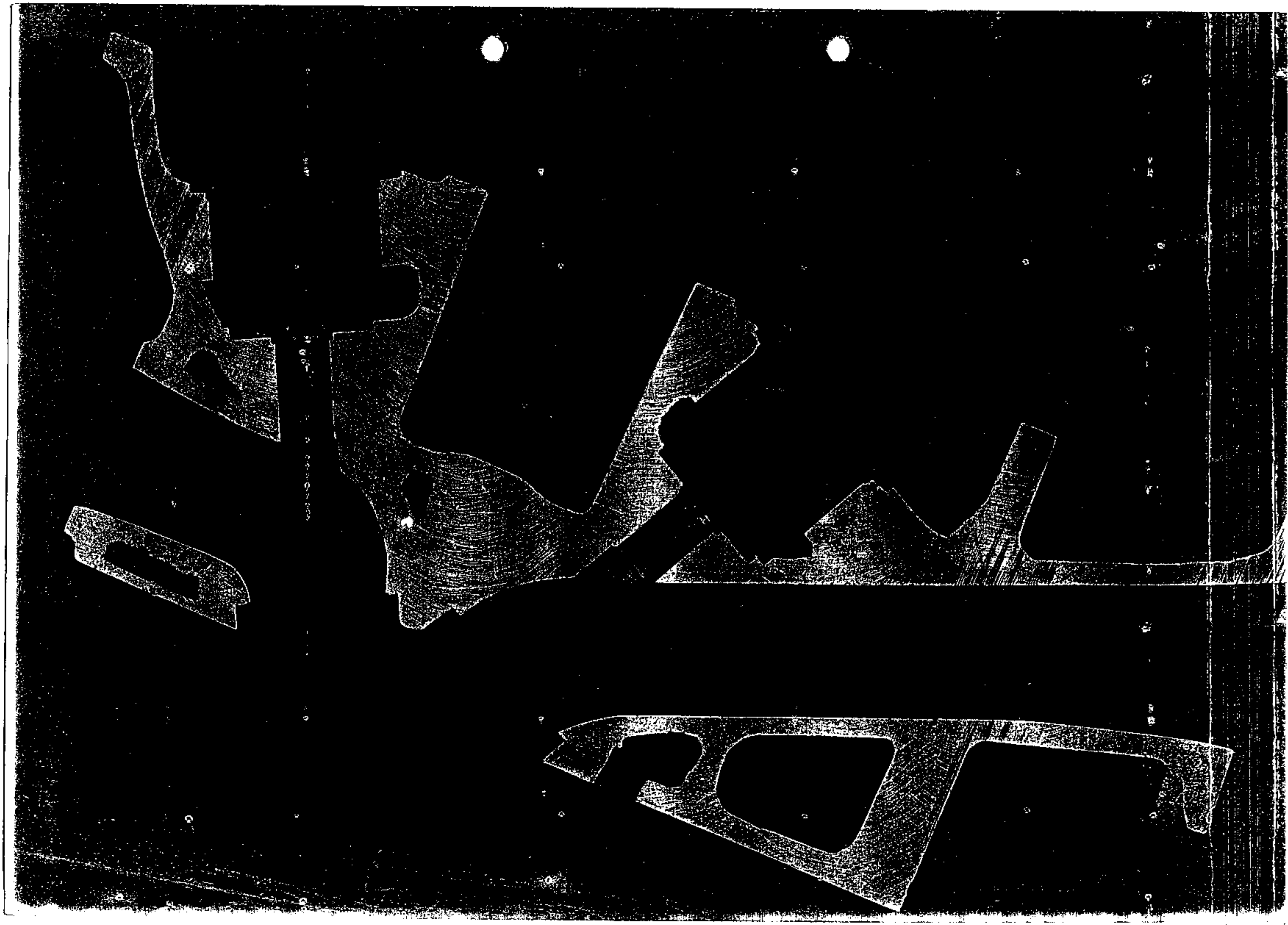

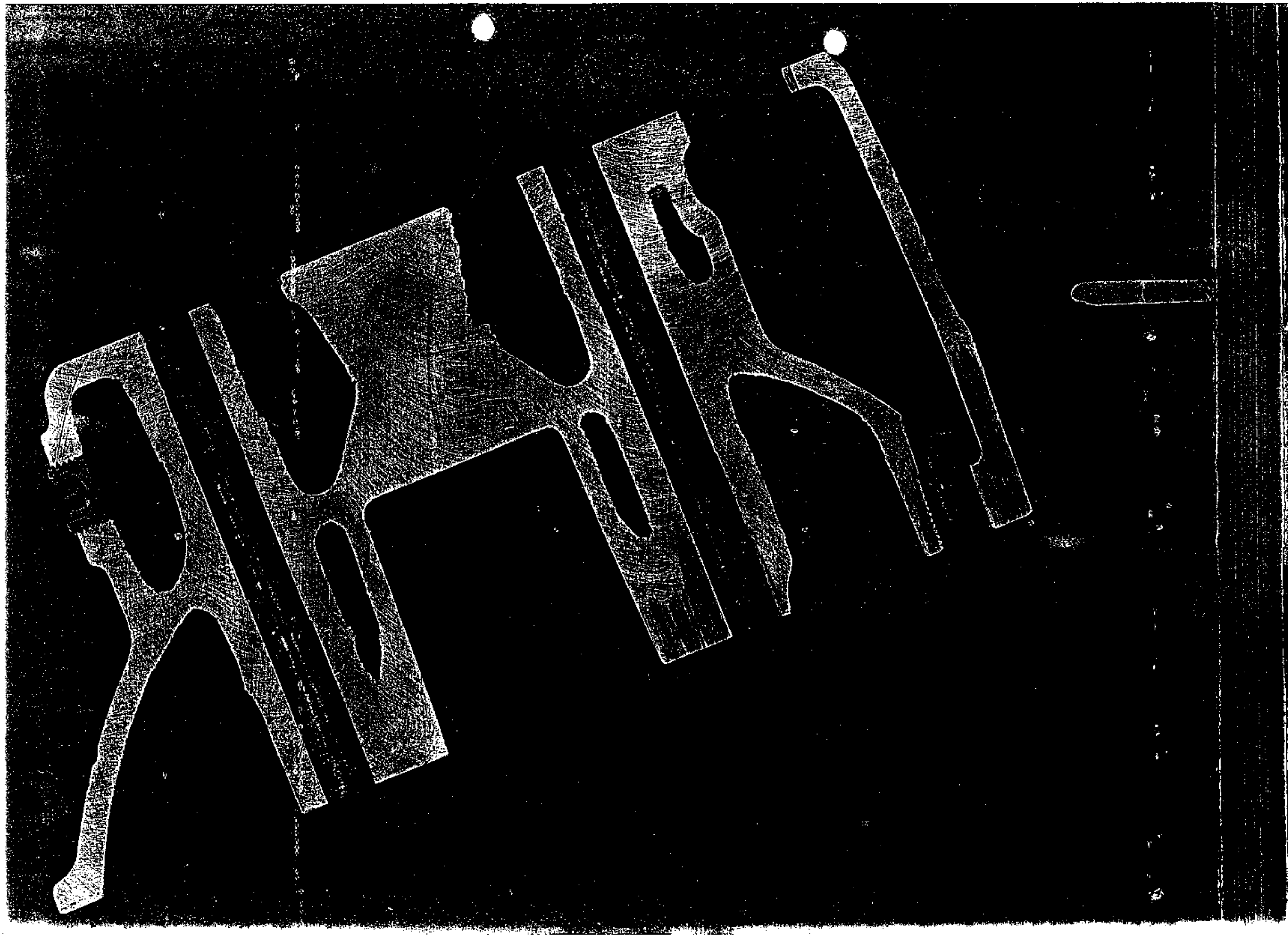

and half a pint of oil into the filter bowl, and fit the filter bowl. The normal sump capacity is six-and-a-half pints. The one pint that has not been poured into the engine should now be pumped into the oil gallery via the oil pressure light switch hole. To facilitate this, replace the oil pressure switch with an adaptor similar to the oil pressure gauge to block union. A Mini or Mini Cooper oil pressure gauge pipe and rubber hose can then be fitted to this union. The rubber hose is then pressed onto the nozzle of an oil can. Commence pumping of the oil can until one pint of oil has been pumped into the oil galleries. With the plugs removed, turn the engine over on the starter motor. If enough oil has been pumped in to completely fill the galleries and prime the pump, an indication of oil pressure will be seen within five seconds. If no oil pressure is seen within ten seconds, cease cranking and resume pumping. Once having attained an indication of oil pressure, plugs and oil pressure light switch can be fitted and the engine started. If an oil cooler is fitted, then an additional amount of oil may be needed to fill this. It may require as much as two-and-a-half pints to be pumped into the gallery.

chapter 2

STAGE ONE HEAD

The head in its standard form is very efficient. If any modifying is contemplated, it must be done to perfection to realize a worthwhile gain in power. The first move is to strip the head down, leaving the bare casting with the guides in. Where possible, remove the worst of the coke with a wire brush, leaving a reasonably clean head to work on. At this point a radius inlet-valve-seat cutter is required. The relevant details of this are shown in Fig. 8. The actual cutter for this should be ground from a centre-drill. The easiest way to grind a true radius on the cutter is by using a small grinding wheel of the correct diameter in a hand-drill. Set the cutter to cut above 0.010" below the required diameter for roughing purposes. Having done this, cut the inlet-valve seats until the cutter form has been established completely around the valve seat. When this has been carried out on all four inlet-valve seats, remove the guides with a drift and a heavy copper mallet as shown in Fig. 7. Be sure to remove the guides from the combustion chamber side outwards and not the other way around, as there is a circlip which prevents the valve guides from passing completely through the head. It is a good idea to keep the circlips from the old guides, as they always seem to be difficult to obtain. The easiest way of removing these circlips is to crush the old guides in a vice taking care not to damage the circlips whilst doing so.

Having roughed out our radiused valve seats, we can then tackle what is probably the most difficult operation as far as modifying this is concerned; the forming of the venturi just below the valve seat. Working with hand tools, this requires painstaking care and patience. This venturi section can only be effectively formed on the sides and lower part of the walls of the port, assuming the head is being viewed with the chambers uppermost. Figs. 9 and 10 will show more clearly the port shaping required, the dotted lines indicating the port profile to aim for.

Mounting the carburetters

The easiest method of matching the carburetters to the head is by

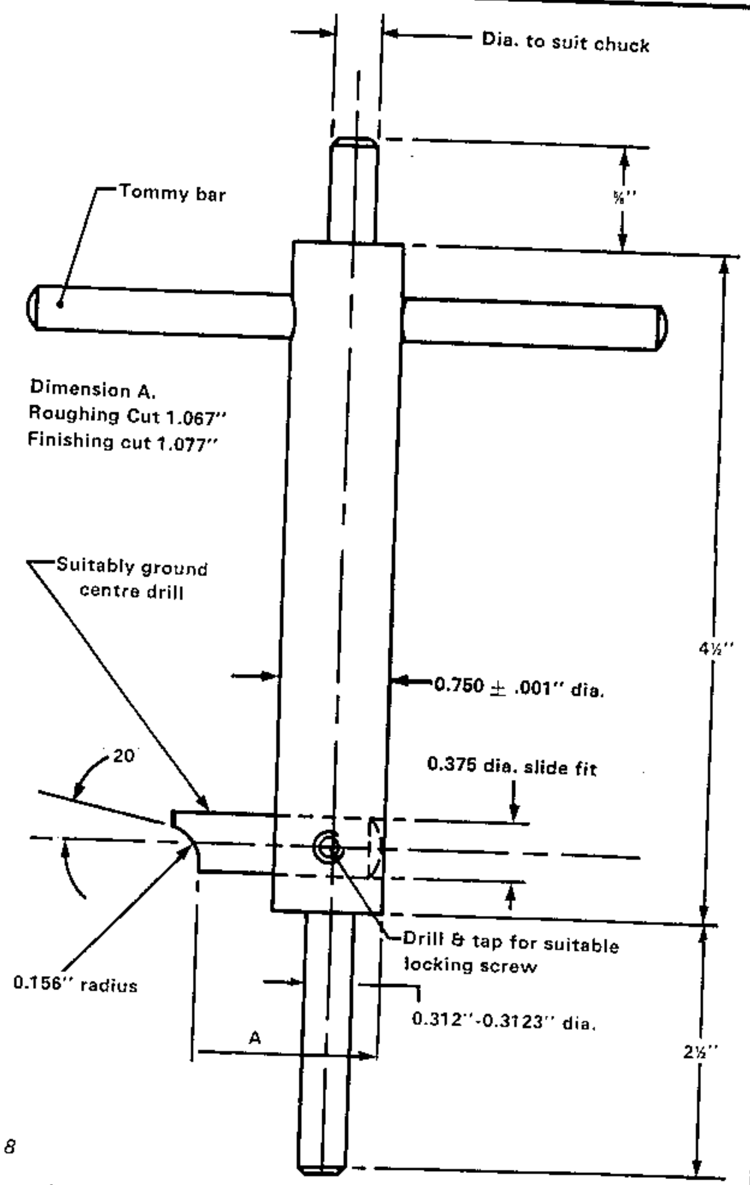

Fig. 8

Radius valve seat tool

using the spacers into which the rubber 'O' ring seals are fitted. Clean the carburetter mounting faces of the head and apply marking blue. It may be wise to point out, for those readers who are not too familiar with engineering terms, that marking blue is a marking agent which quickly dries out; where as the engineers' blue mentioned in connection with valve-lapping is one which does not dry out, thus enabling it to be transferred from one surface to another at the points where contact is made.

Having applied the marking blue and allowed it to dry, fit the carburetter securing studs if they are not already in place. Place the carburetter spacers on the studs, and using a sharp scriber, scribe round the bore of the spacers onto the head. These spacers distort very easily, especially if at one time or another the carburetters have been over-tightened. If any distortion is apparent—this can be easily seen by placing the spacers one on top of another—they must be replaced. Apart from increasing the possibility of air leaks, distorted spacers can lead to a broken carburettor flange due to the need to overtighten nuts, should an air leak be found. A third reason for their replacement, and probably the most obvious, is that it is an utter waste of time trying to match a port up to a spacer and hence to the carburetter when the spacer is inaccurate. On some heads, due to the casting core moving during foundry operations, it may be found to be impossible to match the ports completely and accurately. The ports will have to be matched where possible and one should avoid making any mismatch worse by frantically polishing the section of the ports circumference which does not line up.

It will be seen from Fig. 9 that roughly speaking ,the inlet port can be divided into three sections. The first part is tapered, the second is a parallel section. After this comes a short section which slightly flares out to the valve seat diameter. With the exception of forming the venturi and blending the tapered port section into the parellel one, we must avoid removing any more metal than is necessary to achieve a smoothly-contoured port with a good finish.

Combustion chamber

For the time being we must leave any further work on the inlet ports and move on to the chambers. You will observe that the basic chamber is hemispherical. The valve seats, due to their position and angle, do not blend smoothly into this hemisphere although heads after late '67 do blend in as standard. A cross section through one of the inlet valve ports in Fig. 10 clearly shows how metal should be removed. A similar situation exists round the exhaust valve seats and this is treated in the same manner as the inlet side. When the chamber has been completed it should appear slightly egg-shaped rather than the circular shape it was originally. Since the inlet port is not completely finished, it is unnecessary to polish the chambers at this stage.

Exhaust ports

We now move on to the exhaust ports. The first operation here is to bore the exhaust valve throats to a diameter of 1/8" less than the valve diameter. This will give us a seat width of 1/16". The tool shown in Fig. 7 can be used for this task, the radius tool bit being replaced by a more suitable one set as shown in Fig. 11. It is recommended to bore

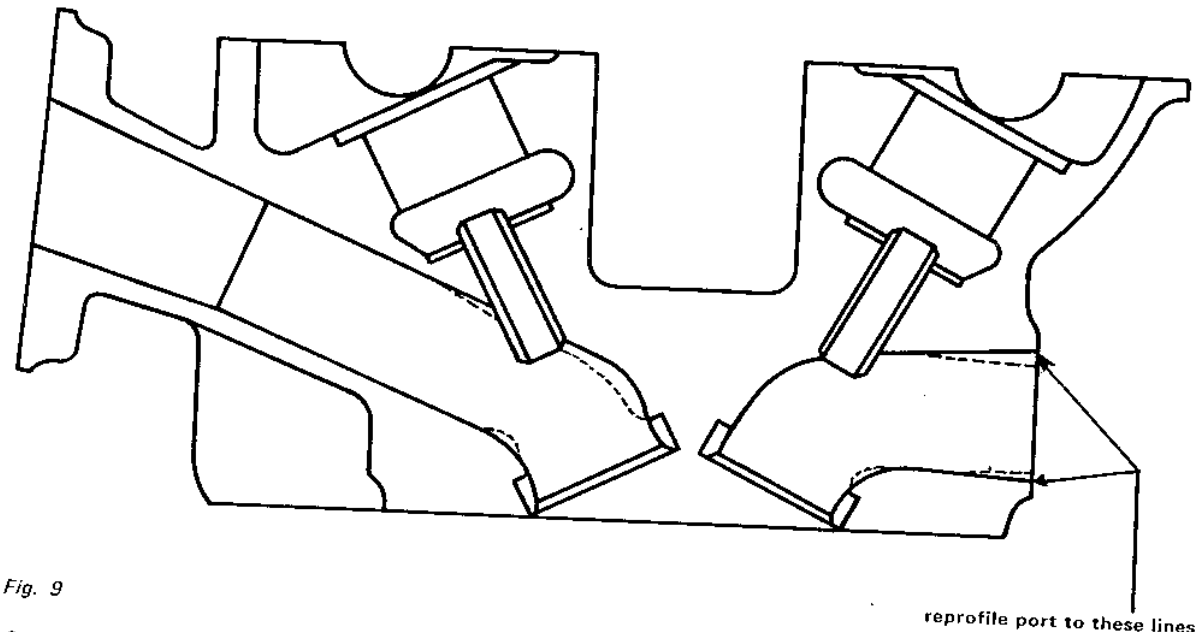

Fig. 9

Cross section of inlet (left) and exhaust ports (right)

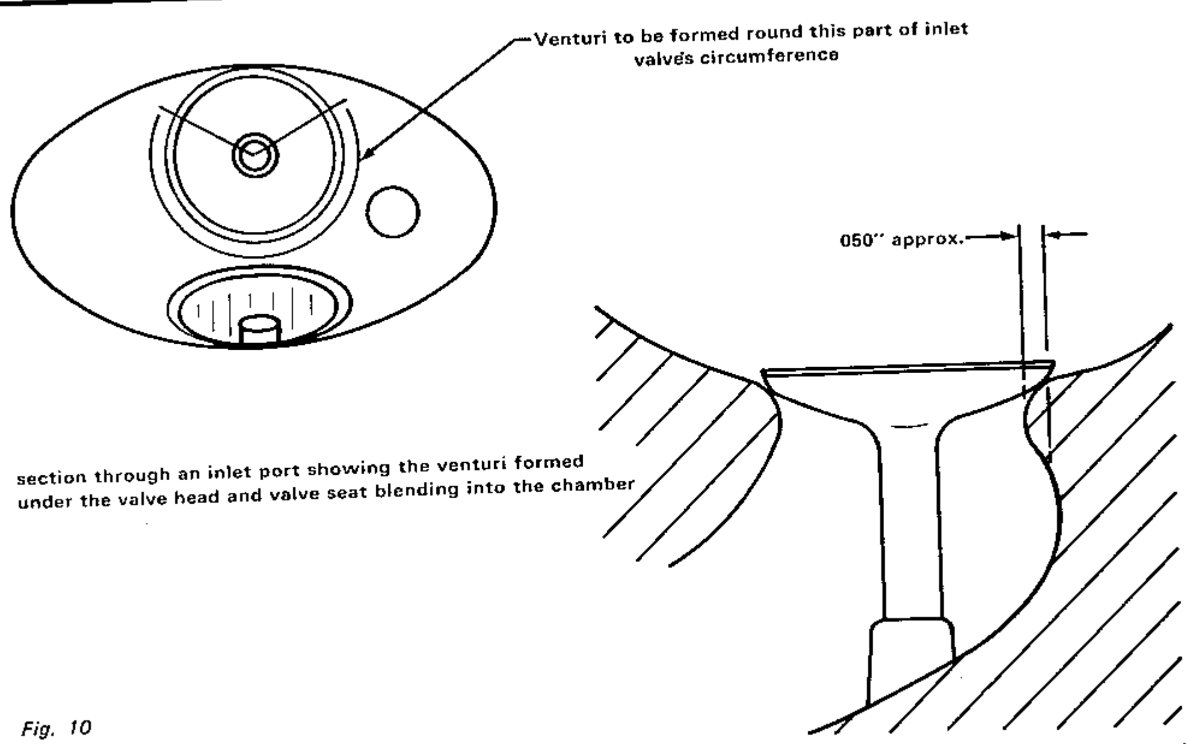

Fig. 10

Inlet valve port details

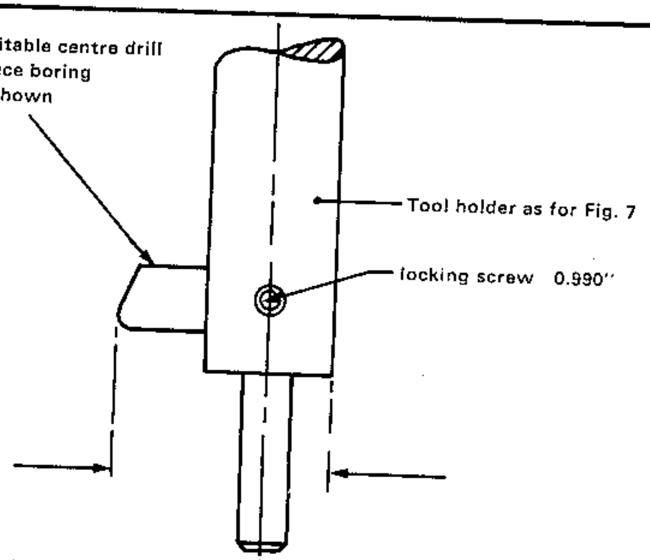

Fig. 11
Valve seat cutting tool shown in Fig. 7 adapted to bore exhaust valve throats by fitting boring tool

the throats using this tool in a pillar drill; although possible, it is exceedingly difficult to do this job by hand or by using a drill gun. Bore the throats to a depth of 3/16". From here on, blend the ports into the bore section by grinding. We now require matching of the exhaust ports to the exhaust manifold. The bore of the exhaust pipe is usually quite a bit larger in diameter than the exhaust port and the bore of the exhaust manifold gasket. Both the gasket and the port diameters must be opened up to suit the exhaust pipe size. If you have a Lotus Elan you may find you have a cast iron exhaust manifold instead of a tubular one which is fitted to Lotus-Cortinas. This being the case, the exhaust manifold itself may want enlarging to the port sizes given. The first job is to enlarge the diameter of the gaskets. This is not quite as easy as it looks, as it cannot be cut with a sharp knife, it just tears. Turning it out on a lathe, even with suitable support, also proves to be unsatisfactory. The easiest and most effective method by far is to make a filing jig as shown in Fig. 12. The gasket is then lined up and clamped between the halves of the jig and the part of the gasket surplus to requirements is merely filed away.

We now have a gasket with a 1.350" bore. Clean the manifold joint face on the head and apply some marking blue. Fit the studs and use the enlarged gaskets to scribe round the exhaust port. Having marked them thus, the ports should be ground out to the scribed line. In doing so, a shallow taper should be formed as shown by the dotted lines on the cross sectional drawing of the head—Fig. 10. Having roughed out the exhaust ports thus, they

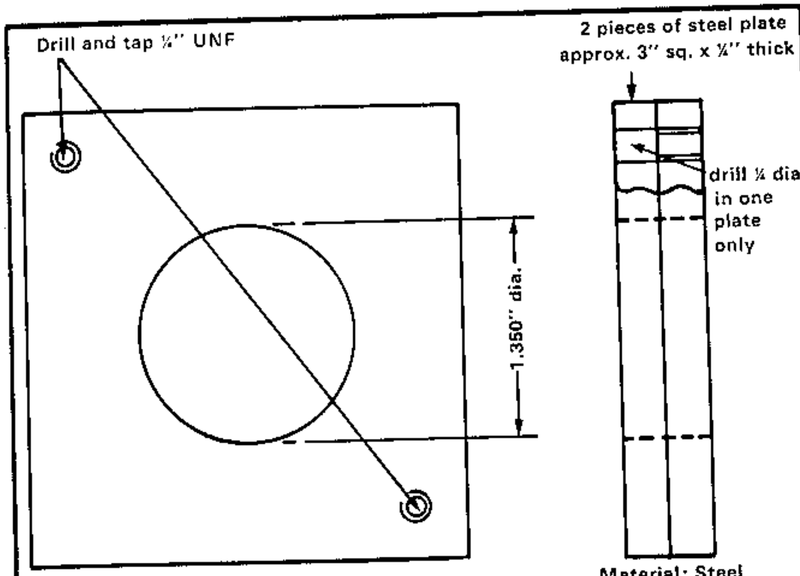

Fig. 12
Details of filing jig for enlarging exhaust gasket

can receive their final polishing.

Fitting valves

Polish and radius the ends of the valves guide as shown in Fig. 13. Fit the circlips onto the guides, using a drift and copper mallet, and replace them in the head. Fitting of the guides can be made easier if the head is heated up to boiling point and the guides cooled in ice. Having fitted the guides, they should be reamed with a very slightly worn reamer.

Set the radius valve-seat cutter to its finishing size—Fig. 8—and carefully re-cut the inlet valve-seat. Take the valve for the particular seat being worked on and using fine grinding paste, lap it in for a minute or so. Remove the valve, clean off all traces of grinding paste, and blue the seat on the valve with engineers blue. Drop the valve into the guide and rotate it to transfer the blue to the high spots on the seat. Remove the valve and inspect the seat. If you are lucky, you will have a blue line right around the valve seat. More than likely you will find the blue shows that contact has been made over only part of the seat. If this is the case, use the radius cutter and lightly recut the part of the seat which has blued up. Lightly lap in the valve again, and using the blue, establish where contact is made between seat and valve. If a non-continuous line is again formed, use the cutter to cut away that part of the seat which has blued. Continue this procedure until the seal shows a continuous blue line of even width in the order of 0.030".

Having finished the seats, a small step will have been formed on both the port and chamber side of the

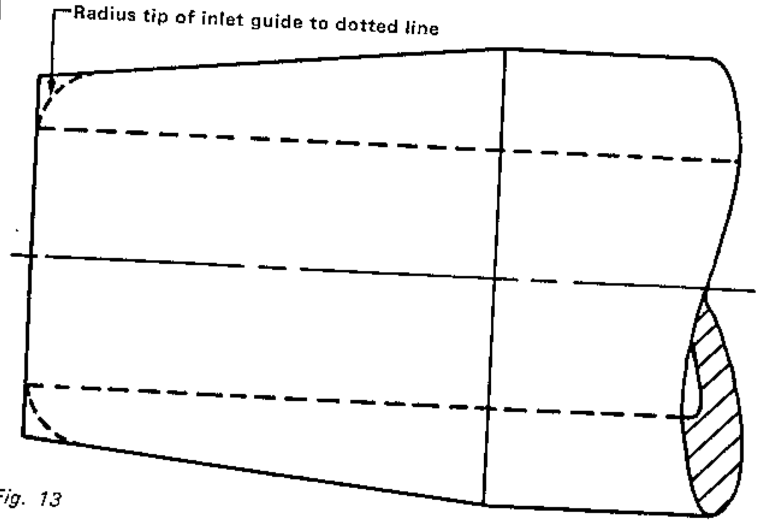

Fig. 13

Valve guide modification

seat itself. This should be carefully blended out. One slip here with the grinder and you find yourself doing the seat or seats again.

The chambers can now be finish polished and, lastly, the exhaust valve seats cut, and the valves lapped-in.

If it is intended to use cams with a substantially higher lift than standard, then the spring bases will want machining to prevent the spring getting coil-bound. If the spring bases are relieved by 0.060", coil-binding will be avoided. This task is best carried out by your local motor machine shop, as they will more than likely have equipment suitable to do the job, readily to hand.

The inlet valves

The head is now ready for skimming. Up to 0.040" can be removed from the face of the head and with the chambers modified as explained previously, it will give a C.R. of 10.5 to 1 on a 1558 c.c. engine.

This virtually winds up the work on the head casting itself and leaves only the reshaping of the inlet valves.

Fig. 14 shows the shape the inlet valves should be made to. In doing so, we must avoid destroying the seat we have just made by lapping into the head. Wipe the valves clean and blue the seats in the head. Drop the valves in and establish the seats on the valve. Reshape the valve as shown in Fig. 15 and reduce the valve seat width to 0.020" if it is greater than this. The reshaping can best be accomplished by spinning the valve in a lathe and grinding off excess metal with a fine grinding stone in a drill gun. You may well be wondering why the valves were reshaped after rather than before lap-

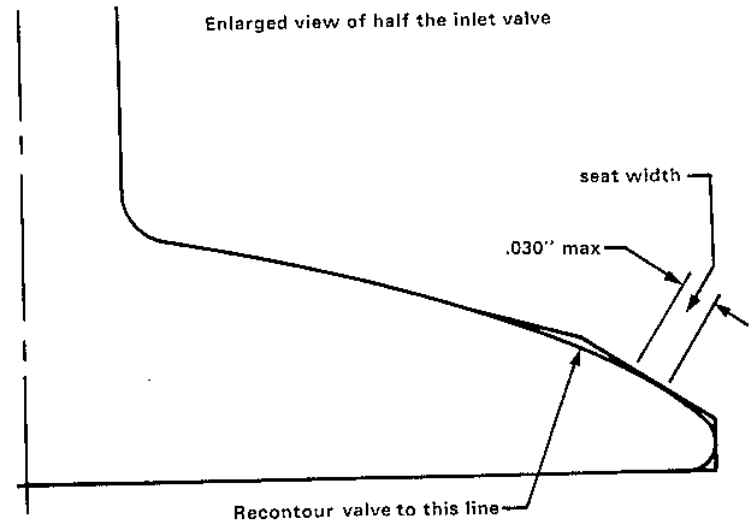

Fig. 14

Re-shaping the inlet valves

ping in. The reason for this is quite simple. If you try lapping in a valve which has line contact or nearly so, the lapping pressure on individual grains of lapping paste is high and can cause scoring until it breaks down sufficiently to even out the grain load. While this is being done, a small step is formed on the valve seat rather than a smooth radius contour. Hence it is better in this instance, since the amount of valve reshaping is limited, to do it after rather than before lapping. If a substantial amount of reshaping had been required, then it would have been better to rough out the valve to the required profile, lap the valve in and then finish it.

All the parts for the head should be thoroughly cleaned to remove all traces of grit and particles of metal prior to assembly. Coat all bearing surfaces, especially valve stems, with engine oil and assemble the head.

If the head is the only intended modification of the engine, then there is no point in fitting any valve springs other than standard as these are entirely adequate for an engine which has a peak power around 6,000 r.p.m. The gain in power with the head modified as described will be between 8-9 b.h.p. With the head alone modified, it is advisable to polish out the chokes and fit the next size up main jet in the carburetters. This, in conjunction with the head, will give about 2 b.h.p. over and above the gain with the head. If the carburetters are not tweaked, the mixture will be found to be a little on the weak side.

If the head is to be used with hotter cams, then it depends on what use the engine is to be put to as to whether or not it is worthwhile fitting stronger springs. If the bottom-end of the engine is not being strengthened in any way, then again the standard springs are best.

The choice of springs to use will be more thoroughly dealt with in the chapter concerning cams, as these are more inter-related to the cam design itself rather than the modification of the head.

If it is intended to use a Stage I head, that is a head with standard valves, in conjunction with full-race cams, it will be necessary to refer in parts to Chapter V.

The EN40B forged steel crank, nitrided and fully balanced.

The steel bearing caps and all Vegantunes Engines

The FVA unit installed in an Escort

chapter 5

STAGE TWO HEAD

If you are aiming for a power output substantially in excess of 160 b.h.p. then the cylinder head will need to be prepared in a slightly different fashion from that described in Chapter 2. A procedure identical to that of the Stage I head should be carried out as far as preparation is concerned, as the differences are dimensional only. It should be pointed out that the head modifications about to be described will only result in a power gain of 3-4 b.h.p. above Stage I. This will occur at the top end of the rev range; therefore this type of head should only be used with the hottest cams available for this motor.

Basically the difference between this head and the Stage I head is the fitting of larger valves. The sizes of these are 1.625" inlet and 1.375" exhaust, as opposed to the 1.560" inlet and 1.350" exhaust fitted as standard. Grind the radius seat cutter tool to 0.161" radius instead of 0.156" radius and set the dimension for roughing to 1.097". Using a reamer, enlarge the parallel section of the inlet port by 1/16", taking care not to go any further with the reamer than the bore of the valve-guide. At this stage the steps formed by the reaming and valve-seat cutting should be blended out and the venturi formed as for the Stage I head. At this point a decision must be made as to the type of carburetters you intend to use or whether or not fuel injectors are going to be fitted. If you intend sticking to 40 DCOEs, then match up the tapered part of the inlet port as for the Stage I head, this having the diameter of the port at the carburetter joint face at 40 m/m. In the case of 45 DCOE Webers, the diameter at this joint face must be enlarged to 45 m/m. This is done in the same manner as for 40's except 45 DCOE 'O' ring spacers are used to mark out the port. The special 'O' ring spacers are available from Vegantune. When porting the head for 45's, care should be taken to produce an even taper down to the parallel section of the port.

If fuel injection is to be used, this being available again from Vegantune or Tecalemit-Jackson, the port diameter at the joint face should be enlarged to suit. Injectors are available having 38 m/m-40 m/m and 42 m/m bore. When preparing the ports for injectors, use the injector-to-head joint-face gasket as a template to achieve the correct positioning.

Having completed the matching operations, modify the chambers exactly as for the Stage I head.

The method to use for modifying the exhaust ports is identical to that used for Stage I with the exception of the size for boring the valve throat. The diameter to which the boring tool should be set is 1.002" instead of 0.990".

The inlet valve seat and throat can now be finished. To do so, set the radius cutter to 1.107" and finish the seat using exactly the same procedure as described earlier. It should be pointed out that since these oversize valves are only a little larger than standard, it is totally unnecessary to fit larger inserts, as the standard ones are plenty big enough to accommodate the larger valves.

Since this head is intended for use at very high r.p.m., it will be essential to counterbore the valve spring platforms to accommodate extra valve lift without coil-binding ensuing. The amount of counterboring needed will be between 0.060"-0.070". If you go much over that, there is a real possibility of the spring platform collapsing into the water jacket. Cam-followers which run directly in the aluminium of the head casting can wear quite quickly on a high revving motor. The possibility of a cam-follower breaking up is far greater if it becomes a loose fit in its bore. It is therefore advisable to fit cam-follower liners into the head, to reduce the possibility of such an unwelcome event.

Special valvegear

To prevent valve-bounce at high revs, stronger valve-springs must be fitted. These are available through Cosworth or Vegantune. With the head modified thus, they are absolutely essential items but be warned, they are not cheap. If you wish to extend the guide life, although it is not drastically short with the standard cast-iron items, Hydural-bronze guides are available. The co-efficient of friction with Hydural-bronze is slightly lower than that of cast iron but the gain in power from this quarter must be regarded as minimal. Their main advantages are a better life and superior transfer of heat to the head casting. In this day and age, the possibility of a burnt-out exhaust valve on a correctly set-up motor has been reduced to a minimum, thanks to the metallurgists. A reduction in exhaust-valve temperature, by use of the Hydural-bronze guides does, however, give more of a safety margin and less likelihood of an exhaust-valve failure.

At very high revs, it is possible for the standard cam-followers to break up, especially when a gear is missed and the rev-counter momentarily disappears off the end of the scale. This does not happen very often, and only then when the cam-followers have seen a good few hours' hard racing usage. Cam-follower breakage can be avoided by replacing them at regular intervals. This, unfortunately, involves the tedious job of resetting the tappet clearances and re-timing the cams. An altogether more pleasant alternative is to fit special steel cam-followers which remove any tendancy to break up.

A useful reduction in spring and valve reciprocating mass can be made by fitting titanium spring-retaining caps. When using the stronger valve-springs, the titanium caps will increase the r.p.m. to valve-bounce by about 125 revolutions. Items like these should, how-

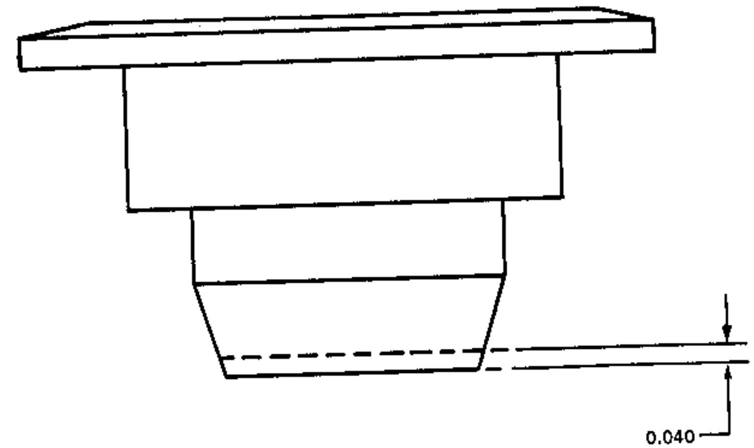

Fig. 18

Valve spring retainer showing point at which metal is removed

ever, be regarded as luxuries as they do not contribute to the power output, if used with the same springs as the steel collars they replace. On the other hand, if the spring pressure was dropped so that the resultant valve-bounce r.p.m. stayed the same as with the stronger springs and steel caps, then a small gain in power would be found because of the slight reduction in cam-follower friction.

It is not uncommon for the steel spring-locating washers under the valve-springs to crack up, especially when stronger springs are used. Their breakage does not usually result in any damage to the engine, but it is not really a good idea to have loose bits of steel wandering around the engine. These locating washers should be renewed every time the head is due for stripping, or replaced entirely by more robust ones machined from solid.

Oversize valves, Hydural-bronze guides, special steel cam-followers, titanium spring-retainers and stronger spring-locating washers are all available from Vegantune.

Another point to watch out for, when using high-lift cams, is fouling of the top of the valve-guides by the lower edge of the valve-spring retainer. If you are using lightweight spring-retainers, such as the Cosworth or Vegantune items, this situation, in all probability, will not arise. To be on the safe side, when using the standard spring retainers 0.040" should be turned off their lower edge (Fig. 18). In most cases this will bring the edge level with the end of the split collets it normally retains. An alternative is to shorten the length of guide protruding through the head casting, but for two reasons this is not such a good idea. Firstly the removal of metal from the end of the guide does nothing to enhance guide life. Secondly, by removing the metal from the spring retainer, we have achieved, however small, a reduction in valve-gear weight.

One last point to check when using a high-lift cam: see that the cam-followers have sufficient travel to accommodate the cam lift. If the cam-follower travel is too little, do not shorten the cam-followers; instead, remove the offending metal from the head. Shortening the cam-followers will only serve to speed up the rate at which wear occurs.

chapter 6
CAMS

The standard cams for the twin-cam engine have a timing of 22°-62° inlet and 62°-22° exhaust, with a lift of 0.350". This is not what you would call a wild cam. They do serve, however, to give the engine a respectable power output whilst retaining good torque characteristics in the lower rev-range. The next stage of cam to use, if you require a little more power at the top end at the expense of a small drop in torque at the bottom end, is the Lotus special-equipment cam. The use of these cams will give a gain of 8-10 b.h.p. over the standard items. This, in conjunction with a Stage I head, will bring the power output up to about 113 b.h.p. Although the factory quote standard power output figures of 105 b.h.p. for the standard engine and 115 b.h.p. for ones fitted with special equipment cams, it is found in practice, when all driven auxiliaries and the silencer are taken into account, to be nearer 95 and 105 b.h.p. respectively.

Cams with even more radical timing can be used to obtain a further increase in power. For instance, the Cosworth C.P. L2 will give a further 5 b.h.p. over the special-equipment cams, with practically no drop in flexibility. This means a genuine 118 b.h.p. with a motor which is still tractable enough for rush-hour driving, and has enough up the top end to make open-road driving more than interesting.

If you want to go to about the limit for road use, then fitting the Cosworth L2 cams will up the power on well-built and correctly set-up motors to about 130-132 b.h.p. The loss in tractability starts to become noticeable with these cams, making town driving a little tiresome. A drop in final-drive ratio can, to a limited extent, ease the situation as far as town driving goes, but of course you pay the penalty of higher revs for a given cruising speed on the open road. Cosworth consider their L2 cam as a long-distance race cam or rally cam. It would seem to be a good choice for the keen rally types who cannot afford engine rebuilds too often, and have to drive their competition motors on the road between meetings. With cams up to the stage of L2, it is not usually necessary to counterbore the spring platforms of the head. It is very difficult to detect coil-binding when the coils only just bind, because the springs are com-