PC16

NORTON 750 COMMANDO ENGINE TUNING NOTES

From time to time we receive requests for information on tuning these engines and also for the earlier 500, 600 and 650cc engines. The subject is really much too diverse for a reply in any way adequate to be sent by letter.
However the following attempt has been made in the space of a few pages to give enough information for the privateer who wishes to work on his own engine, to make a start.

THE CYLINDER HEAD

I do not think it is desirable to fit larger inlet valves, apart from the risk of 'tangling' with the exhaust valve at high r.p.m, it seems that the valve head should be as small as possible in relation to the size of the port.
The port shape can usually be improved compared with the standard, especially the inlet and if this is done well, an appreciable increase of power can be obtained from this source alone.
I think it is worthwhile to fit bronze guides for the exhaust valves, as they transfer heat from valve stem to cylinder head better than the standard iron guides. They do not however, wear so well, so I would retain the iron guide in the inlet where heat is not a problem.
Ensure that the rockers are completely free on their spindles sometimes in service they 'pick up' and then free off but when this has happened there will be sieze marks on the spindle and in the rocker bore. In such cases hold the spindles endwise in the vice and polish with emery tape. Note when replacing the spindles in the head, that the 'flat' on the inlet spindles faces the rear of the machine and the 'flat' on the exhaust spindles faces the front. Some tuners dispense with the spring washers on the rocker spindles and use spacing washers instead, but I retain them in the interest of noise reduction. (Their resistance must be minimal when it is realised that the valve springs apply 110 lbs to the valve on it's seat.) Rockers can be lightened and polished if you wish but do not overdo the lightening.

CYLINDER BARREL

Remove the sharp edge almost always to be found on the top of each cylinder bore - a small bearing scraper is useful for this. At the bottom end of the barrel, file a 1/4" radius on the corner of the con-rod clearance slots and with a file followed by emery tape, remove all sharp edges in the con-rod slots, and on the inside and outside edges of the cylinder bores and cam follower tunnels. Remove the cam followers marking them in pairs left and right hand, and note that the bevelled edges on these go towards the front of the engine when they are replaced. Check the followers for any casting sand remaining inside them. On some cylinders the cutter which makes the slot for the cam follower retaining plates, goes across the tunnel and cuts into its front edge. When this has happened, I file the front edge down to take this out, and to use some of the special camshafts, it is necessary to file away the bottom edges of the cam follower tunnels, in any case to check that you have sufficient cam clearance here, the crankcase halves should be assembled with the camshaft you propose to use fitted.

Then place the cylinder barrel on the crankcase without a base gasket and make sure the camshaft will turn by hand without hitting the lower edges of the tunnels. Even if it only just clears, the thickness of the base gasket will give working clearance on final assembly.) I should point out that the 850cc engines do not use a base gasket so special care should be taken when checking for cam to tunnel clearance on one of these.

It is also important the cylinder should be a completely free fit in the crankcase mouth and over the securing studs and this can be checked at the same time. File away any areas on the sides of the cylinder spigots or cam follower tunnels which might be in hard contact with the inside face or wall of the crankcase.

CRANKCASE

Examine the joint faces carefully for any signs of burrs and remove all sharp edges with a scraper. Ensure that all studs are tight in both halves of the case. Remove them and retighten with two suitable nuts locked together, if jointing cement from a previous assembly has adhered to the cylinder joint face, as this greatly facilitates cleaning the face . Apply some grease to the threads of the studs when re-fitting. If the aluminium shows any sign of 'lifting' around the stud holes, countersink lightly before fitting the studs. Especially is this important in the area of the crankcase joint at the top rear (near where the magneto used to be.) because fretting of the joint causing oil leakage occurs here if the machine is run with the rear crankcases to rear engine plate mounting bolts loose.

Loose bolts here also contribute to cracked lugs on the crankcase and the lugs should be examined very carefully for any cracks, especially on the top lug on the drive side case.

The centre cylinder base stud in the centre front of the crankcase has a shorter thread into the case because of the close proximity of the camshaft tunnel. On some engines this is drilled through but may not be tapped through. It is sometimes possible to tap right through and use a longer stud which will get a better hold although a full length one as used elsewhere in the case, may go through too far and foul the camshaft

If you have an extra long 1/4" twist drill, you can open out the return oilway from the bottom joint face of the timing side crankcase up to the pump face in the timing case, but to do so you have to remove the 5/16" x 26 TPI grub screws (5/16" x UNC grub screw in 1972 engines onwards) which blanks off the vertical drillway which goes up to the oil/pump mounting face. The hole on the face is the forward one as it is - but the left hand one, the feed one will already be rather like a solid figure 8 and you can clean this up with a small rotary file . Great care must be taken when drilling out the return oilway, that the drill does not jam and break. A drill with a shallow cutting angle is best because it will then cut slowly without grabbing - run at about 900 r.p.m (You cannot go larger than 1/4" with this oilway otherwise you will take out the thread for the aforementioned grubscrew. Refit the screw afterwards with a little Wellseal.)

Make certain that no swarf from the drilling remains in the oilway, otherwise the pump may be damaged or even locked. Especially is this important in 1972 engines which do not have the sump filter and where there is an additional drillway running to the bottom front of the sump area which has it's own blanking grub screw outside the case. (Note that this drillway will be already about 1/4" bore so you do not have to drill it or remove it's grub screw but swarf from you drilling can easily lodge in it. If you intend to use a special camshaft, make sure it has clearance to rotate in the tunnel in each half of the case and if not, open out with a rotary file in a drilling machine and finish with an emery bob.

MAIN BEARINGS

On late engines we have had best results with the 'Superblend roller bearings - these have two rollers with slightly tapered ends. We have used two types - RHP type 6MRJA30 and FAG NJ306E. - the former has a Norton part No. 063906 and the latter Norton part No. 064118.

When examining the RHP bearing look very carefully for the 6 which is etched on with an electric pencil comapared with MRJA30 whichis stamped on the inner race before it is hardened. If the 6 is missing, then the bearing is the earlier non-Superblend type. These bearings are used in pairs on the crankshaft but some tuners prefer the crank-shaft to be located end-wise and they then fit a roller bearing on the drive side and a 'notched' ball bearing on the timing side. (Paul Dunstall supplies such a bearing which has 10 balls compared with 7 or 8 in the standard ball bearing by RHP and others. The timing side bearing of whatever type, should not be too tight on the crankshaft- if the original is difficult to remove, ease the shaft journal down with emery tape wrapped round and pulled to and fro, taking care that you work absolutely evenly all round.

The drive side bearing has to be tighter on the shaft because there is nothing else other than interference to secure it, but if it is found to be extremely tight, then the shaft can be eased slightly in the same way. (Note re-fitting bearings into crankcases and on to shafts. For removal and fitting of bearings, crankcase halves should be heated evenly with a 'soft' gas flame - a calor or butane gas or petrol or paraffin blowlamp - and the flame should be played round and round the bearing housing inside the case on as large an area as you can. Obtain two pieces of wood say 2" x 2" x minimum 1ft. long and lay them parallel to one another on a flat floor say 3" apart. Holding the drive side case with a piece of cloth in each hand, bump it face downwards onto the woods so that the dowells pass between the woods and the drive side roller race should then drop out.

The timing side bearing can be removed in the same way but if it is a ball race you may not have to get the case so hot because you can drive the bearing out with a large diameter drift from the timing chest side. Note also that you should take out the long 1/4" and 3/8" stud from the timing side crankcase before bumping on the woods.

When new bearings are fitted in the crankcase, the case should be hot enough so that the bearing will drop home instantly as you let go of it. If it should jam part way in under no circumstances should you try and drive it home - instead drive it out again and cool off in water before making any further attempts to fit it.
In the case of a roller bearing, if you drop the complete bearing inner and outer races into the crankcase, heat will quickly transfer from outer to inner race and then you can take out the hot inner race and 'shoot' it on to the drive shaft by hand and in this way it will often go fully home without any necessity for driving it with a hammer and tube. The important thing is that all bearings should drop fully home into their housings with a metallic 'clonk' so that you know they are fully home.

CRANKSHAFT
If the crankshaft has a roller bearing where cage and rollers remain on the inner race of the shaft, it will be necessary to remove one roller from the cage in order to examine the roller path on the inner race. If you use the jaw of an open-ended spanner - say 1/4" Whitworth you can lever upwards the end of one roller, levering against the face of the crank web. When the roller has been lifted up to an angle of 45 degrees with the spanner, use a small hammer and soft drift and tap the roller upwards from the outside very carefully. Do not let it fly out so that you cannot tell which way round it has been positioned. Place it down carefully on the bench so that it cannot roll, and now rotate the crankshaft on the bench holding the cage and remaining rollers still and all the time looking in at the roller path on the inner race as you turn.
If the race is commencing to break up you will see a rough area which, once having started spreads rapidly. If you find this has begun, the bearing is scrap, so you can use a small chisel and split the cage at each side where you have taken the roller out. Now the cage can be sprung apart and removed with the remaining rollers and the inner race of the bearing pulled off the shaft with Norton engine sprocket puller tool - EST/12.
If the bearing is sound and you intend to re-use it, carefully replace the roller the same way round so that it continues to rotate in the same direction and tap it back into the space in the cage with a soft drift. When it is replaced make certain that it and all other rollers are completely free in the cage.
If you remove the con-rods, mark them with a pencil left and right, and note that the squirting oil holes in each rod point outwards, away from the central flywheel when re-fitting. New shells should be fitted but there is no need to replace the con-rod bolts, and even the nuts can be used again so long as they are still stiff to turn when they reach the full thread position . (Torque figure for con-rod bolts - nuts - 25 lbs ft. or 300" lbs.)
In this connection we would point out that a very recent technical note from our head office at Wolverhampton says that new nuts should always be used when big end bearings are dismantled and re-assembled. - Old part Nos. 23253 and the new part No. is 067827.

When examining con-rods, tap the bolts back and examine the eccentric recesses into which the bolt heads fit. Check for any sign of dural having been ‘scraped’ down by the sharp edge of the underside of the bolt head. The bolts can be removed and this sharp edge taken off the underside of the head and then the head can be polished by spinning the bolt in an electric drill against some emery tape held by hand. It is most important that the bolt heads seat down squarely in the recess in the rod with no ‘foreign’ metal trapped underneath.

Reverting to the crankshaft itself, if it is to be dismantled for cleaning, this should of course, be done before the con-rods are replaced. Make sure to mark the wheel before detaching the cranks so as to ensure that it will be replaced the same way round between them on re-assembly. This is very important because the balance will most likely be disturbed if the wheel is fitted the other way round. Examine the four bolts and two studs which hold the assembly together for any sign of stretching the threads - if they are not stretched they may be used again. The torque figure for these is 25 lbs ft. (300” lbs.) as for the big end nuts. Some workshop manuals give 36 lbs ft. (420” lbs) for these but they will break if they are so tightened and most manuals should have had a corrected data sheet supplied.

On re-assembly note that the bolts go through from left to right that is the bolt heads go to the drive side of the crankshaft. There is no need to re-peen the four nuts. The nuts may be replaced if they are damaged when they are unscrewed by the peening which was done on original assembly. In such cases trim up the end of the bolt with a file before fitting a new nut.

Protect the crank pin journals and the mainshaft journals with plastic or masking tape so that you will not damage them - take care not to let a spanner slip and knock them as they can be bruised and this will damage new shells. (The journals are tough but not very hard and can easily be indented with a spanner if there is weight behind it.) When the journals are protected, you can then file off all sharp edges and radius the edges of all holes on the cranks and the flywheel. If these parts are then sent to a professional polisher, the protecting tape should be left on. The con-rod caps can be filed so that their end contour matches that of the con-rods themselves , but some caps are a very near match as supplied. The caps must not be interchanged with the rods and they must always be fitted the same way round on their own rods. A chisel mark is put on at the works to show this on the outside, but if it becomes cleaned off in the polishing - no matter, when you examine the rod end, the small ‘key’ or notch which locates the shell in the rod, goes to the same side of the joint as the one in the cap.A final point about cleaning the inside of the crankpins and flywheel - the thick solid deposit in the cranks can be scraped out, and then each crank cleaned out with a stiff paintbrush small enough to go inside. Wash in petrol or if paraffin is used, the parts can be rinsed in hot water afterwards. Use a thin strip of cotton and a short piece of thin wire as a ‘pull through’ to clean the oil holes in the crankpins as otherwise they may be missed in the cleaning operation.

Two types of pistons have been used in the standard Commando engine and when the rings are fitted, in outward appearance they are alike. They are of Hepolite manufacture and known as Low expansion thermal slot type. All these have four cast in slots - one at each side of each gudgeon pin boss. On the early piston a saw-cut in the oil control ring groove joins the cast slots round the front and rear of the top of the piston skirt and thus provides a 'heat barrier' between piston crown and skirt and so allows a closer working clearance between skirt and cylinder wall the aim being a quieter operation. The later piston does not have the saw-cut and is thus mechanically stronger. It gives a C.R of between 8.5 and 9 to 1 with a standard cylinder head, but with a Combat head, it will give a ratio of between 9 and 10 to 1. On looking inside a piston with rings fitted, one can see if the saw-cut is present or not and the piston without it has been used for racing, even in the T.T. However, a stronger piston still, without any low expansion device is the Hepolite 'Powermax' and this is the best piston for racing the 750cc engine.
With a standard cylinder head it will give a C.R or around 10:1 - perhaps just over with a cylinder head where the valve seats are well up. If used with a 'Combat' head - these are identified by the letter 'C' stamped on the top front of the rocker box - it is recommended that the head be lifted by about 1mm (.040"). This can be done with a compression plate made up to fit under the cylinder base or by the use of one solid copper head gasket - part No. 064071 with an eyeletted Hallite gasket above and below it, instead of the normal one eyeletted Hallite gasket part no. 063844. (Combat heads may also be marked RH3 - Service release N3/23 gives compression ratio data.)

CAMSHAFTS
It is not generally realised that the so-called standard camshaft fitted to all Commando engines prior to the Combat, and subsequently re-introduced in the 850 and the last 750 engines to be built, was the one designed by D.L Hele for the 1961 production racing Norton twins of 500 and 600cc. Very good performance can still be obtained with this in an engine which has been well built, and with all settings near correct and it has the advantage of giving more reliable valve gear operation in the case of a 'missed' gear change or broken driving chain. The combat engines are fitted with the double S cam which gives a longer timing and higher valve lift and this has since been superseded with the triple S and quadruple S type. Details for the tappet clearances to be used and the timing figures they give are on a separate sheet.
We trust these notes will be of help to those who wish to tune their engines at home - remember patience, cleanliness and care are the very essence of successful tuning - there is no 'secret'.
JOINTING CEMENTS
Excellent results will be obtained with Wellseal, Golden Hermetite and Plastic Gasket and this is the writers order of preference.

Whilst the above information relates chiefly to the Commando engines, much applies equally to the earlier smaller engines. At the beginning we stressed the importance of

Both camshafts should be timed using the normal pinion and sprocket timing marks but it is possible to advance or retard the camshaft in 5 degree stages by re-meshing the pinions and sprockets. (One tooth on the camshaft sprocket equals 40 crankshaft degrees and three teeth on the intermediate gear equals 45 crankshaft degrees)

To make the three degree variation mentioned above therefore, the camshaft sprocket should be turned in the chain one tooth clockwise which will retard it 40 degrees, then the intermediate gear should be rotated three teeth anti-clockwise which will advance the camshaft 45 degrees which equals a net advance of 5 degrees.

This should then be reduced to 3 degrees by filing a tiny step on the camshaft key to turn the sprocket only 1 degree anti-clockwise.

The quadruple S camshaft gives the following timing:-

I.V.O - 65 degrees B.T.D.C)
1.V.C - 83 degrees A.B.D.C) Lift on inlet pushrod at T.D.C.
E.V.O - 88 degrees B.B.D.C) from centre of base circller:-
E.V.C - 60 degrees A.T.D.C) .1885”

Tappet clearance with engine cold -

Double S	= .010” inlet and ex
Triple S	= .016” “ “ “
Quadruple S	= .016” “ “ “