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CRUSADER PISTONS

History

(1) Original low compression pistons for Crusader engines were made from Meteor pistons by adding valve clearance slots. These were cut at 22½° from the horizontal although the valve angle is 32½°. This difference of 10° was to allow for the slight doming on the exhaust valve head (which is the more likely to hit) and was correct for these low compression pistons which had only small valve clearance slots to miss the edge of the valve.

(2) With the introduction of the high compression piston, however, the valve clearance slots became larger. At first, to obviate making them excessively large, they were made to allow 1/32 in. less clearance between valve and piston. This, however, allowed the edge of the exhaust valve to hit when the engine was over-revved and later we altered the angle of the clearance slots to 32½°(i.e. 10° steeper). This gave more clearance with less cut out of the piston crown but cut deeper into the crown in the vicinity of the ring grooves. This alteration was made to the drawing of the piston (drg. No. 9444M. Work No. 43273, H.S.G. Ref. No. 13813) on 20th April 1961. I sent a print of this to Mr. D. Smallwood on 24th April and Hepworths were given instructions to make this modification to future pistons as soon as possible without affecting deliveries. Hepworths accepted these instructions but moved the two top ring grooves down 1/32 in. (reducing the width of the third land from ⅛ in. to 3/32 in.) so as to leave more metal between the bottom

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of the valve pockets and the top ring groove. They offered to send two sample pistons for test. I declined these since this would have meant a delay of 8 weeks and we were anxious to have the modified clearance slots as soon as possible, being in trouble with the old ones. It seemed to me reasonable to accept Hepworths advice regarding land widths and in fact I have no evidence of any trouble from the use of this narrow bottom land on the Hepworth 13813 casting which has plenty of metal behind the scraper ring groove. A piston of this type was returned recently by Kings of Oxford with local scuffing at odd places on the skirt and both compression rings stuck in their grooves, badly scuffed and apparently having been fitted with insufficient gaps. The scraper ring is, however, quite free in its groove and the defects in the piston are not attributable to any fault in the design.

(3) At about this time consideration was given to a still higher compression piston for the Crusader Super 5 engine which was required to have the whole top face of the piston raised by .040 in. (except for the faces of the valve clearance slots). To have machined this from the old 13813 casting would have made a very heavy piston obviously quite unsuitable for a high revving engine, particularly bearing in mind that we were already having trouble with the connecting eyes, caps, bolts and bearing shells on the Crusader Sports when used at really high speeds. To have fitted a heavier piston in a higher revving engine would obviously have caused still more trouble. We therefore called for the Super 5 piston to be made from the lighter Constellation casting. By this time we had been using this piston quite satisfactorily for several months in the Constellation engine whose pistons differ externally from those used in the Crusader Sports only as regards the depth and angle of the valve clearance slots. None of the troubles had occurred which I had thought possible, i.e. holes in the crown, distortion of skirt, etc.

Messrs. Hepworth & Grandage advised us that in their opinion machining the larger valve clearance pockets on this lighter casting would leave the crown locally too thin. We therefore agreed to a small modification of the core to thicken up the crown under the clearance pockets even though this meant adding about 2 drams to the weight of the piston when machined for the Constellation engine.

Pistons from the modified lighter castings were called for both with an extra .040 on the Crown for the Crusader Super 5 (Drg. No. 30278M, Work No. 46912 H.&.G. Ref No. 15663) and to the standard height for the Crusader 250 and Crusader Sports models (Drg. No. 43273/A, H.&.G. Refs No.15664) but so far none of the latter type have been supplied.

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(4) To use up surplus Constellation Pistons it was decided instead of ordering pistons to our drawing No. 43273/A to modify existing Constellation pistons (Drg. No. 9986M , Work No. 45375, H.&.G. Ref. No.14843) cutting on them valve clearance slots as on the Crusader pistons. This was taking a calculated risk since these pistons were from the light castings without the local thickening up beneath the clearance slots referred to above. They had, moreover, not got the compression ring grooves lowered by 1/32 in. so that not only was the metal too thin beneath the clearance slots but also the corner of the clearance slot was dangerously near the back of the top ring groove. Before adopting this course, however, a modified Constellation piston with the valve clearance pockets cut deeper than called on the Drawing No. 43273/A was run in prototype Super 5 engine with the cylinder barrel shortened by .040 in. This gave no trouble.

Present Troubles

(5) Troubles with various 250 pistons can be described as follows :-

(a) Holes burnt through the crown in the Super 5 engine

This is not attributable to the crown being too thin since it has a minimum thickness of 0.26 in. The basic reason is that the compression ratio is too high. This is nominally 9½ to 1 but a variation of 1cc in compression volume, easily produced by variations in machining, makes a difference of ½ ratio, so that some engines may well have a ratio higher than 10 to 1. This has already been dealt with by

(i) Standardising HN3 instead of HN2 sparking plugs
(ii) Raising the carburettor needle one notch
(iii) Fitting one size larger main jet
(iv) Issuing a Service Bulletin recommending the use of 100 octane petrol.

In addition it is now proposed to fit a compression plate about .010 in. thick beneath the cylinder.

(b) Stuck Compression Rings (all 250 cc models)

This seems in general to be associated with rings butting. The ring drawings call for clearances of .013/.018 in. for the top ring and .011/.016 in. for the other two when measured in a ring gauge 2.751 in. diameter (the cylinder diameter.) Rings to these dimensions have been used satisfactorily for years in Crusaders, Bullets and Twins. A large number of rings were checked in a gauge 2.750 ins. diameter. The chrome plated top rings were found to have gaps averaging .010 in. plus and the other rings .008 in.plus. Allowing the extra .00314 in. gap for extra

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.001 in. bore it appears that these rings are on the low limit for gap. Hepworths' recommendation is for .003 in. minimum gap per inch of bore for normal engines and.005 in. minimum per inch for air-cooled racing engines, i.e. for this size of cylinder a minimum of .00825 in. for normal engines or .01375 in. for racing engines. Our minimum figure of .011 in. would therefore seem to be adequate and has in fact proved to be so in the past. It appears, however, that conditions in our 250 cc engines when driven hard are close to those in a racing engine and that more clearance is required. Instructions have now been given to increase the gap on all rings to .015/.020 in., 150 sets of rings with these gaps will be sent to us on 25th inst to enable rings on pistons in stock to be changed. These rings will be charged but credit will be allowed on return of rings removed from pistons. It will be noted that the rings fitted by Hepworths to our pistons are in accordance with the drawings which we have approved although at present their gaps appear to be at or near the low limit. Rings to these drawings have given satisfactory service over many years in 350 singles and 500 and 700 twins and have been satisfactory up to now in the harder worked 250 singles. Why we should now find the gaps insufficient is not clear. Possibly however, previous pistons for Crusader Sports engines have had rings with gaps nearer to the high limit.

(c) Collapse of Piston Crown

This has occurred on the re-worked Constellation pistons. As already stated a calculated risk was taken in cutting Crusader valve clearance slots on these light castings which had neither the top ring groove lowered nor local thickening beneath the slots. The justification for taking this risk was the successful use of such a piston with the slots cut deeper than standard to enable it to be run in a cylinder .040 in. shorter than standard. It now appears that in addition to taking this calculated risk an unknown factor was brought into the picture by the fact that the slots which have been added to these Constell ation pistons have in fact been cut at the old angle of 22½° instead of 32½° . This improves the position so far as thickness of metal between the clearance slot and the ring groove is concerned and does not decrease the minimum thickness of metal. It does, however, mean that the thin metal extends over a much larger area. In several instances this has resulted in partial collapse of the piston crown as a whole and/or locally in the middle of the valve clearance pockets. In some instances this has resulted in fracture of the material, permitting the hot gases to blow through creating a small round hole which is quite different in character from the larger, rougher edged holes in the crowns of someof the Super 5 pistons.

To over come this a Constellation piston is being modified with valve clearance slots cut at 32½° as on the current Crusador piston drawing but

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with the shape of the exhaust clearance slot modified to follow more closely the form of the valve head thus giving more metal between the slot and the top ring groove. This modification to the shape of the clearance slot does not apply in the case of the inlet side, since the inlet valve head is basically flat with a central recess. Tests with plasticene have, however, shown that with clearance slots as shown on the present Crusader piston drawing there is approximately 3/32 in. between the piston and the valve at the closest point. It is not necessary to give so much clearance as this in the case of an inlet valve which is closest to the piston when the valve is opening, whereas the exhaust valve is closest when it is closing. If the engine is over revved the exhaust may close late and hit the piston but no amount of over revving can cause the inlet valve open earlier than is intended. On the inlet side it is therefore only necessary to allow for the valve to clear the piston when the engine is turned over slowly plus a small allowance for variations in machining and for connecting rod stretch.

This sample Constell ation piston is therefore having the inlet clearance slots cut 1/32 in. shallower than called for on the current Crusader piston drawing. This will give approximately the same metal thickness between the slot and the ring groove as on the Crusader piston which has the ring groove 1/32 in lower.

(d) Collapse of Scraper Ring Grooves

On some pistons the scraper ring groove has closed in at the front and rear of the piston trapping the ring and allowing excess oil to reach the combustion chamber. At first this trouble was noticed only on Super-5 pistons which are made from modified light Constellation castings and have the top two ring grooves lowered by 1/32 in. leaving the land immediately above the scraper ring groove only 3/32 in. wide. The heavier Crusader Sports pistons (W.43273) with identical ring groove positions did not show this trouble, neither did Constell ation pistons made from the light casting (W45375) with the two upper ring grooves 1/32 in higher giving a land width of $\frac{1}{8}$ in. immediately above the scraper ring groove. I thought at first therefore that this groove collapse was due to a combination of the light casting and the narrow third land. Unfortunately, however, at least two Constellation pistons have now come to light which have been used in Crusader Sports engines (after re-cutting the valve clearance slots) and which show collapse of the scraper ring grooves as well as of the piston crown. These pistons have no holes in the crown so the coll apse of the ring grooves is not due to excessive heat due to hot gases reaching the inside of the piston. It seems therefore that collapse of this groove is liable to occur with the light casting, when used under the more arduous conditions of the 250 cc

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engine, irrespective of the width of the third land. Nevertheless, the use of a land only 3/32 in. wide seems undesirable in a highly stressed piston and if the experiments with the modified valve clearance slots prove successful there is no reasonwhy the two upper ring grooves should not be raised 1/32 in. to restore them to their original position.

Action Taken

(1) Carburettor setting for Super-5 already altered. plugs changed to HN3.

(2) One dozen oil scraper rings .001 in. narrower than standard received from Hepworth & Grandage for test in Supr-5 pistons to minimise effect of coll apse of oil scraper ring groove. If successful future pistons to have this groove .001 in. wider.

(3) 150 sets of rings with increased gaps being despatched on Monday(25.6.62)

(4) Constell ation piston being re-worked with modified valve clearance slots at correct angle (33½°) but giving adequate metal thickness between clearance slot and top ring groove

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APPENDIX 'A'

PISTONS SUITABLE FOR USE IN 250 CC ENGINES

W.43273 Drg. 9444M H.& G. Ref. 13813

This is the original high compression piston for the Crusader 250 and Crusader Sports engines. It is made from a 'heavy' casting with a minimum crown thicknessof .025 in. Most of these pistons were machined with valve clearance slots at 22½° and the third land ⅛ in. wide. There is a slight local thickening on the under side of the crown to allow for the clearance slots at 22½°. Later pistons of this type had the angle of the clearance slots altered to 32½° and the two top rings lowered by 1/32 in. giving a third land width of 3/32 in. It is doubtful if any of these later type pistons were used in production but some have certainly been supplied as spares. They are quite satisfactory though a little heavy. The earlier pistons with 22½° angle clearance slots are liable to hit the exhaust valve if the engine is over-revved.

W.43273/A Drg. 10304M H.& G. Ref. 13813

This is the piston shown on current schedules for the Crusader 250 and Crusader Sports engines. Externall y it is identical with the later pistons to W.43273 with 32½° clearance slots and a 3/32 in. wide third land. The casting is, however, much lighter with a minimum crown thickness of 0.22 in. and less metal behind the ring grooves, particularly the scraper ring groove. The castings are in fact made from the current light Constellation piston dies modified to maintain 0.22 in. thickness beneath the valve clearance slots. No pistons of this type have yet been supplied but pistons from this casting machined to leave the crown .040 in. higher are used in the Super-5 engines under W.46912, Drg. No. 10278M, H.&.G. Ref. 15663. The Super-5 pistons and Constellation pistons used in Crusader Sports engines are subject to coll apse of the scraper ring groove, trapping the ring. Both W.46912 and W.43273/A pistons are now being redrawn showing extra metal behind the scraper ring groove, the two top rings raised by 1/32 in. to give a ⅛ in. wide third land and the modified valve clearance slots to ensure sufficient thickness of metal between the slots and the ring groove. These pistons will be re-numbered W.46912/A and W.42373/B respectively.

W.38690 Drg. 9348M. H.& G. Ref. 12123

Since the new clearance slots will increase the compression ratio we are now waiting for recommendations from H&G for a reduction in dome height.

This piston was originally used in the Constellation and l ater in the 350 Bullet and 350 Clipper. It is made from a 'heavy' casting with a minimum crown thickness of 0.25 in. When machined with valve clearance slots as on W.43273/A the crown thickness is reduced but not seriously. These slots, however, come dangerously near the top ring groove which is 1/32 in. higher than on W.43273/A. The modified clearance slots as on W.43273/B will make these pistons fit for use in the Crusader 250 and Crusader Sports.

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W.45375. Drg. 9986M. H.&.G. Ref. 14843

This is current Constellation piston made from the lightened casting. When incorrectly cut with valve clearance slots at 22½° the crown beneath the slots has proved too thin. Slots at 32½° as on W.43273/A 1 eave the crown much stronger but are dangerously near the top ring groove. Modified slots as on W.43273/B should make the piston crowns safe but these pistons when used in a 250 cc engine are still liable to collapse of the scraper ring groove.

W.45788 Drg. 10237M H.&.G. Ref. 15081

This is the current 350 Bullet piston. It is made from an identical casting and machined to the same dimensions as W.45375 above, the only difference being the scraper ring equipment. The remarks re W.45375 above therefore apply to W.45788.

APPENDIX 'B'

EFFECT OF DIFFERENT MILLINGS OF CLEARANCE SLOTS

No. 1. Milling 22½° as on original W.43273 and up to now on re-worked Constellation pistons (not safe, valves hit and crown too thin on light castings)

No. 2. Milling 32½° as on l ater W.43273, W.43273/A and W.46912 (Super Sports). Too little metal between clearance slots and top ring groove if this milling is used to re-work Constellation or Bull et pistons.

No. 3. Milling 32½° double angle on exhaust side, inlet left 1/32" higher than with No. 2 milling.

COMPRESSION RATIOS

Super-5 Piston

No. 2. Milling 9.85 : 1 = 28 cc
No. 3 Milling 10.35 : 1 = 26.5 cc

No. 2. Milling with compression plate .017" thick (two paper washers) 9.2 : 1 (30.2 cc).
(To be used for Super-5 for the present).

Crusader Sports Constellation or Bullet Pistons

No. 1. Milling 8.5 : 1 = 33 cc
No. 3. Milling 9.4 : 1 = 29.5 cc

No. 3. Milling with compression plate .017" thick (two paper washers) 8.8 : 1 (31.75 cc).
(To be used for Crusader Sports till stocks of re-worked Bullet and Constell ation pistons have been cleared)

No. 1. Milling with compression plate .017" thick (two paper washers) 35.25 cc = 8.05 : 1
(Suggested for use in 250 Clippers as a possible way of using up about 200 Constellation pistons with this milling which are liable to collapse if run at 8.5 ; 1).
To be tried.