7. Again mix a small amount of gel coat with catalyst - do not use glass fibers. Using your finger or putty knife, fill the depression with gel coat 1/16" above the surrounding surface.

8. Spread the gel coat level with the surrounding area and allow to cure (30 - 60 minutes). See Figure 2J-5. Gel coat can be covered with cellophane, if desired, to aid in spreading evenly. Remove cellophane after gel coat has cured.

9. Sand the patched area, using a sanding block with 600-grit wet sandpaper. Finish by buffing with fine rubbing compound such as DuPont #606 and waxing. Weathering will aid to blend touch-up if a slight color difference can be observed. See Figure 2J-6.

NOTE
Where surface color of part has changed due to weathering, color match of patch may not be satisfactory. In this case, entire panel must be sprayed.

Thin Gel coat with acetone (1 to 1 ratio) and spray panel, blending sprayed area into a radius or corner on the part. Use a touch-up spray gun such as the Binks Model 15. After Gel coat is hard, buff and polish sprayed area.

B. MOLDED-IN-COLOR SURFACE REPAIRS

This type of damage consists of a scratch, hole or gouge that is deep enough to slightly penetrate fiberglass material.

Repair as follows:

1. To be sure that the area to be patched is dry, clean and free of any wax or oil, wash with lacquer thinner.
2. Roughen the bottom and sides of the damaged area, using a power drill with a burr attachment. Feather the edge surrounding the scratch or gouge, being careful not to undercut this edge. See Figure 2J-1.

3. A small amount of filler coat, the same color as the finish should be placed in a small can lid or on a piece of cardboard. Use just enough to fill the damaged area. Add three drops of catalyst per teaspoon of filler coat using an eye dropper. Be sure to mix the catalyst thoroughly for maximum working time. Maximum working time (pot life) will be about 15 to 20 minutes at which time it begins to "gel".

4. Fill the scratch or hole slightly above the surrounding undamaged area, working the filler coat into the damaged area with a putty knife. Be careful to puncture and eliminate any air bubbles which may occur. Patch can be covered with cellophane to aid in spreading evenly (see Figure 2J-5). Allow to cure completely before removing cellophane.

5. Sand smooth with 220-grit sandpaper; then use 600-grit for finish sanding. Blend into surrounding area using 600-grit sandpaper. Buff with polishing compound such as DuPont #600 and finish with paste wax.

**NOTE**

Where surface color of part has changed due to weathering, color match of patch may not be satisfactory. In this case, entire panel must be sprayed. This Gel coat with acetone (1 to 1 ratio) and spray panel, blending sprayed area into a radius or corner on the part. Use a touch-up spray gun such as the Dunks Model 15. After Gel coat is hard, buff and polish sprayed area.

C. PATCHING OF HOLES, PUNCTURES AND BREAKS

If possible, work in shaded spot or in a building where the temperature is between 70° and 80°F.

1. Be sure surface is clean and dry where repair is to be made. Remove all wax and dirt from the damaged area.

   ![Figure 2J-7. Sawing Out Damaged Area](image)

   **Figure 2J-7. Sawing Out Damaged Area**

   **Figure 2J-8. Rough Sanding Inside Surface**

   3. Rough sand the inside surface, using 80-grit dry sandpaper, feathering back about two inches all around the hole in the area the patch will touch. See Figure 2J-8.

   4. Cover a piece of cardboard or aluminum with cellophane and tape it to the outside surface with the cellophane facing toward the hole. Aluminum is used as backing where contour is present. The aluminum should be shaped the same as the contour. See Figure 2J-9.

   ![Figure 2J-9. Taping on Backing](image)

   **Figure 2J-9. Taping on Backing**

   5. Cut glass mat to shape of hole, about 2" larger than hole.

   6. Mix a small amount of pre-accelerated resin and catalyst and daub resin on mat, thoroughly wetting it out. This may be done on a piece of cellophane or wax paper. See Figure 2J-10.
SECTION 2J
Chassis - Fiberglass Body Care and Repair

NOTE

Mix resin 100 parts to 1 part catalyst for an approximate 30 minutes working time. Only mix enough resin for a given patch.

7. Lay patch over hole, cover with cellophane and squeegee out air bubbles. Allow one to two hours to cure, then remove cellophane. See Figure 2J-11.

8. After the patch is cured, remove the cardboard from the outside of the hole and rough sand outside surface, feathering the edge of the hole. See Figure 2J-12.

9. Mask area with tape and paper to protect the surrounding surface; then repeat B Steps 5, 6, 7, and

10. Allow the patch to cure overnight; then sand with dry 80-grit paper on power sander. Smooth the patch and blend it with surrounding surface. If air pockets are present, puncture and fill with catalyzed resin. Let cure and re-sand. See Figure 2J-13.

11. Mix gel coat or filler coat with catalyst. Work Gel Coat into patch with fingers. See Figure 2J-14. Filler Coat should be filled into patch with a putty knife.

12. Patch can be covered with cellophane to aid in spreading evenly (see Figure 2J-5). Allow to cure completely before removing cellophane.

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13. Sand the patch with 220-grit wet sandpaper; then use 600-grit for finish sanding. On painted type surface, paint can be applied at this time. Buff with polishing compound and wax.

NOTE

On Gel Coat finish, it may be necessary to repeat Steps 12 and 13 to insure a smooth, even gel coat surface. See Figure 2J-15.

For large areas the gel coat can also be sprayed.

Figure 2J-15. Buffing Finish

Where surface color of part has changed due to weathering, color match of patch may not be satisfactory. In this case, entire panel must be sprayed.

Thin Gel coat with acetone (1 to 1 ratio) and spray panel, blending sprayed area into a radius or corner on the part. Use a touch-up spray gun such as the Binks Model 15. After Gel coat is hard, buff and polish sprayed area.

Heat lamps may be used if working conditions are cold. CAUTION: Do not place lamp bulb closer than 14 inches to surface or the resin may blister.
94557-55 COMPENSATING SPROCKET SHAFT NUT WRENCH
Pin spanner wrench for compensating sprocket shaft nut.

94619-35 WHEEL LUG WRENCH
Tool for recessed hex head wheel lug screws.

94630-67 WHEEL HUB BEARING LOCKNUT WRENCH
Fits slotted type locknuts.

94681-39 SPOKE NIPPLE WRENCH
For large wheel spokes nipples (.234" across flats).

94700-52B REAR SHOCK SPANNER WRENCH
Used to adjust rear shock absorber units for more or less spring compression.

95020-66 REAR CHAIN CONNECTING LINK PRESS TOOL
Used to install press-fit connecting link sideplate supplied with replacement chains.

95021-29 DISASSEMBLING CHAIN TOOL
Removes press fit roller pins from all chains.

95000-29A WHEEL TRUING STAND
Adjustable stand for truing spoked wheels. Includes arbor.
95815-30A Arbor for wheels of all models. (Can be used to convert old stand 95500-29).
95822-68 Arbor collar for 1968 and later Electra-Glide wheel (brake side).

95600-33B SPROCKET RIVETING SET
Used to rivet rear sprocket to brake shell. Set consists of riveting block, rivet punch, rivet set, adapter and support flange.

95875-58 BRAKE PEDAL LOCKING TOOL
Used to lock rear brake pedal in depressed position when disassembling wheel from motorcycle.

INTERNAL LOCK RING PLIERS
Special pliers for removing and replacing retaining rings.
96215-49 Small.
96216-49 Large.
SECTION 2T

Tools

96219-50 FRAME HEAD BEARING ADJUSTING CONE, AND LOCK NUT WRENCH
Fits head cone lock nut and head bearing adjusting cone.

96245-51 FORK STEM AND CROSS MEMBER ALIGNING GAGE
Used with fork tube straightening blocks (96246-50) when fork stem is being aligned.

96246-50 FORK TUBE STRAIGHTENING BLOCK
Three recommended for use to support fork tubes while straightening on an arbor press.

96250-50 FORK SLIDER OIL SEAL DRIVER
Used to install fork slider oil seal.

96254-50 FORK SLIDER BUSHING TOOLS FOR HYDRA-GLIDE FORK
Complete set of tools consists of Fork Slider Bushing Puller (1), Bushing Driver (2) and Bushing Reamer (3) with long and short pilots. Tools used to remove worn fork slider bushings, install new parts and ream to size.

94644-65 CHAIN ADJUSTER SHOE BOLT WRENCH
For adjusting chain tension through chain cover access hole.

96806-40 BENDING BAR
Used for straightening handlebar, forks and frames. Hooks on tubes for applying bending leverage.

96810-63 MOTORCYCLE SHOP STAND
Used to support motorcycle on shop or showroom floor to provide sturdy support. Lock bar with curved end slips through motorcycle frame cross tube below transmission. Operating bar fits into socket on either side providing leverage to raise or lower motorcycle rear end.

97010-52A REAR SHOCK ABSORBER TOOL
Compresses rear shock absorber for disassembly or assembly. Holds shock absorber spring in compression while parts are disassembled.

97019-52A Block only for 1967 and later.

97280-60 BRAKE DRUM TURNING ARBOR
Used for refinishing brake friction surface when doing a brake lining job. Fits between lathe centers. Brake drum mounts to arbor, with same bolts used to fasten drum to wheel.

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GENERAL

ENGINE SPECIFICATIONS

VALVES (3B)

Fit in guide (EX) ..................... .004 - .006 in.
Fit in guide (ID) ..................... .005 - .004 in.
Spring (FL) ...........................
(Outer) .............................. 55 - 55 lbs. at 1-13/32 in. (closed)
110 - 120 lbs. at 1-1/16 in. (open)
Free length ........................... 7-1/16 in.
Inner) ............................... 25 - 35 lbs. at 1-1/4 in. (closed)
70 - 80 lbs. at 29/32 in. (open)
Free length ........................... 1-15/32 in.

Spring (FLH) ...........................
(Outer) .............................. 105 - 115 lbs. at 1-3/8 in. (closed)
160 - 190 lbs. at 1 in. (open)
Free length ........................... 1-31/32 in.
Inner) ............................... 20 - 30 lbs. at 1-3/16 in. (closed)
70 - 80 lbs. at 51/64 in. (open)
Free length ........................... 1-25/64 in.

Tappet adjustment .................... Hydraulic tappet unit compressed 1/8 in. from fully extended position.

ROCKER ARM (3B)

Fit in bushing ....................... .0005 - .002 in. loose
End clearance ....................... .004 - .025 in.

PISTON (3C)

Fit in cylinder ..................... .001 - .002 in. loose
Ring gap ............................. .010 - .020 in.
Compression ring side clearance .... .004 - .005 in.
Oil ring side clearance .............. .003 - .005 in.
Piston pin fit ........................ Light hand press at 70° F.

CONNECTING ROD (3C)

Piston pin fit ....................... .0008 - .0012 in. loose
End play between flywheels .......... .006 - .010 in.
Fit on crankpin ........................
(1959 & earlier) ..................... .001 - .0015 in. loose
(1960 & later) ....................... .0008 - .001 in. loose

OIL PUMP PRESSURE (3D) ............... (30 MPH) 25 lbs./sq. in.
........................................ (30 MPH) 35 lbs./sq. in.
........................................ (60 MPH) 35 lbs./sq. in.
........................................ (90 MPH) 35 lbs./sq. in.

IGNITION TIMING (3D)

Breaker point setting ............... .020 in. gap
(Dwell) ............................... 90° @ 2000 RPM
Ignition Timing (Retarded) ....... 5° BTDC (1/64 in. before
Piston T.C.)
(Automatic Advance) ............... 35° BTDC (7/16 in. before
Piston T.C.)
Spark plug gap setting ............. .025 to .030 in.

TAPPETS (3D)

Guide fit ............................ .002 tight - .002 loose sq
Fit in guide ......................... .001 - .002 in. loose
Roller fit ........................... .0005 - .001 in.
Roller end clearance ............... .008 - .010 in.

GEARCASE (3D)

Timer gear end play ................. .003 - .007 in.
Idler gear end play .................. .003 - .020 in.
Breather gear end play ............. .001 - .005 in.
Cam gear shaft in bushing .......... .001 - .0015 in.
Cam gear shaft in bearing .......... .0005 - .001 in.
Cam gear end play ................... .001 - .005 in.
Intermediate and idler gear ......... .001 - .0015 in.
Oil pump drive shaft ............... .0008 - .0012 in.

FLYWHEEL ASSEMBLY (3E)

Gear shaft nut torque ............... 100 ft.-lbs.
Sprocket shaft nut torque ........... 100 ft.-lbs.
Crank pin nuts torque ............... 175 ft.-lbs.
Runout (flywheels) .................. .003 in. maximum at rim
Runout (mainshafts) ................. .001 in. maximum

SPOCKET SHAFT BEARING (3E)

Cup fit in crankcase ................. .0015 - .0035 in. press
Cone fit on shaft .................... .0002 - .0015 in. press
End play ............................ .0005 - .006 in.

PINION SHAFT BEARINGS (3E)

Roller bearing fit ................... .0004 - .0008 in. loose
Cover bushing fit .................... .0005 - .0012 in. loose

ENGINE DESCRIPTION

The Duo-Glide engine is a two-cylinder, four-cycle, air cooled, overhead-valve, V-type engine with 74 cu. in. displacement. It has three major component assemblies; cylinder, crankcase and gearcase.

Cylinder assemblies include cylinder head, valves, rocker arms and piston. Cylinders mount on the engine crankcase in a 45 degree "V," with both connecting rods connected to a single crank pin.

The reciprocating, linear motion of the piston in the cylinder is converted to circular motion in the crankcase. The built-up crankshaft consists of an off-center crankpin interposed between two counter-weighted flywheels which rotate on two end shafts (pinion and sprocket shafts) supported by antifriction roller bearings. The lower end of the rear
Figure 3A-1. Engine Cutaway (1967 Model Shown)
DUO-GLIDE

SECTION 3A
Engine - General

Flywheel rotation is clockwise (viewing engine from right side). Using the front cylinder firing position as a starting point, the rear cylinder fires at 315 degrees rotation (360 degrees minus the 45 degrees between cylinders). The front fires in an additional 405 degrees (360 degrees plus the 45 degrees between cylinders), completing the 720 degrees of flywheel rotation necessary for the four piston strokes.

The gearcase is located on the right side of the crankcase and houses a gear train which operates and times the valves, ignition and crankcase breather. The generator is also driven from the gear train.

The rotary crankcase breather valve is located between the crankcase and gearcase compartments and functions to relieve crankcase pressure caused by downstroke of pistons, and controls the flow of oil in the lubrication system.

A single camshaft with four cam lobes is gear driven. The engine valves are opened and closed through the mechanical linkage of tappets, push rods and rocker arms. Tappets serve to transmit the cam action to the valve linkage. Hydraulic lifters installed in the tappets automatically compensate for heat expansion to maintain a no-lash fit of parts. Valve and breather timing are obtained by meshing gearcase gears with timing marks aligned.

Ignition spark is produced by operation of circuit breaker points, oil and spark plugs. The breaking of circuit breaker points by a cam on the timer shaft determines the spark timing.

Ignition spark on 1960 and earlier Models and on 1965 and later Models is produced through operation of a single set of circuit breaker points by a double-lobed cam on the timer shaft. The narrow lobe times the front cylinder. The wide lobe times the rear cylinder. Both spark plugs fire each crankshaft revolution. However, the spark in one cylinder occurs ineffectually during its exhaust stroke.

Ignition spark on 1961 to 1964 Models is produced by operation of separate circuit breaker points and ignition coils for each spark plug. The breaking of each set of breaker points by a single-lobed cam on the timer shaft determines the spark timing. The single lobe cam opens the breaker points individually firing alternate cylinders every crankshaft revolution. The front cylinder breaker points (stamped "F" on circuit breaker base) fire the front cylinder and the rear breaker points fire the rear cylinder.

Most other engine components function similar to usual internal combustion engine design. For further description of part function, see pertinent manual sections.

LUBRICATION

The engine is lubricated by a pressure system circulating oil from the tank through the moving parts and back to tank. For adequate lubrication the tank must contain an ample supply of clean oil at all times.

Oil consumption varies from 250 to 500 miles per quart depending on the nature of service, solo or sidecar, fast or moderate driving, and how well the engine is kept tuned. If mileage is not within this range, see following engine overhaul section.

Remove tank cap and check oil supply at not more than 300 miles after each complete refill. If level is down near "Refill" mark on gauge rod, add oil. When level is down to "Refill" mark, add two quarts. Engine will run cooler and usage will be less with oil level well up in tank.

The oil tank capacity is one gallon. The tank is full when the oil level is about one inch from top. Do not fill above this level. The tank needs some air space. Tighten the cap securely to prevent leakage.

Change oil in new engine after first 500 and 1,000 miles, and at about 2,000 mile intervals thereafter. Completely drain oil tank of used oil and refill with fresh oil. If service is extremely hard, hot, on dusty roads or in competition, drain and refill at shorter intervals. Draining should be done while oil is hot. It is not necessary to drain the crankcase for it does not accumulate more than about 5 oz. of oil at any time. At the time of the first oil change, and along with at least every second oil change thereafter, thoroughly flush and clean out tank with kerosene to remove any sediment and sludge that may have accumulated.

---

KEY FOR FIGURE 3A-1

| 1. | Rocker arm |
| 2. | Rocker arm shaft |
| 3. | Carburetor insulator |
| 4. | Engine mounting bracket |
| 5. | Oil line |
| 6. | Carburetor |
| 7. | Rocker arm cover |
| 8. | Cylinder head |
| 9. | Push rod cover keeper |
| 10. | Push rod |
| 11. | Push rod cover |
| 12. | Circuit breaker (timer) |
| 13. | Clamp |
| 14. | Generator drive gear |
| 15. | Idler gear |
| 16. | Hydraulic lifter |
| 17. | Intermediate gear |
| 18. | Tappet and roller assembly |
| 19. | Pinion gear |
| 20. | Cam gear |
| 21. | Breather gear |
| 22. | Breather screen |
| 23. | Chain oiler screw |
| 24. | By-pass valve |
| 25. | Oil feed pump drive gears |
| 26. | Oil scavenger drive gears |
| 27. | Oil feed nipple |
| 28. | Oil pump cover |
| 29. | Oil return nipple |
| 30. | Check valve |
| 31. | Breather outlet |
| 32. | Chain oil return |
| 33. | Oil pressure switch |
| 34. | Crankcase |
| 35. | Flywheel |
| 36. | Crankpin |
| 37. | Connecting rod roller bearing |
| 38. | Connecting rod |
| 39. | Piston |

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3A-3
SECTION 3A
Engine - General

WINTER LUBRICATION

Combustion in any engine generates water vapor. When starting and warming up in cold weather, especially in freezing or cold weather, the vapor that gets into the crankcase condenses to water before the crankcase is hot enough to exhaust the vapor through the outside breather. If engine is run often enough to get the crankcase thoroughly warmed up, most of this water is again vaporized and blown out through the breather. A moderately drives engine, making short runs and seldom allowed to thoroughly warm up, will accumulate increasing amounts of water in the oil tank. This water will, in freezing weather, become slush or ice and if allowed to accumulate, will block oil lines and damage the engine. Water mixed with oil for some time forms sludge that is harmful to the engine and causes rapid wear of various working parts. In winter the oil should be changed more often than in normal weather. Any engine used for short runs, particularly in commercial service, must have oil changed frequently and tank thoroughly flushed to remove water and sludge, before new oil is put in tank. The farther below freezing the temperature drops, the shorter the oil change interval should be.

CHANGING OIL

Run engine until it is fully warm. Block motorcycle upright or tilted to right at a slight angle. Remove oil tank plug from bottom of tank at right rear corner. Allow all oil to drain. Replace plug. Pour a quart of kerosene into tank and agitate by rocking motorcycle from side to side. Remove plug and drain. Replace plug and fill with recommended grade oil as follows:

<table>
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<th>Use Harley-Davidson Oil Grade</th>
<th>Use Conditions</th>
<th>Air Temperature (Cold Engine Starting)</th>
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<tr>
<td>Medium Heavy 75</td>
<td></td>
<td>Above 40°F</td>
</tr>
<tr>
<td>Special Light 58</td>
<td></td>
<td>Below 40°F</td>
</tr>
<tr>
<td>Regular Heavy 105</td>
<td></td>
<td>Severe operating conditions at high air temperatures</td>
</tr>
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</table>

Old oil may be removed using a suction gun through filler hole and flushed by squirting kerosene into tank from a gun.

OIL PRESSURE SIGNAL LIGHT

The oil signal light, located above ignition switch on instrument panel, indicates oil circulation. If the oil signal light fails to go off at speeds above idling, it is usually due to low or a diluted oil supply. In freezing weather the oil feed pipe may clog with ice and sludge, preventing circulation of oil. A grounded oil signal switch wire, faulty signal switch, or trouble with oil pump will also cause the light to stay on. If the oil signal light fails to go off, always check the oil supply first. Then, if oil supply is normal, look inside the oil tank to determine if oil returns to the tank from the oil return pipe outlet located at front of oil tank near filler hole when the engine is running. If it is returning to the tank there is some circulation, and engine may be run a short distance if necessary. If no oil returns, shut off engine until trouble is located and corrected.

OPERATING OIL PRESSURE

Operating oil pressure may be checked as follows:

Fill oil tank with Harley-Davidson 75 oil. Disconnect oil pressure switch wire at top of switch and remove switch. Install Oil Pressure Gauge, Part No. 96921-52. Attach gauge bracket to motorcycle and road run or simulate road running until engine is completely warmed. A full operating temperature is essential for accurate gauging. Pressure should be 25 to 28 pounds per square inch at 30 mph. At 30 mph and over, pressure should be steady at 35 to 36 pounds.

OIL FILTER (EXTERNAL)

If motorcycle is equipped with an oil filter, thoroughly wash the filter element in clean gasoline or solvent at least once every 2,000 miles when the engine oil is changed. Blow out element with compressed air before installing.

To remove the filter element, take off acorn nut, fiber washer and cup. Remove element retaining nuts and metal element retainer. Then pull element off stud. If upper metal retainer (retainer with five holes in it for oil passage) comes off with the filter element, make sure that it is reinstalled as the upper retainer when replacing the element.

Replace filter element every 5,000 miles.

OIL FILTER (OIL TANK)

The tank is equipped with a large mouth filler opening and a screw cover with oil filter attached.

Wash filter element (3) in clean gasoline or solvent at 2,000 mile intervals, renew at 5,000 mile intervals. To service filter element, remove cap from oil tank, remove retaining spring (1) and washer (2) and pull out filter. Make certain "O" ring is positioned against filter cup flange (7) when filter is installed in tank.

SERVICING OIL TANK CAP AND FILLER OPENING.

To disassemble, follow order shown in Fig. 3A-2. Assembly is reverse order of disassembly. Clean and inspect all parts. Replace any that are worn or damaged.

If oil leak should occur between the tank cap and the filler opening, with cap and gasket in serviceable condition, check the lip of the filler opening. A cap...
1. Filter clip
2. Cap seal washer
3. Filter element
4. Filter lower retainer
5. Cup spring
6. Cup seal
7. Cup
8.  "O" ring
9. Dipstick and valve assembly
10. Cap gasket
11. Cap cotter pin
12. Cap screw
13. Cap washer
14. Cap nut
15. Cap top

Figure 3A-2. Oil Tank Filter - Exploded View

drawn too tight will bend the lip of the filter opening resulting in an imperfect seal between gasket and lip.

Drain oil from tank. Using a mallet as a driver and a block of wood as a cushion, bend the lip down until flush with sealing surface of tank cap. Remove nicks and rough spots with emery cloth. Flush tank before refilling.

ELECTRA-GLIDE ENGINE OILING AND BREATHER SYSTEM (Fig. 3A-3, 3A-4 and 4A-4A)

1. Gravity feed from tank to feed pump.

2. Feed (pressure) section of oil pump.

3. Check valve prevents gravity oil drainage from tank to engine. Builds up oil pressure to operate oil signal switch.

4. Oil pressure regulating valve limits maximum pressure. Surplus oil is dumped back into gearcase.

5. Oil is forced through pinion gear shaft to lubricate lower connecting rod bearings from which oil splashes to cylinder walls, piston, piston pin and main bearings.

6. Oil is forced through passages or external oil lines to lubricate rocker arm bearings and rods, valve stems, valve springs and push rod sockets. A branch passage supplies oil to the hydraulic lifters. On some models, oil supply is filtered through oil screen (6A).

7. Front chain oil. Oil is bled from by-pass oil for front chain lubrication. On 1964 and earlier models, chain oiler screw on pump is adjustable.

8. Oil drains from cylinder rocker housing through passage in each cylinder, then flows through hole in the base of each cylinder, lubricating cylinder walls, piston, piston rings and main bearings.

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Figure 3A-3. Electra-Glide Lubrication System
Figure 3A-4. 1963 to 1965 Oil Feed Pressure System

Revised: 10-65
Figure 3A-4A. 1965 and Earlier Oil Scavenger System
9. Oil flows from the rocker arm bearings through push rod covers into the gearcase compartment, lubricating push rods and tappets.

10. Rotary breather valve is timed to open on the downward stroke of pistons, allowing crankcase exhaust air pressure to expel scavage oil from crankcase breather oil trap into gearcase. Breather valve closes on upward stroke of pistons, creating vacuum in crankcase.

During this interval, the small ports in breather valve line up with passage in crankcase. Oil is then retrieved through passage by vacuum from breather oil trap in crankcase, and (on 1965 model) from front chain compartment.

11. Oil blown and drained into timing gearcase (steps 4, 8 and 9), lubricates generator drive gear, timing gears and gear shaft bearings.

12. Gearcase oil settles in gearcase sump from where it returns to pump.

13. Scavenge (return) section of oil pump.

14. Engine oil return to tank.

15. Exhaust air baffle and transfer passage to breather oil trap.

16. Breather oil trap with screen.

17. Oil transfer passage to breather valve.

18. Crankcase exhaust air escapes from gearcase through outside breather tube on 1965 and later model. Air exhausts to front chain guard on earlier models.

19. Return line from chain housing (1965 and later).

20. Vent line to oil tank and chain housing.

21. Rear chain oiler.

22. Pressure switch fitting.

ENGINE REPAIR PROCEDURE

GENERAL

When an engine needs repair, it is not always possible to definitely determine beforehand whether the engine can be repaired by disassembling only cylinders and heads, only gearcase; or whether engine must be completely disassembled for crankcase section repair.

Usually, only upper-end repair is needed and it is recommended procedure to first strip motorcycle for cylinder head, cylinder and piston repair as described in "Stripping Motorcycle for Engine Repair," steps 1 through 10.

After disassembling cylinder head and cylinder it may be found that lower end repair is necessary. This requires removal of engine crankcase from frame as described in steps 10 through 20 in "Stripping Motorcycle for Engine Repair."

In cases where it has been definitely determined beforehand that the lower portion of engine (crankcase) is in need of repair, remove complete engine from chassis before starting disassembly as described in steps 1 through 20 of "Stripping Motorcycle for Engine Repair."

Symptoms indicating a need for engine repair are often misleading, but generally if more than one symptom is present, possible symptom causes can be narrowed down to make at least a partial diagnosis. An above normal consumption of oil, for example, could be caused by several mechanical faults (see "Locating Operating Troubles," Section 1D). But when accompanied by a blue-gray smoke from the exhaust, and when low compression is present, it indicates the rings need replacing. Low compression by itself, however, indicates improperly seated valves, not worn rings.

A noisy engine is usually caused by loose bearings. Main bearings are generally more durable than rod bearings or bushings so the latter should be suspected first. Certain "knocking" noises may be caused by loose bearings, others by piston slap, a condition where piston or cylinder or both are worn out of round and loose fitting, allowing the piston to slap from front to rear of cylinder as it moves up and down.

Most frequently, valves, rings, pins, bushings and bearings need attention at about the same time. If the symptoms can be narrowed down through the process of elimination to indicate any one of the above components is worn, it is best to give attention to all of the cylinder head and cylinder parts.

STRIPPING MOTORCYCLE FOR ENGINE REPAIR

Use the following procedure to strip the motorcycle for either cylinder head and cylinder removal for repair with engine in chassis, or for engine removal for complete overhaul.

1. To remove instrument cover take out mounting base center screw and pry off cover side plate located at trip mileage set screw.

2. Release seat clevis spring, pull clevis pin and tip seat forward.

3. Disconnect fuel lines and interconnecting line from tanks, and drain into a proper container. Gasoline may be pumped out through tank filler opening before disconnecting pipes.
SECTION 3A
Engine - General

4. Remove upper and lower bolts at the front and the
two stud nuts between the gasoline tanks at the rear.
Remove tanks. On tank attached hand shift models,
remove shift lever bottom bolts so shift lever may
be removed with left tank.

5. Remove cylinder head bracket. Note washers be-
tween bracket and frame lug, use same washer when
bracket is assembled.

6. Remove spark plugs to avoid damaging. Discon-
nect ground wire at battery.

7. On 1964 and earlier models, turn out center screw
and remove horn power pack cover. Disconnect two
wires from horn power pack. Remove two bolts
mounting horn power pack to bracket. Loosen horn
trumpet nut and turn horn power pack off trumpet.

Remove carburetor intake manifold clamps.

8. Remove air cleaner cover, filter element, four
bolts, lock washers and air cleaner back plate from
carburetor body.

9. Disconnect throttle and choke controls from car-
buretor. Disconnect fuel and vent lines. Disconnect
carburetor support bracket and remove carburetor.

10. On 1964 and earlier models, remove horn trump-
et mounting bolt and horn trumpet. Disconnect ex-
haust pipes from cylinder head ports. Remove regu-
lator mounting screws and move regulator away.
It is not necessary to disconnect wires from regu-
lator.

At this stage, the cylinder heads and cylinders may
be removed.

To remove engine crankcase or complete engine,
continue stripping motorcycle as follows:

11. Remove left footrest and chain guard cover. If
motorcycle is equipped with compensating sprocket,
use Compensating Sprocket Shaft Nut Wrench, Part
No. 94655-55, to remove compensating sprocket
shaft nut. If not equipped with compensating
sprocket, use 1-3/8 inch socket or box wrench to
remove nut. Loosen nut by striking wrench handle
several sharp blows with hammer.

On 1965 and later models, remove chain adjuster
mounting bolt and large brass starter shaft thrust
washer.

Remove push rod adjusting screw lock nut (nut on
center screw on clutch sprocket), slip washer (any
metal washer about 1-3/4 in. in diameter with 3/8
in. hole) over push rod adjusting screw and replace
lock nut. Remove three spring tension adjusting nuts
and pull clutch outer disc and spring collar assembly
off clutch drive hub pins. Move clutch sprocket and
motor sprocket out and remove from shafts.

12. Remove three bolts, attaching chain cover to en-
gine sprocket shaft.

On 1965 and later models, loosen the 5 transmission
base mounting nuts. Remove the 4 inner chain guard
to transmission attaching bolts. Remove clutch hub
using Clutch Hub Nut Wrench Part No. 94645-41 and
Clutch Hub Puller, Part No. 95960-41A. Remove
shaft key. Remove the 2 inner chain guard stud nuts
which attach to starter housing. Remove wire from
solenoid. Pull inner chain guard from mainshaft
using Puller Part No. 95960-41A which has 4 screws
to fit tapped holes in chain housing. Remove chain
roller pole at oil pump. Remove other hoses from
connections at back of chain housing.

13. Disconnect timer wire at coil, Disconnect wires
from generator. Disconnect wire from oil pressure
switch.

15. Drain oil tank and remove oil lines from oil
pump. On 1965 and later models, remove crankcase
breather pipe.

16. Remove footboard rear stud nut from inside of
frame member and front footboard mounting stud
bolts from brake master cylinder by removing nut
and lock washer on back side. Remove brake mas-
ter cylinder attaching stud bolt which passes through
master cylinder and frame with a lock washer and
nut on back side of frame member. Remove brake
master cylinder sideplate bolt located behind master
cylinder plunger boot. Master cylinder and sideplate
assembly is free to swing down away from engine
 crankcase.

17. Remove exhaust system.

19. On 1964 and earlier models, remove spark ad-
 vance control wire at circuit breaker. Remove two
rear screws from horn trumpet bracket and slip out
spark advance control wire.

20. Remove two front and two rear engine mounting
bolts. Engine is now completely stripped and may be
removed from right side of motorcycle.

Assembly is essentially the reverse order of disas-
sembly.

On 1965 and later models, Loc-Tite "Grade A"
should be applied to transmission shaft ball bearing
recess in chain housing and on shaft. Pack ball race
with grease after housing is tapped in place. Apply
aluminum paint to joining surface of chain housing
and engine-transmission, also use new cover gasket
when reassembling.

NOTE
Leave transmission base mounting nuts loose
until engine and transmission are secured to
chain housing.

IMPORTANT
After assembly, chain housing must be air
tight. Vacuum in chain housing can be
checked with Vacuum Gage Part No. 96960-58
and should be 12 in. water or more at 1500
RPM. A lower reading than this indicates
an air leak into chain housing at gasket, sole-
noid, starter shaft or hoses.
Cylinder Head

Removing Cylinder Head Assembly

1966 and Later (Fig. 3B-1)

Before removing cylinder head assembly, strip motorcycle as described in "Stripping Motorcycle For Engine Repair," Section 3A. Free carburetor and manifold assembly from motorcycle by removing two manifold clamps and carburetor support bracket nut at crankcase.

Disconnect overhead oil feed line (1) and cylinder interconnecting oil line (1C) at fittings.

Remove spring cap retainers 4A on push rod covers by prying down on cover spring cap with screwdriver wedged between cylinder cooling fins and pulling spring cap retainers out.

Remove five head bolts and washers (2) from each head. Lift cylinder head enough to slip out push rods (3) and push rod covers (4). Remove cylinder head (5). Remove cylinder head gasket (6). Mark push rods so that they will be reassembled in same position.

1965 and Earlier (Fig. 3B-1A)

Disconnect overhead oil feed line (1) at fittings (1963 and later). Remove spring cap retainers 4A on push rod covers by prying down on cover spring cap with screwdriver wedged between cylinder cooling fins and pulling spring cap retainers out.

Remove five head bolts and washers (2) from each head. Lift cylinder head enough to slip out push rods (3) and push rod covers (4). Remove cylinder head (5). Remove cylinder head gasket (6). Mark push rods so that they will be reassembled in same position.

Disassembling Cylinder Head

1966 and Later (Fig. 3B-1)

Free the rocker arm cover (9) from cylinder head by removing stud nuts (7). Before further disassembly, carefully check the rocker arm pads and ball sockets for pitting and excessive wear. Also, check the rocker arm shaft (12) for appreciable end play.

Remove rocker arm shaft screw and "O" ring (13), acorn nut and washer (16). Discard shaft screw "O" ring. Tap rocker arm shaft (12) from cover and remove rocker arm (15) and spacer (11). Mark rocker arm shaft and arm in some manner so all parts may be returned to respective locations during assembly. Rocker arms are not interchangeable.

Compress valve springs using Valve Spring Compressor, Part No. 96600-36, and remove valve keys (18) from ends of valve stems as shown in Fig. 3B-2. Mark keys to identify them with their respective valves. Remove valve spring collars (19 and 22), springs (20 and 21) and valves (23). It is customary to reassemble valves in same cylinder head from which they were removed; therefore, before removing, mark them in some manner to identify them with front and rear cylinder head.

1965 and Earlier (Fig. 3B-1A)

Remove the 12 cover reinforcing screws (7) and lift off reinforcing ring (8), rocker arm cover (9) and cover gasket (11). Cover pad (10) is cemented inside cover and needs no attention if in serviceable condition.

Turn off the eight rocker arm bearing stud nuts (12), and lift intake valve oiler (13) off studs. Remove rocker arm bearing halves (14 and 16) with rocker arms (15).

Remove exhaust valve stem pads (17) (if used). Compress valve springs with Valve Spring Compressor, Part No. 96600-36, as shown in Fig. 3B-2. Remove valve key halves (18).

Remove upper valve spring collar (19), outer valve spring (20) and inner valve spring (21) and lower valve spring collar (22). Slip valves (23) out of valve guides in head.

Do not interchange valves, rocker arms or rocker arm bearing halves. Either process parts separately or mark them in some manner so they may be returned to their respective positions.

Cleaning and Inspection

Clean outside of cylinder head with a wire brush. Scrape carbon from head, top of cylinder, top of bore above ring path, and inlet and exhaust valve ports. When scraping carbon, be careful to avoid scratching or nicking cylinder head and cylinder joint faces or bore. Blow off loosened carbon or dirt with compressed air.

Wash all parts in Harley-Davidson "Gunk Hydro-Seal". Blow out oil passages in head. Be sure they are free of sludge and carbon particles. Remove loosened carbon from valve head and stem with a wire wheel. Never use a file or other hardened tool that will scratch or nick valve. Polish valve stem with very fine emery cloth or steel wool. Check valve stem for excessive wear.

Valve head should have a seating surface about 1/16 in. wide, it should be free of pit marks and burn spots. Exhaust valves should contain carbon that is black or dark brown. White or light buff carbon indicates excessive heat and burning.

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1. Overhead oil feed line
   1A. Feed line nut (3)
   1B. Feed line rubber sleeve (3)
   1C. Cylinder interconnecting oil line
2. Head bolt and washer (5)
3. Push rod (2)
4. Push rod cover (2)
4A. Spring cap retainer (2)
5. Cylinder head
6. Cylinder head gasket
7. Rocker housing nut and washer (5)
8. Oil feed line nipple
9. Rocker arm housing
10. Rocker arm shaft acorn nut and washer
11. Rocker arm spacer (2)
12. Rocker arm shaft (2)
13. Rocker arm shaft screw and O-ring (2 each)
14. Rocker arm bushing (4)
15. Rocker arm (2)
16. Valve seat insert (one exhaust, one intake)
17. Rocker housing stud (8)
18. Valve key (2)
19. Upper valve spring collar (2)
20. Outer valve spring (2)
21. Inner valve spring (2)
22. Lower spring collar (2)
23. Valve (one exhaust, one intake)
24. Valve guide (one exhaust, one intake)
25. Valve guide gasket (2)

Figure following name of part indicates quantity necessary for one complete assembly.

Figure 3B-1. 1966 and Later Cylinder Head - Exploded View
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SECTION 3B
Engine - Cylinder Head

1. Overhead oil feed line (1965)
   1A. Feed line nut (3)
   1B. Feed line rubber sleeve (3)
2. Head bolt and washer (5)
3. Push rod (2)
4. Push rod cover (2)
4A. Spring cap retainer (2)
5. Cylinder head
6. Cylinder head gasket
7. Cover reinforcing screw (12)
8. Cover reinforcing ring
9. Rocker arm cover
10. Cover pad
11. Cover gasket
12. Rocker arm bearing stud nut (8)
13. Intake valve oiler
14. Rocker arm bearing top half (2)
15. Rocker arm (2)
16. Rocker arm bearing bottom half (2)
17. Exhaust valve stem pad (early models)
18. Valve key (2)
19. Upper valve spring collar (2)
20. Outer valve spring (2)
21. Inner valve spring (2)
22. Lower spring collar (2)
23. Valve (one exhaust, one intake)
24. Valve guide (one exhaust, one intake)

Figure following name of part indicates quantity necessary for one complete assembly.

Figure 3B-1A. 1965 and Earlier Cylinder Head - Exploded View

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SECTION 3B
Engine - Cylinder Head

Valve seats are also subject to wear, pitting and burning. They should be resurfaced whenever valves are refinished. Clean valve guides with the Harley-Davidson Valve Guide Reamer, Part No. 94830-47, and check for wear and valve stem clearance.

Inspect valve springs for broken or discolored coils. Check free length or check tension of each spring. If a spring is more than 1/8 in. shorter than a new spring, or tension shows spring to be below low limit tension of new spring, replace it with a new spring. Check valve spring compression with valve spring tester against tolerances shown in "Engine Specifications," Section 3A.

Examine push rods, particularly the ball ends. Replace any rods that are bent, worn, discolored or broken. Check cup at end of rocker arm to make certain there are no chips broken out.

Blow out oil passages in rocker arms, rocker arm bearings and rocker arm covers.

If the rocker arm pads show uneven wear or pitting, dress on a grinder, maintaining original curve. If possible, compare with a new unit during this operation to insure a correctly contoured surface.

Carefully check the rocker arm and shaft for wear. Replace rocker arm bushings if shaft is over .002 in. loose in bushings, as described in "Repairing Rocker Arms and Bearings."

REPAIRING ROCKER ARMS AND BEARINGS

1966 and Later

To replace worn bushings (14), press or drive them from rocker arm. If bushing is difficult to remove, insert a tap (5/8-11 thread) into bushing. From opposite side of rocker arm, drift out bushing and tap. Press or drive replacement bushing into rocker arm, flush with arm end, oil hole correctly aligned and split portion of bushing towards the top of arm.

Line ream new bushings with Harley-Davidson reamer tool, Part No. 94604-57.

1965 and Earlier

Assemble rocker arms and bearings on head (dry). Check rocker arm clearance in bearing. If rocker arm fit in bearing is greater than .002 in., repair bearings that are otherwise serviceable as follows: Remove locating dowel pins from bearing covers and sand matching faces of top and bottom rocker arm bearing halves on a sheet of emery cloth laid on a fairly true firm surface. Sand both halves an equal amount. Wash parts and assemble (with dowel pins) to cylinder head, but omit rocker arm. Line ream hole in bearing with a standard 7/8 in. reamer. Disassemble, wash parts and reassemble, including rocker arm. Check fit and repeat sanding and reaming procedure until desired tolerance fitting is reached. Rocker arms must be free in bearings or hydraulic lifters will not fill with oil. Always strike edges of rocker bearings a medium blow to align parts before checking fit.

REPLACING VALVE GUIDES

Replacing valve guides if necessary, must be done before valve seat and face are ground since the valve stem hole in valve guide is the basis from which all face and seat grinding is done. Valve stem-valve guide clearance is as follows: Exhaust valves, .004 in. to .006 in. loose; intake valves, .002 in. to .004 in. loose. If valve stems and/or guides are worn to exceed the maximum tolerances by more than .002 in., new parts must be installed.

Tap out valve guides with shouldered drift pin (from chamber side) and insert replacement guide on arbor press. Be particularly careful to press replacement guide squarely into hole.

New valve guides are reamed to correct size. However, when guides are pressed into cylinder heads,
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SECTION 3B
Engine - Cylinder Head

Figure 3B-2. Compressing Valve Spring

they may close up slightly; also the ends may be burred. Therefore, after new guides are in place, they should be sized and cleaned with Valve Guide Reamer, Part No. 94630-47.

It is of prime importance that valve guides fit tightly in cylinder heads, or valves may not seat properly. If original guide or new standard guide is not a tight press fit, an oversize guide must be installed. Oversize guides can be obtained .001 in. to .006 in. oversize.

REPLACING VALVE SEATS

After installing valve guides, valve seats must be refaced to true them with guides.

If valves have been reseated several times, valve seats may have become too wide and/or valve may be seating itself too deeply in head. When valve seat becomes wider than 1/16 in. (see Fig. 3B-3) valve seat relief must be counterbored or ground to reduce seat to 1/16 in. Countertere dimensions are shown. Tools for this purpose are available commercially. To determine if valve is seating itself too deeply in head, measure distance from shoulder of valve guide to end of valve stem. See dimension in Fig. 3B-3. When valve stem extends through guide excess of maximum shown valve seat inserts must be replaced.

A special gage is available under Part No. 96490-59A which is used to measure this dimension. The tool consists of gage valves and gage which is placed over the valve stem as shown. If top end of gage valve stem is between steps on gage, the valve seat location is satisfactory.

1966 and later inserts are pressed-in and cylinder heads may be returned to the factory for replacement with new inserts.

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Figure 3B-3. Valve Seat Tolerances

1965 and earlier cylinder heads, having cast-in inserts, may be returned to factory through authorized Harley-Davidson dealer for valve seat insert replacement. Heads are bored out to remove old seats, and new seats are pressed into place.

5/32 in. oversize service valve, Part No. 10082-60, is available for replacement of standard size, 1965 and earlier, intake and exhaust valves which are seating too deeply. A new valve seat must be cut in the old valve seat insert with boring or grinding tools according to instructions which come with service valve.

GRINDING VALVE FACES AND SEATS

Valve seat grinding tools and fixtures are available commercially. Grind and seat each valve in same port from which it was disassembled.

Valve face angle is 45° for both intake and exhaust valves, and valve refacing grinder must be adjusted exactly to this angle. It is important to not remove any more metal than is necessary to clean up and true valve face. If grinding leaves the edge of valve very thin or sharp, install a new valve. A valve in this condition does not seat normally, will burn easily and may cause pre-ignition. There is also danger of cracking. Valves that do not clean up quickly are probably warped or too deeply pitted to be used. If end of valve stem shows uneven wear, true end of stem on a valve refacing grinder equipped with suitable attachment.

Standard intake and exhaust valves are made of different materials and must not be interchanged on 1965 and earlier models. Intake valves are marked "IN" on head; exhaust valves are marked "EX." 1966 models have larger intake valve and cannot be interchanged.
LAPPING VALVE FACES AND SEATS

If valve faces and seats have been smoothly and accurately refaced, very little lapping will be required to complete seating operation. Apply a light coat of fine lapping compound to valve face, insert valve in guide and give it a few oscillations with Valve Grinding Tool, Part No. 96550-36. Lift valve and rotate it about 1/3 of a turn. Repeat lapping procedure as shown in Fig. 3B-4. After full turn, remove valve, wash valve face and seat, and dry with cloth that is immediately discarded so grinding compound cannot be transferred to engine parts. If inspection shows an unbroken lapped finish of uniform width around both valve and seat, valve is well seated. If lapped finish is not complete, further lapping, or grinding and lapping is necessary.

ASSEMBLING CYLINDER HEAD

Replace valve and valve spring assemblies using Valve Spring Compressor, Part No. 96600-36. Position valve keys so spaces between key halves are equal. Spaces between key halves must face front and rear of engine on intake valves.

Replace rocker arm assemblies. On 1965 and earlier models use new intake valve oiler, making sure intake valve oiler is in place on intake rocker bearing, with oiler tube 3/32 in. from rocker arm. Rocker arms must be free or hydraulic lifters will not fill with oil.

Replace rocker arm cover. In 1965 and earlier models having reinforcing ring, use new cover gasket and pull down cover reinforcing screws evenly to obtain tight seal. On 1966 models, aluminum paint should be used on cover faces and cover nuts tightened evenly to 15 ft. lbs.

IMPORTANT

On 1966 model be sure to see that rocker arm ends do not jam against valve stems as rocker box is installed on head studs. Use a screwdriver to raise valve end of arm when cover assembly is installed.

Install new cylinder head to cylinder gasket and position rear head. Start cylinder head bolts. Turn engine until front cylinder exhaust tappet is just starting upward. Install rear cylinder exhaust push rod and push rod cover. Make certain both push rod ends are properly seated in rocker arm and tappet.

Rotate engine until front cylinder intake tappet is just starting upward. Install rear cylinder intake push rod in same manner as exhaust push rod. Tighten head bolts evenly to insure a proper seal. First turn bolts snug, then using a torque wrench tighten each 1/4 turn at a time until all are drawn to 65 ft. lbs.

Repeat procedure to install front cylinder head.

ADJUSTING TAPPETS (Fig. 3B-5)

Engine must be cold. Loosen tappet adjusting lock nut (1) and turn adjusting screw (2) upward, shortening push rod, until push rod has noticeable shake. Keep push rod from turning by holding with wrench on flats provided at base of push rod (3). Slowly turn push rod adjusting screw downward, lengthening rod, until all shake has been taken up. Mark adjusting screw with chalk and turn it downward exactly four full turns. Lock adjustment by tightening tappet adjusting lock nut. Always adjust tappets with push rod at its lowest position. Lowest position may be found by rotating engine until like tappet (intake or exhaust) in other cylinder is at highest point (valve fully open).

Install push rod cover spring cap retainers.

Always use new gasket at all joints unless otherwise specified. Clean off surfaces with a greaseless solvent (white gasoline is satisfactory) and install gaskets dry. Greased gaskets adhere to joint surfaces and become impossible to remove without damaging joint surfaces.


Figure 3B-5. Adjusting Tappets
CYLINDER

DISASSEMBLING CYLINDER AND PISTON (Fig. 3C-1)

Strip motorcycle as described in "Stripping Motorcycle for Engine Repair," Section 3A, steps 1 through 10.

Remove cylinder head as described in "Disassembling Cylinder Head," Section 3B.

Remove all cylinder base stud nuts and washers (1) except one on rear cylinder using Cylinder Base Nut Wrench, Part No. 94585-30. Raise front cylinder and piston enough to permit placing a cloth over crankcase opening. This will prevent dirt or pieces of broken ring from falling into crankcase. With piston at bottom of stroke, remove cylinder (2). Remove remaining stud nut from rear cylinder. Remove rear cylinder in same manner. Discard cylinder to crankcase gasket (3).

Spring piston rings (4) outward until they clear ring grooves in piston and lift off. Use a commercial ring expander if necessary. Pry right piston pin lock ring (5) off piston pin using the Piston Lock Ring Tool, Part No. 96750-32A and screwdriver as shown in Fig. 3C-2. Right end of piston pin has slots for this purpose. Tap out piston pin (6) and lift off piston (7).

Remove piston pin bushing (8), if necessary (see "Cleaning and Inspection"), using Piston Pin Bushing Tool, Part No. 95970-32A. Do not drive bushing out with a drift pin unless rod is disconnected and well supported around piston pin hole.

CLEANING AND INSPECTION

Place cylinders and pistons in "Gunk Hydro-Seal" or other carbon and gum dissolving agent until deposits are soft. Scrub piston dome and outside of cylinder to remove deposits. Where carbon deposit is thick and hard, it is advisable to scrape carbon before cleaning. Use a putty knife or ground tip on an old file. Use care to keep from scraping into aluminum of piston.

Wash all parts in solvent and blow dry with compressed air. Force air through feed and return oil passages in cylinder. Clean piston ring grooves with a piece of compression ring ground to a chisel shape.

Examine piston pin to see that it is not pitted or scored. Check the piston pin bushing to see that it is not loose in connecting rod, grooved, pitted or scored. A piston pin, properly fitted, is a light hand press fit in piston and has .001 in. clearance in connecting rod upper bearing. If piston pin to bushing free fit exceeds .002 in., replace worn parts, (see "Connecting Rod Bushings").

If piston pin is to be used again, examine lock ring on unslotted end of pin. If ring is tight in its groove, it is not necessary to remove it. When a new ring is required, clean ring groove and install ring before pin is installed in piston. The piston pin included with new piston assembly will have lock ring already installed on unslotted end.
Figure 3C-2. Removing Piston Pin Lock Ring

Examine piston and cylinder for cracks, burrs, burned spots, grooves and gouges.

Check rods for up and down play on lower bearings. See Fig. 3C-3. When up and down play is detected and either rod has more than 3/32 in. side shake at extreme upper end, lower bearing should be refitted. This requires removing and disassembling engine crankcase (see Section 3E).

REFINISHING CYLINDERS

Gauge pistons and cylinders to see if they are worn to the point where cylinders must be rebored and oversize pistons installed. Inside and outside micrometers used for piston to cylinder fitting should be checked together to be sure they are adjusted to read exactly the same. Subtract piston measurement from bore measurement to obtain clearance. Bore measurement of a cylinder should be taken in ring path, starting about 1/2 in. from the top of cylinder, measuring front to rear then side to side. Repeat procedure at the center and at the bottom of ring travel (see Fig. 3C-4). This process will determine if cylinder is out of round or "egged" and will also show any cylinder taper or bulge.

Pistons are measured front to rear at base of piston skirt as shown in Fig. 3C-5. Pistons are cam ground to an egged or oval shape so only front and rear surfaces are touching cylinder wall.

If cylinders are not scuffed, scored and are worn less than .002 in., it is not necessary to rebore oversize at time of cylinder repair. It may be done at time of next complete engine overhaul. If desired, a new piston may be installed to reduce clearance for more quiet operation.

Figure 3C-3. Checking Connecting Rod Fit

Figure 3C-4. Measuring Cylinder Bore

If cylinders show more than .002 in. wear, they should be rebored and/or honed to next standard oversize and refitted with corresponding pistons and rings.
DUO-GLIDE

Pistons are regularly supplied in the following oversizes: .005, .010, .020, .030, .040, .050, .060 and .070 in. Oversize pistons have their oversize stamped on head; 19, 20, etc.

Cylinders can be refinished oversize with a hone only, or with a boring bar followed by a finishing hone. In general practice only cylinders not scored and not badly worn are refinished entirely with a hone. Cylinders badly worn or deeply scored are first rebored to nearly the required oversize and then are finish-honed to exact size. Exact final size of the cylinder bore is determined by size of the piston to be used in that cylinder. Measure piston diameter accurately as described previously, then add desired piston clearance in cylinder. This will equal the exact final size to which cylinder bore should be refinished, example: the .020 in. oversize piston to be used measures 3.4578 in., adding .001 in. (desired clearance) equals 3.4585 in. (finish-honed size). When cylinders require reboring to beyond .070 in. oversize to clean up, their oversize limit has been exceeded and the cylinders must be replaced.

When cylinders are worn less than the .002 in. maximum, and reboring is unnecessary, unless they are scuffed or grooved the same pistons may be used with the replacement of rings and the roughing of cylinder walls to facilitate ring seating. Use No. 150 carborundum emery cloth to rough walls.

FITTING PISTON RINGS

Piston rings are of two types - compression (plain face) and oil control ring. The two compression rings are positioned in the two upper piston ring grooves with the stamped word "TOP" or a dot (.) upward. Rings are regularly supplied in the following oversizes to fit standard oversize pistons: .010, .020, .030, .040, .050, .060 and .070 in.

Compression rings must have proper side clearance in ring grooves. Check with thickness gauge as shown in Fig. 3C-6. Ring gap (space between ends) must also be as specified, see "Specifications", Section 3A.

Figure 3C-6. Measuring Ring Side Clearance

Figure 3C-7. Checking Ring Gap
SECTION 3C
Engine - Cylinder

The oil ring is a full width slotted oil control ring using a spring expander.

Figure 3C-9. Assembling Rings with Ring Expander

To check ring gap, place a piston in cylinder with top end of piston about 1/2 in. from top of cylinder. Place ring in cylinder bore squarely against piston and check gap with thickness gauge (see Fig. 3C-7).

Use only standard size rings and piston in standard bore, and only matching oversize rings and piston in the same oversize bore.

If gap is less than specified, ring ends may butt under expansion, and be scored or broken. Compression ring gap may be increased by filing with fine-cut file.

Use a commercially available piston ring expander (Fig. 3C-9) to guide and slip rings over the piston into their respective grooves without over expanding or twisting rings and damaging the finely finished piston surface.

CONNECTING ROD BUSHING

When connecting rod bushing is tight in rod but is worn to excessive pin clearance (.002 in. or more) it is possible to service by reaming oversize and fitting an oversize pin. However, it is recommended that a new bushing be installed and reamed to fit a standard pin, except when piston to be used had previously been fitted with oversize pin, or pin is loose in bosses, necessitating fitting with an oversize pin. The objection to fitting upper end oversize is that considerably more time is required for the job. New pistons, standard or oversize, obtained from factory are supplied correctly fitted with standard pin, and may be installed in a short time if the rod bushing is already reamed to standard size. If bushing has been reamed oversize, either a new bushing must be installed and reamed to standard size or piston must be reamed oversize to fit an oversize pin, which involves extra time.

When replacing bushings in connection with only a top overhaul, use Harley-Davidson special tools as shown in Fig. 3C-10, Bushing Tool, Part No. 95970-32A and Connecting Rod Clamping Fixture, Part No. 95952-33. Be careful to start new bushing with oil slot in alignment with oil slot in rod.

Ream new bushing to size with Special Reamer, Part No. 94800-26. A properly fitted pin should have .001 in. clearance; with this clearance, pin will have just noticeable shake in bushing. Fitting tighter is likely to result in a seized pin or bushing loosed in rod. Oversize piston pins are available .002, .004, .006 and .008 in. oversize.

STRAIGHTENING CONNECTING RODS

In refitting and reassembling connecting rods, and finally fitting pistons, rods may be bent or twisted, throwing upper bearing and lower bearing out of alignment with each other.

After pistons have been installed, rods must be checked and re-aligned as necessary. If a rod is bent or twisted, piston has a "cocked" relation to cylinder bore and the result is excessive noise and rapid wear.

Check rod alignment with Piston Squaring Plate, Part No. 96179-18 as shown in Fig. 3C-11. Be sure crankcase face is clean and free from burrs so that squaring plate seats fully.
NOTE

Piston skirt is cut away at bottom (below piston pin) for flywheel clearance, therefore, it cannot be used with squaring plate for checking rod alignment. Temporarily install a 61 O.H.V. piston to check rod alignment.

If a rod is in perfect alignment piston bottom will rest squarely on plate when flywheels are turned so that crank pin is in forward and rear position. This check, to be accurate, depends upon checking with crank pin alternately in both forward and rear positions. It is the change of rod angle, resulting from changing crank pin from one position to the other that influences the seat of piston on squaring plate and thus indicates whether or not rod is in alignment.

Insert narrow strips of paper of equal thickness underneath piston, one on each side, below piston pin, as shown in Fig. 3C-11. Press piston down lightly with finger tips resting on center of piston head and pull first one paper, then the other, partially from underneath piston. If piston is perfectly square (rod in alignment), both will have the same amount of drag.

If rod proves to be out of alignment, it can be straightened by means of a bar inserted through piston pin, as shown in Fig. 3C-12. Use a bar with a diameter as close to the hole diameter in the piston pin as possible. The manner in which piston seats on squaring plate indicates as follows:

1. Piston high on same side, both crank pin positions; rod is bent.
2. Piston high on opposite sides as crank pin position is changed; rod is twisted.

3. Piston square or nearly square with crank pin in one position and high on one side with crank pin in other position; rod is bent and twisted.

Correct as follows:

1. To straighten a bent rod, insert straightening bar through piston pin hole on low side of piston and apply upward force.
2. To straighten a twisted rod, insert straightening bar through piston pin hole on high side of piston, and if crank pin position is to front apply force to rear - if crank pin position is to rear apply force to front.
SECTION 3C
Engine - Cylinder

3. To straighten a bent and twisted rod (combination of a bend and twist) remove bend first and then remove twist.

After rods have been aligned check to see that pistons center in crankcase cylinder opening, without side pressure on upper rod ends. If further realigning is necessary to center pistons, correct by dressing off end of rod bushing on interfering side with a file. This allows the piston to shift slightly on rod to find a more suitable alignment of rod, piston, and cylinder bore.

ASSEMBLING CYLINDER AND PISTON

Attach piston to connecting rod with a piston pin. Position piston so lug on piston pin boss inside piston skirt is to right side of engine. See Fig. 3C-13.

Clean lock ring groove and install lock ring on end of pin that is not slotted if it was removed. Start slotted end of pin into piston boss from left side and drive through in the same manner in which pin was removed.

If the piston is heated in boiling water, the pin may be inserted into piston as a slip fit.

After pin is in place, clean lock ring groove and install the other lock ring (see Fig. 3C-14). It is important that special Lock Ring Tool, Part No. 96780-32A be used for installing lock rings.

Figure 3C-15. Slipping Cylinder over Piston

NOTE

Lock ring is expanded just enough to go over end of pin. Other means of installing may over-expand ring and possibly crack it. Make sure ring groove is clean and that ring seats firmly in groove.

A lock ring incorrectly installed will soon loosen in service and finally come off pin, resulting in both piston and cylinder being damaged beyond repair. Never install a used lock ring or a new one that has been installed and then removed. Always use an unused lock ring.

Lubricate cylinder walls, pistons, pins and rod bushings with engine oil. Rotate rings until gaps are equidistant around rear piston. Turn engine until crank pin is at bottom center. Install new cylinder base gasket. Position Piston Inserter Ring Tool, Part No. 96333-51A on rear piston and slip rear cylinder down over piston as shown in Fig. 3C-15.

Install lock washers and nuts and pull them down evenly. Repeat process to assemble front cylinder.

Assemble cylinder heads and remaining portions of motorcycle as indicated in "Assembling Cylinder Heads," Section 3B, and reverse order of "Stripping Motorcycle for Engine Repair," Section 3A, steps 10 through 1.
GEARCASE

OIL PUMP

GENERAL

The oil feed pump and scavenger (oil return) pump are gear type pumps housed in one pump body and located on rear of gearcase on right side of motorcycle. The feed pump incorporates an automatic bypass valve that reroutes surplus oil (above the amount needed to lubricate the engine) directly to the gearcase. A ball check valve is located ahead of the pressure regulating valve to prevent oil drainage from tank, and to operate the pressure switch. Under normal operating conditions, the pump is a comparatively trouble-free unit. The most common trouble with pump operation is the introduction into the pump of a metal or hard carbon chip. If either gets between the gear teeth, it is possible to shear a key, fracture a gear or break off a gear tooth.

If oil fails to return to the tank, check the scavenger pump gear drive shaft key. When the engine receives no lubrication (oil remains in tank), the drive shaft key on the feed pump drive gear may be sheared. Both conditions together could be caused by shearing of the oil pump (gearcase) drive gear key. In cold weather slush ice formed from moisture condensation in oil may block oil passages and cause any of above troubles.

DISASSEMBLING OIL PUMP (Fig. 3D-1)

NOTE

See Fig. 3D-1 or 3D-1A corresponding to pump being worked on.

The oil pump may be removed from the motorcycle as a unit only if the engine is removed from the chassis. The oil pump may be disassembled, piece-by-piece without removing gearcase cover, with engine in chassis as follows:

Disconnect oil lines and oil pressure switch (1) from pump. See Fig. 3D-1B or 3D-1D. Remove nuts and washers or bolts and lock washers (2) from gearcase studs, that hold oil pump cover in place. Remove oil pump cover (3) and gasket (4). Remove lock ring (5), drive gear (6), gear key (7) and idler gear (8). Remove two oil pump body mounting stud nuts (9) and slip pump body (10) off studs and gear drive shaft (11). Remove drive gear (12), key (13), and idler gear (14).

Turn relief valve plug (15) out of pump body and remove relief valve spring (16) and valve (17). Remove check valve spring cover screw (18), valve spring (19) and bail (20). On adjustable chain oiler equipped models, loosen chain oiler adjusting screw lock nut (21) and turn in adjusting screw (22). Count the turns necessary to bottom screw then remove. Bolt and turn out same number of turns when assembling. Remove chain oiler screw (22A). Oil pump nipples (24) may be turned out of pump cover to facilitate cleaning.

To remove oil pump unit from gearcase with engine removed from chassis, remove gearcase cover screws, cover and gasket. (See “Gearcase Timing Gears”.) Turn pinion gear nut off pinion shaft using the special tool, Gear Shaft Nut Socket Wrench, Part No. 94559-55 (left hand thread). Pull pinion gear using Pinion Gear Puller and Installer, Part No. 96830-51, remove key, spring, spacing collar and oil pump pinion shaft gear. Pry spring ring off pump drive gear shaft and remove drive gear and key. Remove pump body nuts and bolts (2 and 9) and slip pump with drive shaft (11) out of gearcase. Pump is then disassembled as above.

CLEANING AND INSPECTION

Thoroughly clean all parts in cleaning solvent and blow pump body passages clear with compressed air. Inspect valves and valve seats for pitting and wear. Replace pump having worn or damaged valve seat, inspect keys and keyways. Inspect scavenger and feed pump gear teeth for gouging or cracking caused by foreign materials going through pump. Pump shafts and bushings normally last lifetime of engine.

ASSEMBLING OIL PUMP

Oil pump is assembled in reverse order of disassembly. Do not mix gears and keys - return to correct location. Oil pump gaskets should always be replaced. Use only “factory made” gaskets. Lock rings are often damaged when removing them. It is advisable to install a new lock ring when assembling pump. Make sure ring is engaged and seated in retaining groove.

Bolts and nuts must be drawn down evenly to approximately 50 inch-pounds, but no more than 60 inch-pounds torque (four to five feet-pounds).

This is important because the oil pump cover gasket and body gasket are made from plastic material. If overtightened, the plastic material will be squeezed out of place and eliminate pump gear side clearance which may seize and damage the pump parts.

If a leakage problem exists, disassemble pump and inspect all gasket surfaces making sure they are flat and smooth. Install new gaskets and reassemble pump, tightening four bolts and two nuts evenly to 50 inch-pounds torque.

On late models, oil hose connections have one piece band type clamps and must be replaced each time hoses are connected. Use Hose Clamp Tool Part No. 97087-65 to squeeze clamps tight as shown in Fig. 3D-1C.
Figure 3D-1. Oil Pump - Exploded View (1967 and Earlier)

Figure 3D-1A Oil Pump - Exploded View (1968 and Later)

KEY FOR FIGURES 3D-1 AND 3D-1A

1. Oil pressure switch
2. Cover stud nut or bolt
   and washer
3. Oil pump cover
4. Cover gasket
5. Lock ring
6. Drive gear
7. Gear key
8. Idler gear
9. Oil pump body mounting stud
   nuts and washers (2)
10. Oil pump body
11. Oil pump gear drive shaft
12. Drive gear
13. Gear key
14. Idler gear
15. By-pass valve plug
16. By-pass valve spring
17. Check valve spring cover
18. Check valve spring cover
19. Check valve spring
20. Check valve ball
21. Chain oiler adjusting screw
   lock nut
22. Chain oiler adjusting screw
22A. Chain oiler screw (1965-67)
23. Chain oiler adj. screw washer
24. Oil line nipple (2) (1964
   and earlier)
24A. Oil line nipple (2) (1965)
24B. Oil line nipple (2) (1966)
25. Chain oiler pipe
26. Body gasket
27. Idler gear shaft

Figure following name of part indicates quantity necessary for one complete assembly.
Duo-Glide

Valve Tappets and Guides

General

The tappet assembly consists of tappet, roller and hydraulic unit. The tappet and roller, under com-

pression force from valve spring, follow the surface of the revolving cam. The linear motion produced is transmitted to the valve stem by the hydraulic unit, push rod and rocker arm. The hydraulic unit contains a piston or plunger and cylinder plus a ball check valve which allow the unit to pump itself full of engine oil to take up all play in the entire valve train. On late 1966 and some earlier models, oil is filtered through screen located beneath plug in crank-case (7, Fig. 3D-1B or 3D-1D).

When hydraulic units are functioning properly the assembly operates with no tappet clearance. The

Figure 3D-1B. Oil Pump and Connecting Lines (1965-67 Models)

Figure 3D-1C. Hose Clamp Connection

Figure 3D-1D. Oil Pump and Connecting Lines (1968 Models)

1. Oil supply line from tank
2. Oil return line to tank
3. Vent line to oil tank
4. Vent line to chain housing
5. Return line from chain housing
6. Front chain oiler line to chain housing
7. Overhead and tappet oil screen plug
8. Rear chain oiler adjusting screw

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units automatically compensate for heat expansion to maintain a no-clearance condition.

It is normal for tappets to click when engine is started after standing for some time. Hydraulic units have a definite “leak down” rate which permits the oil in the hydraulic unit cylinder to escape. This is necessary to allow units to compensate for various expansion conditions of parts and still maintain no-clearance operation. Push rod assemblies are functioning properly if they become quiet before or as engine reaches full operating temperature.

DISASSEMBLING TAPPETS (Fig. 3D-2)

If engine cylinder head is not disassembled, remove push rod cover spring cap retainer. Lift push rod covers and retract push rod adjusting screw until push rod may be lifted out of ball sockets.

Turn out tappet guide screws (1). Lift out hydraulic units (2). Loosen tappet guides by tapping gently with rawhide or soft metal hammer. Insert thumb and forefinger into push rod opening in tappet guide and press tops of tappets against side of guides.

Remove tappet and guide assembly. Be careful to avoid dropping a tappet through guide mounting hole and into gearcase. Slip push rod cover cork washers (3) out of top of tappet guide (4). Pull tappet and roller (5) out bottom of tappet guide and remove tappet guide gasket (6).

CLEANING AND INSPECTION

Wash all parts except hydraulic units and gaskets in grease solvent. Hydraulic unit parts are selectively fitted and may not be interchanged so they must be individually and separately washed. Twist and pull hydraulic piston and spring from cylinder and wash parts.

Blow out oil passages in tappets, tappet guides and hydraulic units with compressed air. Insert a length of wire into oil channel openings in tappet guide to make sure passages are open. Air dry all parts.

Examine cams through tappet guide holes in gearcase for nicked, grooved or chipped condition. Examine tappet-guide matching surfaces for scuffing or grooving.

When tappet fit in guide exceeds maximum tolerance shown in "Engine Specifications" by .001 in. or more, replace worn parts. If roller is loose, force out pin on arbor press, insert new parts and peen or stake pin ends.

Check roller end clearance. Replace all units exceeding tolerances listed in specifications.

CHECKING HYDRAULIC UNITS (2, Fig. 3D-2)

Hydraulic units may be checked as follows: Wash and air dry piston and cylinder. Blow out cylinder from bottom to make sure ball and seat are dry. Insert piston in cylinder. Hold in an upright position and press down piston, until spring touches cylinder, without covering hole in bottom of cylinder. Hold for count of 6 and release. If piston bounces back, unit is serviceable. If piston does not bounce back, cover hole in bottom of cylinder and repeat above process. If piston does not bounce back, unit is worn and must be replaced. If piston bounces back, ball is not seating, and unit should be replaced. Before replacing hydraulic units, check possibility of plugged or partially plugged screen under large cap screw located near rear tappet guide. Remove screen as described.
SECTION 3D
Engine = Gearcase

in "Disassembling Gearcase," and operate engine without screen and cork washers long enough to compare results.

ASSEMBLING TAPPETS (Fig. 3D-2)

Assemble tappets as follows: Slip tappets (5) into guide (4) so flat surfaces on tappets are toward center of guide as shown in Fig. 3D-3. If flat surfaces with holes are not toward center of guide, engine oil will not feed across and one hydraulic unit cannot fill with oil. Assemble tappet guide gasket dry and insert tappet assembly in place on gearcase, holding tappets in place with thumb and forefinger as when unit was removed.

Assemble push rod cover cork washers, push rod hydraulic units and tappet guide screws.

Assemble remainder of push rod assembly in same order disassembled.

Adjust tappet clearance as described in Section 3B-5.

Figure following name of part indicates quantity necessary for one complete assembly.

Figure 3D-4. Gearcase - Exploded View

3D-4

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GEARCASE TIMING GEARS

GENERAL

The gearcase, located on the right side of the engine crankcase, contains a train of gears which transmit engine power to the cam shaft, crankcase breather, timer, oil pump and generator. The gearcase is lubricated with engine oil through the by-pass circulatory system and through the breather valve from engine crankcase.

All gear shafts run in bushings except the crankcase side of the cam shaft which operates in a needle roller bearing. The circuit breaker (timer) gear and intermediate gear turn on stationary shafts and are fitted with bronze bushings.

DISASSEMBLY (Fig. 3D-4)

Before disassembling gearcase, it is advisable to remove push rods, tappets, push rod hydraulic units and tappet guides as described in "Disassembling Tappets."

Remove oil screen cap (1), gasket (2), screen body (3) or spring (3A) screen (4), and screen seal (1 or 2 used) (5). Remove screen from screen housing by rotating screen until notch in screen lines up with key in housing.

Remove 12 gearcase cover screws (6), oil passage screw (6A) with washer (6B), and two long generator fastening screws (7), and remove generator.

Remove two timer-to-motor bolts and slip timer assembly out top of gearcase.

Tap gearcase cover with wood or rawhide mallet to loosen and remove gearcase cover (8) and gearcase cover gasket (9).

Remove idler gear spacer (10) and circuit breaker gear spacer (11). Make a mark on one of the spacers to insure its assembly to the same gear. The spacers look identical but one may be thicker than the other.

Remove breather valve spacing washer (12).

Remove cam gear (13), spacing washer (14), and thrust washer (15).

Remove breather gear (16), circuit breaker gear (17) and idler gear (18).

Remove pinion gear shaft nut (19) which has a left-hand thread. Use Gear Shaft Nut Socket Wrench, Part No. 94555-55. Pull pinion gear (20) using Pinion Gear Puller and Installer, Part No. 96830-51 as shown in Fig. 3D-5. Tool has left-hand threads.

Remove key (21). Slip off spring (22), gear shaft pinion spacer (23), oil pump pinion shaft gear (24) and key (25).

Slip breather screen (26) and separator (27) out of pocket in gearcase.

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Engine - Gearcase

Remove oiler drive gear shaft spring ring (28), oiler drive gear (29) and oiler drive gear key (30).

If necessary, remove oil pump stud nuts and washers and remove oil pump from gearcase. See "Disassembling Oil Pump."

CLEANING AND INSPECTION (Fig. 3D-4)

Wash and air-dry all parts. Wash inside of case.

If crankcase is to be disassembled, wash parts after complete disassembly. If it is not to be repaired, be careful to get no grease solvent into crankcase when washing gearcase.

Inspect oil screen (4) carefully to make sure mesh is open. Holding screen to light is not an absolute check. It is possible for oil screen to be plugged or partially plugged with tiny lint-like fibers and still permit light to pass. Replace plugged or partially plugged screen. Probe oil screen hole in gearcase with a length of wire formed to a short hook to determine if there are any additional oil screen seal gaskets (5) in hole. More than the prescribed number will block off oil feed channel when screening unit is assembled.

Inspect breather screen (26). It must be clean and unobstructed.

Inspect cam gear and pinion gear bushings (37 and 38) in gearcase cover for pitting, scuffing and grooving. Determine amount of pinion and cam shaft wear in cover bushings. If it exceeds maximum tolerance shown in "Engine Specifications," Section 3A, by .001 in., install new bushings.

Inspect circuit breaker and idler gear fit on respective shaft. Examine bushings (34, 35 and 36) and stud shaft for pitting, grooving or scuffing. If amount of wear exceeds maximum tolerance shown in "Engine Specifications" by .001 in., replace bushings and/or stud shafts (32 and 33).

Attach dial indicator to gearcase cover mounting screw hole and determine amount of pinion shaft play in right main roller bearing. When tolerance in "Engine Specifications" is exceeded by .001 in., bearings should be replaced.

Inspect needle bearing (31) for wear, broken or gouged bearings. If end of cam shaft shows any appreciable wear (.003 in. or more), needle bearing is probably worn to a point where replacement of bearing and cam shaft are advisable.

Needle bearing can be removed and installed in crankcase without disassembling crankcase with Puller Tool, Part No. 95760-69. Press needle roller bearing into crankcase with Tool, Part No. 97272-60, as shown in figure 3D-9. Press from heavier end having the manufacturer's name only. Pressing from opposite end will crush roller race and bind rollers. Push new bearing into crankcase from gearcase side. Pinion shaft main roller bearing may be replaced only when crankcase is disassembled (see "Disassembling Crankcase," Section 3E).
SECTION 3D
Engine - Gearcase

Figure 3D-5. Pulling Pinion Gear

Inspect gears for wear. Assemble pinion and cam gears to respective positions in gearcase. Mesh is considered ideal when no play between gears can be felt and cam gear can be moved back and forth along shaft axis without restriction. Omit cam gear end spacer in assembly for purposes of this check and attach cover with at least four cover screws.

REPLACING GEARCASE COVER BUSHINGS (Fig. 3D-4)

Remove pinion shaft cover bushing using Puller Tool, Part No. 95780-69 (Fig. 3D-6).

Figure 3D-6. Removing Pinion Shaft Cover Bushing

Install new pinion gear shaft bushing (38) in hole in cover as follows:

Position bushing in cover so oil hole in bushing is exactly in line with lubrication channel outlet in cover. Press in bushing on arbor press until top of bushing is flush with cast bushing boss on cover. Locate and center punch new dowel pin location 1/8 in. or more from original location. Drill No. 31 hole 3/16 in. deep. Press in bushing until it bottoms on shoulder in cover boss hole. Continue drilling dowel pin hole to depth of 9/32 in. from top of bushing. Drive in new dowel pin and carefully peen edges of hole to lock pin in place.

To replace cam shaft cover bushing, proceed as follows:

Use Puller Tool, Part No. 95780-69, to extract old bushing. Make a mark on outside of bushing boss to locate original dowel pin hole. Press in new bushing with arbor press until shoulder is against cover boss. Locate new dowel pin hole at least 1/8 in. from original hole, centerpunch and drill No. 31 hole exactly 9/32 in. deep. Drive in new dowel pin and peen bushing edges over dowel to secure it.

Drill lubrication oil hole through wall of bushing with 5/32 in. drill, using oil hole in bushing boss as a drill guide.

Pinion shaft and cam shaft bushings must be line reamed to remove burrs and irregularities from hole.
and to insure perfect alignment. If crankcase is not disassembled, use any right crankcase side. Fasten cover in place with at least four screws.

To ream pinion shaft bushing, insert reamer pilot in right crankcase roller race. Insert 9/16 in. Pinion Shaft Cover Bushing Reamer, Part No. 94805-57, through pilot and push into cover bushing until it bottoms (see Fig. 3D-7), then give reamer one complete turn to size bushing. Rotate reamer the same direction (clockwise) during extraction.

To ream cam gear cover bushing, insert Cam Gear Shaft Bushing Reamer, Part No. 94802-36, through needle bearing in crankcase, into cover bushing. Turn reamer until it bottoms in gearcase cover.

Bushings in circuit breaker and idler gears may be pressed out on an arbor press using a suitable drift pin, and new bushings pressed in.

ASSEMBLY

Before assembling gear train, determine amount of end play in breather gear as follows: Assemble breather gear and dry cover gasket to gearcase. Select spacer washer (use washer disassembled unless it is known to give incorrect spacing) and position on end of breather gear. Place a steel straightedge across gearcase at spacer. With thickness gauge, measure distance between straightedge and spacer. Subtract .006 in. (amount gasket will compress) from this figure to determine gear end play. An end play tolerance of .001 to .005 in. is correct. If end play exceeds maximum, insert thicker spacer. Breather valve and gear spacer washers are available .115, .120 and .125 in. thick.

Establish proper cam gear end play as follows: Install thrust washer, spacing washer and cam gear. Position cover gasket and secure cover with at least four screws. Measure cam shaft end play between cam gear and cover bushing with thickness gauge through tappet guide hole in gearcase. End play should be from .001 to .005 in. If measurement is under or over tolerance, remove cover and replace spacing washer with one to give suitable clearance. Cam gear spacing washers are available .050, .055, .060, .065 and .070 in. thick.

Make final gearcase assembly including all parts in approximate reverse of disassembly order. Breather, cam, pinion and circuit breaker gears contain timing marks which must be aligned or matched as shown in Fig. 3D-8. Rotate gear train and note if it revolves freely. A bind indicates gear are meshed too tightly. Make sure circuit breaker and idler gear spacers are assembled to their respective shafts.

Apply a coat of non-hardening gasket sealer to crankcase and cover gasket surface. Position new cover gasket and secure cover with all cover screws. Pour about 1/4 pint of engine oil over gears to provide initial lubrication before securing cover.

Assemble remainder of gearcase, generator and circuit breaker in reverse of order removed.
CRANKCASE

GENERAL

When rod bearings, pinion shaft bearings or sprocket shaft bearings are in need of repair, the engine must be removed from the motorcycle as described in "Stripping Motorcycle for Engine Repair," Section 3A. It is recommended procedure to check and make repairs to cylinder heads, cylinders and gearcase at the same time, or in other words, perform an entire engine overhaul.

Flywheel End Play Check:

Before starting crankcase disassembly, check flywheel assembly end play to determine sprocket shaft bearing wear using a dial indicator. Assemble engine sprocket and nut or compensating sprocket to sprocket shaft before taking reading to assure accurate measurement. Attach indicator securely to crankcase with indicator stem resting on end of sprocket shaft. Measure total endplay by lifting flywheel assembly vertically using a screwdriver as a pry as shown in Figure 3E-17A. If play exceeds .006 maximum allowable endplay bearings must be replaced if found worn or damaged. If not worn, shimming can be used to take up endplay as described on page 3E-10.

Starting with the 1969 model season, the sprocket shaft bearing was changed as shown in Fig. 3E-3. The new bearing is locked in place with a combination lock ring-spacer which is located in a groove between the two bearing outer races. As with 1968 and earlier bearings, if any part of the bearing set requires replacement the entire bearing assembly, including bearings, races, lock ring and inner race spacer, must be replaced as a set.

DISASSEMBLING CRANKCASE

Remove cylinder heads as described in "Disassembling Cylinder Head," Section 3B.

Remove cylinders as described in "Disassembling Cylinder," Section 3C.

Remove gearcase parts as described in "Disassembling Gearcase," Section 3D. See "Crankcase," above for checking procedure before starting crankcase disassembly.

Refer to Fig. 3E-1 and proceed as follows:

Remove crankcase bolt (1), stud (2), crankcase breather stud assembly (3) or (3A), stud (4), top and right crankcase studs (5) and two lower crankcase studs (6). It is necessary to remove only one stud nut and slip stud and other nut out opposite side of crankcase.

Refer to Fig. 3E-2 and continue disassembly:

Position crankcase with gearcase (right side) up. Tap crankcase with rawhide or soft metal mallet to

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1. Crankcase stud bolt, 3/8 x 3-1/4 in. (2)
2. Crankcase stud, 5/16 x 5 in. (right center)
3. Crankcase breather stud and chain oiler (1963 and earlier)
3A. Crankcase breather stud and chain oiler (1964)
4. Crankcase stud, 5/16 x 6 in. (left center)
5. Crankcase stud, 5/16 x 5-7/16 in. (2) (top and top right)
6. Crankcase stud, 11/32 x 5-13/16 in. (2) (left and right bottom)

Figure following name of part indicates quantity necessary for one complete assembly. Locations are as viewed from left side of engine.
loosen top half. Lift right crankcase half (1) off pinion shaft main bearings. Remove spiral lock ring (2) from pinion shaft with tip of screwdriver. Lift bearing washers (3 and 5) with bearings and bearing retainers (4) off pinion shaft.

On 1968 and earlier models, remove sprocket shaft spacer (6) secure pinion shaft end of flywheels in copper vise jaws and turn out sprocket shaft bearing nut (7) with Sprocket Shaft Bearing Nut Wrench, Part No. 97235-55A. Thread is left hand.

Mount flywheel and left case assembly on press table supporting case on parallel bars (Fig. 3E-4) and press on end of sprocket shaft with arbor press until flywheel assembly (8) drops out, freeing sprocket side bearing half (9 or 9A), washer (7A) and spacer (11 or 11A).

On 1968 and earlier models, remove flywheel side outer race snap ring (10) from groove in case by prying end with screwdriver and inserting thin screwdriver or knife blade between snap ring and case.

On 1968 and earlier models only, reposition case on press table and press out outer races (12 and 14) and bearing spacer (13) from case (15) using Sprocket Shaft Bearing Outer Race Press Plug, Part No. 97194-57 (Fig. 3E-5).

On 1969 models, tap out bearing races (12A and 14A) from opposite sides of crankcase hole, using a brass drift and hammer. If bearing set is being replaced, remove lock ring-spacer (13A) using a 1/8 in. pin punch or similar tool with a tapered point. Rotate lock ring in groove so that one edge is near oil hole. Insert tool into oil hole with tapered end underneath lock ring. Tap on tool to force one end out of groove as shown in Fig. 3E-6. Starting at this free end, push ring out of bearing bore.

If flywheels are to be disassembled, grip pinion shaft in vise and pull bearing from sprocket shaft using the Bearing Puller Part No. 96015-56. Place hooked ends of puller halves behind bearing and hold collar over puller halves. Engage puller screw cross in puller slots and pull bearing off by tightening puller.
screw against sprocket shaft center as shown in Fig. 3E-7. Keep bearings in a set with proper bearing outer races.

DISASSEMBLING FLYWHEELS (Fig. 3E-8)

Grip pinion shaft in copper covered vise jaws so shafts are in vertical position. Insert a rod about 5 in. long and 1/2 in. in diameter through holes in flywheels to keep them from turning. Remove lock plate screw (1), lock plate (2) and crank pin nut (3). Strike left flywheel with soft metal mallet at about 90 degrees from crank pin hole on wheel periphery to loosen. Lift left flywheel (4) off crank pin.

Hold down bearing assembly with a short length of pipe or tubing so connecting rods (8) may be slipped off bearings. Remove bearings (6). Hold together in set until bearings are washed and refitted to crank pin.

Remove lock plate screw (7), lock plate (8) and gear shaft nut (9). Tap pinion shaft (11) out of flywheel (10). Remove key (12) from shaft.

Clamp crank pin in vise. Remove lock plate screw (13), lock plate (14) and crank pin lock nut (15). Tap crank pin (16) out of flywheel and remove key (17).

Grip sprocket shaft in vise and remove lock plate screw (18), lock plate (19) and sprocket shaft lock nut (20). Remove sprocket shaft (21) by tapping it out of flywheel, and remove key (22).

CLEANING AND INSPECTION

Wash all parts in grease solvent and blow dry with compressed air. Examine crank pin for wear, grooving and pitting. If the surface is all worn, replace with new pin. Examine flywheel washers (23 and 24). If either washer is worn and grooved, it should be renewed.

Examine connecting rod lower races. If they appear slightly grooved or shoudered where edge of bearing rollers ride, they may be lapped out and oversize bearing rollers installed. If they appear badly worn, grooved or pitted, new rods should be installed, preferably as an assembly with new bearings and crankpin.
SECTION 3E
Engine – Crankcase

Examine pinion shaft and right crankcase bushing (see 16, Fig. 3E-2) for pitting, grooving and gouging at point where right main roller bearings ride. A shaft that is worn must be replaced. If bushing is worn beyond repair, replace as described in "Truing and Sizing Pinion Shaft Main Bearing."

Examine sprocket shaft outer races for wear, grooving, and pitting. Examine bearing rollers for wear, pitting, grooving and heat discoloration. The sprocket shaft Timken tapered roller bearings are manufactured in selectively fitted sets. The same serial number appears on all parts. If any part is unusable, the complete set must be replaced.

REPLACING FLYWHEEL WASHERS

Replace worn flywheel washers as follows:

Washer is a close fit in recess in flywheel and is secured originally by punching flywheel metal tight against the washer at several points. It is usually necessary to drill a small hole (1/8 in. or smaller) at the outer edge of the washer to permit getting a pointed tool underneath to pry it out. The hole is drilled only slightly deeper than the thickness of the washer to avoid removing more metal than necessary.

Before installing new washer, scrape outer edge of washer recess where metal was punched against it so new washer may seat fully against recess bottom. If washer does not seat fully, forked rod is not likely to have necessary clearance for side play.

LAPPING CONNECTING ROD RACES

Connecting rod lower races that are likely to clean up within the range of oversize bearing rollers and are otherwise in serviceable condition, should be trued and sized with Connecting Rod Lapping Arbor, Part No. 98740-36, as shown in Fig. 3E-9.

Turn lap in lathe at 150 to 200 rpm. Adjust lap by means of adjusting nut to a dragging but free fit in rod race. Clean lap before using, then apply fine lapping compound (No. 220 grit grinding compound mixed with oil) to lap. A loose or tight lap will "bell mouth" bearing race so it must be kept adjusted at all times. To avoid grooving or tapering lapped surface in rod, work rod back and forth the full length of the lap holding rod as near race end as possible. Lap rods individually.

When rods are lapped true and all traces of pit marks or grooving are cleaned up, wash rods and blow dry. Surface should have a soft velvety appearance and be free of shiny spots. Assemble crank pin on right flywheel (see "Fitting Rod Bearings" before assembling flywheels). Wipe pin taper and flywheel taper perfectly clean and free from oil. Insert key in keyway and position flywheel over pin held in vise. Tighten nut very tight using Crank Pin and Flywheel Nut Wrench Part No. 94545-26. If necessary, tighten nut to make lock plate notches line up with corners of the nut with the lock washer screw hole in alignment. Never loosen nut to achieve this register. Never use length of pipe over handle of crank pin nut wrench. If a torque wrench is available tighten nuts to foot-pound reading as given in "Engine Specifications."

Assemble pinion shaft to right flywheel, with the Crank Pin and Flywheel Nut Wrench or Torque Wrench.

FITTING ROD BEARINGS

There are three ways to determine oversize rollers to use. All will result in properly fitted bearings if applied correctly.

1. Use a micrometer to measure the outside diameter of the crank pin at its center. Use an inside micrometer or telescoping hole gauge to measure the inside diameter of the rod races. Subtract the diameter of the crank pin from the inside diameter of the bearing race. Subtract from this figure the standard allowance for bearing running fit size. This answer, divided by two will give proper roller size. To find
oversize amount of bearing, subtract from this figure the diameter of a standard roller.

Example:

The rod bearing race measures 1.6263 in. after lapping and truing. The crank pin is slightly worn and measures 1.2485 in. Subtract 1.2485 in. from 1.6263 in. The answer, .3778 in., represents the diameters of both rollers (one on each side) plus clearance for running fit. Subtract minimum clearance for running fit (.001 in.). The answer (.3768 in.) is then divided by two to get the diameter of each oversize roller. In this case it would be .1884 in. To find how much oversize each roller must be, subtract from this figure the diameter of a standard roller, or .1873 in. Rollers must be .0009 in. oversize.

2. Install any new set of oversize rollers to bearing races and position on crank pin. Slip rods over bearings. If they will not fit, it is obvious rollers are too large and a smaller size must be tried. If they fit and spin freely, install a larger set of rollers. Try various roller sizes until the rods will turn with a very slight drag. This is a plug fit. Determining running fit is merely a matter of subtracting one half the desired running fit clearance (.0005 in.) from the roller size to find the running fit roller size.

It may be easier to gauge a plug fit as follows:

3. Fit any size rollers into races. Position bearings in rods. Support rods and bearings with left hand. Drop crank pin (not attached to flywheel) through crank pin hole. Plug fit has been achieved when crank pin will slide slowly through hole from its own weight. Running fit is then determined by subtracting one half running clearance from oversize of rollers used to make plug fit.

Example:

Plug fit is achieved with .0009 in. oversize rollers. By subtracting from this one half the minimum clearance (.0005 in.) it is determined that a .0004 in. oversize roller set will give desired running fit.

If lower end race of one rod is found to be slightly larger than the other, select rollers to fit the larger rod race and lap smaller roller race to same size as larger race rather than fitting rollers of two sizes.

When rods are correctly fitted with required bearing clearance, extreme upper end of female (forked) rod will have just barely noticeable side shake while the upper end of the male rod will have .025 in. to 1/32 in. (.001 in.) side shake. All fitting and checking must be made with bearings, rods and crankpin clean and free of oil.

Fitting bearings tighter than described may result in seizing and bearing damage when heat expands parts.

Check overall width of roller retainer assembly. It must be less than width of female rod end.

ASSEMBLING FLYWHEELS

After correct connecting rod bearing fit has been attained, clean and assemble parts as follows: Install sprocket shaft to left flywheel and pinion shaft and crank pin to right flywheel. Check to make sure oil passages through pinion shaft, right flywheel and crank pin are clear by blowing compressed air into hole near end of pinion shaft.

Position right flywheel assembly in vise, crank pin up. Wipe crank pin taper clean. Slip bearings and connecting rods over crank pin with forked rod to

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Figure 3E-7. Pulling Bearing from Sprocket Shaft
Figure 3E-8. Flywheel Assembly - Exploded View

1. Lock plate screw (4)  8. Lock plate (2)  17. Crank pin key
2. Lock plate (2)  9. Gear shaft nut (2)  18. Lock plate screw (see item 1)
3. Crank pin nut (2)  10. Right flywheel  19. Lock plate (see item 8)
4. Left flywheel  11. Pinion shaft  20. Sprocket shaft nut (see item 9)
5. Connecting rods (one forked,  12. Pinion shaft key one single end)  21. Sprocket shaft
6. Bearing rollers and retainer  13. Lock plate screw (see item 1)  22. Sprocket shaft key
7. Lock plate screw (see item 1)  14. Lock plate (see item 2)  23. Flywheel washer (2)
8. Crank pin lock nut (see item 3)  15. Crank pin
9. Crank pin

Figure following name of part indicates quantity necessary for one complete assembly.

rear cylinder. Wipe crank pin hole in left flywheel clean and dry. Install left flywheel and tighten nut lightly. Hold steel straightedge along outer face of wheel rims at 90 degrees from crank pin as shown in Fig. 3E-10. Tap outer rim of top wheel until wheels are concentric. Tighten nut. Recheck with straightedge at frequent intervals. Use soft metal hammer to realign wheels. To prevent flywheel assembly from turning in vise while tightening nut, insert a rod 5 in. long and about 1/2 in. in diameter through holes in flywheels and between vise jaws so that rod bears against some part of the vise.

When nut is fairly tight, install flywheel assembly in Flywheel Truing Device, Part No. 96550-30. Adjust so centers are snug. Wheels must turn freely but shafts may not be loose in centers. If flywheel assembly is either loose or squeezed, indicators will not indicate accurately. Adjust indicators to take reading as near to flywheels as possible, so pointers read at about the middle of the scales.

Turn flywheels slowly and observe the movement of indicator pointers. Movement toward flywheels indicate high points of shafts. Find highest point of

Figure 3E-9. Lapping Connecting Rod Bearing Race

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Figure 3E-10. Squaring Flywheel Faces

Figure 3E-11. Correcting Flywheel Alignment

each shaft and chalk-mark flywheel rims at these points. Loosen centers slightly, just enough so looseness may be detected, and make corrections as follows:

Flywheels may be out of true three ways, A, B and C, Fig. 3E-11 or a combination of two of the three ways.

When wheels are both out of true as indicated in "A," tighten a C-clamp on rims of wheels opposite crank pin and lightly tap the rim at the crank pin with lead or copper mallet.

When wheels are both out of true as indicated in "B," drive a hardwood wedge between the wheels opposite the crank pin and lightly tap the rims near the crank pins with a mallet.

Figure 3E-12. Truing Flywheels on Truing Stand

When wheels are out of true as indicated in "C," strike the rim of the wheel a firm blow at about 90 degrees from crank pin on high side (see Fig. 3E-12).

When wheels are out of true in a combination of any of conditions shown, correct A or B first, tapping rim of offending wheel only, and then correct condition C.

The number of blows required and how hard they should be struck depends on how far shafts are out of true and how tight nuts are drawn. Remember that centers must be loosened slightly before striking flywheels. Making them too loose may result in damaged centers. Never strike wheels a hard blow near crank pin. This could result in a broken crank pin.

Readjust centers, revolve wheels and take reading from indicator. Repeat truing operation until indicated run out does not exceed .001 in. (each graduation on indicator is .002 in.).

If it is impossible to true wheels, check for a cracked flywheel, damaged or enlarged tapered hole, or a sprocket or pinion shaft worn out of round at surface where indicator reading is being taken. When wheels are true, position in vise and draw crank pin nuts very tight using Crank Pin and Flywheel Nut Wrench, Part No. 94545-26, or use torque wrench and tighten to foot-pound reading given in "Engine Specifications." Check connecting rod side play with thickness gauge as shown in Fig. 3E-13. If it is greater than tolerance shown in "Engine Specifications," Section 3A, draw up crank pin nuts until within tolerance. Insufficient play between rods and flywheel face is caused by one of the following conditions:

1. Flywheels and crank pin assembled with oil or tapers and nuts over-tightened. Disassemble, clean, reassemble.

2. New flywheel washers installed and not fully seated. Disassemble, inspect, replace deepest seating flywheel or exchange crank pin. As last resort, grind down width of forked rod.

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3. Taper holes enlarged as a result of having been taken apart several times. Replace wheel seating deepest.


If sides of forked rod are ground to get desired clearance, backs of bearing retainers must be ground down to remain narrower than width of female rod.

After rod sideplay is checked and adjusted, crank pin nut pulled very tight and lock plate and screw installed, again recheck wheel trueness on truing device. Correct any run-out as above.

TRUING AND SIZING PINION SHAFT MAIN BEARING

Before fitting new pinion shaft main bearings, lap bearing race in crankcase to true it and remove traces of wear shoulder at sides of roller paths. Using Crankcase Main Bearing Lap, Part No. 96710-40, consisting of lapping shaft, handle, lapping arbor and guide sleeve (Fig. 3E-14).

A race that is worn beyond limits of oversize bearings must be replaced. To remove worn bearing race, remove two bearing race lock screws (17, Fig. 3E-2) from inside of case. Heat case to 275 - 300 degrees F. Heating expands case and makes it possible to remove bearing race using less force. Press worn race (18, Fig. 3E-2) out and new race in. New race must be lapped slightly to true and align with left case bearing, and to attain a size compatible with roller sizes available.

LAPPING ENGINE MAIN BEARINGS (Fig. 3E-15). Secure right and left crankcase halves with three crankcase stud bolts (top center and bottom left and right). The sprocket shaft bearing outer races and large spacer must be installed in left crankcase.

Assemble lapping arbor to lapping handle and assemble guide sleeve to sprocket shaft bearing bushing. Sleeves for use with tapered bearing, are assembled to case with bearings and small spacer collar. Turn sleeve parts finger tight.

Insert lap shaft with arbor assembled through pinion bearing bushing and into guide sleeve. Tighten arbor expansion collars using a length of 5/32 in. rod as spanner until arbor begins to drag. Do not adjust arbor snug in bushing or bushing will "bell," a condition where hole is larger at ends than it is in the center.

Withdraw arbor far enough to coat lightly with fine lapping compound. Do not apply a heavy coat. Re-position lap in bushing and turn handle at moderate hand speed. Work lap back and forth in bushing as it is revolved to avoid grooving and tapering.

At frequent intervals, remove lap from crankcase, wash and inspect bushing. Lapping is completed when entire bushing surface has a dull, satin finish rather than a glossy, smooth appearance. If necessary, flush off lap in cleaning solvent, air dry and apply fresh, light coat of fine lapping compound.
Fitting Pinion Shaft Bearing

The fitting of pinion shaft bearing is done in much the same way as fitting lower rod bearings (see "Fitting Rod Bearings"). A plug fit is first determined using the pinion shaft that will be used on engine being overhauled, or spare shaft of exactly same size. When a plug fit has been found, pinion shaft will enter bearing slowly under its own weight, will turn with only a very light drag and will have no perceptible shake.

A running fit is determined from a plug fit by subtracting one half the desired running fit clearance from the size of the plug fit rollers.

Example:

Running fit clearance is .0005 to .001 in. loose. See "Engine Specifications," Section 3A. If a plug fit was achieved with .0006 in. oversize rollers, subtract one half running fit clearance from plug fit roller oversize. Use figure representing middle or average of tolerance span, .00075 or .0008 in. One half the average of tolerance (.0004 in.), subtracted from roller oversize (.0006 in.), indicates that .0002 in. oversize rollers should be used to produce a suitable running fit.

Oversize rollers are available in .0002, .0004, .0006, .0008 and .001 in. sizes. All calculations should therefore be made to nearest available even-numbered size. In the example above, it would be possible to arbitrarily decide upon .0006 in. as a running fit rather than the .0008 in. if desired. Final decision would rest largely upon intended use of motorcycle. For highspeed work, the more free fit would be better, while the closer tolerance is suited to road use at average speeds. This consideration may be made in fitting all tolerances.

All fitting must be done with bearings that are clean and dry. Oiled surfaces will take up some clearance and give a false reading.

Fitting Sprocket Bearing

If Timken tapered roller bearings and races pass visual check and have no apparent wear, the same set may be reinstalled. Make certain all parts of bearing are installed in exactly the same order they were removed. If any part of bearing assembly is worn, entire assembly should be replaced.

Assembling Crankcase (Fig. 3E-2)

Install flywheel side outer race snap ring (10 or 13A) in case. Using arbor press and Outer Race Press Plug, Part No. 97194-57 to press outer race parts into crankcase bushing one at a time as shown in Fig. 3E-3. Press the races into the case with widest ends outward to match taper of bearings. Be sure the first race bottoms on the snap ring and each successive part tight against the one before.

Install bearing and spacer on sprocket shaft using Bearing Installing Tool, Part No. 97225-55. Press the parts on using sprocket shaft spacer (11) as a pressing spacer only. Turn tool screw onto sprocket shaft thread and tighten securely. Remove...
flange on flywheel using the tool driver and handle as shown in Fig. 3E-16.

Position flywheel assembly in vise with sprocket shaft up. Slip crankcase half, with outer race parts installed, over shaft. Slip bearing over tool screw, small end down toward bearing inner spacer. Position tool sleeve and turn on driver. Turn driver down against sleeve pressing bearings tightly together as shown in Fig. 3E-17. Bearings must be tight against the bearing spacer to provide correct bearing clearance.

Before proceeding with further assembly, check to see that the bearing is not preloaded by shaking crankcase half and feeling for a slight amount of play of crankcase half on bearing. Note: If there is no noticeable shake, or if flywheel assembly does not rotate freely in bearing, disassemble bearing and add a .003 shim, Part No. 23741-55, on one side of inner race spacer (11 or 11A, Figure 3E-3). Again install bearing with tool and recheck for slight play in bearing.

On 1968 and earlier models, install bearing lock nut (7) in crankcase using Sprocket Shaft Bearing Nut Wrench, Part No. 97235-55A. Nut should be started by hand. Thread is left hand. Final tightening may be left until case is assembled.

Remove assembly from vise and install bearing washer (5), bearings (4) and bearing washer (3) to pinion shaft. Install new spiral lock ring (2) to groove in pinion shaft. Slip right case half over bearing and against left case half after applying a coat of non-hardening gasket sealer to parting surfaces.

See Fig. 3E-1. Align case halves and tap crankcase stud bolts (6 and 8) into holes. These two studs properly align the case halves and must be installed before remaining studs. Start nuts and tighten until snug. Insert remaining studs and bolt and tighten all nuts securely.

Check exact amount of flywheel endplay with a dial indicator as directed at the beginning of this Section to determine if within specified limits. See Figure 3E-17A.

Tighten 1968 and earlier sprocket shaft bearing nut. Install sprocket spacer (6 or seal washer 7A and spacer, Fig. 3E-2) and sprocket or sprocket shaft extension. Start sprocket nut and tighten securely.

NOTE
Sprocket must be aligned with rear sprocket through use of correct thickness sprocket spacers. Method for checking and determining correct spacer thickness is given in Section 2B of this manual.
The Model HD carburetor is a dual-venturi, diaphragm-type carburetor with an automatic economizer and accelerating pump.

The fuel inlet needle is operated through a compression-spring balanced lever that is controlled by the diaphragm to regulate the flow of fuel into the metering chamber. The amount of fuel going into the carburetor metering chamber is exactly equal to the amount of fuel being used by the engine.

This type of fuel supply control operates at any tilt angle and is resistant to any vibration which could cause a poor fuel-air mixture or flooding.

The small primary venturi is offset to the bottom of the large secondary venturi where the main nozzle outlet protrudes from the metering chamber. The accelerating pump discharges into the small venturi to take advantage of the venturi pressure drop that breaks up the solid stream of accelerating-pump fuel.

The accelerating unit is a positive-acting plunger type pump that is connected to the throttle shaft through a cam lever. The pump plunger is a spring-loaded leather cup that operates in a smooth plastic cylinder, and draws its fuel directly from the metering chamber to provide extra fuel for accelerating.

The automatic economizer is a hydraulically-operated enrichment valve that controls the main-nozzle fuel mixture at very low engine speeds. The valve opens an auxiliary fixed main jet as the venturi air flow decreases, allowing the fuel mixture to be maintained at a full-power richness. As the air flow through the carburetor increases, or as the engine speed increases, the valve closes to prevent an over-rich mixture at intermediate speeds.

**OPERATION**

**STARTING OPERATION** (Fig. 3F-2)

Choke is in the closed position and the throttle in a slightly open position. As the engine is cranked, the entire metering system—idle, intermediate, and nozzle—is subjected to engine suction which is transmitted to the fuel chamber via the metering system.
channels, creating a low pressure on the fuel side of the metering diaphragm. Atmospheric pressure from the atmospheric vent moves the metering diaphragm toward the inlet control lever to allow fuel to enter the carburetor through the inlet needle and seat. The fuel is then forced through the metering system, out into the carburetor mixing passage, and into the manifold and engine. When the engine fires and starts to run, the volume of air drawn through the carburetor increases, and the spring-loaded top half of the choke shutter opens to provide the additional air required by the engine, to prevent an over-rich mixture. The choke can then be moved to a half-open position for engine warm-up.

During hot weather, or after an engine has been run long enough to reach stable operating temperatures, and then shut off for a short period of time, a small amount of fuel vapor may form in the fuel lines or in the fuel chamber of the carburetor. The vapor in the fuel lines will enter the fuel inlet and rise out of the vapor outlet, to be vented back into the fuel tank. The vapor that forms in the fuel chamber must escape through the metering system because there is no other vent to the fuel chamber. Starting a warm engine where vapor may be in the system, is most easily accomplished by placing the choke in the half-closed position, and starting as described above. The choke helps to get the vapor quickly out of the fuel system so that the fuel flowing through the carburetor and fuel line can cool the system to a normal temperature.

Starting is always more easily accomplished using the choke--full choke for a cold engine, and half choke for a warm engine.

**Figure 3F-2. Starting**

**Figure 3F-3. Idle**

**IDLE OPERATION (Fig. 3F-3)**

The throttle shutter is slightly open when the engine is idling and the carburetor mixing passage on the engine side of the throttle shutter is exposed to engine suction, while the mixing passage between the throttle shutter and the air cleaner is at nearly atmospheric pressure. The engine suction is transmitted through the primary idle discharge port to the fuel chamber side of the metering diaphragm via the bypass chamber, idle fuel supply channel, intermediate adjustment channel, nozzle well, main fuel jet, and main fuel supply channel, creating a sub-atmospheric pressure, in the fuel chamber. The metering diaphragm is forced upward by atmospheric pressure, moving the inlet control lever to overcome the inlet compression spring pressure, allowing fuel to enter the fuel chamber through the inlet needle and seat. The fuel flows through the main fuel supply, main fuel jet, nozzle well, intermediate adjustment channel (where it mixes with air from the idle airbleed) idle fuel supply channel, to the bypass chamber, where it mixes with air from the secondary idle discharge ports, and on out into the carburetor mixing passage through the primary idle discharge port. The mixture of well-atomized fuel and air then travels through the manifold and into the engine combustion chamber.

**ACCELERATION (Fig. 3F-4)**

Acceleration is accomplished by the use of a positive-action accelerating pump that is actuated from the throttle shaft by a cam lever. The pump cylinder is filled when the pump is raised to the top of its stroke. Fuel is drawn from the fuel chamber, through the accelerating pump inlet channel, past

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the inlet check valve. The outlet check valve is closed to prevent air from being drawn into the accelerating pump system. As the accelerating pump is depressed, the pressure of the fuel closes the inlet check valve, the fuel flows through the pump channels, past the outlet check valve, through the accelerating pump outlet channel, and through the boost venturi into carburetor mixing passage.

INTERMEDIATE OR CRUISE OPERATION (Fig. 3F-5)

Fuel is delivered into the carburetor as described in idle operation, and the same fuel channels are in use. As the throttle shutter opens to increase engine speed, the secondary idle discharge ports are exposed to engine suction, and fuel is delivered from both the primary and secondary idle discharge ports to supply the additional fuel demanded by the engine. As the throttle shutter is opened farther, the air velocity through the boost venturi increases, creating a low pressure area at the nozzle outlet. Fuel flows from the fuel chamber through the nozzle outlet via the nozzle well, main fuel jet, main fuel supply channel, and economizer valve when the pressure at the nozzle outlet is less than the pressure in the fuel chamber. At the idle and lower intermediate speeds, the check ball in the economizer valve is away from the valve seat, allowing free flow from the fuel chamber through the economizer valve to the nozzle well and nozzle outlet. Fuel flow from the primary and secondary idle ports decreases as fuel flow from the nozzle outlet increases.

HIGH-SPEED OPERATION (Fig. 3F-6)

Fuel flow from the nozzle outlet increases as the shutter is opened past the intermediate position to the fully-open position. The fuel is delivered through the nozzle outlet from the fuel chamber via the main fuel supply channel and the main fuel jet. The increased pressure difference between the small venturi and the metering chamber, plus the force of fuel flowing through the economizer valve, causes the check ball to seat, stopping the flow of fuel from this part of the main metering system. This gives increased economy at high speeds. The diaphragm action and the method of fuel delivery to the fuel chamber is the same as previously described.