Publication 9274
December, 1952

SERVICE MANUAL

(PART 1)

RUSTON

SMALL VERTICAL OIL ENGINES

VTO . VSO
VTH . VSH

RUSTON & HORNSBY LTD.
LINCOLN . . ENGLAND
(Associated with Davey, Paxman & Co. Ltd., Colchester)

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FOREWORD

This manual has been prepared to give the best possible guidance to our Agents and their Engineers, particularly overseas, in overhauling RUSTON engines in their respective territories.

Our object is to cover all dismantling and re-assembling operations, and at the same time give dimensions and constructional details of the special tools etc., which are required. By careful study of the MANUAL, Agents and their Engineers should be able to effect engine overhauls in much the same manner as carried out in our shops.

All special tools and equipment described may be purchased from us, or if desired may be manufactured in clients' own workshops from the drawings contained herein.

The wide range of our productions compels us to have several divisions, viz:—

Small Vertical Engines.

Medium Vertical Engines.

Large Vertical Engines.

Horizontal Engines.

Locomotives.

General Products.

Each division is sub-divided into Sections, so arranged to cover, in order of method of overhaul, the particular engine, or engines it is convenient to include in the Section.

Improvement in methods of production, and in overhauling, are always being made, consequently we have adopted the loose-leaf principle so that information on the latest methods in overhaul and service practice can be added to the MANUAL, and for this purpose arrangements have been made to keep Agents up-to-date by sending them further pages, or Sections, as and when the need arises.

It will, no doubt, be realised that the adoption of the loose-leaf method of compilation precludes the consecutive numbering of pages and illustrations, therefore each section, within its sub-division, is self-contained to date, but can be added to when necessary.

Finally, we would ask that Agents do not hesitate to communicate with us in the event of any precise difficulties where the methods stated herein cannot be employed in a particular instance, when we shall be pleased to afford every possible assistance in resolving their problem. On the other hand any suggestions for improvements to the tools and equipment described, which our friends in their experience have found to save time and/or materials, would be warmly received.

SECTION INDEX

DECEMBER, 1953

CORRECTION SHEET

ISSUED DECEMBER, 1953

This Sheet replaces that issued in February, 1953

New SECTION INDEX dated December, 1953, replaces present SECTION INDEX, undated.

SECTION S.V.2 (f)

Pages 7 to 10 dated February, 1953 replaced pages dated December, 1952 which should have been destroyed.

SECTION S.V.8 (f) and (g)

Grey lead sheet dated December, 1953 replaces that dated December, 1952.

Remove page 11 dated December, 1952.

New pages 11 to 20 inclusive dated December, 1953 to be inserted between page 10 and the grey lead sheet of S.V.9.

SECTION S.V.11 (a), (d) and (e)

Grey lead sheet dated December, 1953 replaces that dated December, 1952.

Pages 5 and 6, Sub-section (*a*) dated December, 1953 replace pages 5 and 6, dated December, 1952.

New pages 19 to 28 inclusive dated December, 1953 to be inserted between page 18 and the grey lead sheet of S.V.12.

SECTION S.V.12 (a) to (g)

Remove the two sheets dated December, 1952.

New grey lead sheet and pages 1 to 22 inclusive dated December, 1953 to be inserted between page 28 of S.V.11 and grey lead sheet of S.V.13.

SECTION S.V.14 (a)

Pages 1 and 2 dated February, 1953 replaced pages dated December, 1952 which should have been destroyed.

Pages 1 and 2, Sub-section (*a*) dated December, 1953, replace pages 1 and 2, dated February, 1953.

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ERRATUM

SECTION S.V.8 (a) page 4

Item 7 in the Table of Parts should read :—

Stock	$\frac{5}{8}$" B.S.F. Setscrew	One

SECTION S.V.II (a) page 4

The last line should read :—

The adaptor required is 6-SD-84 No. 1 Swan neck.

SECTION S.V.I3 (a) page 1

Line 9(a) should read :—

B.M.E.P. at 1000 R.P.M.	p.s.i.	78.8	83

SECTION S.V.I3 (b) page 3

The figures for lubricating oil pressure should read :—

Lubricating Oil working pressure	p.s.i	20 to 30
	kgs/cm²	1.4 to 2.1
Lubricating Oil minimum pressure	p.s.i.	8 to 10
	kgs/cm²	0.56 to 0.7

SERVICE DATA

CLASS VRH

No. of Cylinders		3	4	6		
B.H.P.	At 1500 r.p.m.			90		
B.S. Rating	At 1250 r.p.m.	37.5	50	75		
Curve 3.	AT 1200 r.p.m.	36	48	72		
	At 1000 r.p.m.	30	40	60		
Bore in (mm)		4.5			114.3	
Stroke in (mm)		5.5			139.7	
Compression Pressure p.s.i. (kg/cm^2)		450			31.7	
Firing Pressure p.s.i. (kg/cm^2)		825/875			58/61.5	
Injection Pressure p.s.i. (kg/cm^2)		2900/3100			204/218	
Lub. Oil Pressure Wkg. p.s.i. (kg/cm^2)		20 to 30 MIN 15			1.4 to 2.1 MIN 1.0	
Bumping Clearance in.(mm)		.0375 to .0425			.095 to .11	
Gasket Thickness in.(mm)		.042/.047 + beading			1.067/1.194	
Shims available in.(mm)		.004 & 010			.101 & .254	
Liner projection in.(mm)		.004 to .006			.101 To .153	
Inlet Valve Tappet Clearance Cold in.(mm)		.010			.25	
Exhaust Valve Tappet Clearance Cold in.(mm)		.010			.25	
Fuel Pump Plunger Head Clearance in.(mm)						
Water Inlet Temp. Recommended ^oF (^oC)		160			71	
Water Outlet Temp. Maximum ^oF (^oC)		180			82	
Lub. Oil Temp. Maximum ^oF (^oC)		160			71	

Grade of Lub. Oil STRAIGHT MINERAL or HD	Amb. temp. Over 40°F (4.4°C) S.A.E. 20	Below 40°F (4.4°C) S.A.E. 20	Over 85°F (30°C) S.A.E. 30	
Lub. Oil Sump Capacity Gal. (Litres)	5(22.7)	6½(29.5)	9(40.8)	
Water Capacity. Jackets Gal. (Litres)	2½(11)	3½(16)	5¼(24)	
Water Capacity. Radiator Gal. (Litres)	5.7(26)	5.7(26)	7.5(34)	
Lub. Oil Consumption. Pints (Litres)per hr.	.13(.074)	.174(.098)	.31(.176)	

Spanner Torque lb.ft. (kgm)	At Nut	At Extension
Cylinder Head Stud Nuts (Large)	130/140	(17.8/9.4)
Cylinder Head Stud Nuts (Small)	90/100	(12.4/13.8)
Cylinder Block or Barrel Stud Nuts		
Main Bearing Stud Nuts		
L.E. Bearing Bolts & Setscrews		
Flywheel Retaining Screw		
Main Bearing Cap NIP in.(mm)		
Connecting Rod Bolts or Setscrews Re-newal	4000 hours at 1500 R.P.M.	6000 hours at 1000
Connecting Rod Bolts Stretch in.(mm)		
Main Bearing Bolts Stretch in.(mm)		

	Drg. Size in	Drg. Size mm	Designed Clearance in	Designed Clearance mm	Maximum. Permissible in	Maximum. Permissible mm
Crankshaft Main Journal	2.9995/2.999	76.19/76.18	.0038/.0054	.096/.137	.008	.20
Main Bearing 3&4 VRH only	3.0033/3.0044	76.28/76.3				
Crankshaft Centre Journal	3.624/3.6235	92.05/92.04	.0035/0055	.09/.14	.008	.20
Main Bearing Centre 6VRHonly	3.6275/3.629	92.13/92.18				
Crankshaft Large End Pin	2.9995/2.999	76.19/76.18	.0020/.0042	.05/.11	.007	.178
Large End Bearing	3.0015/3.0032	76.24/76.28				
Gudgeon Pin	1.4995/1.499	38.09/38.07	.0015/.0025	.038/.063	.004	.10
Small End Bush	1.501/1.5015	38.12/38.13				
Valve Stem	.434/.433	11.02/11.00	.0035/.0055	.09/.14	.010	.254
Valve Guide	.4375/.4385	11.11/11.13				
Piston Ring Width	.125/.124	3.175/3.150	.001/.003	.0254/.0762	.007	.178
Piston Ring Groove Width	.126/.127	3.18/3.22				
Piston Ring Gap			.011/.016	.28/.40	.030	.76
Crankshaft End Float			.002/.005	.0508/.127	.012	.30
Gudgeon Pin End Float						
Liner or Barrel	4.500/4.501	114.3/114.32			.015	.38

Basic Valve Settings:-

Air Valve Opens	10°	B.T.D.C.	Air Valve Closes	50° A.B.D.C.
Exhaust Valve Opens	45°	B.B.D.C.	Exhaust Valve Closes	15° A.T.D.C.
Starter Valve Opens		D.C.	Starter Valve Closes	B.D.C.
Injection Commences	32°	B.T.D.C. 3 & 4 VRH		

Overwidth Piston Rings Available	in.		.010	.020	.030	
	mm.		.25	.51	.76	
Undersize Bearings Available	in.	.005	.010	.020	.030	.040
	mm.	.127	.254	.508	.762	1.01
Oversize Pistons Available	in.					
	mm.					

DECEMBER, 1952

SVI

ENGINE DESCRIPTION

ENGINE DESCRIPTION

ARRANGEMENT OF SINGLE CYLINDER ENGINE
VTH–VSH

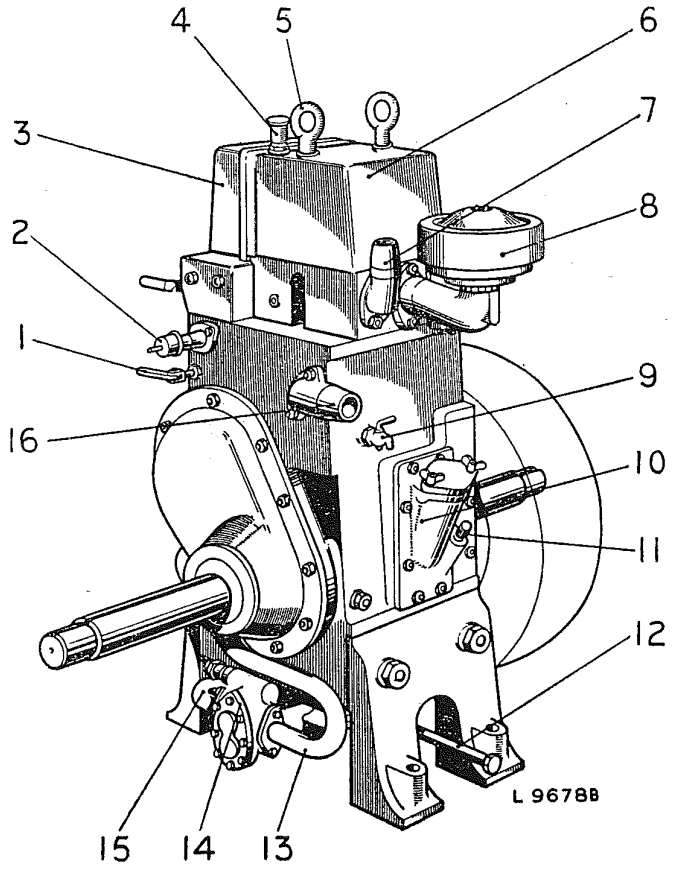

Fig. 1 Single Cylinder Engine (opposite Camshaft side)

1. Cut out lever for fuel pump
2. Speed controller
3. Valve gear cover
4. Oil cup for valve rocker lubrication
5. Eye bolt for lifting engine
6. Cylinder head cover
7. Water outlet connection
8. Air filter
9. Water drain tap
10. Lubricating oil filler
11. Dipstick
12. Lubricating oil drain pipe
13. Lubricating oil delivery pipe, pump to crankcase
14. Lubricating oil pump
15. Lubricating oil suction pipe, sump to pump
16. Water inlet connection

ARRANGEMENT OF SINGLE CYLINDER ENGINE
VTH—VSH

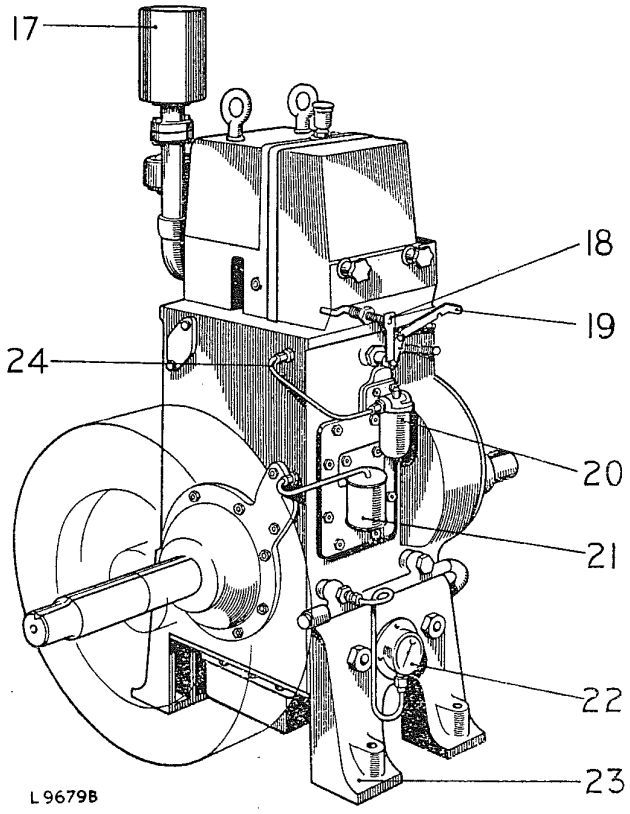

Fig. 1a Single Cylinder Engine (Camshaft side)

17. Exhaust silencer
18. Overload stop control
19. Spragging gear lever
20. Fuel oil filter
21. Injector drip can
22. Lubricating oil pressure gauge
23. Engine bearers
24. Fuel pipe from filter to pipe rail in housing

"CUT AWAY" SECTION OF RUSTON 4 VSH ENGINE

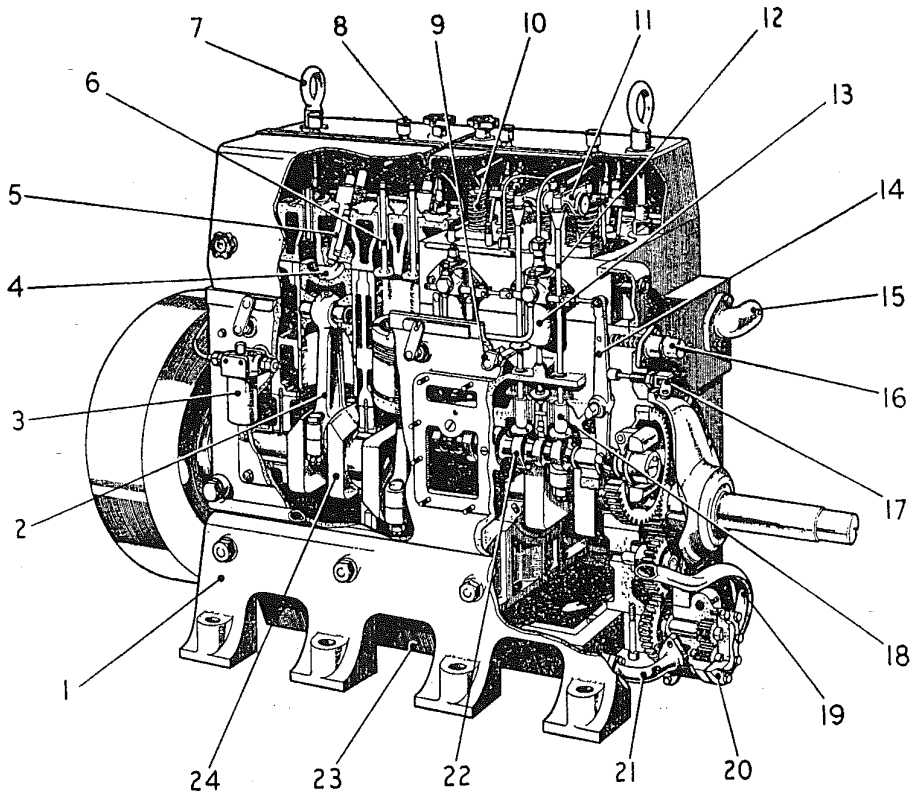

Fig. 2 Cut away section of Ruston 4 VSH engine

1. Engine bearers
2. Connecting rod
3. Fuel oil filter
4. Piston
5. Injector
6. Inlet and exhaust valves
7. Eye bolt for lifting engine
8. Lubricator for rocker lever lubrication
9. Spragging gear
10. Valve spring
11. Valve rocker lever
12. Valve push rod
13. Fuel pump
14. Governor lever
15. Water inlet connection
16. Speed control
17. Cut out lever for fuel pump
18. Valve tappet
19. Lubricating oil delivery pipe, pump to crankcase
20. Lubricating oil pump
21. Lubricating oil suction pipe, sump to pump
22. Cams and camshaft
23. Lubricating oil sump
24. Crankshaft

ENGINE DESCRIPTION

Ruston engines work on the four-stroke cycle—*i.e.* (1) suction-stroke, during which pure air is drawn into the engine cylinder, (2) compression-stroke, towards the end of which fuel is injected, (3) working-stroke, during which combustion and expansion of the charge takes place, (4) exhaust-stroke, during which the products of combustion are expelled.

Ignition of the combustible charge is efficiently effected by the rise of temperature caused by compression, and starting from cold is an easy procedure.

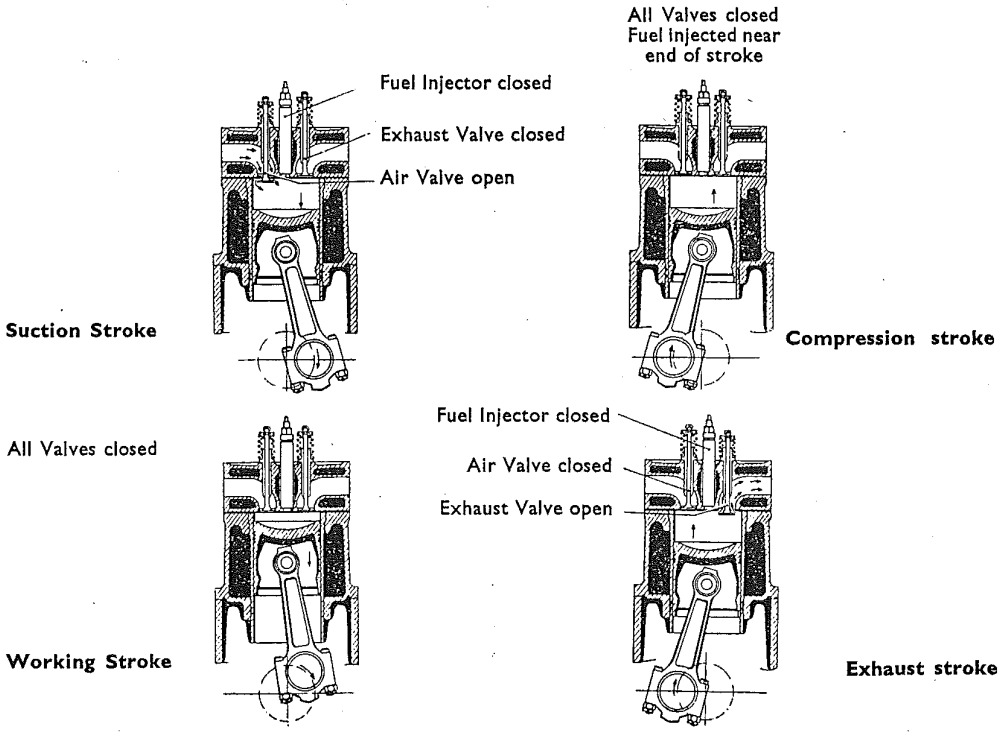

Fig. 3 4-stroke cycle.

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SV 2

CYLINDER HEAD

CYLINDER HEAD

CYLINDER HEAD

REMOVAL

i. Drain cooling water by drain cock at lowest point of cooling system—*e.g.*, item 9 in single cylinder arrangemens, see Fig. 1 S.V.1.

ii. Remove head covers and support bar when fitted.

iii. Disconnect and remove fuel oil, water and air pipes.

iv. Remove water outlet, air inlet and exhaust manifolds and the injection equipment.

v. Remove cylinder head nuts.

NOTE If engines are to be serviced in large numbers it will be found helpful to have tube and ring spanners for this operation.

vi. When the cylinder head nuts have all been removed the valve rocker bracket should be lifted off.

vii. The cylinder head may now be removed.

NOTE If reasonable care is exercised it is possible to preserve cylinder head and other joints through several overhauls.

REPLACEMENT

i. ALL DAMAGED or doubtful joints must be renewed.

ii. Clean joint and joint faces and smear soft soap thinly on either side of the joint.

iii(*a*) Reverse procedure stated in **REMOVAL** and with regard to vi. above, the rocker bracket should be so positioned as to make the centre-line of the rocker pads, when looking from the end of the engine, co-incident with the centre-line of valve caps to prevent side thrust on the valve stem.

A glance at illustration Fig. 8, covering valve tappet clearances will make this point clear.

iii(*b*) On the four cylinder engine the procedure differs slightly due to the fact that two separate blocks, covering two cylinders each, are fitted. To ensure that the two heads are in line one with the other, they should be dropped on and head nuts put on finger tight only, then the air, and/or exhaust manifold complete with joints should be fitted and tightened into position.

Tighten head nuts in accordance with the note over.

IMPORTANT NOTE

All cylinder head nuts must be under even tension and this can only be ensured by TIGHTENING PROGRESSIVELY in order those nuts which are diametrically opposed.

It is recommended that the order of tightening shown in Fig. 1 be followed.

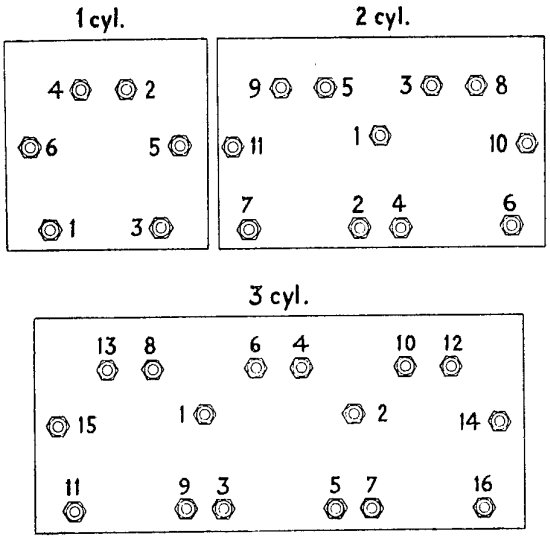


Fig. 1

Tension MUST BE applied gradually to prevent distortion.

FOLLOWING UP

After the initial run the head nuts should be further tightened whilst the engine is at running temperature, using NO MORE FORCE than is necessary to obtain a gas tight joint.

VALVE SPRINGS

The valve springs can, if necessary, be removed and replaced without disturbing the cylinder head.

REMOVAL with cylinder head on engine, but with valve gear cover off.

i. Set piston on top dead centre (Firing Stroke).

ii. Remove valve rocker bracket assembly after undoing two only cylinder head nuts.

iii. Hardened caps to be removed from valve stems.

iv(*a*) (**Exhaust Valve**) Decompress valve spring retaining collar, sufficient to remove collets.

Tool in Fig. 2 may be used or any other bar-cum-lever arrangement with a hole in it to allow the valve stem to protrude and collets to be removed.

iv(*b*) (**Inlet Valve**) Remove split pin from valve stem and spring retaining collar—then proceed as for exhaust valve.

NOTE This valve is fitted with a shroud, therefore the illustration—Fig. 3, serves to emphasize the important fact that the split pin hole in the inlet valve stem is OFF-SET to prevent the possibility of replacing the valve wrongly.

REPLACE Reverse the procedure stated above taking great care to put split pin hole in the inlet valve stem exactly in line with the slot in the pear shaped spring retaining collar.

IMPORTANT

The flywheel **MUST NOT** be turned during this operation otherwise the valves will drop into the engine cylinder and the head would then have to be removed to replace the valves in their guides.

The hardened valve cap **MUST NOT** touch collets, or retaining collar, but rest on top of valve stem.

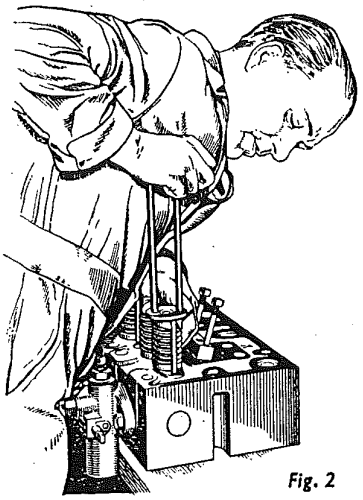


Fig. 2

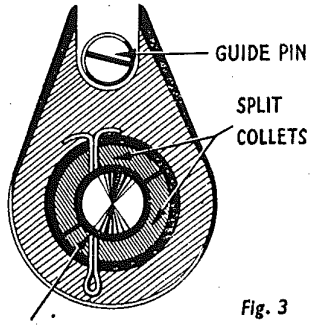


Fig. 3

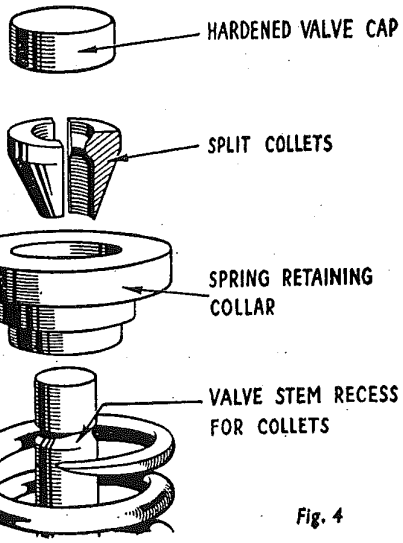


Fig. 4

INLET AND EXHAUST VALVES

The instructions assume that the cylinder head and the valve rocker gear have been removed from the engine.

REMOVAL

i. Place head on the bench on two wooden battens, not less than 1½ in. thick, to protect joint face, fuel pump and injector nozzle from damage.

ii. Remove valve springs (See Valve Springs).

iii. Withdraw valves from the underside.

REGRIND

If, upon examination, the line of contact on either valve or seating is found to be blackened, or pitted, the following procedure should be adopted:—

i. Place the head with seating in a convenient position.

ii. Smear fine, or if valves and/or seats are badly pitted, coarse carborundum paste, on the valve face (if coarse paste is required in the first instance, it will be necessary to finish with a fine abrasive). Great care must be taken to prevent abrasive from getting on the valve stem.

iii. Put a spot of oil on seating and insert valve in guide and with a joiner's hand brace and screw turn, grind the valve to seating with an oscillating movement—lifting from time to time, to grind in, in a fresh position.

NOTE A **light** spring under the head of the valve will be found extremely helpful. (See Fig. 5). The spring is just strong enough to lift the valve off its seating when pressure is released, thus enabling a fresh position to be obtained without having to reach over the head to lift the valve by hand.

Renew abrasive when it becomes inoperative.

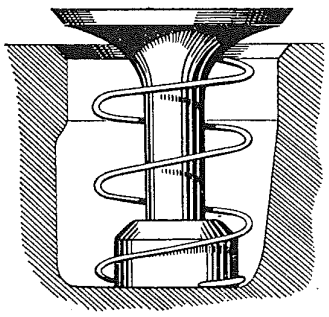


Fig. 5

CHECKING

Clean the valve and seating thoroughly and check by putting pencil lines diagonally across the seating—insert valve—apply direct pressure—move valve approximately ⅛"—lift and if **ALL** lines are found to be broken—the valve is seating correctly.

An alternative method is to clean the valve and seat of abrasive and then rotate valve with continuous circular movement with a spot of oil on the seat and if a bright unbroken line becomes evident the valve is seating correctly.

REPLACEMENT

Oil valve stem, insert in guide and fit springs as instructed on page 3.

IMPORTANT

In grinding valves and seats, always remember to remove only that amount of metal necessary to re-seat valve. To re-grind without regard to metal removed will reduce the working life of the parts concerned accordingly.

VALVE GUIDES

Inlet and exhaust valve guides are a driving fit in the cylinder head. The instruction assumes that the head has been removed from the engine.

REMOVAL

i. Stand head upside down on wooden blocks, or a frame, to give sufficient room for the valve guide to clear the bench when driven out; approximately 4" is required.

ii. Drive the guide out with tool 8224/3 IW. and a $\frac{3}{4}$" diameter steel bar about 9" long.

FITTING NEW GUIDE

i. Stand head right way up on wooden blocks.

ii. Ensure that the hole is free from burrs.

iii. Enter guide in the hole, taking care to see that it is at right angles (all ways) to the top facing.

iv. With tool (spigoted drift) and hammer, as shown in Fig. 6, drive the guide in until the faces of the bottom flange makes contact with the cylinder head facing.

Fig. 7 gives dimensions and manufacturing particulars of tool 8224/3 IW.

NOTE The diameters given are for VSO/H, figures for VTO/H diameters are $\frac{5}{8}$" and $\frac{5}{16}$" respectively, subject to the same tolerance.

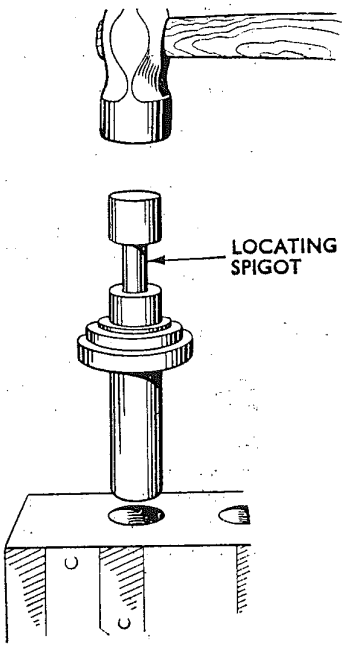


Fig. 6

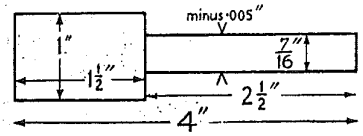


Fig. 7

VALVE TAPPET CLEARANCES

Valve tappet clearances require checking from time to time, and, of course, always after the cylinder head has been removed and replaced.

CHECKING

i. The engine should be ' COLD '.

ii. Turn flywheel until BACK-CAM position of the valve to be checked is reached. See Fig. 8.

If the engine cover has not been removed it is a good plan to put a chalk mark on the flywheel at **full-lift** and then turn the wheel 360° (one full turn).

iii. Check clearance, after applying slight pressure on top of adjusting screw, between hardened valve cap and the rocker pad. See Fig. 9.

iv. Adjust by means of the slotted screw and lock-nut—with screw driver and appropriate sized spanner.

NOTE A method which we have found most helpful in adjusting clearances, is to employ two feeler gauges, or sets of feelers, one gauge to be minus .001" and the other plus .001".

e.g.

in the case of the VTH where .006" is required a gauge .005" is the ' GO ' and .007" is the ' NO-GO '. By this means adjustment is quickly and accurately made. See Fig. 10.

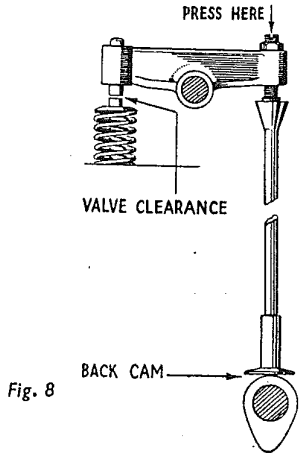


Fig. 8

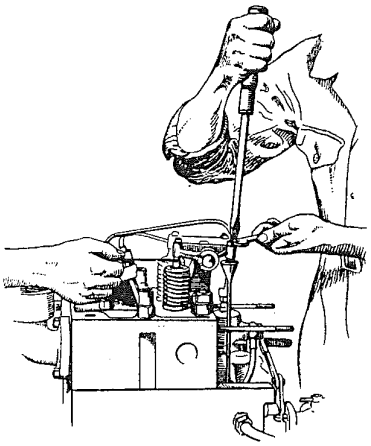


Fig. 9

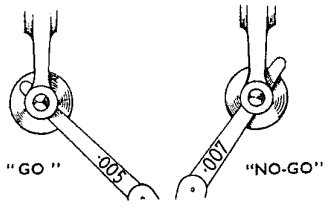


Fig. 10

CLEARANCES

VTO VTH	VSO VSH
.006 ins. .152 mm.	.007 ins. .178 mm.

TUBE FOR INJECTOR HOLE

VTH & VSH

This tube, part number 6786, the outside of which for part of its length is in contact with the water chamber, see Fig. 11, requires an expander, or special tools and treatment if and when it develops a leak or requires replacing. Tool numbers, or sizes are given below and the order of their use clearly shown. A study of the illustration, together with the following instructions will assist in carrying out the re-tubing operation quite readily.

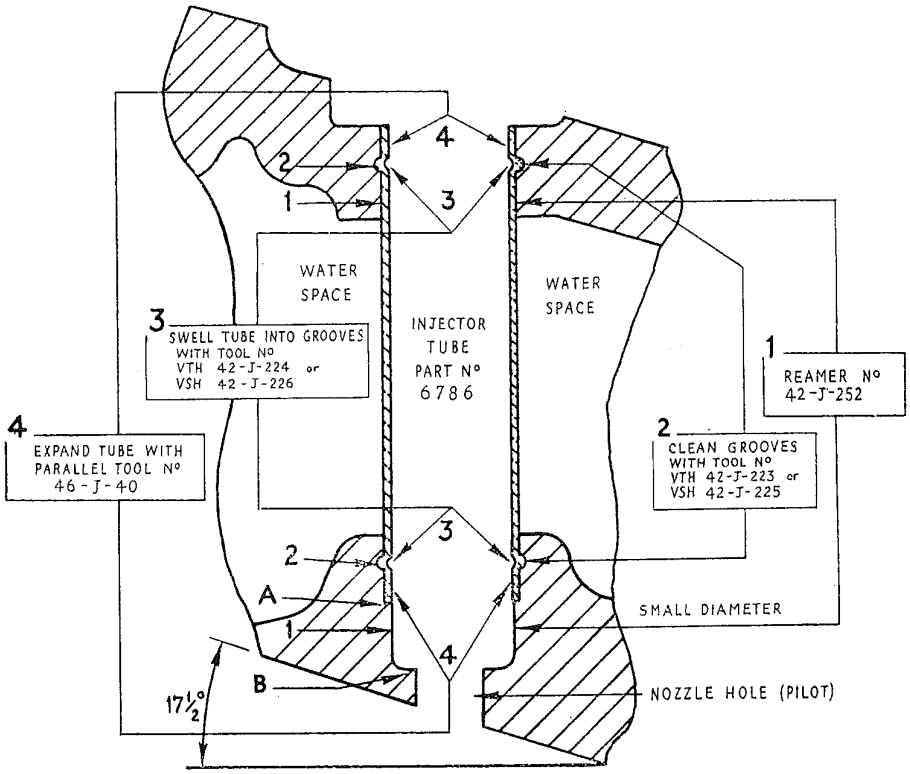


Fig. 11

5 **Final operation.** Clean hole with reamer, 1" + .010" dia.

No metal to be removed from shoulders 'A' and ' B ' during operation 1.

LEAKING TUBE

Should the tube leak, it is always advisable to try to cure this by means of the ball and parallel expanding tools in the first instance.

The expanding operation can be carried out by hand, whilst the cylinder head is on the housing, by merely removing the injector and retaining bar. Use the ball expander first.

Tool Nos. 42-J-224 and 42-J-226 are ball expanders, whilst tool 46-J-40 is a typical double taper expander, with single inner and multi taper needle roller outers, expansion being parallel to the bore. See items 6 and 7 illustration Fig. 12.

METHOD

i. Withdraw the mandrel in the sleeve to obtain smallest possible diameter of expander.

ii. Insert the expander into the injector tube making certain that the pilot, or end of the expander enters the bottom hole.

iii. With suitable wrench exert as much pressure as possible on the tool whilst turning, as if trying to reamer the hole.

Repeat each operation a few times and then test. If the leak cannot be cured by this means then the tube will have to be replaced.

The removal and fitting of new tubes is a job requiring workshop equipment, therefore the following instructions assume that adequate facilities are available.

EQUIPMENT AND TOOLS REQUIRED

i. Drill and table with about 2 ft. head room and say 1 ft. feed, having spindle speeds of 168 r.p.m. and 600 r.p.m. approximate, head suitable for No. 4 morse taper.

ii. Angle bracket to give 17½° from horizontal. See Fig. 12.

iii. Reamer, tool No. 42-J-252 (1, Fig. 12) *i.e.*, the finishing tool for the two diameters.

iv. Tool 42-J-223 or 42-J-225 (2, Fig. 12), for cleaning top and bottom grooves.

v. Ball expander, tool No. 42-J-224 or 42-J-226, (3, Fig. 12), for swelling tube into the grooves, thus locating it.

vi. Parallel expander, tool No. 46-J-40, (4, Fig. 12), for expanding tube in the bore.

vii. Reamer, at least 7″—8″ long, 1″ + .010″ dia. (5, Fig. 12), for clearing the hole finally.

REMOVING FAULTY TUBE

i Remove the head from the engine, strip it of accessory equipment and remove the injector studs.

ii. Mount and fix on the angle bracket 17½° from the horizontal, the parallel plane being at right angles to a line drawn through the centre of the two valves.

iii. With tool No. 42-J-252 machine the old tube out with a steady feed. This will clear the tube a little below the first swelling, and then, as may be expected, the tube will turn in the bottom groove.

iv. Remove the head from the machine and place on a bench, then by means of a narrow, slightly bent, round nosed chisel through the nozzle hole, collapse the tube until it is possible to remove it entirely.

NOTE **Great care** must be exercised during this operation to avoid damaging the holes in the casting.

FITTING NEW TUBE

i. Mount and fix head on angle plate.

ii. Clean holes out with reamer tool No. 42-J-252.

iii. Clean the grooves out with either tool No. 42-J-223 or 42-J-225. Spindle speed should be about 168 r.p.m.

NOTE Do not remove any cast iron from the grooves, or the bottoms of the holes.

iv. Drive the tube in, after clearing the hole of all drillings, etc.

v. Swell the tube into the two grooves with APPROPRIATE BALL expander, either 42-J-224 or 42-J-226, with spindle speed 600 r.p.m.

vi. Expand the tube with tool No. 46-J-40, spindle speed 600 r.p.m.

vii. Clear the hole out with the 1" + 010" reamer finally.

viii. Subject the head to a water test of 30 p.s.i.

The illustration Fig. 12 shows a two cylinder head on the angle bracket mounted on the block of a radial arm drill. Tools are shown in order of use during the expanding operation, with the exception of items 6 and 7 which show the hand operated versions of the BALL and PARALLEL EXPANDERS respectively.

The operator has completed one injector hole and is seen driving the tube in the second hole.

NOTE the angle of bracket.

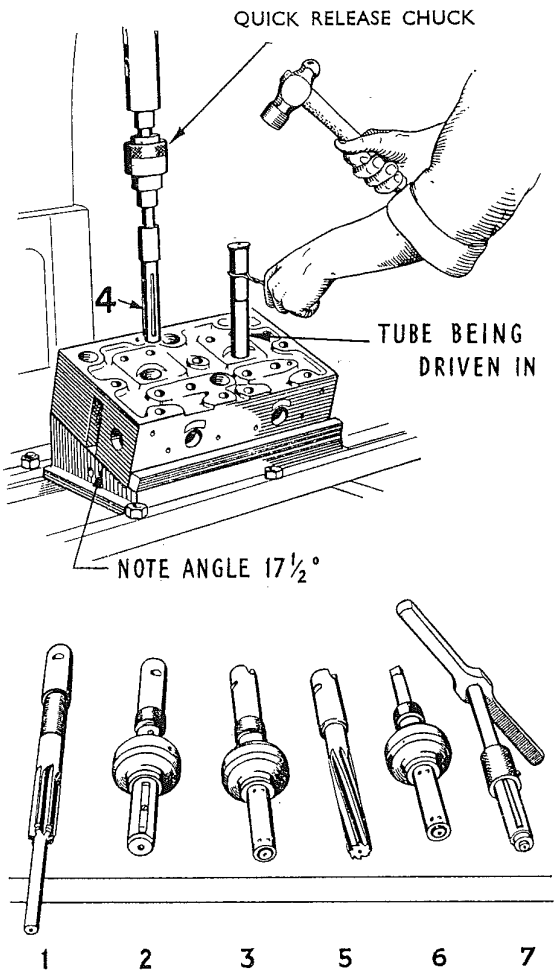


Fig. 12

VTO & VSO

To expand or renew the tube on the earlier model of this engine involves practically the same procedure, with, of course, one or two modifications and different tools.

Try to cure a leaky tube by the hand operated BALL and PARALLEL expanding tools using the same method as described for VTH and VSH.

For the method see VTH and VSH.

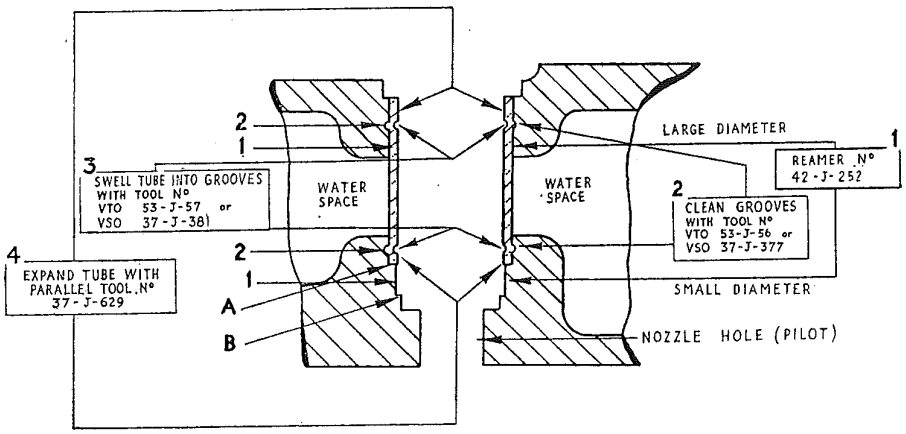


Fig. 13

5—Final operation. Clean hole with Reamer 1" + .010" dia.

No metal to be removed from 'A' and ' B ' during operation 1.

EQUIPMENT AND TOOLS REQUIRED

i. As for VTH and VSH.
ii. Angle bracket NOT required.
iii. The same, *i.e.*, tool No. 42-J-252. (1, Fig. 12).
iv. Tool No. 53-J-56 or 37-J-377. (2, Fig. 12).
v. Tool No. 53-J-57 or 37-J-381. (3, Fig. 12).
vi. Tool. No 37-J-629. (4, Fig. 12).
vii. As for VTH and VSH. (5, Fig. 12).

REMOVING FAULTY TUBE

Repeat as for VTH and VSH, except that no angle bracket will be needed.

FITTING NEW TUBE

i. Mount on drill block.
ii. Clean holes out with reamer 42-J-252.
iii. Clean grooves with tool No. 53-J-56 or 37-J-377, spindle speed 168 r.p.m.
NOTE No cast iron to be removed from bottoms of holes, or the grooves.
iv. Drive tube in.
v. Swell tube into grooves with tool No. 53-J-57 or 37-J-381, spindle speed 600 r.p.m.
vi. Expand tube with tool No. 37-J-629.
vii. Clean hole finally with reamer 1" + 010" dia.
viii. Test under pressure.

VALVE SEAT INSERTS

After a long period of service the valve seats of our small vertical engines may become badly recessed due to wear and repeated grinding in, to the point where normally consideration must be given to replacing the cylinder head.

To enable such heads to be reclaimed we give herewith dimensions and full particulars of the method to be adopted for the fitting of valve seat inserts.

THE INSERTS

The inserts should be obtained from PARTS SERVICE DEPARTMENT; the INSERT PART MARK AND ENGINE TYPE AND NUMBER to be clearly stated on your order.

The insert part mark is given in column 2 on the dimensioned sketch.

THE CUTTERS

The cutters for the recess will be supplied against your order and are recommended for ensuring that the machining of the head exactly conforms to the requirements of the inserts. See Fig. 14.

Quote the tool number in column 10 when ordering.

N.B. If these cutters are employed it will be necessary to remove the valve guides and to use the hole in the head as the pilot. In consequence the dimensions of the guide bolt, Fig. 15, will have to be suitably modified.

METHOD

i. Machine cylinder heads in accordance with the dimensions and instructions given, taking care to obtain a perfectly smooth finish at the side and **bottom** of the recess. The use of the cutters described above will ensure this.

ii. " Freeze " the seating until its temperature is approximately minus (—) 10° F. or —23.4° C. (For further particulars see note below).

iii. Wipe the seating clean and press into the recess as quickly as possible, making certain that it enters squarely and that the bottom face of the seating makes contact with the face in the head.

DO NOT TOUCH THE SEATING WITH BARE HANDS.

IMPORTANT

i. DO NOT DRIVE THE SEATINGS IN WITHOUT FREEZING.

To do so results in the removal by shearing of that amount of metal which provides the TIGHT FIT upon expansion, and the insert would rapidly become loose.

ii. After grinding valve and seating together, the head of the valve SHOULD NOT PROJECT more than the amount specified on the drawing above the face of the cylinder head.

FREEZING EQUIPMENT

The equipment we employ in our Works consists of a deep, narrow tank, heavily insulated at sides and bottom, designed and supplied by the Carbon Dioxide Company Ltd., of Great Britain. The tank contains at the bottom a quantity of alcohol (methylated spirits) into which a wire basket is placed so that the inserts to be frozen are in the liquid. An amount of ' CARDICE,' *i.e.*, solid carbon dioxide (CO^2) is placed in the container and the insulated lid put into position.

NOTE

With a liquid temperature of minus (—) 58°F. (—50° C.) in the refrigerator an immersion time of approximately 30 minutes is required to give the necessary reduction in size for PRESSING IN.

PRESSING IN

A tool and plate, similar to that shown on the sketch should be used, the actual insertion being best done under a press.

It is preferable, although not essential, to employ a guide when a press is available, but if a hammer and " set " is the only means of driving the insert into position then a guide MUST BE USED.

NOTE If a suitable old valve is available it will form a useful basis for the guide and press tool if reduced under the head in the manner shown.

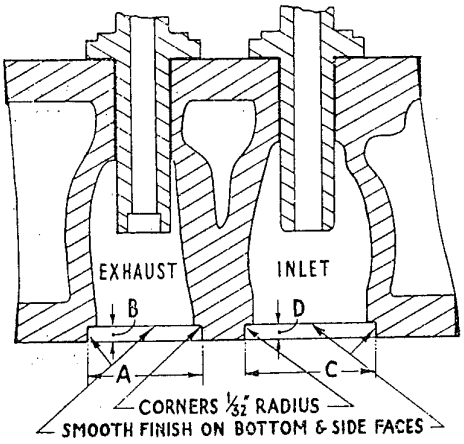


Fig. 14

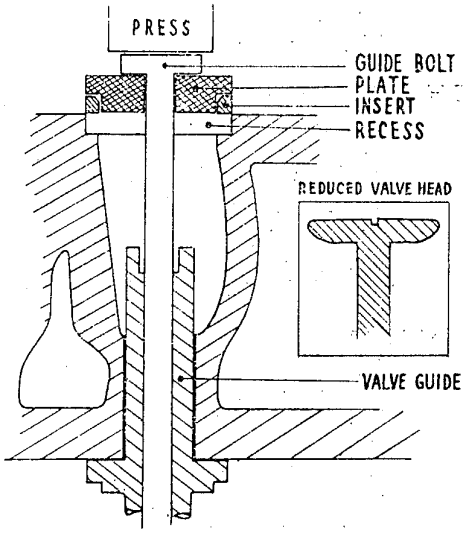


Fig. 15

Engine Type	Insert Part Mark		Exhaust Dimension.	Exhaust Limits (Thous.)		Inlet Dimension.	Inlet Limits (Thous.)	Projection.	Cutters. Tool Number.
VTO	40–313 Ref. 1	A	1½"	+0 −1 −0	C	1½"	+0 −1 −0	1/32"	52-J-317
		B	¼"	+3	D	¼"	+3		
VTH	50–1925 Ex. Ref. 2 In. Ref. 3	A	1½"	−1 +0	C	1 1/16"	−1 +0	1/32"	Ex. 52-J-317 In. 50-J-709
		B	7/32"	±1	D	7/32"	±1		
VSO	40–313 Ref. 3	A	1¾"	+0 −1 −0	C	1¾"	+0 −1 −0	1/32"	52-J-318
		B	9/32"	+3	D	9/32"	+3		
VSH	50–1926 Ex. Ref. 2 In. Ref. 3	A	1¾"	+0 −1	C	2"	+0 −1	1/32"	Ex. 52-J-318 In. 52-J-319
		B	7/32"	±1	D	7/32"	±1		

DECEMBER, 1952

SV 3

PISTON AND CONNECTING ROD

PISTON and CONNECTING ROD

RUSTON & HORNSBY

PISTON AND CONNECTING ROD

REMOVAL

i. Drain the water jacket, remove cylinder heads, manifolds, etc., and the crankcase doors, and protect the sump against falling particles.

ii. Uncouple the large-end bolts, the nuts of which may be locked by either tab washers or split pin and castle nut, according to date of installation.

iii. Withdraw piston and con rod through the liner.

iv. Remove circlips from gudgeon pin hole and soak piston in boiling water, or hot oil for a few minutes, after which the gudgeon pin may be pushed out quite easily.

GIVE ATTENTION TO PISTON AND CONNECTING ROD IN ACCORDANCE WITH S.V.4 and 5.

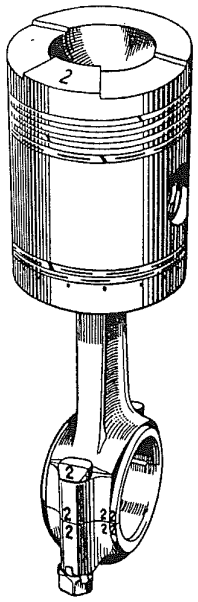


Fig. 1

REPLACEMENT

i. Study the illustration Fig. 1 which clearly shows the method of marking the parts that make up the assembly. Each part is numbered to suit the cylinder into which it is fitted. (The one shown is No. 2).

ii. Check that all parts belong to the assembly.

iii. Warm piston to facilitate fitting the gudgeon. Press this in with all numbers facing one way.

iv. Fit circlips.

v. Space the ring gaps evenly round the piston and smear with oil.

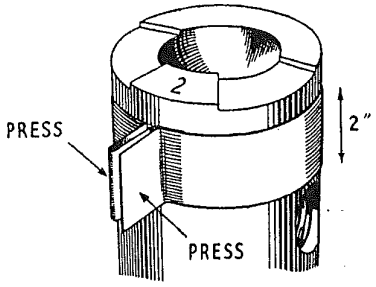
vi. The liner and crankpin should be clean and oiled.

vii. Fit piston and connecting rod into the liner, with the numbers facing the front, or camshaft side of the engine. A piston ring clip, made from 2″ wide tin or thin steel, about 20″ long to fit round the rings will facilitate getting them into the bore, see Fig. 2 and fold as shown in inset.

viii. Re-connect the large end bearing, fit split pin or tab washers as required.

NOTE Whilst the nuts should always be tight, care should be taken not to overstress the bolt, we therefore recommend that the length of spanner be limited to 10″.

ix. Replace crankcase doors and head, etc.



FOLD LIKE THIS
FOR OVERLAP

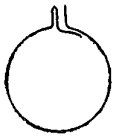


Fig. 2

DECEMBER, 1952

SV 4

SERVICING PISTON AND RINGS

SERVICING PISTON and RINGS

PISTON RINGS

The instruction assumes that the piston is removed from the engine and has been separated from the connecting rod. See Sections S.V.3 and S.V.5.

NOTE Before attempting to remove the rings it is recommended that the piston be immersed in paraffin.

REMOVAL

Two methods of removing rings have our approval:—

i. Four spring steel blades about .020" thick and say $\frac{3}{8}$" wide. One blade placed under each ' horn ' or at the gap, the other two at equidistant points round the piston. Hacksaw blades, with the teeth ground off, are suitable.

The ring is thus held clear of the piston grooves and can be eased off.

ii. A pair of ring ' pliers,' or ' expander ' of which there are a number of excellent types on the market.

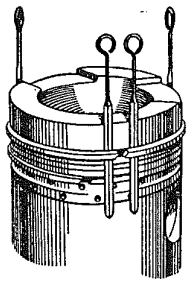


Fig. 1. Spring steel blades in use.

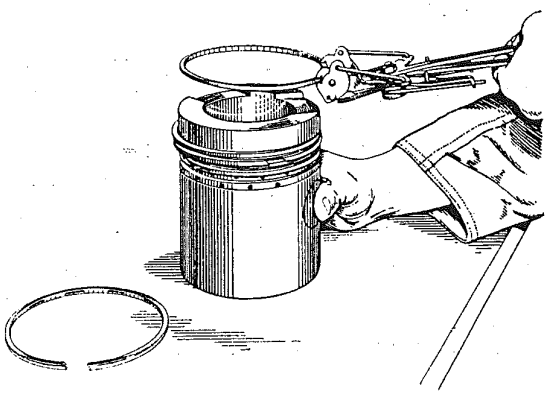


Fig. 2. Expander in use.

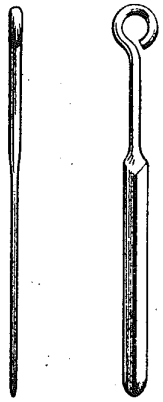


Fig. 3. A convenient shape of blade.

REPLACEMENT OR RENEWAL

i. Thoroughly clean the ring grooves.

ii. Try the ring in its groove to make sure it is free all round and is a good bed on the top and bottom faces of the groove, see Fig. 4.

iii. With " blades ' or ' expander ' fit ring in groove.

iv. Check that the ring turns freely and that the side clearance (see Fig. 4) is not excessive. If excessive proceed as for overwidth rings.

NOTE All spare piston rings leave our Works with the correct ' gap,' there is therefore no fitting to be done in this respect.

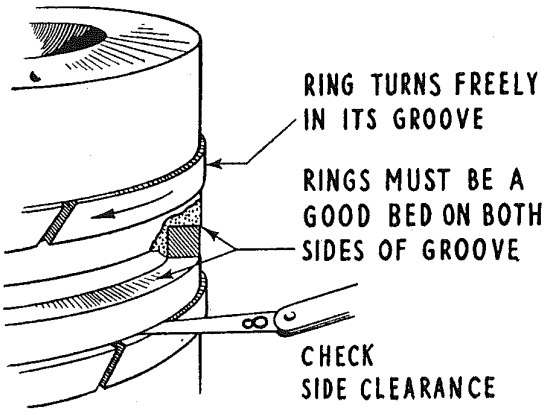


Fig. 4

FITTING OVERWIDTH PISTON RINGS

When the side clearance exceeds the maximum of eight thous. (.008″) generally as indicated in Fig. 5, or the sides become irregular and will not permit a good bed for the ring, (see Fig. 6) then **overwidth** rings should be fitted.

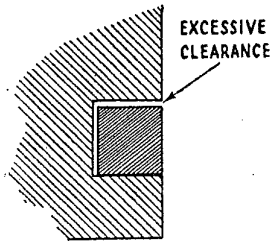


Fig. 5

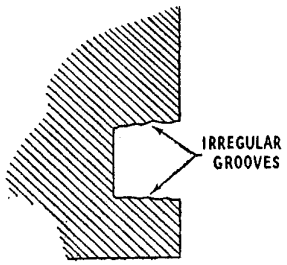


Fig. 6

The present standard piston is fitted with three .125″ ($\frac{1}{8}$″) thick pressure and three .125″ ($\frac{1}{8}$″) scraper rings, two scraper rings in one groove below the gudgeon pin.

Overwidth piston rings can be supplied as follows:—

Marks VTO and VTH $\frac{1}{8}$″ + .005″ and $\frac{1}{8}$″ + .010″ Max.
Marks VSO and VSH $\frac{1}{8}$″ + .010″ and $\frac{1}{8}$″ + .015″ Max.

The grooves should be machined so that metal is removed evenly on either side of the groove, using a tool of a size that will give the ring a side clearance of .002″.

Rings of a width greater than the maximums stated should not be fitted.

NOTE

In our experience we have found that the fitting of rings **oversize in diameter** in standard liners offers no advantage.

SV 5

SERVICING
CONNECTING RODS

SERVICING CONNECTING RODS

CONNECTING RODS

ALIGNMENT

The alignment of connecting rods should be checked during complete engine overhauls, or in the event of piston, large and/or small-end bearing troubles. The first check, particularly if trouble has been experienced with piston seizure, should be made on the bore of the connecting rod at the large end. A DUMMY shaft will be required about 6" long with diameter given in sketch Fig. 1.

PROCEDURE

i. Remove both halves of the bearing from the rod.

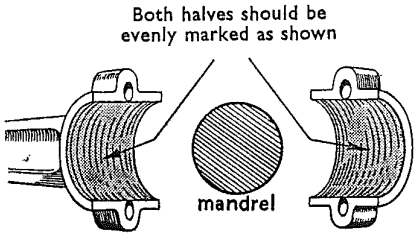
ii. Replace bottom bearing cap with nuts finger tight.

iii. Smear engineers' marking on dummy shaft, insert in rod end and tighten the nuts to the same tension as if in the engine.

iv. Dummy shaft to be turned a few times, withdrawn, and the marking examined, when any distortion will be revealed by gaps in the marking.

NOTE

Should bearing, piston or liner trouble have been experienced in the particular cylinder of which the connecting rod under examination is a part, AND AN EVEN MARKING as shown in sketch Fig. 1 is not obtained THE CONNECTING ROD SHOULD BE REJECTED.



Mandrel Size

VTH $2\frac{13}{16}$" $\pm \frac{000"}{0005"}$

VSH $3\frac{1}{8}$" $\frac{+000"}{-0005"}$

Fig. 1

Subject to the first check proving satisfactory a final check should be made as under:—

EQUIPMENT. See Fig. 3.

(1) Scribing block (2) Iron or wooden block
(3) gudgeon pins (4) clock micrometer
(5) faceplate (6) dummy large end shaft
(7) pair VEE BLOCKS.

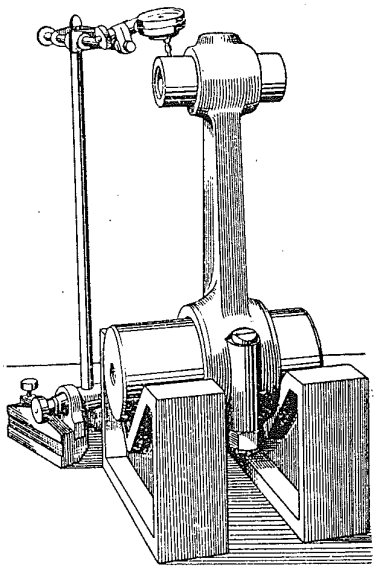


Fig. 2

CHECKING

i. Replace large end bearings in the rod.

ii. Assemble connecting rod, dummy shaft and gudgeon pin in manner indicated in Fig. 2.

iii. With clock micrometer check parallelism of dummy shaft with faceplate. NOTE carefully any discrepancy so that due allowance can be made when taking further readings.

iv. Whilst connecting rod is in the vertical position (Fig. 2) take readings on either side of the gudgeon pin, when subject to any discrepancy referred to in iii the readings should be exactly the same.

v. Lower connecting rod through 90° (Fig. 3) and take further readings on either side of the rod and the readings should be the same.

LIMITS

Connecting rods are issued from our works with the two bores parallel one with the other to within one thousandth (.001″) in.; in an assumed length of 12″, hence with gudgeon pin 6″ long one half a thousandth (.0005″) only is allowed; if this limit cannot be conformed to, then the connecting rod should be rejected, or rectified.

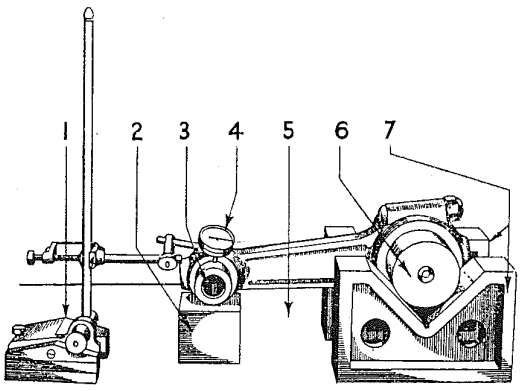


Fig. 3

ADJUSTING OR FITTING LARGE END BEARING

The connecting rod large end bearings are renewable and consist of a steel shell lined with high grade anti-friction metal.

BEARING CLEARANCE

It is important to maintain the correct bearing clearance. On a new engine the running clearance is .0015″ to .004″ maximum. Insufficient clearance causes excessive friction, and therefore heating, wear, and danger of damage to the bearings. Excessive clearance causes reduced lubrication pressure, hammering, and therefore excessive wear.

ADJUSTMENT

When the large end bearing clearance exceeds .006″ adjust as follows:—

i. If crankpin wear is less than 0.003″ oval, fit new bearing shells.

ii. If crankpin wear is more than 0.003″ oval, regrind the pin and fit a suitable undersize shell.

PRE-FINISHED BEARINGS

Pre-finished shells are marked ' PF '. PF bearings may be used to replace either a similar type, or hand fitted bearings.

NOTE Before they are fitted, ' PF ' bearings are not exactly round; they are broader across the horns to allow correct bedding when fitted. See Fig. 4, and also NOTE ii. on page 4.

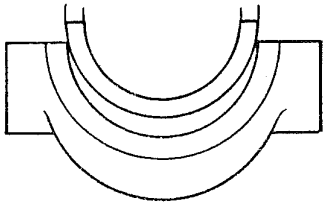


Fig. 4

IDENTIFICATION OF " FINE-BORED " CONNECTING RODS

The procedure for fitting PF bearings in new type or " fine-bored " connecting rods differs from the method used for fitting in " non-fine-bored " connecting rods. The bores of " fine bored " connecting rods are finished very smooth, giving the appearance of a ground finish, whereas the bores of " non-fine-bored " rods show tool marks.

FITTING PF BEARINGS IN " FINE-BORED " CONNECTING RODS

i. Assemble the bearings in the bore of the connecting rod. (Do **not** file the outside or scrape the bore).

ii. Tighten the connecting rod bearing nuts **by hand-spanner** not longer than 10″. The bearing will then be an accurate fit.

FITTING PF BEARINGS IN " NON-FINE-BORED " CONNECTING RODS

i. Fit the dowel peg in the bearing cap.

ii. Ensure that all parts are clean and smear the outside of the bearing shell with marking paste.

iii. Assemble the bearings in the bore of the connecting rod and tighten the connecting rod bearing nuts by hand-spanner not longer than 10″.

iv. Dismantle the bearing assembly and examine the marking in the shell. This will indicate that the shell bears hardest on the horns but these must not be relieved (See Note, above).

v. To obtain overall bedding of the shell in the bore of the connecting rod, commence by filing accurately the joint faces of the cap only. The amount to be filed will probably not exceed .002″ (Fig. 5).

vi. Repeat operations ii, iii, iv and v, until the marking shows that there is contact between the outside of the bearing shell and the crown of the bore of the connecting rod and cap. Scrape away high spots in the bore to obtain an even bedding.

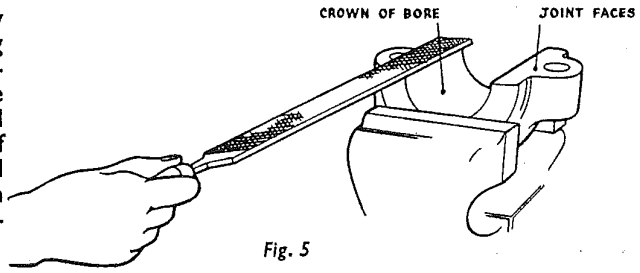


Fig. 5

IMPORTANT Take great care when filing the joint faces of the cap to ensure that when the assembly is finally tightened these faces make solid contact with the corresponding faces on the connecting rod. In all cases, the " nip " of the connecting rod cap on the bearing should be carefully checked, see Fig. 3, S.V.9 and the gap should be .0015″/ .002″ on one side ONLY.

WARNING

Do not scrape the white metal on the inside of the bearing or file the outside of the shell.

SPARE BEARINGS

Under-sized pre-finished bearings are available to suit reconditioned crankpins. When replacements are obtained from our works and the exact dimensions of the crankpins are known the pre-finished bearings can be bored to suit.

Replacements can be supplied in three sizes.

*** i. Bored .005″ undersize.**

ii. Bored .015″ undersize.

iii. Bored .030″ undersize.

In all cases the outside dimension of the shell is standard.

* For crankpins not worn sufficient to warrant regrinding.

NOTES

i. When once a " non-fine-bored " con-rod has been serviced strictly in accordance with these instructions it may thereafter be treated in the same way as a " fine-bored " rod.

ii. Should it be required to check the bore of the bearing, the two halves must be " nipped " together in the connecting rod to obtain a true reading.

CONNECTING ROD BOLTS

CONNECTING ROD BOLTS

All bolts must be renewed after the engine has run a number of hours as follows, or earlier if required, *i.e.*, after piston seizure.

at :— **1500 r.p.m.—4000 hrs.**
1250 r.p.m.—5000 hrs.
1000 r.p.m.—6000 hrs.

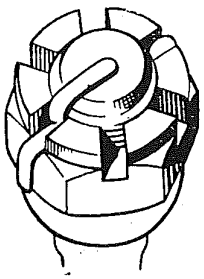


Fig. 6

CASTLE NUT AND SPLIT PIN

After tightening up the nuts, the split pins should be driven in until the heads are right inside the castellation of the nuts, and one end bent vertically, the other to be flattened over the nut. See Fig. 6

NOTE Split pins should NEVER BE USED TWICE, and replacements should be a light driving fit in the hole.

TAB WASHERS

On later engines the bolts have tab washers to lock the nuts, and it is important that the 'TAB' be bent over the flat which is machined the full width of the boss of the large end. See Fig. 7.

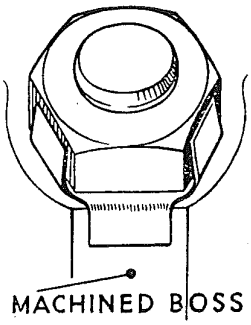


Fig. 7

IMPORTANT Under no circumstances should bolts be annealed and used again. Such action is FALSE ECONOMY.

This also applies to TAB WASHERS WHICH SHOULD NOT BE USED AGAIN.

SMALL END BEARINGS

SMALL END BEARING

This is a phosphor bronze bush which is a press fit in the rod. When it becomes necessary to replace, simply drive the old bush out with suitable drift or by press.

The service bush, like the large end bearing, is prefinished, consequently allowance has already been made for closure upon pressing in.

PRESSING IN

It is preferable to employ a press to ensure that the bush enters the hole at 90° in all directions to the bore of the rod. Should no press be available, use either a spigoted drift, or a draw bolt and washers. Fig. 8 gives manufacturing particulars.

IMPORTANT

The bush must enter the hole squarely.

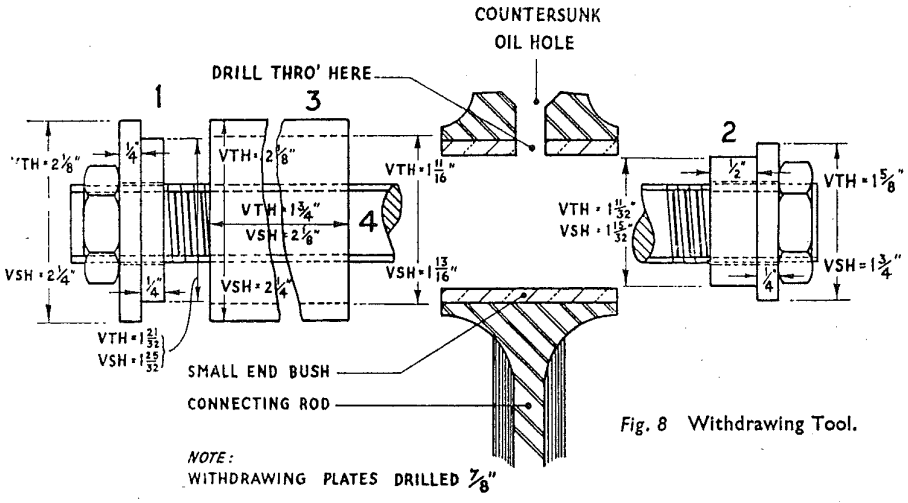


Fig. 8 Withdrawing Tool.

Item	Description	Material	No. off.
1	Withdrawing plate	E.N.3A.	1
2	Withdrawing plate	"	1
3	Tubular distance piece	"	1
4	½" B.S.P. plugging	Steel	8
5	½" B.S.P. nuts	"	2
6	¾" washers	"	2
VTO, VTH, VSO, VSH	S.E. Bearing Part No. 208.		

DRILLING

The lubrication of the small end is through the countersunk hole in the top of the rod, see Fig. 8, therefore the new bush will require drilling through the same size hole as in the old one.

Remove the burrs from the hole and the rod is ready for the piston.

CYLINDER LINERS

RUSTON & HORNSBY

CYLINDER LINERS

When it is required to remove the cylinder liner the following methods should be adopted in the order given.

In all cases the instructions assume that the cylinder heads, pistons and connecting rods have been removed, also the crankcase covers.

REMOVAL

METHOD 1

i. Turn crank so that maximum accessibility is given to the bottom of the liner at the back of the engine—this is approximately with crank 20° after top dead centre, see Fig. 1.

ii. Protect crankpin with clean rag tied on and also the bottom of the sump with brown paper against falling particles.

iii. Through the crankcase door hole at the back, give the liner a sharp blow at the point indicated in Fig. 1 and it should move—if it does, knock it up until the top flange clears the housing, when the liner may be lifted out.

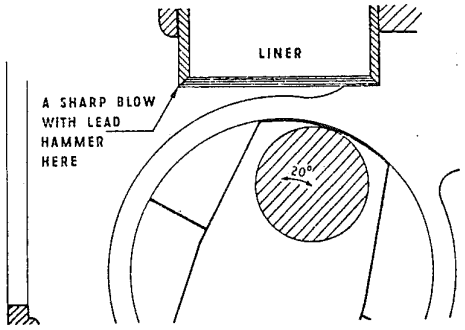


Fig. 1

Should this method prove unsuccessful, try :—

METHOD 2

i. As in i above, but see Fig. 2.

ii. As in ii above.

iii. With a wooden bar and a short piece, using the casting as a fulcrum, all as shown in sketch—Fig. 2, prise the liner out.

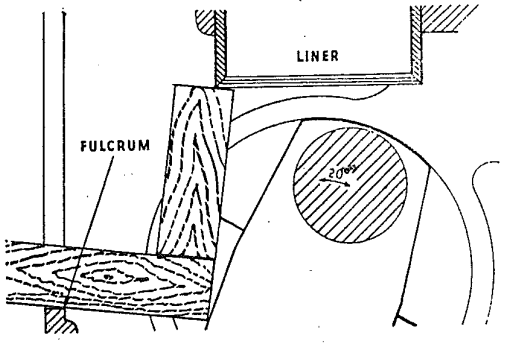


Fig. 2

Should method 2 fail, use :—

METHOD 3

i. As in method i but with crank turned about 45°.

ii. As in method 1.

iii. Assemble withdrawing gear as shown in Fig. 3, taking care to enter spigot of bottom plate into the liner at the bottom and that the sides of the bridge piece are clear of the liner at the top.

iv. Lock bottom nuts together and withdraw liner by turning draw-nut, see Fig. 4—until the liner comes clear of the bottom rubber joint rings, after which it can be lifted out by hand—see Fig. 5.

Fig. 6 gives dimensions and manufacturing particulars for liner withdrawing tool No. 39-J-482

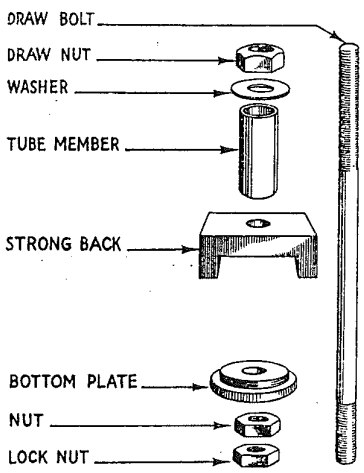


Fig. 3

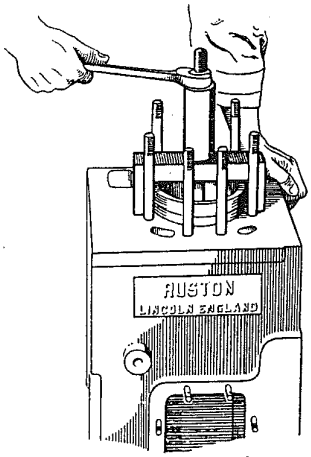


Fig. 4

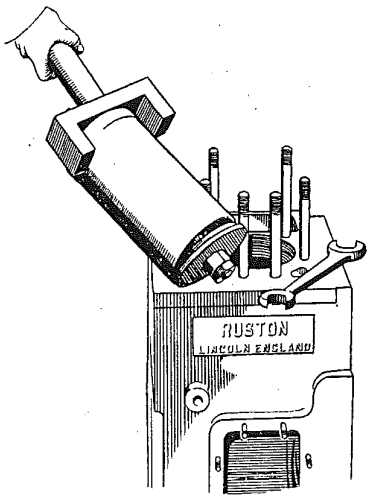


Fig. 5

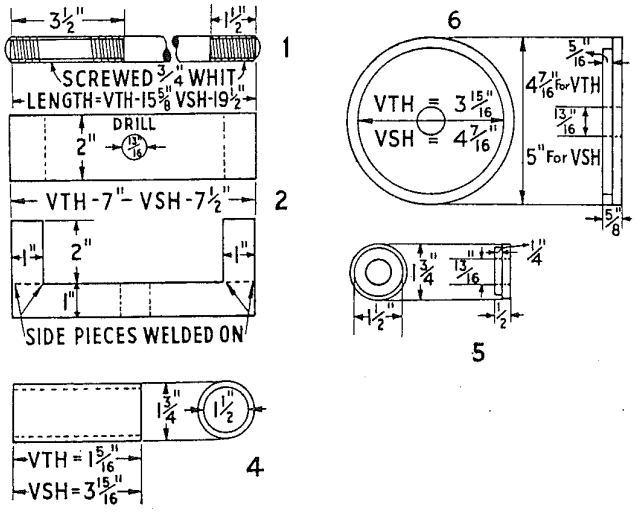


Fig. 6

Ref. No.	Description	No. off.	Material.
1	Withdrawing bolt	1	Steel E.N.3A.
2	Strong back (Thrust-plate) .. .. .. comprising 2" x 1" steel bar with side pieces welded on	1	"
4	Distance piece	1	"
5	Distance piece collar	2	"
6	Withdrawal plate	1	"
	¾" Whit. nuts	2	Stock
	¾" Whit. lock nut	1	"

Details of liner withdrawing gear. Part No. VH2. VTO, VTH, VSO, VSH engines. Tool No. 39-J-482.

CYLINDER LINERS

REPLACEMENT

i. The housing should be thoroughly cleaned, both at the top where the shoulder of the liner will rest and at the bottom where the rubber joint rings will seal the water jacket (See Fig. 7)

ii. The liner should be cleaned of its protective grease and, with a smear of engineer's marking under the shoulder, tried in the housing and rubbed round to see if it is free to revolve and if a good metal to metal joint between faces is evident.

NOTE If in doubt about this, a smear of very fine carborundum will quickly clean the faces up.

iii. Rubber rings should then be placed in the two grooves in the liner taking care to see THAT THEY ARE NOT TWISTED.

iv. Smear soft soap liberally on the rubber rings and also on the LEAD IN or TAPER of the bottom hole in the housing.

v. Although not absolutely necessary, a thin application of jointing compound on the top ledge may be made.

vi. The liner should then be PRESSED IN by HAND. The liner should not be forced in, otherwise distortion may take place.

NOTE If the liner cannot be pressed in by hand, it should be withdrawn and an examination made to see that the rubber rings have not become twisted.

vii. Finally the liner should be firmly held on its seating and the amount by which the top face of the liner is above the housing face carefully checked by means of a straight edge and feelers. See Fig. 8.

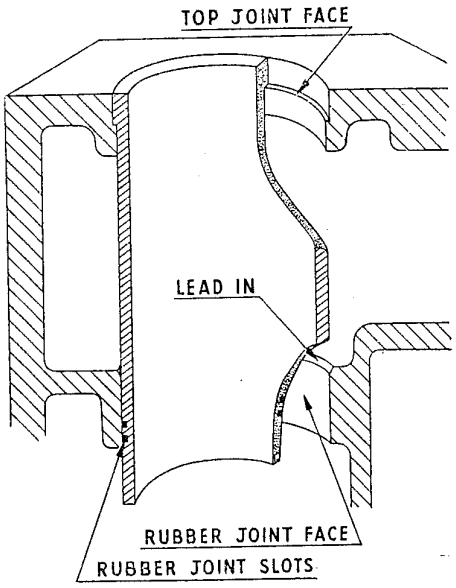


Fig. 7

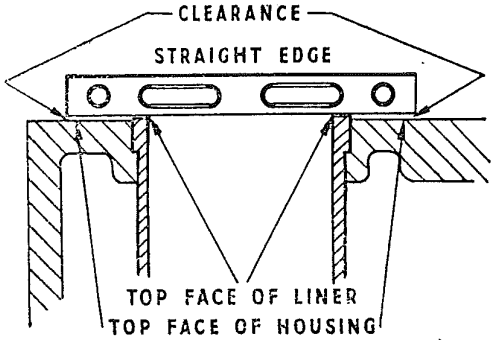


Fig. 8

IMPORTANT

To ensure a gas and water tight joint the top facing of the liner should be NOT LESS THAN two thousandths (.002") and NOT MORE THAN six thousandths (.006") above the top of the housing.

CRANKCASE or HOUSING

VALVE TAPPET BUSHES

Valve tappet bushes are a driving fit in reamered holes in the crankcase and are NOT locked in position.

The instruction assumes that the camshaft and all accessory equipment have been removed and that the housing has been laid on its side.

REMOVAL (1)

Insert the spigoted phosphor bronze drift (3) in the tappet bush (4) from top side and with steel bar (1) through the push rod guide bush (2) tap the bush through into the crankcase.

Dimensions of the phosphor bronze drift and round steel bar are given in Fig. 2.

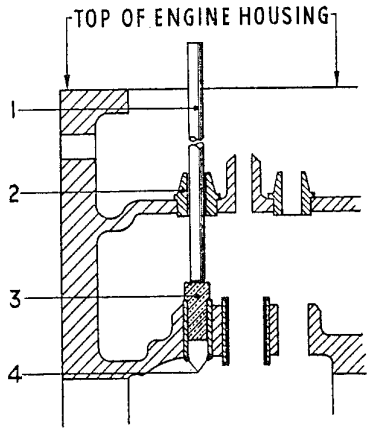


Fig. 1

REPLACEMENT

With drift (3) and bar (1) drive the bush into the hole until the lower end of the bush (4) is within approximately $\frac{1}{8}$" of being flush (level) with the casting, see Fig. 1.

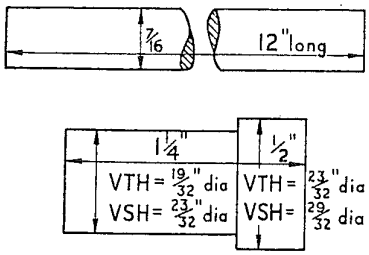


Fig. 2

ALTERNATIVELY

If it is not convenient to lift the engine from its foundation or fixing, the bushes may be removed by means of a drawbolt, complete with nuts, washers and tubular distance piece (see Fig. 3) which also gives dimensions.

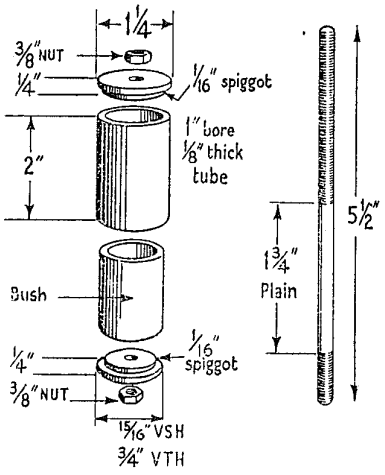


Fig. 3

REMOVAL (2)

Assemble as shown in Fig. 3, drawing the bush downwards into the crankcase. Care should be taken to ensure that the bush enters the tube piece.

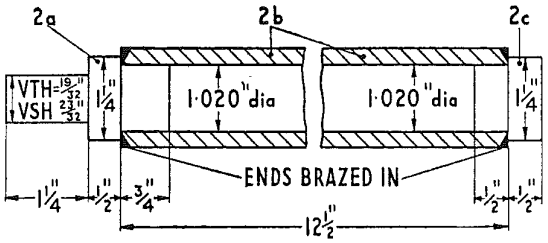


Fig. 4

REPLACEMENT

Simply reverse procedure stated in removal using either a shorter tube piece, or a longer ⅜" bolt.

Should large number of engines be serviced, it will be found convenient to remove the bushes as in (1) and to employ the drift—tool No. 8224/2.1W.—to drive the bushes in. The tool comprises a piece of steam tube with phosphor bronze ends brazed in.

Fig. 4 gives dimensions and constructional details of tool 8224/2.1W.

Fig. 5 shows a cut-away view of the housing with the bush being driven into position with tool No. 8224/2.1W.

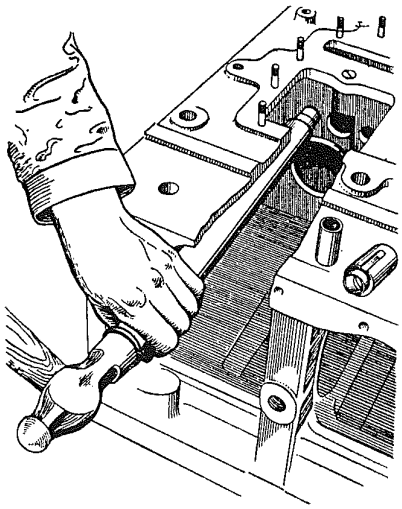


Fig. 5

IMPORTANT

The bushes are made of a special mixture of cast iron, consequently care MUST be taken to ensure that upon replacement, each bush enters the hole squarely before pressure is applied, otherwise there is a risk of the bush collapsing.

FUEL PUMP TAPPET BUSHES

The bushes are a driving fit in reamered holes in the crankcase and are located in position. The instruction assumes that the camshaft and accessory equipment have been removed and the housing laid on its side.

REMOVAL (1)

(*a*) Take out the countersunk headed locating screw. This is clearly shown on Fig. 10.

(*b*) Insert the spigoted phosphor bronze drift (3) in the bush (4) from the top side and with round steel bar (1) through fuel pump tappet rod hole (2) drive the bush into the crankcase. See Fig. 6.

For dimensions of drift and bar see Fig. 7.

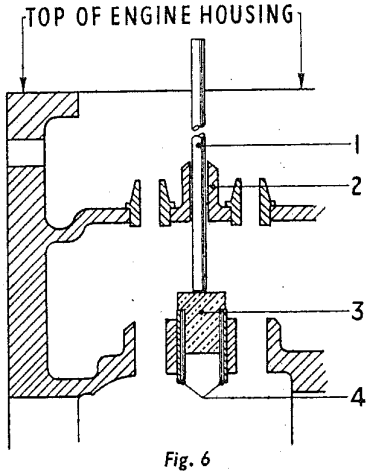


Fig. 6

REPLACEMENT

(*a*) Enter the bush carefully into the hole with the outside slot facing upwards and in line with the locating screw hole.

(*b*) Put in the locating screw so that it enters the slot for guide purposes.

(*c*) Using drift (3) and steel bar (1) drive the bush in until it projects evenly above and below the casting—about $\frac{1}{4}$" below.

(*d*) Tighten the counter sunk headed screw remembering that its only purpose is to prevent the bush from turning.

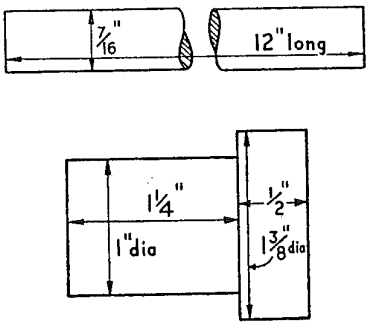


Fig. 7.

ALTERNATIVELY if the engine cannot be lifted from its fixing.

REMOVAL (2)

Using draw bolt assembly shown in Fig. 8 draw the bush out downwards, taking care to see that the bush enters the tube piece.

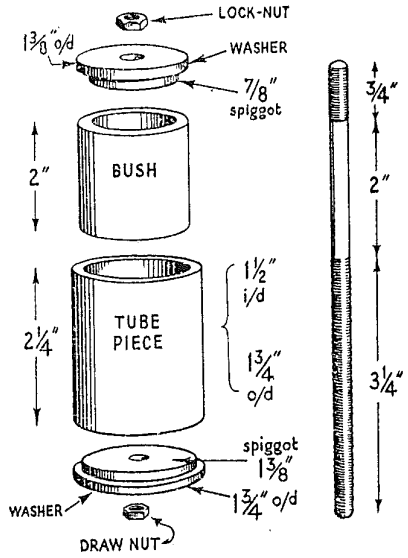


Fig. 8

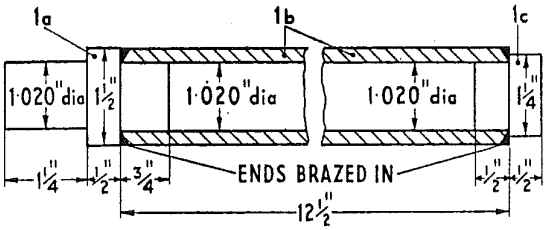


Fig. 9

REPLACEMENT

Simply reverse the procedure under removal, but using either a shorter tube piece, or a longer bolt.

Should large numbers of engines be serviced it will be found convenient to remove the bushes as in (1) and to employ drift tool No. 8224/1.IW. to drive the bushes in.

Fig. 9 gives dimensions and contructional details of the drift, tool No. 8224/1.IW. which comprises a piece of steam pipe with ends brazed in.

Fig. 10 shows a ' cut away ' view of the housing with the bush being driven into position with tool No. 8224/1.IW.

IMPORTANT

The bushes are made of a special mixture of cast iron, consequently care MUST be taken to ensure that upon replacement, each bush enters the hole squarely before pressure is applied, otherwise there is risk of the bush collapsing.

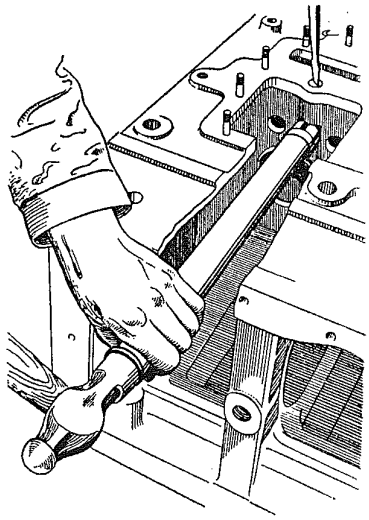


Fig. 10

LUBRICATING OIL PUMP

The gear driven gear pump is always flooded with lubricating oil, consequently rarely, if ever, requires any servicing attention. Should occasion arise to renew parts the following instructions will be found helpful.

REMOVAL

(a) Lubricating Oil Pump

i. Drain the oil from the sump, preferably whilst the engine is still warm.

ii. Remove the setscrews on the delivery side and the suction pipe altogether.

iii. Undo the three setscrews item (2) holding the pump to the housing —after which it may be taken away—see Fig. 11.

(b) Idler Wheel.

i. The end cover (gear end) and a crankcase inspection cover should be removed.

ii. With finger, or drift $\frac{3}{8}$" dia. through the hole in the crankcase press the spindle out withdrawing the wheel downwards. Fig. 11 shows drift pressing spindle out.

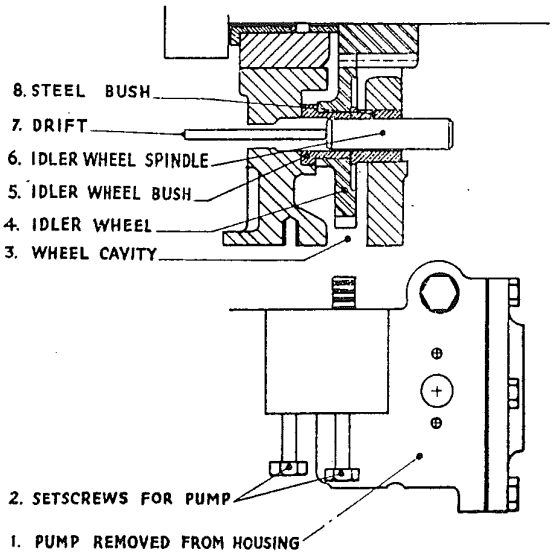


Fig. 11

(c) Idler Wheel Spindle Bush

This hardened steel bush should be driven through into the wheel chamber with bronze drift.

REPLACEMENT

(c) Idler Wheel Spindle Bush.

Enter the new bush squarely into the hole from inside the wheel chamber, and with a pinch bar and a piece of thin wood, using the casting as a "fulcrum," tap the bush in with lever action until it will go NO further. See illustration, Fig. 12.

ALTERNATIVELY

The bush can be inserted by means of a draw bolt, nuts, washers and tube member, *i.e.*, similar to valve tappet bush sections.

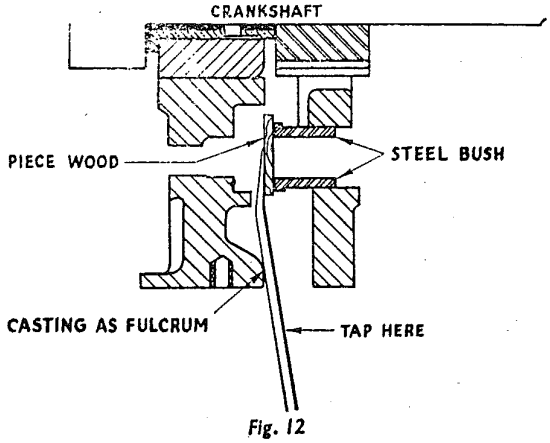


Fig. 12

(*b*) **Idler Wheel**

i. Enter the wheel into the cavity with boss and bush flange facing inwards. See Fig. 11.

ii. Engage teeth with those on crankshaft spurwheel and press the spindle in until the end is level with the housing face.

iii. Check end cover joint to see if damaged.

iv. The end cover may now be replaced, using sleeve, tool No. 8943 IW. see S.V. 8, Figs. 13 and 14, so as not to damage the oil seal, when pressing on to the larger diameter of the crankshaft.

v. Tighten cover into position.

vi. Replace crankcase cover.

DISMANTLING THE PUMP (*a*)

See Fig. 13.

Remove setscrews (1) with ring or tube spanner, prise the cover (2) off, taking care not to damage faces or joint (3). Turn wheel (6) until it is possible to close the split portion of the taper pin (4) then drive this out.

The gearwheel drive (5) and driving wheel (6) may now be removed.

Finally—the spindle (7) and oil gear wheel (8) may be slipped out.

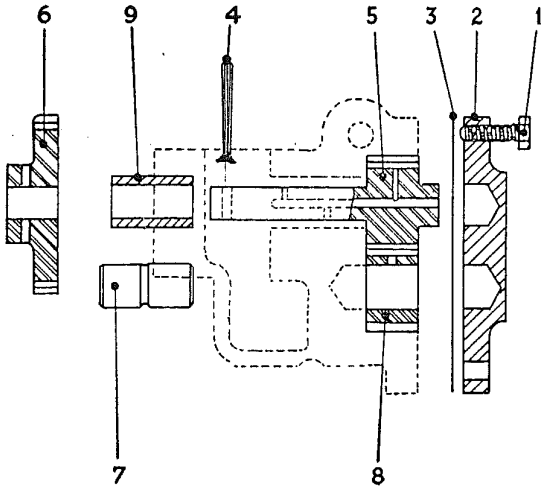


Fig. 13

REMOVAL OF THE PUMP DRIVING SPINDLE BUSH

The bush (9) is a press fit in the pump body and should therefore be drawn out.

A draw bolt arrangement similar to Fig. 3 can be utilised for this purpose.

IMPORTANT

Very special care must be exercised during the withdrawal operation to avoid damage to the inside of the pump body—otherwise the efficiency of the pump may be impaired.

REPLACEMENT OF THE BUSH

The new bush (9) should be tapped in with brass drift until the face at the driving end is level with the body of the pump.

RE-ASSEMBLING THE PUMP

Insert oil gearwheel (5) in bush (9) and thread spindle into driving wheel (6) with boss facing away from end of bush (9). Fit taper pin (4) correctly and open out the split end. Oil gear wheel (8) and pin (7) should be inserted next.

CHECKING

Without the dowel pins and the joint (3) the cover should be tried on with four screws and if it is assembled correctly it should not be possible to turn the pump easily.

After this check—remove the cover, fit the joint (3) and progressively tighten the setscrews (1) after of course fitting the two dowel pins. The pump should now revolve freely, without any appreciable end-play. The actual clearance limits are between two and three thousandths (.002″—.003″).

IMPORTANT

Loss of oil pressure is generally occasioned by excessive end clearance developing rather than wear on the teeth of the gearwheels.

REPLACEMENT

(*a*) Lubricating Oil Pump

i. Clean joint faces and check joint for soundness.

NOTE The joint must be the correct thickness, $\frac{1}{32}$″ (.031″) to obtain correct engagement of the gearwheel teeth. Ensure that the backlash is .005″/.006″.

ii. Engage driving gearwheel with idler wheel.

iii. Fit and progressively tighten the three setscrews.

iv. Replace suction pipe and joint and setscrews in the delivery side. Take care to tighten setscrews progressively and evenly to obtain an oil tight joint.

CRANKSHAFT and FLYWHEEL

RUSTON HORNSBY

CRANKSHAFT

REMOVAL

The instructions assume that the connecting rods, etc., have been removed.

I. THE FLYWHEEL (if keyed on):—

(a) By using two steel wedges in the manner indicated in Fig. 1 driving one wedge against the other between the flywheel boss and the key-head. Parallel packing should be added as required between the wedges and the boss.

Wedge Dimensions—4" long by $\frac{1}{2}$"/$\frac{3}{4}$" wide tapering from maximum thickness of $\frac{3}{8}$" at one end to zero at the other.

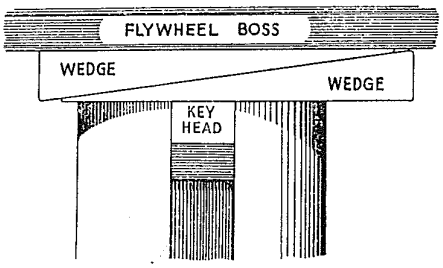


Fig. 1

(b) When a number of engines are serviced at any one time we recommend the employment of Gib head key extractor tool No. 47-J-738 as illustrated in Fig. 2 which removes keys without effort or damage to key heads.

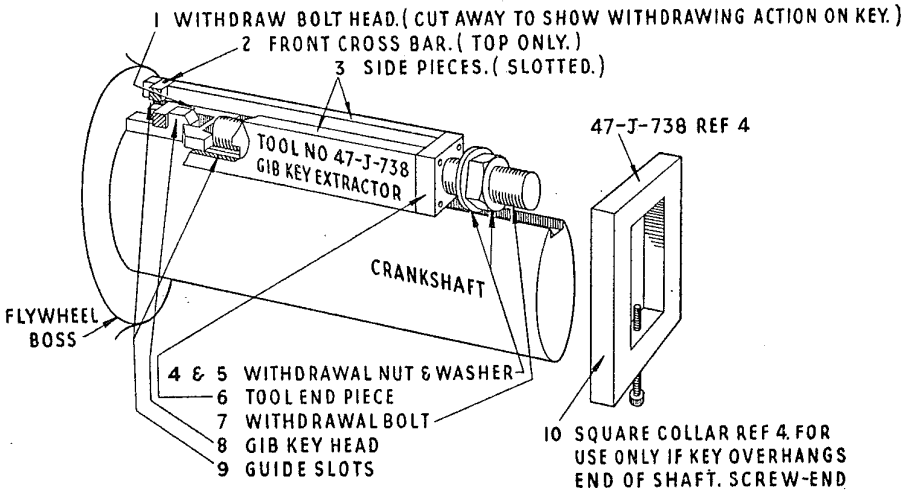


Fig. 2

i. If the key head is as shown in Fig. 2 remove item 10, the square collar, ref. 4, from the tool, and with the front cross bar (2) on top, put the tool on the shaft so that the square hole in the withdraw bolt head (1) fits on the key head (8). Tighten the nut (4) until the side pieces (3) press on the flywheel boss, after which the key can be withdrawn by turning the nut (4) with a tube spanner and a bar.

ii. When the key head projects beyond the end of the crankshaft, the collar (10) should be put on the tool with screw underneath and operation carried out as in (i) but with the screw end under the head of the key to prevent it from bending when pressure is applied.

THE FLYWHEEL (if secured by locknut) :—

i. Remove the locking wire, the three setscrews, and then the locking plate.

ii. Undo the flywheel locknut about two turns only, with a ring spanner for preference.

iii. With tool No. 3950 IW. comprising a steel bar, 2 studs with nuts and washers used in the manner indicated in Fig. 3, *i.e.*, with the lock-nut providing centre support, tighten the withdrawing nuts so that the bar is parallel with the face of the wheel; next, with a lead hammer, give a sharp blow to the centre of the bar—when the wheel should spring clear of the taper—the nut preventing the wheel from falling off the end of the shaft.

Fig. 4 gives dimensions and constructional details of flywheel withdrawing tool No. 3950 IW.

iv. Remove locknut, flywheel and woodruff key.

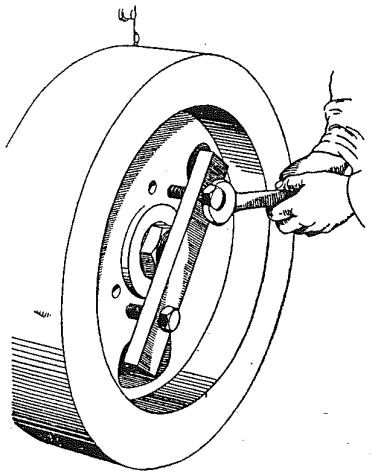


Fig. 3

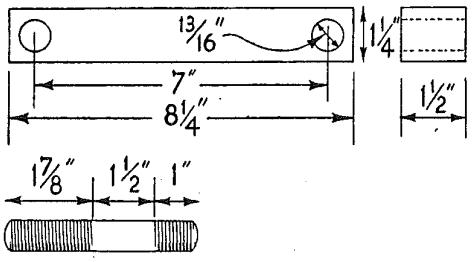


Fig. 4

2. END COVERS

Both end covers should now be removed and also the crankcase covers, and, of course, the sump.

3. BUSH BEARING

THE FOLLOWING INSTRUCTION APPLIES **ONLY** IF IT IS REQUIRED TO **EXAMINE** or RENEW THE BUSH BEARING, there being no need to remove the gearwheel, part number V.1177, in the ordinary crankshaft removal operation.

i. Assemble withdrawing tool No. 9750 IW. as shown in Fig. 5, viz:—
Screw draw studs (1) into the tapped holes in the gear wheel, put recessed plate (6) on studs, recess to face and fit on shaft and with B.S.F. screw (7) located in keyway, fit draw bar (3) next as close as possible to (6) tighten nuts evenly so that the bar is exactly at right angles to a centre line through the crankshaft.

ii. Prevent the wheel from turning by means of a block, or lead hammer between crankshaft and the housing.

iii. Draw the wheel off by screwing bolt (2) against the plate (6) using two bars, or equal, bolted on to the head of the bolt as shown in Fig. 6.

N.B. As the wheel has to be drawn all the way off the raised portion, approximate 6"—7", it is recommended that after each one inch or so, the bolt (2) be turned back and the draw bar (3) moved closer to the plate (6) thereby preventing the draw studs from twisting.

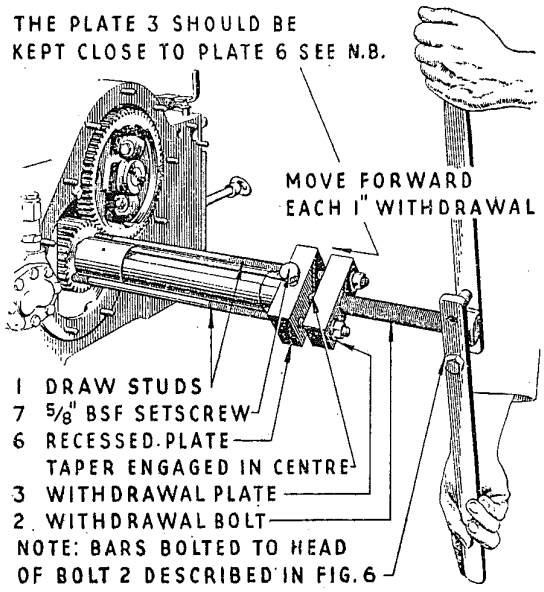


Fig. 5

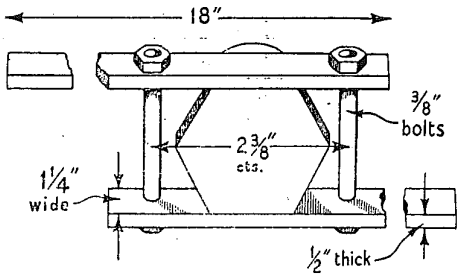
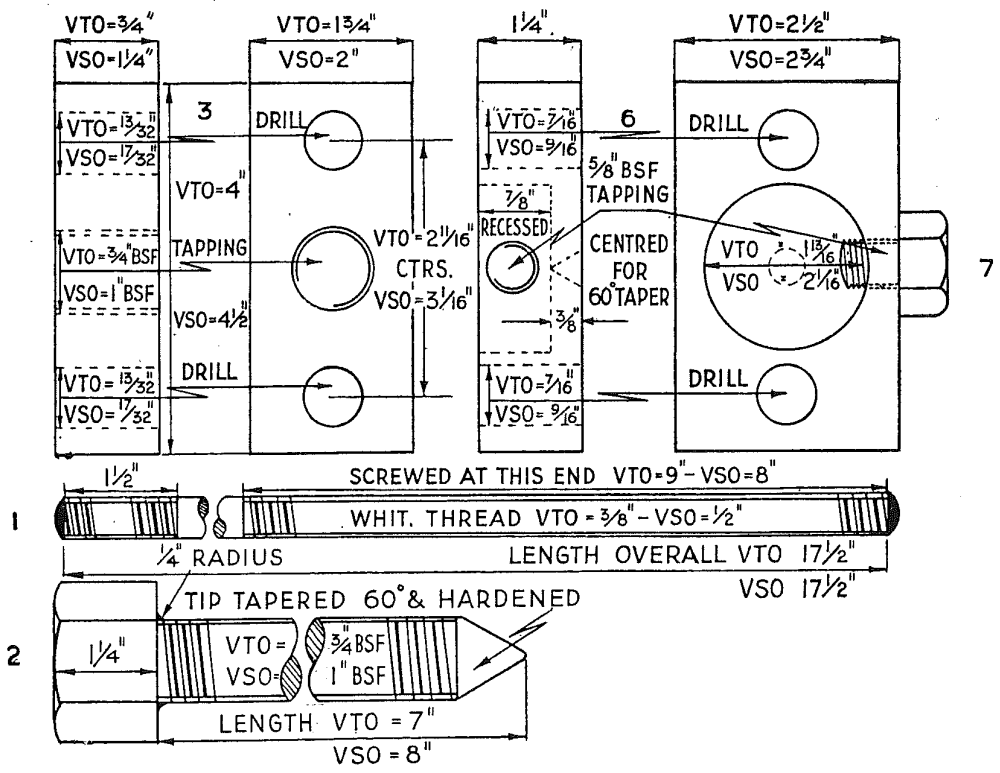


Fig. 6

SEE S.V.9, MAIN BEARINGS, REGARDING CRANKSHAFT REGRINDING.

Constructional details for the manufacture of tool 9750 IW. are given in Fig. 7.



TOOL No. 9750 IW.

Withdrawing Gearwheel from Crankshaft			Part No. V 1177
Item	Material	Description	No. off
1	EN. 16 R.	Draw Studs	Two
2	EN. 16 R.	Bolt	One
3	EN. 3 A.	Plate	One
4	Stock	Washers	Two
5	Stock	Nuts	Two
6	EN. 3 A.	Plate (recessed and centred) ..	One
7	Stock	⅜" B.S.F. Setscrew	One
VTO, VSO, VTH and VSH Engines			

Fig. 7

SEE S.V.9, MAIN BEARINGS, REGARDING CRANKSHAFT REGRINDING.

Proceed as follows to remove:—

4. The lubricating oil pipe rail.
5. The lubricating oil connection stops (1) from behind the pipe rail.
6. The bearing location stops (2) from the opposite side to the pipe rail.
7. The stops (3) from the bottom of the housing. (This applies to all except single cylinder engines).

Fig. 8 shows the stops to be removed from thrust bearing housings.

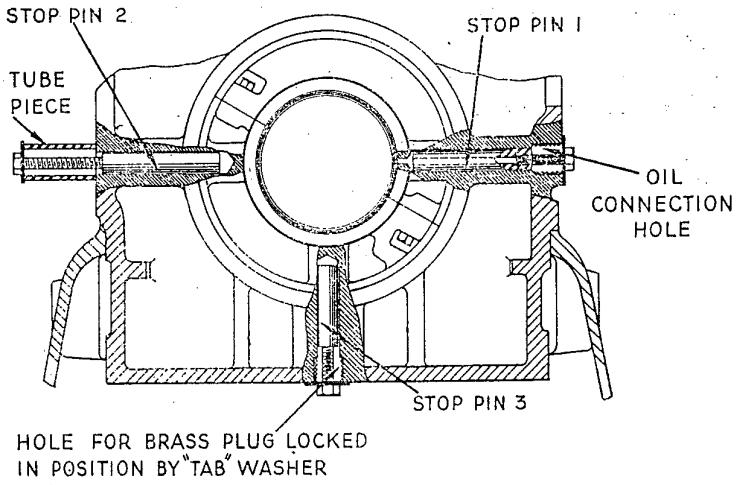


Fig. 8

Fig. 9 shows the stops to be removed from each end bearing housing on single cylinder engines. On engines of two cylinders and upwards one only stop (1) on Fig. 8, is fitted. The intermediate bearing housings on three and four cylinder engines are fitted with two stops (1 & 3), on Fig. 8. The stops on VSH engines are drilled and tapped $\frac{3}{8}$" whit. and VTH $\frac{5}{16}$" whit. and should be withdrawn by setscrew, nut and $1\frac{1}{8}$" outside diameter washer as shown. In some cases it may be necessary to use a short tube piece between washer and housing.

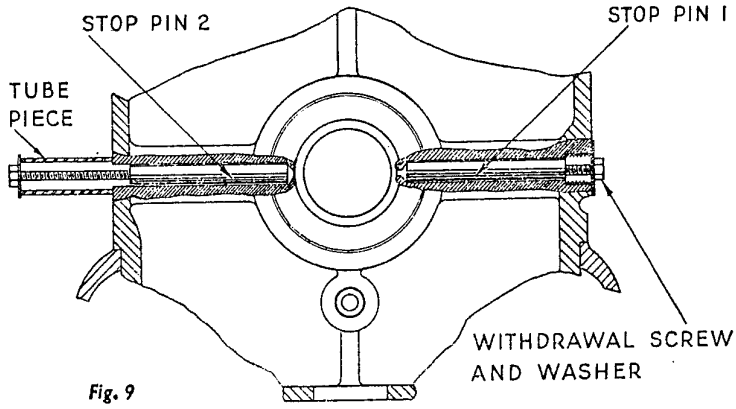


Fig. 9

IMPORTANT

Before proceeding with operation 8, it will be found helpful if lines are scribed on bearings, housings and crankcase, so that upon replacing the crank, the lines can be brought together and thus facilitate the fitting of the stops.

8. The crankshaft may now be removed, viz:—

(*a*) Support the free end of the crankshaft with sling and pulley blocks so that the shaft can move freely in line with the bore of the housing and does not sag.

(*b*) With lead hammer, or equal, knock the shaft out by blows at the gear wheel end.

(*c*) When the shaft is approximately half-way out, move the sling to the point of balance, *i.e.*, near the centre of the cranks, so that when the last bearing housing is drawn clear of the crankcase the crank can be lifted easily.

If the shaft has a screwed end (taper shaft) the use of a suitable sized piping (see Fig. 10) will assist in removal

BEARINGS SHOULD BE GIVEN ATTENTION IN ACCORDANCE WITH THE INSTRUCTIONS IN SECTION S.V.9.

CRANKSHAFT

REPLACING

This operation is a reversal of the foregoing procedure, therefore it is assumed that the crankshaft is assembled complete with bearings and slung ready for entry into the crankcase bores:

1.

(*a*) Turn bearing housings so that the countersunk holes face the holes on the side of the crankcase to which the oil pipe rail fits, *i.e.*, the one drilled through the bearing.

(*b*) Enter the crankshaft, gear wheel end first into the crankcase and gently tap into position with lead hammer, care to be taken to ensure that the oil holes are kept in line. As in removal the free end of the shaft should be supported to ensure ease of entry.

(*c*) To bring holes into line it will be found helpful to use a $\frac{5}{8}$" dia. bar tapered at one end for the VSH and $\frac{1}{2}$" dia. for the VTH.

2. Replace Lubricating oil connection stops (1) on Fig. 8, taking care that the right length of stop is used and that the tapped end faces outwards, and that it is drilled right through.

3. Replace stops (2) on Fig. 8.

4. Replace stops (3) on Fig. 8, replace brass plugs and tab washers.

FITTING NEW BEARING HOUSINGS

Should it become necessary to replace any of the BEARING HOUSINGS the following instructions should be followed:—

The bearing housings are delivered with one only hole drilled, *i.e.*, for lubricating oil location stop (1) on Fig. 8 (this is the one that is countersunk), therefore each bearing housing has to be drilled and reamered for the other stops when the crankshaft is in position in the crankcase.

VSO & VSH

The size of drill required is $\frac{33}{64}$" and reamer is $\frac{5}{8}$".

VTO & VTH

$\frac{31}{64}$" drill and $\frac{1}{2}$" reamer.

NOTE It is of course important that the hole be drilled and reamered to the same depth as the one in the housing which is being replaced.

5. Replace the pipe rail after softening the copper joint rings by raising them to blood red heat and then quenching in water.

When re-making the lubricating oil pump joint make quite certain the joint faces are in line and that the pipe flanges do not have to be sprung into position.

6. REPLACING THE GEARWHEEL

This instruction applies only when the crankshaft gearwheel (Part No. 1177) has been removed, see instruction 3 in removal.

(*a*) The crankshaft and bore of gearwheel should be cleaned of any burrs caused during removal.

(*b*) Replace the woodruff key, remember this type of key fits on the sides only, NOT ON TOP.

When removing the wheel it will have been noted that it is a tight fit on the shaft. This is to ensure that it will not come loose in service. The temperature of the wheel will therefore have to be raised to about 300°F. To obtain this we recommend that the wheel be placed in an oven, or on a hot plate, NOT IN DIRECT CONTACT WITH THE FLAMES, and leaving for 30 minutes so that the heat goes right through the wheel, but does NOT DISCOLOUR IT.

(*c*) **Next, with all possible speed,** slip the wheel on the raised portion of the shaft and with the ram tool No. 9996 IW. (see figures 13 and 15) drive the wheel on until a clearance of fifteen thousandths (.015″) remains between the wheel face and bearing.

Fig. 10 shows the wheel being driven on by the ram, with the .015″ feeler in position to ensure the correct clearance.

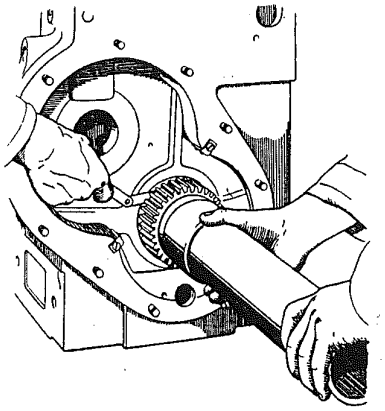


Fig. 10

7. Replace end covers, sump and crankcase doors, etc.

8. REPLACING THE FLYWHEEL

(*a*) If keyed on:—

i. Put the wheel on the shaft with the DEEPER side of the keyway facing outwards.

ii. Smear tallow fat or grease on the key and drive it in until the hammer shows signs of springing back.

(*b*) If secured by lock nut on taper:—

i. Insert woodruff key in shaft.

ii. Lift wheel and fit on taper, making certain that the key enters the keyway.

iii. Put on lock nut and tighten with ring spanner and hammer.

Prevent the wheel from turning by using a setscrew, lock nut and wooden spar in the manner indicated in Fig. 11, or by any other convenient means.

iv. Fit the locking plate, which being cut as a twelve (12) pointed star, permits the locking screw holes to be brought into line with a very small movement of the locknut.

v. Fit and tighten the three locking setscrews and thread $\frac{1}{16}$″ diameter soft iron wire through the holes in the heads, bring the ends together and twist.

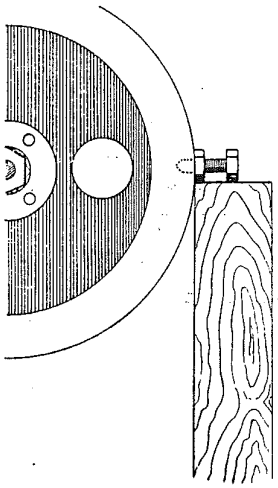


Fig. 11

FITTING NEW FLYWHEEL (Taper crank).

Should it become necessary to fit a new flywheel, the bore should be ' blued ' or smeared with marking and rubbed on the taper of the crankshaft and if it is not evenly marked upon removal, then the bore should be lapped on to the taper by means of fine abrasive.

For this operation the crankshaft should be vertical with taper on top to ensure an even lapping action by using the weight of the wheel.

CRANKSHAFT OIL SEALS

The instruction assumes that the flywheel and driving gear have been removed, *i.e.*, that both ends of the crankshaft are clear.

IMPORTANT

The oil seals are a press fit in the end covers, but due to its necessary fragile construction it is not possible to remove the seal without damage, or distortion; consequently once a seal has been removed FROM THE HOUSING, IT SHOULD NOT, UNDER ANY CIRCUMSTANCES BE USED AGAIN.

REMOVAL

i. Remove end covers and place on some material, to prevent joint face damage, on bench with oil seal uppermost.

ii. Prise the seal out in the manner indicated in Fig. 12, with a wedge pointed pinch bar, or any similar pointed tool.

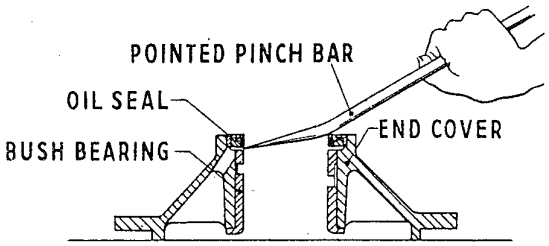


Fig. 12

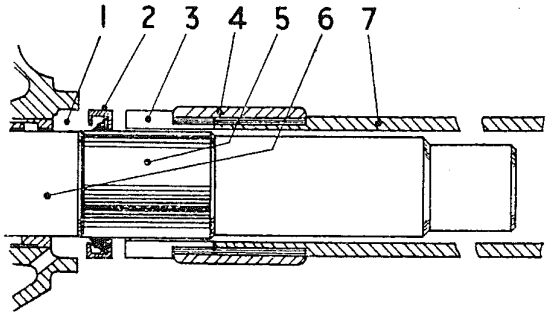


Fig. 13

FIT NEW SEAL

i. Clean end cover, removing any burrs which may have been caused during the removal operation, replace on engine and tighten into position.

ii. Refer to Fig. 13.

Press oil seal (2) on to sleeve (5) so that fabric in seal faces Non-taper end. Thread sleeve on to the crankshaft, Non-taper end first, until it butts against the raised portion of the shaft (6) then with tool No. 9996 IW., after smearing jointing compound on the rim, gently tap the seal (2) into the cavity (1) until it will go no further.

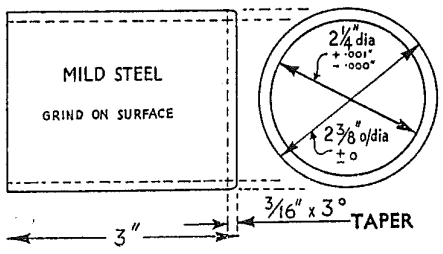


Fig. 14

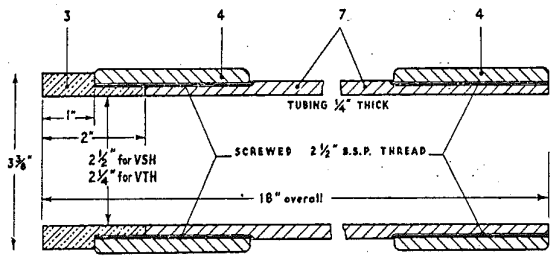


Fig. 15

Tool No. 9996 IW.

Ram for Driving Crankshaft Oil Seal In.			Part No. V 7247
Item	Material	Description	No. off
3	Phos. Bronze ..	Ram End	1
4	Steel (Stock) ..	Running Socket (2½" B.S.P.)	2
7	Steel (Stock) ..	Steam Tubing (2½" B.S.P.)	1
VTO, VTH, VSO & VSH Engines			

ALTERNATIVELY

If ram is not available, the seal may be tapped in by means of a wooden block or drift, always providing the seal does not become twisted during the operation; to avoid this tap the drift gently against the seal whilst rotating it round the shaft.

Fig. 14 gives dimensions and constructional details of the sleeve, tool No. 8943 IW.

NOTE The diameters given are for VSO/H, figures for VTO/H diameters are 2" and 2⅛" respectively, subject to the same tolerances.

Fig. 15 gives dimensions and constructional details of the ram, tool No. 9996 IW.

Fig. 16 shows the ram in use, the seal has just been tapped into position. It will be observed that no additional weight is required, *i.e.*, the weight of the ram is all that is needed to position the seal.

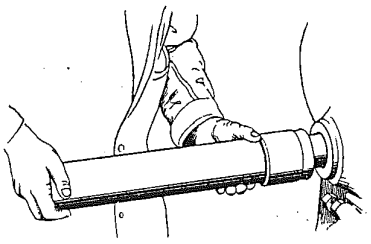


Fig. 16

SPECIAL CRANKSHAFT

AVELING BARFORD ENGINES

On the ' Barford ' road roller engines the main bearings and shaft systems are as for standard industrial types, except in regard to the size two cylinder, VSHR, viz:—

The 2VSO/H " R " engine has the flywheel fitted by taper seat and locknut instead of the usual parallel shaft and gib key.

At present, and in the two sizes of engine under review A. B. equipment incorporates 2, 3 and 4 cyl VSO/H engines, hence it will be noted that the 2 cyl. size is made to conform to the same specification as 3 and 4 cyl. sizes as regards flywheel fixing.

CONSOLIDATED PNEUMATIC TOOL CO. ENGINES

The mark 3VTO/H engines are equipped in so far as the crankshaft system is concerned on similar lines to the foregoing.

For other C.P.T. specials refer to **S.V.9 sub-section** (*d*).

CRANKSHAFT RE-GRINDING

When a crankshaft has been returned to the workshops it must be checked on all bearing journals to assess the amount of wear, and a decision taken as to the grinding necessary to clean up respective journals, having regard to the two sizes of large end and main bearings supplied to suit reduced crankshaft diameters.

THESE ARE

1st Regrind	**15 thous. (.015″)** and
2nd Regrind (maximum)	**30 thous. (.030″)**

and apply to both main bearing and large end journals.

THE IMPORTANCE OF THE FIRST CHECK FOR STRAIGHTNESS CANNOT BE TOO STRONGLY STRESSED AND MUST WITHOUT EXCEPTION TAKE PLACE BEFORE RE-GRINDING.

Failure to observe this instruction may result in the scrapping of a crankshaft which would otherwise still do many hours of useful work.

BALANCE WEIGHTS

See Sub-section (G).

CHECKING (1st)

Refer to Fig. 17

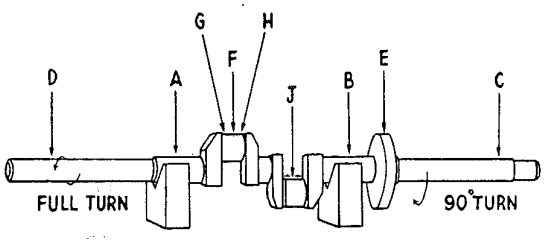


Fig. 17

i. Place the crankshaft on VEE BLOCKS in the manner shown, making sure that the surface-plate, vee blocks and journals are perfectly clean so that true readings can be taken. Surface-plate dimensions 6 feet by 3 feet approximately.

ii. With clock micrometer and stand (illustrated in Fig. 24) take readings at points A and B, i.e. directly over the vee blocks. Adjust blocks until both readings are the same, by shims or use adjustable vee blocks.

iii. Take a reading with clock micrometer at point C or at end of shaft, then at point D or opposite end of shaft, turning the shaft one complete turn, at each point, see arrow near point D.

iv. The shaft is straight only when there IS NO variation in the reading taken at any one point through ONE COMPLETE REVOLUTION of the shaft.

Crankshafts fitted into engines in our shops are straight and true throughout their length to within a limit of:—

Two thous. (.002″).

For crankshafts which have to be re-ground on account of wear, damage, or because for other reasons they are considered to be distorted, it is sufficient if, before regrinding and after DUE ALLOWANCE has been made FOR UN-EVEN WEAR, they are straight to within a limit of:—

Five thous. (.005″).

Consequently if the crankshaft is more than five thous. out of true throughout its entire length, it must be straightened on a suitable press.

STRAIGHTENING

It is difficult to state categorically the size of press required, but we estimate that a 10 ton minimum capacity press would do all that is required for VSH crankshafts.

The process of crankshaft straightening is a **highly skilled task** requiring considerable care and experience on the part of the press operator, consisting in the main of locating the points where the **deflection** begins, supporting them by vee blocks, then determining the **point of maximum deflection,** and exerting pressure on this point.

Repeat process until the shaft is straight within the prescribed limits, taking care not to damage the journals.

It is advisable to use a piece of brass sheet between the end of the press ram and the shaft.

WARNING

There are limits of bending beyond which it is **not possible** to straighten a crankshaft; for example if the bend is a purely local one in a short length of the shaft, an attempt to straighten might fail, or if successful at the time, the shaft may **revert** to out-of-true later.

RE-GRINDING

The dimensions given in the following table are for new shafts therefore after grinding, bearing and crank journals should be less .015″ or .030″ as required.

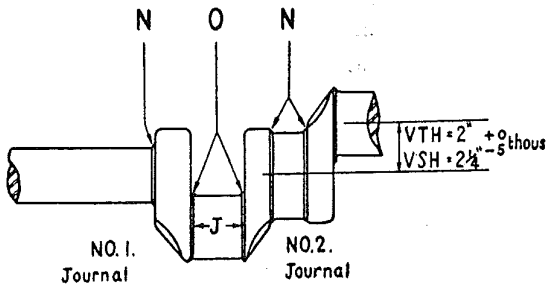


Fig. 18

Large End Journals should be ground on centres shown in Fig. 18, i.e.:—

VTO/H—2″ plus ' 0 ' minus 5 thous. (.005″).

VSO/H—2¼″ plus ' 0 ' minus 5 thous. (.005″).

relative to the crankshaft centre and the limits **must not be exceeded.**

NOTE

Maintaining the lengths of throws within machining limits is specially important on multi-cylinder engines where, due to there being a common cylinder head for two and three cylinders, it is not possible to adjust gaskets and shims individually for each line to compensate for varying lengths of crankthrow, in order to obtain correct bumping clearances.

Failure to maintain uniformity in bumping clearances in an engine may adversely effect its performance.

BEARING JOURNALS

Engine	Large End Pins	End Mains	No. 2	No. 3	No. 4
1VTO/H	$2\frac{1}{2}{}^{-\frac{1}{2}}_{-1}$	$2\frac{1}{8}{}^{-\frac{1}{2}}_{-1}$	—	—	—
2VTO/H	$2\frac{1}{2}{}^{-\frac{1}{2}}_{-1}$	$2\frac{1}{8}{}^{-\frac{1}{2}}_{-1}$	$3\frac{1}{4}{}^{-\frac{1}{2}}_{-1}$	—	—
1VSO/H	$2\frac{3}{4}{}^{-\frac{1}{2}}_{-1}$	$2\frac{3}{8}{}^{-\frac{1}{2}}_{-1}$	—	—	—
2VSO/H	$2\frac{3}{4}{}^{-\frac{1}{2}}_{-1}$	$2\frac{3}{8}{}^{-\frac{1}{2}}_{-1}$	$3\frac{3}{4}{}^{-1}_{-1\frac{1}{2}}$	—	—
3VSO/H	$2\frac{3}{4}{}^{-\frac{1}{2}}_{-1}$	$2\frac{3}{8}{}^{-\frac{1}{2}}_{-1}$	$3\frac{3}{4}{}^{-1}_{-1\frac{1}{2}}$	$3\frac{3}{4}{}^{-1}_{-1\frac{1}{2}}$	—
4VSO/H	$2\frac{3}{4}{}^{-\frac{1}{2}}_{-1}$	$2\frac{3}{8}{}^{-\frac{1}{2}}_{-1}$	$3\frac{3}{4}{}^{-1}_{-1\frac{1}{2}}$	$3\ {}^{-\frac{1}{2}}_{-1}$	$3\frac{3}{4}{}^{-1}_{-1\frac{1}{2}}$

Dimensions in inches. Limits in thous. Bearings numbered from flywheel end.

REQUIREMENTS

Refer to Fig. 20

i. **Grinding machine,** with drive to give crankshaft speed of 60/70 R.P.M. and a face-plate diameter of at least 14″ to allow for a 7″ throw of the crank.

ii. **Throw blocks,** one pair, **accurately matched and preferably on fixed centres** to suit both VTO/H and VSO/H crankshafts. The blocks should be capable of receiving counter balance weights. The ends of the shaft should be protected against damage.

Fig. 19 shows three views of a typical **throw block** which will prove a good guide to manufacture. The one illustrated is suitable for one, two and four throw shafts and the same type, but with three centres, is suggested for the three throw (120°) shafts.

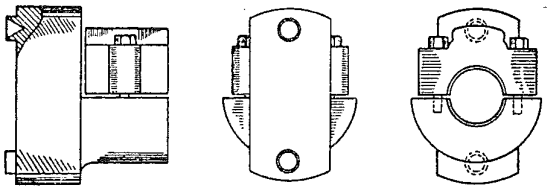


Fig. 19

iii. Make provision on the plate end for the adjustable counter balance weights.

iv. **Counter balance weights,** one pair, the weight required will, of course, depend upon the design of the blocks, but should be such as to permit any crankshaft to be revolved smoothly whilst grinding. To this end the position and amount of weight should be adjustable.

v. We use a $2\frac{1}{4}$″ wide wheel on VSO/H and 2″ on VTO/H Crankshafts, (with edges) suitably radiused.

SETTING UP

Refer to Fig. 20

Setting up the crankshaft for grinding both main and large end journals should be done with **great care.** See page 16 for adverse effects caused by incorrect setting up.

Mains

i. The crankshaft axis **AA** should revolve on the machine axis **BB.**

ii. Check with clock micrometer on grinding head by moving along the full length of the shaft, with the clock held (1) vertically and (2) horizontally.

iii. DO NOT attempt to grind until the crankshaft is parallel within the prescribed limits, making due allowances for uneven wear on the journals.

Large Ends

i. The axis of the large end journal to be ground should revolve on the machine axis **BB.**

ii. The crankshaft axis **AA** MUST be parallel and in line with both machine axis **BB** and centre line of bedplate **CC.**

iii. The ends of the shaft should be firmly held in the throw blocks which have fixed, proved centres.

iv. Check parallelism as above, i.e. with clock held (1) vertically and (2) horizontally. This should be done with crankshaft on top as shown in the illustration.

v. Turn the crank through 90° and repeat the check.

DO NOT attempt to grind until the crankshaft is parallel within the prescribed limits, making due allowances for uneven wear on the journals.

CRANKSHAFT SPEED 60/70 r.p.m. GRINDING WHEEL FOR STEEL SHAFTS.

N.B. Makers' instructions should be strictly adhered to.

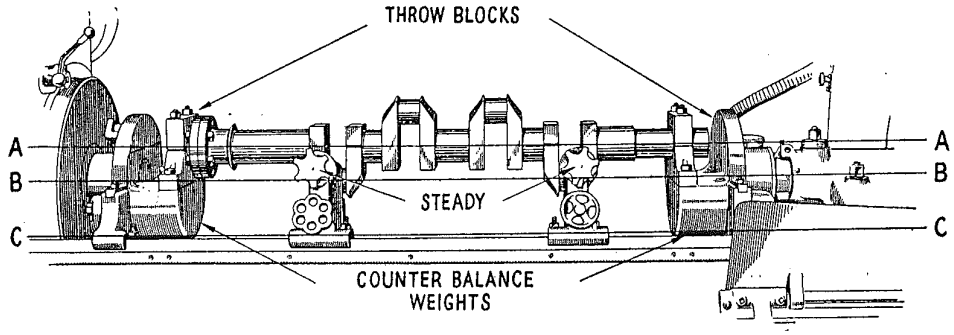


Fig. 20

NOTES

i. All oil holes to have corners broken with $\frac{1}{32}$" **radius.**

ii. All diameters to be round and parallel within $\frac{1}{2}$ **thou. (.0005").**

iii. All radii to be replaced as original shaft:—

Main bearing pins—$\frac{3}{16}$" **radius** see **N** Fig. 18

Large end pins —$\frac{1}{8}$" **radius** see **O** Fig. 18

NOTE

In each case out-of parallelism and twisting of throw blocks has been emphasised for illustration purposes.

Fig. 21 shows clearly the adverse effect of using inaccurately matched throw blocks.

The centre of the crankpin 'CP' is not parallel with the centre of the crankshaft 'AA'

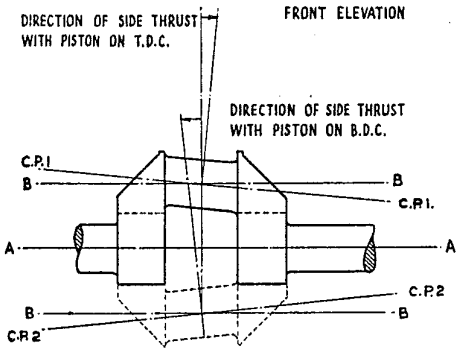


Fig. 21.

Fig. 22 illustrates how it is possible, even with accurately matched throw blocks, to set up in the machine with the blocks twisted in relation to each other.

It is therefore most important to ensure that the crankshaft centre 'AA' is in line axially with the crankpin 'CP' when in the vertical plane.

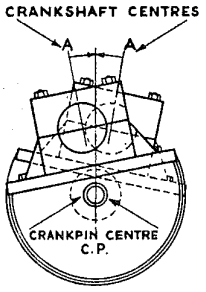


Fig. 22.

Fig. 23 shows the adverse effect of machining with twisted throw blocks.

Note that heavier pressure is created on alternate sides of the crankpin *i.e.* at half stroke downwards, on the side 'B,' and at half stroke upwards, on the side 'C.'

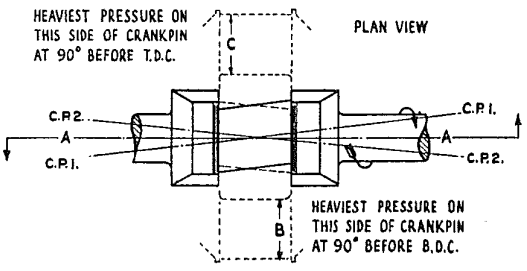


Fig. 23.

CHECKING (2nd)

Refer to Fig. 17 for 1, 2 and 4 throw crankshafts

i. Place crankshaft in vee blocks, see 1st check.

ii. Fit disc for profile check on one of the main bearing journals. See Fig. 26 for size.

iii. Set crank with large end pin to be checked on top.

iv. Check height of disc at '**E**', set clock micrometer needle at zero.

v. Check large end pin at '**F**', and the reading should be within the limits specified on Fig. 18, i.e.:—

$$\text{ZERO } {}^{+0''}_{-.005''}$$

This is a most important check—the limits must under no circumstances be exceeded.

vi. Whilst the crankshaft is in the same position check the pin for parallelism at points '**G**' and '**H**'.

vii. Turn crankshaft 90°, see right hand arrow and again check the pin at points '**G**' and '**H**'. There should of course be no variation throughout the length of the pin, within a limit of $\frac{1}{2}$ thou. (.0005″).

viii. Repeat for other large end pins.

Refer to Fig. 24 for 3 throw crankshafts

The three throw crankshaft requires an additional check as follows:—

i. Place the 30° protractor, Fig. 25, firmly against the milled profile of No. 1 crank, generally as shown.

ii. Set the clock micrometer to ZERO at point '**K**' with a $\frac{3}{16}$″ (.1875″)* 'slip' or 'block' gauge between the crankshaft journal and the toe of the clock, to allow for differences in diameters. *Standard—make suitable allowance for reduced diameters.

iii. Check No. 3 pin at point '**L**' as shown and the reading obtained should **be within the limits of zero, plus 30 thous. to minus 30 thous.**

The foregoing check can be carried out by means of a disc marked out in degrees, in which case the limits would be:—

120° plus 45′ (.75°) to minus 45′ (.75°).

Check the other large end pins similarly.

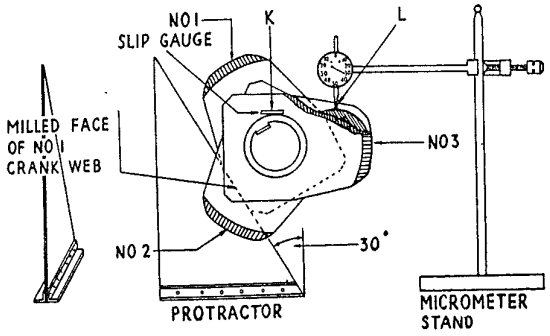


Fig. 25 *Fig. 24*

Figure 25 shows an isometric view of the 30 degree protractor from which it will be seen that it consists of a 30° angle plate rivetted between 2 angle pieces to hold it upright and enable it to be moved about on the surface-plate at will.

Refer again to Fig. 17 for all sizes

ix. Check for straightness throughout the length of the crankshaft as detailed in 1st Check on Page 12.

x. Straighten if necessary.

xi. Check dimension '**J**' Fig. 17 and 18, i.e. between large end thrust faces which should be:—

VTO/H $2'' \pm 0$
VSO/H $2\frac{1}{4}'' \pm 0$

Fig. 26 gives manufacturing details of the three sizes of disc required for the standard, first and second regrind crankshafts for VTO/H and VSO/H engines.

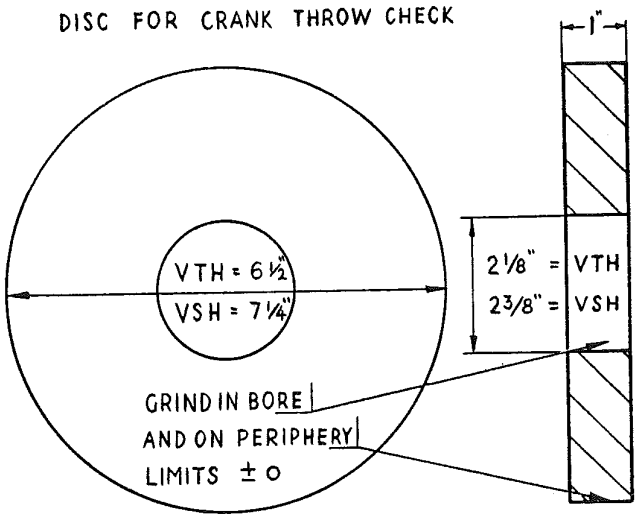


Fig. 26

NOTES

i. The disc is not to check parallelism of large end pin and crankshaft, but to check that the stroke of the crank is within the limits allowed.

ii. Straightening is the only operation which should be undertaken, as under normal service conditions, if the crankshaft is not straight it can only be due to the shaft having sprung in the crank profiles, or on bearing pins.

iii. NO attempt should be made to heat and/or twist the crankshaft, but if it will not respond to the treatment detailed, or does not check within the limits laid down, the shaft should be replaced.

BALANCE WEIGHTS

When balance weights are fitted they must be removed before the grinding operation.

Before attempting to remove the weights read these instructions carefully.

GENERAL

Two types of setscrews are employed to secure the weights to the crank webs.

i. $\frac{5}{16}$" hexagonal head, for which special spanner tool No. 8588 I.W. is required, with a $\frac{3}{4}$" round steel bar 2' long for turning.

ii. $\frac{9}{16}$" square head requiring special spanner tool No. 4603 I.W. and the $\frac{3}{4}$" round steel bar.

Each setscrew is locked after tightening in position by a dowel pin, serrated for half its length, and driven in so that the top is just below the face of the shoulder. The corners of the hole are peened.

Fig. 27 shows a section through the balance weight with the setscrew cut-away to reveal the locking arrangement.

NOTE On early engines the lockpin was positioned at right angles to the setscrew, through the side of the balance weight, therefore if the pin hole cannot be located at the top as shown, it will be found at the side.

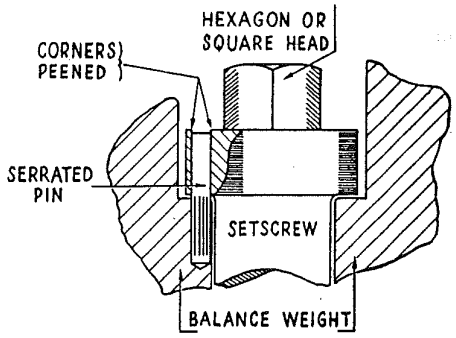


Fig. 27

REMOVAL

i. The crankshaft should be firmly secured to a bench or in a vice.

ii. Mark each weight so that it can be replaced on its correct web.

iii. With the appropriate spanner firmly fitted on the setscrew head and the bar arranged to give maximum leverage it should be possible to shear the pin.

iv. In case of difficulty drill an $\frac{1}{8}$" hole in the centre of the pin $\frac{3}{8}$" down to weaken it. This applies particularly to the old type pins see NOTE above.

REPLACING

i. Clean all parts and remove any burrs caused by shearing the pin.

ii. Replace the weight on the web from which it was removed.

iii. This is most important for **balance** purposes.

iv. Note the position of the pin-hole in the weight.

v. **Fit new Setscrews, do not use the old ones.**

vi. Tighten the setscrew with appropriate spanner and bar, **but do not over-tighten** by extending the length of the bar.

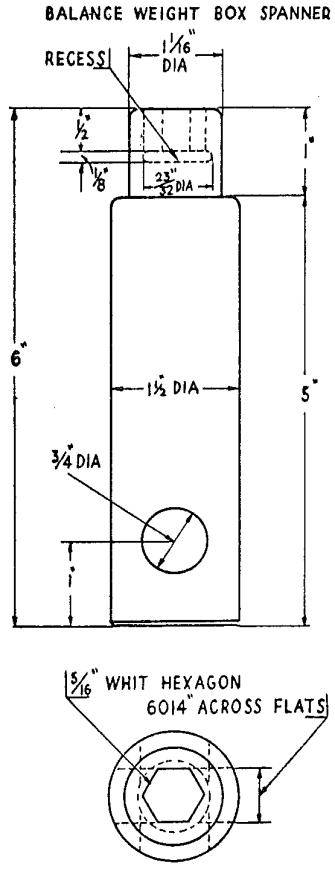
vii. Check that the drilled hole in the setscrew **does not come in line** with original pin hole. (If it does drill a **new** hole).

viii. Drill $\frac{5}{32}$" hole $\frac{13}{16}$" deep.

ix. Drive serrated pin in, see Fig. 27.

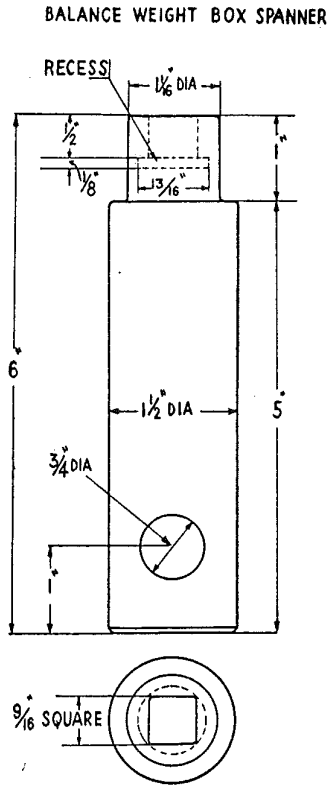
x. Peen corners of the holes as shown.

Figs. 28 and 29 give manufacturing particulars of Tools Nos. 8588 and 4603 I.W. respectively.



TOOL NO. 8588. I.W.
MATERIAL EN. 24 T.

Fig. 28



TOOL NO. 4603. I.W.
MATERIAL EN. 24 T.

Fig. 29

DECEMBER, 1952

SV 9

CRANKSHAFT
MAIN BEARINGS

CRANKSHAFT MAIN BEARINGS

CRANKSHAFT MAIN BEARINGS

NOTE All bearings are pre-finished before despatch, therefore no work will be required to be done on them except scrape the side clearance on the thrust bearings on standard engines.

BUSH BEARINGS. Part No. V-66.

(Common to all engines).

This bearing is a press fit in:—

(*a*)	End cover	Part No. V-1135
(*b*)	Bearing housing	Part No. V-6993
(*c*)	Bearing housing	Part No. V-6787
(*d*)	End covers	Part No. V-271

i. Remove the bush by means of tool No. 3949 IW.

ii. Replace by the same tool, but using item 1, withdrawing plate B instead of A to get more purchase on the antifriction metal on the face of the flange.

Sketch Fig. 1 shows the tool in cross section assembled for withdrawing the bush with plate 'A'; plate 'B' is shown in dotted outline in position for drawing the bush in.

Fig. 2 gives dimensions and constructional details of the component parts of tool No. 3949 IW.

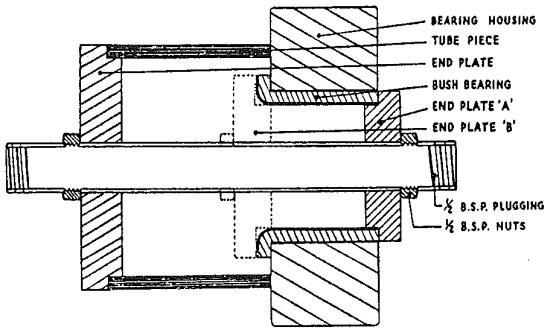


Fig. 1

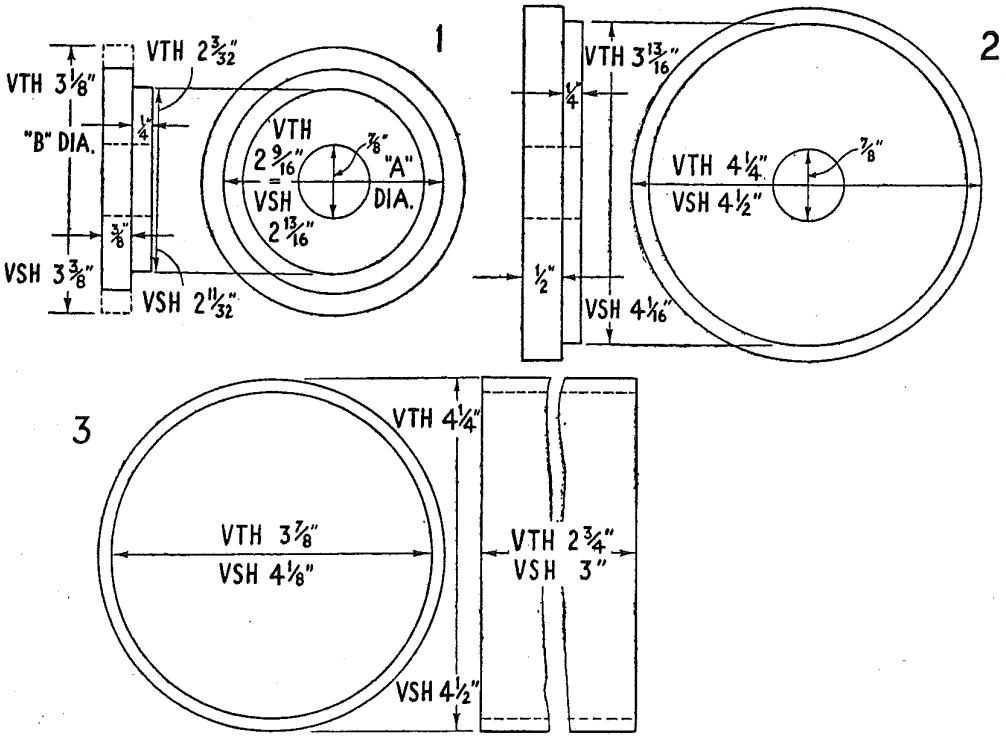


Fig. 2

WITHDRAWAL TOOL No. 3949 IW.			
Item	Description	Material	Number
1	Withdrawing Plate ..	E.N.3.A.	1 — "A" 1 — "B"
2	Withdrawing Plate ..	E.N.3.A.	1
3	Tubular Distance Piece ..	E.N.3.A.	1
4	½" B.S.P. Plugging ..	Steel	VTH 9½" long VSH 10" long
5	½" B.S.P. Nuts	Steel	2
6	¾" Washers	Steel	2
VTO, VTH, VSO & VSH		Bush Bearing Part No. V-66	

THRUST BEARINGS. Part No. V-161.

(on all multi-cylinder engines)

This is a split bearing fitting into housing part number V-6833.

i. The two halves are aligned one with the other by two fitting studs or screw bolts. To remove undo the nuts and prise the two halves of the bearing housing off the shaft.

ii. Remove the bearings and fit new ones, if necessary.

iii. Bolt the two halves together and check the overall width and scrape the flanges until the requisite end float is obtained, *i.e.*,

4—6 thous. (.004″ to .006″).

NOTES

1 We scrape the clearance to a gauge (Go and No-go) but if this is not available, then use the crankshaft, scraping each half separately on **one side only.** Checking finally upon assembly.

2 On single cylinder engines the thrust is taken between the two inner bush bearings (V-66) and the clearance should be adjusted to:—

3—6 thous. (.003″ to .006″).

3 On no account must the bearing housings be let up, although the operator should check that the housing when bolted together holds the bearing firmly. This check can be made quite readily with the aid of a set of feelers as follows:—

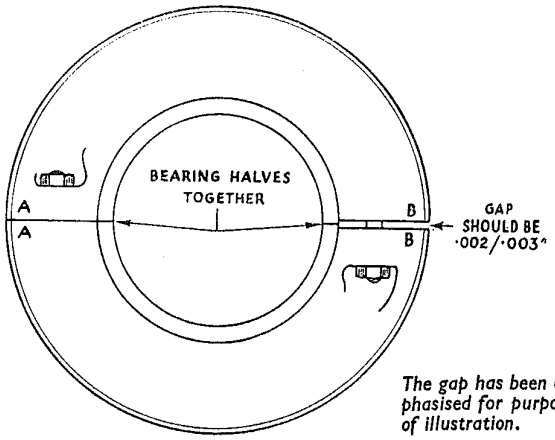
i. Fit bearings into bearing housing.

ii. Put the two halves together with the nut on **one** side finger tight so that points AA are in contact. See Fig. 3.

iii. Tighten the nut on the opposite side, also finger tight, *i.e.*, holding spanner at jaws, until the two halves of the bearing are together, as illustration. THIS will leave a gap between faces **BB.**

iv. For correctly fitting bearings the gap at BB will be **2—3 thous. (.002″ to .003″).**

4 When checking bores, the bearing halves should be nipped together.



The gap has been emphasised for purposes of illustration.

Fig. 3

3 and 4 Cylinder Industrial Engines only.

BUSH V-68 (in halves) fitting into
HOUSING V-64 (in halves).

This intermediate bearing requires the same fitting as V-161 except that there is NO SIDE CLEARANCE to scrape.

4 Cylinder Industrial Engines only.

BUSH V-6832 (in halves) fitting into
HOUSING V-6834 (in halves).

The only difference between this and other intermediate bearings is that it is longer and therefore the two halves of the housing are secured by 4 fitting studs and nuts instead of 2.

Repeat as for V-68 and V-64.

CRANKSHAFT MAIN BEARINGS

REGRINDS

Specially bored bearings will be supplied against order to suit crankshafts that have been reground in accordance with our recommendations.

Two regrinds are permissible, *i.e.*

i. **Size minus 15 thous.** (**.015**″) and
ii. **Size minus 30 thous.** (**.030**″).

When the crankshaft has been reground it is, of course, necessary to fit a **crankshaft gearwheel,** part No. V.1177, **which has been bored suitably undersize.**

The standard crankshaft oil seal, part No. V.7247 may, however, still be used, although the instructions given in S.V.8 sub-section (*c*) should be followed when fitting.

ORDERS for bearings and wheel should clearly state the amount by which it is proposed to regrind the crankshaft.

NOTE For crankshafts that are only slightly worn, *i.e.*, not sufficient to warrant regrinding, we can supply bearings bored :—

Size minus 5 thous. (.005″).

SPECIAL
CRANKSHAFT MAIN BEARINGS

LOCO ENGINE THRUST Part No. VL-66

This bearing is fitted on 2 and 3 cylinder VSO/H Loco engines only and is designed to withstand the axial shock loading common to LOCOMOTIVE applications.

It comprises two bush bearings VL-66, each a press fit in end cover VL-271 as shown in Fig. 4.

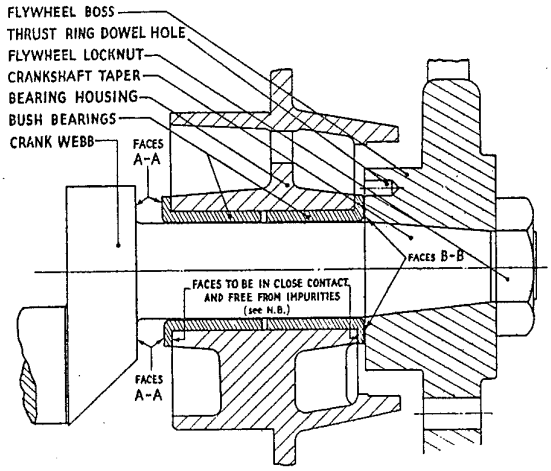


Fig. 4

DISMANTLING

Spider Coupling.

Both ends of the shaft should be cleared of accessory equipment and here it will be helpful to give a hint as to the removal of the spider coupling at the opposite end to the flywheel.

Refer to Figure 5.

The gib head (3) of the key points to the crankshaft (2) centre and the illustration demonstrates an easy means of providing necessary support to the under-side of the key, without which removal is extremely difficult.

i. Remove the bolts and the coupling disc.

ii. Assemble the wedge (4) and the retaining bar (5) using one of the bolts (6) generally as shown.

iii. Drive the key out by means of taper wedges, see Fig. 1, S.V.8.

iv. Remove the spider.

Dimensions of the parts required are given in inset on Fig. 5.

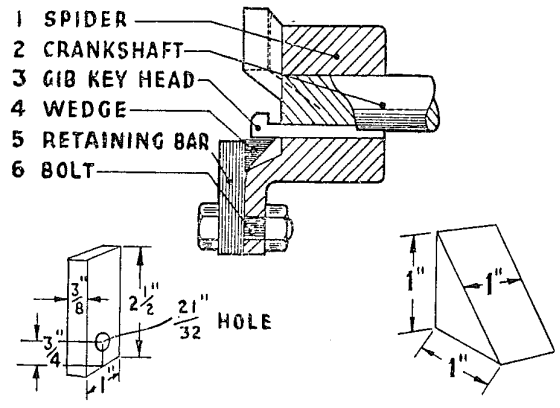


Fig. 5

FLYWHEEL

Remove per instructions given in S.V.8, sub-section (a), covering flywheels fitted on taper shaft by locknut, etc., using tool 3950 IW.

BEARING HOUSING

Remove by two $\frac{3}{8}$" dia. forcing setscrews in the tapped holes in the flange of the housing.

CRANKSHAFT

To remove see also S.V.8, sub-section (a).

OIL SEAL

The seal will have to be removed to facilitate the fitting of a new thrust plate or adjusting the end clearance thereof. See S.V.8, sub-section (c).

BUSH BEARINGS

Due to the construction of the bearing, *i.e.*, having thrust flanges at each end, the removal of one of the bushes is an operation requiring some care.

i. Try to remove **ONE** bush by driving out with a brass drift inserted in the gap between the bushes, failing this it may be necessary to split the bearing by chipping down the centre with a narrow ($\frac{1}{8}$") grooving chisel, after which the bush can easily be removed. DO NOT DAMAGE THE BORE OF THE BEARING HOUSING, DURING THIS OPERATION.

ii. Remove the other bush by means of tool No. 3949 IW. using plate 'A' (see Fig. 1).

iii. Fit new bearings with the tool, using plate ' B '.

N.B. It is important that the inner flanges of the bushes are in close contact with the faces of the bearing housing, otherwise there is a risk of excessive end float developing after the initial run. (See Fig. 4).

THRUST CLEARANCE. (End float).

This is checked whilst the crankshaft is out of the engine and it is assumed that all bearings have been removed from the shaft. It is recommended that the shaft be strapped to a bench with the end clear to receive bearing and flywheel.

i. Put the completed bearing on the shaft right way on.

ii. Remove the thrust plate and the dowel pins from the flywheel. Replace the woodruff (side fit only) key and after cleaning taper and bore, fit wheel on shaft and tighten AS IF ON FINAL ASSEMBLY.

Illustration Fig. 4 shows arrangement.

iii. The locking plate for the flywheel locknut should now be fitted.

The inset on Fig. 6 shows the locking plate machining, by means of which very little movement of the locknut is required to put the set-screw holes in line.

Try all positions before tightening the nut further.

iv. Scribe a line through the parts as shown in Fig. 6, *i.e.*, 2, 4, 5 and 6.

v. With faces BB (Fig. 4) held tightly together check the clearance between the faces AA very carefully indeed.

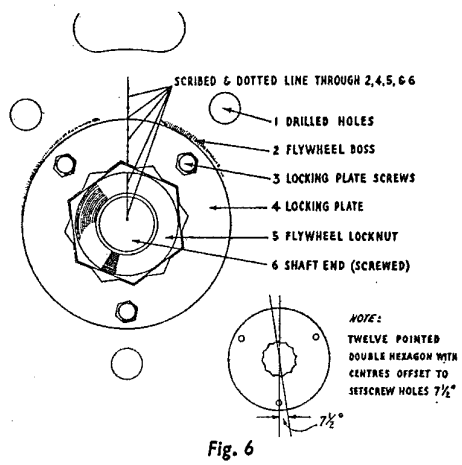


Fig. 6

THIS IS A VERY IMPORTANT CHECK, therefore exercise great care to ensure a correct figure, using, if possible, a pair of inside calipers that can be locked in any desired position.

vi. The dimension obtained with the calipers should now be checked with an 0"—1" micrometer and the plate, after dismantling the assembly, should be ground to a thickness four/six- thousandths less than the reading obtained.

e.g., **Micrometer reads .730".**
Grind plate to .726"/.724"

IMPORTANT

vii. If, after fitting new bearings as in the foregoing, the plate is found to be a thou. or two small it is possible to reduce the end-float by grinding the bore of the wheel on to the shaft.

Bear in mind that a thou. or two off the taper will permit the wheel to go further on the shaft several thousandths of an inch, and by exercising a little care much time and effort can be saved in the plate grinding operation.

FITTING NEW THRUST-PLATE

Important points to remember are:—

(*a*) Dowel pins are a push fit into the holes in the flywheel, but are an easy fit in the plate.

(*b*) The plate will only fit on the dowels one way—see key plan, Fig. 7.

(*c*) The thrust face of the plate MUST PRESENT an unbroken surface to the bearing.

(*d*) Plates should be a light driving fit on the crankshaft.

This MUST be checked when fitting as if the plate is slack on the shaft the oil seal would be rendered useless (see Fig. 7).

(*e*) Again the bore MUST be concentric with the periphery, as should the plate run eccentrically the efficiency of the seal would be impaired.

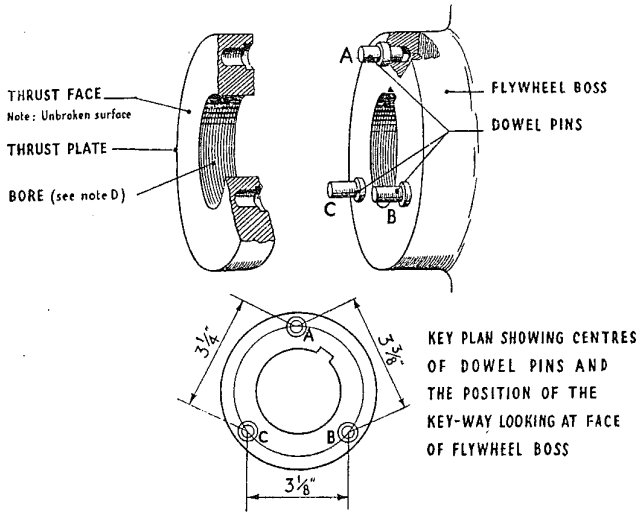


Fig. 7

PROCEED AS FOLLOWS :—

i. Scribe a line on the flywheel boss to mark the centre of the keyway in accordance with (1) on Fig. 8.

ii. Fit dowel pins in wheel and the thrust-plate over the dowels and holding it tightly against the boss scribe a line to correspond with line on wheel, extending the line when plate is removed as (2) on left hand illustration Fig. 8.

iii. Scribe a line (3) on the crankshaft taper through the centre of the keyway.

iv. Press or tap the thrust-plate on to the shaft about 1″ or so further than running position; see that the two scribed lines coincide.

v. Fit the woodruff key.

vi. Put on the flywheel, tightening it lightly into position with the locknut.

vii. Tap the thrust-plate along the shaft, making certain that the dowel pins are clear in the holes, until the plate face makes contact with the flywheel boss.

NOTE This operation is necessary to ensure that the thrust plate fits over the dowels without pulling on the shaft, and thereby causing distortion. (See note (*d*) on page 8).

viii. Remove locknut, flywheel, woodruff key and thrust-plate.

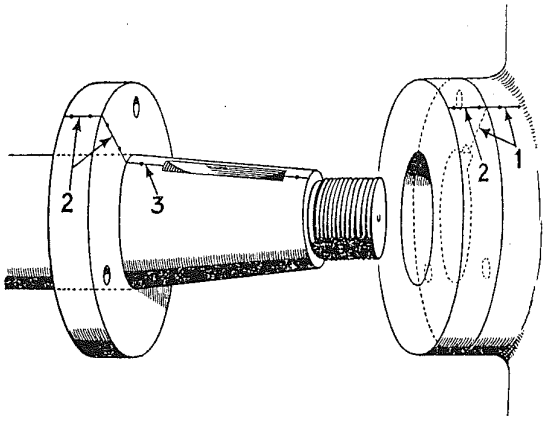


Fig. 8

COMPLETING THE OPERATION

Proceed as for Thrust Clearance.

REPLACING THE THRUST BEARING

The instructions assume that all other bearings have been fitted and that the crankshaft has been replaced in the engine in accordance with S.V. 7, sub-section (*b*).

i. Fit the bearing into the housing.

ii. Smear jointing compound on the rim and fit the oil seal. Although this seal is larger in diameter than the standard, it is a light driving fit and can be readily driven in using a piece of hard wood as a drift. Care should, of course, be taken to drive in evenly to prevent distortion. See S.V.8. sub-section (*c*).

iii. Turn the crank so that keyway is on top.

iv. Fit the thrust-plate, with the lines together, see Fig. 8, to within $\frac{1}{16}$″ (approx.) of final position.

v. Insert key, replace the wheel and tighten the locknut until all lines coincide, see Fig. 6.

vi. Give a sharp blow to the locknut end of the shaft with lead hammer, or equal and check clearance finally between crank web and bearing as indicated in Fig. 9 which shows clearly in cross-section the FINAL ASSEMBLY.

vii. Finish off by fitting lockplate and threading soft iron wire through the holes in the three setscrews. Bring the ends of the wire together and twist.

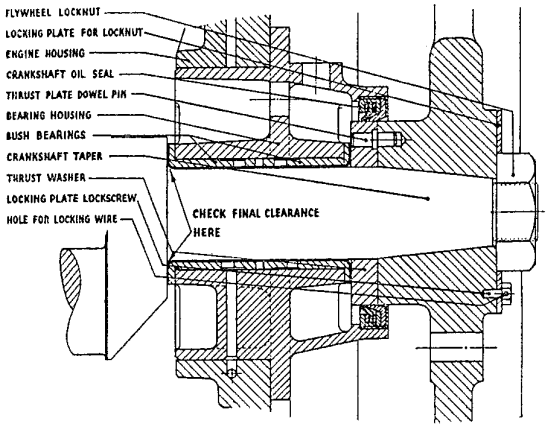


Fig. 9

NOTE

On all loco engines the standard thrust bearing is replaced by

Bearing housing (split) part No. VL-64.

Bearing bush (split) part No. V-68.

Any service attention given should be in accordance with instructions for standard thrust,

EXCEPT THAT THERE IS NO SIDE CLEARANCE TO SCRAPE.

SPECIAL
CRANKSHAFT MAIN BEARINGS

CONSOLIDATED PNEUMATIC TOOL CO. ENGINES

Two sizes of engines are fitted into C.P.T. equipment at present, viz:

1. **MARK 3 VTO or 3 VTH** to which reference is made in S.V. 8, sub-section (e).

2. **MARK 3 VSO or 3 VSH** which are fitted with a special crankshaft and bearings involving different methods in servicing, etc.

The instructions assume that the engine has been lifted from the chassis and that the clutch has been removed, so that the engine presents an appearance as the one on the left hand of the illustration, Fig. 10.

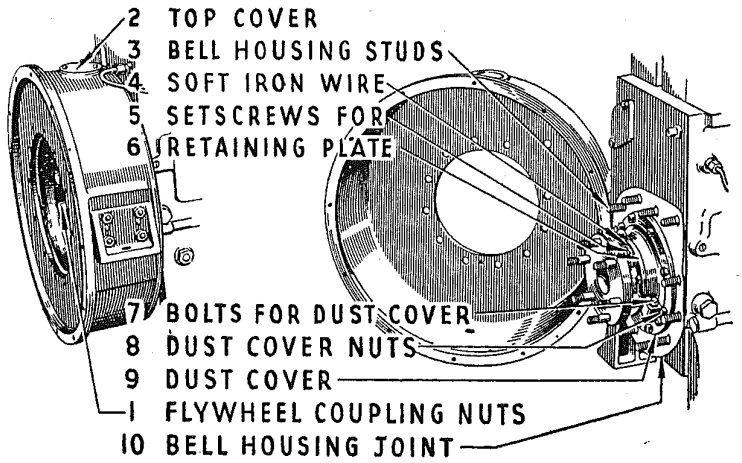


Fig. 10

DISMANTLING

The Fan Pulley.

i. Remove the starting dog from shaft at opposite flywheel end. This is merely screwed on tight and can be undone by giving a sharp blow on the end of an appropriate size of spanner.

ii. The pulley can be removed by using forcing screws in the $\frac{3}{8}$" holes provided pieces of $\frac{1}{16}$" plate are inserted between the pulley and the end cover.

iii. Remove the end cover.

The Crankshaft End Bearing Assembly

Refer to Fig. 10.

i. Remove flywheel coupling nuts (1) and spring (Kolok) washers.

ii. Remove the top cover (2) from bell housing and turn wheel to put lifting hole on top.

iii. Force the wheel off with two $\frac{1}{2}$" B.S.W. forcing screws in the tapped holes provided. Support the wheel during this operation until a lifting eye can be screwed in.

iv. Remove the bell housing, see illustration.

v. Remove the soft iron wire (4), the setscrews (5) and the oil retaining plate (6), the latter is in two halves.

vi. The two bolts (7), the nuts (8) and the dust cover (9), also in halves, to be removed.

NOTE This exposes the oil throwing arrangement which on this engine displaces the oil seal.

It is not necessary to remove the disc, but, of course, care MUST be taken in handling the crankshaft, to prevent damage to it.

vii. The crankshaft can now be removed in accordance with S.V.8 (*a*).

THE MAIN BEARING. Part No. R.71A.

This is a special split bearing bush fitting into bearing housing part No. R.6787A also split and is found only in C.P.T. engines where a flywheel coupling is shrunk on.

FITTING NEW BEARING

Follow same instructions as for other split bearings which are NON-THRUST.

RE-ASSEMBLING

i. Fit ALL the bearings on to the crankshaft.

ii. Replace the shaft. See S.V.8 (*b*).

iii. Replace gearwheel end cover, using sleeve tool No. 8943 IW. to protect the oil seal. See S.V.8 (*c*).

iv. Drive the fan pulley on and fit the starting dog.

v. Replace the dust cover (9) and tighten into position.

vi. Fit the oil retaining plate, after checking the felt washer for soundness. Thread soft iron wire through the heads of the setscrews, bring the ends together and twist.

vii. Replace the bell housing making quite certain that ALL nuts are tightened on to their ' KOLOK ' washers, and that there is no foreign matter at the back.

viii. In replacing the flywheel remember that the bolts are a " PRESS FIT " and that care must be exercised in entering the plain part of the bolts before any pressure is applied.

Both the end of the coupling and the flywheel are marked so as to avoid the possibility of replacing wrongly.

Here again the nuts should be tightened carefully with a ' Kolok ' washer beneath.

The clutch and other equipment may now be replaced.