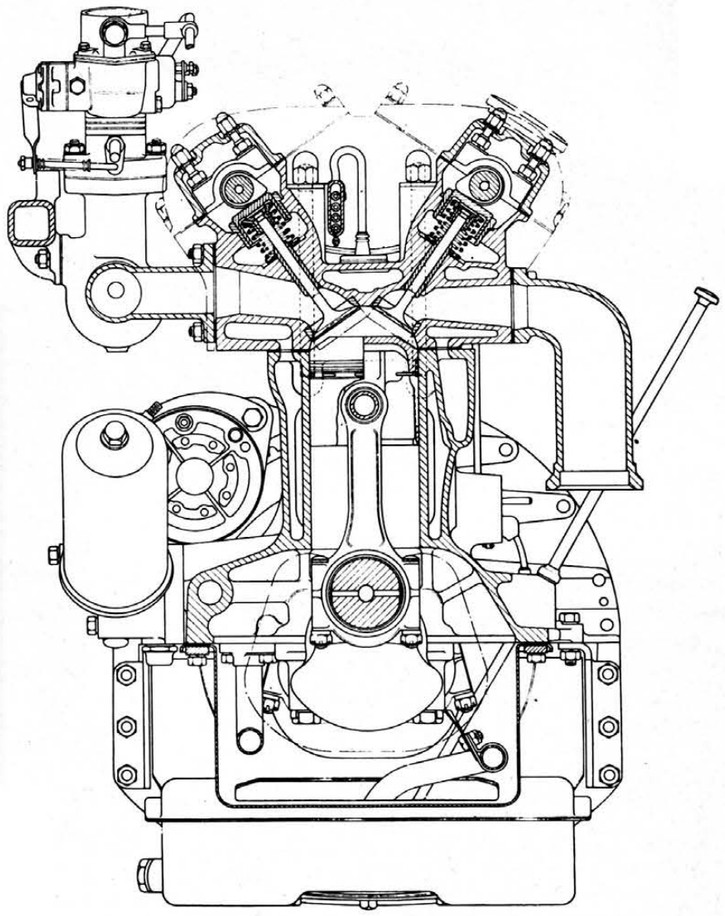
Jaguar's Sawed 6 Off

Engineering drawing of the 2.4 Jaguar engine shows the plant's good points—short, stiff connecting rods, straight ports and two-cam head. Restricted intake manifold is readily apparent and represents first point of attack.



BY KARL LUDVIGSEN

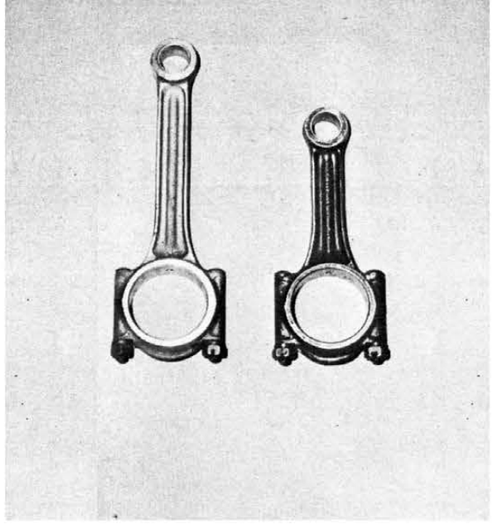
IN SPITE of the overwhelming supremacy in numbers of the modern V8 engine, there are still a lot of very good reasons for building the "outmoded" six. On all the points of production, cost, maintenance, piston area and mechanical efficiency it offers a useful compromise between the simple four and the more complex eight. Inherently, the six is the best balanced of the common engine layouts, and its carburetion and exhaust systems are very easy to plan for maximum cylinder charging.

As a result of its smoothness and freedom, the six is often at its best when there's a lot of area on the tach to be covered. When properly set up, they can be winding fools, as those will testify who have heard the two and three liter Maseratis in full song. Mercedes has fielded hot sixes from the SSKL's to the 300 series, and the modern Lancia V6's and Aston-Martins are equally known for potency.

Unfortunately this type of engine has been beaten into the dust in this country by economy-minded manufacturers, but even here the Chevy, GMC and Willys sixes have been polished up to put out properly. Without doubt, though, one of the most remarkable stories since the war concerns the 3.5 liter Jaguar six. This engine is not modern in all

Fully capable of 100-plus miles an hour in stock form, the new sedan can be made to storm by a few simple changes.

Stiff con rod used in 2.4, right, compared with rod from XK series engine. Short rod is practically indestructible.



respects, having been laid out around 1946, but since its introduction in late 1948 it has been steadily developed to the point where it is producing very nearly twice its original horsepower. Some late American V8's have also approached this, but their strokes are a lot shorter than that of the Jaguar, which at its power peak has a piston speed of about 4000 feet per minute. This is like turning a Cadillac to 6600.

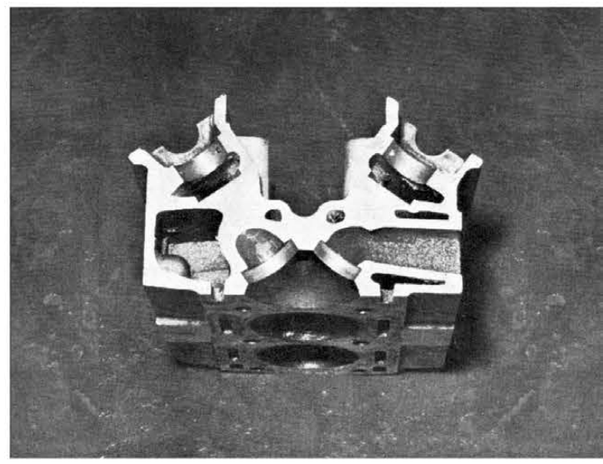
SCI has covered the 210 cubic inch Jag engine before, though, and the really newsworthy item now is the powerplant in their Two-Point-Four sedan for 1956. William Lyons needed a smaller-displacement unit for his freshly-designed smaller four-door, so his engineers simply lopped off the stroke of the big version, leaving the bore and other important dimensions the same. This removes the one big objection to the XK engine, and opens up a brand new field for experimentation.

For one thing, assuming the above maximum piston speed, the 2.4 engine should easily be capable of 8000 rpm without danger of immediate bearing failure. When examining and reworking this mill, this potential should be kept in mind and all efforts made to approach it. This is the only way to wring real power from 151.5 cubic inches. Similarly, the revs alone are of no use if the engine can't breathe fully at that speed.

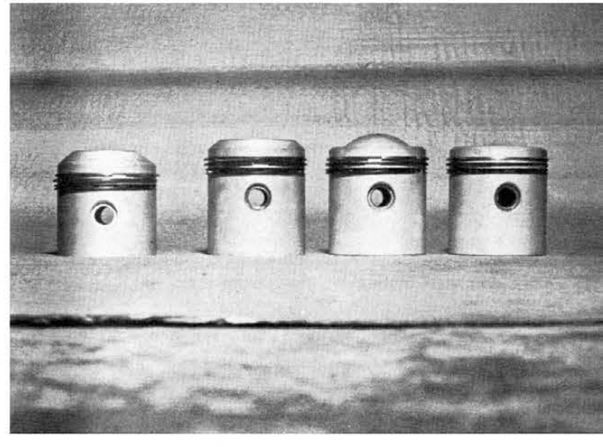
One of the most inspiring features of the 2.4 is of course its ridiculously rugged bottom end (in view of its present output of 112 horsepower). This was a natural result of the design procedure, which chopped $2^{31}/_{32}$ inches off the block height and produced a new crank and connecting rods to suit. In search of manufacturing simplicity, the bottom face of the block is machined off on the centerline of the crankshaft. This stiffens the block structure laterally at this point, but doesn't give positive location for the seven main bearing caps, each of which is retained by two bolts and two locating dowels.

The block is cast in a chrome-iron alloy, and carries part no. C8611. Since it doesn't house a camshaft, the block is nearly symmetrical and thus avoids most bore distortion resulting from uneven expansion. A $^{5}/_{64}$ inch oil gallery runs along the right side of the crankcase, and feeds the mains through $^{3}/_{8}$ inch ducts. Since the center main is heavily loaded, it alone is not required to supply oil to the crankshaft big-end drillings. The Hobour-Eaton pump operates at half engine speed, partially submerged in the sump supply. Slightly less than six quarts of oil are carried in a wide section at the rear of the sump, which allows low overall height akin to that of a dry sump, and requires a remote oil pickup. The full-flow oil filter housing includes a pressure relief valve, which lifts at 50 psi.

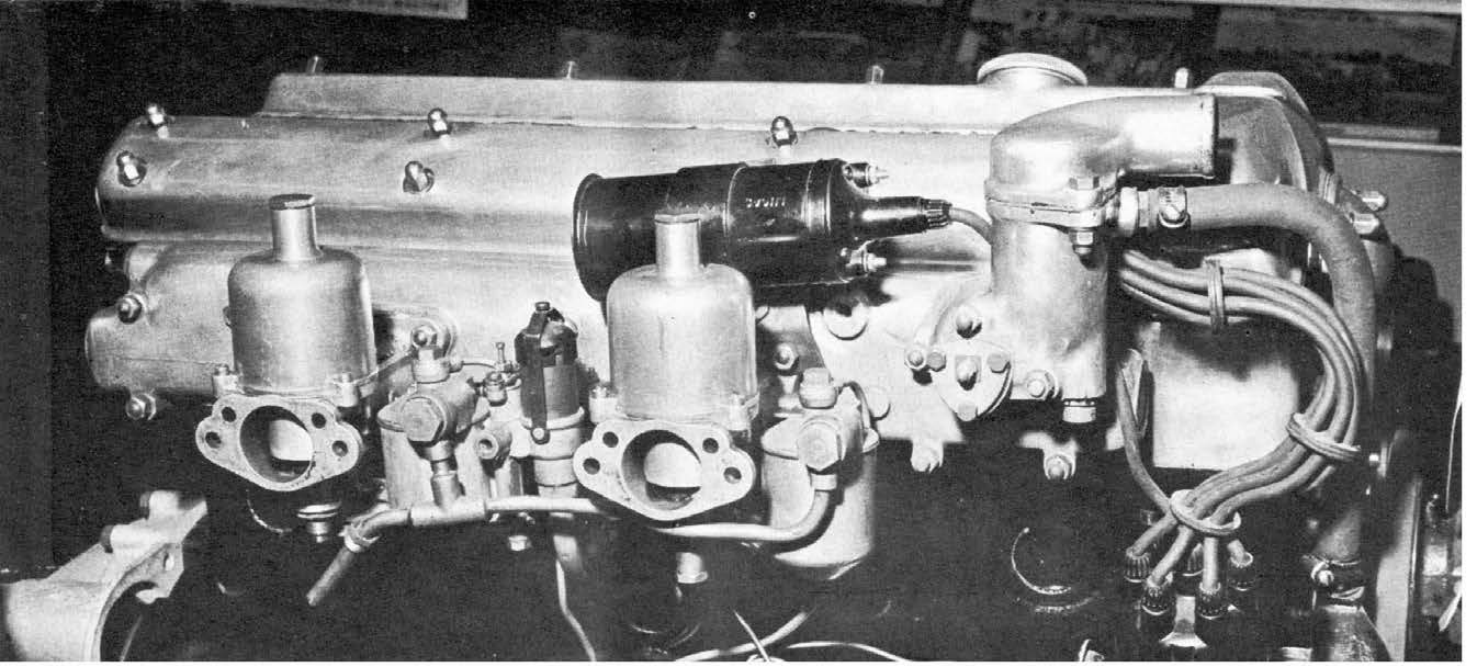
The crankshaft in the big Jag engine is renowned for its sturdiness, but the new short-stroke version is a real honey. Forged of EN 16 steel, its seven mains are $2^{3}/_{4}$ inches in diameter and one inch wide except for the front, center and rear, which are $1^{1}/_{2}$ inches wide. Thrust is taken at the center main, all these details being identical to the big engine. The big-end journals are 2.0863 inches in diameter by one inch wide, and these figures along with the 3.01 inch stroke give an idea of the healthy amount of crank web overlap between adjacent journals. Both here and throughout the engine, oil holes and passage junctions are countersunk and bevelled to reduce stress concentration, improve flow and avoid manufacturing



Ports in stock Jaguar head have plenty of meat for porting operations, removal of more than 1/16 total is unnecessary.



Pistons, l. to r. are 2.4, XK 140 MC, 120 M and stock 120. Short 2.4 piston is good for most modifications. (See text)



Standard XK 120 and 140 intake manifold will fit 2.4 head with no changes since pattern is same. Manifold uses large 1¾" SU's.

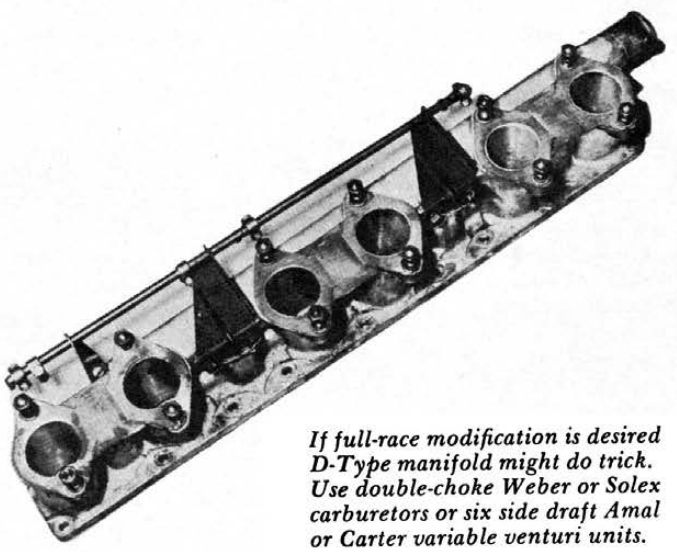
filings in the system.

Standard bearing shells are Vandervell D2 Bimetal, babbit-lined, but Indium-coated lead-bronze shells are available for hard work. These have the necessary extra clearance built in. The crank itself is part no. C8628, while the magnificent connecting rods are numbered C8417. These alone make the older engine look like a refugee from a tractor factory, since they measure a squat 5⅝ inches from center to center. Forged of EN 16T3, they weigh in at one pound 9½ ounces complete with cap, shell and bolts. This is not light. but no strength has been sacrificed, and for high loadings we might take a leaf from the Jaguar D-Type book and polish both these and the crankshaft all over without removing any significant amount of metal. The wrist pin bushing is of Clevite 10 phosphor bronze, and is 1.08 inches long with an inner diameter of ⅞ inch.

In other words, this little engine has a bottom end which is unique among production sixes and outstanding even in racing company. Fortunately the head layout is such by deliberately choking down the 2.4. As a matter of fact, the standard data are hardly worth mentioning, since they are back in line with the first XK 120. Both the cylinder head and the upper camshaft chain carrier are fully interchangeable with those offered for the bigger brother, however, so the changes can be rung all the way to D-Type equipment, about which more later.

The overhead valves are inclined at an included angle of 70 degrees, and seat on Brimol austenitic cast iron inserts in a symmetrically-machined hemispherical combustion chamber. The seats are fitted at 150 degrees C, while the cast iron valve guides are pressed in at 80 degrees C. Standard valve sizes are 1¾ inch intake and 1⁷⁄₁₆ exhaust, and the valves themselves are of a nice tulip shape and well polished. No. C8248, the intakes are made of EN 52 silicon chrome steel, while the no. C8213 exhausts are Fox 1282 austenitic steel.

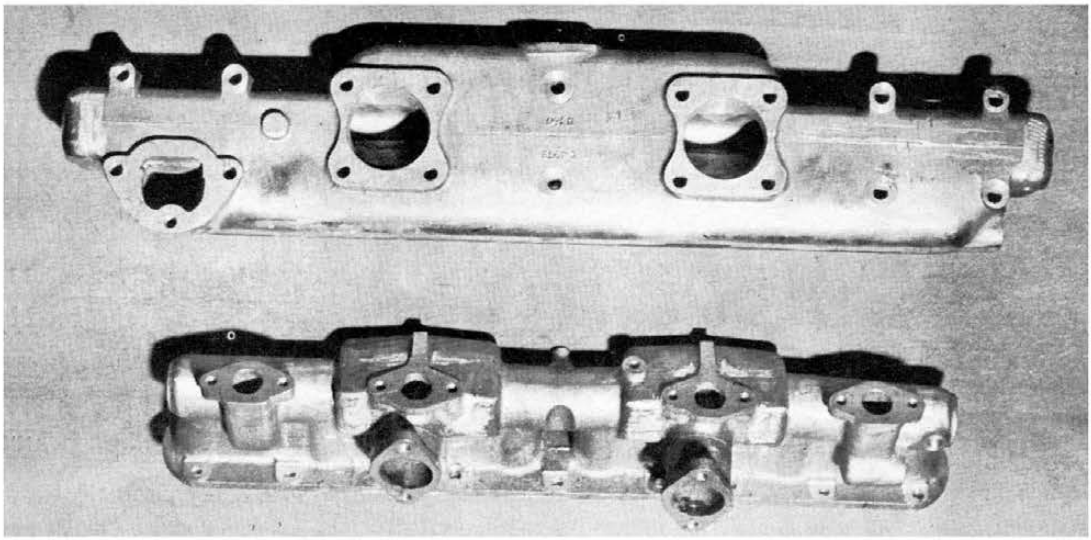
Along with manifolding changes, this basic head can be made to work very well if the ports are cleaned up, but a really worthwhile basis would be the C-Type head casting, which readily accommodates valves of 1⅞ and 1½ inches, and is the foundation of the production D-Type head. All these heads are of course aluminum castings, of DTD 424 alloy, and the standard part is no. C6733/1. The complete head assembly weighs 50 pounds, in contrast to 120 pounds for a similar cast iron head.



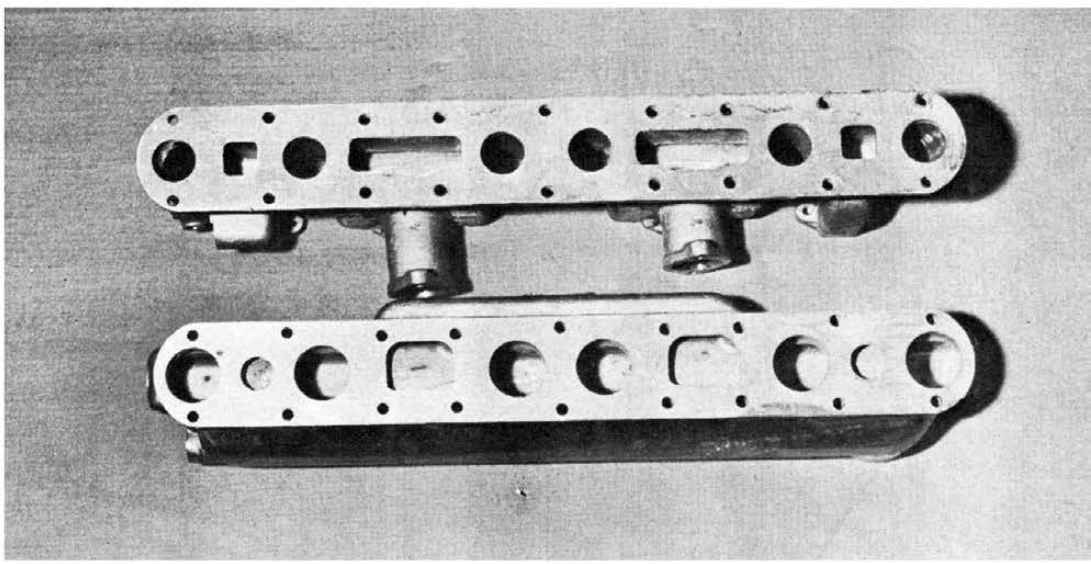
If full-race modification is desired D-Type manifold might do trick. Use double-choke Weber or Solex carburetors or six side draft Amal or Carter variable venturi units.

A lot of study has gone into the design of the Jaguar intake ports, which are given a marked curve to improve turbulence and thus running smoothness. This does not apply quite so much to flat-out power, however, and it's possible that a slight straightening of the contours might improve cylinder filling at the very high engine speeds we're reaching for. There's not much meat along the passages themselves, but some could be lightly trimmed, specially at the outer ends, and the intake manifolding inclined accordingly. As in the works heads, the intake valve guide can be cut back even with the port surface. The contours near the seats are critical and should be touched lightly, if at all, while the chamber itself is very well finished as stock.

Pistons for both 7/1 and 8/1 ratios are available for the 2.4, their numbers being C8632 and C8633 respectively. The higher ratio is the only one we should consider, unless supercharging is contemplated, for which 7/1 might



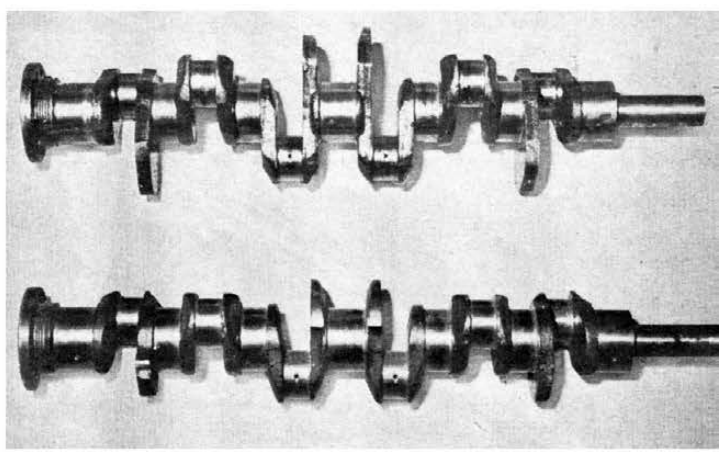
A comparison between 120 manifold, bot. and 2.4 log, top, shows restriction to breathing in 2.4. Two manifolds are interchangeable, turning Jaguar parts bin into made to order speed shop.



The reverse or mating sides of two manifolds also point up the advantages to be gained by swap. The ports in the XK manifold at bottom are almost a third larger in area than those of the 2.4 layout. Different shape of water ports is unimportant.

be better. Unfortunately, Jaguar doesn't supply sodium-cooled exhaust valves, though they have experimented with them. 8/1 piston is tin-plated aluminum alloy, and weighs slightly more than one pound three ounces. It has a T-slotted short full skirt and a flat crown chamfered to fit up into the chamber. Larger flat chamfers at each side prevent valve interference. In general these should be very satisfactory, but for higher compression ratios custom pistons would be in order, which might be of the slipper type and have more extreme version of the standard crown.

As a sidelight, some might wonder if the compact 2.4 piston would fit in the big engine, but with relation to the rings and the upper bore edge the 2.4 wrist pin is 1/16 inch lower and the crown slightly less than 3/16 inch higher than those in the 9/1 XK piston. As a result the 2.4 piston would stick up some 7/32 inch higher, and couldn't be accommodated without alterations that would seriously weaken the crown strength. If you decide to try it, though, be sure to let us know! It would give a fine compression ratio, somewhere in the neighborhood of 11 to 1 — while it lasts. *(Continued on page 55)*



Extreme stiffness of the 2.4 crankshaft (bottom) is seen here. Although both main and rod journals are the same in both cases, the short-stroke 2.4 shaft is materially strengthened by overlap at webs.

Sawed-off Six

(Continued from page 27)

Jaguar's characteristic twin overhead cams are driven by a two-stage double-row chain layout, with separate tensioning for the upper and lower chains. The top one is tightened by an eccentric idler sprocket, while new height restrictions have caused a hydraulically actuated Neoprene-faced slipper to take the place of the long Weller spring tensioner used on the bottom chain of the 3.5 engine. The cams themselves are very conservative, with intake timing identical to that on the first XK 120's. Now standard in the 140's, the old "M" cam has the same 240 degree duration with the lift increased from 5/16 to 3/8 inch by continuing the flanks and eliminating the dwell. This is a good road cam, but a special grind would be much more appreciable to the potential of the 2.4. It must, however, recognize the limitations of the flat-faced chilled cast-iron cup tappets.

With the standard cams, and inner and outer valve springs rated respectively at 69.3 and 77.4 pounds per inch, valve float is held off until 700 rpm. This is very good for these moderate pressures, thanks to the low weight of the valve train, and some factory racing versions have used stretched stock springs with satisfaction. A special cam for these speeds should have springs to match, however, and this means intelligent experimentation.

Carburetion

Now that the valves and ports have been loosened up, it's time to throw away that intake manifold. Two Solex downdraft carburetors are standard, each feeding a group of three cylinders with a 1/2 inch balancing orifice cast between. The design is of the most basic type, heavily water-jacketed to improve vaporization. Similar criticism can be made of the manifolds for the XK series, but they at any rate can carry twin SU sidedraft carburetors up to two inches in diameter. These will bolt right on the 2.4, and there seems to be plenty of room for them in the standard sedan, which is no surprise.

If you take your motoring seriously, though, a specially fabricated manifold is more than worth the moderate effort involved. Possible gasworks that could be fitted are trios of SU or Zenith sidedrafts, of of Carter sidedrafts with their variable venturis. To cater fully to the six ports, if you have the jingle in your jeans you can order up three twin-choke Weber or Solex sidedrafts, the former of which is available from the factory as used in the D-Types. Less cash but more hard work would be required by six single Amals, and the ultimate would probably be injection, either by the Jaguar-developed Lucas system or by one of Hilborn's latest gas adapted constant-flow units.

Special intake manifolding with six separate chokes or injectors both improves distribution and allows remarkable cylinder filling through the use of tuned intake lengths. Don't forget, though, that a special water riser manifold must also be fabricated, preferably with air-space distance between it and the intake piping. Tuning is equally valuable on the exhaust end, and indispensable for the revs we want to run. The stock manifolding is right in principle but heavy and rough internally, while the latest factory D-Type looks about perfect, with smooth welded piping for the front and rear groups of three leading into separate single pipes to a low-pressure area at the rear of the car.

Practiaclly all hot Jags of the larger size have performed creditably with straightforwards single-breaker coil ignition, which is actually quite adequate for a six. This could be overworked above 6500 rpm on the 2.4, which

deserves a special breaker, a Magspark, or a full magneto. A wide range of plugs is available from several manufacturers, and the standard 8/1 compression is Champion N8B. A point to watch in the combustion chamber is that portion of head threading that is not covered by a fully-inserted plug. It's a possible hot-spot source, and should be custom-trimmed away.

Cooling

Since they had their own private Le Mans disaster in 1952, Jaguars improved the design of their water pump, which is now efficient at very high speeds. Nevertheless, a reduction in the present drive ration of 1 to 9.9 might be necessary for faster crank rotation. The pump output feeds into a duct cast high on the exhaust side of the block, and vertical vents from this carry "cool" water across the head joint and directly to the exhaust valve seats and guides. This is a top feature, but can be improved as was done on a production D head specially factory tuned for Lou Brero. It has small sheet metal baffles in those vents that send the water directly to the seats without pre-heating from the exhaust port surface.

Pumped water passes straight across the intake valves. The cylinder bores the head to the four outlet holes, via are cooled by thermosyphon circulation only, which keeps their temperature level relatively high and reduces the amount of heat rejection to the cooling water.

The Jaguar 2.4 engine actually made its first public appearance in 1954, when the factory put two prototype engines in D-Types to try to take advantage of the handicapping in the Tourist Trophy. The cars weren't successful, but their speeds were very close to those of the 3.5 liter cars, since they were topped by the same modified C heads and twin-choke Webers. In stark theory, the 2.4 should have the same output as its big brother if the curve of bmep to piston speed could be held at the same level. This has been the objective of the preceding modifications, and the factory, not overlooking the fact that the present Grand Prix limit is 2.5 liters, have done a little development work on their own.

They've fitted it with the top-secret works D-Type head, which has intake and exhaust valves of two and 1 11/16 inches diameter respectively, more steeply inclined in a non-hemispherical pent-roof chamber with provisions for twin ignition. Special slipper pistons are matched to this chamber and their high crowns are deeply bevelled for valve clearance, while the compression ratio remains at the factory limit of 9/1. The intake ports are huge and die-straight, and the whole valve train from cams on down has been overdesigned to allow very high loadings with moderate ramp angles.

With the above head, plus the Lucas fuel injection that has made the big D the hottest thing from Sebring to Silverstone, this production block has been delivering a reliable 270 horsepower at 6000 rpm, which the experimental department regards as the steady operating limit. This is *on gas*, of course, and is approaching both GP outputs and two horsepower per cubic inch. They have a space-frame single-seater to carry it, but the chances are that Lyons will guide his firm away fro mthe rigors of Grand Prix competition. The engine is certainly suitable for the private GP car builder, though, the only drawback being the high weight of 529 pounds. There's an aluminum 2.4 block kicking around the Jag shops, but it's unfortunately not getting much attention. That poundage is put to good use, in a sturdy crankcase and beam-like shaft, and the 2.4 should set new records for output and unbreakability. A final thought in passing, too, is the new 151 cubic inch limit due to go into operation in USAC Championship events, including Indianapolis. Poor man's Miller anyone? *Ludvigsen*

Morgan

(Continued from page 19)

MG owners know what the behind seat trunk room is like and know that it can hold a surprising amount when the top is up. Two twist catches allow the wooden floor to be lifted for quick access to the twin six-volt batteries and the Salisbury hypoid rear axle.

You may have gathered by now that the creature comforts are on the slim side, though starkly honest, and the ride of the Plus Four has the same raw attitude. It tackles big bumps with a leaping, bounding motion which yet avoids the discomfort of true pitching. Our car was fitted with Michelin X tires, which can be run effectively at very low pressures and were thus of great help in lessening the effect of small ripples on the stiff Morgan suspension. The frame is unusually stiff for a classic suspension layout, but small vibrations still give the body a hard time and search out all potential rattle sources. Generally the ride is hard but reassuring in that its response is always consistent.

To the enthusiastic driver, though, it's all more than worthwhile when he wrings the Plus Four out through every variety of bend and finds it clinging tight, flat and fast. There is very little roll and no unwelcome dip at either end, thanks to the stiff springing. This also led us to expect, in combination with a slightly rearward weight bias, an oversteer on corners, but in fact the Morgan understeers very powerfully at most speeds. This is accounted for by the front suspension geometry, which is such that the wheels lean out with the car on corners, and also by the fact that the front end is much stiffer than the rear and thus assumes more of the overturning couple in spite of a low front roll center.

Steering

Steer characteristics is a function of *relative* front-rear cornering powers, and on an *overall* basis the Morgan ranks as one of the stickingest cars we have tested. Steering is not ideal, with two inches of play at the rim and a strong caster action that verges on heaviness, but it is fast and free from excessive road reaction. Understeer plus heaviness means that the Morgan will go wherever you have the strength to point it. The rear end just follows along and never tries to get out of hand, though bumpy surfaces can catch it off balance. We tried tire pressures from 23 to 30 pounds, and the only penalty of the lower figure was a slight amount of tire howl. Wheel response is instantaneous and predictable, and the close-up driving position is well matched to the requirements of the job. At higher speeds there is just enough surplus power available to allow honest drifting, which rounds out the Plus Four's range and confirms it as tops in handling.

Stiff rear leaf springs have further benefits when used with a Hotchkiss drive, as demonstrated by the TR3 Morgan, which bats off from a standing start without a trace of axle hop, windup or judder. Fither a chirp or momentary wheelspin, according to taste, and away you go. Clutch pedal travel is short, and the engagement is smooth yet solid, remaining that way through all our tests. The gearbox setup is one of the Morgan's unusual features, in that the clutch housing and transmission are separated by some nineteen inches of cast tube and splined clutch shaft. The box thus rests at the forward edge of the seats and that short handy lever goes right down into the works without the aid of remote controls. Since the gear layout and casing are substantially the same as those used in the Jaguar, the unit is

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