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NORTON TUNING

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INTRODUCTION

Since the introduction of the first Norton Dominator twin – designed by Mr Herbert Hopwood in 1947, the twin-cylinder engine has undergone many detail changes and alterations in swept volume Starting as a 500 cc unit, the first capacity increase, to 600 cc, came in 1956, a year after the first light-alloy heads were fitted to the 500 cc Dominators.

From the very first, the factory, then in Bracebridge Street, Birmingham, offered certain tuning parts, including the Daytona camshaft followed by the SS version made available in 1961.

A year later the 647 cc engine came on the market to be followed in 1965 by the even-further enlarged Atlas 745 cc engine, later to be used in modified form in the new Commando machine.

This manual deals with all motor cycles using the 647 and 745 cc engine units – the 650 SS, Atlas, P11, G15 and all variants of the Commando.

Years of experience with Norton engines, their tuning for fast road and track use and possible modifications have gone into the writing of this work which also combines all the essential information to enable the enthusiast with a basic knowledge of motor-cycle servicing to noticeably improve the performance of his road-going machine and for the road racer to obtain the ultimate in power from his unit.

Although tuning is often thought of simply in terms of improving engine power, full reference is given in this manual to the other important aspects of performance – machine handling and braking.

Any competent person who carefully follows the advice given need have no fears that the extra performance achieved would be gained at the expense [illegible]. If any proof is needed that speed and long [illegible] in a Norton engine, way back in 1967 one [illegible] road going Dunstall Nortons broke the world [illegible] record at Monza, Italy, averaging 126.7 mph for 60 minutes, with highest speeds on the straights of over 140 mph.

The aim of tuning is to increase the efficiency of an engine and, if done properly, this can benefit fuel consumption as well as horsepower.

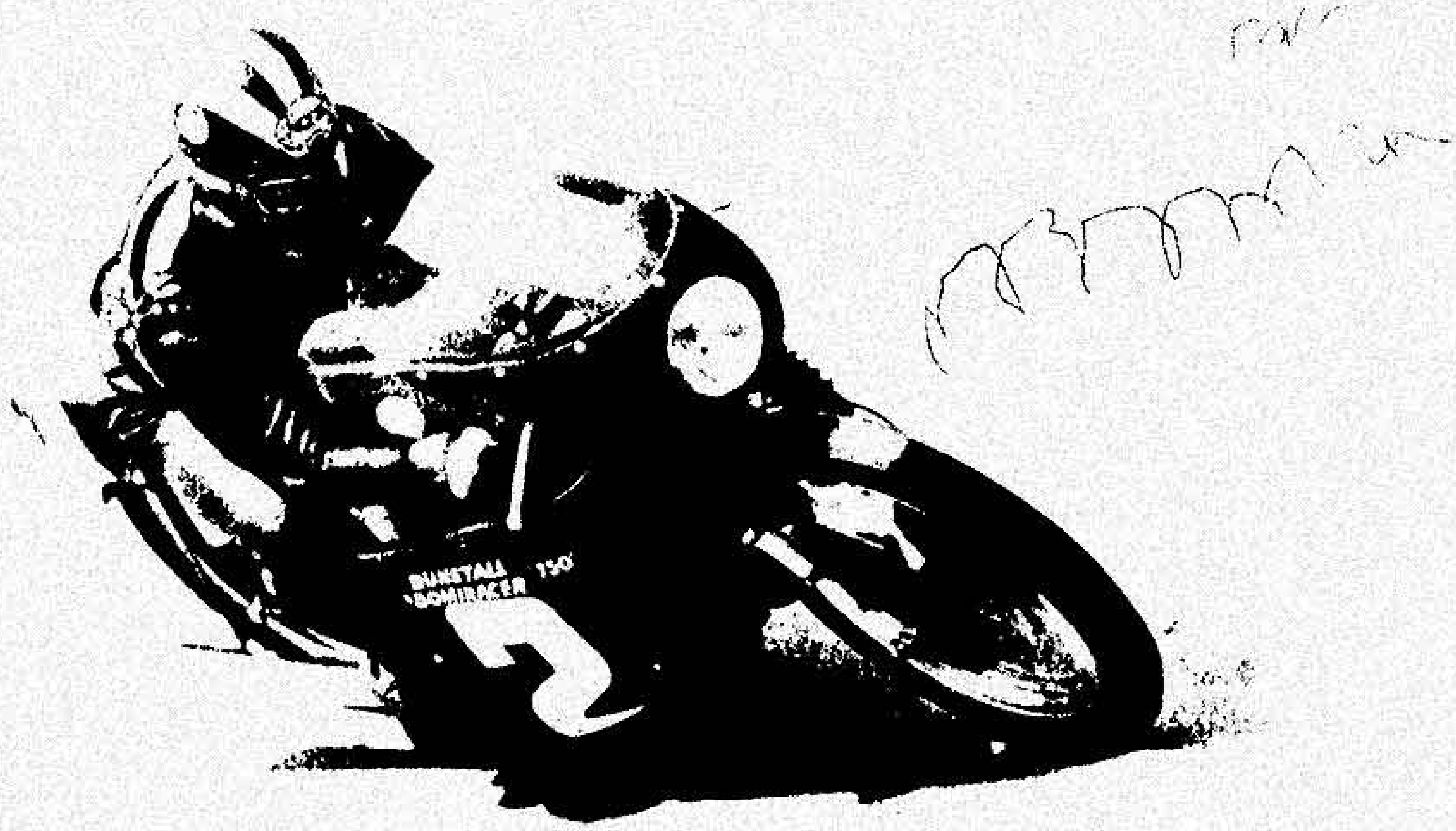
Two types of tuning are dealt with. Much of the information given is applicable for road and track but where modifications are stated to be for racing only, this advice should be followed.

The need for cleanliness and care when working on a competition engine, or that for a road bike, just cannot be overstressed.

We try to keep our workshops looking as near an operating theatre as possible.

Always clean down an engine before dismantling and then clean each part as it is removed. Individual cleaning of each part gives one the opportunity for careful inspection which often reveals faults before they become serious and costly. When rebuilding, a further check for [illegible] faults cannot come amiss.

It always takes a little time for oil to start circulating in a newly built engine. Therefore it is advisable to make sure that all parts such as pistons, cams, valve stems, rockers etc are well oiled during assembly.



Monza Italy 1967. Rex Butcher on a Dunstall Norton putting 127 miles into one hour
Motor Cycle Photograph.

CHAPTER I

THE CYLINDER HEAD

The basic design of the Norton Cylinder Head is very good and all modifications should therefore be aimed at making the design work to it's fullest efficiency. This means altering the ports in such a way as to permit better gas flow, promote more down draught effect, assist turbulance and improve the efficiency of the exhaust.

THE INLET PORT

For much of the time, the inlet valve is open only slightly and increasing gas flow at low lift is particularly desirable. For this reason it is advisable to keep the valve seat width as narrow as possible. However, a minimum width of 1/32 inch should be observed if the seating and valve are to have a reasonable life span.

Because of valve overlap, discussed in chapter 4, there is a great danger of a percentage of the incoming mixture being deflected directly out of the still open exhaust valve and completely wasted.

For this reason the bore of an efficient inlet port should not be kept completely parallel throughout its length. Instead the down-draught effect should be over emphasised to induce the incoming charge downwards away from the exhaust valve and towards the piston.

Ideally, the inlet port should have a pocket above the valve head and behind the guide to over emphasise the downward flow of gases.

The valve guides must be removed before carrying out the following work.

For ease of understanding, it is best to consider the port in three sections: –

(1) Parallel part from the carburettor to the valve guide. This should be enlarged to match the carburettor size. Take great care when enlarging the port to match the 32mm carburettor not to break through the casting.

(2) The bend from the guide area down to the valve throat. As already mentioned, it is most advantageous to over emphasise the downward path of the gases by exaggerating their change of direction by removing material until a pocket is formed (see Fig. 1) behind the guide. This gives an exaggerated curve to the port and will promote the extra downward flow required.

(3) After the bend there should be a short parallel section – 3/16 inch long running into a radiused valve seat.

The radiused area of the valve seat is essential to allow the incoming gases to flow efficiently at small valve openings. Improving gas flow at small valve openings is very important and the radius, as shown in Fig. 1, provides a better path for gases under these circumstances.

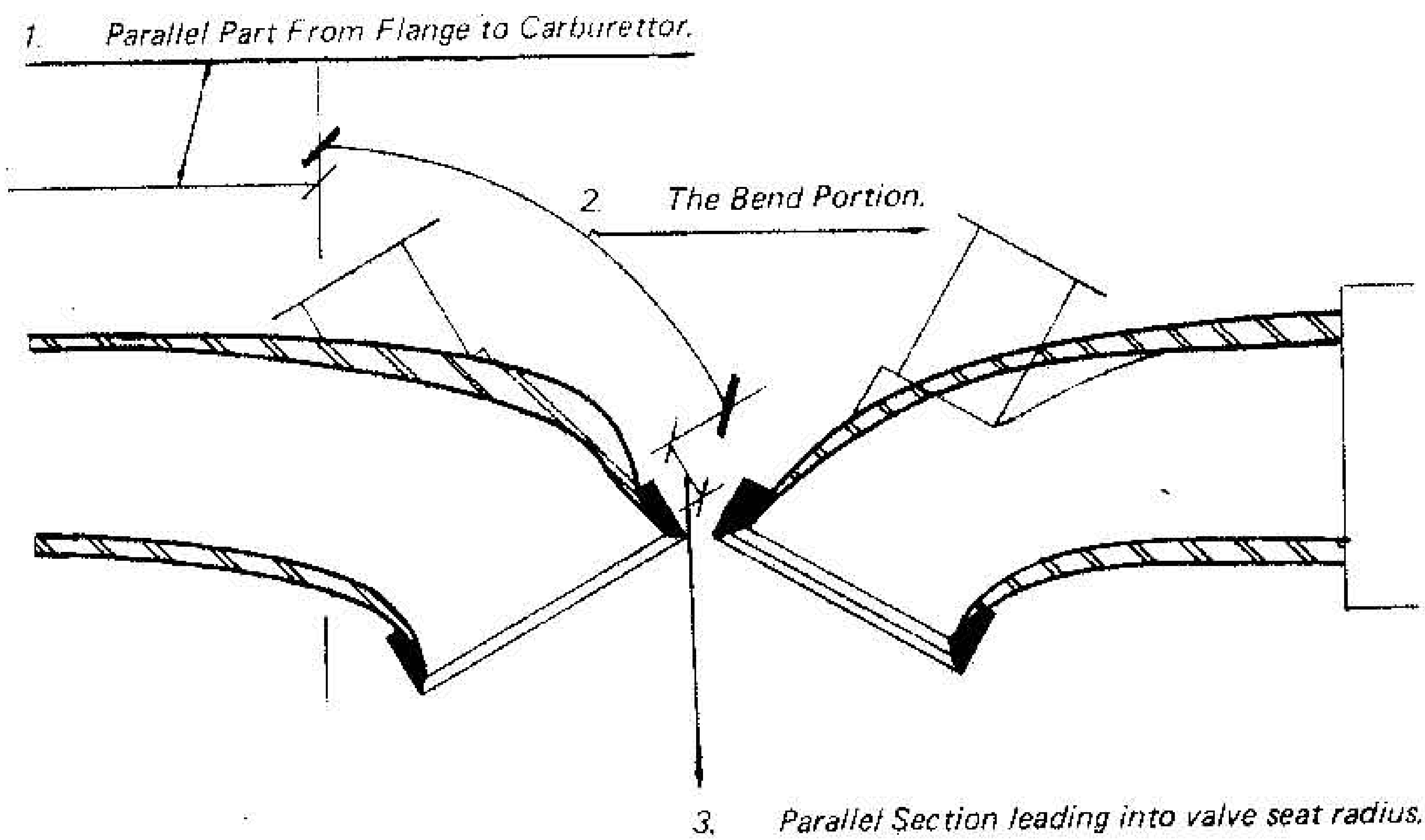


Fig. 1. The shaded areas illustrate where material should be removed

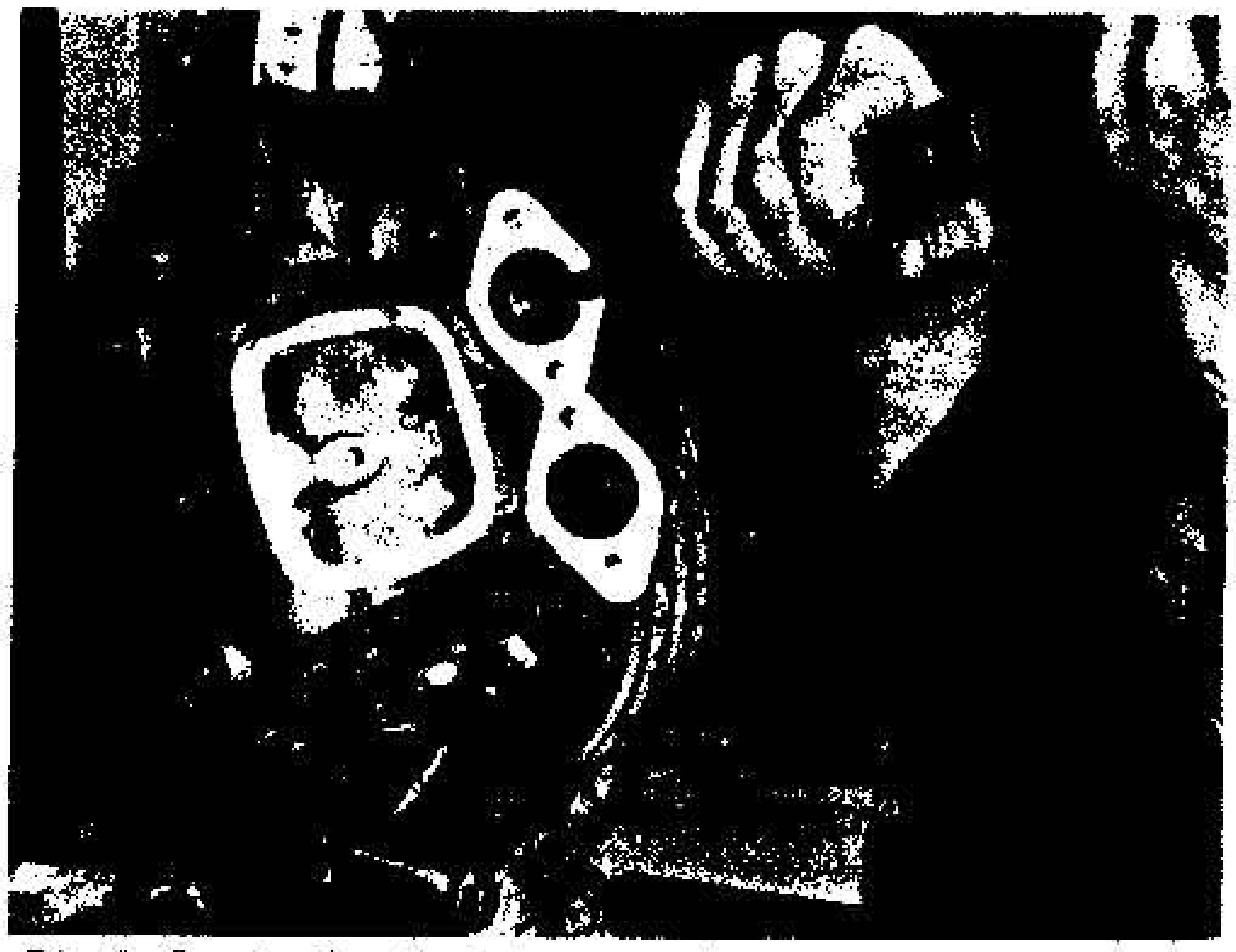


Fig. 2. Re-shaping the inlet ports.

There is great disagreement between tuners over whether the finally shaped port should be highly polished. Some maintain that a highly polished port helps speed gas flow. Others insist that an unpolished port helps induce swirl and greater atomisation of the fuel mixture.

The Norton head is particularly good at inducing swirl because the design incorporates offset ports which have a biased discharge onto the inside of each cylinder. This promotes swirl and gives good turbulence, which accounts for the rapid flame spread and therefore comparatively late ignition timing (28° compared with 38° on some other parallel twins).

I therefore consider it safe and advisable to polish the inlet after shaping.

Tuners make great use of riffler files when shaping ports but modern electric drills and rotary files or burrs can more than play their part in removing metal.

Final smoothing can best be done with abrasive bands and mops and polishing with felt bobs dipped in metal polish.

For those without abrasive mops or bands, these can be made by winding a length of abrasive tape around a slotted length of steel rod which can then be fitted in the chuck of a flexible drive or electric drill. The grade of tape (which can be lengths cut from a sheet of emery cloth) should depend on the amount of metal to be removed. Always finish with the finest grade of cloth available.

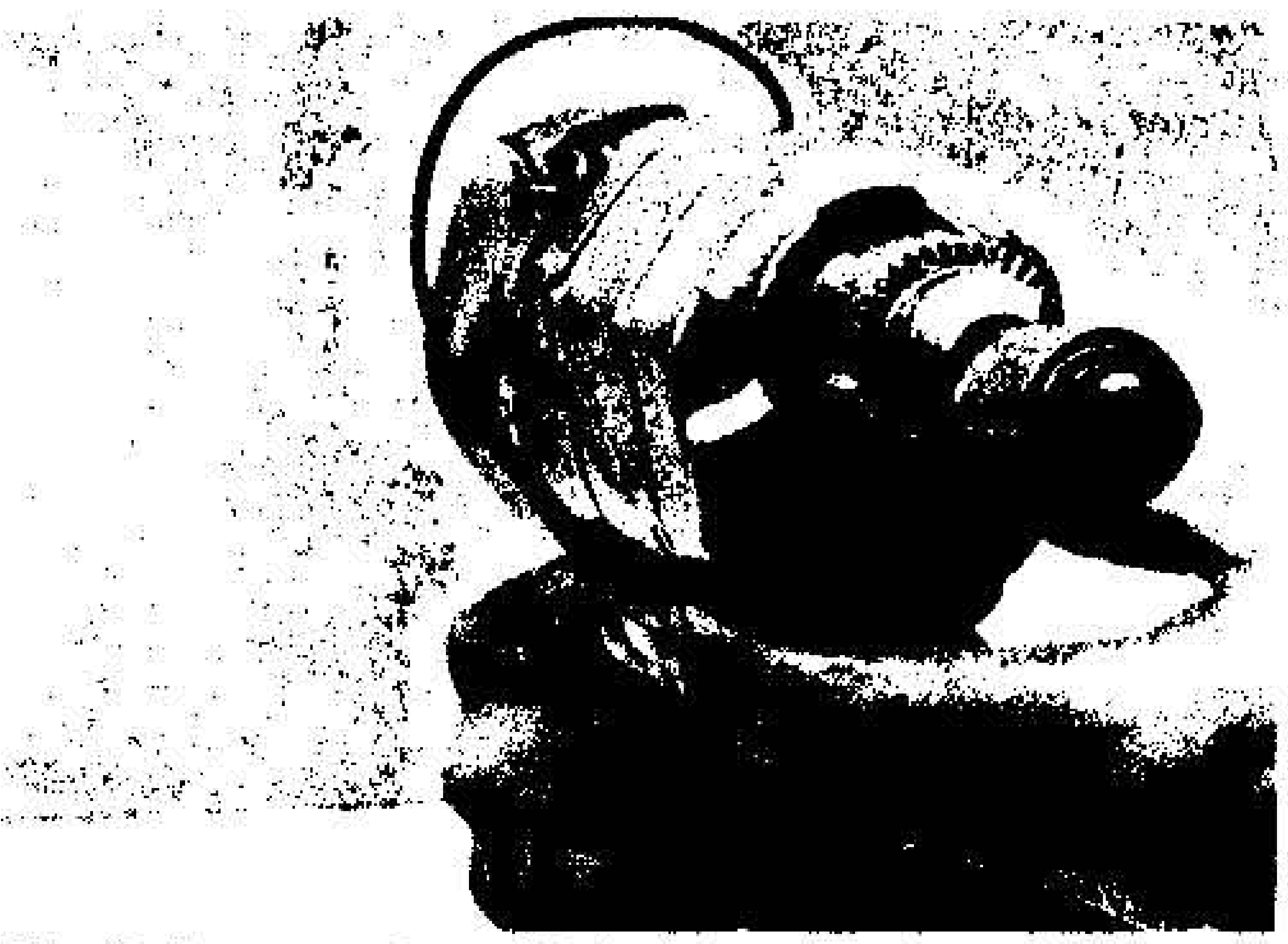


Fig. 3. Easy to make polishing mop.

It is easy to overdo the opening of an inlet port as a too-large size will hamper an engine rather than improve it.

I recommend a maximum port size of 32 mm for all 750 cc engines and 30 mm for 650 cc motors.

THE EXHAUST PORT

Do not waste time on needless polishing of the exhaust port. A port with a thin coating of carbon is, in fact, more efficient than a brightly polished item.

The reason for this is that carbon is a poor heat conductor and the port, and the head itself, will, therefore, absorb less of the waste heat which is better lost through the exhaust pipe.

The exhaust port will benefit from being enlarged, working from the valve seat and gradually increasing in size through to the outlet. Match the outlet size to the inside diameter of the exhaust pipe top flange. Care must be taken not to break through into the stud hole below the exhaust port.

There is no real merit in cutting down the length of the exhaust valve guide. The increase in port area is minimal and unimportant. And exposing more of the valve stem to the exhaust gasses will shorten its life. The valve to guide contact is also essential as a means of transferring the heat from the valve to the head.

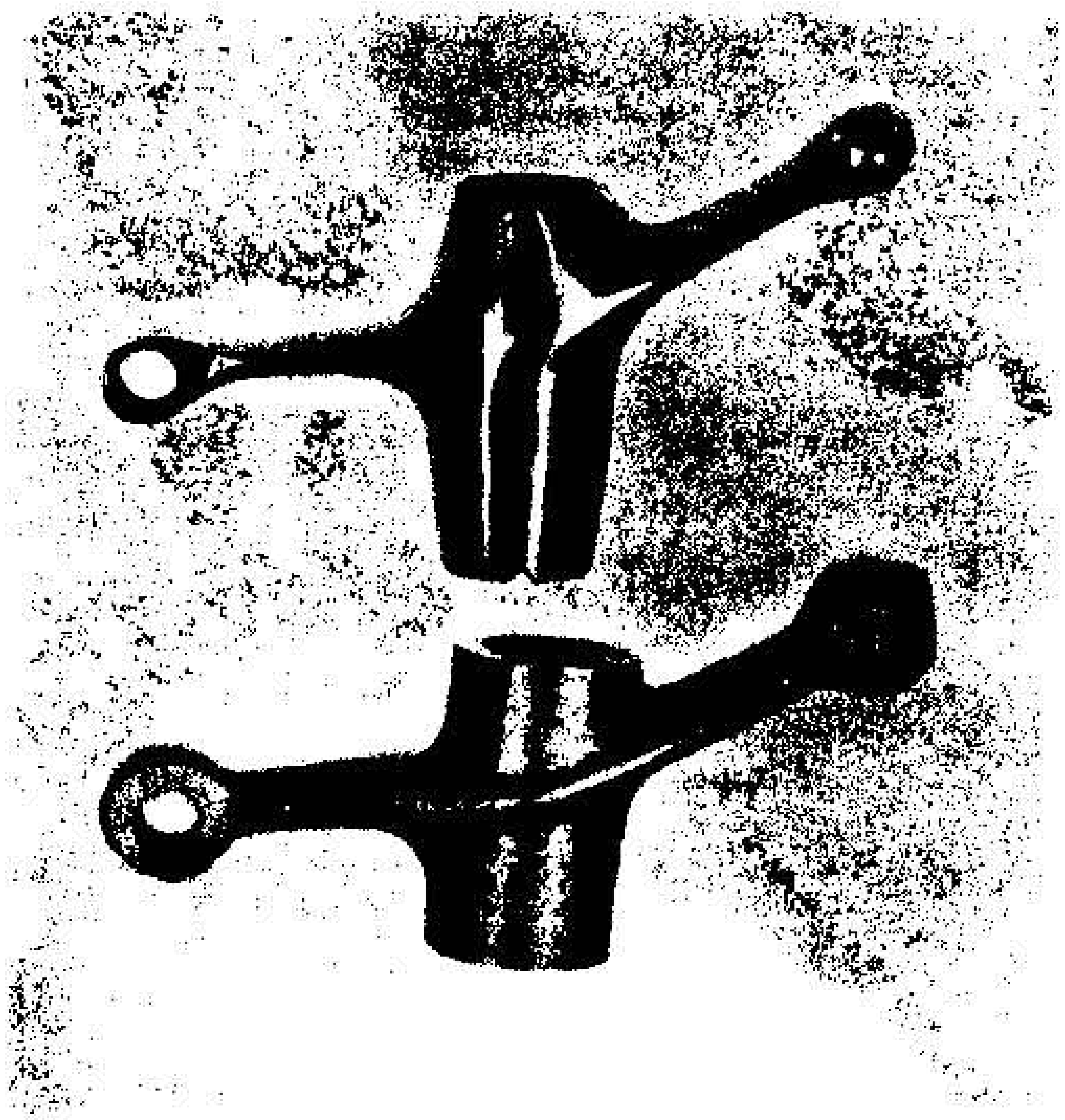


Fig. 4. Standard and Lightened Rocker.

LIGHTENING ROCKERS

Lightening any part of the valve gear is beneficial in that it decreases the inertia of the components and allows higher revs with the decreased risk of valve float and damage.

As the ends of the rockers are the parts which move the furthest, there is clearly little point in removing metal from the arms near the pivot position.

Lightening should be very carefully done on a grindstone and, after sufficient metal has been removed, the whole rocker should be polished, first with an emery band and finished off with a calico mop.

ROUTINE CYLINDER HEAD MAINTENANCE

Removal of the cylinder head is straightforward. There are five nuts below the head and five bolts above it. Two of the nuts are difficult to find, being hidden in the barrel fins up under the exhaust ports, so count to make sure you have undone all ten before trying to break the head gasket seal.

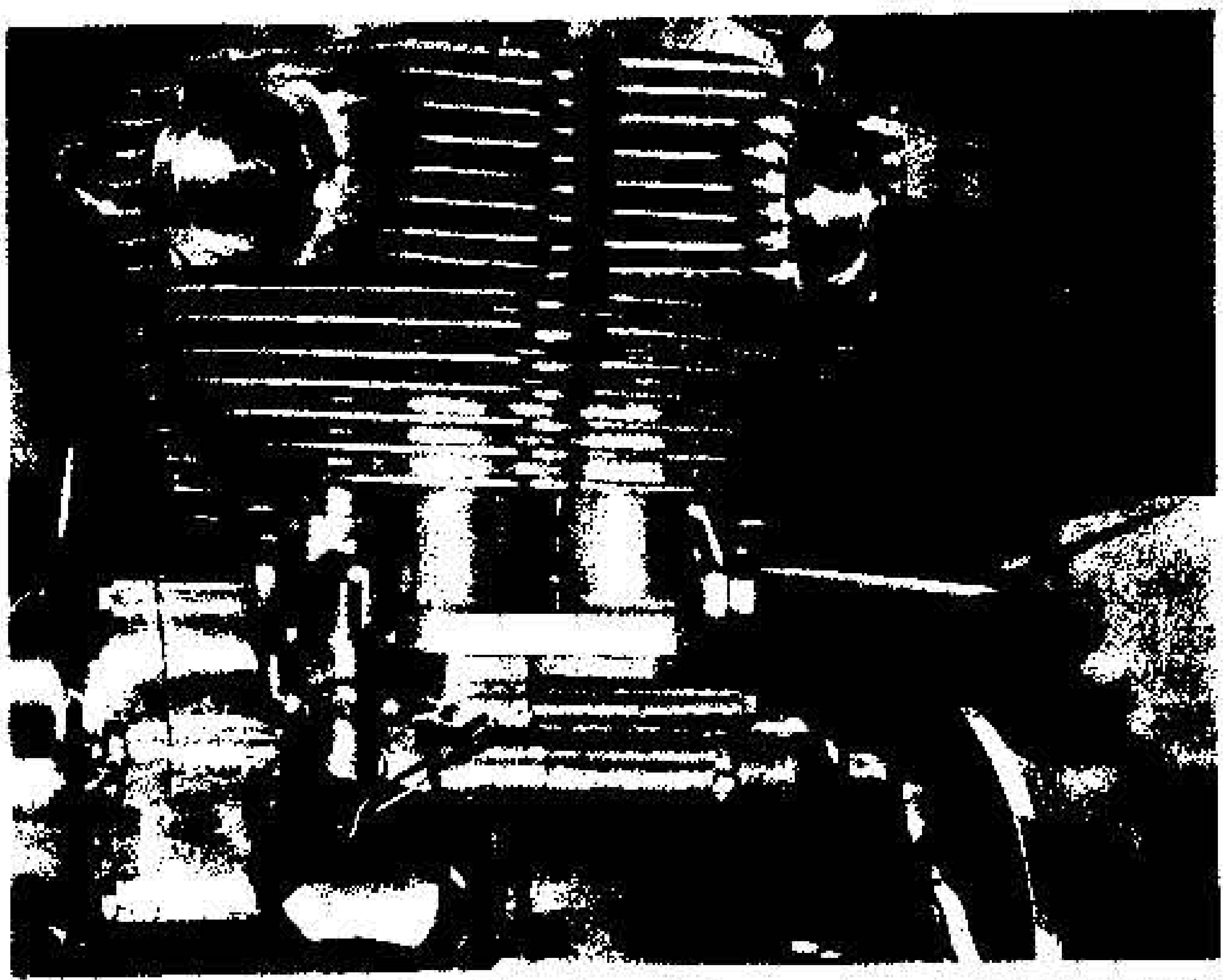


Fig. 5. Two Cylinder Head retaining nuts are concealed in the fins.

When bolting down the head, the bolts and nuts should be tightened to 360 inch lbs for the 3/8 inch bolts and nuts and 240 inch lbs for the two 5/16 inch bolts in the order shown in the photograph. After the engine has been test run, the head nuts and bolts should be re-torqued and the tappet settings re-set.

Always re-new the head gasket, using copper asbestos on engines with spigoted barrels and the reinforced fibre type on the later non-spigoted barrels.

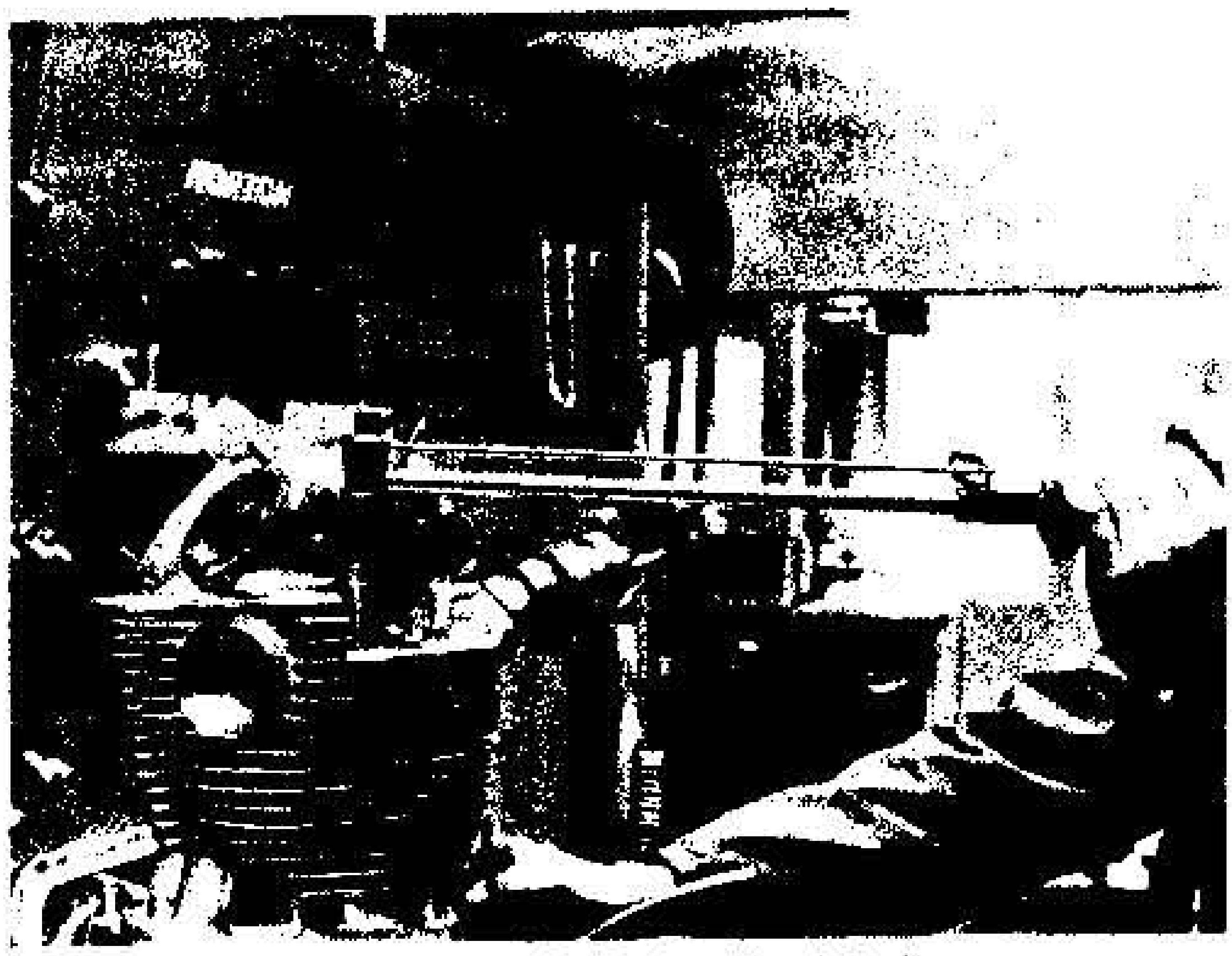


Fig. 6. Setting Torque on Cylinder Head Bolts.

REMOVING THE ROCKERS

The rocker spindles are a tight, press fit in the cylinder head and heat and an extractor tool are necessary if they are to be removed without risk of damage.

The removal tool can be made from a 5/16 inch x 26 t.p.i. cyclethread bolt and a clutch-spring cup or length of steel tube with an internal diameter larger than that of the rocker spindle (.499 inch).

This bolt, inserted through the tube and screwed into the rocker spindle will, when tightened, draw out the spindle as shown in the photograph.

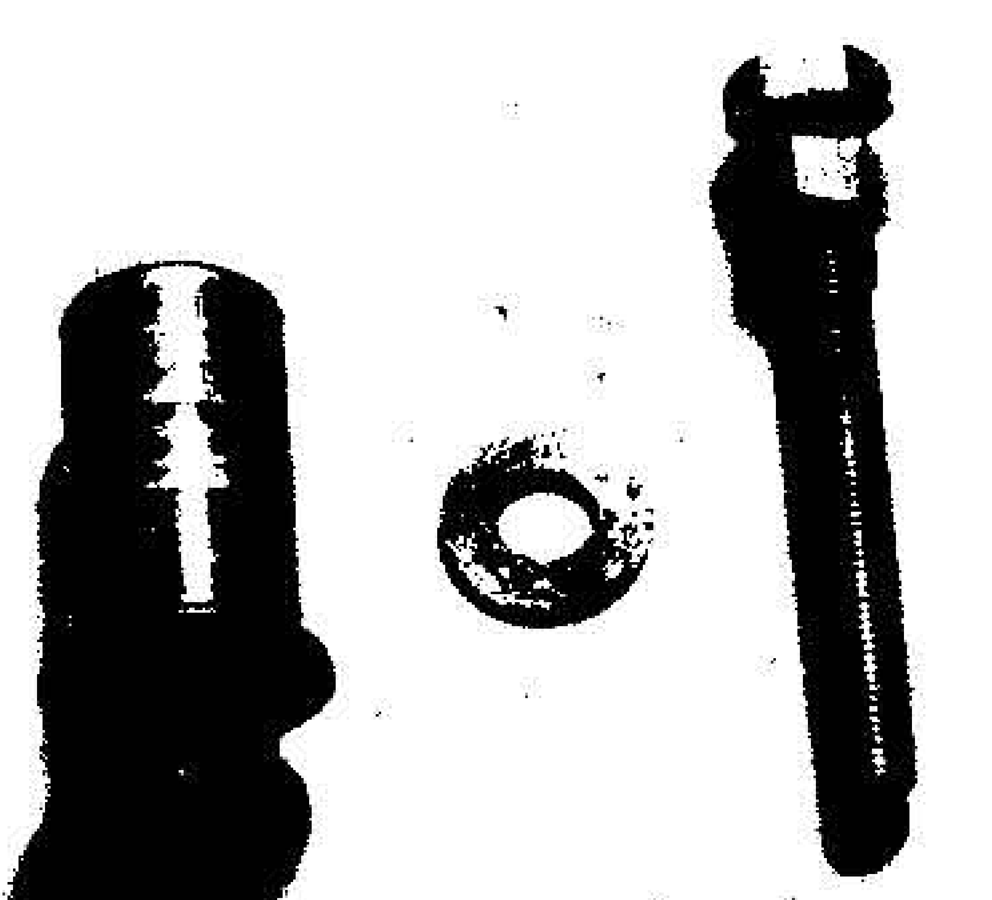


Fig. 7. Components necessary to make rocker spindle removing tool.

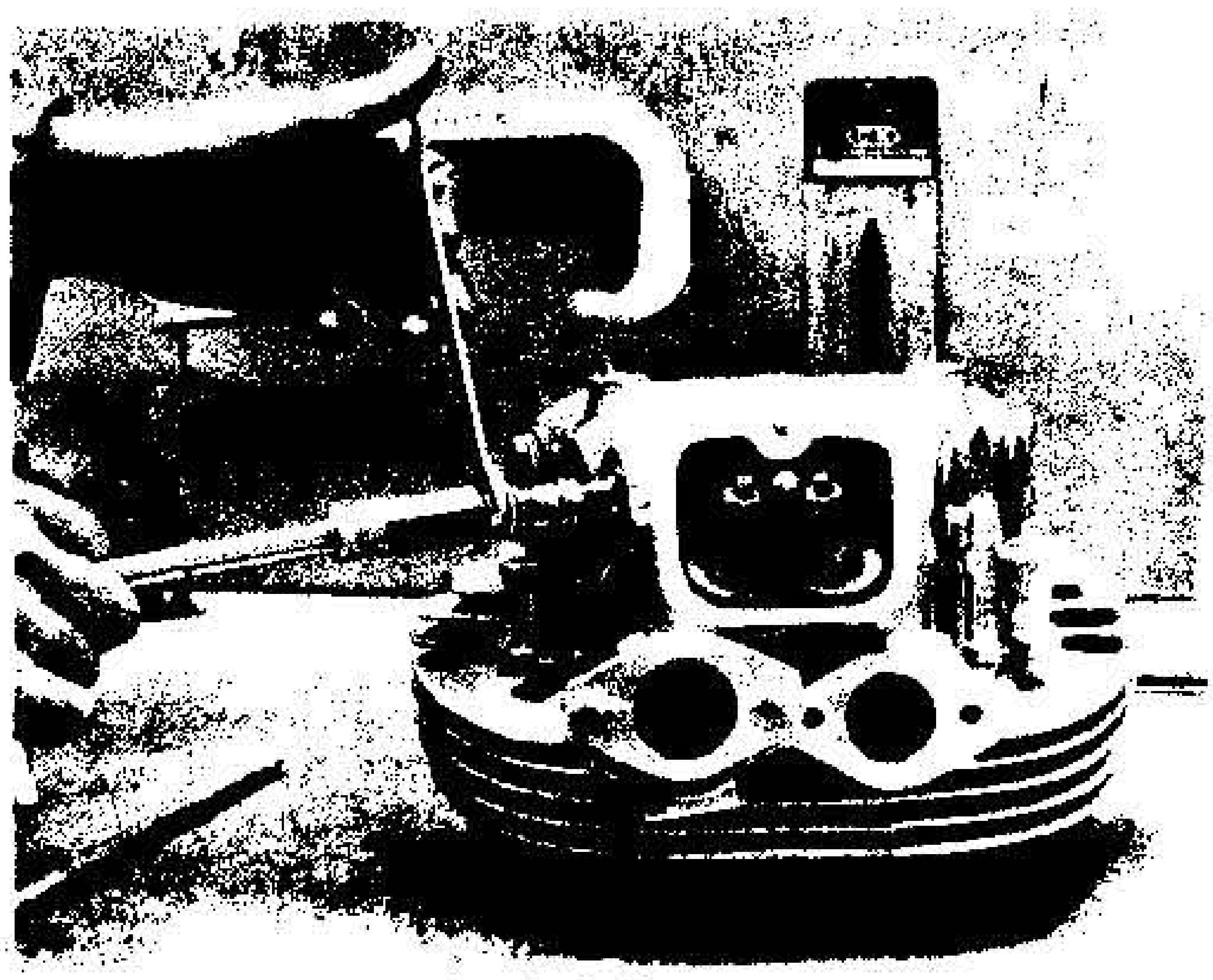


Fig. 8. Removing Rocker Spindle.

Also, an interference fit, the rocker ball-end should be drifted out for safety before any grinding is done on the rockers.

When refitting the ball, its oil hole should line up with the oil drilling in the rocker. The ball shaft should be pressed home as far as possible. This can be done in a vice but a soft face – a sheet of alloy or a lead block is ideal – should be used to protect the ball from the vice jaws.

When refitting the rockers, the oil hole in the rocker spindle must face away from the centre of the cylinder head towards its valve and the slot at the end of the spindle should be horizontal so that it engages with the two tags on the locating plate.

The rockers should be assembled in the following order: shim washer; the rocker itself; the spring washer; the spindle; first paper gasket (with hole in centre); tagged locating plates; second paper gasket; plain oval plate.

Be sure to oil the rocker spindle before inserting it so that it has a source of lubrication the second the engine starts to run.

VALVES

Valves and seatings on all Norton twins have 45° angles. Engineers disagree over the ideal seat angle, some opting for a flatter, 30° seat.

It is true that the 30° seating is more effective at the initial opening period, giving a greater percentage of flow area. But, as the valve opens further, this advantage becomes less and less.

The advantage of the 45° seat is that it gives a far better self-centering action – essential for good seating on engines with relatively short valve guides.

The valves fitted to Norton twins can really only be improved by using those made of a superior material than standard.

We opt for valves of H. 18 S (Silchrome regd.) special alloy steel but Nimonic 80 A, the material used for some Gold Star and Manx Norton valves, would also be suitable.

Our valves are also slightly different in having a repositioned collet groove position and a dip-chrome radius on the valve head.

This has been machined differently so that the correct spring length is maintained when racing cams are fitted.

Valves on the Commando twins are slightly longer (.070 inch) and the pushrods correspondingly shorter to give a slight improvement in the rocker geometry.

Exhaust valve sizes are quite adequate for road and racing use on all twins but some advantage can be gained by fitting the large (1½ inch) Commando inlet valve to 650 cc engines.

SEATING THE VALVES

The easiest check on the efficiency of valve seatings is to carefully pour petrol into each tract in turn watching the combustion chamber for any signs of seepage past the valve.

Inlet valves seats should be kept as narrow as possible, but a wider seating is permissable with exhaust valves which lose much of their accumulated heat through the seat to the head itself.

Worn valve seats that have become pocketed tend to mask the valve, preventing effective flow at small valve openings. This can normally be overcome by re-cutting the valve seat with a hand or electric seat cutting tool. However, if the seat wear is excessive, new valve seats should be fitted.

Fitting valve seats is a specialised job and the bare cylinder head should be taken to an engineering company that has previous experience with this kind of work.

Never grind a valve into its seat more than is necessary, for excessive grinding can destroy the seat angle. Badly pitted valves should be replaced and burnt seating should carefully be re-cut to the original 45° angle.

Fig. 9. Testing Valve Seat Efficiency.

VALVE REMOVAL

Removal of Norton valves presents no particular problems if the conventional spring compressing tool is used. However, the job is made easier by first unscrewing the inlet rocker cover stud. Always replace all valves, collets, springs and spring-retaining collars in their original positions unless they are to be replaced by new items.

Valves should be replaced when the seatings are badly pitted or when the stem diameter measured with a micrometer, does not meet the standard tolerance – .3095 inch to .3105 inch for both inlet and exhaust.

VALVE GUIDES

Valve guides are normally made from either cast iron or a phosphor-bronze alloy.

Cast guides are usually employed in low-performance engines but for any power plant which is to be stressed and from which the maximum available horsepower is to be released, guides from phosphor-bronze are desirable.

Phosphor-bronze guides are more expensive than cast iron components for two reasons — the raw material costs more and it is slightly more costly to machine.

But despite the extra cost, the phosphor bronze guides are well worth using for three reasons:

Firstly phosphor bronze has greater heat dissipation qualities and will take more heat from the valves and transfer it to the cylinder head than is the case with cast iron guides.

Cast iron is not such a good bearing material as phosphor bronze which does in fact have self lubricating properties.

Phosphor bronze has a certain elasticity which means that a valve kissing a piston will possibly only result in a belled out guide. With a cast iron version, the bending of a valve often results in the breaking off of a piece of the guide protruding into the inlet or exhaust tract. If this broken chip of guide finishes up in the combustion chamber, which is quite likely, the engine damage can be quite extensive.

There are many grades of phosphor bronze alloy, each having different tensile strengths and bearing characteristics.

We use a special grade known as Hi-Dural Bronze (regd.) which, in fact, is the same as that used in Manx Norton and 7R AJS racing engines.

I do not believe in shortening or further tapering of the guides. Our bronze guides are designed to allow maximum gas flow without imparing the life of the guide or valve.

As with the vast majority of engines, Norton valve guides are a force fit in the cylinder head. This means that the cylinder head must be pre-heated before attempting to drift the guides out.

Unless, the head is heated, the excessive scuffing which would take place between head and guide would soon lessen the fit between the two components.

The head should also be pre-heated before any attempt is made to drift in new guides.

Although the head can be heated with an oxy acetylene or propane torch or a hot plate of an electric stove. An oven is really more suitable because it avoids localised heat build up and, therefore, the risk of distortion. The temperature of the unit should not be allowed to exceed 200° centigrade.

Fig. 10. Valve Guide Removing Tool.

Fig. 11. Valve Guide Fitting Tool.

Care should be taken when drifting guides in or out and a tool should be made and kept especially for the job.

This should be turned from 31/64 inch round mild steel bar about seven inches long. Reduce the bar to .312 inch diameter for 2 inches at one end and ensure a square corner at a diameter change point.

Fig. 12. Drifting Out Valve Guide.

VALVE SPRINGS

Standard valve springs fitted to 650, 750 cc and Commando engines are quite satisfactory for use with the standard camshaft and only when a high-lift performance cam is used is it really necessary to fit alternative springs.

With a higher-lift cam, a more efficient spring is necessary to control the valve, which is being subjected to higher rates of acceleration and deceleration.

To minimise the likelihood of float when using high-lift camshafts, the valve gear must be lightened within sensible limits as detailed earlier in this chapter and springs used whose performance are matched to the camshaft in use.

No valve springs last forever and eventually they lose some of their tension.

Often it is the exhaust valve spring which suffers first because it receives more heat from the exhaust port. But the inlet spring also suffers because of the greater weight of its valve.

On all Norton twins, heat problems are kept to a minimum by the fitting of insulating washers between the valve spring seat and the cylinder head.

Standard valve springs measure, when new, 1.531 inch for the inner coil and 1.700 inch for the outer coil on all Norton twins. Should this free length be reduced by .187 inch or more by use, the springs should be scrapped and new items fitted.

Although dual rate springs work and wear quite well with high-lift cams, I have found that, without a doubt, the best springs available are the American S & W brand.

These springs are made from a special steel wire which is drawn oversize from a bar. The oversize wire is then ground to the correct diameter on precision machines. The resulting springs can have treble the life span of a normal item.

CYLINDER BARREL

The cylinder barrel on Norton twins is a cast-iron component and requires no special maintenance treatment other than care when bolting down to the crankcase. The base nuts must not be done up tightly by simply working round the cylinder. The nuts should be tightened diagonally to obviate any chance of distortion.

In late 1969 the Commando barrel was re-cast to strengthen it slightly around the top bosses.

Bore wear should be checked at a point about 1 inch below the top of the cylinder. Also check lower in the bore for possible tapering. The point of maximum wear in any cylinder is just below its piston's top-dead-centre position measured from front to back in the bore.

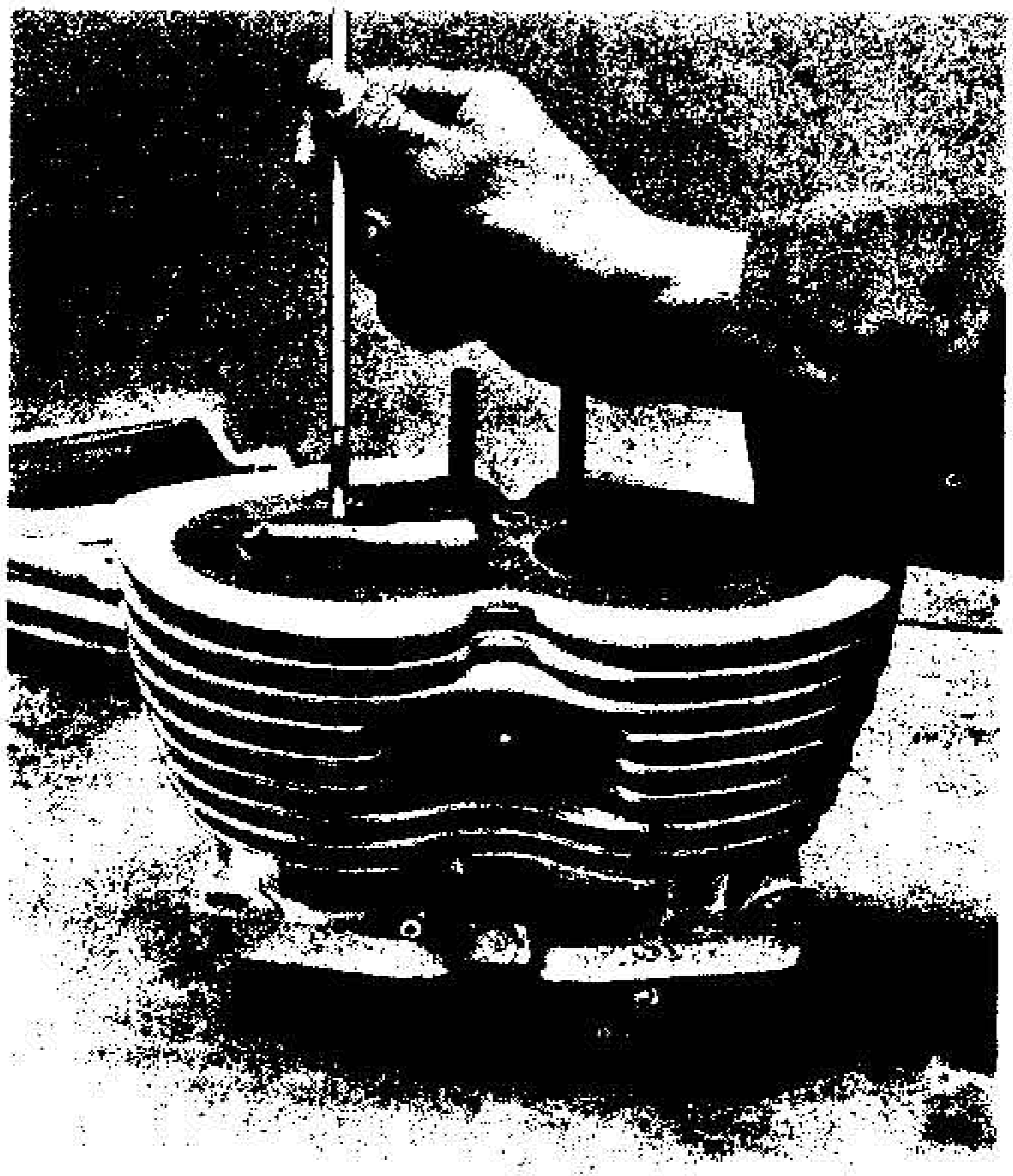


Fig. 13. Use an Internal Micrometer to measure bore wear.

TAPPETS

There is scope for lightening the tappets as shown in Fig. 14. but this should only be done when the standard camshaft is to be retained.

Tappets should be left standard when a racing cam is fitted so as to be able to cope with the extra load transmitted from the fiercer opening ramp.

Fig. 14. Standard and Lightened Camfollower.

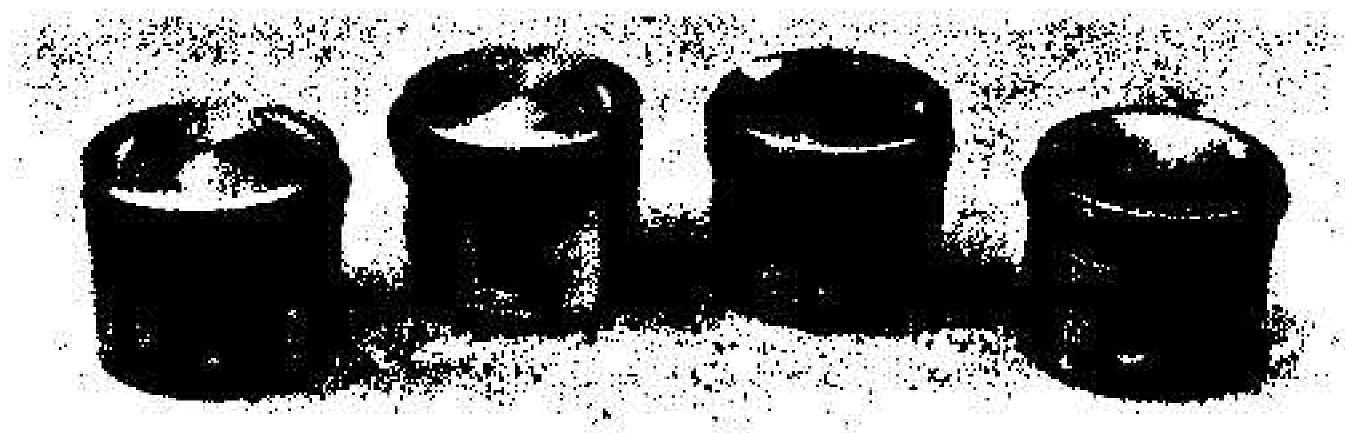


Fig. 15. Pistons for 750. 10.5 to 1, 10 to 1, 8.9 to 1. and 7.4 to 1.

PISTONS

A wide range of pistons are available for 650 and 750 cc engines allowing a good choice for road or racing use.

For 650 cc twins, two varieties are on the market. The standard 8.9 : 1 compression ratio piston which should have .0045 inch clearance in the bore.

The alternative high performance piston for the 650 cc engine is a special spun cast unit which gives a compression ratio of 10.5 to 1. These spun cast pistons have a very high silicon content which lowers the expansion rate and allows a tighter clearance of only .004 inch to be used.

Four different pistons are available for the 750 cc Atlas and Commando engines. There is the standard 7 4 to 1 Atlas piston and the 8.9 to 1 Commando component. The alternatives to these for road work are the 10 to 1 spun cast pistons which are also spun cast low expansion type, needing only .0045 inch bore clearance.

For racing only the spun cast piston is available with one Dykes compression ring in place of the normal rings and a compression ratio of 10.5 to 1.

Changing to spun cast pistons from standard items affects the balance factor by only 2 per-cent and it is not worth rebalancing an engine to allow for this small difference.

PISTON RINGS

Piston rings on Norton machines are, as standard, somewhat unusual.

The compression ring is chrome plated and is cargraph treated. The red coating on this ring should not be removed.

A number of different oil control rings have been fitted by Nortons in recent years. Extra efficient oil control rings became necessary in 1966 when the modified conrod with oil hole, was introduced. Proprietory rings like the

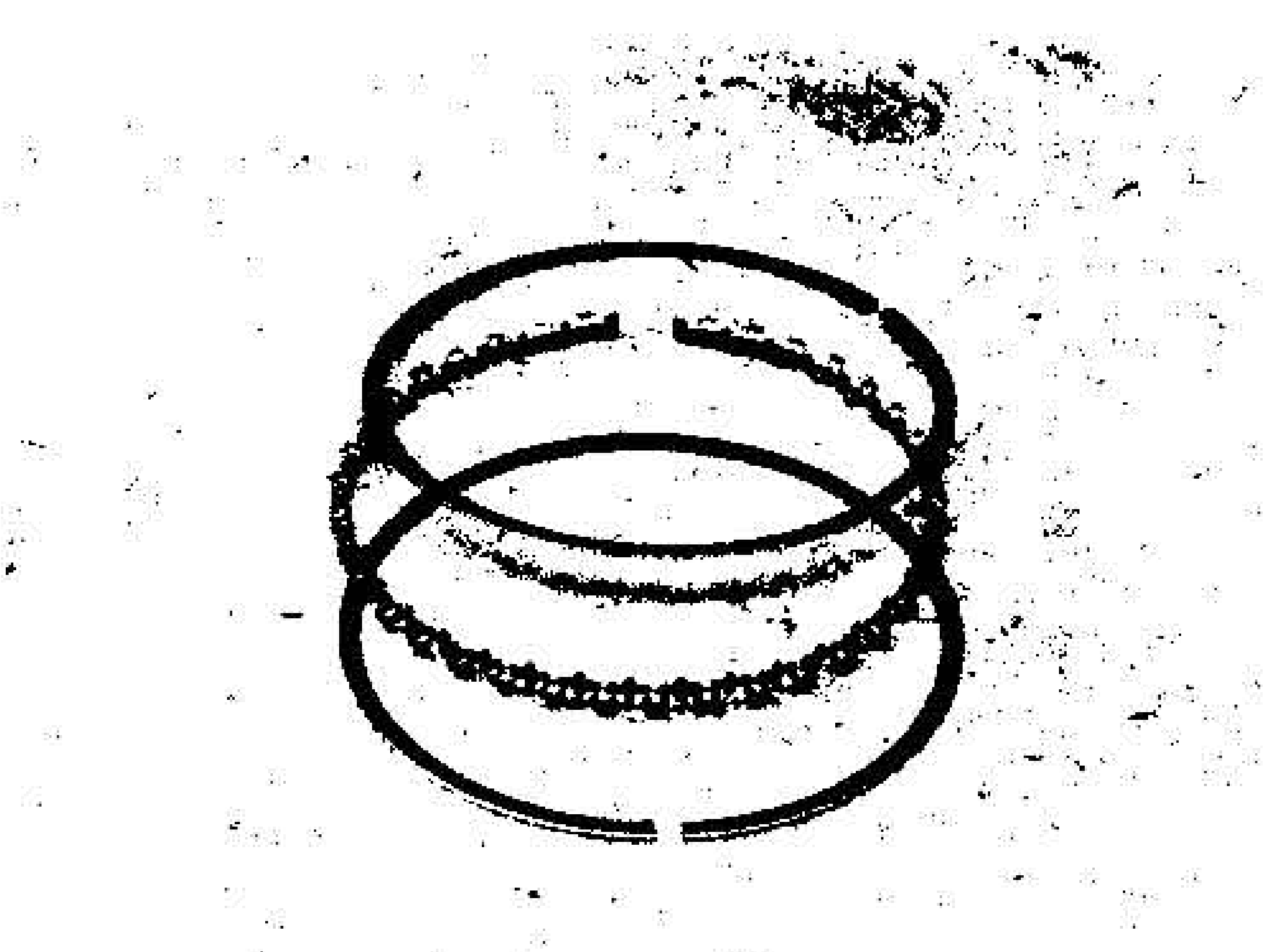


Fig. 16. Apex (Regd) Piston Ring.

Twinflex, Duoflex and Apex all work satisfactorily.

The Apex ring is now used almost exclusively and is of three part construction, having two thin rails with an expander ring sandwiched between them.

Two points should be carefully noted when fitting these rings. The ends of the centre expander ring should not overlap. The gaps in the expander and rail rings should be equally spaced — at 120° — around the piston.

The easiest method of assembling the three-part ring on the piston is to position one rail ring just below the ring groove, fit the expander ring. Then the lower rail ring can be fitted beneath the expander and the second rail mounted above it.

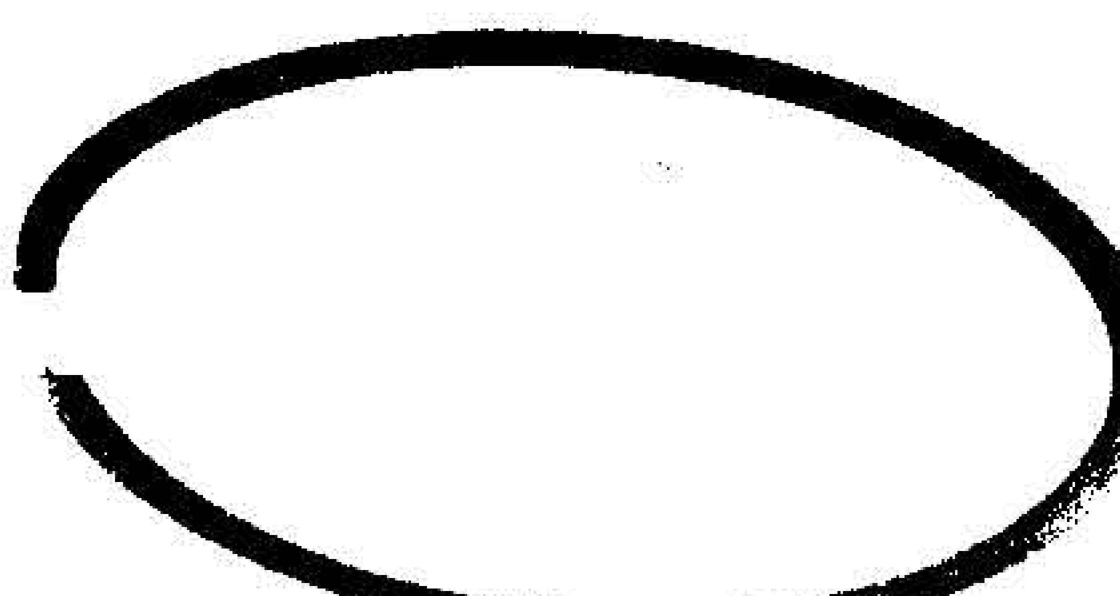


Fig. 17. Dykes Piston Ring.

As stated earlier, the top ring on the 10.5 to 1 Racing piston is of the Dykes pattern. This form of ring provides a superior gas seal. The gas tightness of this piston ring comes about not from the natural expansion of the cast iron ring against the cylinder bore but by the fact that gas forced down behind the ring presses it outwards, against the walls of the barrel.

A Dykes ring has an L shaped cross section with one leg of the L locating in the piston and large clearance at the top of the ring allowing a clean path for gas to flow down behind the ring and force it against the bore.

Piston ring gaps on all models should be .011 to .013 inch for the two compression rings and for the two thin oil scraper rings. The central expander oil ring is pre-sized and need not be altered.

Although the piston assemblies are matched pairs, it may be found that, due to machine tolerances when the cylinder head was made and the depth of wear on the valve seats, that compression ratios for each combustion chamber are slightly different.

The compression ratio of an engine can be worked out if the swept area and the combustion chamber volume with the piston at top dead centre are known.

The swept volume of the engine is known — 745 cc for the Commando and Atlas and 647 cc for the smaller engines, giving 372.5 and 323.5 cc respectively for each cylinder.

To find the capacity of the combustion chamber, the engine should be positioned with the plug hole vertical. Ensuring that the cylinder to be checked is at top-dead-centre on the compression stroke, decant a light engine oil from a graduated burette through the sparking plug hole moving the engine slightly to clear any trapped air, until the lubricant is halfway up the plug thread.

Note the amount of oil decanted and calling it X, work out the compression ratio using the following formula:

$$\frac{\text{swept volume} + X}{X} = \text{Compression ratio}$$

Example: — If the cylinder took 30 cc.

$$\frac{372.5 + 30\text{ cc}}{30\text{ cc}} = \frac{402.5}{30}$$

giving a ratio of 12.75 to 1.

Fig. 18. Measuring Capacity of Combustion Chamber.

But all that is necessary to equal out the compression ratios on each cylinder is to measure the volume of combustion chamber of each to find any discrepancy.

Any difference between the volumes should be corrected by careful machining of the piston crown of the cylinder with the smallest capacity until the two combustion chambers are equal.

Fig. 19. Machining Piston Crown.

THE BOTTOM HALF

The crankcase and bearings of the 650 and 750 cc Norton twins were originally designed for the Model 7 500 cc engine. These same components were later asked to cope with the increased power and loadings of the enlarged 600 cc motor, then the 650 cc unit and, finally, the 750 cc Atlas and Commando power plants.

It is of great credit to the original design that the cases and bearings used can cope with the increased stresses but it is not unfair to add that on the full-blown 750 cc racer things are getting a little near the limit.

The danger of a bottom half upheaval can be minimised by strict attention to the cases and bearings.

Apart from careful inspection of components, there are two definite modifications which can be made to the crankcase bearings to improve the load bearing characteristics and increase the life expectancy of the components.

For racing purposes, the mainshaft bearings should be pegged to prevent their moving in their crankcase housings.

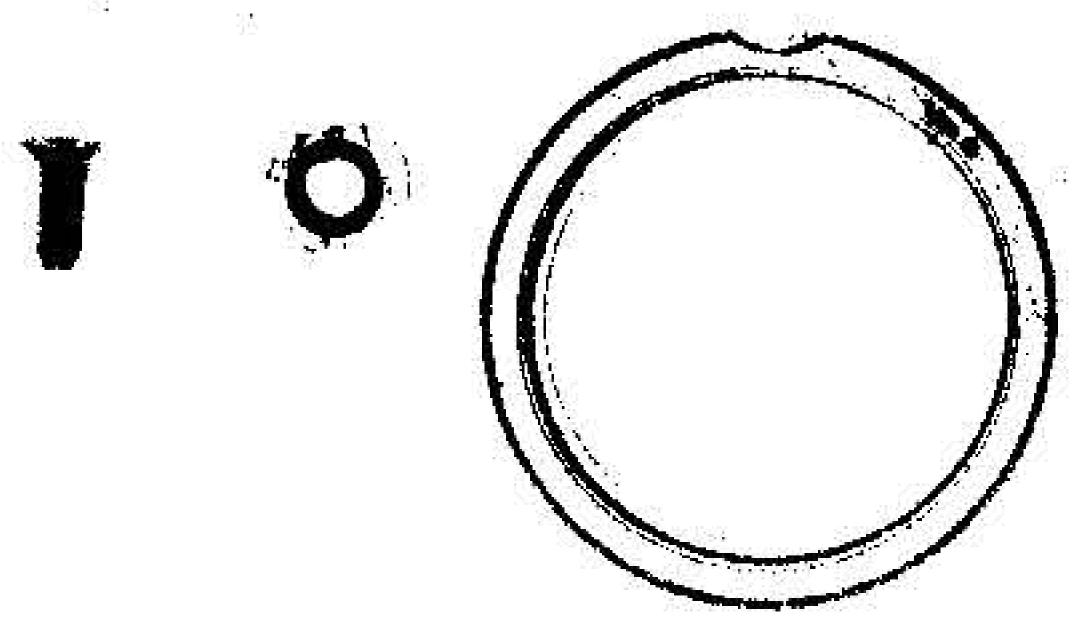


Fig. 20. Components necessary to rigidly locate main bearing.

This involves making a hardened spacer, ¾ inch diameter x 1/8 inch thick, countersunk to accept an allen screw. The crankcase must then be machined to accept the spacer in the edge of the bearing boss with an overlap into the bearing diameter of 3/32 inch. The crankcase should then be drilled and tapped to accept a ¼ inch B.S.F. countersunk Allen Screw which will retain the hardened spacer. A niche must then be ground in the bearing outer track, taking care not to overheat the bearing. A thread locking solution should be used on the countersunk Allen Screw. This provides positive location for the bearing outer track, preventing it from rotating which would wear the crankcases. This modification is beneficial to both main bearings.

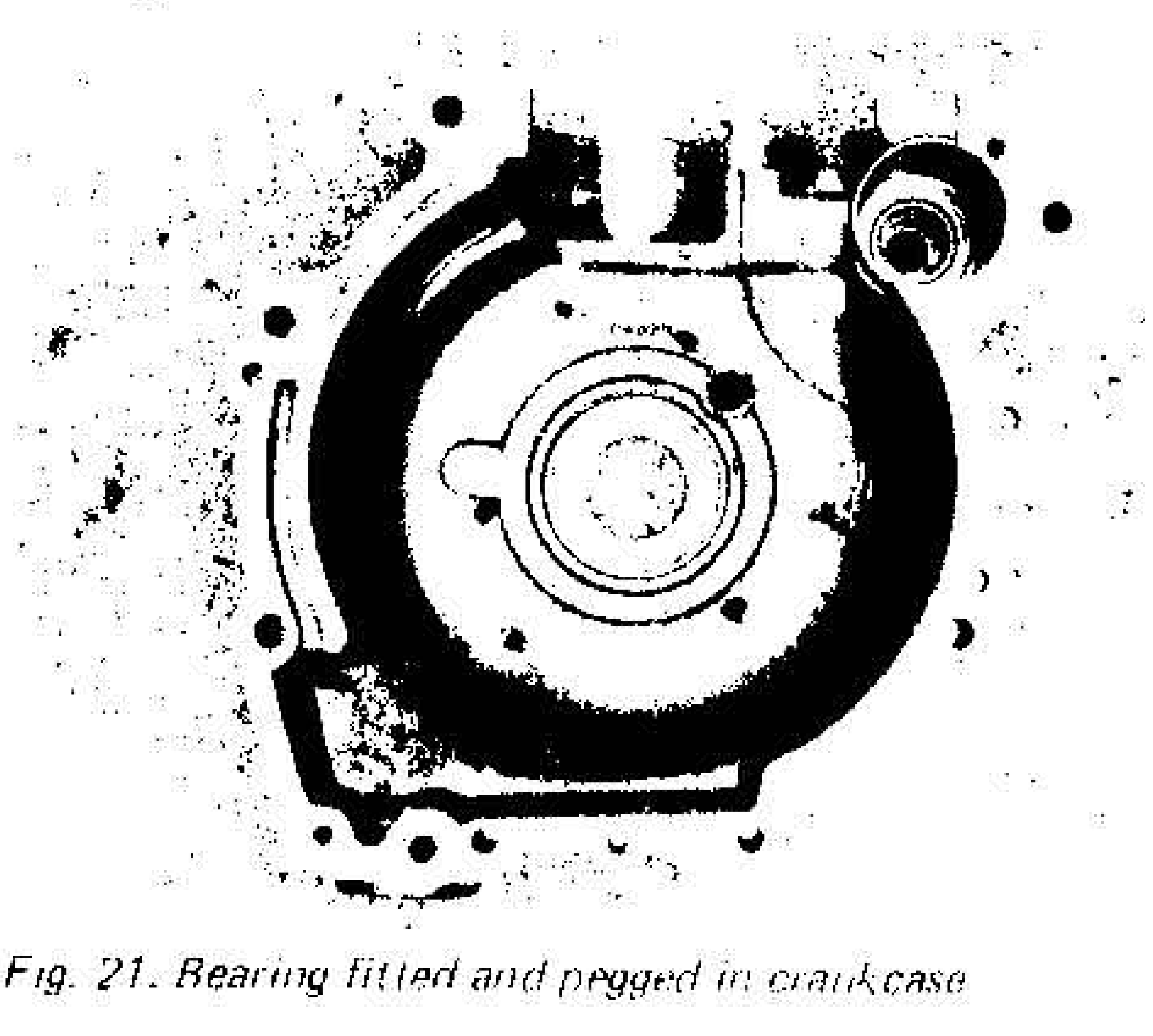


Fig. 21. Bearing fitted and pegged in crankcase

An additional method of positively locating the bearings is to use the tighter fitting drive-side main which was introduced in 1969. This bearing (available under part number MRJA30 ODC single dot) will fit all twins.

The timing side mainshaft bearing can also be improved by replacing the standard eight ball race with a special 10 or 11-ball version. These have a greater contact area between the balls and the outer and inner track of the bearing and, therefore, increase load capacity.

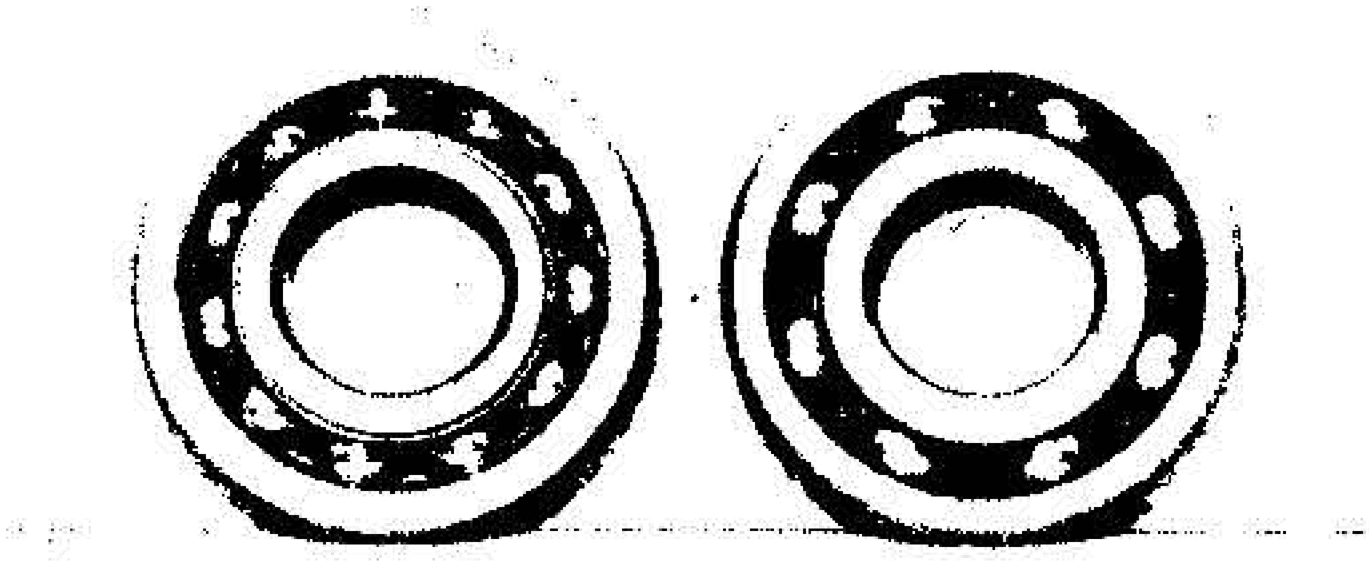


Fig. 22. Comparison high capacity and standard main bearing.

When fitting or removing bearings, the crankcase should be pre-heated in an oven, on a hot plate or with any oxy-acetelene or propane torch to a temperature of no more than 200°C.

The Drive Side Race can prove to be very difficult to remove from its housing because there is no way of getting behind it and efforts to wedge levers between the bearing and case will only result in damaged crankcases. A simple and easy method is to pre-heat the crankcase half as usual and then insert a piece of damp cloth into the bearing, as shown in the illustration. This rapidly cools and shrinks the bearing which will then drop out when the crankcase half is knocked against a soft wood base.

Fig. 23. Damp Cloth will Chill.

SERVICING THE CRANKSHAFT

The con-rods should be removed from the crankshaft by undoing the two self-locking nuts on each con rod cap. It should be noted that when the bores for the big-end shells are machined in the con-rods with the caps in situ and therefore the parts should always be kept together.

Not only should each cap be kept with its respective rod, but the caps should always be repositioned correctly on their rods when the engine is being rebuilt. Each rod and cap has an oblique mark near one bolt hole. These marks should always coincide when the rods and caps are bolted up.

Fig. 24. Assemble Conrods with marks in line.

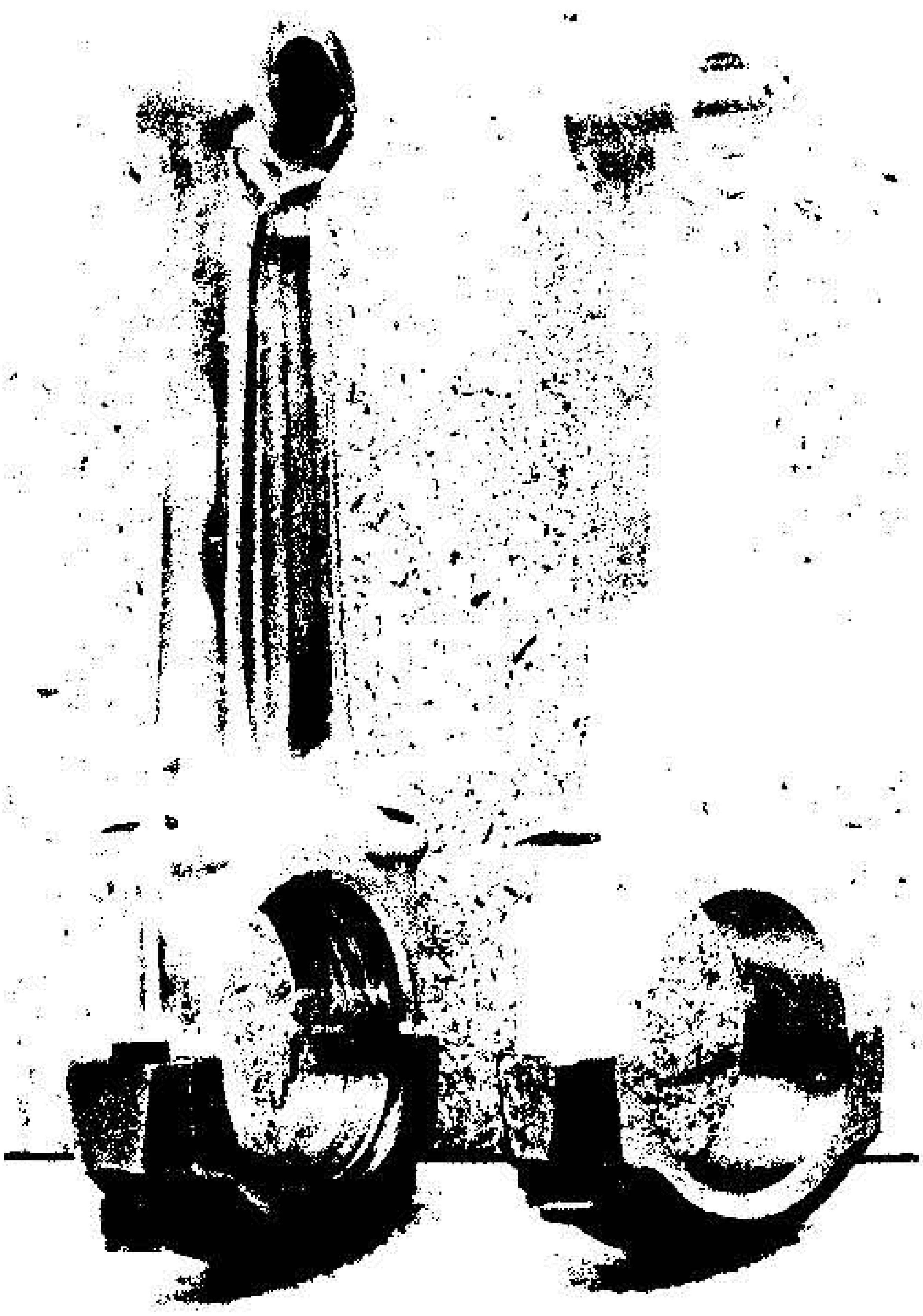


Fig. 25. Comparison of Polished and Standard Conrods.

The con-rods used on Norton machines are quite robust but, to lessen any chance of fracture during severe racing use, the rods should be polished all over and replaced about twice a season. Always use new bolts and nuts each time the rods are reassembled. The reason for this is that, like all highly stressed bolts, they tend to stretch and weaken in use. Self-locking nuts lose quite a large percentage of their locking ability after they have been used more than once.

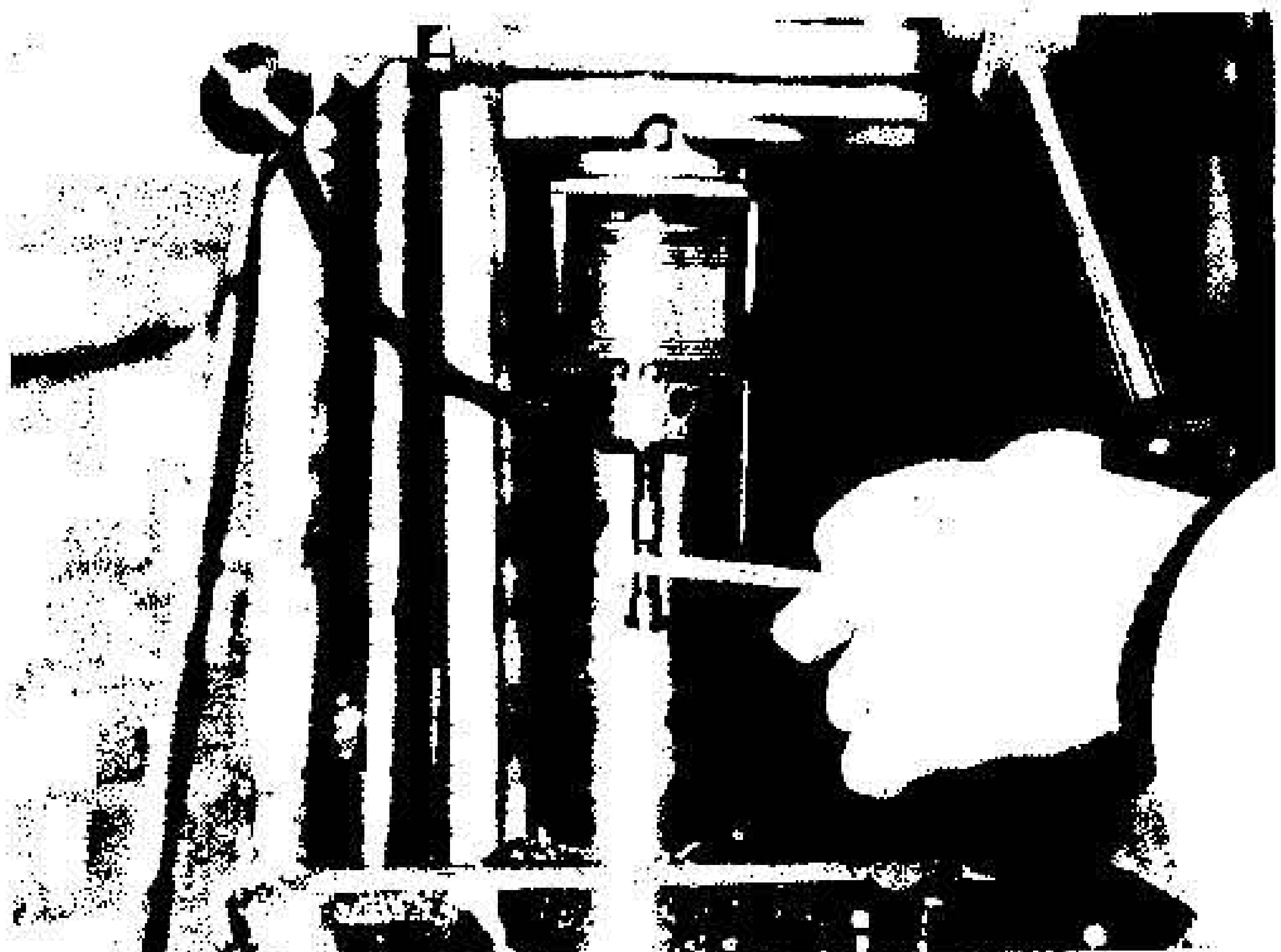


Fig. 26. Polishing machining marks out of Conrod Rod Bolt.

New con-rod bolts can be made less liable to fatique fracture by polishing the relieved portion of the bolt until it is free from scratches which could, in use, develop into cracks.

The crankshaft big-end journals should be examined and measured with a micrometer to check for wear and ovality.

Any deep scratches on the bearing surface are an indication that contaminated oil has been circulating. A journal in this condition should be reground to the nearest possible undersize and new, oversize big-end shells fitted. If the journals appear to be in good condition they should, nevertheless, be measured with a micrometer.

Anything over .001 inch down on size or ovality of over .0005 inch indicates that regrinding is necessary. Wear through ovality is most likely to be found vertically with the crankshaft at top-dead-centre position.

Oversize big-end shells to match undersize-ground crankshafts are available in .010, .020 and .030 inch sizes.

If you have your crankshaft re-ground other than by a concern familiar with Norton models, the following information should be given:

Undersize dimensions: for .010 inch grind, finished size should be 1.7405 to 1.7400 inch; for .020 inch, 1.7305 to 1.7300 inch, for .030 inch, 1.7205 inch to 1.7200 inch.

In all cases, the face radius should be .090 inch. If your grinding firm does not have a wheel with this radius and is not prepared to specially dress one to it, take the job elsewhere.

Con-rod bolts on all Norton twins should be tightened to 22ft lbs.

When fitting new big-end shells, do not finger the polished surfaces of the shells but smear a little oil on the outer, unpolished surface of each shell to ensure that it centralises itself in the cap or con-rod.

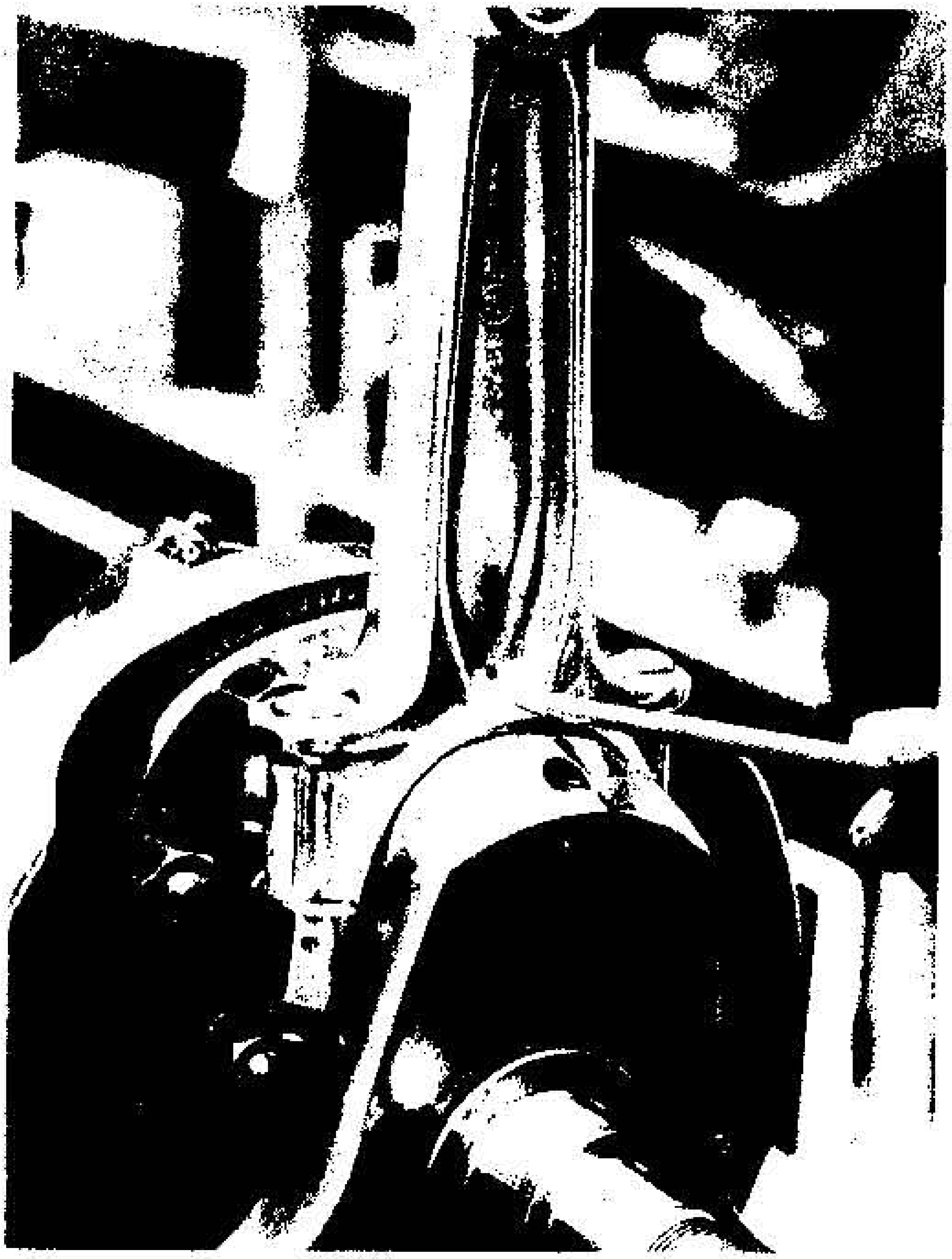


Fig. 27. Oil Holes in Conrod must face away from the centre.

When fitting the rods to the crankshaft, ensure that the small oil holes face away from the flywheel centre.

After assembly, force oil through the crankshaft — with a pressurised oil can — until lubricant comes out of each side of each con-rod.

One reason for the relatively long life of the crankshaft journals is the built-in sludge trap, machined in the crankshaft.

This sludge trap is in the form of a cavity in the crankshaft centre and should be cleaned out carefully at every available opportunity.

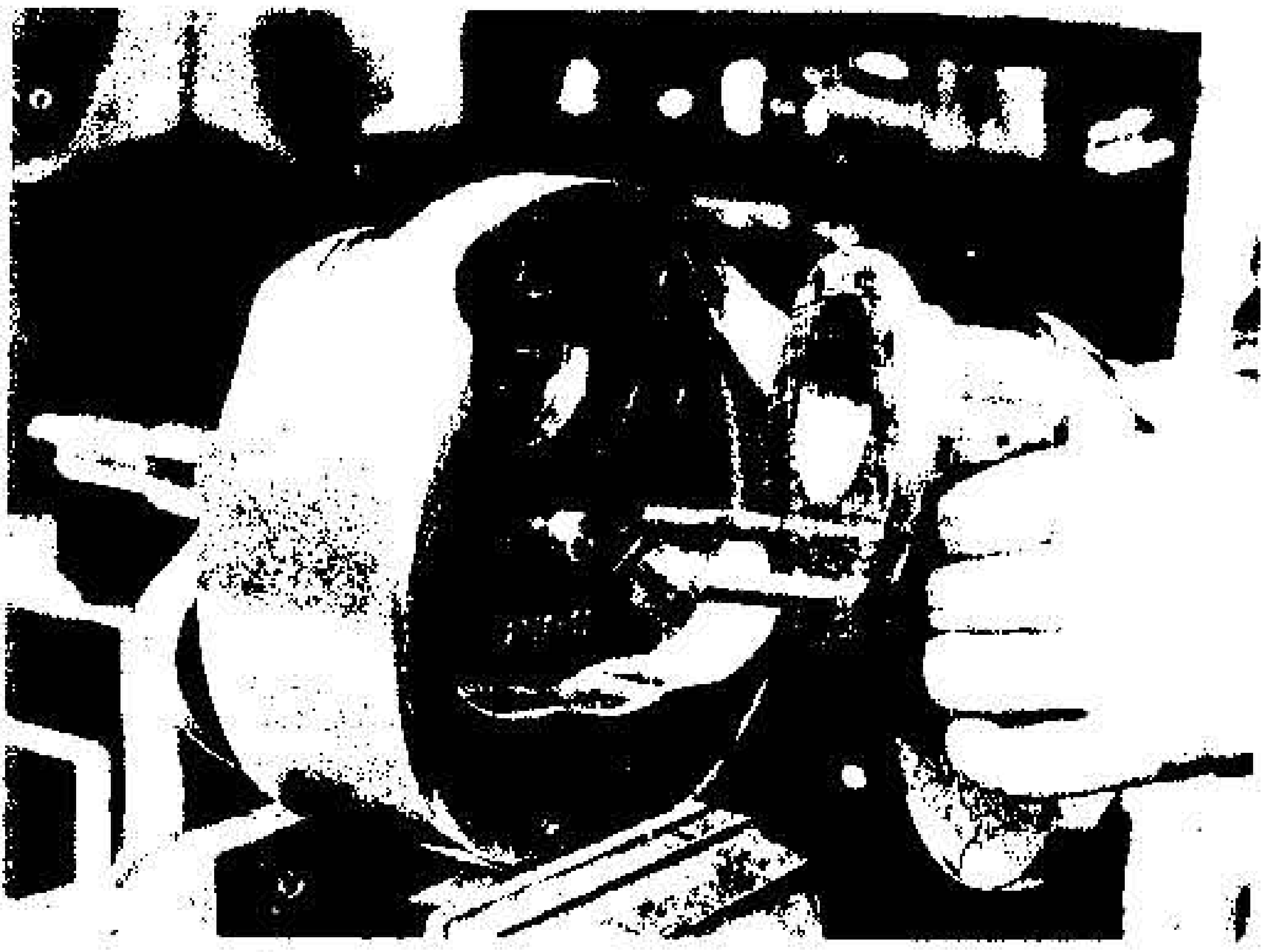


Fig 28. Crankshaft Sludge Trap.

If the crankshaft is to be dismantled, the flywheel should be marked to identify its position, either timing-side or drive-side of the shaft. Unless this is done, and if the shaft is re-assembled with the flywheel in a different position, crankshaft balance will be lost.

Journals and bob weights can be removed from the fly wheel after the six nuts (two on studs, four on bolts) have been unscrewed.

When rebuilding the shaft ensure that the correct high tensile bolts are used. The method of locking the nuts to the four bolts, is to peen over the end of the bolt with a centre punch. Although this works well as a locking method, it also means that the threads of the nuts will be damaged when being removed and, therefore, new items should be fitted.

In the case of studs, locking tab washers are used. Although the tabs of these may be straightened and reused again, it is foolish policy. The locking washers are cheap enough to make their replacement a matter of routine.

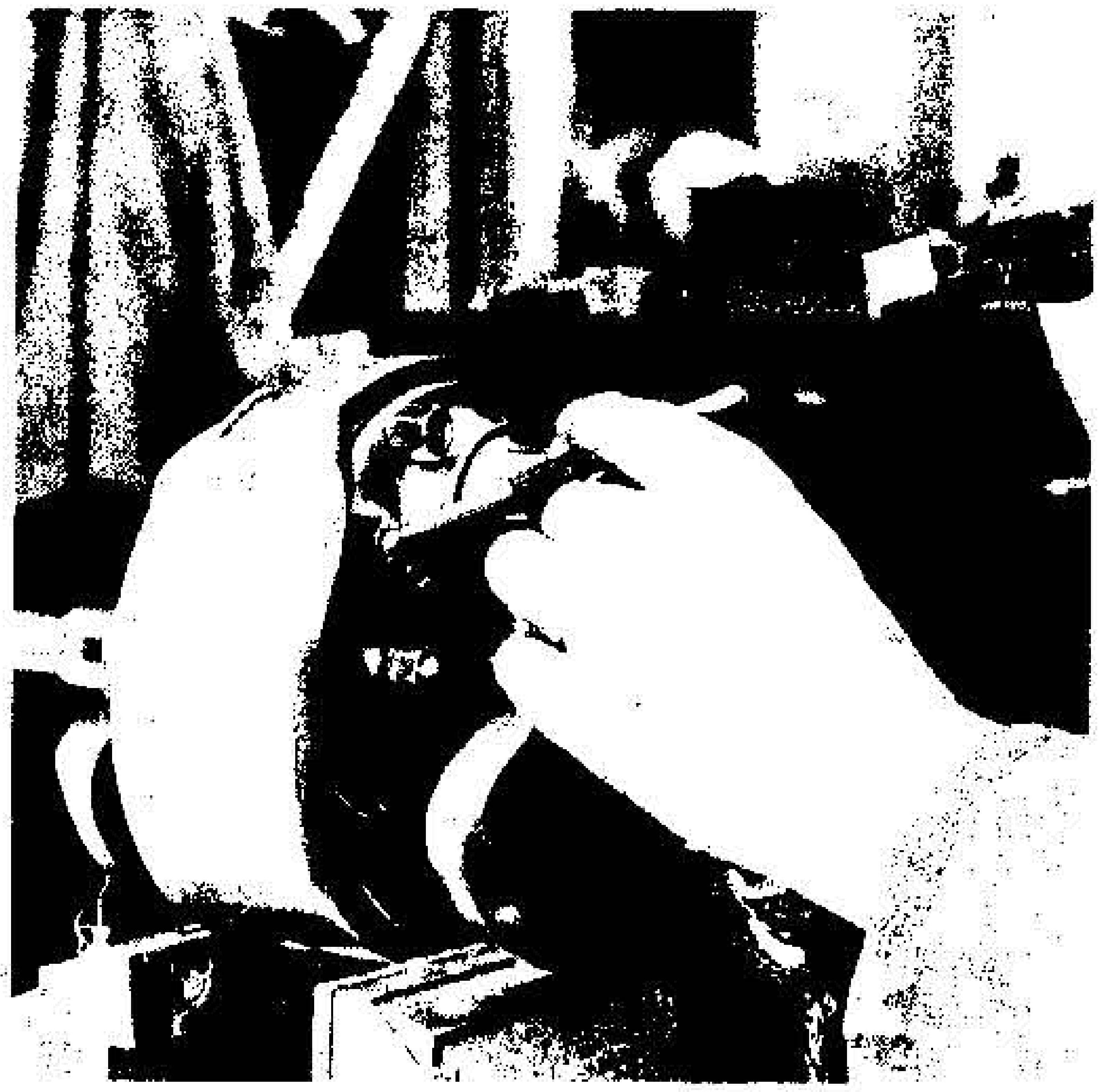


Fig. 29. Peen the four Crankshaft Bolts with a centre punch.

ENGINE BALANCE

For racing, engine balancing is vital to reduce vibration and allow the engine to rev freely, as vibration actually absorbs engine power. It is impossible to give a formula for working out the ideal balance factor. Such figures are only achieved by experiments along lines defined by experience.

For Norton twins, I recommend the following factors when the engines are fitted in standard Norton frames:

Atlas 750 cc	84%
650 cc	70%
Commando 750 cc	52%

The low Commando factor is made necessary by the flexible mounting of the engine in the frame, and is not suitable for a rigidly-mounted engine.

For example, should a Commando engine be mounted rigidly in a special frame — for racing for example — the Atlas balance factor of 84% would be much near the ideal.

CAMSHAFTS

Three cams are currently available for Norton twins and each has its own characteristics. The three cams give the following timings in degrees:

Timings are with tappets set to their standard clearances (.006 inlet, .008 exhaust on S/S and Mk 3 street cams and .008 inlet and .010 exhaust for the racing cam. Clearances are best set with the aid of a dial gauge.

	inlet opens before tdc	inlet closes after bdc	exhaust opens before bdc	exhaust closes after tdc
S/S	50	74	82	42
Mk 3 Street	56	76	86	54
Racing	71	69	78	51

CHOOSING A CAM

The Mk 3 street camshaft offers improved efficiency and therefore more power than the standard S/S cam but without loss of flexibility. The racing cams are intended to be used with megaphone exhaust systems and give a narrower power band than the street or standard items.

These racing cams deliver usable power from 4,500 to 7,000 rpm and, within this rev band, give appreciably more power.

CAM INSTALLATION

The racing cam, because of the additional loads it generates, should be run on needle-roller bearings with a pressure oil feed to each cam.

To fit the cam and bearings, the standard bushes and breather plate must be removed. It will be necessary to heat the crankcases when removing and fitting the bearing. The new needle roller bearings and their special oil seal can be fitted without alterations to the crankcase but care should be taken to avoid damaging the roller bearings when driving them into their housings.

Best way is to make up a drift from 1 inch diameter mild steel round bar with ¾ inch turned down to 13/16 inch. Radius the face of the shoulder to fit the face of the bearing housing.

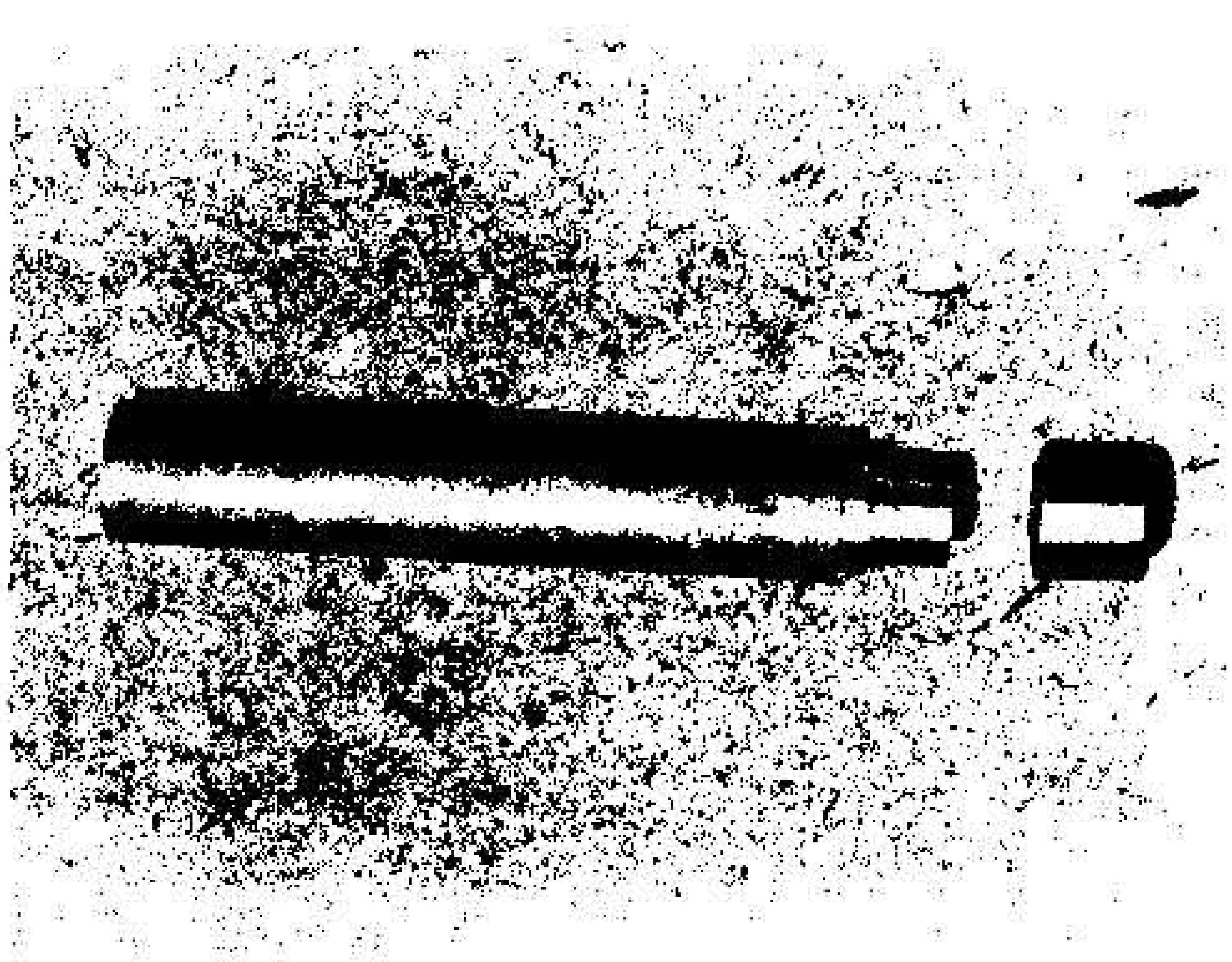


Fig. 31. Camshaft Bearing Drift.

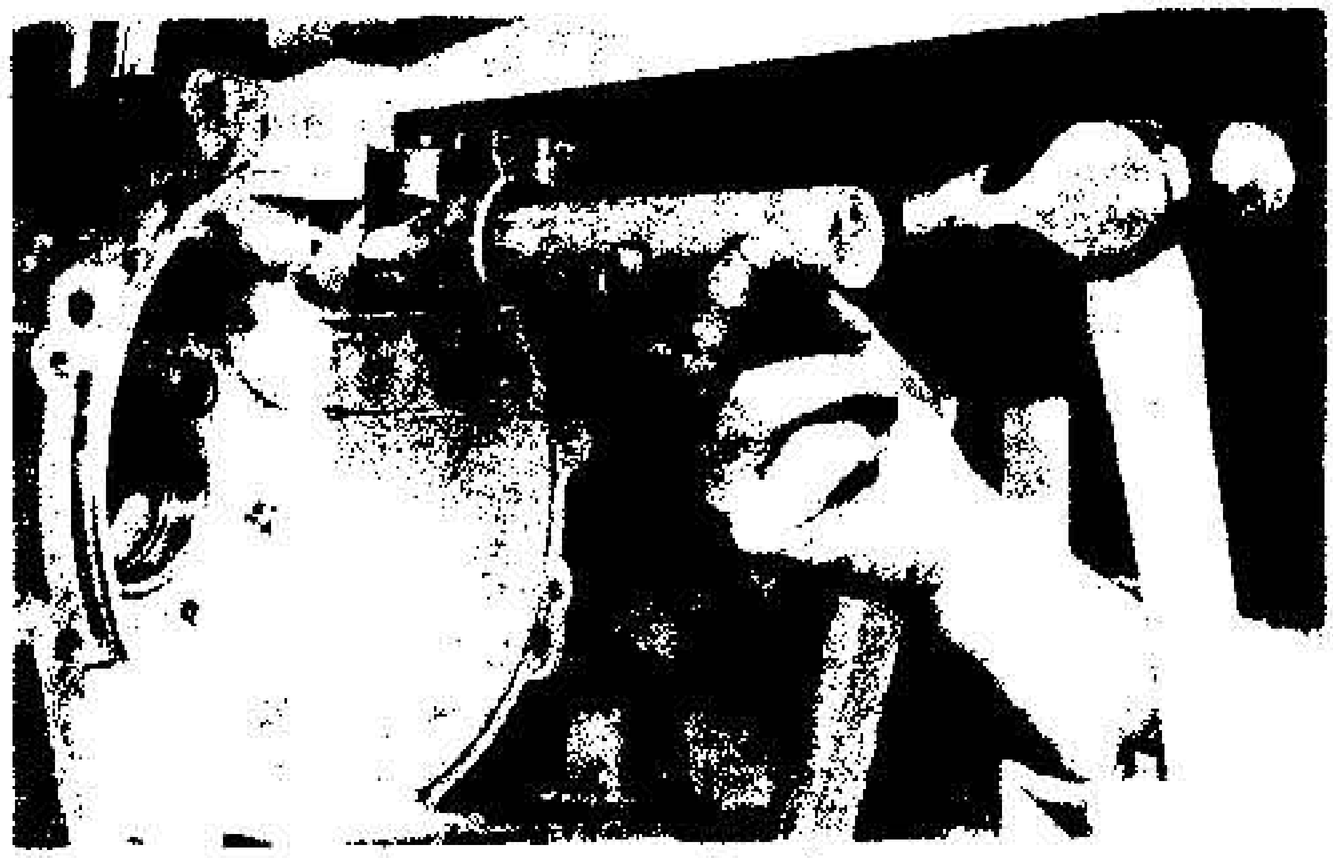


Fig. 32. Fitting a Needle Roller Bearing.

Slight alteration is, however, necessary to the crankcases to take the larger lobes of the inlet cams. The cam tunnel should be enlarged so that there is ample room for the shaft to revolve. The metal is easily removed with the aid of a rotary file held in the chuck of a flexible shaft or even a hand-held electric drill. Use a fairly fine cut file and, if the drill is of the dual-speed variety, use the faster speed.

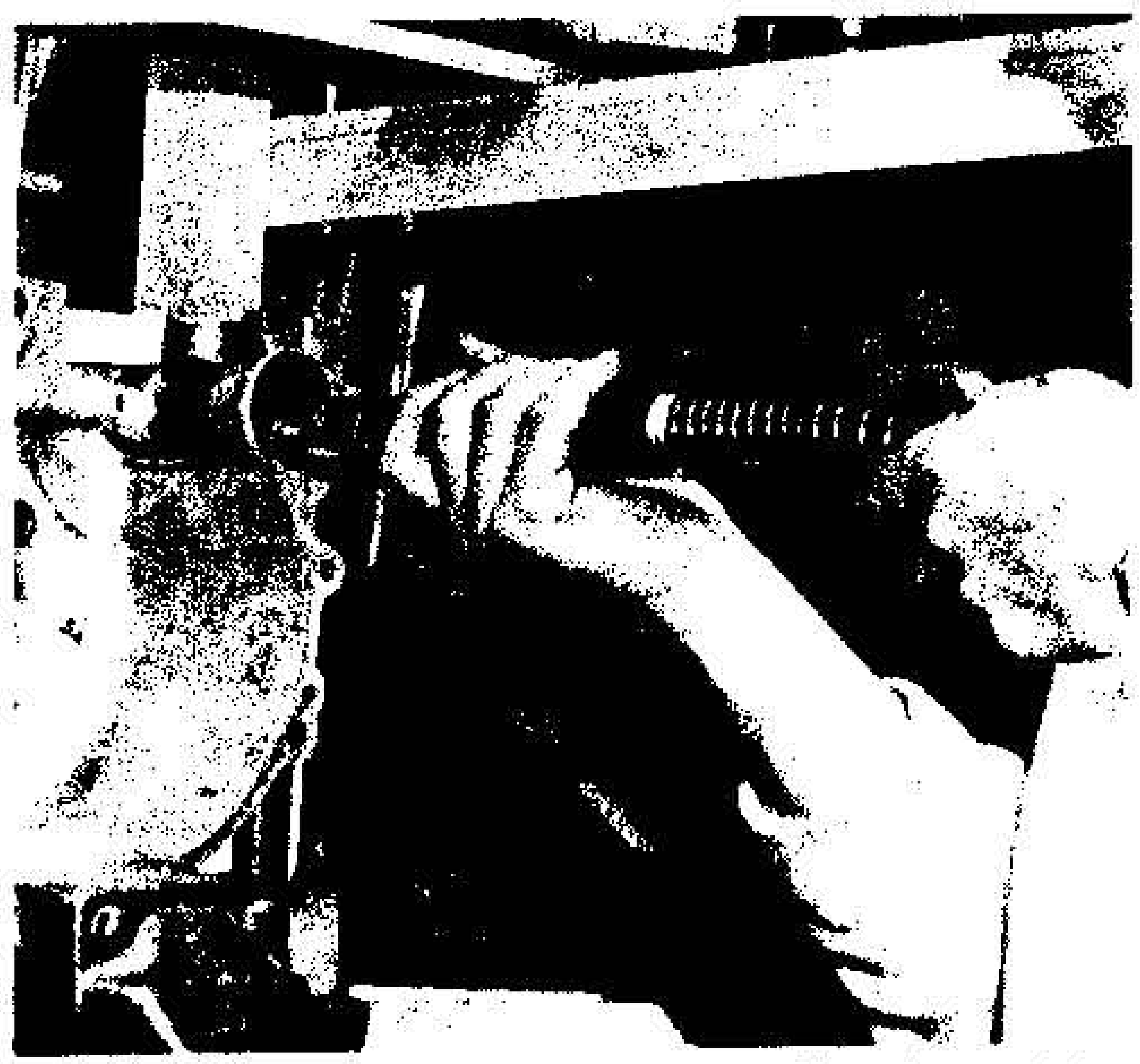


Fig. 33. Enlarging Camshaft Tunnel to Clear Larger Inlet Cam Lobes.

The pressure oil feed to the cams can be supplied by a special feed kit which delivers lubricant from the timing cover to the cams and to the rocker gear. The banjo bolts used oon this feed kit are specially metered to allow the correct amount of lubricant to be fed through them and properly distributed between the cam and the rocker assembly.

As said earlier, the standard engine breather must be removed to fit the high-lift race cam and another breather should be substituted in its place. An engine running without a breather would build up crankcase pressure and push oil out of any joint that could not take the force.

Ideally, a breather should pass only air with, of course, the inevitable oil mist. There are two methods of replacing the original breather and one is preferable in that it is less likely to pass neat oil.

Perhaps the easiest method is to re-locate the original breather elbow in the drive side crankcase just below the barrel as shown by Fig. 34. The elbow thread is ½ inch x 20 t.p.i., tapping drill size is 29/64 inch. But the better method of replacing the breather is to fit the flapper-type valve originally designed for G50 racing Matchless engines.

This valve may be fitted after turning off the crankshaft extension which, on road machines, held the rotor and drilling out the centre of the mainshaft with a ⅝" drill. The hole should then be machined out and threaded to take the new breather, as shown in the photograph.

The obvious advantage of this set up is that excess oil is thrown from the centre of the shaft by centrifugal force and only air and mist is passed by the flap valve.

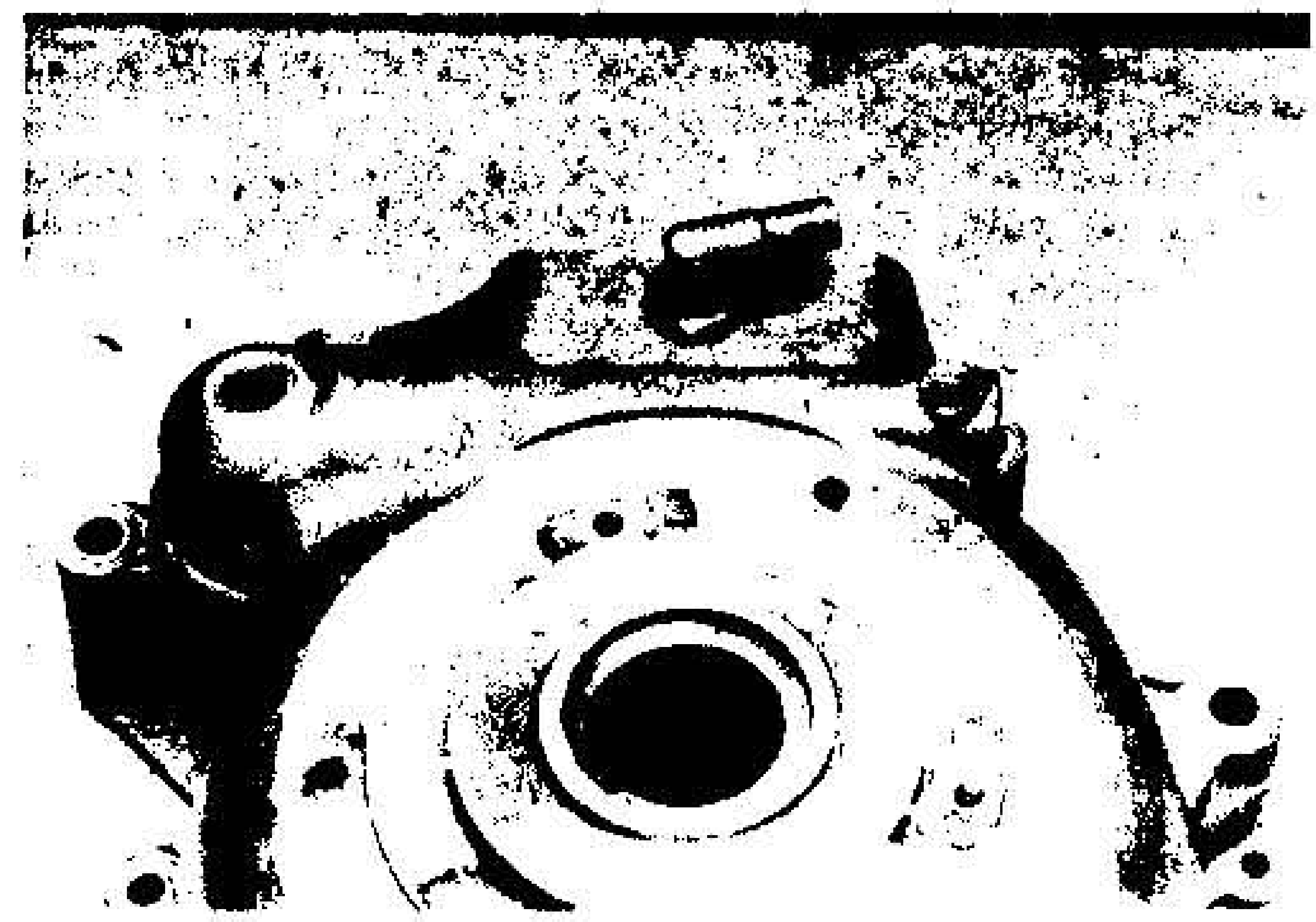


Fig. 34. Alternative Breather Position.

VALVE TIMING

When fitting the special street cam in place of the standard item, no special timing is necessary. As long as chain and sprocket positions are maintained, the street cam will simply replace the standard unit.

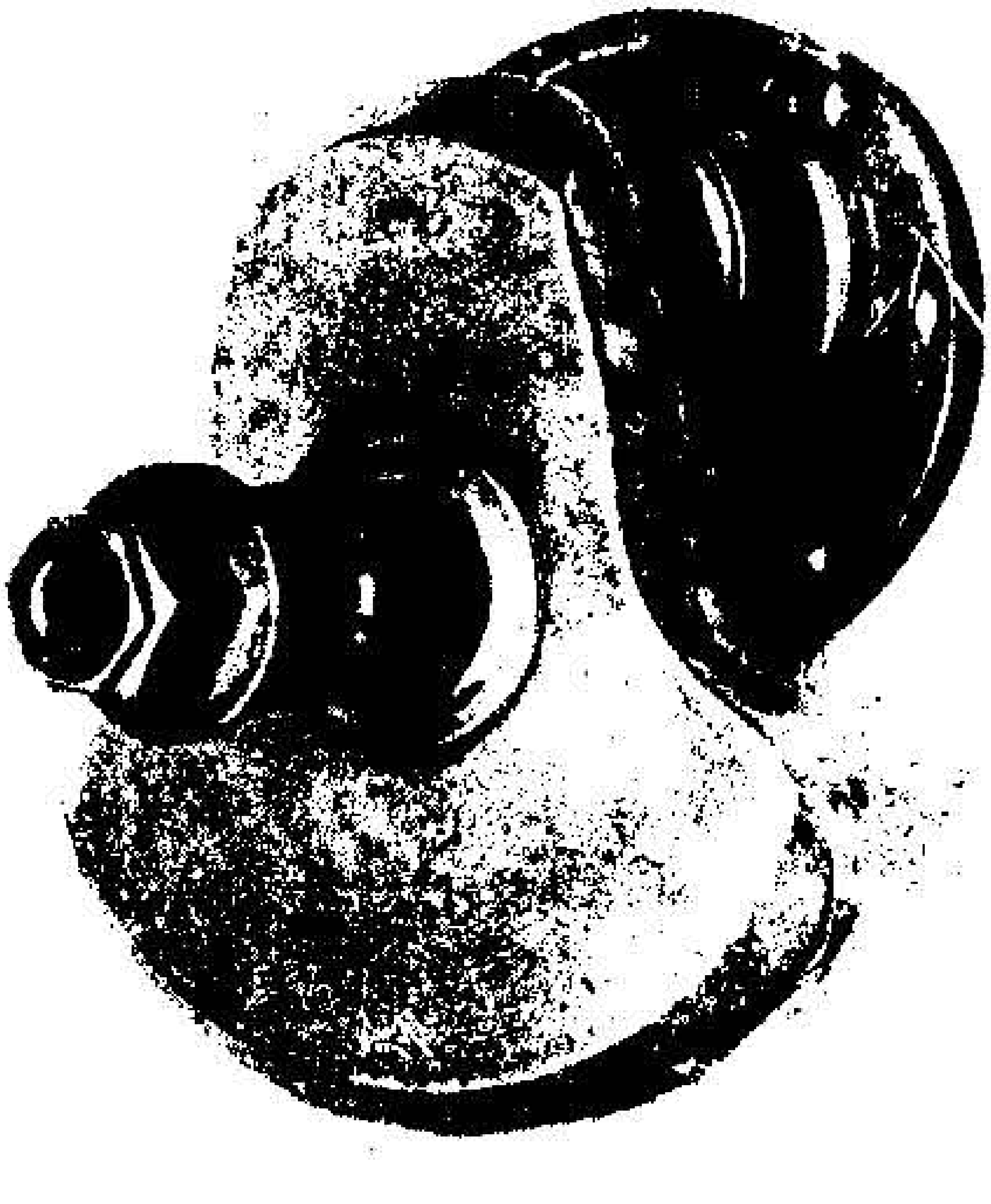


Fig. 35 Flapper Valve Breather Fitted in Mainshaft.

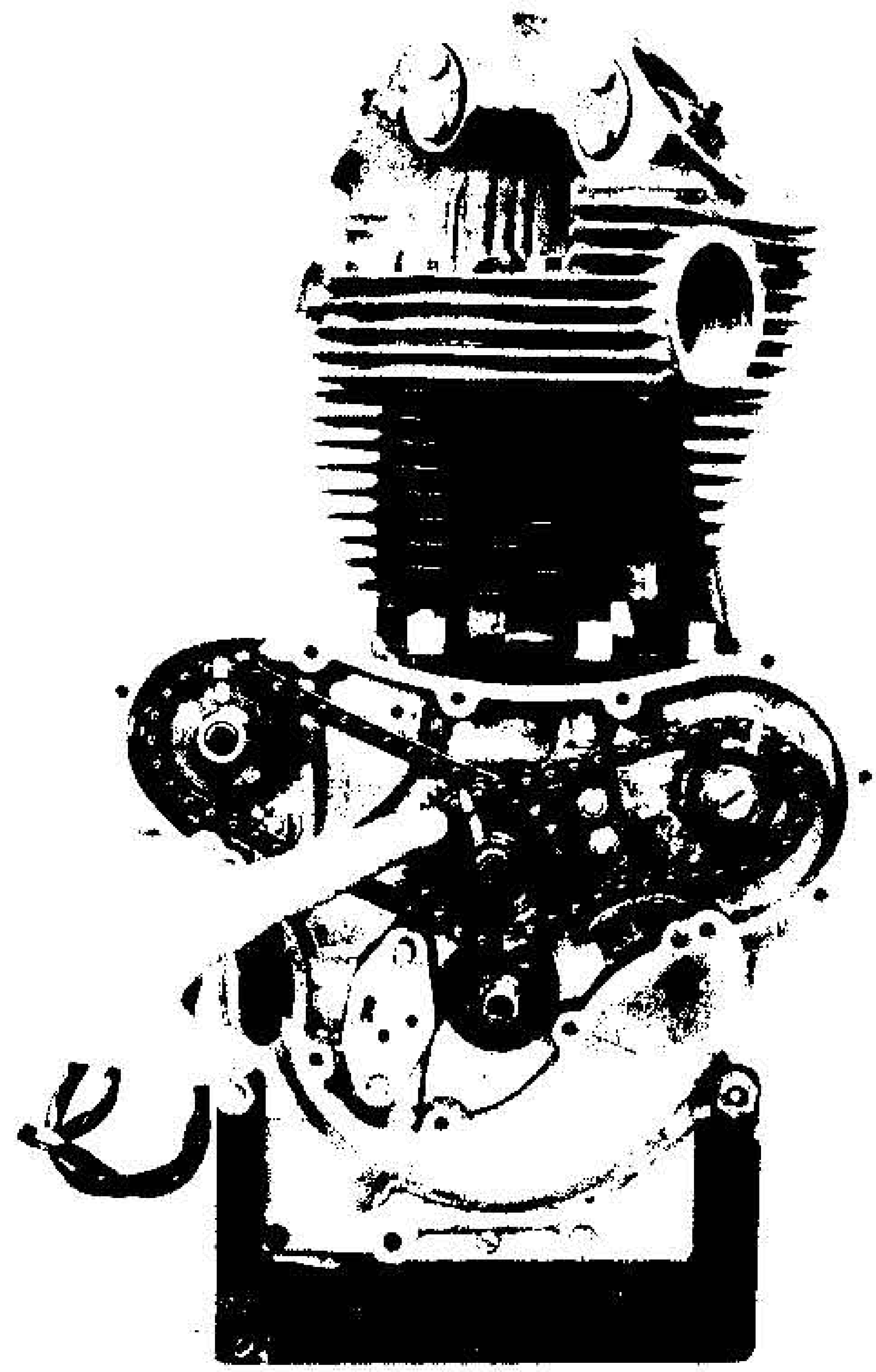


Fig. 30 Mark Timing Chains and Sprockets prior to stripping

However, should the camshaft be removed or the engine dismantled without holding the existing timing, the timing can be set simply with the use of the timing punch dots marked on the half-time pinion, the intermediate combined pinion and sprocket and the camshaft sprocket.

The dots on the half-time pinion and idler should be lined up. Now the dot on the intermediate sprocket is uppermost. Fit the timing chain and cam sprocket so that there are 10 chain pins between the two dots.

This procedure will give sufficiently accurate valve timing when using the standard or street cam but for the racing cam there is no short cut and the job must be done with timing disc and vernier sprocket on the camshaft.

Set up the timing disc and pointer as in picture 36. The tappets should be set to .008 inch on inlet and .010 inch exhaust.

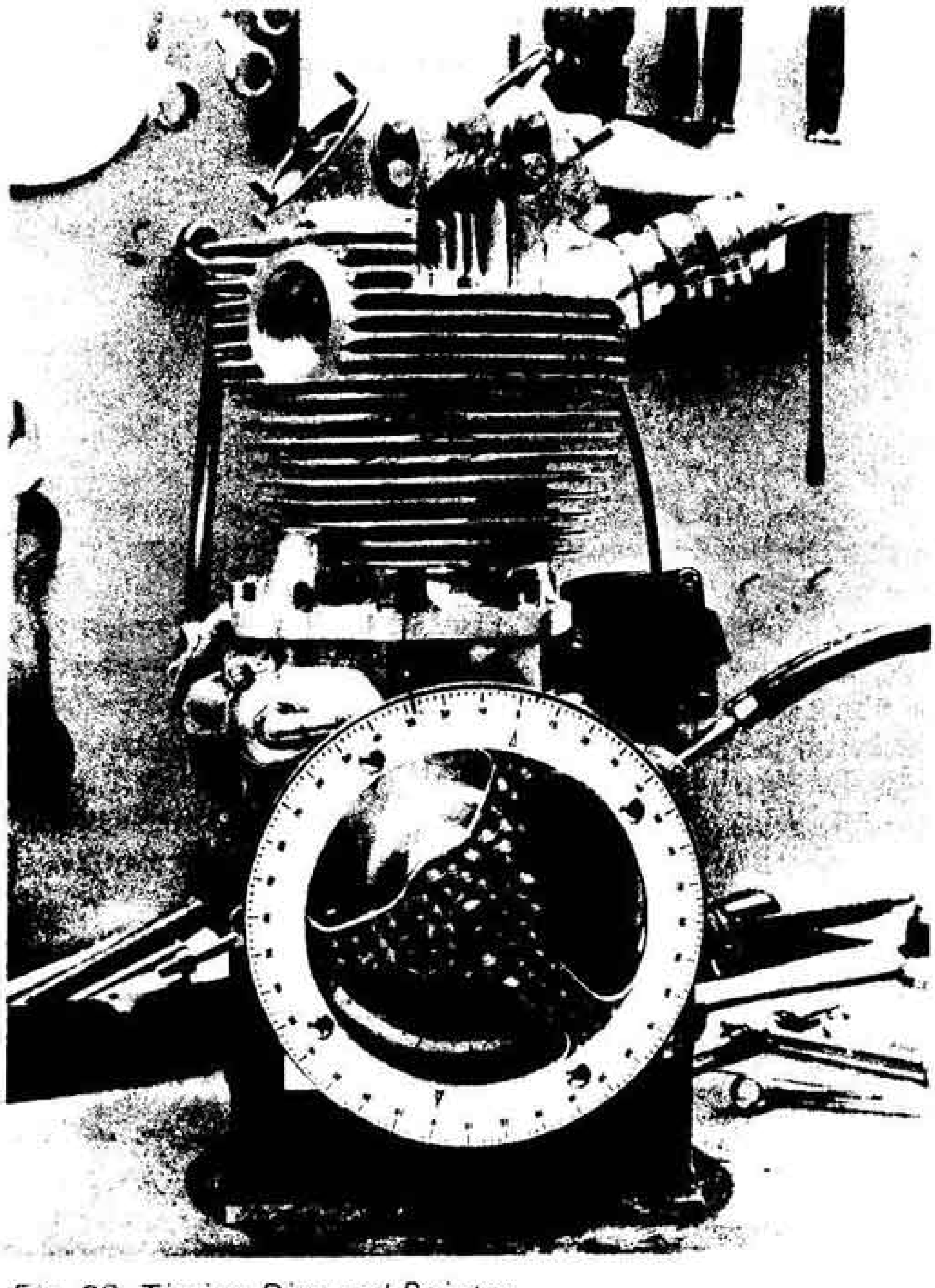


Fig. 36. Timing Disc and Pointer.

With the vernier sprocket carrier fitted to the shaft, set the engine at tdc, turn the camshaft independantly until .215 inch lift is achieved using a dial gauge on one of the inlet valves. Then fit the pin retainer and plate into the pair of holes that align.

Check the timing to see that it measures up to the figures mentioned earlier. It must be pointed out that it is unlikely that you will achieve the exact figures quoted. This is because many small things effect the valve timing, including tappet wear, tight and slack spots in the chain and altering mechanical advantages as the rocker attitude changes. For this reason it is important with the racing cam to concentrate more on achieving .215 inch to .220 inch lift at tdc on the inlet valve.

Fig. 37. Vernier Camshaft Sprocket.

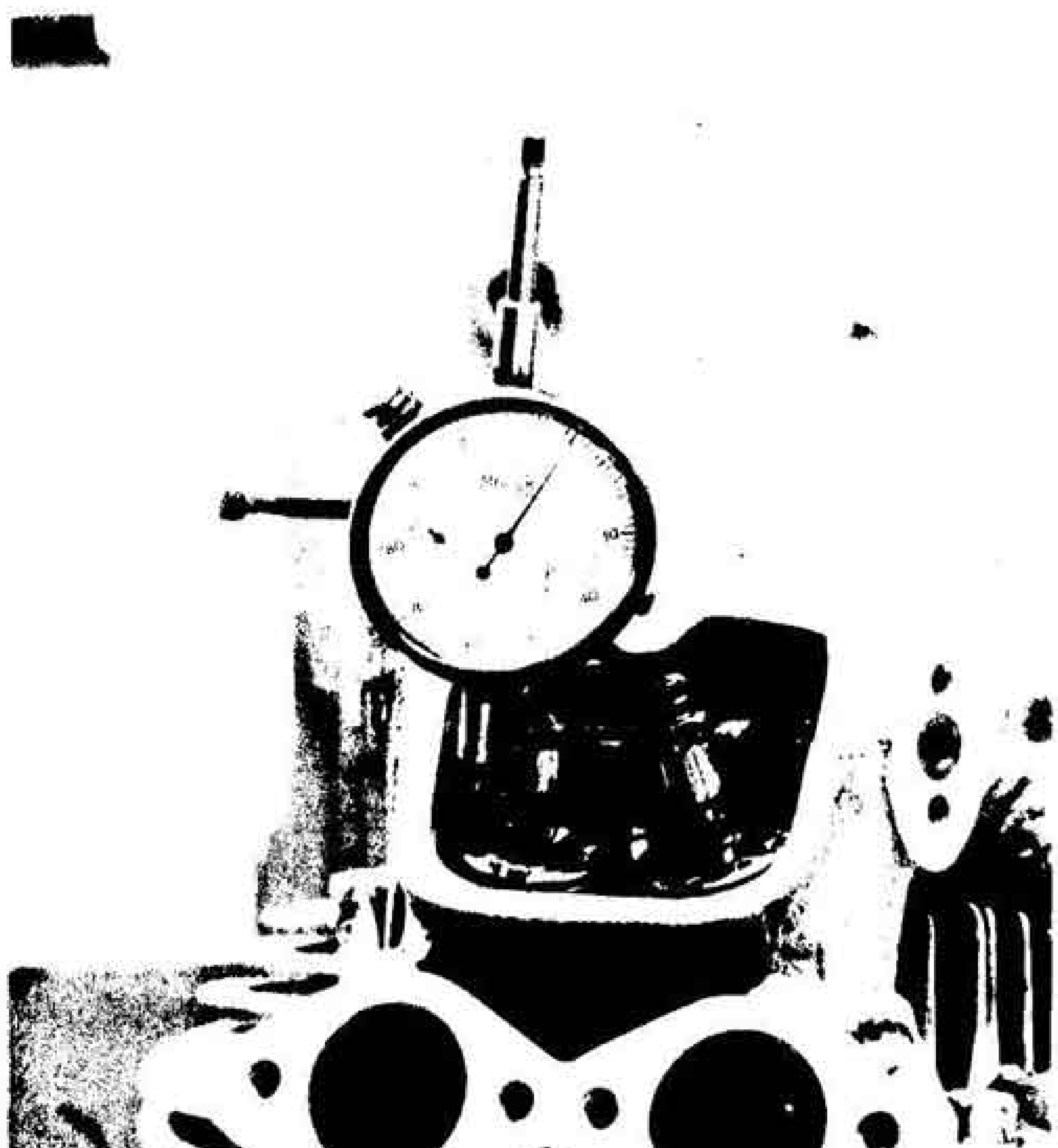


Fig. 38. Setting Valve Lift At T.D.C.

When assembling the timing side of the engine note that the oil pump worm drive nut has a left-hand thread and, when fitting the oil pump nuts, tighten them down together – not one at a time – to a torque setting of 180 inch pounds.

When adjusting the tension of the cam and ignition chain, difficulty may be experienced because the intermediate pinion shaft is not supported on the outside.

Anyone who will regularly strip down these engines will find that a cut-away timing cover – allowing access to the adjuster and sprocket nuts is desirable.

This cover can easily be made from an old cover cut away as shown in picture 39.

The chain should be adjusted by raising the sliding slipper until there is 3/16 inch slack in the chain at the centre of its top run.

Slack on the timing chain should be the same amount and is adjusted by moving the magneto or distributor (depending on the ignition system in use on the particular engine).

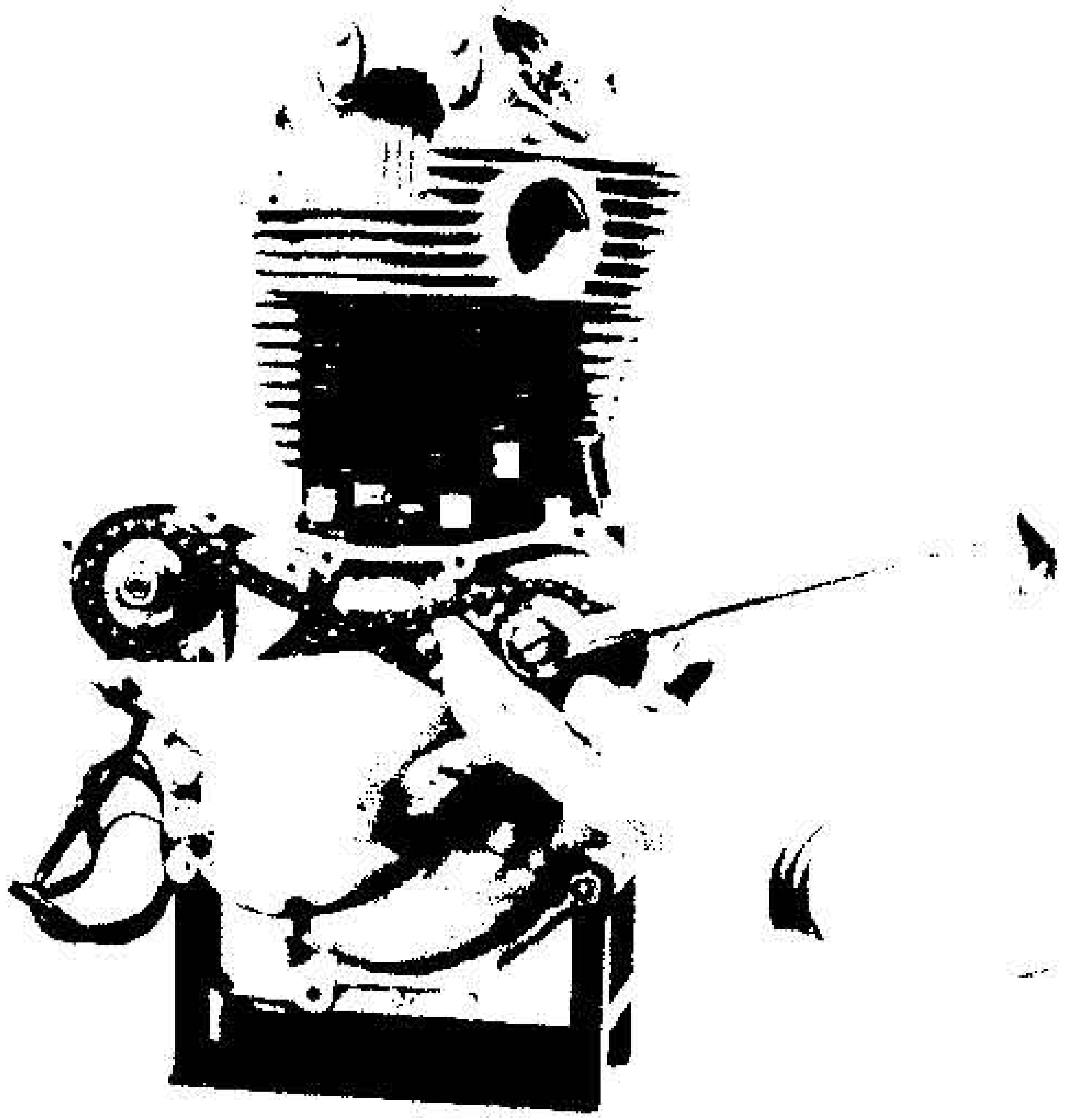


Fig. 39. Adjusting Timing Chains.

With the racing cam, valve springs must be accurately set to be .045" from the coil bound position at full lift. To set the springs at this factor the valve and spring should be assembled in the head with the tappet adjustment at the correct running setting. Now the camshaft should be turned until the valve is in the fully open position. A dial gauge set with the indicator arm of the gauge on the valve will show the fully open position.

The scheme is now to measure, with the aid of the dial gauge, how much further the valve can be opened before the spring closes and becomes coil bound. To achieve this the rocker shaft must be forced downwards at the valve end. This is best done, using great care, with a lever as shown in photograph 40. The amount of movement can be read off the dial gauge which is normally calibrated in thousands of an inch but, on occasions, in tenths of thousands.

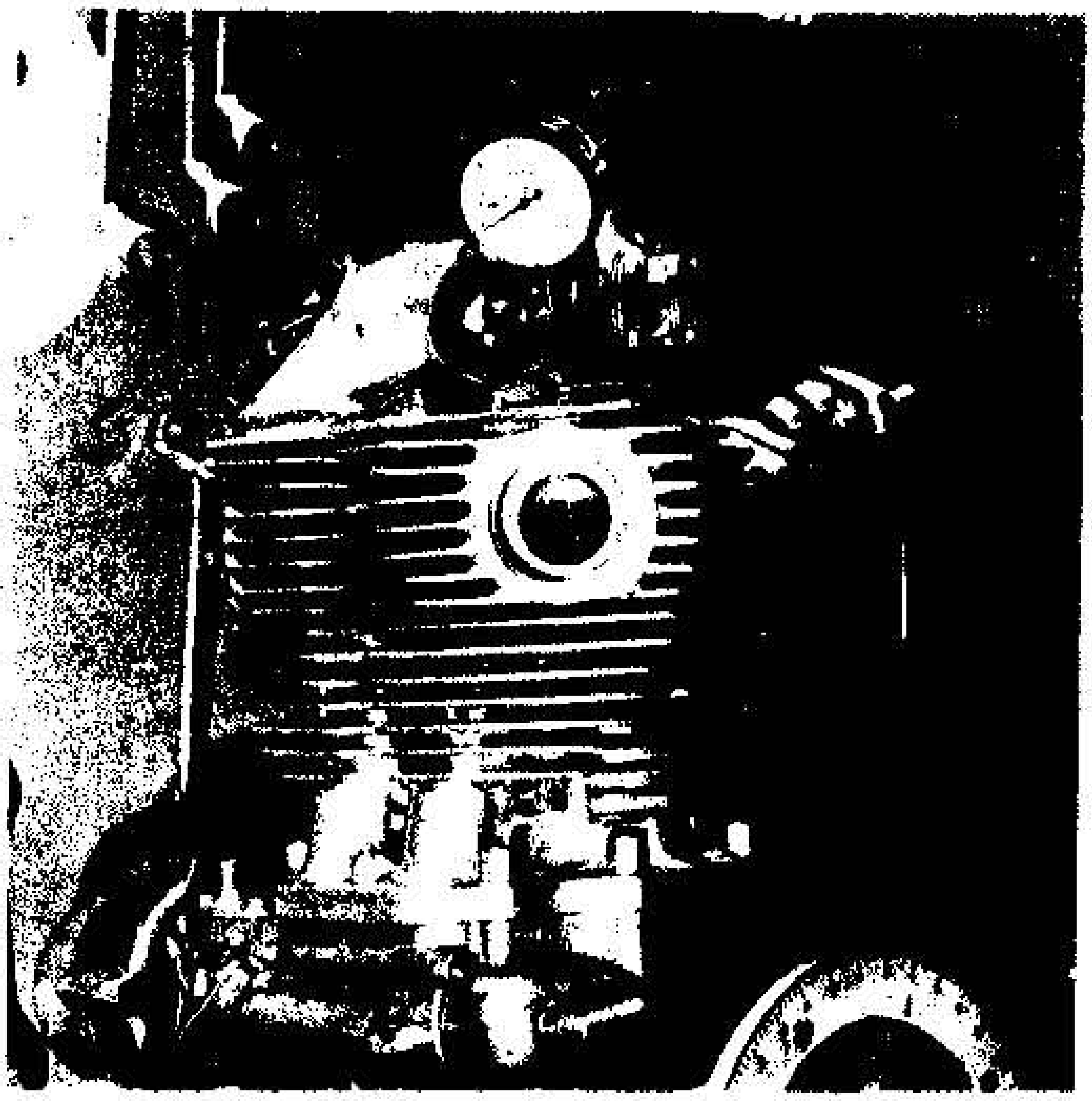


Fig. 40. Use a Dial Guage to Find Peak Lift.

The free motion of the valve before the spring becomes coil bound should be restricted to .045 inch. To do this the springs should be packed out between the bottom retaining collar and the cylinder head with steel shim washers.

Find the thickness of washer needed by subtracting .045 inch from the free motion period measured earlier with the dial gauge.

Although valve springs may settle down with heat and use, the shim once fitted need not be changed as the setting is not altered. As the only thing that affects the shim thickness is the lift of the cam shaft, the length of the valve and the number of coils and gauge of wire used for the springs, the only time that the shim requirements need be re-measured is when any of the above items is changed or the valve is ground further into its seat.

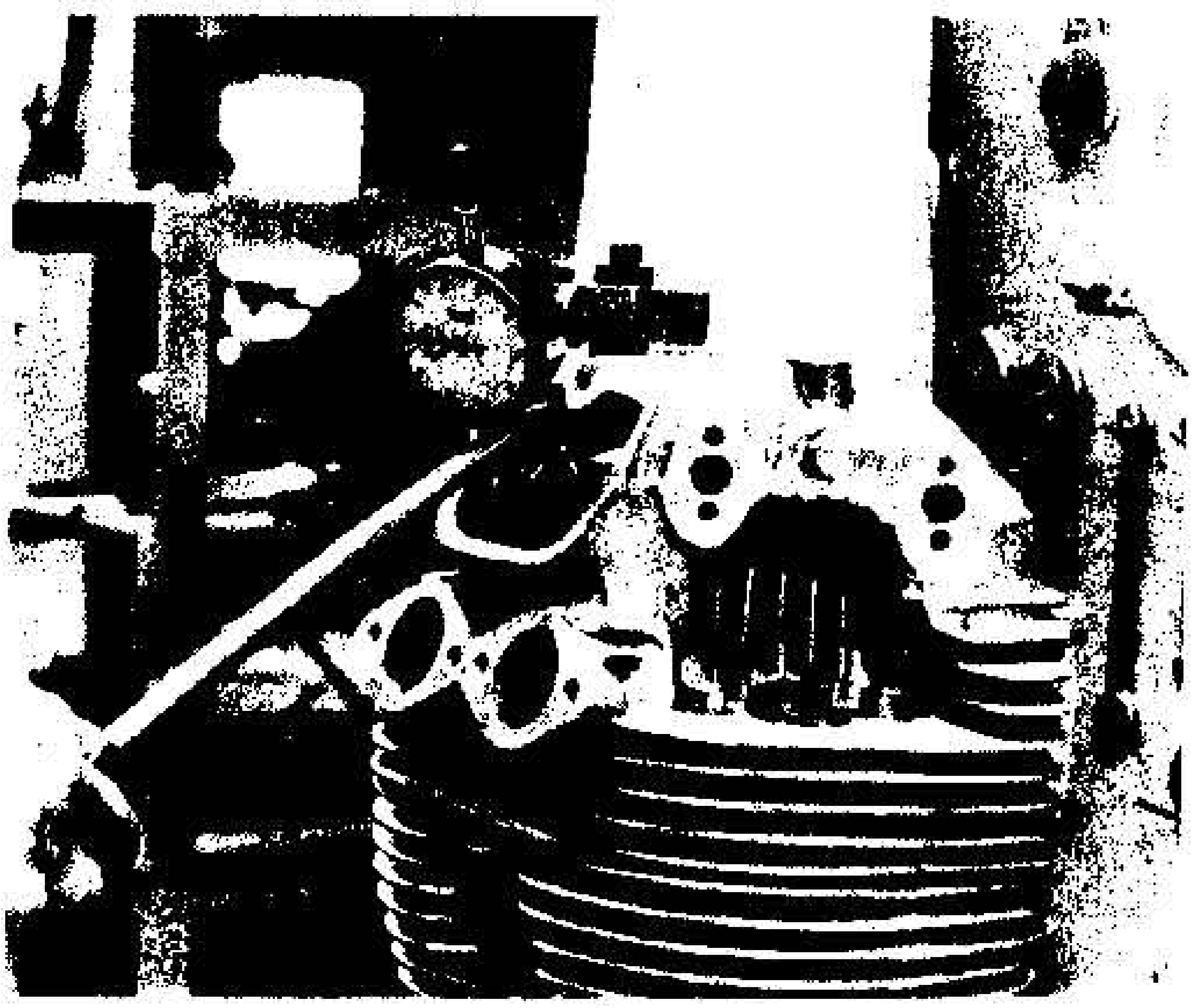


Fig. 41. Measuring Clearance from Coilbound.

CAMSHAFT DESIGN

To the uninitiated, valve timings given by current camshafts are odd in that it would appear that the inlet valve opens too early and closes far too late.

At the first glance the obvious valve timing would be for all inlet valves to open when the piston was at top dead centre about to descend on the induction stroke. By the same reasoning, the valve should close when the piston reaches bottom dead centre and the suction motion is over.

But the above discounts the inertia of the inlet charge and the fact that the valve opens gradually. Time elapses between the piston's sucking motion and the actual movement of the gasses in the induction tract. Therefore, the valve is moved early so that it is in the fully open position as early as possible during the piston's downward stroke.

When the piston reaches the bottom of its strokes it stops momentarily before it changes direction. But the gases weeping into the cylinder do not come to a similar abrupt halt and their inertia continues moving them into the cylinder. The petrol-air mixture will, in fact, continue to charge the cylinder whilst the piston is commencing its upward stroke.

Therefore, it is obviously advisable to leave the valve open until such time as the forces generated by the rising piston match those of the incoming charge.

By the same reasoning, the exhaust valve is opened before the finish of the combustion down stroke of the piston and remains open through the exhaust stroke and into the induction stroke. This part of the engine cycle when both valves are open together is known as the overlap period.

The dangers of this overlap period are obvious: that there may be a reversal of flow and that the exhaust charge may be carried back into the combustion chamber and contaminate the fresh charge or that, if the inlet valve is opening very early, the inlet charge will have to battle against the pressure of the exhaust gases still in the cylinder.

But these conditions are most likely to manifest themselves at small throttle openings. Once the engine revs rise above a certain point the disadvantages become less and less and designers of racing machinery, which does not have to run at tick-over and slow throttle openings, can make more use of exaggerated overlap than can a man building a cam which has to be a compromise for high-speed touring and town traffic work.

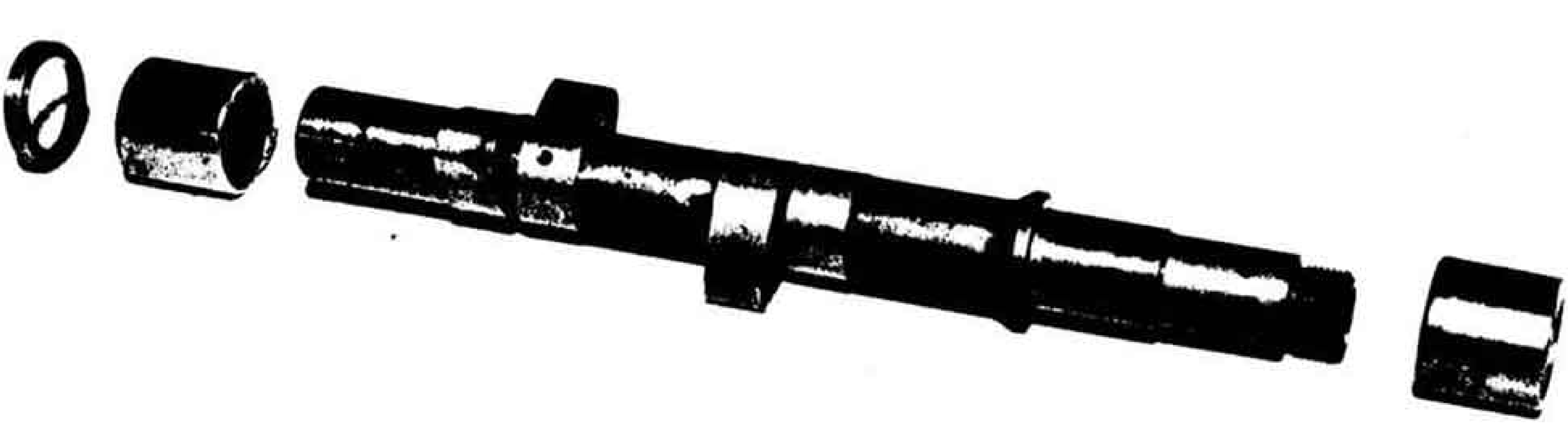
The cam designer has other desisions to make at the same time.

He must, always bear in mind the use to which his camshaft will be put, not only decide the overlap but the total opening period of each valve, the period for which the cam will hold the valve wide open, the actual amount of lift and the provision of quietening ramps.

The degree of lift given to a valve by the camshaft can only be measured at the valve itself – not necessarily at the cam. It is certainly possible, with the cam fixed, between the centres of a lathe for example, to use a dial gauge to measure the difference in heights between the base circle and the top of the cam lobe.

But this measurement is not necessarily the actual lift of the valve for the cam lift must go through the rocker before being transmitted to the valve stem. Since the distances between the push rod and valve ends of the rocker to the spindle are not equal, the cam lift is exaggerated by the rocker ratios – 1.1 exhaust and 1.13 to 1 for the inlet – as the valves lift.

Actual lift should be measured with a dial gauge against the top of the valve spring cap.



Racing Camshaft with needle roller bearings and oil seal.

LUBRICATION SYSTEM

The oil pump fitted to current Norton twins is one of the best in the business. It is driven via a skew gear from the crankshaft and passes oil at 45 to 60 psi at normal running temperatures.

The pump employs gears which have a long life span unless foreign matter is accidentally introduced into the lubricant.

Dismantling the pump is unnecessary unless harshness is felt when spinning the pump by hand.

Dismantling for cleaning and rebuilding the pump is straightforward. It should, however, be noted that the radius on the oil scavenge gear should face towards the inside of the pump body.

Identification of the delivery and scavenge (return) gears is simple. In order to avoid an excess of oil forming in the crankcase, scavenge gears are always of greater capacity (and therefore larger) than the delivery ones.

The easiest check for wear in the oil pump is to try to feel end float or rock in the spindle. There should be neither.

Two types of skew drive gears have been fitted. Early engines had a three-start gear. Six start versions were later produced as special parts doubling the pump rate. The six start gears are now standard.

For fast road work and racing, the six-start gears are essential.

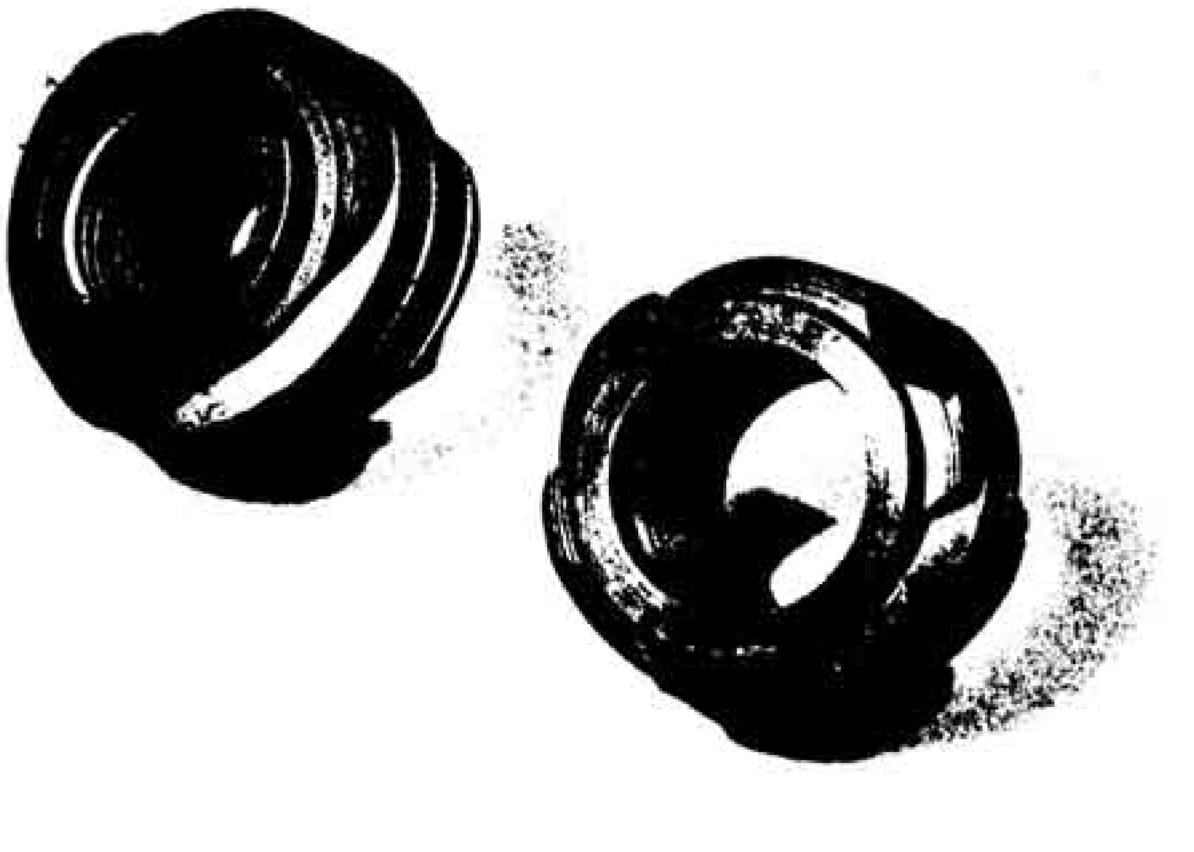


Fig. 42. S Start & 6 Start Pump Drive Gears.

Before 1963 the Norton pump had small gears which were increased in size that year for the S type pumps. The later pumps are outwardly identical to the earlier versions and can be fitted to pre-1963 engines without modifications.

This later pump is ideal for road use but for racing where revs rarely drop below 5,000 rpm the earlier type – with suitable modifications – is the better unit.

Excessive oil lying in the crankcase does no useful job and, in fact, robs the engine of power because of the drag it causes to the crankshaft.

To ensure that there is no excessive lubricant, an even greater scavenge-to-feed ratio in the pump gears is desirable.

This is achieved by using the old type pump with its existing small feed gear sizes. The pump is then machined out on the scavenge side to allow the later, larger return gears to be fitted.

With this arrangement, the pump action will equal the pressure release valve at 4,500 rpm.

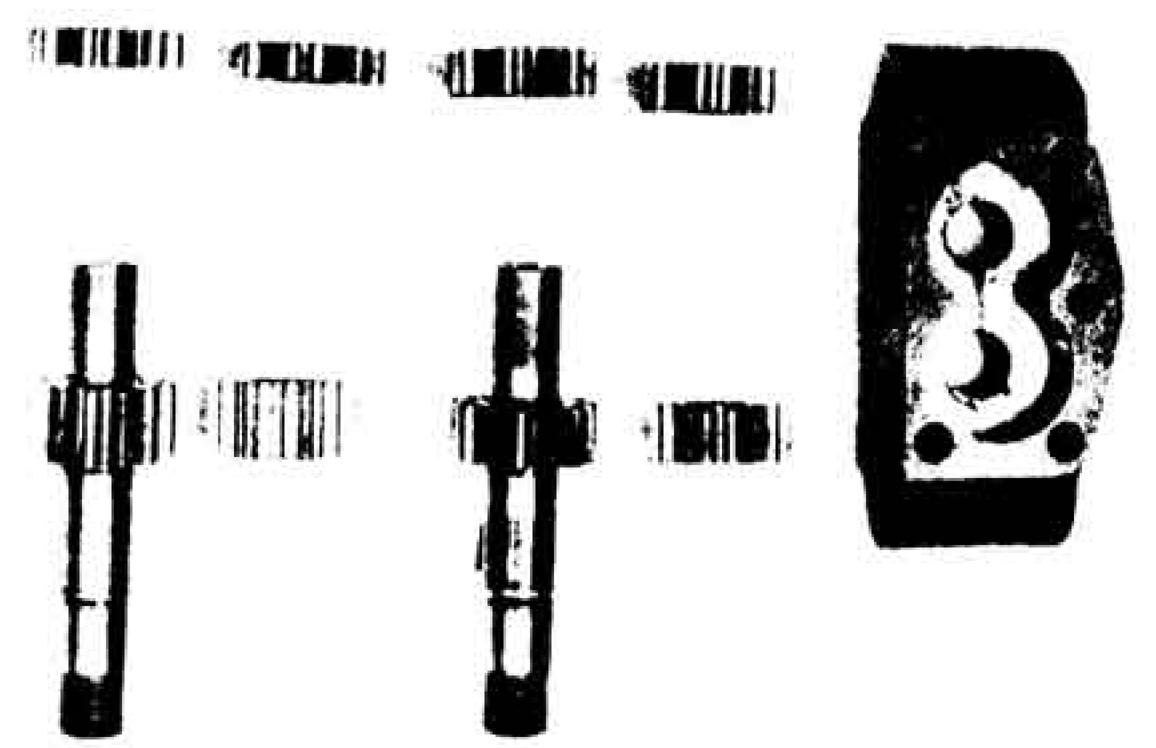


Fig. 43. Comparison of Pump Gear Widths.

The release valve is preset at the factory by the use of shims and a spring and should need no routine maintenance.

Two oil filters are fitted to Norton machines, one at the oil tank and another in the sump drain plug.

The sump filter gauze is held in place by a wire circlip which, under extreme conditions can work loose and cause a nasty mess in the bottom of the engine.

To prevent this, it is advisable to solder the circlip in position. This does not present any future problems as the solder can be removed by gentle heat when it is necessary to remove the circlip.

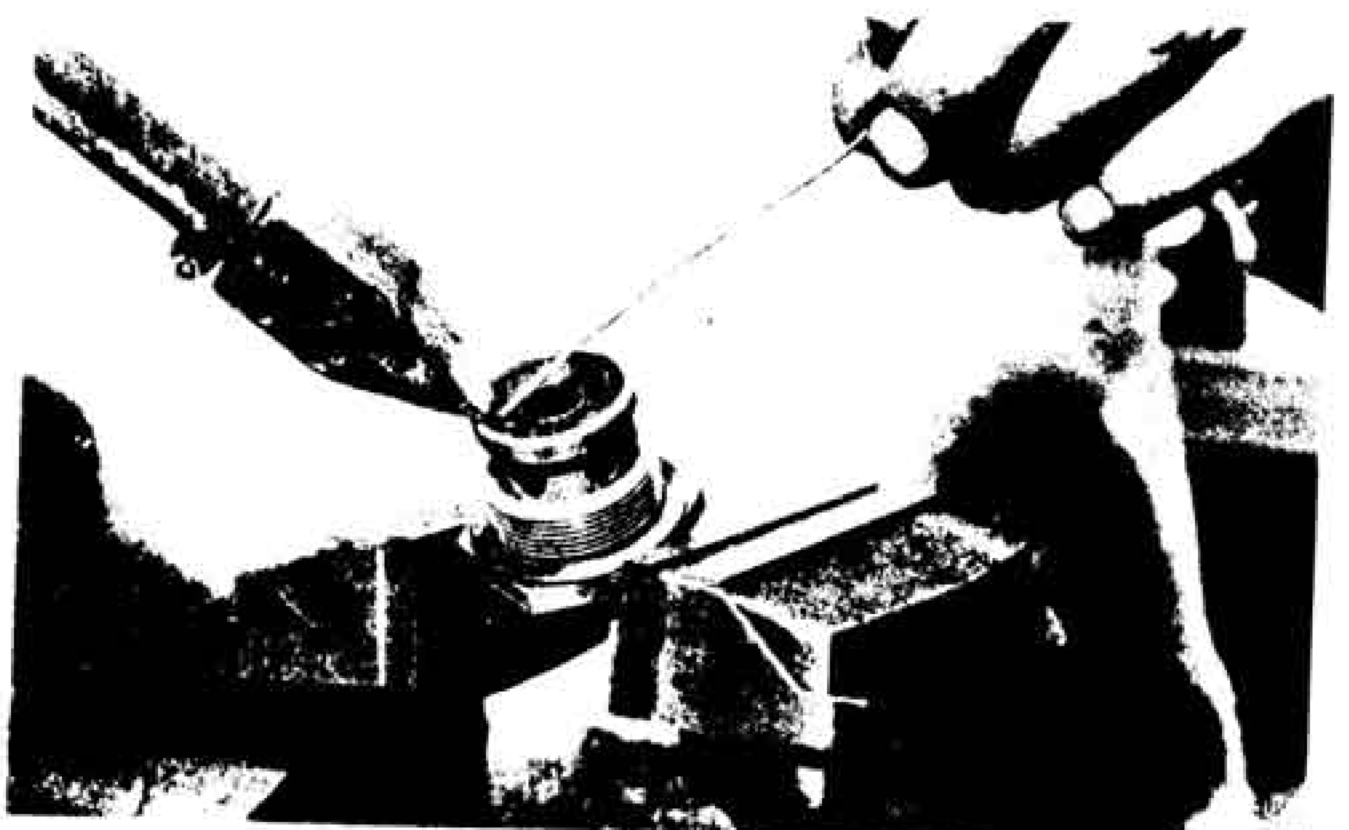


Fig. 44. Soldering Circlip into Sump Filter.

CHOICE OF OIL

Use a good quality mineral oil of SAE 40 grade for the engine, primary chaincase and gearbox for road use.

There is no doubt that for racing purposes a vegetable-based "R" racing oil has definite advantages over mineral oil for road use, mineral oil comes out best every time.

For summer use Castrol R40 grade is the best for racing but for the occasional winter meeting, a change to R30 will cut down the warming up period and get the lubricant around the engine quicker.

Mineral oils on street machines should be changed every 2,500 miles. On racing machines the frequency of oil changes must obviously be much greater.

The crankcase oil filter should be cleaned each time the engine oil is changed.

Rocker oil feed kits are available, replacing the rigid copper pipes with flexible plastic pipes having far greater resistance to cracking and weeping.

IGNITION

Norton twin engines have had their fair share of different ignition systems. Early models featured a magneto with a separate dynamo for lighting. Then coil ignition became standard on all machines. When the 650 SS was introduced in 1962 a Lucas magneto was reintroduced.

The factory continued using magnetos for the sports models until late 1966 when an AC generator and coil ignition was once again fitted.

Whatever the type of ignition system used, the timing of the spark is critical.

For accurate ignition timing, the use of a degree disc is all important. It is not possible to properly time an engine by dropping a marked rod down the sparking plug hole, hoping to find top-dead-centre and then turn the engine over until the piston is positioned so many fractions of an inch before tdc.

The ignition timing settings shown below are matched to the compression ratios of available pistons. Engine modifications other than changing the compression ratio should not necessitate any deviation from these figures.

Compression ratio	Ignition advance
7.4 to 1	31
8.9 to 1	29
10 to 1	28
10.5 to 1	27-28

The settings given are for ignition fully advanced. For setting timing with the engine stationary, the advance/retard unit must be held in the fully advanced position.

Fig. 46. Timing Disc in Use.

Fig. 47. Connecting a Timing Light.

MOUNTING THE TIMING DISC

Timing discs, graduated in degrees, are available from many sources. The disc should have a 5/8 inch hole in its centre and should be mounted securely on the engine drive-side mainshaft.

A pointer is best made from a piece of wire trapped under a cylinder base nut and washer and bent over the timing disc.

Locate top-dead-centre on the compression stroke roughly and set the pointer to 0° on the timing disc. Turn the engine clockwise and, using a graduated probe – a 6 inch length of 1/16 inch welding rod with file markings is ideal – through the sparking plug hole, lower the piston to the graduation mark. Note the amount of movement of the degree disc. Return the engine to 0° on the disc and turn the crankshaft anti-clockwise, again until the graduated line.

Check the timing disc. The movement in degrees should be identical to the clockwise rotation. If it is not, adjust the position of the pointer on the degree disc. Recheck until the same reading is given either side of top-dead-centre.

The engine is now ready for ignition timing.

SETTING IGNITION TIMING

Check that contact breaker points are clean and free from pitting and set the gap to .015 in on all models.

Rotate engine backwards from top-dead-centre and then forwards again until the number of degrees before tdc is shown against the pointer and the timing disc. The points assembly should now be adjusted until the contacts are about to open.

Attaching a battery-powered bulb across the points – on magnetos remember to remove the centre bolt, the points-assembly taper is sufficient to hold the unit for timing purposes – rotate the cam in a forwards direction until the light just flickers off.

Because of manufacturing tolerances it is quite possible that, although the timing has been correctly set up on one cylinder, it will be found to be wrong on the other.

With magneto ignition models, there is little that can be done other than to split the difference between the two cylinders.

Rotate the engine forwards and note the position of the spark on each cylinder. If the required 29° is set on the offside cylinder and the nearside shows a spark at 31°, it is better to reset the ignition to achieve 28° and 30°.

On early (pre-1969) coil ignition models, the ignition timing can be set in a similar manner but the balance between the two cylinders can be adjusted by slight alteration in the points gap.

In 1969 with the introduction of the Lucas type 6CA points assembly it became possible to set the timing on each cylinder accurately and still maintain the correct points gap on both sets of contact breakers.

The 6CA provides individual spark position adjustment but for large degrees of adjustment, the complete points assembly may be swivelled in its housing.

When setting the points gap on 6CA units, position the nylon points heels against the datum line on the cam.

Timing on Commando and late Atlas engines can be more accurately set with the aid of a stroboscope and what is, in effect, a built-in timing disc.

A line marking on the alternator rotor registers with a degree marking seen through the inspection cover of the primary chaincase. To time engines equipped with the rotor marking follow the same ~~engines equiped with the rotor marking follow the same~~ procedure with the bulb and battery.

For stroboscopic timing, the lamp should be connected to the machine as specified by the manufacturer of the light unit–various lamps have different electrical connections.

To ensure that the ignition is fully advanced, run the engine at 2,000 rpm and check the rotor timing mark against the chaincase housing calibrations.

If a large amount of adjustment is necessary, rotate the entire points assembly. Ideally the first cylinder should be set with the individual points adjustment in its mid position.

Once one cylinder is set, the setting for the other cylinder should be set and adjusted if necessary. When adjusting the second cylinder, only the individual points adjustment should be used. Do not move the points backplate or the setting for the first cylinder will be lost.

To avoid frustration resulting from timing the incorrect set of points for an individual cylinder, note that on coil ignition models the left contact breaker set in the distributor, to which a yellow and black wire is attached as standard, provides the ignition circuit for the drive-side cylinder.

SPARKING PLUGS

Our experience shows that the best sparking plug for road use is either the Champion N6OY or N6Y. For racing the Champion N.54.R is recommended.

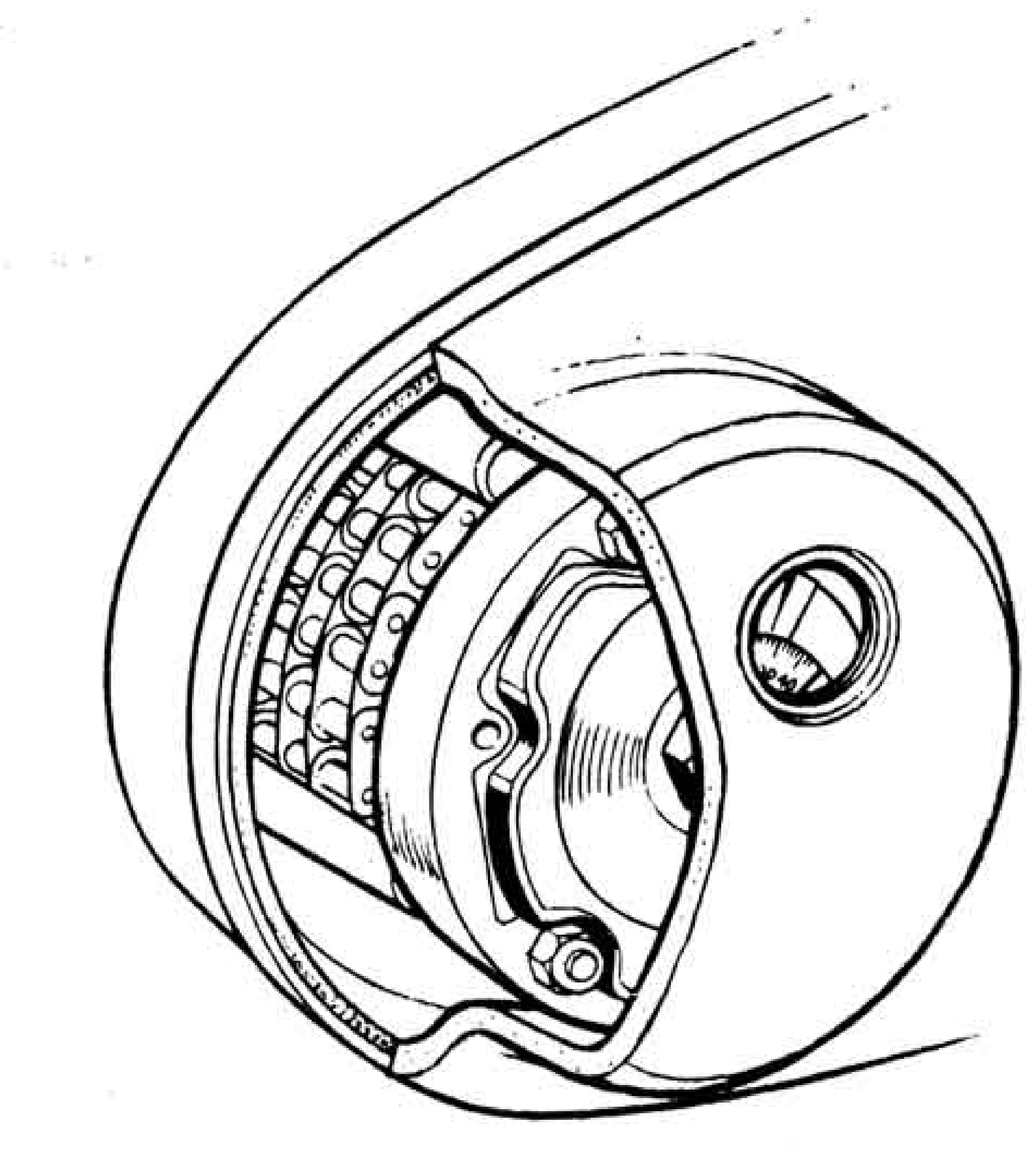


Fig. 48. Strobe Timing Marks on Commando.

CARBURATION

The latest Amal concentric carburetters can be fitted to all 650 and 750 cc engines which were originally supplied with the earlier Monobloc instruments.

Although individual machines may call for slightly different settings, the following are recommended as a basis for carburetter tuning.

750 cc

Amal 932 carburetter with a 107 needle jet and number 3 cut-away slide.

The main jet only is affected by the compression ratio and exhaust system used. With 10 to 1 or 10.5 to 1 pistons and silencers the main jets should be 270 or 280. For the same piston choice but megaphones, the jet sizes will need to be increased to 300 or 310.

Standard, low compression ratio, silencer-equipped models require 930 carburetters with a 220 main jet and a 106 needle jet.

650 cc

The concentric Amal best suited to the 650 cc engines is the 930 version.

Settings for high compression engines are as for the 750 cc unit but with 230 or 240 main jets where silencers are fitted and 270 or 280 jets for megaphone equipped machines.

Standard, low compression engines need 200 to 210.

Just as important as correct settings are the induction tract lengths. For road use, the spacers between the cylinder head flange and the carburetter should be 1½ inches long.

In racing greater emphasis must be placed on preventing any engine vibration affecting float bowl levels and therefore upsetting carburation—a too weak mixture can rapidly lead to disastrous engine trouble and over rich running is simply pouring power, and petrol down the drain. Fortunately, the race cam needs a longer induction manifold which gives us the chance to use flexible induction pipes 3 inches long to isolate each carhuretter from the cylinder head.

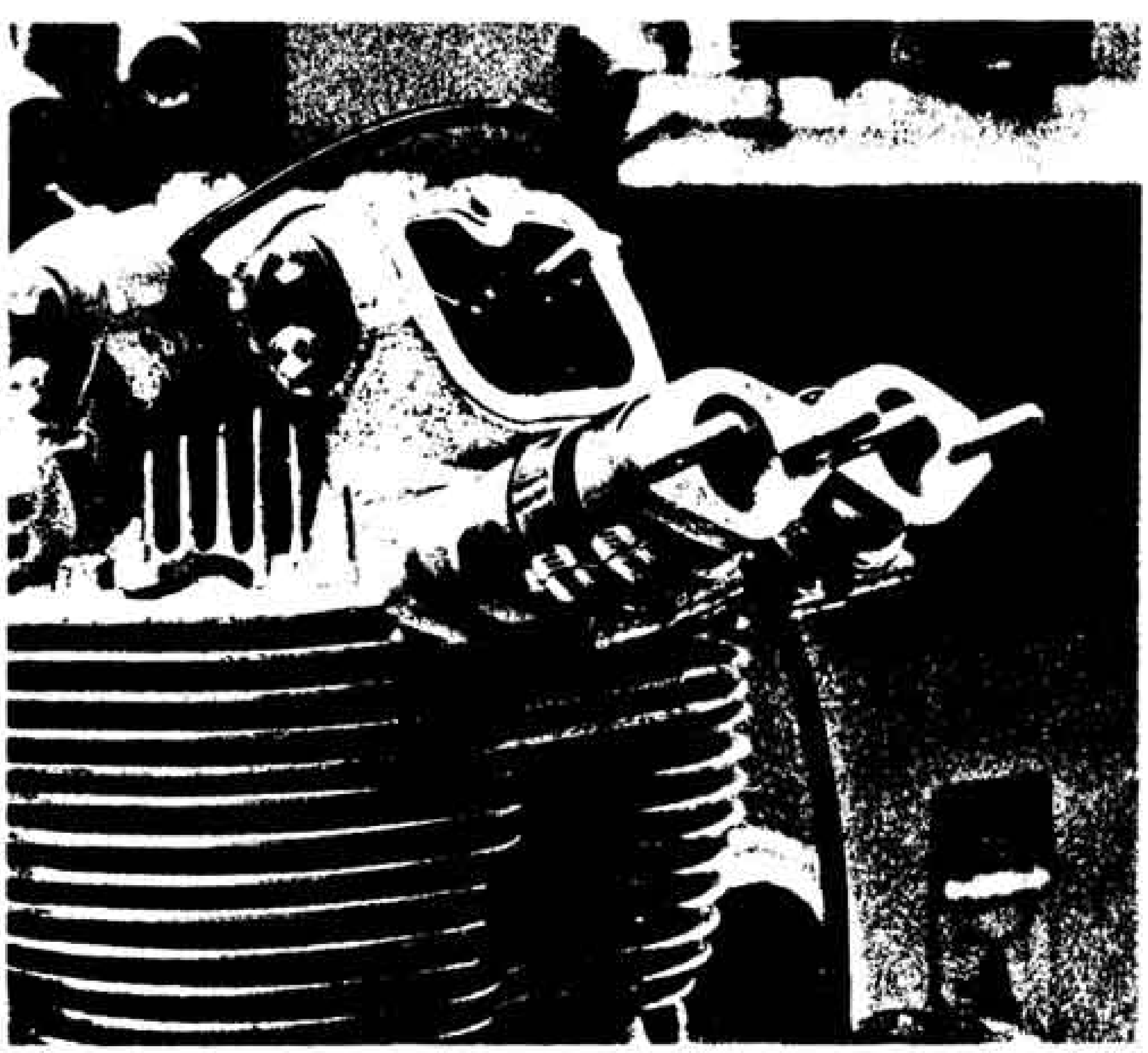


Fig. 50. Flexible Induction Manifolds.

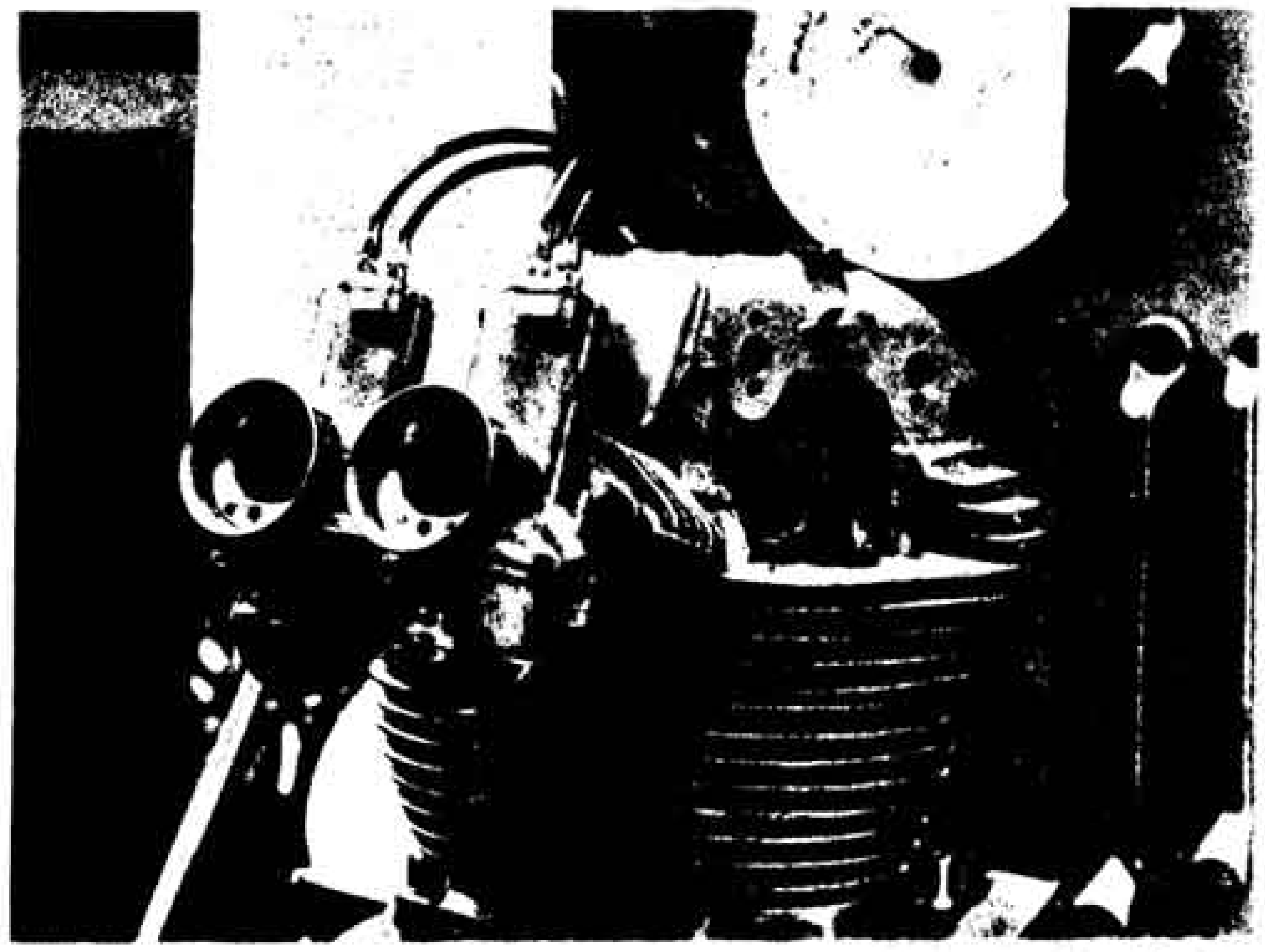


Fig. 49. Amal 32 mm Carburettors on 1½ inch Manifolds.

Although long bell mouths may add to the racy look of a machine they do not, in my experience, add any performance where concentric carburetters are used.

Any theoretical ram effect is more than cancelled out by the fact that long bell mouths obscure the atmosphere compensation hole and, therefore, reduce the pressure difference between the induction tract and the float chamber.

SETTING UP TWIN CARBURETTERS

Twin carburetters certainly give a power advantage over a single unit on a twin-cylinder machine—but only if they are correctly adjusted.

Both combustion chambers should be identical and therefore each requires an identical charge of fuel air mixture to work at maximum efficiency. With poorly set carburetters, one piston in an engine is all too often acting as a passenger and being dragged along by its companion.

Always ensure before starting to adjust carburetters that cable runs are smooth. Re-running a cable after a carburetter has been set up can easily throw out the adjustment.

There are several ways of going about synchronising twin carburetters. The following is the system I use and gives perfect results if the tuner takes reasonable care:

Remove air filters if fitted

Fully unscrew both throttle stop screws

Release all adjustment in the throttle cables

Taking one carburetter at a time, reduce the free play in each cable until the slightest movement of the throttle begins to lift the slides.

To adjust the throttle stop screws, the engine must be started and the screws raised until the engine ticks over smoothly. By removing one sparking plug lead at a time, individual tick over can be checked and any necessary adjustment of the pilot air screw carried out.

Apart from regular checking for adjustment, concentric carburetters need little maintenance but be careful not to over tighten the mounting flange or float-bowl screws as this can lead to distortion. Each time the carburetter is removed check the O ring in the flange face. This ring should not have any form of gasket cement applied to it. In good condition it provides an ideal seal on its own.

For racing, the air slide, spring cable and lever are not used. If the slide is removed, blank over the cable hole in the mixing chamber top.

Main jets are interchangeable between concentric and earlier Monoblock carburetters.

EXHAUST SYSTEMS

Designing efficient exhaust systems is often as much as a result of suck-it-and-see experience as drawing board technology.

I have carried out much experimental work on silencers and exhaust systems, trying each new idea and modification on the road and track in an effort to come up with the system which gives most usable power bearing in mind that, for road use, legalities must be observed.

An ill-chosen exhaust system can rob a machine of all the extra brake horse power put into it by careful and intelligent assembly and tuning.

What is more, the correct system will give a power boost. And you're getting something for nothing. Not only does a well matched system release more horses, it gives the engine an easier time into the bargain and invariably improves fuel consumption.

ROAD USE

By far the best system for fast road work is separate exhausts joined by a balance pipe, up close to the cylinders.

The pipe diameter should reduce in diameter from 1⅝ inch to 1½ inch immediately after the balance pipe. Correct overall pipe length is 30 inch. Any variation in length is very unlikely to result in a performance gain—in fact the reverse is true.

Our absorbtion-type Decibel silencers cut down the noise decibel rate to an acceptable level and do not rob the engine of power.

My experiments prove that the above system actually gives more brake horsepower than a racing megaphone set up at 5,500 rpm. Of course, as the revs go up, the megaphone-system comes into its own and at 7,000 rpm realised 2 to 3 bhp more power. But at 5,500 we actually show a 5.8 bhp increase over a megaphone equipped-engine.

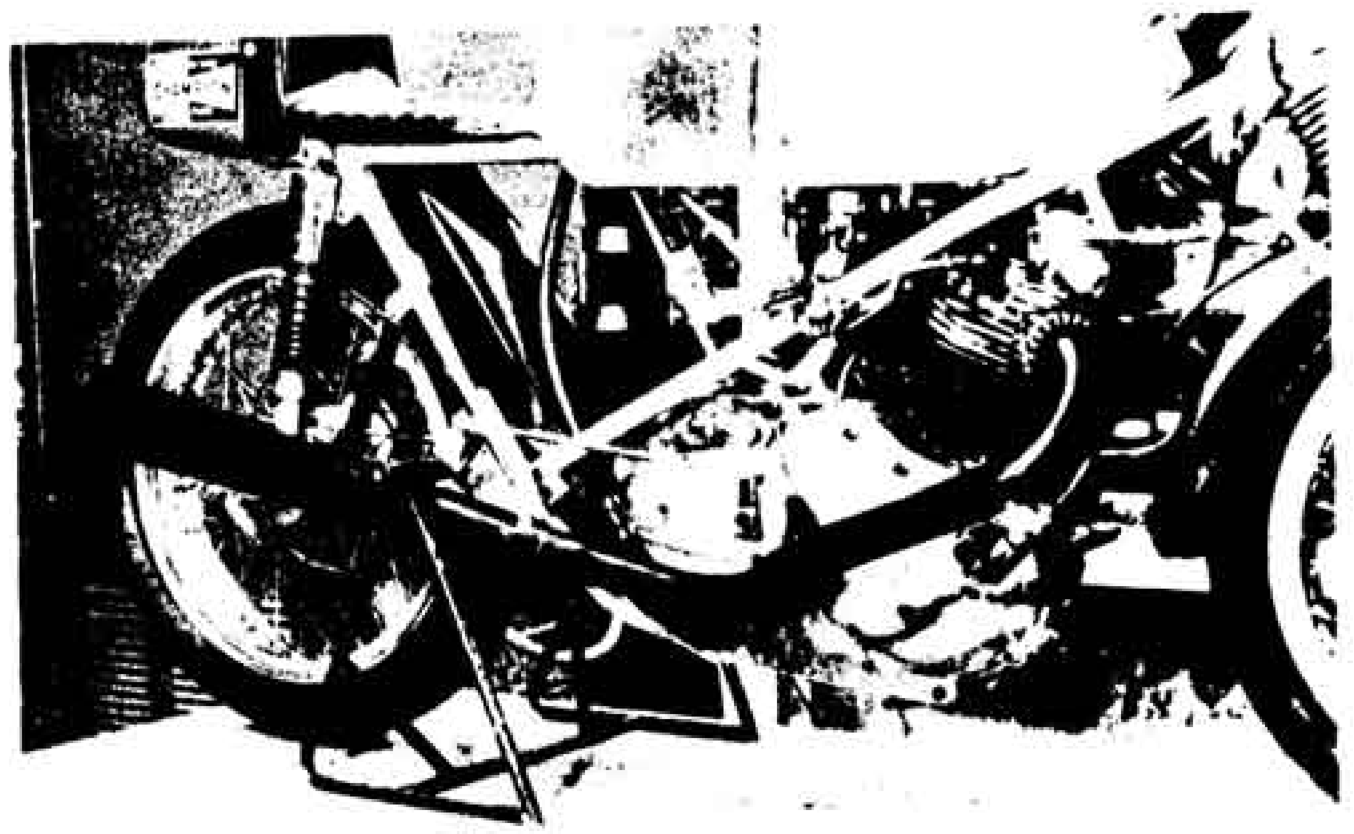


Fig. 52. Typical Racing Exhaust System.

RACING SYSTEMS

Despite the capacity difference between the 650 and 750 cc twins the same exhaust systems work as well on the track for either engine.

Exhaust systems are closely related to camshaft design.

For the street cam, the best system is a 1¾ inch-diameter pipe, 32 inches long with a 21 inch megaphone opening to 3 inches at its outlet.

The racing camshaft demands a wider (1⅞-inch) but shorter (28 inch) pipe and a 24 inch megaphone, again with a 3 inch outlet.

There can be no hard and fast rules for exhaust systems where other camshafts are used. The only answer is to experiment. Even so the above dimensions will give some guide lines towards a usable system.

Surprising as it may seem, sharp bends in the exhaust pipe do not, in my experience, effect power output in any way, But bends in megaphones do rob an engine of power and should never exceed 10 degrees.

With its rubber suspended engine, the Commando must always have its exhaust system resiliently mounted

Exhaust ring nuts will work lose under racing and even fast road use and it is advisable always to drill one lobe and wire the ring so that it cannot come undone.

This modification also obviates the need for excessive tightening of the nut and possible damage to the thread in the cylinder head—an expensive item to repair or replace

Fig. 51. Balanced Exhaust System on Commando.

Fig. 53. Lock wired Exhaust Nut.

CHAPTER IX

GEARING

Up until a short time ago the majority of motor cycles were deliberately overgeared when assembled at the factory as a safeguard against over-revving in top gear.

This policy certainly paid dividends in increasing engine life but in recent years, as customers have become more performance conscious, manufacturers have tended to lower overall gearing for the increase obtainable in top speed.

This trend is born out by the fact that road tests in the motor cycle papers and magazines now often give the information that a machine will actually over-rev in top gear. For road work with a normal four speed gear box, this is not necessarily a bad thing, for road conditions and speed limits usually dictate speeds well below the machine's maximum.

In fact, the street rider has a choice. He can overgear to give the engine an easier time and decrease fuel consumption at the expense of acceleration or he can lower the gearing to such a point as to ensure maximum revs at the maximum speed he is ever likely to use.

The road racer has no alternative. To get the best from his machine he must gear it so that, for any given circuit, he will just obtain maximum revs in top gear at the fastest part of the course.

To achieve this, he must decide on the maximum safe revs for the engine and after practice on the circuit, gear the machine to achieve them. But even the racer can overgear at times. On a circuit with very long straights which would keep the engines running at peak revs for long periods he may well decide to overgear slightly for reliability, especially if the event is of long duration.

The range of Norton sprockets available for changing the gearing is sufficient for any circuit in the world and the serious racer will always arrive at a meeting with a sufficient range of sprockets to make gearing variations.

As an example: although an engine may well usually pull a certain gear at a known circuit, there may be circumstances where a change may be necessary. If a engine is slightly off tune and nothing can be done on the spot, it is quite likely that better performance will be achieved by a slight drop in overall gearing.

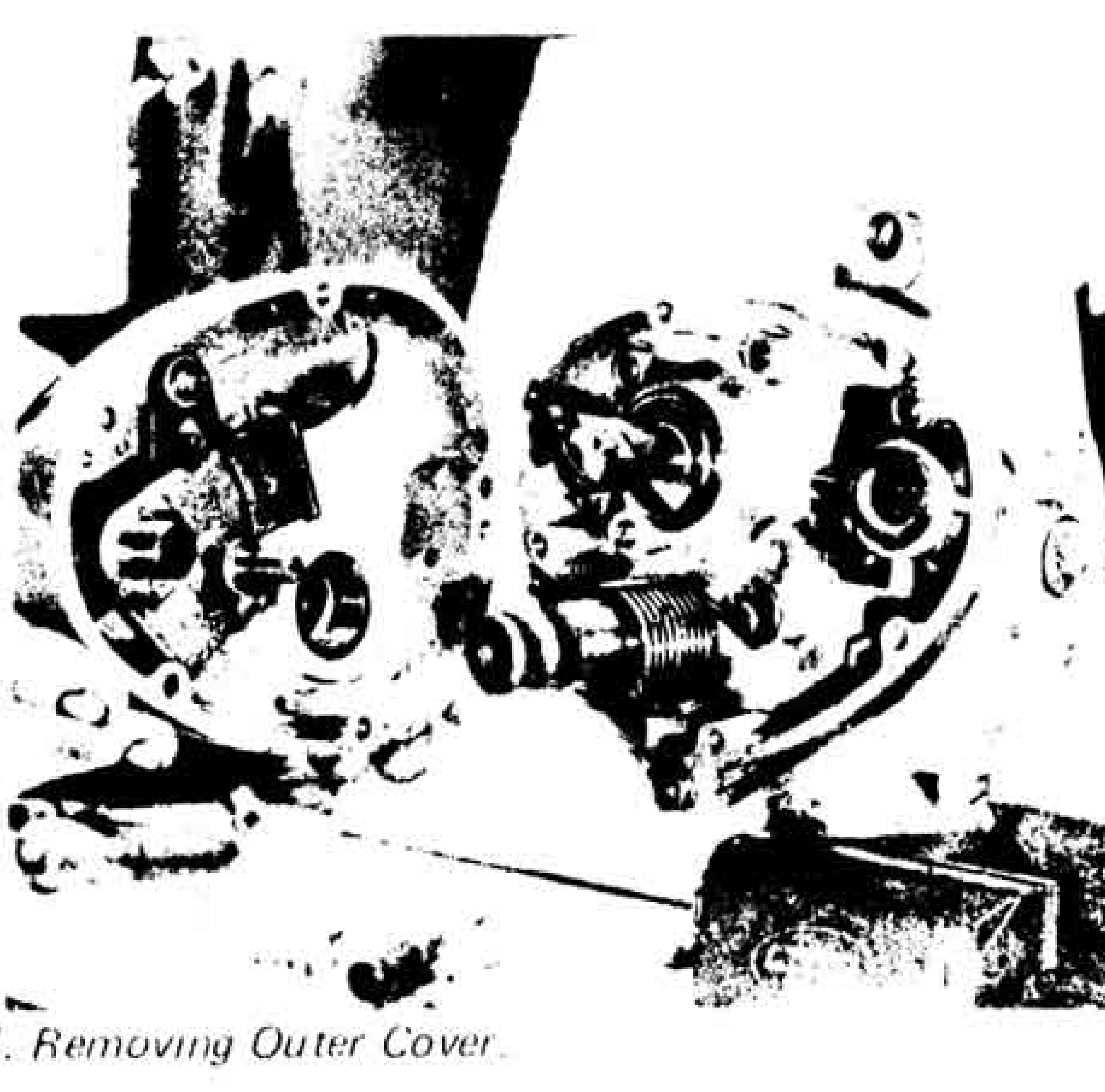
Fig. 55. Removing Inner Cover.

Gearing alterations are made in two ways on Norton machines.

On all but Commando twins, the engine sprocket should be changed. Available sprockets range from 17 to 24 teeth in one-tooth jumps.

When the Commando engine was introduced, the Norton factory went over to a triplex primary chain drive. To avoid the obvious expense of a range of three-row sprockets, alterations are made at the gear box sprocket. Available are sprockets from 19 to 24 teeth, again in one tooth jumps.

Maximum advised revs are 7,400 rpm on the 650 and 6,800 rpm on the 750.



54. Removing Outer Cover.

Fig. 56. Unscrewing Selector Rod.

The rider has also to decide on the internal reductions best suited to the job in hand.

Gear clusters are usually referred to as standard, semi-close, or close ratio sets.

A machine with standard internal ratios will clearly get off the line quite smartly but acceleration will then taper off as the change from gear to gear, drops the engine revolutions out of the useful rev range.

An opposite set up is needed for road racing. Once the machine has been started and got away, the road speed seldom drop sufficiently to warrant a low first gear.

This means that in a racing machine, the gears can be grouped high up and sufficiently close together to allow the engine speed to be maintained within a tight power band.

Standard ratios are just as the name suggests, a compromise between wide and close clusters to give all round acceleration and a usable first gear which will not be destroyed by a few miles of stop-go riding. Close-ratio gears to Manx racing specifications are available to fit directly into the gear boxes fitted as standard to Norton twins.

Within reason, the more gears available the better.

Small, high revving racing two-strokes, in the mid 1960's, had as many as 14 gears, to compensate for ultra-narrow power bands but, with a fairly flexible, large-capacity four-stroke unit such exotic boxes are unnecessary and five gears are the most that should ever be required.

Perhaps the best known five speed gearbox for Nortons is the Austrian Schaftlietner which is used by many top line competitors.

A number of British-made five speed gearboxes are now becoming available as well.

Fig. 57. Removing Sleeve Gear.

When dismantling the standard Norton gearbox, the outer cover can be removed after removing the kick-starter and gear indicator bolt. The gear lever should be left in position and can be used to pull off the cover. Five-cheese-headed screws hold the cover. Before the inner cover can be removed, the following parts should be taken out; ratchet plate and spindle, clutch operating roller and arm, clutch arm pivot lock ring and body and mainshaft nut. There are seven nuts holding the cover.

The box is most easily dismantled by removing components in the following order: mainshaft bottom gear pinion; unscrew selector-fork spindles; both selector forks, mainshaft with third and second pinions; layshaft with pinions.

The gear box sprocket is secured to the sleeve gear (main shaft top gear pinion) by a nut (left hand thread) and locking washer secured by a screw.

The cam plate can be lifted out with the quadrant after the dome nut, plunger and spring and the two securing bolts have been removed.

Fig. 58. Camplate Removed.

To re-assemble the gear box, first fit the sleeve gear and then the cam plate and quadrant, correctly positioned to index all gears.

This is done by first fitting the quadrant and positioning with the lever radius in line with the top cover stud. The cam plate should be placed so that the first two quadrant teeth can be seen through the cam plate slot.

Assemble the pinions in the following order: mainshaft with third gear; second gear with striker fork positioned in pinion and then into cam plate; mainshaft bottom gear, layshaft with top, third and second gear pinions and striker plate (engage striker with cam plate before pushing the layshaft home into its bush); striker fork spindle and layshaft bottom gear pinion. The remainder of the gear box assembling is a reversal of the dismantling procedure. Before tightening the lock ring take care to position the clutch lever pivot body so that the lever lines up with the clutch cable entry hole.

CHAPTER X

STEERING

All Norton machines use the world renowned "Roadholder" front forks, developed in line with the "Featherbed" frame.

Earlier, girder-type forks had damping systems comprised of friction discs but in modern telescopic forks, the damping medium is oil. This does not give the wide range of adjustment possible with the old friction damper, but it is simply foolproof and, above all, consistent damping method.

Damping on motor cycle forks has two jobs to do—to damp out oscillations of the springs and to prevent inertia overthrow.

Oscillations are set up by a spring which, when released after being compressed—as by a bump in the road— will vibrate. A wheel which has a spring but no damper will probably bounce up and down many times after hitting a bump.

The ability of a damper to overcome inertia overthrow is also important. If a bump is hit at a fast rate the wheel will rise, possibly at sufficient a rate to overcome the resistance of the spring and continue upward higher in fact, than necessary to ride over the bump.

A damper provides increased resistance to the inertia of the wheel and plays a great part in keeping the wheels in contact with the ground.

Damping in oil controlled forks—such as those used on Norton machines—can be varied by the viscosity of the lubricant used.

Simplified, the oil provides damping by its resistance to being forced between piston and bore. Therefore, the thicker the oil, the greater the damping action.

The official Norton recommendation is that an SAE 20 oil should be used but if an increase in damping is necessary—racing on a particularly bumpy airfield circuit for instance—SAE 30 could be used. The capacity of each fork leg is 150 cc.

The standard springs fitted to "Roadholder" forks are single -rate items but for racing use the dual-rate Manx spring which is superior.

A single-rate spring is easy to identify. Its coils will be wound evenly throughout its entire length whereas a dual-rate spring will have coils closer together at one portion of its length. With a single-rate spring a given force will compress it a certain amount. If the force is doubled, the compressing will also be twice as much and so on until the spring becomes coil bound.

Dual-rate springs, as we have said, have certain coils which are closer together. When a compressing load is put on the spring, these closer coils come together and any further load has to compress the spring over a shorter length and therefore requires much more force. It can be seen, therefore, that the advantage of the dual-rate spring is that it provides a relatively soft initial suspension setting, ideal for absorbing small pumps. It also stiffens up as the front fork compression increase, and prevents bottoming on severe bumps.

Damping is just as important on the rear of the machine where Girling units are used. These are filled with fluid at the factory and sealed to prevent the ingress of dirt. Because of manufacturing tolerances, one unit may give slightly different damping characteristics than another of the same type.

To avoid these differences, specially matched pairs are available and should be used on racing machines. These units are tested on a special rig at the factory and two units, having identical performance characteristics are packaged and sold as matched pairs.

Girling provide a very wide selection of springs of various poundages as shown below, complete with the painted colour coding used for identification.

This table gives spring poundages for springs of 8-inch fitted length as fitted on Norton twins other than the Commando;

lbs per inch	Colours
75 Yellow-yellow-yellow	
90 Green-yellow-green	
60/90 dual rate	Green-purple-green
110	Red-red-red
132	Red-orange-red
145	Blue-yellow-blue

On Commando twins the units have a fitted spring length of 8.4 inch and the poundage identifications are as follows:

lbs per inch	Colours
100	Green-green-green
70/100 dual rate	Green-pink-green
110	Red-blue-red
126	Red-yellow-red
150	Blue-red-blue

For the average weight rider I recommend 110 rear springs for road use on the Commando and 70/100 for racing. For the Atlas, 90 for racing and 110 for road work have found to be near ideal.

STEERING DAMPERS

As road surfaces, and suspension systems have improved, the steering damper has all but disappeared from production road machines.

The vast majority of dampers fitted to road machines in the past have been of the friction disc type rather than the cylindrical varieties but current racing practice is to use a telescopic cylindrical unit.

The effectiveness of the cylindrical damper can be adjusted to suit different circuits by using alternative fixing points. If it is pivoted near to the fork centre it will have less movement and therefore less damping effect. If it is mounted further away from the fork centre the opposite will apply, giving stiffer damping.

Even the best frame and fork set ups—and the Norton is clearly included in any such test—will suffer "head wagging" of the front forks under certain road conditions. A steering damper combats such irregularities by inducing resistance to steering-head movement.

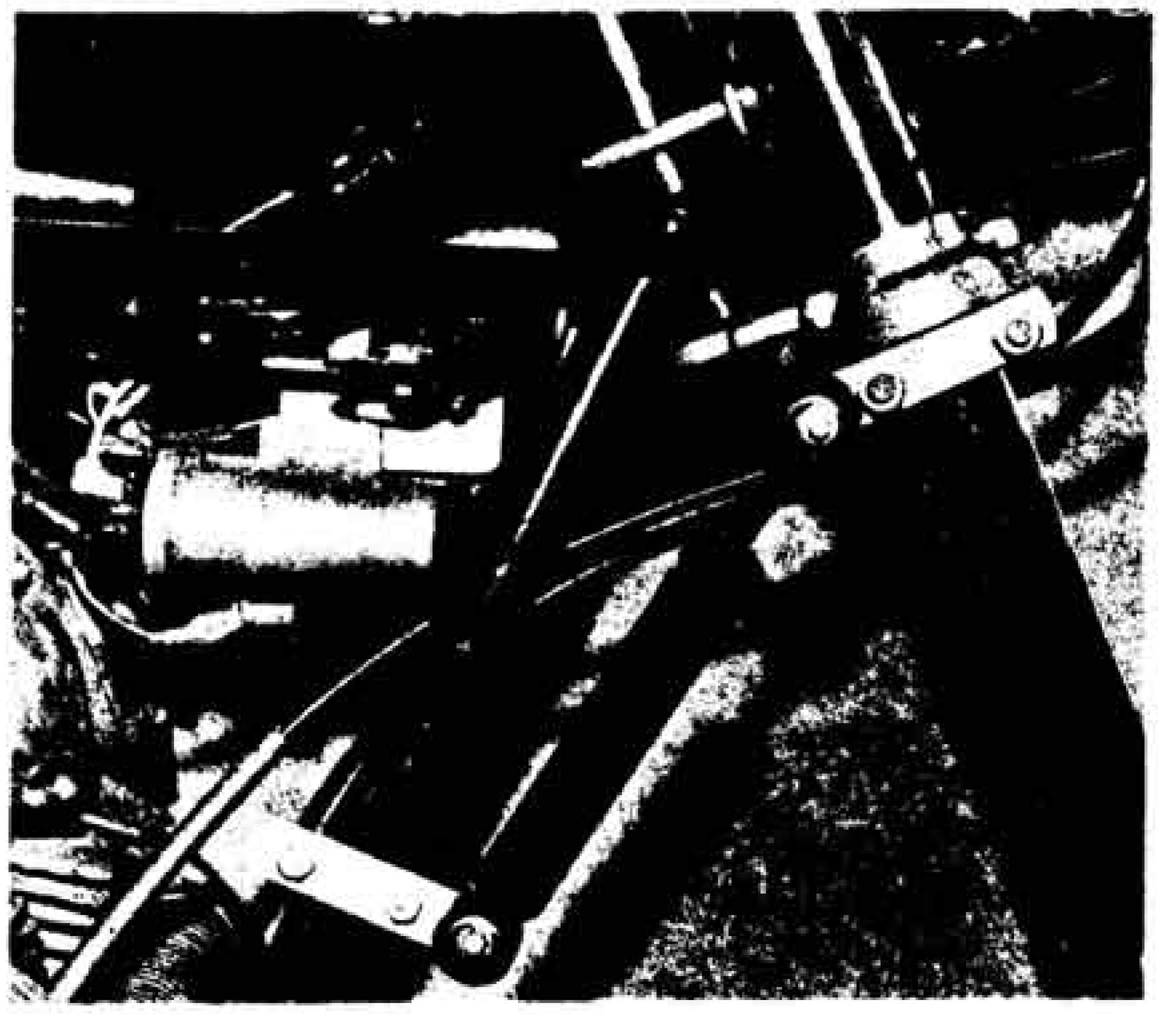


Fig. 59. Cylindrical Steering Damper.

WHEEL RIMS

Practically every road racing machine in use today has alloy wheel rims—and not just for the decrease in weight. The weight difference is quite appreciable especially as the saving is from the all-important unsprung weight of the machine.

The other important reduction is in the gyroscopic effect of the front wheel. This is especially important when the wheel is off the ground—perhaps over a jump—when a movement of the handlebars in one direction will result in the complete machine banking in the opposite direction. The lower the weight of the wheel as a percentage of the complete machine weight, the less this reaction will be.

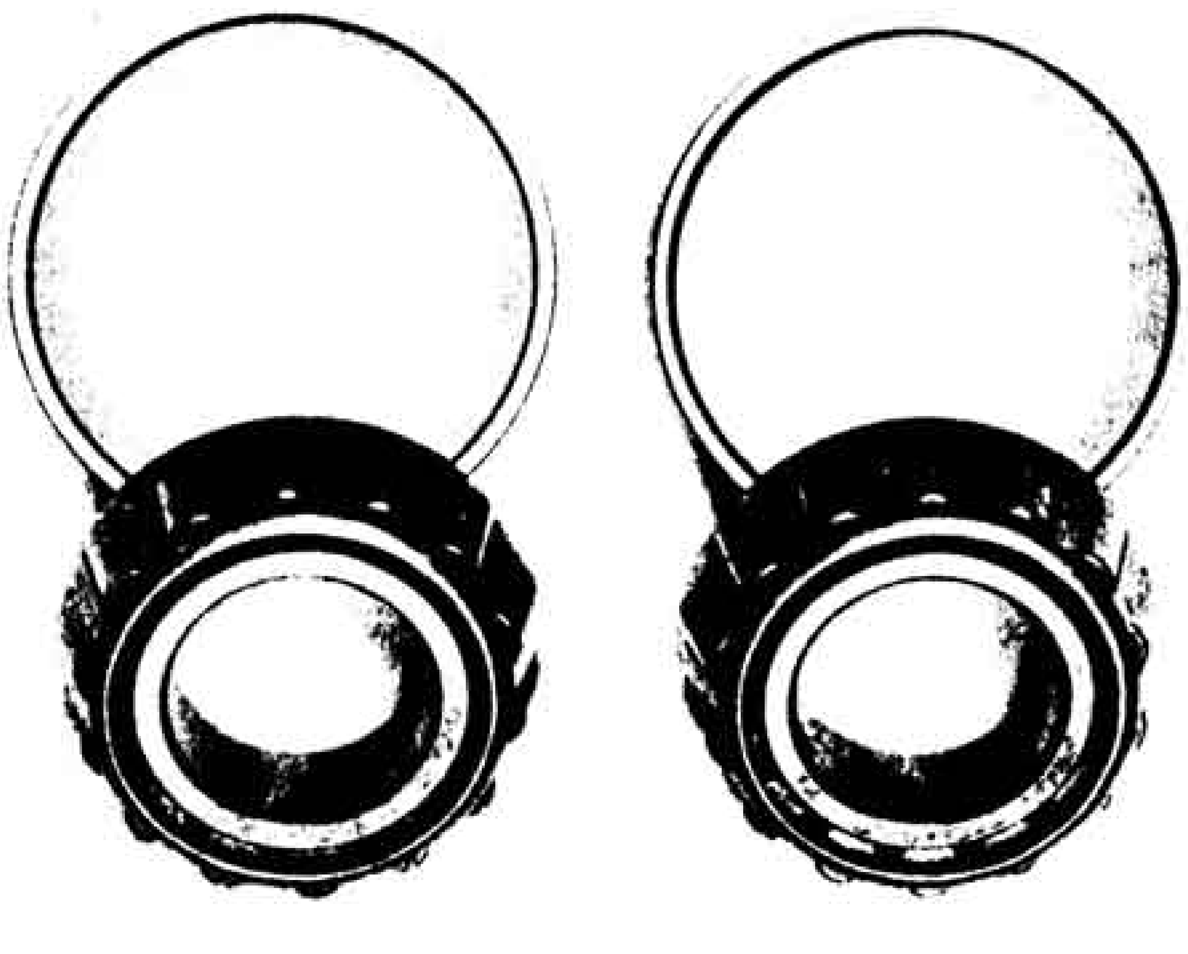


Fig. 60. Taper-Roller Head Races.

STEERING HEAD BEARINGS

Standard steering-head bearings on Norton roadsters are a series of balls held between two cupped rings.

A worthwhile modification is the replacement of the standard set up with a pair of taper-roller bearings. These are easier to adjust, have a greater bearing surface area and a better angle to resist movement, last practically indefinitely and make fork fitting a much easier job.

SWINGING ARM BEARINGS

One sensible modification to the swinging arm is to replace the "silentbloc" rubber bushes with bronze bushes.

These wear a little quicker but give a more positive location of the assembly.

This modification is possible on all Norton twins with the exception of the Commando model with its patented rubber mounting system.

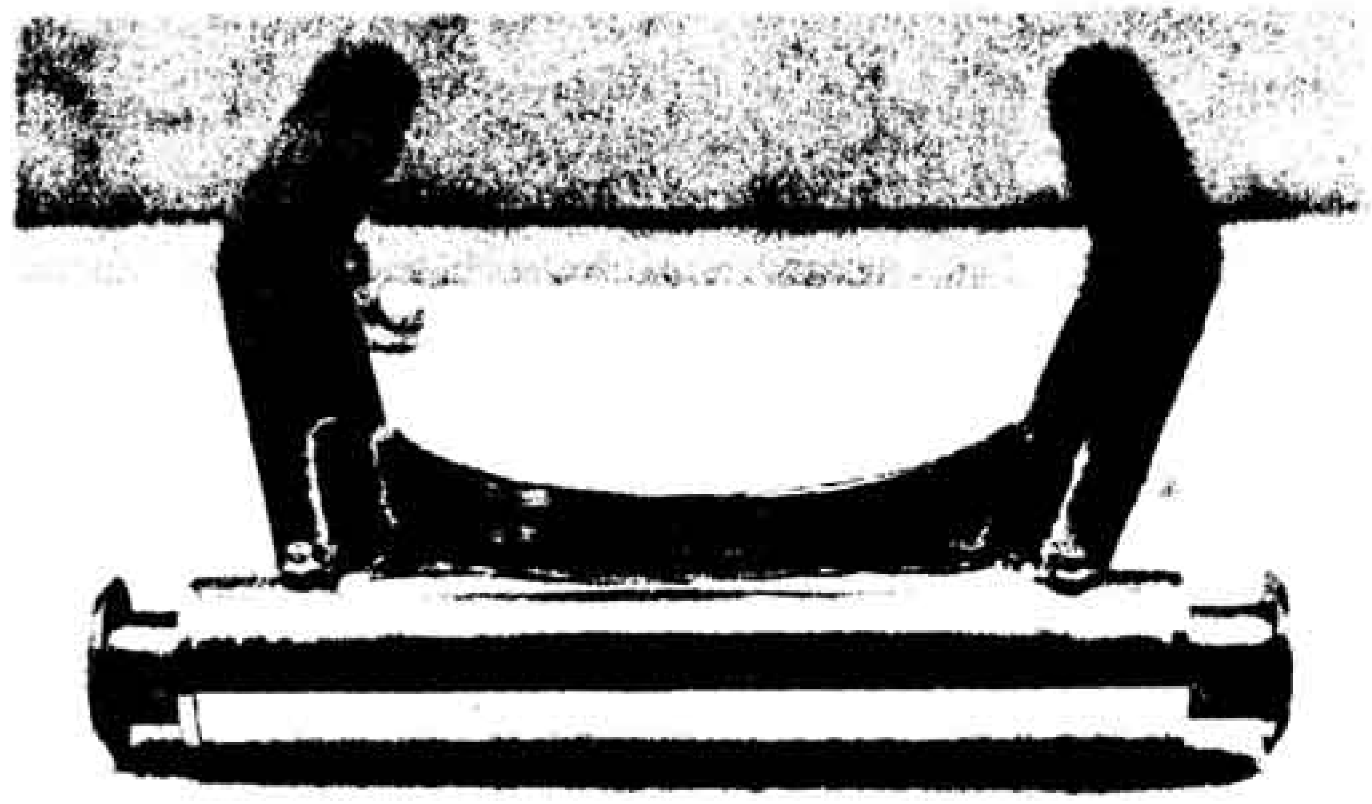
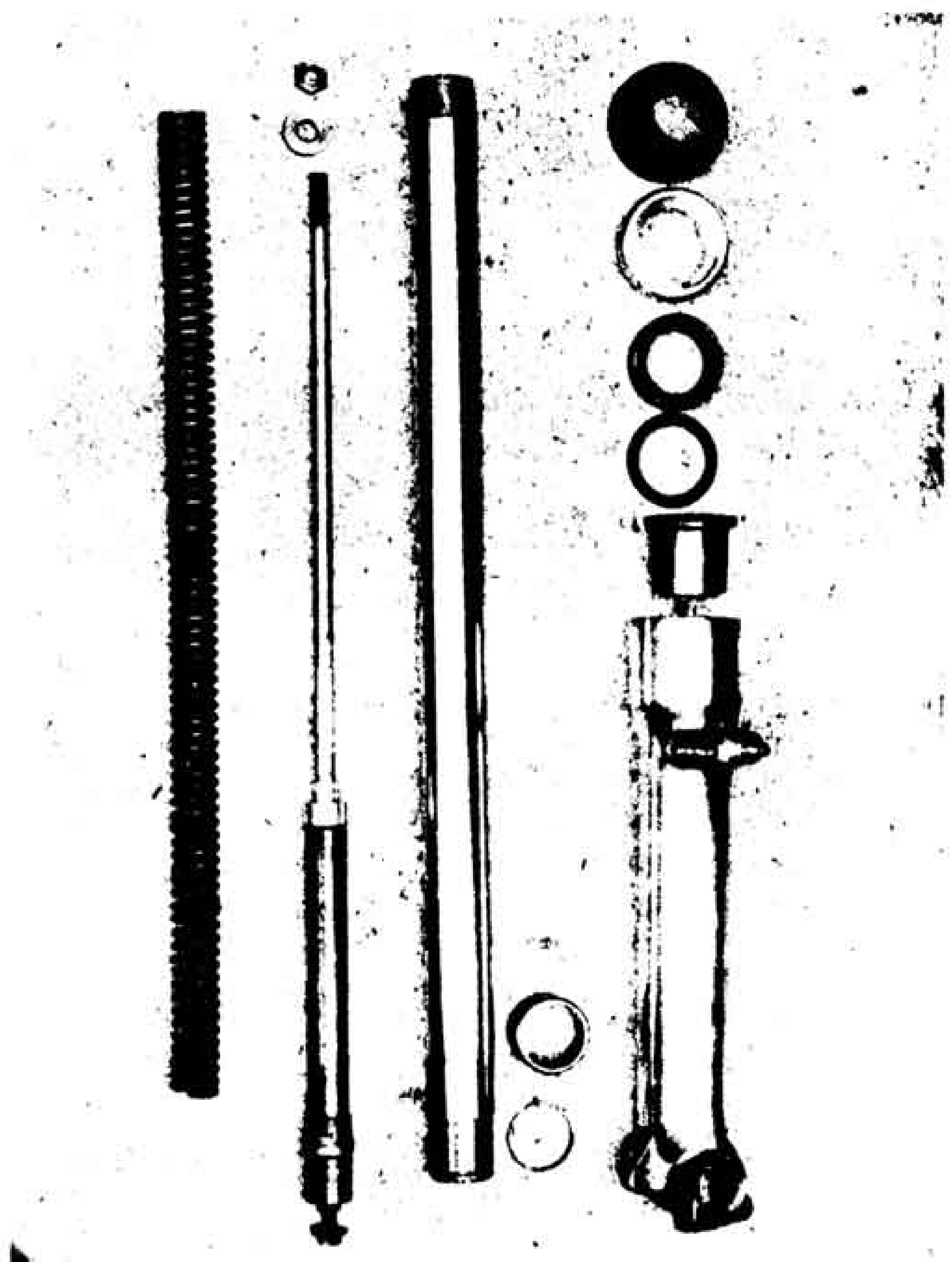


Fig. 61. Swinging Arm Fitted with Bronze Bushes and Steel Sleeves.

SERVICING "ROADHOLDER" FORKS

Removing the fork legs is straight forward. To dismantle the fork for inspection or oil seal replacement, the following sequence should be followed: remove the damper tube fixing bolt from beneath the fork leg; unscrew the bottom extensions and remove the slider; remove damper tube and spring; with a tommy bar through the damper tube holes unscrew the tube cap. The oil seal can now be removed with the sealing washer and flanged bush. The fork tube steel bush may now be withdrawn after the circlip has been removed.

Rebuilding is a reversal of the dismantling procedure.



BRAKING

Good brakes—and this means reliable, smooth acting, powerful units—are as important on the road as they are on the race track.

For street use, brakes can mean all the difference between life and death. This is just as true on the race track where they are doubly important as there is not much point in having more speed and acceleration than your competitors if you continually have to roll back the throttle and start braking earlier for the corners.

REAR BRAKE

The rear brake fitted to all large capacity Norton twins is a well proven, single leading-shoe unit with a separate cast iron drum and sprocket, bolted to the full-width alloy hub.

On all models but the Commando, it is rod operated. Because of the rubber engine suspension system used on the Commando, cable operation is specified and it is not possible to convert this machine to a rod system.

The only improvements over standard that can be made to the rear brake is the fitting of racing quality linings and skimming the assembly to accurately fit the individual brake drum.

Racing quality linings usually demand higher lever pressures for the same stopping power as conventional street linings but have a far greater resistance to fade. They should be considered a must for track work.

Because of manufacturing tolerances in brake shoes, linings and lining fitting, brake back plate assemblies are seldom an ideal fit and should be trued up on a lathe. This not only improves the braking by increasing the contact area between lining and drum but considerably cuts down the bedding-in period.

Centralise the assembled brake plate on the lathe and insert a .020 inch shin between each shoe and cam. The lining area should then be turned down until it exactly matches the drum diameter.

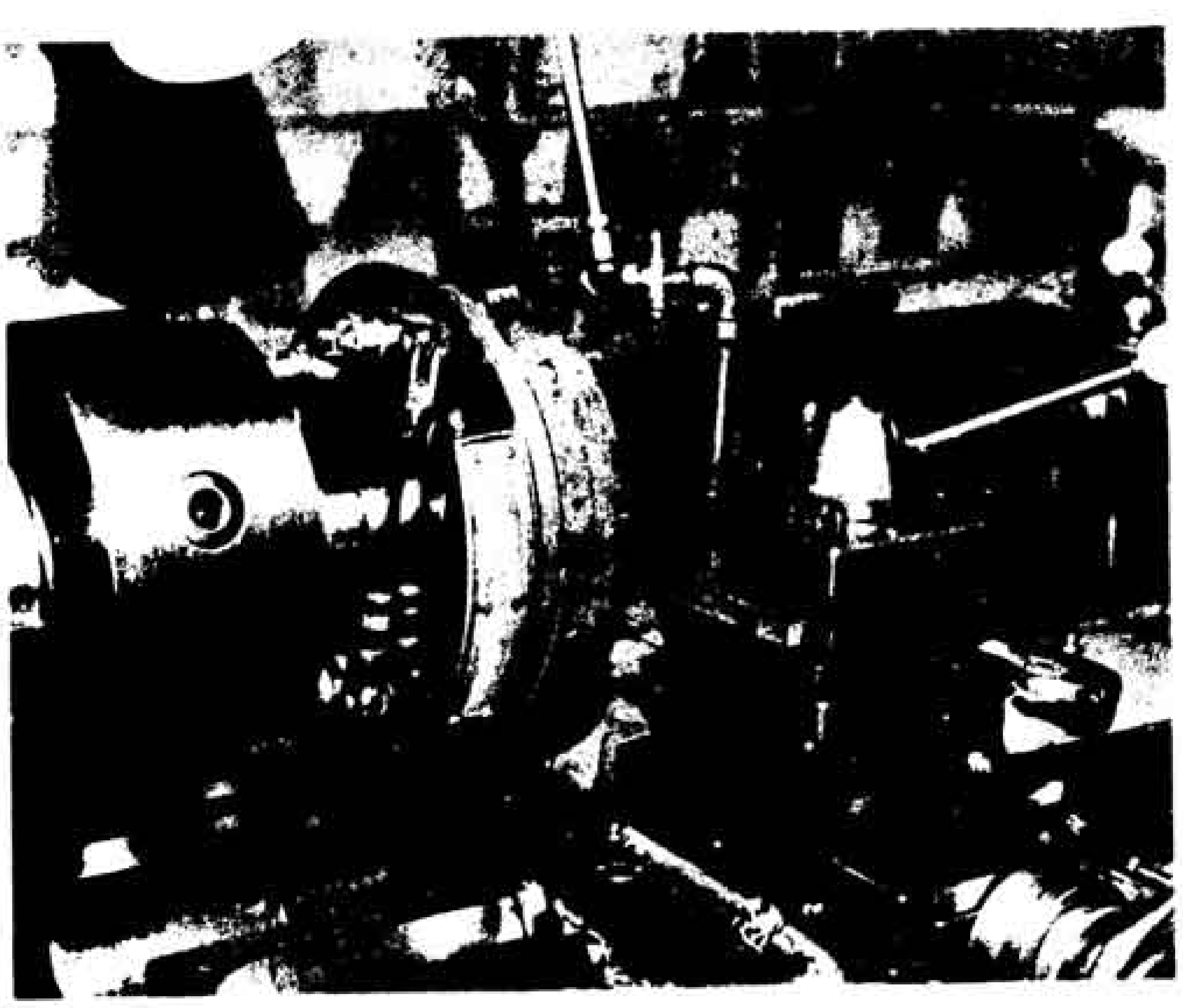


Fig. 62. Turning a Brake Plate Assembly to match the Drum Diameter.

FRONT BRAKES

There is far more that can be done in the way of fitting alternative equipment to the front brake. This is as it should be for it is at the front that most of the braking is done.

When the brakes are applied, weight distribution moves dramatically to the front wheel. Under such circumstances, heavy rear wheel braking simply locks the wheel so it must be left to the front brake to provide by far the majority of the stopping power.

The standard, single leading-shoe brake fitted to pre-Commando twins can be improved by fitting racing linings and truing the linings on a lathe, in a similar manner to the rear.

For road racing, airscoops play an important part in keeping down the temperature of the brake drum and linings. But they are useless unless provision is also made for letting out the air after it has passe; across the brake area.

Therefore, an exit hole or series of holes are necessary. A simple orifice at the front of the brake plate would collect very little air as the face of the hole would be at right angles to the airstream. Because of this a scoop should be added to direct and force the cooling air through the brake plate.

More radical brake tuning demands the fitting of other components such as a twin leading-shoe back plate or, the ultimate, a disc-brake assembly.

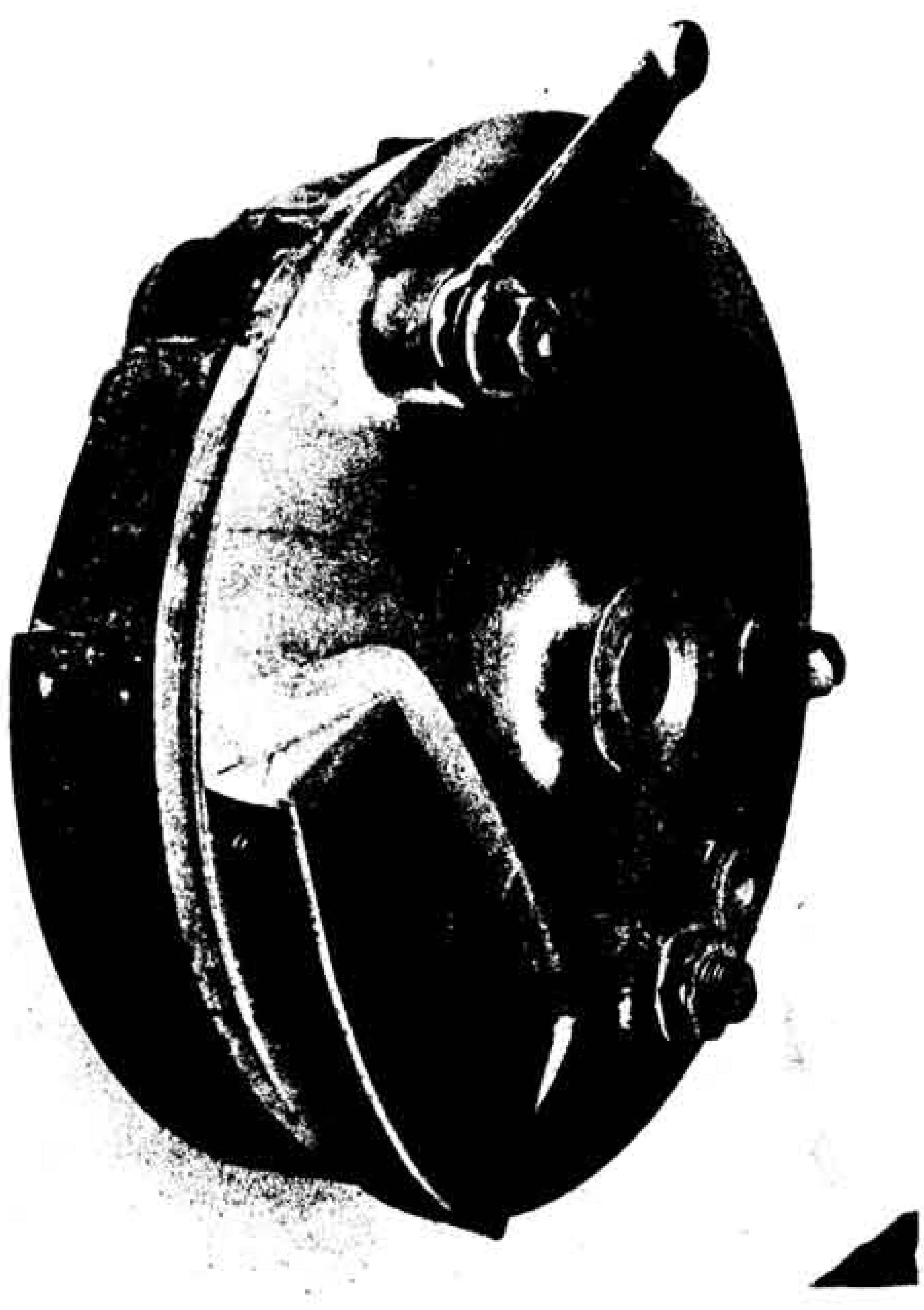


Fig. 63. An Airscoop can be easily fabricated from sheet alloy.

On a single leading-shoe set up there is but one cam which operates against the end face of the brake shoes. This means that only one shoe gets the benefit of the servo effect of the rotating drum. The other shoe simply drags against the drum surface. Twin leading-shoe brakes have two inter-connected cams and each shoe benefits from servo action.

Such twin leading-shoe back plates are fitted as standard to the Commando and can be used on any other Norton having the alloy full-width hub.

Several other concerns market twin leading-shoe assemblies for the Norton hub.

Many of these, including the standard Commando unit, come with the airscoop and air exit holes blanked off. This is ideal for road work. Scoops are only necessary for track work and open scoops on the road usually cut down braking performance by letting in water and allowing dust and road dirt to damage the drum and linings.

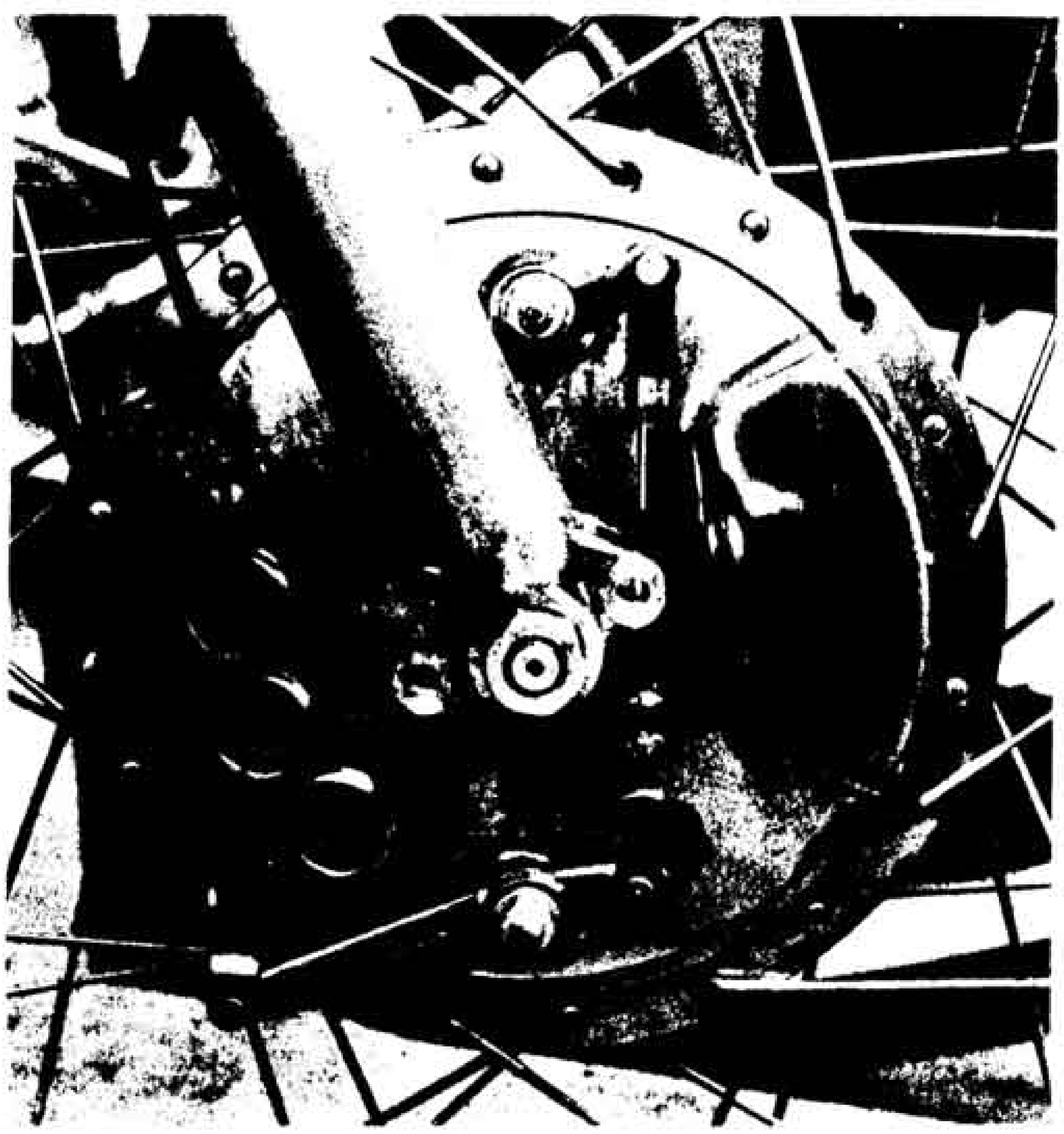


Fig. 64. Twin Leading Shoe Brake Plate.

Twin leading-shoe brakes also benefit from having the linings skimmed, to match the drum, on a lathe.

More exotic are the four leading-shoe brakes manufactured, mainly, by Italian companies. These are, in effect, two normal twin leading-shoe units mounted, one either side of the wheel.

As far as drum brakes go, these are probably the ultimate and to gain further improvement a disc-brake assembly must be fitted.

Virtually unknown on motor cycles until the 1960s, disc brakes offer very large improvements over drum units.

Disc brakes can be built lighter than drum versions and are more controllable and less likely to lock.

There are several versions available, some designed from existing car components, others specially designed for motor cycles.

Hydraulic disc brakes are also self-adjusting and need less servicing, other than a regular, careful check on fluid level in the reservoir and pad wear.

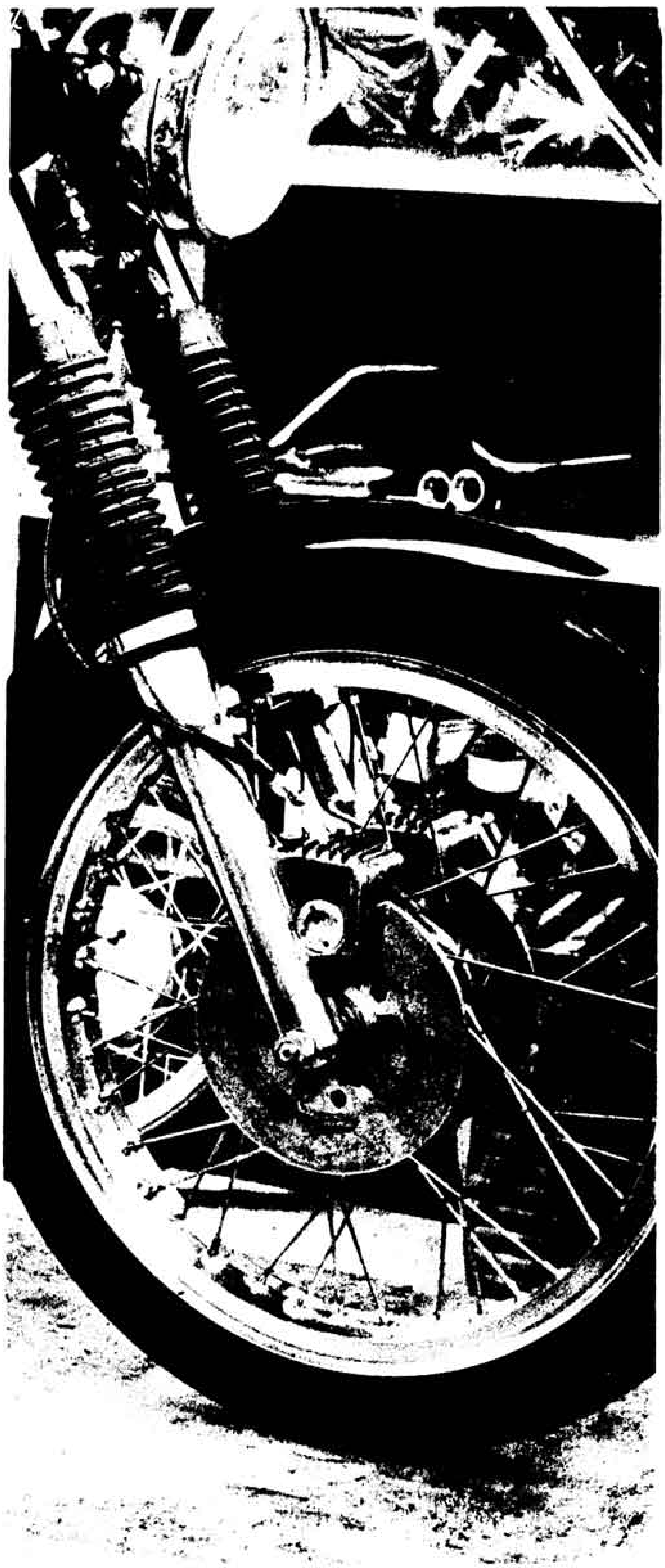


Fig. 65. Dunstall Twin Disc Front Brake.

SERVICING DRUM BRAKES

The better the surface area of the brake drum the better the braking. Scored drums may be cleaned out by skimming on a lathe, preferably done, if the machine has a large enough swing, with the wheel spoked on. This is simply to ensure that the drum is not trued and then possibly distorted by the pull of the spokes.

It is important with Norton front wheels, which do not have fully floating brake plates, to centralise the plate in the hub when mounting the wheel in the forks. There is little play between the back plate centre hole and the spindle and this allows the plate to be centralised in the drum.

Centralising the plate ensures that there is no binding when the brake is not in use and that both shoes operate at the same time against the drum.

The wheel, with plate in place, should be fitted to the forks with the spindle in place but its nut only finger tight. Operate the front brake lever on the handlebar and, holding the brake on, tighten the spindle nut fully.

The same sequence should be carried out with the rear wheel brake plate.

BRAKE ADJUSTMENT

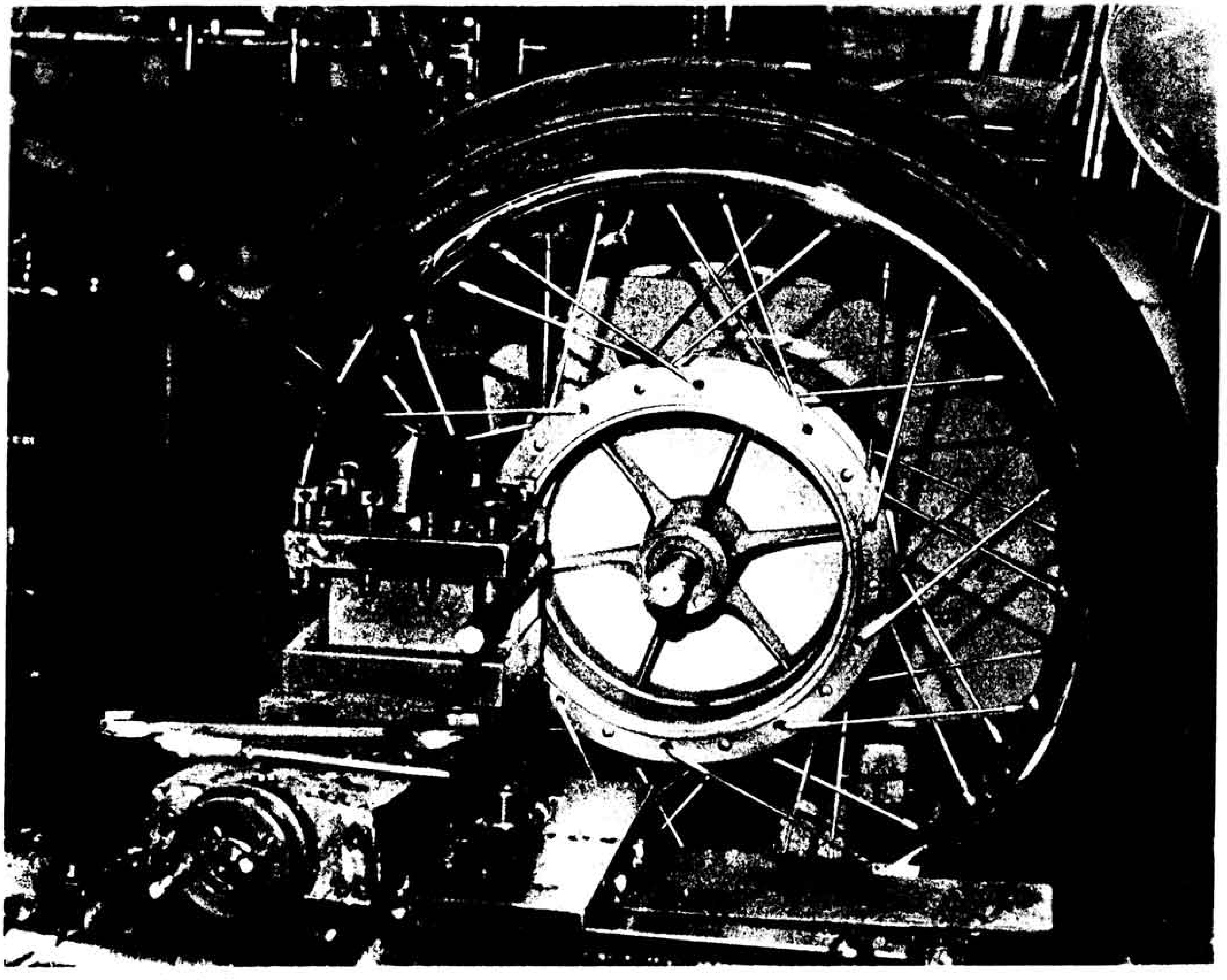
Lever and pedal adjustment should be carried out in the normal way. Normally, the connecting rod between the cam levers on twin leading-shoe brakes is adjusted when leaving the factory and adjustment is necessary only when new shoes or linings are fitted.

To adjust the unit, the clevis pin should be removed from one cam lever. Both levers should be operated by hand and held—a friend's help comes in handy here—until the clevis pin is an easy fit through the yoke of the rod and the hole in the cam lever.

Do not forget to tighten the lock nut on the rod adjuster.

Dismantling the wheel hubs is straightforward and no problems are involved in reassembly provided that the sequence of removal of bearings, spacers, shims and seals is carefully noted and reversed.

The bearing locking ring in the rear wheel hub has a left hand thread. The front wheel ring has a normal, right hand thread.



. 66. Skimming a Brake Drum.

RACING PREPARATION

General preparation should include meticulous attention to detail. It is a good idea to keep a log on your machine listing all maintenance and modifications carried out together with any troubles that occur and the remedies carried out.

When preparing your machine pay particular attention to achieving a comfortable riding position to suit your own style. Footrest height, gear lever and brake pedal angle, clip-on height and angle, seat position, etc., should all be as near as possible to your requirements.

The primary chain on a 750 Norton Racer needs particular attention if it is going to give reliable service. Always rivet the chain instead of using spring links and ensure that the chain oiler is working efficiently. Also check the sprocket alignment and correct any discrepancies.

Tyre pressures are to some degree a matter of personal choice but as a guide I have found 23 psi front and 24 psi rear to be ideal for our 750 racers and 26 psi front, 27 psi rear on our production racers.

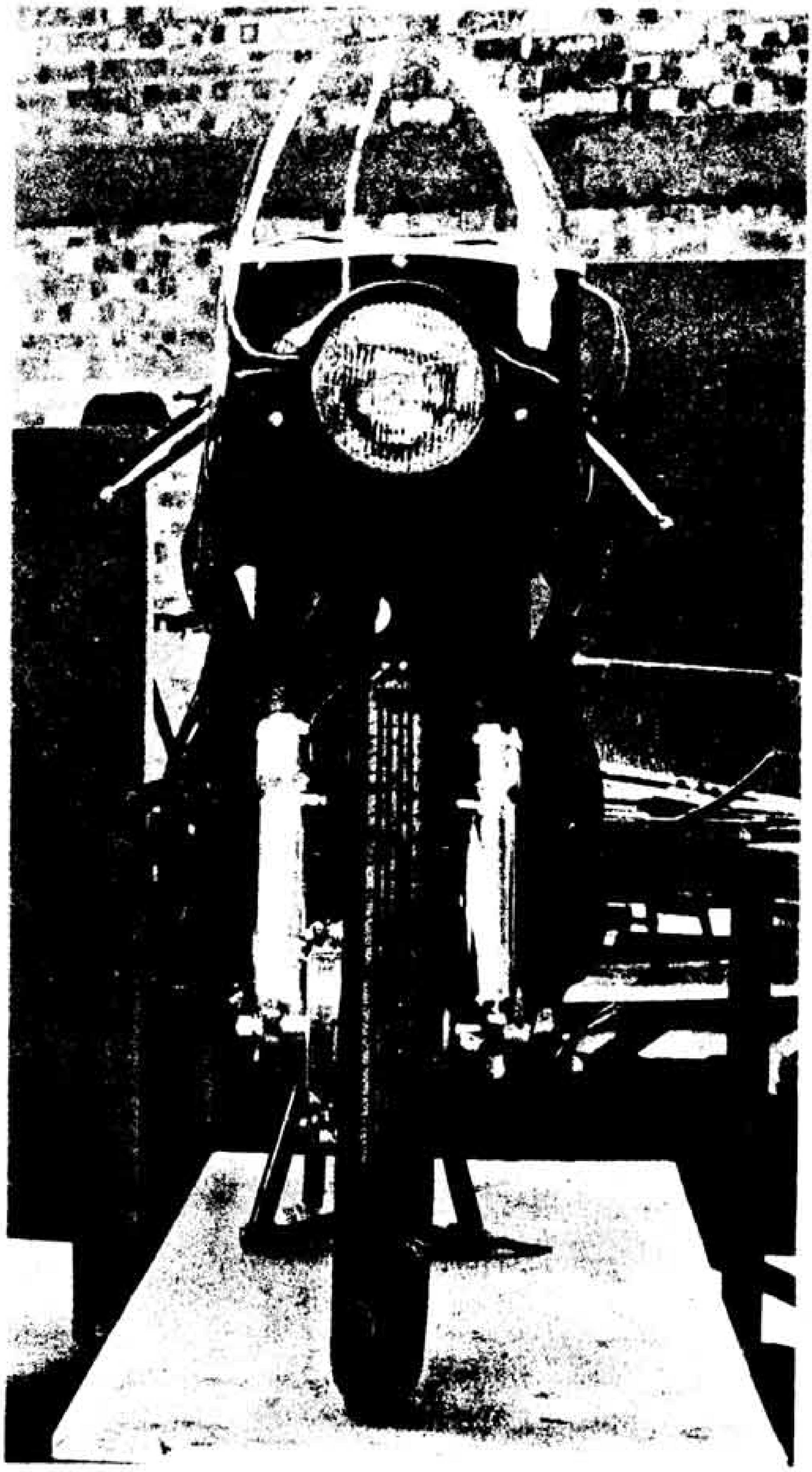
FAIRINGS

Fairings for road racing are, of course, a matter of personal choice but do not make the mistake of thinking that the smaller the frontal area of a shell, the better the penetration.

This is not necessarily so. Part of the job of a fairing is to streamline the machine but it must also cover the rider. An ultra narrow fairing may well present a smaller frontal area, a rider's head, elbows and legs sticking out present a far worse streamlined shape than a wider fairing.

We have tried two main types of fairing, one considerably wider than the other.

Experiments on the track with electronic-eye speed-measuring equipment proved each time that the wider fairing, with its greater rider protection was found to have better air penetration and resulted in higher speeds.



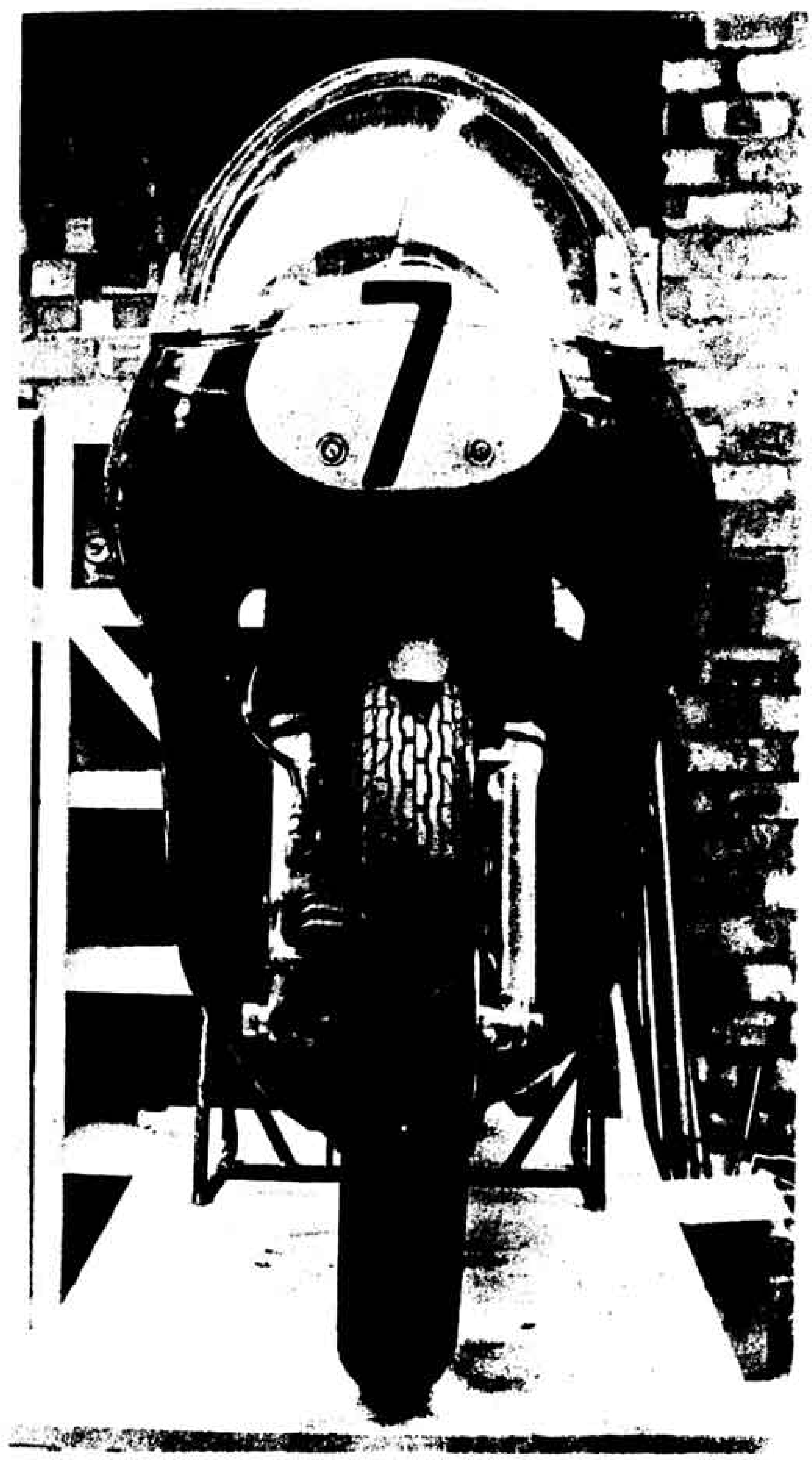


Fig. 67. Fairing Comparison. The larger fairing (No. 7.) the best penetration.

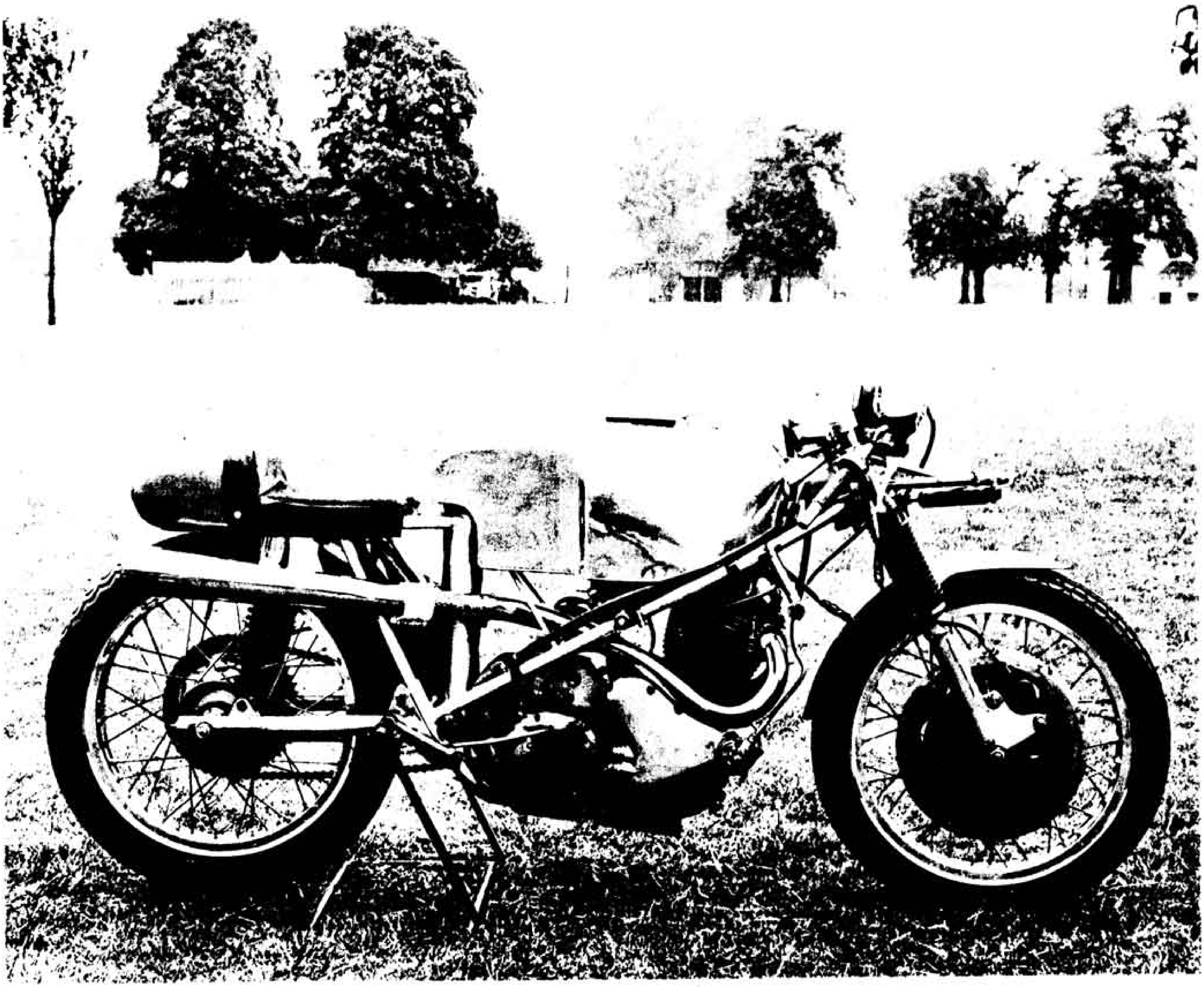


Fig. 68. A 750 cc Dunstall Norton Racer.

ENGINE DATA

	750	650
Cylinder Bore	2.875" – 2.8758"	2.6780" – 2.6786"
Stroke	3.503"	3.503"
Capacity	45.5 cu. in. (745cc)	39.45 cu. in. (646cc)
Plug Gap	For Road Work	.016"
	For Racing	.019"
Tappet Clearance [		
	Inlet	.006" (Racing .008")
	Exhaust	.008" (Racing .010")

TORQUE SETTINGS

	inch lbs
Cylinder head 3/8" bolts and units	360
Cylinder head 5/16" bolts and nuts	240
Cylinder head base nuts	240
Con rod big-end cap nuts	300
Rocker shaft cover plate bolt	100
Gear box inner cover nuts	140
Cam chain tensioner nuts	180
Oil pump stud nuts	180
Banjo bolts	180
Engine mounting bolts	300
Alternator studs	120

To convert inch lbs to ft lbs divide by 12.