

OVERHAUL MANUAL FOR
650cc UNIT CONSTRUCTION
TRIUMPH MOTORCYCLE
ENGINES SINCE 1963

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INTRODUCTION

This manual is intended to be a guide for the repair of all unit construction 650cc Triumph engines. It is recommended that the procedures outlined here be followed exactly until they become a matter of routine.

Over 100 mechanics of varying experience have used this manual to assemble and disassemble their own engines at our TRI-COR Mechanics Training Center. Based on this experience one comment seems necessary. It has been demonstrated time and again that if these directions are followed exactly word for word, the work will be correct and progress smoothly. Deviations from the methods outlined here will only result in outright errors or lost time.

Instructions for Dismantling the "B" Range 650cc Unit Construction Motorcycle Engine

NOTE: Before commencing any work on an engine check the engine number and review 650cc Service Bulletins. Also check the engine change list in this bulletin for engine changes. Be sure you have the correct parts book for this engine number. It is most important to know exactly what model engine you are dealing with!

Illustrations and a briefer explanation of procedures can be found in the 650cc Triumph Workshop Manual CD411. Use the latest blue and white covered edition from engine #DU44394 for the most complete information on "B" Range Twins.

Parts to be replaced or repaired should be written down as the engine is disassembled. When checking all parts, refer to the specification table in CD411 for proper specifications.

TRIUMPH TOOLS NEEDED FOR COMPLETE OVERHAUL

Dis-Assembly

T138	Valve spring compressor (or equivalent)
Z151	Crankcase parting tool
Z121	Crankshaft pinion puller
Z89	Camshaft gear puller and installer
CD150	Clutch holder (or equivalent made from welding or bolting T1362 and T1363 together)
CD222	Clutch hub puller
D484T	Breaker point cam extractor
D496	Primary chain tensioner
CD474	Engine locking tool
P311TR	Universal puller
CD422	Wrist pin drift
	Special wrench as per Service Bulletin 65/4 for speedo cable nut if applicable.
	Impact driver (often useful for loosening stubborn screws)
CD522	Engine stand

While Apart

CD473	Layshaft needle bearing drift
CD114	Wrist pin bush tool
CD121	Cylinder head holder
Z16	Valve guide punch
ZT23	Tappet guide block punch

Assembly

CD456	Ignition timing kit
D486T	Camshaft oil seal guide
Z89	Camshaft gear puller and installer
CD150	Clutch holder (or equivalent made from welding or bolting T1362 and T1363 together)
D496	Primary chain tensioner
CD474	Engine locking tool
233	Electrical circuit tester
D571/2T	TDC indicator
CD441	Exhaust pipe adaptor wrench
CD422	Wrist pin drift
CD3	Timing disc
CD123	Timing disc adaptor
T138	Valve spring compressor or equivalent

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NOTE: Most bolt and nut sizes are Whitworth (B.S.F. interchangeable) except where U.S. sizes are gradually being introduced.

LIST OF ENGINE CHANGES RELATING TO MAJOR ENGINE WORK
(By Serial Number and Approx. Year)

Unit Construction Engines Start with DU101, 1963 Models

1964-DU5825 T120 1-19/32" intake valve (E4603) and 1-7/16" exh. valve (E2904) instead of 1-1/2" inlet (E3310) and 1-11/32" exhaust (E3927)

1965-DU13375 Oil release valve changed to blind cap (no oil pressure indicator)

DU13375-24874 Crankshaft located by drive side (before DU13375 and after DU24874 crankshaft located by timing side - see applicable parts manuals and CD411)

DU19895-25377 Oil bleed holes in connecting rods

1966-DU24875 New tappet guide block and push rod tube seals
Pressure lubricated exhaust tappets, (E6329 Std. radius - E6490 "R" radius) metering jet dowel E6800/3 or E6348 in timing cover.
Light flywheel E6327.
Roller drive side main bearing instead of ball bearing

T120 Change from E3001/3002 to E4221/4222 valve springs
T120 Change to "R" tappets (1-1/8" radius) E3059R and E6490
T120 9:1 pistons (CP206) instead of 8.5:1 (CP200)

DU31119 approx. Sports exhaust camshaft E4855 replaced by racing camshaft E5047 (T120/R and T120/TT only)

1967-DU44394 9:1 pistons (all models) - (E6868) in place of CP206 or CP200
Larger oil pump (scavenge side) E6928
TR6 1-19/32" intake valve and 1-7/16" exhaust valve instead of 1-1/2" intake and 1-11/32" exhaust
TR6 Change to "R" tappets (1-1/8" radius) E3059R and E6490
TR6 Sports exhaust camshaft E4855 replaced by racing camshaft E5047

DU47006 T120 Change to heavy-duty connecting rods
Check on all models by measuring across front or back of rod shank at a point 1" below bottom of pin hole - old type measures .550" new heavy duty type measures .605". Caution: See note on assembly sheet.

DU48144 Change to unified thread transmission mainshaft

DU51771 160° ignition cam #54419124

DU63043 "Timed" lubrication exhaust tappets (3/32" flat) E8801 (R radius) and E8895 (Std. radius) - change back to plain timing cover dowel T989

DU63241 "O" Ring under shoulder of tappet guide blocks

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GENERAL INSTRUCTIONS

For a complete overhaul, it is generally best to remove the engine from the frame as soon as possible and install it in a suitable holder on a clean, well lighted work bench. Engine removal from the frame is fairly straightforward. Remember to do the following:

- 1) Disconnect alternator leads and breather hose under engine
- 2) Disconnect Black/Yellow and Black/White ignition leads at connector under gas tank
- 3) Drain oil from gearbox, primary case and oil tank
- 4) Disconnect rear chain

On the TR6 and 6T the carburetor must be removed. On the TL20 models just pull the slides out of the carbs. Both rocker boxes must be removed to remove (or install) the engine from (in) the frame. To do this remove the rocker caps, loosen the adjusting screw lock nuts and turn the engine over until both exhaust or intake valves are closed - then, on the rocker box where both valves are closed:

- a) Remove the engine torque stays
- b) Remove the three nuts and washers from the underside of the rocker box - on the TR6 intake box remove the center nut, loosen the two outside nuts, then remove them as the box is lifted
- c) Remove the two outer bolts from the rocker box
- d) Remove the two head bolts - these bolts will clear the frame if both bolts are lifted and the rocker box tilted
- e) Remove the pushrods

Repeat the above steps for other rocker box.

At this point remove the engine from the frame. Install the engine in a suitable engine stand (CD522) and place the engine assembly in a vise with the primary facing you.

HEAD REMOVAL:

- a) Remove the five remaining head bolts
- b) Lift off the head, head gasket, and remove the pushrod tubes and seals

At this point check: - pushrods for straightness, and cups for cracks and wear
- head gasket surface for flatness
- remove valves from head and check seats, guides, and valve stems for wear, scoring, pitting
- valve springs for proper tension

CAUTION: See assembly notes on head work before proceeding with the assembly and/or work on head.

Now install the CD474 engine locking tool on the cylinder barrel (do NOT use D571/2T TDC tool in flywheel) and proceed as follows:

PRIMARY:

- a) Remove the primary cover
- b) Using the D496 tool or a screwdriver remove the primary chain tensioner adjusting nut
- c) Remove the three clutch spring screws, springs, pressure plate, spring cups and twelve clutch plates from the clutch and also the clutch pushrod from the mainshaft.
- d) Bend back the lock tabs on the crankshaft and mainshaft nuts (no tab washer on mainshaft from Eng. DU48144). Using clutch locking device (CD150 or substitute) and a socket wrench remove the mainshaft and crankshaft nuts and washers. Leave this clutch lock installed to facilitate installing the CD222 clutch pulling tool in step g.
- e) Remove the three stator nuts and washers. Pull the alternator lead harness thru the sleeve nut about 2" and remove the stator from its mount studs. Place the stator on top of the transmission temporarily.

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- f) Remove the rotor from the crankshaft (using a two jaw puller if necessary). Then remove the key and distance piece from the crankshaft (no key in the E.T. system - a pin in a larger distance piece is fitted on these E.T. systems which are used on all "Competition Models")
- g) Thread a CD222 clutch puller all the way into the clutch hub. Tighten the bolt and give it a sharp rap with a hammer to break the clutch hub loose from the tapered mainshaft.
- h) Using a universal puller such as a Bonney # P311 (NOT a screwdriver or prybar) remove the engine sprocket while holding the clutch hub assembly together. Be careful that the chain doesn't jam against the stator studs. Guide the clutch hub assembly, chain and engine sprocket off as a unit - then pull out the engine sprocket and pass the stator thru the chain. Keep the clutch hub and center together to avoid spilling the twenty rollers from the bearing.
- i) Unscrew the stator sleeve nut and pull the lead assembly thru the case. Leave the three stator studs in the case in order to use Z151 crankcase parting tool.
- j) Remove the chain tensioner. Also be sure to remove the Woodruff key from the mainshaft.
- k) Remove the chain oiler tube.

At this point check:

- chain and sprockets for wear, broken teeth or rollers
- clutch plates for wear, burning, warpage, and broken, bent, or worn teeth (driver plates should be about .140" thick at corks - replace if below .120" thick).
- stator for broken or frayed leads, shorts, opens
- rotor for evidence of rubbing on stator, hub bore for snug fit on crankshaft, hub tight
- clutch hub bearing rollers, races and thrust washer for wear
- chain tensioner for wear
- clutch shock absorber for worn or deteriorated rubbers, loose flat head screws. The cover plate on one side must be removed to check the rubbers. Use Loctite on the 6 flat head screws when reassembling.
- Crankcase for evidence of chain rubbing on it

TRANSMISSION:

- a) Remove the outer cover (it is not necessary to remove the shift and kickstart levers), and also the oil lines and junction block.
- b) Remove the inner cover assembly by removing one each bolt, allen screw and Phillips screw. The mainshaft will come out with the cover - don't lose the right side layshaft thrust washer.
- c) Remove the second and third mainshaft gears from the upper shift fork, also remove the layshaft first gear. Then pull the pin holding the selector forks and remove the forks and layshaft together. Don't lose the two rollers from the shift fork pins or the inner thrust washer from the layshaft.
- d) Turn the camplate until it will clear the mainshaft fourth gear and remove it. Then remove the plunger, spring and plunger cap.

At this point check:

- Shift camplate for wear on insides of track and on outside plunger track.
- Plunger spring for proper free length (see CD411)
- Thrust washers for wear, evidence of improper fit
- Gears and engagement dogs for chips and wear
- Kickstarter ratchet for wear on teeth, and ability to slide freely on pinion sleeve, also see that spring is not cracked or broken.
- Shift forks, pins and rollers for wear
- 4th gear bush, ball bearing, and countershaft sprocket for wear
- Mainshaft ball bearing (right side) for wear, pitted races or balls
- Layshaft needle bearings for loose or missing needles

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TIMING COVER

- a) Remove the contact breaker cover, two pillar bolts and pull the contact plate assembly out of housing. It is not necessary to disconnect the two lead wires at this time.
- b) Remove the auto advance mechanism bolt and replace it with D484T puller. Thread this tool in until the auto advance assembly breaks off its taper and can be removed. You must use the CD523 puller on 1968 models as it is about 1/8" longer than the D484T.

At this point check:

- Contacts for pitting, burning
 - "freeness" of advance mechanism, also advance slot and cam for wear
- CAUTION: See assembly note regarding this part.

- c) Remove the oil pressure plug from the front of the timing cover (also the screen filter if fitted).
- d) Remove the timing cover (tap on the cover with a hide or plastic hammer to loosen - do NOT pry off with screwdrivers or a prybar). The ignition leads will pull thru the crankcase and stay with the cover.
- e) Remove the oil pump and slider block. Note the condition and alignment of the oil pump gasket.
- f) Remove the two camshaft nuts (left hand thread - clockwise to loosen) and the crankshaft nut.
- g) Using the Z89 puller (or P311 puller if '63 model with two threaded holes in gear) remove the two camshaft gears. You must use the Z1145T adapter in the exhaust camshaft to remove the exhaust camwheel. (It is NOT necessary to remove these nuts and gears to split the crankcases; however, it is much easier to accomplish this now and necessary for the proper cleaning of parts.)
- h) Remove the intermediate wheel.
- i) Using the Z121 pinion gear remover with the protector for the end of the crankshaft, remove the crankshaft pinion.
- j) Remove the keys from all three shafts and also the clamping washer (if fitted) from the crankshaft.
- k) Remove the oil pressure relief valve assembly from crankcase.

At this point check:

- Gears, keys, and keyways for wear or chips on teeth
- Intermediate wheel spindle for wear, also intermediate wheel bush for wear
- dis-assemble oil pump and check for metal chips, condition of ball seats, flatness of gasket surface, and slider block and plungers for wear
- dis-assemble oil pressure relief valve and inspect for sticking plunger and correct spring length. Hold the assembly in an upside down socket held in a vise to prevent distortion of the relief valve body.

Now remove the engine locking tool and proceed as follows:

- a) lift up the tappets and wedge half of a gas tank rubber (#F967) or similar item in between them to hold them in the tappet blocks.
- b) remove the eight cylinder base nuts with a ground down box wrench
- c) carefully lift the cylinder barrel off. Do not let the pistons and rods "crash" against the crankcase or studs.
- d) install cut handlegrips or other protective devices on the rod shanks to prevent them from being damaged.
- e) remove the four circlips from the pistons with a small screwdriver
- f) If the piston pins will not push out by hand, heat the pistons until the pins will push or lightly tap out with a hide or plastic hammer and CD422 drift. Support the back of piston when tapping out the pin with a drift. Mark the inside of the pistons "T" and "D" for later analysis and assembly.
- g) remove the tappets from the guide blocks and mark them so they can be reassembled to same cam lobe if they are re-used

At this point check:

- Tappets for scuffing, wear and cracks in stellite facing, also wear on stems see specs. for allowable stem dia.
- cylinder bores for wear. To do this use a micrometer and mike the cylinder about 1/4" below the top in the front-back (90° to pin) direction and also in line with the pin. Subtract these dimensions to obtain the out of round dimension of the cylinder. Now mike the cylinder about 1" up from the bottom (any direction). Subtract this dimension from the top front to back 90° to pin dimension to obtain the cylinder's taper dimension.
A piston ring can alternatively be used to check the taper as follows:
Measure the ring end gap with a feeler gauge at the top (1/4" below) and bottom (1" up) of the cylinder. Subtract the two measurements and divide by 3.14
- the resulting figure will be the approximate taper of the cylinder.
Cylinders must be rebored if the taper or out of round exceeds .004".
- tappet guide block bores for wear - use a hole gauge and compare with specs.
- pistons for wear of skirts and ring lands

SEPARATING CRANKCASE ASSEMBLY:

- a) Remove the two inner 1/4" screws from the crankcase at the cylinder base boss
- b) Remove the remaining case bolts and studs. Don't forget the bolt at the top extreme rear of the primary side. Also, at this time remove the scavenge oil passage plug (1/4W) at the bottom of the right side case.
- c) Bolt the Z151 crankcase parting tool to the stator studs and tighten the bolt against the crankshaft stud to separate the crankcase halves. If the cases won't part with moderate tightening of the bolt, check to see that all case bolts and studs have been removed. It may be necessary to heat the crankcases so a main bearing will come out of one crankcase as the cases separate.
- d) Remove the camshafts. Don't lose the breather valve disc and spring from the left side intake cam bush.
- e) The crankshaft may slip out of other case half - if not do NOT try to drive it out! Heat the crankcase until the bearing and crankshaft assembly will drop out. Then use a wheel bearing puller in conjunction with a universal puller (P311) to pull the bearing off crankshaft.
- f) Heat the crankcase with a torch to remove the other bearing or race from the crankcase.
- g) Remove the drive side oil seal from the left crankcase.

NOTE: The countershaft sprocket may now be removed if necessary. Grip the sprocket in a soft jawed vise and remove the nut. Now remove the sprocket, 4th gear and the oil seal. The sprockets are now being "loctited" to the 4th gear at the factory. It may be necessary to heat the sprocket to destroy the effect of the loctite and sprockets can be removed. An offset screwdriver is a handy tool to pry the oil seal out with. After the snap ring is removed, the ball bearing can be removed from the case. Heat the case if necessary to remove the bearing.

Now grip the crankshaft assembly by the flywheel in a soft jawed vise and proceed as follows:

- a) Remove the connecting rods. Reinstall the cap to the connecting rod it came off of and the nuts to their proper bolts as you remove the rods from the crankshaft. Mark the rods "D" and "T" for later analysis and assembly.
- b) Remove the three flywheel bolts and check that the flywheel is not loose on the crankshaft by lightly tapping the flywheel with a hammer. The flywheel should not move when this is done. If it is a tight fit on the crankshaft there is no need to remove the flywheel.

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- c) Using a 1/8" or 3/16" drill bit - drill out the punch mark on the sludge trap plug and remove the sludge trap plug. A ground down drag link socket and an impact driver is a good tool for this job. The sludge trap plugs are now being "loctited" at the factory. It may be necessary to carefully heat just the plug to destroy the effect of the loctite so the plug can be removed.
- d) Using an old spoke, remove the sludge trap by hooking the spoke in the flywheel bolt hole of the sludge trap tube and pulling the tube out. ALWAYS remove the sludge trap for thorough cleaning of the crankshaft assembly.
- e) If the flywheel is loose or broken and must be replaced, heat around the flywheel with a torch until the flywheel can be lightly tapped off the crankshaft toward the timing side.

At this point check:

- Cam lobes for wear, scuffing, and tightness of tach drive thimble in exhaust camshaft. Measure the base circle (side-side) and lift circle (top-bottom) to determine lobe wear. Subtract these measurements to determine the lift of each lobe.
- camshaft bushes and bearing surfaces for wear.
- crankshaft rod journals for wear in at least two places 90° apart. Wear or out of round exceeding .001" dictates that the crankshaft must be reground.
- scavenge tube in crankcase for tightness and leaks. Place a rubber hose on the tube and block off the hole at oil pump and the bottom of the crankcase. Suck on the hose - no air leaks should be noticeable.
- oil passages in crankcase and crankshaft for absence of foreign matter.
- wrist pin bushes for wear. Using a new wrist pin, place it in the rod bushing. The pin should be a snug sliding fit at room temperature. Look for horizontal and vertical play in the pin. Replace the rod bushing using CD114 bushing remover and installer if play is noticeable.

ASSEMBLY

Caution: All parts must be scrupulously clean and dry before any re-assembly work may be started.

Engine Sub-Assemblies

1. Crankcase, Connecting Rods and Flywheel

- a) Always measure the journals on a new or reground crankshaft and check against specifications. On a reground crankshaft, the radius on the sides of each journal must be .070 - .080". Also check the timing side end of the shaft to see that the surface that the seal contacts is smooth and the diameter is about .622 - .623".
- b) If the flywheel has been removed, place the crankshaft in a soft jawed vise by its drive end. Heat the flywheel with a torch until it will slip on to the crankshaft in its proper location (heavy part 180° opposite from crankpins). Insert the three bolts enough to locate the flywheel accurately and let the flywheel and crankshaft cool at this point.
- c) After the flywheel and crankshaft cool to room temperature, remove the three old flywheel bolts and insert the sludge trap into the crankshaft aligning its large hole with the adjacent flywheel bolt hole. Then using Loctite, install and tighten three new flywheel bolts to a torque of 33 lb. ft.
- d) Coat the threads of the sludge trap plug with Permatex-Super 300 gasket cement and install this plug in the crankshaft. Tighten the plug with an impact driver and center punch it right next to the place drilled when the old plug was removed. The plug shouldn't be more than one thread past flush with the side of the crankshaft when tight or it may block the oil supply hole in the crankshaft.

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1. Crankcase, Connecting Rods and Flywheel Cont'd

- e) At this point it is wise to check the balance of the crankshaft. Use the correct Triumph bob weights and be sure your parallel bars are clean and level.
Z138 - 689 grams 1964 and later
Z120 - 590 grams 1963 and before
NOTE: Before the next step make sure both connecting rods are either the old type or the new stronger design. Never fit one of each rod as this could cause an out of balance condition. See the engine change list for how to identify the new design.
- f) Make sure that the connecting rods are clean in the bearing bores, and no bits of metal or dirt are on the rod and cap faces. Install clean new rod bearing shells in the connecting rod and cap. Push the bearing completely into each part and wipe off any excess metal that is scraped off the back of each bearing shell.
Under no circumstances put any oil between the back of the bearing shell and the rod or cap. Caution: Never remove any metal from either rod or cap face.
- g) Coat the crankshaft journal and bearing surfaces with clean oil. Assemble the connecting rod to the crankshaft. Be sure that the dots (or alternatively the bearing shell lock tabs on the cap and rod shells) are on the same side of the journal. Tighten the connecting rod nuts to a snug fit and repeat steps f and g for the other connecting rod. Always put each nut back on the bolt it came from.
- h) With the nuts "snugged up" they should be about 1/4 turn away from their correct position. Tighten the "single dot" nut about 1/4 turn until the dot is even with the dot on the rod cap. Tighten the "double dot" nut about 1/4 turn until the two dots are evenly facing the outside of the rod. Tightening the nuts in this manner insures the rod bolts are as tight as they were when the rod bearing bore was machined. Both rods should fall of their own weight after tightening.
- i) If you have lost track of the rod nuts and bolts or fitted new nuts and bolts proceed as follows:
Tighten the rod nuts evenly until (preferred method) the connecting bolts have stretched .004" to .005" (mike the length of the connecting rod bolt before and after tightening) or (second best method) torque the connecting rod nuts to a torque of 28 lb. ft. Make sure you tighten all four nuts.
- j) Tape the shanks of the connecting rods to prevent damage and wrap this entire sub-assembly in clean rags or paper and set aside for now.

2. Oil Pump

- a) Be absolutely sure that the oil pump and all its parts are thoroughly clean.
b) Be sure the gasket surface of the pump is flat and smooth.
c) Check the two ball seats in the brass pump body. They should be concentric with their holes and have no grooves or pits in them.
d) Assemble a ball, spring and cap on each side of the pump. Be sure to tighten the caps.
e) Oil the two plungers and insert them in the pump. The plungers should slide freely in the brass body.

NOTE: To test the oil pump for proper seating of the check valve balls, push both plungers all the way into the brass body. Then fill both scavenge and pressure outlet ports with SAE30 oil. Cover both scavenge and pressure intake ports with your finger and slowly withdraw both plungers. The oil level in the outlet ports should not drop as the plungers are withdrawn. If the oil level drops on either side the check valve is leaking and the cause of this leak must be ascertained and remedied. Don't waste time seeing how the pump squirts oil. Also, don't be concerned about light score marks, etc., on the plungers. As long as the body and the plungers fall within the specs. in CD411 they should work correctly.

- f) Put the aluminum slider block in the plungers. Wrap the pump in a clean cloth or rag and set aside for now.

Oil Pressure Relief Valve

- a) Be sure that the spring is up to specifications for free length and proper tension at load length. Also, see that the piston diameter falls within specifications.
- b) See that the screen is clean and intact.
- c) See that the piston does not stick in the body (use light oil on the piston while checking). Before step d note the following:

CAUTION: Do not put the oil pressure relief valve body in a vise for assembly. This could cause distortion of the body. Place the body in an upside down socket held in a vise.

- d) Assemble the oiled piston, spring, gasket and cap to the main body and hand tighten the cap at this point. Wrap this assembly in a clean rag and set aside for now.

NOTE: If you are putting the oil pressure indicator on the oil pressure relief valve see the CD411 manual for information on these steps.

4. Cylinder Head

- a) Be sure the head gasket surface is flat. If it isn't, have the head re-surfaced or grind the head gasket surface on a piece of plate glass and emery cloth.
- b) Measure the valve stems for wear and replace any valves whose stems are scored, or bent, or whose seats are excessively burned, cracked, or warped. Be sure to replace any valve with a KE valve if it is available. Chrome stem valves are also available if desired.
- c) Regrind the valves to a 44° angle. If the ends of the stems are dished, grind them flat again.
- d) Replace any valve guide that is excessively worn. Check the inside of the valve guide with a small hole gauge against the specification to determine if replacement is necessary. Use a Z16 valve guide punch after warming the head to remove and replace valve guides. Valve guides should be a snug fit in the head when it is warm. If the valve guide is too loose in the head replace it with an oversize O.D. valve guide. Note the different valve guide lengths - make sure you use the right guide for intake and exhaust.
- e) Once it has been assured that either new or good valve guides are in the cylinder head, grind the valve seats at a 45° angle. Be sure the pilot you use is a tight fit in the guide. The newly ground seat must be smooth and free of chatter marks. Do not hand lap the valves to their seats if you are using the steps above and grinding the seats and faces to the recommended interference angle.
- f) If you are not grinding the valves to an interference angle as outlined above, hand lap the valves to their seats to insure good seating.
- g) Be sure the valve springs check with tension specifications. Then oil the valve guides and assemble the valves in the cylinder head. Use shims CD255/30 and CD255/60 under the bottom cup until the valve spring is installed at its correct length. Correct installed valve spring length (int. and ex.) is $1-3/8$ " with the E1544 bottom cup and E3001 - E3002 valve springs and $1-1/4$ " with the E6439 bottom cup and E4221 - E4222 valve spring. Before measuring for installed length, tap on the end of the valve stem with a hammer to seat the retainer fully on the taper of the keeper keys. Wrap the cylinder head in a clean rag or paper and set the assembly aside for now.

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5. Pistons, Pins, Rods, Cylinder Barrel

- a) If the cylinder has to be rebored, measure the oversize pistons before boring and bore directly to the size that will give the desired piston clearance. Always measure the pistons at the extreme bottom of the skirt at 90° to the piston pin.
- b) If the cylinders don't need reboring, wet hone the cylinders from the bottom to remove the glaze and scratches from the cylinder walls. Measure the cylinders when done and see that the pistons have the desired clearance. Sometimes by the selective fitting of pistons, the desired clearance can be obtained without having to bore to the next larger oversize.
- c) After honing or reboring, be sure to wash the cylinders thoroughly with hot soapy water to remove all traces of metal and grit.
- d) Always be sure to check the ring end gap on all six rings. Push the rings evenly into the cylinder with the top or bottom of a piston. Ring end gap from .010" to .017" is permissible.
- e) Thoroughly clean the old or new pistons and rings and install the rings on the pistons.
- f) Check for proper piston pin fit in the rod bush and piston. A slightly lubricated pin should be a snug hand push fit through the pin bush and piston at room temperature. Polish the pin with fine emery cloth in a lathe or drill to reduce the diameter slightly if needed. Replace the rod bush using CD114 piston pin bush remover/installer and ream it to proper size if necessary. Cover the above parts and set aside for now.

The engine is now ready to be assembled. Proceed as follows:

Countershaft Sprocket/Mainshaft High Gear Assembly

- a) Heat the case with a torch until the high gear ball bearing will drop all the way into the case. After the case has cooled install the snap ring for the bearing.
- b) Oil the ball bearing and install a new countershaft seal in the case. Be sure the open side (side with wire coil) faces into the gearbox.
- c) Oil the high gear bush thoroughly and install the high gear through the ball bearing.
- d) Coat the countershafts splines of the gear with Permatex-Super 300 gasket cement and install the countershaft sprocket, T2116 tab washer, and nut.
- e) Grip the sprocket in a soft jawed vise and tighten the nut to a torque of at least 90 lb. ft. Bend the lock tab to one side of the nut when it is tight.
- f) If a new inner layshaft needle bearing is to be installed drive the old one out. Using the CD473 bearing drift with a layshaft thrust washer between the bearing and drift, drive the new needle bearing into the case until the thrust washer is up against the case. As you get close to the case, guide the thrust washer on to its pin.

Crankcase Halves

- a) Measure the crankcase main bearing bores and the outside diameter of the new main bearings. New bearings should always be used to reduce the possibility of failure and the high labor cost of replacement. The bearing bores should be .001" to .002" smaller than the bearing outside diameter for correct fit. If they are not, evenly enlarge them with emery cloth to the correct size or try another bearing until the sizes are correct.
- b) Polish the bearing shoulders on the crankshaft with emery cloth until each new bearing is a snug sliding fit on its shoulder.

Continued.....

Crankcase Halves Cont'd

- c) Heat both cases with a torch until the ball bearings or race for the roller bearing will drop all the way into the crankcase bore. Do not pound the bearings or race into the case. If the race or bearing "cocks", remove it by hitting the case on a block of wood and start again. Check the bearings for free rotation after the cases cool.
- d) Place the left crankcase half inside up on 4" blocks of wood. Be sure it is well supported.
- e) Oil all cam bushes and both main bearings. Install the breather disc and spring in the left intake cam bush.
- f) Install the intake cam into its left bush and engage the cam with the two teeth on the breather disc.
- g) Doublecheck that the E4700 tach drive thimble is installed in the exhaust camshaft. Then install the exhaust cam in the left exhaust cam bush.
- h) If you are using a roller bearing on the drive side, push the inner race/roller assembly onto the crankshaft. Install the crankshaft assembly in the left main bearing or race.
- i) After making sure that both crankcase joint surfaces are clean and flat, coat both the surfaces with Permatex-Super 300 gasket cement. Be sure to coat below the oil transfer hole at the rear bottom of both cases.
- j) Lower the right crankcase half down onto the left crankcase half. The cases should push completely together by hand. Install the case studs, nuts, and/or bolts and tighten as evenly as possible.
- k) While the crankcase is on its side, install the engine sump plug with its washer and also the scavenge passageway plug in the right crankcase half.
- l) Now install the engine in an appropriate (CD522) engine stand and place the engine upright in a vise - timing side facing you.
- m) Install the two 1/4" screws in the top crankcase flanges at the cylinder barrel hole and tighten them with an offset screwdriver.
- n) Check to see that the crankshaft assembly will turn freely. If it does not, the cause of the tightness or bind must be determined. Chances are it is due to one of three reasons -1. Main bearings cocked or not all the way into the crankcase, 2. Too much pre-load on the main bearings due to excessive interference fit of the bearings in the crankcase, or 3. A bent crankshaft or out of line crankcases. Check also to see if the camshafts rotate freely.
- o) Install a new primary crankshaft oil seal open side (wire ring side) facing out toward the primary. Do NOT drive the seal all the way in - it must not seat against the drive side bearing and cause a drag on the crankshaft.

Timing Side Assembly

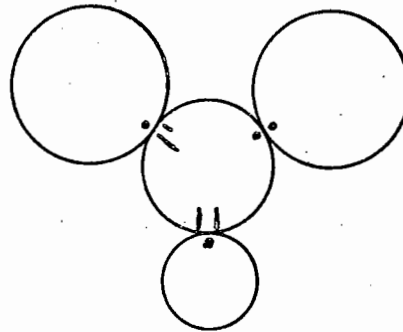
- a) Install the clamping washer (refer to engine change list), key, and timing pinion on the crankshaft. Use a hide mallet and deep socket to tap the pinion gear on. Be sure the inside of the socket does not damage the end of the crankshaft.
- b) Install the keys in the camshafts and using the Z89 cam wheel installer, install the cam wheels on the camshafts. For standard timing use the keyway directly under the timing dot on the cam wheel. When installing the cam wheels use the engine locking tool CD474 in the connecting rods and place the intermediate gear on its spindle to keep the cam from turning while you push the gear on by turning the L.H. threaded nut on the Z89.
- c) Leave the engine locking tool CD474 in the connecting rods and install the cam wheel nuts and crank pinion nut. Tighten all three nuts to a torque of 80 lb. ft. Remember the cam wheel nuts are left hand threads.

Continued.....

Timing Side Assembly Cont'd

- d) Now the valve timing must be established. To do so refer to diagram below and align the wheels as shown.

Long (Bottom) dash all TR6 - T120
Short dash 6T (Thunderbird)



- e) Install a new oil pump gasket and the oil pump assembly. Use new lock washers and tighten the two oil pump nuts to 6 lb. ft. torque.
- f) Coat all the gears and the oil pump slider block with oil.
- g) Be sure that new seals are installed in the timing cover correctly. The crankshaft seal faces into the cover (wire ring toward the cover), and the exhaust cam seal faces toward the engine (wire ring toward the engine). Be sure also that the circlip for the crankshaft oil seal is installed in the cover.
- h) Install the D486T oil seal guide in the exhaust camshaft.

CAUTION: At this time be sure you have the right dowel in the timing cover for the exhaust tappets you plan to use (from engine #DU24875 on). The metering jet dowel E6800/3 or E6348 goes with the "old" exhaust tappets E6490 and E6329. The plain dowel T989 without the metering jet goes with the new "timed" tappets E8801 and E8895.

- i) Make sure both gasket surfaces are clean and dry. Using Permatex-Super 300 gasket cement or a CD338 timing cover gasket, install the timing cover on the engine. If the primary ignition leads are with the cover they must be threaded through the gasket. The longest two screws (1-5/16") go into the two bottom holes. If you have a third long screw it goes in the upper left hand corner hole.
- j) Insert the screen filter (if fitted) and install the E2515 plug and washer in the front of the timing cover.
- k) Install the oil pressure relief valve assembly with a new gasket. Tighten the body first and then tighten the cap.

Transmission Assembly

- a) Lubricate the spindle of the shift cam and install it in the crankcase.
- b) Install the cam plunger, spring and cap in the case and also the drain plug with two new gaskets.
- c) Position the camplate so that the neutral notch between second and third is engaged by the plunger. This is the notch at the "bottom" of the cam adjacent to the drilled hole.
- d) Smear a layshaft thrust washer with grease and install it on the pin at the left side needle bearing. The four slots on the washer should face toward the inside of the gearbox.
- e) Assemble the second and third gears in their proper order on the layshaft (See CD411)
- f) Grease the pins on the shifter forks and assemble the rollers to the pins. Assemble the shifter fork locating pin through the forks with the shouldered end in. The inside shifter (T260B) points up for the mainshaft with the pin/roller to the inside of the gearbox. The roller pin on this T260B shifter fork is offset to the bottom when the shifter is viewed in line with the locating pin hole. The outside shifter (T913) points down for the layshaft with the pin/roller to the outside of the gearbox. The roller pin on this T913 shifter fork is centered when the shifter is viewed in line with the locating pin hole.

Continued.....

Transmission Assembly Cont'd

- g) Hold the shifter fork assembly properly assembled to the second and third gears of the layshaft and slide the entire assembly into the gearbox locating the layshaft and shifter locating pin all the way into their holes.
- h) Place the second and third mainshaft gears in their proper positions in the mainshaft shifter fork (See CD411). Install the first gear layshaft gear.
- i) Smear the other layshaft thrust washer with grease and install it on the pin at the needle bearing in the inner cover. Again the four slots should point toward the inside of the gearbox.
- j) If the mainshaft is not assembled to the inner gearbox cover, install it through the ball bearing. Then install the plain washer, pinion sleeve, pinion spring, kickstarter pinion and ratchet, a new tab washer and nut on the end of the mainshaft. Grip the splined portion of the mainshaft in a soft jawed vise and tighten the nut to a torque of 45 lb. ft. Be sure to bend the tab washer against the tightened nut.
- k) Lightly lubricate all gears, bearings, and sliding surfaces.
- l) Be sure the joint surfaces of the crankcase and inner cover are clean, dry and flat. Smear both surfaces with Permatex-Super 300 gasket cement. Push the mainshaft through the three mainshaft gears until the cover is about 1/2" away from the crankcase. (Turning the mainshaft will help it to go through the three gears).
- m) Press down on the camplate operating quadrant until it is about level and push the cover/mainshaft in tight against the crankcase. The shift cam timing can be checked and corrected at this point if necessary. The top of the second tooth on the quadrant must be even (within 1/16") with a line through the center of the mainshaft and the center of the gearchange quadrant hole in the inner cover. Use a straight edge to line the two centers and top of second tooth up. Pull the cover/mainshaft back out and retime if necessary. Once the timing is correct proceed as follows.
- n) Insert the Allen head screw, 1" Phillips head screw, and 1-1/8" bolt with washer(s) into the inner cover and tighten fully.

At this point it is easier to install the oil pipes and junction block on the engine before installing the outer gearbox cover.

- a) Be sure the pipes are thoroughly clean.
 - b) Using a new E3763T gasket, install the junction block to the engine.
 - c) Loctite the E1310 nut and tighten it. Be sure the pipe and gasket are aligned correctly on the crankcase surfaces.
 - d) Tape the unconnected end of the oil lines to prevent dirt from entering them.
- o) Be sure the joint surfaces on the inner and outer cover are clean, dry and flat. Oil the kickstarter, ratchet and sleeve assembly and coat the joint surfaces with Permatex-Super 300 gasket cement.
 - p) Wind the kickstarter lever around 1 to 1-1/2 turns until it is upright. Grab the pointed front of the cover - not the shift lever - so the plungers won't pop out of the gearchange quadrant.
 - q) Install the outer cover and tighten the screws and nuts thoroughly.
 - r) Now it is wise to double check the shift cam timing. Shift the gearbox to all four gears rapidly - if the cam over shifts beyond first or fourth gear, it will jam and further shifting will be impossible. Obviously, the cam timing will be incorrect and must be redone correctly.

NOTE: Now turn the engine around in the vise so that the primary side faces you.

Continued.....

Primary Assembly

- a) Install the Woodruff key in the mainshaft.
- b) Pass the stator leads with the rubber grommet and sleeve nut through the crankcase and tighten the sleeve nut into the crankcase.
- c) Install the chain oiler tube and bracket.
- d) Assemble the clutch hub, thrust washer, twenty rollers, sprocket and center with the three clutch screws together.
- e) Place the primary chain on the clutch sprocket and pass the stator through the chain - lay the stator on top of the transmission for now.
- f) Place the engine sprocket in the chain (seal shoulder in) and guide the engine and clutch sprockets onto their respective shafts.
- g) Assemble the flat washer, new tab lock washer, and clutch nut to mainshaft. The cup side of the flat washer faces out. If the engine number is after DU48144 just a flat washer is installed before the self-locking nut.
- h) Assemble the spacer, rotor, new tab washer and crankshaft nut to the crankshaft. (If E.T. system, a larger spacer and pin replaces the flat key and small spacer of the battery models).

NOTE: Be sure the three clutch spring screws are turned correctly and are straight, and the clutch center is pushed all the way in before tightening the clutch center nut. You should not be able to turn the three screws if they are positioned correctly and the center is all the way in.

- i) Install the CD150 or equivalent clutch locking tool and torque both the rotor and clutch nuts to 50 lb. ft. Bend the lock tabs to the nuts after tightening.
- j) Loctite and install the three stator studs.
- k) Install the chain tensioner assembly and start the nut on its screw.
- l) Install alternately the twelve clutch plates (cork plate first), then the clutch release push rod, clutch pressure plate, three spring cups, three new clutch springs, and the three brass or steel spring nuts. Tighten the nuts until they are flush with the ends of the screws.
- m) Adjust the primary chain until there is 1/2" free play in the top of the chain. Install the plug and gasket for the adjuster screw.
- n) Hook a clutch cable, T1644 abutment, and T2062 or T2063 adaptor to the connector at the gearbox and attach the clutch cable to a clutch lever assembly attached at a convenient position on your work bench.
- o) Screw in the three clutch spring nuts until the three clutch springs just coil bind evenly when the clutch is released all the way. Back out the three nuts one turn each. Then adjust the three clutch nuts until the clutch pressure plate wobbles in and out less than 1/16" when it is released and the clutch center is rotated by the kickstarter lever. Disconnect the clutch cable.
- p) Install the stator on its studs with three washers and nuts. Torque the nuts to 20 lb. ft. Check the clearance between the rotor and stator by passing a .010" feeler gauge completely around between the rotor and stator.
- q) Adjust the clutch center screw by screwing it in until the clutch just begins to release. Back the screw up 1/3 of a turn and lock the lock nut.

This completes the primary assembly for now. Don't install the primary cover yet as it is more accurate and convenient to mount a degree wheel on the crankshaft for purposes of ignition timing. Remove the D474 engine locking tool and turn the engine around in the vise so the timing side is facing you.

Continued.....

Piston and Cylinder Barrel Assembly

- a) Install a new cylinder base gasket on the crankcase.
- b) Oil the tappet guide blocks and install the tappets in the guide blocks. Always put the lubricated exhaust tappets in so that the flats on the stems face away from each other. Wedge the tappet stems with an old gas tank rubber to hold them in the guide blocks.
- c) Untape the connecting rod shanks and install the pistons on the connecting rods. Note any difference in valve cut outs or any arrows or "front" labels on the pistons tops and be sure the pistons face the right way. Be sure to install all four new circlips in the pistons.
- d) Turn the rings on each piston so the end gaps are 120° (1/3 of a circle) away from each other and install suitable clean ring compressors on each piston. Terry #1182 ring compressors are good for this job.
- e) Use a convenient method of blocking the pistons up out of the crankcase. Be sure you have the two locating dowels on their proper studs to accurately locate the cylinder barrel. Oil the cylinder walls and gently lower the cylinder barrel (with the middle 5/16" head bolt hole facing forward) down over the pistons. Remove the ring compressors and blocks, and lower the barrel completely.
- f) Install the eight cylinder base nuts. The four 1/4 Whitworth nuts are for the inside four studs and the four 5/16" W nuts go on the outside four studs.
- g) TORQUE the eight cylinder base nuts to 25 lb. ft.
- h) Remove the rubbers from the tappets.

Ignition Timing

- a) Be sure the auto advance mechanism is well lubricated and works freely.
- b) Install the auto advance mechanism in the exhaust cam. Engage the slot in the peg if the peg is fitted in the exhaust camshaft. Install the bolt, tightened to 8 lb. ft., and remove the bolt. If you have an exhaust camshaft with no peg in it, do not install the cam until after the next two steps.
CAUTION: On 12 volt models, make sure the 160° ignition cam (#514119124) is installed.
- c) Using D571/2T TDC tool rotate and "pin" the crankshaft at top dead center.
- d) Using the "long" part of the CD123 timing disc adaptor together with an E3114 crankshaft stud, screw the adaptor into the rotor nut until it is tightly "jammed". Attach the CD3 timing disc to the adaptor so that the printed side faces you. Fasten a steady pointer in an easily visible place to read the degree wheel accurately. Adjust the degree wheel to read on top dead center. To find TDC on early engines that have no TDC hole use the bar of CD474 engine locking tool as a positive stop. Rotate the engine completely from one "stopped" position to the other and record the total number of degrees this takes. Split this figure in half and rotate the engine back to the 1/2 way point. Set BDC on the timing wheel to be at this 1/2 way figure. Make final adjustments until the number of degrees from BDC forward or backward to stop is equal.
NOTE: The CD456 ignition timing kit disc can be used for timing, however, it saves time and trouble to use the CD3 disc if most of the engine is apart.
- e) Skip this step if you have followed step b. If you have an exhaust camshaft with no peg, rotate the engine forward until the right intake tappet is closing and stop the engine at about 16° before top dead center. Place the auto advance assembly in the exhaust camshaft and install the contact plate in the housing. Rotate the plate until it is in the middle of its adjustment and install and tighten the two 1/4" pillar bolts and washers. Now holding the auto advance unit snugly into its taper with your thumb, and with the rubbing block of the left contact set about 1/2 way around the "open part of the cam", make a rough adjustment of the left contact set to about .016" gap. Then checking that the engine is still at the 16° before top dead center position as outlined above, rotate just the auto advance unit clockwise until the left contact set just

Ignition Timing Cont'd

- e) Continued
(Leave the auto advance unit in the retard position to do this). Insert the auto advance bolt at this point and tighten to 8 lb. ft. and remove it again. This should lock the auto advance unit in the right place to accurately time the engine.
- f) Install the contact plate assembly with two washers and the two 1/4" pillar bolts. The black/yellow lead should go to the rear set of points. Be sure that the cardboard or rubber insulators on the condensers are folded properly to prevent shorting of the ignition leads. See that the plate can be rotated freely (with the pillar bolt loose) and that the black/yellow - black/white leads are not pinched any where. Tighten the pillar bolts.
- g) Check the point gap on each set of points with a clean feeler gauge blade. Point gap after the points are fully open should be .018" (new points), .015" (used points).
- h) Thread the advance locking part of CD456 or CD368 ignition timing kit into the exhaust camshaft and lock the ignition cam in the fully advance position (all the way clockwise). Do not overtighten this tool!
- i) Using 233 electrical circuit tester or a similar device, clip the one end to a good clean unpainted part of the engine. Hold the probe end on the spring of one contact set and observe on the degree disc when the light goes out as the engine is rotated forward (the light will go out when the points open). Write this figure down and do the same for the other contact set. Try rotating the contact plate until both cylinders time as close to 38° as possible. Then small errors of 3 or 4 degrees can be eliminated by adjusting the point gaps of the individual cylinders. Open the point gap slightly to advance the timing. Close the point gap slightly to retard the timing. When checking a cylinder's timing, be sure that the pillar bolts and contact adjusting lock screw are tight to avoid errors. Final timing should be 38° before top dead center on both cylinders plus or minus 1/2 of a degree and the point gaps must be in the range of .011" to .019".
- j) Remove the advance lock, and reinstall the auto advance bolt and washer. Retighten the bolt to a torque of 8 lb. ft. and recheck to see that the cam advances and retards freely. Remove the degree wheel and pointer, also the D571/2T top dead center tool. Insert the plug and gasket in the top dead center hole.
- k) Using a new E5049T gasket, install the contact cover with the two screws and lock washers.

Now the primary cover along with a new T1770T gasket can be installed. Do not leave off the two brass washers under the dome nuts at the front of the primary cover.

Cylinder Head Installation

- a) Place a new head gasket on the clean dry gasket surface of the cylinder barrel.
- b) Install the lower push rod cups and white push rod tube seals (E4752) on the tappet guide blocks (DU24875 on). On older engines install the black lower push rod tube seal on the tappet guide block.
- c) Install the white "O" ring seals (E3547) on the tops of the pushrod tubes. Install the pushrod tube over the tappet guide blocks.
- d) Lower the cylinder head on to the barrel. Be sure to engage the tops of the push rod tubes into the head properly. Before putting any bolts through the cylinder head, measure the clearance between the cylinder head and gasket. A 1/16" drill or welding rod serves as a convenient measuring device. Combinations of push rod tube rubbers must be used to get the desired 1/16" clearance. There are three seals of different thicknesses available:

Continued.....

Cylinder Head Installation Cont'd

d) Continued

E1497RT - .070"
E3547 - .095"
E4752 - .125"

- e) Turn the push rod tubes until the push rod guides at the top are straight across the engine. Use a straight edge and sight along the two inner head bolt holes to determine the tube alignment.
- f) Install the four outer head bolts and the small 5/16" inner bolt and tighten until snug.
- g) Install the intake manifold (s) or carburetor(s) as required using new gaskets and "O" rings.

The engine is now ready to be installed back in the frame. Be sure the oil tank has been cleaned thoroughly. As soon as the engine is in the frame securely, hook up the two engine oil lines. The front pipe of the oil junction block goes to the rear feed pipe of the oil tank. The rear pipe of the oil junction block goes to front return pipe of the oil tank. Fill the engine, gearbox and primary with the proper amount and grade of oil. Be sure all attaching parts are properly installed at this time. The F7389 engine plate nuts should be tightened last to a torque of 100 lb. ft.

Rockerbox Installation

- a) Turn the engine over until both intake or exhaust tappets are all the way down. Pump a liberal amount of oil in this push rod tube.
- b) Insert the two push rods on their two tappets making sure that they properly seat on the tappet. Crank the engine through a couple of times to see that the push rods are seated properly. Leave the push rods all the way down and put a drop of oil in each push rod cup.
- c) Install a new rocker box gasket E4549 on the rocker box and holding the two rocker arms all the way up (through the adjuster cap holes) install the rocker box. The acorn nut on the rocker box should be on the timing side of the engine. Be sure the two rocker arms balls seat properly in the push rods. Insert the 2 - 3/8" head bolts and snugly tighten them. Install the remaining three nuts and washers, and two bolts and washers and tighten them snugly. Crank the engine over a couple of times to make sure the push rods are seated at both ends correctly.
- d) Repeat steps (a) thru (c) for the other rocker box.
- e) Torque the eight 3/8" dia. head bolts to 25 lb. ft. and the 5/16" head bolt to 20 lb. ft.
- f) Tighten thoroughly the remaining six nuts and four bolts holding the rocker boxes on.
- g) Use a CD411 spigot wrench to verify that the exhaust spigots in the cylinder head are tight.

Final Assembly Steps:

- a) Adjust the valves to .004" intake and .006" exhaust. Be careful when using a feeler gauge to adjust the valve lash as an inaccurate reading will result from dished valve stem ends. 1/8 of a turn of the adjusting screw (1/2 of "flat") = approx. .005".
- b) Install the rocker caps with new gaskets.
- c) Install new spark plugs gapped at .020" and torque them to 25 lb. ft.
- d) After starting the engine, check the oil pressure and scavenge suction. (See Service Bulletin 67/6)
- e) Adjust carb (s).
- f) Be sure the motorcycle's spark plugs and carburetor jets are as specified in the Owner's Manual or CD411 Workshop Manual.
- g) Road test the motorcycle to check for any discrepancies in engine performance.