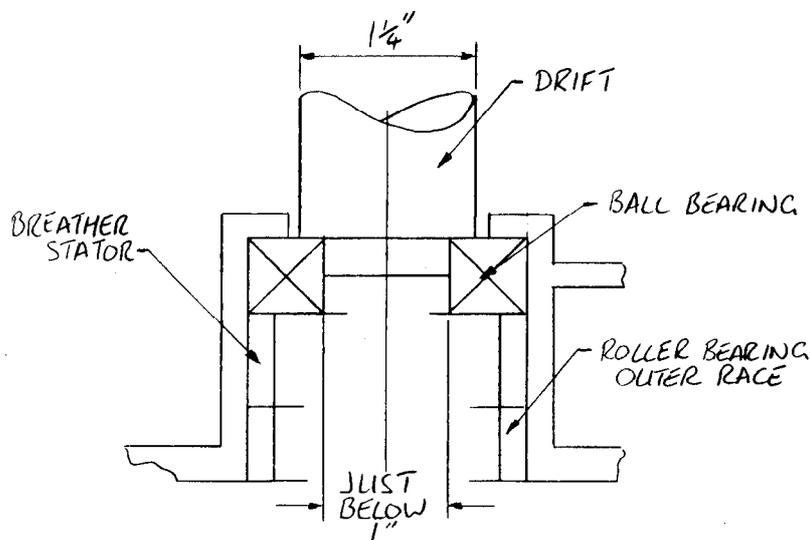
The plunger oil pump must be removed before separating the crankcases. Occasionally difficulty is experienced in removing the plunger after the guide pin is removed. It has to be pushed towards the rear of the engine. Usually it can be pulled out using the end of a spoke, but if necessary, use a bolt (bearing against the front casting wall), nut and sleeve to push it out, see sketch (A below).



Sketch A

The timing pinion must also be removed before separating the crankcases.

Before the main bearings can be drifted out of the crankcases, the peening next to the inboard bearing (usually just the outer race of a roller bearing) must be removed. The screw holding the breather stator must also be removed. On some engines, this was incorporated with the breather pipe. Uniformly heat the casing and remove the assembly by using a drift on the ball bearing inner race (this may be difficult on some engines, if so use a drift with a shoulder that sits well in the ball bearing inner race). (Sketch B below)



DRIFT TO REMOVE MAIN BEARINGS

Sketch B

If there is a flat on the oil pump plunger guide pin it must be replaced.

Check that all the oil passages in both crankcases, barrel and cylinder head are not blocked. Also see that the small breather hole from the oil tank to crankcase cavity is clear (I have heard of the factory failing to drill this hole). It is right at the top of the tank by the filler cap.

All parts must be clean before assembly. Rubbing parts, bearings and gears must be well lubricated. Use clean engine oil or, if the engine is going to stand for some time before use, a high quality anti-scuffing paste.

The crankcases are matching pairs and are dowelled together. If there is a step between the cases at the mouth of the cylinder or the hole for the cylinder spigot is mismatched, you have problems. The former can be machined flat, but it would be wiser to look for another pair of crankcases in both cases.

The early engines used two ball bearings as drive side main bearings; how these were assembled with the crankshaft and drive side casing is a mystery. The inboard bearing should be replaced by a roller bearing, thus allowing the outer race to be fitted with the outboard ball bearing and breather stator. The race should be peened into the crankcase in three positions. The crankshaft with the drive side axle carrying the breather rotor (keyed to the axle) and the rest of the roller bearing can then be fitted into the crankcase.

The crankshaft end float, without the alternator fitted, must be greater than 0.020 inch. If it is not the inside face of the timing side bush must be machined or ground back. If there is end float with the alternator fitted and tight first check that the engine sprocket is fitted the correct way round. If so, the main bearings are loose in the drive side crankcase. This can be cured by Loctiting the outer races of the main bearings into the casing or sleeving the casing to give the correct bore for the bearings. If the crank is absolutely tight and cannot be rotated the breather rotor has probably been left out.

When assembling the oil pump, check that the guide pin has successfully engaged the plunger.

If new piston rings are fitted the glaze on the cylinder bore should be lightly removed by emery paper. A proprietary emery flap wheel is sold for this purpose. The wear step at the top of the bore should be removed or at least blended out.

The piston has cut-aways for the valves which are of different sizes. The small cut-away, for the exhaust valve, must face forward.

Make sure that the small oil feed hole on top of the cylinder head, between push rods, is not masked by the rocker box gasket.

The screw which controls the supply of oil to the inlet valve guide should only be a third of a turn open. Later heads do not have this screw.

Cut the sealing rubber for the tappet inspection cover to the correct length and join the ends to make a ring using superglue.

The sparking plug should be a Champion N5, Bosch W8CC or NGK B7ES. It is probably unwise to use an N9Y as an equivalent to an N5. 1965 /1966 engines used a Champion N3 plug.

Bolt torques

Big end nuts – 190 ft.lbf (140ft.lbf on early cast iron flywheels).

Cylinder head bolts – 35 ft.lbf.

Rocker box bolts - 10.5 ft.lbf (with both valves closed).

The bolts should be tightened in stages with the torque settings increasing until reaching the above values. Both cylinder head and rocker box bolts must be tightened down in a diagonal sequence. The service sheets do not say if the threads should be lubricated but they must be clean.

Valve timings

It is worth noting that when the piston is at one top dead centre, both valves should be closed. At the next both should be slightly open with the exhaust about to close and the inlet opening. The engine will run if this is the case, even if the valve timings are out.

Since there is only a single camshaft, timing is easy; just line up the dot on the cam wheel with the one on the timing pinion. The piston should be at the top of its stroke (top dead centre) at this position.

Tappet adjustment

Note, feeler gauges are not required. The tappet adjustment must be done with both valves closed and the engine warm.

Take off the inspection cover on the rocker box.

At the top of the push rod, undo the locking nut and screw the end cup out until it is finger tight.

Do up the lock nut and you should just be able to rotate the push rod with your fingers.

Repeat for the other push rod.

Ignition timing

The contact breaker gap, fully open, should be 0.012 inch.

The timing must be set for the fully advanced position. The timings are as follows:

250cc (up to 1964) and 350cc - 34° - 1/4 (0.267) inches before top dead centre

250cc (1964) - 24° - 3/16 (0.136) inches before top dead centre

250cc (1966) - 27° - 3/16 (0.171) inches before top dead centre

The fraction measurements are quoted in the handbook while those in brackets are calculated from the angle.

If a low compression piston is fitted to a late engine the early 250cc timing should be used.

A timing disc can be used, and may be more accurate, but it involves removing the outer primary chaincase which is always a pain. Therefore, the details are solely for the spoke-through-the-spark-plug-hole method.

1. Remove the contact breaker cover. Disconnect the wire to the contact breaker and remove the contact breaker carrying plate.
2. Remove the spark plug, and with the rear wheel off the ground select top gear.
3. Put a thumb over the spark plug hole and rotate the rear wheel forwards, anticlockwise, looking from the left hand side of the bike until you feel the cylinder pressure lifting your thumb off the cylinder head.
4. Take an old spoke and bend it so that it cannot drop into the cylinder. Hold it as near vertical as possible and rotate the rear wheel forwards, then, just rocking the wheel, set the piston at the top of the cylinder (top dead centre).
5. Make a mark with a spirit based pen on the spoke that lines up with a feature on the cylinder head.
6. Remove the spoke and scratch a permanent mark on the pen mark using the edge of a file.
7. Lightly scratch a second mark the required distance from the first away from the end that went into the cylinder. Check the distance and correct it by adjusting the direction of cut of the file.
8. Check the top dead centre position of the piston and then rotate the rear wheel backwards, clockwise from the left side, until the top mark on the spoke lines up with your chosen feature on the cylinder head.
9. At this position, an imaginary line through the gaps between the bob weights of the advance and retard mechanism should point at the anticlockwise faces of the screw bosses for the contact breaker plate (see sketch below). The lobe of the contact breaker cam should be pointing downwards. If it is not pull the mechanism off the camshaft and reset the position. If you have repositioned the advance and retard mechanism, check that the piston is still at the correct position.
10. Refit the contact breaker plate so that the contacts are just open. Nip up the screws holding the plate.
 - Insert a clean 0.0015inch feeler gauge (the thinnest in a feeler gauge set) between the contacts.
 - Using a screwdriver through the hole in the contact breaker plate separate the bob weights to get the maximum advanced position. If the timing is correct, the feeler gauge should just be free.
 - If the feeler gauge is not, scratch a mark that crosses from the plate to the surrounding casting.
 - Loosen the screws, rotate the plate a fraction (clockwise if the feeler gauge was loose, anticlockwise if tight) and then tighten. Insert the feeler gauge between the contact breakers and repeat the process until the feeler gauge is just free.
11. Tighten everything and recheck before reconnecting the wire, fitting the spark plug and replacing the cover with its gasket.

An electrical continuity test can be used instead of the feeler gauge.

Carburation

Since I intend to deal with carburetors in detail in a later article, I will not give a lot of details about jets, etc. In practice, if the carburetor is in good condition there should be no reason to alter the jets and the slide from the values given in the manual.

If the main body of the carb is heavily worn, that is if a new slide can rattle around when it is at the bottom of its travel, it is well worth getting the body sleeved.

The heat insulating block between the cylinder head and carburetor should be in good condition and not have any cracks in it. An O-ring should be used in the flange if there is a groove for one. If it is the gasket can be dispensed with. The nuts on the carburetor studs should not be done up very tight.

If a Concentric has been fitted instead of a Monobloc the main jet should be reduced in size by 30.

Oil capacities

The engine oil capacity is small, about two and a half pints. Since the oil remains hot in the engine it should be changed frequently - every 2000 miles or less. Before topping up, run the engine to scavenge the crankcase.

The gear clusters are at the top of the gearbox; the 'box really does need three pints.

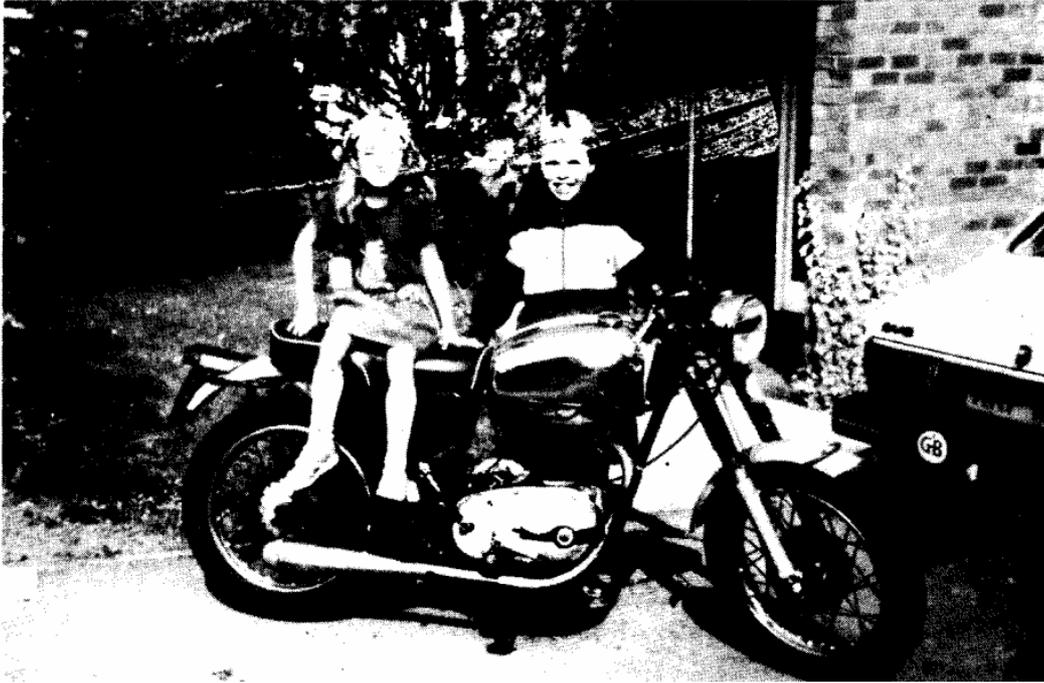
Special tools

Timing pinion puller (043332), a sprocket puller cannot be used.

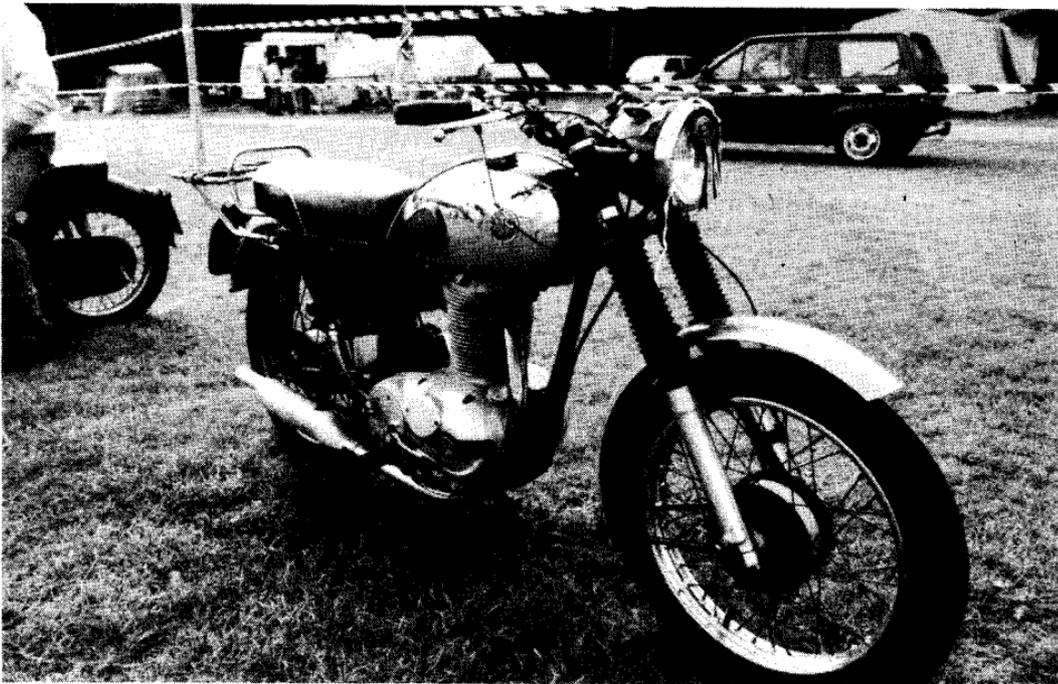
Bolt for removing advance/retard mechanism (042247).

Hairpin valve spring tool (018276).

Car-type valve spring compressor for coil springs.

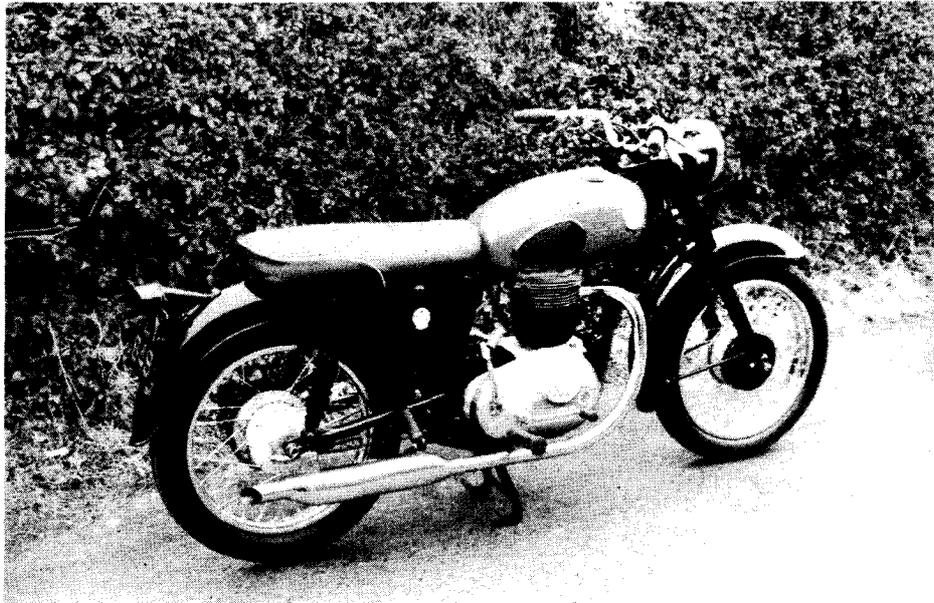


This (unsurprisingly, perhaps) is a very late 250CSR, of the type which has been causing such a commotion in the Letters pages. It should have a cigar-shaped silencer...



Many of the early 250 lightweight's shortcomings were answered when AMC introduced the 350s. Sadly, they were in production for only two years. This is the AJS Model 8 which won the Lightweight Concours at the '89 Jampot Rally.

It belongs to Paul Hinert



Lightweight singles rarely command high prices, so when buying them it pays to be careful, checking that what you buy is what is advertised. This AJS, for instance, is a 350 Model 8, but it clearly wears a 250 front end...



And, to close John Allen's fine series, here is a lightweight single of a different style entirely. AJS 2-strokes are still largely unloved, and still largely under-valued. And who cares whether they are indeed 'real' Ajays; they're fast, they're fun, and they're affordable! Buy now...