PCM®

marine engines

SERVICE MANUAL

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PLEASURECRAFT ENGINE GROUP

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PLEASURECRAFT MARINE ENGINE SERVICE MANUAL

302-351 & 460 FORD BASED ENGINES
305-350 & 454 CHEVROLET BASED ENGINES

INDEX

SERVICE MANUAL — FOREWORD —

The purpose of this manual is to provide a guideline in the testing, diagnosis, repair and overhaul of all parts of the PCM engine and drive train, and to provide the correct specifications, tolerances, and procedures to be used throughout. It is extremely important that this data be used at all times.

The use of special tools and elaborate testing equipment has been held to a minimum throughout this manual, in deference to the lower volume class of servicing operator who may find it difficult to justify the cost of elaborate or sophisticated equipment. However, the use of good testing equipment & special tools is encouraged, since these items will greatly assist in providing top quality service results with the lowest labor expenditure. The manufacturers of such equipment can provide the necessary details involving its use.

The repair of certain items such as alternators, starters, distributors, carburetors, etc., although covered in this manual, can usually be best accomplished by the distributor for the particular item. Prestolite, for example, has distributorships throughout the world who are equipped to deal with any problem which may arise involving Prestolite products. Obviously, the final decision in this regard must depend on individual circumstances.

FUELS: The variety of available motor fuels is rapidly becoming greater, and as a result, many opinions are being formed which are totally, or in part, incorrect. The ideal gasoline for one engine type might totally destroy an engine of another type, and the fuel requirements for two identical engines may be totally different, if the two engines are being used in two different applications.

Since marine engines are generally considered to be in a severe service application, it is important that the manufacturers fuel recommendations be followed. Unleaded fuels should not be used, and fuels of low lead/high phosphorous content should only be used intermittently. Octane ratings of any fuels used should be above the manufacturers recommended minimums.

OILS: Follow carefully all of the oil specifications called out in this manual.

EXHAUST SYSTEMS: Exhaust systems should be designed to provide a minimum of bends and curves. A pitch of ½" per foot of exhaust line is desirable, eliminating all low spots or sags which tend to trap water. The exhaust system should be of adequate size to prevent back pressure. Exhaust system materials and construction should conform to BIA or Marine Underwriters specifications.

PROPELLER SELECTION: Propellers should be chosen which will allow the engine to develop maximum recommended RPMs at wide open throttle with the boat normally loaded. Too much propeller, either in diameter or pitch, will overload the engine and cause premature failures of valves, pistons, rings and bearings, if operated at sustained high throttle settings.

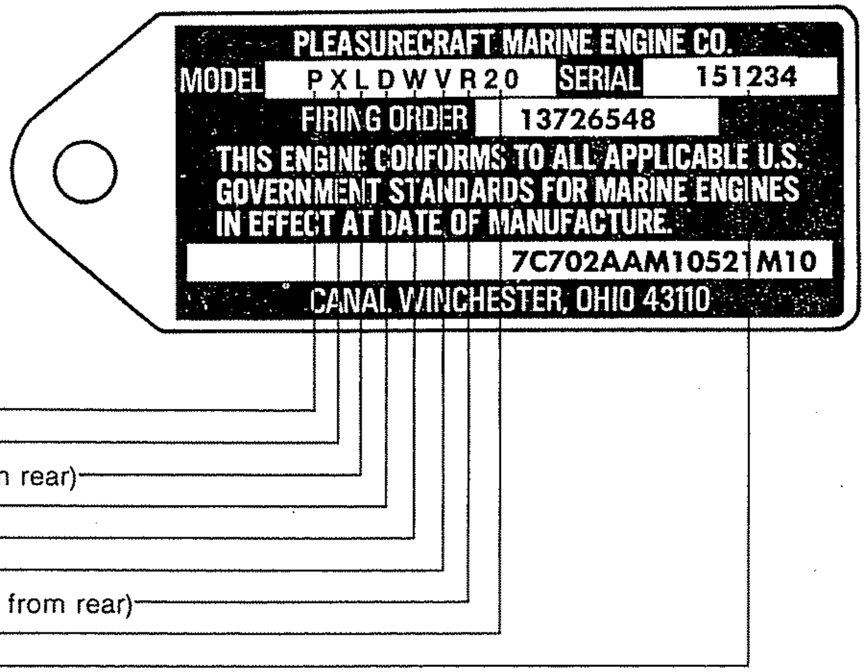
Propellers with too little diameter or pitch will allow the engine to overspeed above recommended R.P.M. limits, and damage to the engine will result.

Operation with damaged or defective propellers will result in damage to the entire drive train. Operation of this nature should be confined to emergency situations only.

MODEL IDENTIFICATION

Before ordering parts, be sure to verify the identification of the Engine and/or Drive from the information on the identification plate which is attached to the Engine, as shown.

Identification Code Breakdown is as follows:



P - PLEASURE CRAFT
X - FRESHWATER COOLED
L - ENGINE ROTATION (Viewed from rear)
D - HORSEPOWER AND TYPE
W - DRIVE MANUFACTURER
V - DRIVE TYPE
R - PROPELLER ROTATION (Viewed from rear)
20 - DRIVE REDUCTION
151234 - ENGINE SERIAL NUMBER

The example shown indicates that the power package is a Pleasurecraft Marine, left-hand rotation, 351 CID - 255 h.p. engine with VEE drive, right-hand propeller rotation, with 2.0 gear reduction. Engine serial number is 151234.

The complete breakdown of the code is as follows:

1st Space P — Manufacturer -
Pleasurecraft Marine

2nd Space X — Factory Freshwater Cooling

3rd Space L — Rotation, Left-Hand from Rear
R — Rotation, Right-Hand from Rear

4th Space D — Engine Type - *
A = 302CID - 155 h.p.
B = 302CID - 185 h.p.
C = 302CID - 215 h.p.
D = 351CID - 255 h.p.
E = 302CID - 165 h.p.
F = 460CID - 350 h.p.
G = 305CID - 240 h.p.
H = 350CID - 280 h.p.
I = 305CID - 230 h.p.
J = 350CID - 270 h.p.
K = 454CID - 350 h.p.
L = 350CID - 300 h.p.
M = 302CID - 175 h.p.

5th Space W — Drive Manufacturer -
W = Warner
D = Dana
J = Jacuzzi
B = Berkley
P = Pleasurecraft

6th Space V — Drive Type -
S = Stern Drive (I/O)
R = Reverse or Reduction Gear
V = Vee Drive
J = Jet Drive

7th Space R — Propeller Shaft Rotation, from rear -
L = Left-Hand Propeller
R = Right-Hand Propeller

8th Space 20 — Drive Gear Ratio or Reduction -
10 = Direct Drive (1:1)
15 = Reduction, (1.52:1)
16 = Reduction, (1.6:1)
18 = Reduction, (1.89:1)
19 = Reduction, (1.91:1)
21 = Reduction, (2.15:1)
25 = Reduction, (2.57:1)
30 = Reduction, (2.91:1)

* NOTE 302 - 351 & 460 CID Engines are Ford Blocks; 305 - 350 & 454 CID Engines are Chevrolet Blocks

SECTION A - ELECTRICAL THEORY - REFRESHER

One of the major problems in marine engine service is the inability to quickly and accurately diagnose the source of a malfunction. This chapter is provided to help create a complete understanding of the whys and hows of electricity, with the feeling that such an understanding will assist in diagnosis of any problem which may occur.

It must be understood and, hopefully, accepted that from a standpoint of electrical engineering or advanced electronics, some of the theory material submitted herein may be technically incorrect. However, the purpose of this chapter is to reduce the material to its absolute simplest form in order to produce an understanding of electricity and its function as it relates to our specific needs. Therefore, these liberties have been taken, only to help create such an understanding in the simplest and briefest manner. To the advanced scholar of electricity and electronics, we beg your forgiveness.

1. ELECTRICITY AND MAGNETISM, TERMS:

1. *ELECTRICITY:* The movement or flow of free electrons through a conductor.
2. *CONDUCTOR:* A material whose molecular structure contains a high percentage of free electrons which can readily flow in either direction.
3. *INSULATOR:* A material whose molecular structure contains a minimum of free electrons whose flow is inhibited.
4. *RECTIFIER (SYMBOL):* A device consisting of a material whose makeup allows electricity to flow in only one direction.
5. *DIODE (SYMBOL):* A form of rectifier, usually referred to as a "solid state" rectifier when grouped, a diode when used singly.
6. *POLARITY:* A term used to describe the direction of flow of electricity, (+ positive) to (− negative) or lines of magnetic force (N. north) to (S. south).
7. *LINES OF MAGNETIC FORCE:* Invisible lines of force flowing from pole to pole of a magnet, or around the outside of a conductor through which electricity is flowing.
8. *MAGNET:* Any one of many devices (or natural substance) which generate a flow of lines of magnetic force, commonly referred to as a magnetic field.
9. *MAGNETIC FIELD:* Lines of magnetic force, controlled in a manner designed to create maximum magnetic tendencies, as in an electro-magnet.
10. *ELECTRO-MAGNET:* A device designed to create at will a strong magnetic field by flowing electricity through a winding placed around a core, and which will instantly lose its magnetic properties when the electrical flow ceases.
11. *WINDING (SYMBOL):* A continuous length of conductive material, usually wire, wrapped in multiple turns around a core. The type of core and the material used depends on the specific purpose of the winding.
12. *VOLT:* A unit of measurement used to determine electrical pressure.
13. *AMPERE:* A unit of measurement used to determine electrical flow.
14. *WATT:* A unit of measurement used to determine electrical volume or usage - Formula: Watts = Amperes X Volts.
15. *KILOVOLT (K.V.):* Volts X 1,000. Normally used to measure ignition coil secondary output.
16. *OHM:* A unit of measurement used to determine the resistance to electrical flow through a circuit.
17. *FARAD:* A unit of measurement used to determine the storage capacity of a condenser or capacitor.
18. *CONDENSER (SYMBOL):* A device used to absorb, and momentarily store, the surge of current induced in the primary winding of the ignition coil during the collapse of the magnetic field.
19. *CAPACITOR (SYMBOL):* A device similar in construction to a condenser used in various electrical circuits to absorb electrical surges and voltage peaks. Normally used to supress radio interference.
20. *RELAY (SYMBOL):* An electrical switch actuated by electromagnetic force and operated from another switch at a remote location. Usually designed to open or close a circuit with high amperage demands to minimize line drop within the circuit.
21. *LINE DROP:* The accumulative resistance within a given electrical circuit, beyond the engineered resistance which is built into the circuit.

22. *SOLENOID:* A device actuated by electromagnetic action which performs a mechanical function, or a combination of mechanical and electrical functions. Normally, operated from another remote mounted switch. Example: A starter solenoid which simultaneously engages the starter drive gear and actuates the starter motor.

23. *REGULATOR (OR VOLTAGE REGULATOR):* A device which senses battery condition and regulates the output of the alternator accordingly.

24. *ALTERNATOR:* A type of generator which produces AC current, which is converted to DC current through the use of rectifiers, which is used to charge the battery.

25. *AC (ALTERNATING CURRENT):* Electric current which alternately flows in both directions within a conductor.

26. *DC (DIRECT CURRENT):* Electric current which flows in a constant direction within a conductor.

27. *PRIMARY CIRCUIT:* A term most commonly used to describe the electrical circuit which carries battery voltage (12V) through the ignition system. Consists of battery, switch, primary resistor, coil, distributor points, condenser and wiring. The circuit is grounded through the distributor base to the engine, and is completed through the ground cable to the ground terminal of the battery.

28. *SECONDARY CIRCUIT:* A term normally used to describe the high voltage circuit of the ignition system, and consists of coil, distributor cap and rotor, spark plug cables, and spark plugs.

2. ELECTRICAL SOURCE

To produce electrical current three basic factors are required:

1. a magnetic field,
2. an electrical conductor,
3. relative movement between the two.

Current produced in this manner is referred to as induced current. The current is induced in the conductor by moving the conductor through the magnetic field, or by moving the magnetic field through the conductor. The strength of the current can be controlled by varying any one, or all three, factors: (1) the speed of the relative movement, (2) the strength of the magnetic field, (3) the size of the conductor.

Obviously, the material chosen for the conductor is also of prime importance.

Two basic sources of magnetic fields are commonly found. (1) a permanent magnet, (2) an electromagnet. Permanent magnets may be found in a natural state, (lodestone), or may be created by magnetizing any one of a selection of different materials which will accept and retain a magnetic charge when exposed to a magnetic field. High quality steel is commonly used. Magnetism occurs within a piece of steel (or other material) when the molecules within that material lose their random pattern and become aligned in the same direction in parallel rows. The simplest way of creating a magnet, and of proving out the magnetic theory, is to place a steel bar on a table with one end pointing directly toward magnetic North, (parallel to the direction of the Earth's magnetic lines of force), raise the South end slightly, and hit the South end a sharp blow with a hammer. The hammer blow will cause the molecules of the steel to align themselves parallel to the length of the bar (parallel to the Earth's field), and the bar has become a weak magnet. Turn the bar to an East-West direction, again hit the end, and the magnetism within the bar will be lost. The existence of magnetism, and the polarity of the magnet, can be proven by placing an ordinary compass near first one end of the bar, and then the other. If magnetism exists, one end of the bar will attract the North pole of the compass needle, and the other end of the bar will attract the South pole of the compass needle. When two magnets are placed in juxtaposition, the opposite poles attract each other, and the like poles repel each other. Therefore, the South pole of the bar will attract the North pole of the needle; and the North pole of the bar will attract the South pole of the needle. If no magnetism exists within the bar, the North seeking needle of the compass will be attracted to all portions of the bar.

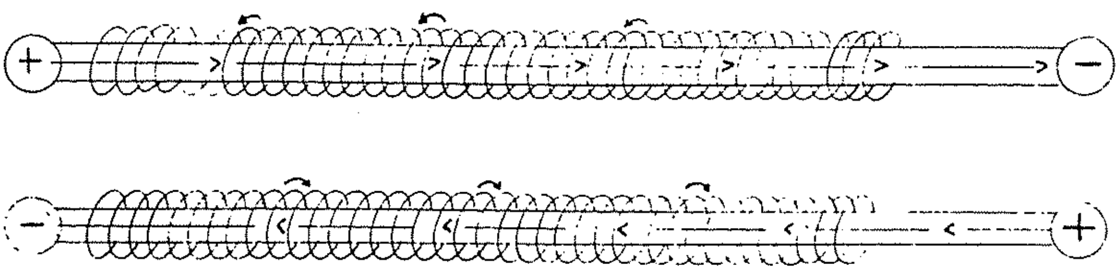


Fig. 1

3. ELECTROMAGNETS

When electrical current is allowed to flow through a straight piece of wire, a magnetic field occurs around the outside of the wire. Try to imagine an invisible coil spring, such as a screen door spring, with a wire passed through the center of it. When the wire is energized by a flow of electrical current, the magnetic field created is similar to the coil of the spring; and the movement of the field resembles the movement of the spring being rotated in a given direction. When the direction of current flow is reversed, the rotation of the field reverses - See Fig. 1.

A field of this nature has little, if any, usefulness. However, if the wire were wrapped around a soft iron core, the "coil spring" pattern would disappear; and a much stronger field would be built up, with the iron core becoming an electromagnet. See Fig. 2.

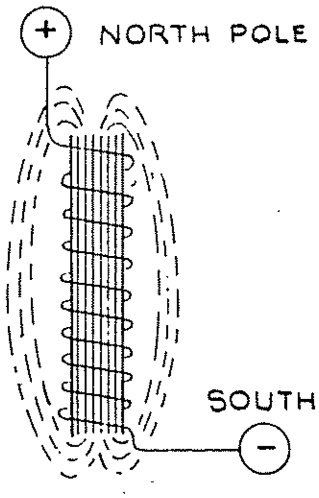


Fig. 2

This occurs, because the core has provided a path for the magnetic force lines to follow, concentrating these lines into a controlled and established pattern. The strength of the field may be increased by increasing the number of turns in the winding, or the amount of current flow through the winding. Soft iron is used as a core, since it provides good conductivity for magnetic force lines, with a low tendency to retain magnetism when the current flow has ceased. A hard steel core would instantly become a permanent magnet. In most instances, the soft iron core consists of thin segments of iron laminated together, or thin rods of iron bundled together, to speed degauzing (loss of magnetism) when the current flow is stopped.

Solenoids and relays are simple forms of electromagnetic devices commonly used on marine engines, but the range and variety of useful electromagnetic devices is almost infinite, including telegraphs, telephones, tape recorders, and computers.

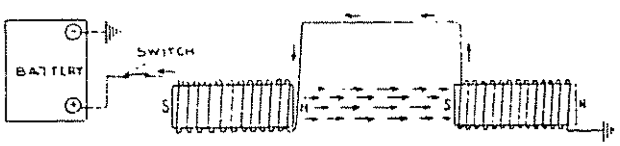


Fig. 3

4. GENERATING ELECTRIC CURRENT

As mentioned earlier, electrical current is induced within a conductor, when the conductor is moved through a magnetic field; or when a magnetic field is allowed to move through a conductor. A simple form of generator can be diagrammed as in Fig. 3 and 4.

Fig. 3 illustrates the circuit used to create a strong magnetic field by placing two electromagnets in opposing positions. When the switch is closed, the battery energizes both field windings, creating a strong flow of magnetic force lines between the N. pole of the left magnet and the S. pole of the right magnet, as indicated by the broken lines. Note that when the switch is closed, the circuit is complete, enabling the current to flow from ground (⫴) through the field windings and the battery, and back to ground. It is readily apparent that removal of either ground will open the circuit and interrupt the flow of current.

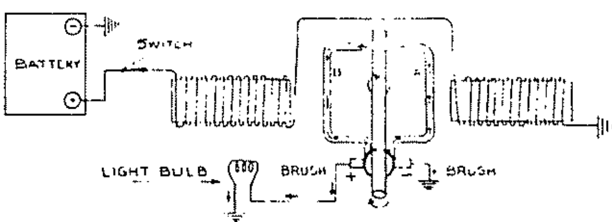


Fig. 4

In Fig. 4, a rotating conductor (*Armature*) has been placed between the field poles. When the rotating armature conductor is slicing through the magnetic field, current is induced within the conductor, flowing from ground through the ground brush, through the conductor to the + brush, through the light bulb and to ground, completing the circuit. The segmented portion of the armature, which contacts the brushes, is called a commutator, and is used to provide DC, maintaining a constant flow direction; even though the actual flow through the conductor reverses with every 180 degrees of rotation. Note that the flow through side A is front to rear, side B is rear to front. When the armature turns 180 degrees, Sides A and B reverse position and the current flow within the conductor reverses direction.

To construct an AC generator, the commutator is replaced by slip rings. See Fig. 5.

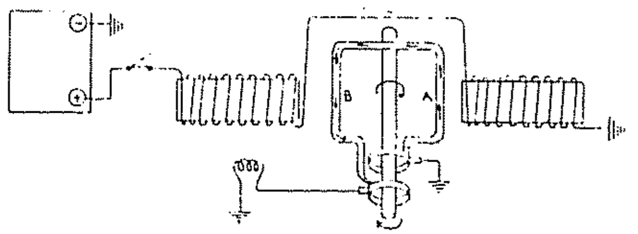


Fig. 5

When the armature has rotated 180 degrees, the flow of current in the conductor bar will have reversed, and will continue to reverse each 180 degrees of rotation.

An alternator is similar in operation and principle to the AC Generator in Fig. 5, except that the magnetic field is created in the revolving member (rotor) and the conductor is in a fixed position around the outer diameter of the rotor. The conductor in an alternator is called the stator. See Fig 6.

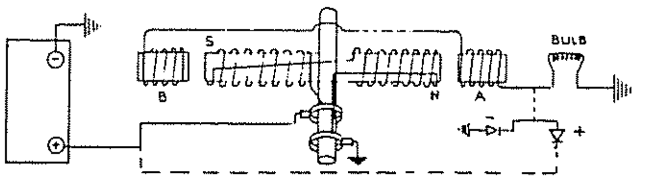


Fig. 6

The rotor field windings are energized through the brushes and slip rings, creating a N and S pole. As the rotor revolves, the direction of current flow in the conductor alternates, due to the N pole of the magnet alternating position between the A and B windings of the conductor. If we were to replace the bulb with a battery, it would be necessary to use a rectifier to convert the AC flow to DC for battery charging purposes - see broken line, diagram, Fig. 6. In this case, the rectifier would consist of a bank of two diodes, ( ), one positive (+) and one negative (−). When the flow through the conductor is − to +, the flow goes through the + diode to the battery. When the flow through the conductor reverses, + to −, the flow goes through the − diode, only to complete the circuit. Flow through a diode is only in the direction of the arrow ( ).

Fig. 7 is a wave form diagram which illustrates the current flow pattern which would be produced by the alternator illustrated in Fig. 6.

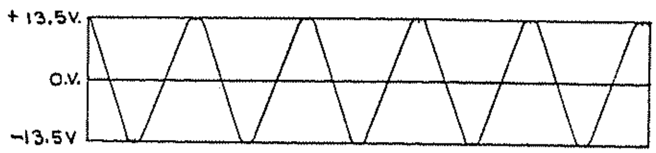


Fig. 7

Note that the top horizontal line of the diagram represents peak + current (flowing − to +), the center line represents zero current, and the bottom horizontal line represents peak − current (flowing + to −).

Assuming peak current is 13.5 volts, and that the AC output is being rectified to DC, it will be noted that the DC flow will be a fluctuating series of widely spaced peaks, since only the portion above the center line can be utilized as DC output. To compensate for this condition, most alternator manufacturers utilize a three-phase alternator, which consists of a stator winding arrangement containing three individual windings, each one of which overlaps the other two. See Fig. 8.

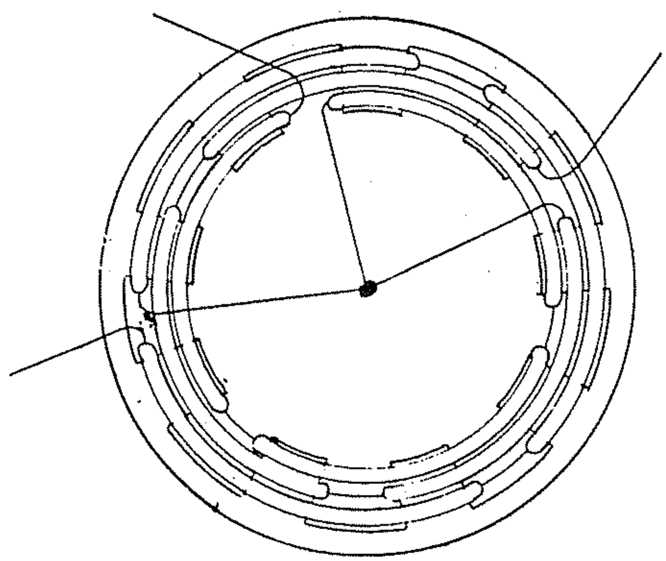


Fig. 8

This provides a much smoother flow of current, with much less voltage fluctuation. The wave form diagram in Fig. 9 illustrates that although each individual winding goes through the full cycle from 13.5V+ to 13.5V−, the rectified current being transmitted to the battery never falls below approximately 7 volts+. See dotted line across intersection of wave form lines, Fig. 9.

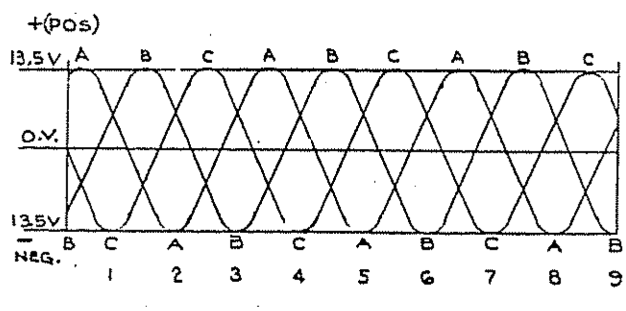


Fig. 9

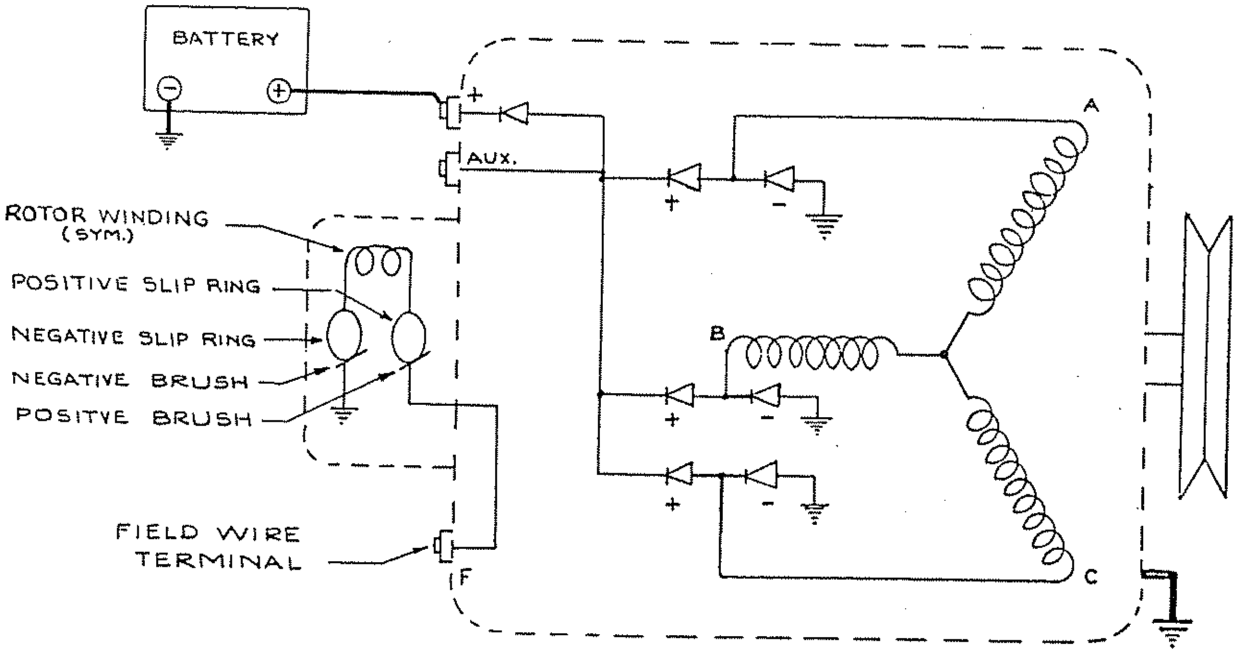


Fig. 9A

Fig. 9A shows the method of rectifying the AC current of the three stator windings, indicated as A, B, & C. Note that this is accomplished by using three positive (+) diodes and three negative (−) diodes. The diode pictured near the output terminal (+) of the alternator is an isolation diode to prevent battery current from flowing through the stator windings when the alternator is not in operation.

The numbers 1 through 9 at the bottom of the wave form diagram represent the changing positions of the rotor as it revolves, and the vertical lines above the numbers indicate the charging action in progress at that particular position of the rotor.

In position 1, both A and B windings are producing + current, A diminishing, and B building up. C winding is producing − current. The current flow from A & B is through the + diodes to the + terminal of the battery, through the battery to ground (—|||·). The circuit is completed by the current flowing from ground through the − diode of C winding, and through the C winding to the common union of the three windings.

In position 2, B & C windings are producing + current, and A is producing − current. The flow is through the + diodes for B & C, to and through the battery and to ground, and the circuit is completed by current flow through the − diode of the A winding to the common union of the windings.

By following the numbered lines across the wave form diagram, one can trace the current flow through any particular circuit of the charging cycle.

5. VOLTAGE REGULATOR

Alternator output is controlled by an external Voltage Regulator. The voltage regulator senses the voltage in the battery and adjusts the charging rate of the alternator accordingly, by supplying more or less current to the field terminal. This terminal supplies the current to the field windings of the rotor, through the positive brush and slip ring, through the field winding, negative slip ring, negative brush and to ground (a complete circuit). The more current supplied to the field winding, the stronger the magnetic field, and the more current produced by the alternator. As the increased alternator output raises battery voltage, the regulator senses it and reduces field current until the correct voltage balance is achieved.

While some voltage regulators can be adjusted, those used on PCM engines are of the sealed solid state variety and cannot be serviced except by replacement.

6. BATTERY

While many different types of batteries exist, the only one of interest herein is the 6-cell, 12V., wet plate storage battery.

This type of battery has a capacity rating expressed in ampere hours: A 70 A.H. battery rating simply stated means that the battery has sufficient plate area to supply 1 ampere of current for 70 hours of operation without recharging.

Heavy duty batteries of 70 A.H. or higher ratings should be used for best results.

BATTERY CONSTRUCTION AND OPERATION:

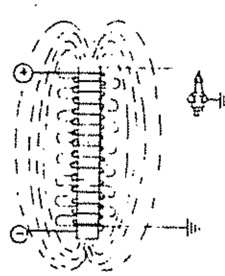
A storage battery does not store electricity. A chemical energy is stored, which, when being consumed, creates DC electrical current. This is accomplished by immersing a series of plates of lead in a solution of sulphuric acid, called electrolyte. Each series of plates comprise a cell which will produce 2 volts. A 12 volt battery consists of 6 cells. The positive plates in each cell are connected together and the cells are interconnected to each other and to the positive terminal of the battery. The negative plates are connected together, the cells interconnected to each other and to the negative terminal of the battery. Separators of wood, fiberglass, or hard rubber are inserted between the negative and positive plates to prevent the plates from touching together. When such a contact does occur, the cell is "shorted" and the battery becomes inoperative. This is the condition commonly called a "dead cell."

When DC current is flowed through the battery from positive (+) to negative (−), the current forces the chemical and molecular structure of the plates to change. The positive plates become lead peroxide and the negative plates become lead sulfate and lead oxide. This chemical change is brought about by forcing a transfer of free electrons from the positive plate to the negative plates. The tendency of these free electrons to flow back to their original position is the source of electrical current. (This is oversimplified. The total chemical action is far more complex.)

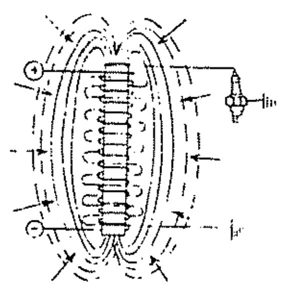
7. IGNITION COIL OPERATION AND CONSTRUCTION

The sole purpose of the ignition coil is to produce an electrical current of sufficient voltage to jump across the gap of a spark plug and create sufficient heat to ignite the fuel charge within the cylinder. Normal voltage requirements for this purpose range from 14,000 to 18,000 volts. In order to produce this high voltage from a source of 12 available volts, it is necessary to utilize an induction coil. This coil consists of a primary winding around a soft iron core, as in Fig. 2 — to create an electro-magnetic field. Another winding, called a secondary winding, is placed over the outside of the primary winding. The secondary winding consists of thousands of turns of extremely fine wire. The high number of turns determines the high voltage output. The small diameter of the wire restricts the amperage output. An electrical shock from this high voltage, low amperage type current, although painful, is rarely dangerous; since the amperage is so low. *CAUTION: ELECTRICAL SHOCK FROM C.D. (CAPACITIVE DISCHARGE) SYSTEMS CAN BE HARMFUL, AND EXPOSURE TO SUCH SHOCK SHOULD BE AVOIDED!!*

Earlier in this text is mentioned the fact that electrical current can be produced by moving a conductor through a magnetic field, as in the case of a generator, or moving a magnetic field through a conductor, as in the case of an alternator. The induction coil utilizes the movement of the magnetic field (established by the energizing of the primary winding) through a conductor (the secondary winding) by intermittently causing this field to build up and collapse. The collapse of the field is caused by interrupting the flow of current through the primary winding. See Figs. 10 and 11.



Field Built Up
Fig. 10A



Field Collapsing
Fig. 10B

Fig. 11 diagrams a complete ignition circuit consisting of battery, switch, coil, breaker points, condenser, and spark plug. When the switch is "on" and the breaker points are closed, the primary circuit is completed, and current is flowing through the primary winding causing the buildup of a magnetic field as in Fig. 10A. When

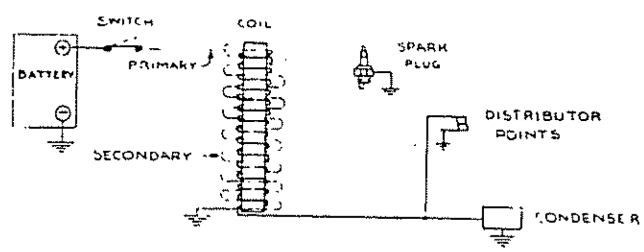


Fig. 11

the breaker points open, current ceases to flow through the primary winding. The field collapses, the lines of force begin to move straight inward toward the core of the coil, and in so doing, pass through the secondary winding of the coil. See Fig. 10B. This movement of the field through the secondary winding induces the secondary voltage buildup. However, the voltage at this point is not sufficiently high to force a spark across the gap of the spark plug. To achieve the desired voltage, the speed of the field collapse must be increased. The condenser takes over this job in the following manner. As the points begin to open, starting the collapse of the field, the movement of the field begins to induce a voltage buildup within the *primary* winding. This increased voltage is absorbed by the condenser, and is stored until the voltage within the condenser becomes higher than the voltage within the primary. Since the points are now open, restricting any current flow in that direction, the condenser must discharge its stored electrical charge back through the primary circuit. This reversal of flow direction causes a great increase in the speed of the field collapse, since the field is trying to reverse itself. The speed increase induces the required voltage within the secondary to cause a spark to jump the spark plug gap and ignite the fuel charge.

8. STARTER MOTOR PRINCIPLE

Starter motors use the principle of magnetic attraction and repulsion to provide the energy necessary to crank the engine. See diagram, Fig. 12.

When the switch is closed, the field windings are energized, creating a magnetic force as shown. The armature windings are also energized through

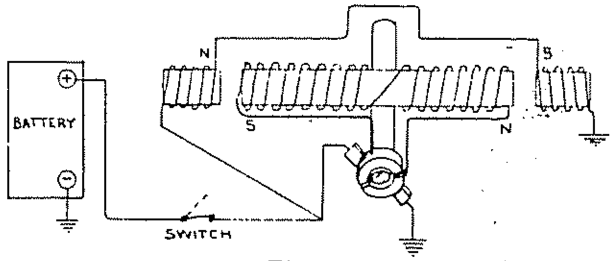


Fig. 12

the brushes and commutator segments, making a strong electromagnet of the armature. As the armature poles are approaching the field poles, a strong magnetic attraction is present between the two, due to unlike polarity of the two electromagnets. The arrangement of the commutator bars is such that as the armature poles become adjacent to the field poles, the brushes contact the opposite commutator bars and the current flow through the armature windings is reversed. This reverses the polarity of the armature electromagnets, and the former magnetic attraction becomes magnetic repulsion, thrusting the armature away from the field poles. (Unlike magnetic poles attract, like magnetic poles repel.) This armature polarity reverses itself each 180 degrees of rotation of the armature, while the field polarity remains constant.

SECTION B — ENGINE ACCESSORIES, TEST & TUNE

CAUTION: System is negative (−) ground. If polarity is reversed, alternator and regulator will be damaged! Do not operate alternator with "A" terminal open!

Test; repair:

1. ALTERNATOR, REGULATOR AND WIRING HARNESS

To most easily test the charging system components, the following equipment will be required:

1. An ammeter equipped with leads with alligator clamps. Leads should be at least 2 ft. long.
2. A 12 volt circuit tracer with probe and ground lead.
3. Two jumper wires of 14 or 16 gauge, 3 ft. long, with alligator clamps on both ends.

PROCEDURE: engine stopped and ignition off.

A. Disconnect positive cable from terminal of battery.

B. Remove wire from the "A" (output) terminal of the alternator. Secure end of wire to prevent it from grounding out.

C. Connect − ammeter lead to "A" terminal, and + ammeter lead to + terminal of starter solenoid (the terminal to which the + battery cable attaches).

D. Re-connect battery cable to + battery terminal, after being certain all clamps, leads, etc., are positioned so as not to short out to ground.

E. Read ammeter: if a reading shows; the isolation diode in the alternator is defective, allowing current to flow through the stator windings. (Replace diode.)

F. If there is no indication of flow into the alternator, start engine, and set idle speed at approximately 1500 RPM — BE CAREFUL THAT ALL WIRES, TEST EQUIPMENT, HANDS, AND CLOTHING ARE CLEAR OF ALL BELTS AND PULLEYS.

G. Observe reading at the ammeter, and note output, if any.

H. Disconnect the wire from the "F" (Field) terminal of the alternator, securing the end to prevent it from grounding out. Connect a jumper wire to the "F" terminal, the other end to the + terminal of the solenoid, and observe ammeter reading. The alternator should now be producing approximately 35 Amps., some variation depending upon the condition of the battery. *(DO NOT GROUND ALTERNATOR "A" — "F" OR "AUX" TERMINALS.) If alternator output is present, as indicated, assume alternator operation is satisfactory. If output is present, but reduced by 1/3 or 2/3, it is reasonable to assume that one or more diodes* *of the rectifier are defective, and alternator repair will be necessary. If no output is present, alternator repair will be necessary.*

REGULATOR CHECK:

If alternator performance has been proven acceptable, stop engine and proceed as follows:

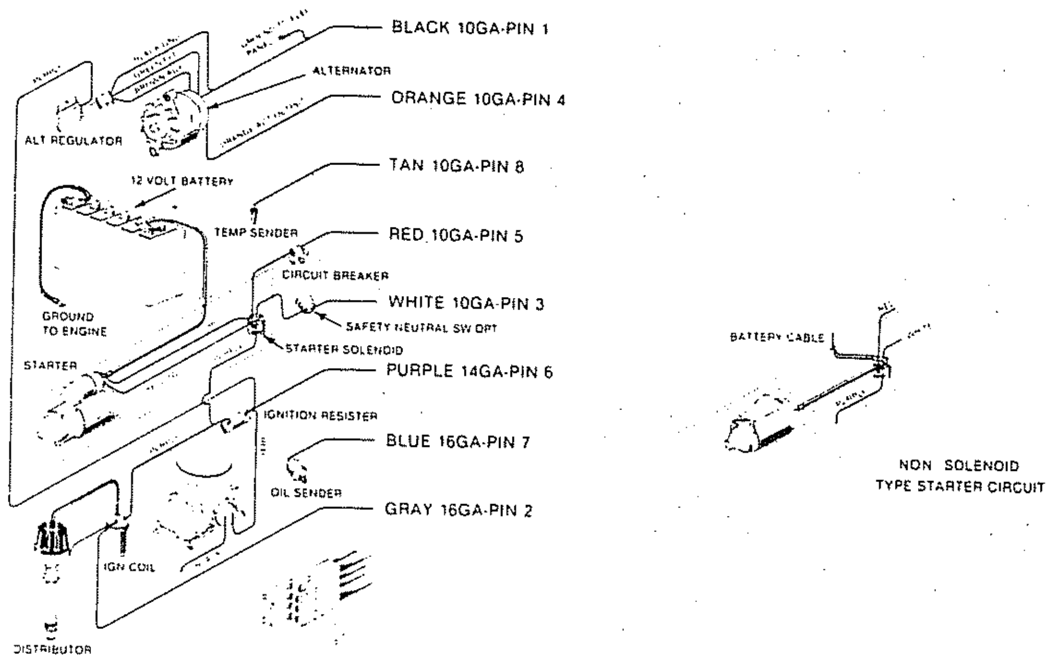
A. Disconnect jumper wire from "F" terminal, and reinstall field wire.

B. Remove coil wire from center of distributor cap, and ground it to prevent open spark. (Unless battery charge is know to be low) Crank engine with starter for 10 seconds to reduce battery charge.

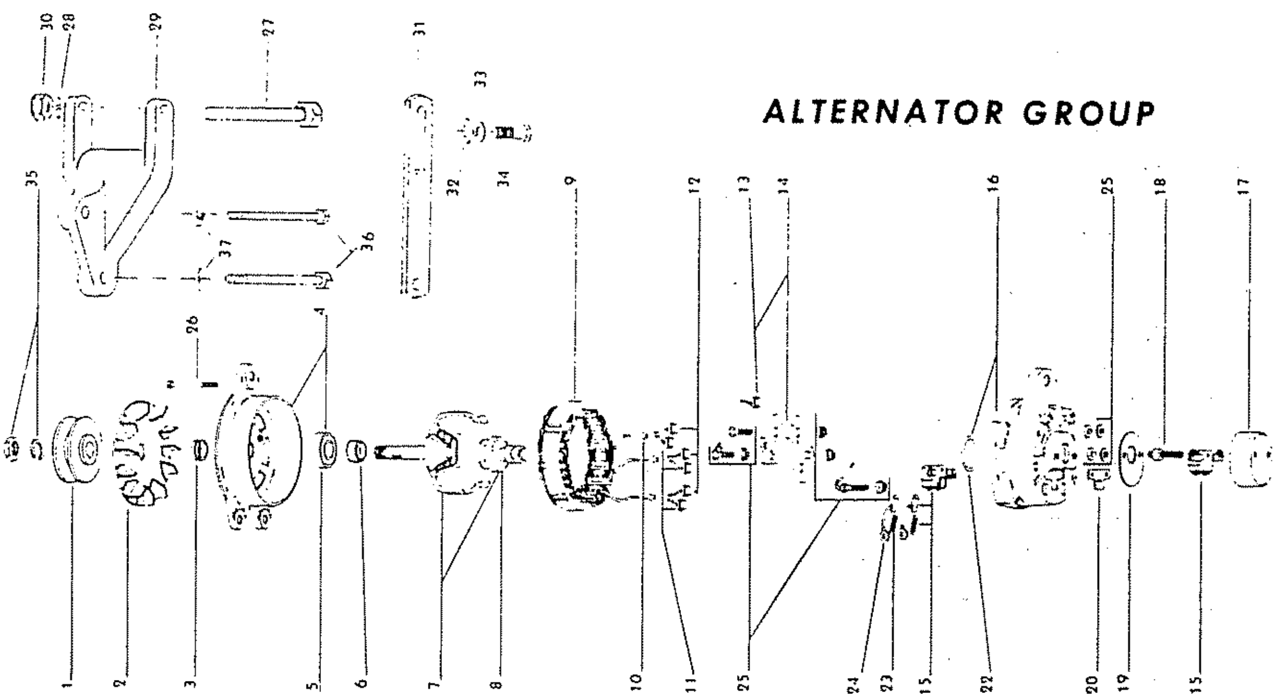
C. With the test ammeter still in place, replace the coil wire and start engine. The test ammeter should show a relatively high charging rate (15 to 20 Amps or more) which should gradually reduce as the battery is restored to normal full charge. If the charge rate follows this pattern and reduces to nearly zero at a voltage of approximately 13.6 to 14.5 volts, regulator function is normal. If any variation from this pattern exists, the regulator should be replaced, and the test repeated. If the repeat test shows a problem still exists, check the wiring harness for broken wires or loose connections.

GENERAL WIRING DIAGRAM

INCLUDING SOLENOID TYPE STARTER CIRCUIT



ALTERNATOR GROUP



2. CARBURETOR AND FUEL PUMP

FUEL PUMP:

The fuel pump used is a marine approved double diaphragm type, equipped with a sight tube as a safety feature. APPEARANCE OF FUEL IN THE TUBE INDICATES A LEAKY DIAPHRAGM, AND THE PUMP SHOULD BE REPAIRED OR REPLACED IMMEDIATELY. Regular visual inspection should be made.

FUEL PUMP TESTING:

The variety of fuel systems and installation variations make it necessary to proceed with caution when testing fuel systems.

Tests should be made using good equipment which may be of the T joint or direct attachment type.

"CAUTION" — Gasoline is a highly explosive fuel and, when vaporized, or in its liquid state, is extremely dangerous. Be sure to observe safe handling practices when making the necessary tests. Do not allow the fuel to spill into the bilges or spray onto or near the engine. Do not smoke or allow stray electrical sparks, or open flames in the area. Be certain the area is well-ventilated and have a good fire extinguisher close at hand.

The PCM Engine fuel system includes the components shown in the fuel pump drawing. The fuel lines supplied by the boat manufacturer or engine installer must be of sufficient size with a minimum of connections, fittings, anti-syphon devices, and check valves.

The fuel flow and pressure requirements must meet, or exceed engine demands for proper engine performance and life. Fuel pump pressure must be checked with a fuel pump pressure gauge and may be checked at the fuel pump or at the carburetor. The pressure should be —

	PSI	PSI
at the pump	5 lbs. min.	6 lbs. max.

Maximum pump pressure that is excessive could be the cause of rich running or flooding.

Minimum pressure below 5 lbs. PSI could cause lean running or cutting out of the engine because of fuel starvation.

If pressure is within specifications, it will then be necessary to check fuel flow. The pump should deliver 1 pint of fuel in approximately 10 seconds @ 600 RPM or at idle speed.

If pump pressure is good, but flow is low, the possibility of a restriction in the fuel system ahead of the pump exists. This restriction may be too small fuel lines for the length, foreign material in the tank, lines, filters, etc., check valves, restrictive fittings, breaks or holes in the fuel pick-up in the tank as well as others.

If pressure and volume are within specs and fuel starvation problems still exist, they must be between the fuel pump and carburetor. See carburetor section for carburetor repairs.

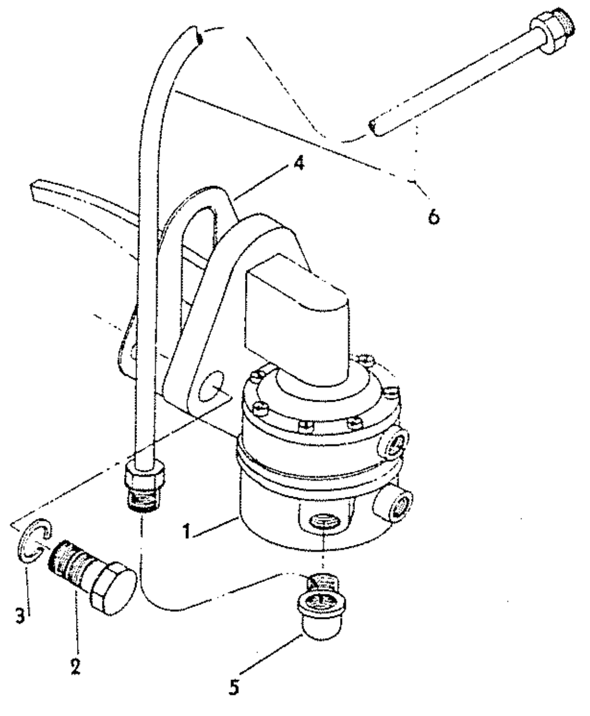
TESTING TIP:

If fuel flow is low and pressure good it sometimes speeds diagnosis time to draw fuel from a container near the fuel pump and bypass the boat fuel system. This will show immediately if the pump is bad or the fuel system restrictive.

FUEL FILTERS:

The remote mounted fuel filter offered by PCM contains a replaceable filter element inside the can. This is readily accessible by loosening retaining screw, removing the outer shell, replacing the filter element, and re-assembling the shell. Care should be exercised not to spill gasoline in the bilges, and after assembly the filter should be inspected for leaks before operating.

Fuel Pump



A second filter is incorporated in the carburetor. Remove the fuel line from the carburetor, and remove the fuel line adapter fitting. This filter can be cleaned with compressed air in an emergency situation, but normally should be replaced if causing trouble. Always check for leaks after replacing or servicing this filter.

OVERHAUL OF CARBURETOR

1. *INTRODUCTION:*

The overhaul procedure can be accomplished with ordinary tools and a reasonable amount of care. Factory approved tools are available to facilitate overhaul and protect parts which might be damaged by ordinary tools. Use of these tools is strongly recommended.

Proper overhaul of a carburetor can be accomplished if the unit is completely disassembled and each part is thoroughly and carefully cleaned. Cleaned parts must be inspected for signs of wear, damage or deterioration. All defective parts must be replaced with genuine replacement parts. The carburetor must be carefully rebuilt and accurately adjusted to insure power, economy and performance.

2. *SPECIAL TOOLS:*

The special tools recommended for overhauling these carburetors will be found at the rear of this section.

3. *MASTER REPAIR KITS:*

The Master Repair Kits contain replacements for parts which are subject to wear and damage. All items should be discarded for which replacements are provided in the Master Repair Kit. The proper Master Repair Kit for these carburetors is listed in the current Parts catalog sheets.

4. *DISASSEMBLY:*

The sections following contain exploded views of the component parts of each carburetor with a list of each part numbered in the order of its removal during disassembly. During disassembly discard all gaskets and all parts which have replacements in the Master Repair Kit.

5. *SPECIAL INSTRUCTIONS:*

Special cautions and instructions are on the pages following the disassembly procedures. These instructions will assist during assembly in avoiding mistakes during reassembly and insure good performance after installation on the engine.

6. *ADJUSTMENTS:*

Some adjustments must be made during assembly while others are made after installation. The particular adjustments for each carburetor model are contained at the end of the overhaul section.

ELECTRICAL SYSTEM

At the connector plug of the engine wiring harness, at the rear of the engine, a short orange wire is provided which connects to the battery cable terminal of the starter solenoid. This wire is provided to shunt the alternator output directly to the battery, if a voltmeter is used in the instrument panel. If an ammeter is used in place of a voltmeter, disconnect the wire from the circuit breaker, and snip it off close to the harness. *It is advisable to cover the snipped-off end with plastic electrical tape to prevent a ground or short circuit from occurring. A voltmeter is recommended to be used in the instrument panel. While this is a slight departure from convention, it provides a three-fold advantage over the traditional ammeter.

* **CAUTION:** *Do not seperate wires which are connected to this terminal they must remain connected together.*

1. By simply turning on the ignition key for a moment, it is possible to tell the charge condition of your battery.
2. By enabling the alternator output to shunt directly to the battery, rather than all the way to the instrument panel and back, there is virtually no current loss or line drop. In installations requiring an unusually long harness, such as houseboats, this is especially desirable.
3. Any overcharging tendency can be readily detected as an abnormally high voltage reading on the voltmeter, and corrections can be made before battery damage occurs.

Batteries tend to discharge when not in use, the rate of discharge varying with the condition of the battery itself and/or the entire electrical system.

When checking the battery condition, a normal average reading is 10 to 11.5 volts, after a reasonable period of disuse. If voltage reading is 10 volts or below, the battery should be charged by either a charging device or operation of the engine. Within one or two minutes after starting the engine, the voltage reading on the meter should begin to slowly rise, and ultimately level off at a reading of 13.5 to 14.5 volts, as the engine continues to operate. If the voltage does not rise after starting the engine, have the charging system checked. If the voltage rises and stays above 15 volts, the charging system should be checked. High voltages can result in battery damage, false instrument readings, and blown bulbs.

Circuit Breaker

The electrical system of all PCM engines is protected by a 40 amp circuit breaker under the electrical panel cover at the rear of the engine. This breaker is designed and assembled to disconnect all systems from the battery should an electrical overload occur.

In the event that all electrical systems are dead push firmly on the red button with the number 40, which protrudes through the electrical cover, until it resets. After the breaker is reset you should be able to start the engine(s).

If the breaker again disconnects or if reseting does not resolve the problem have a qualified marine mechanic inspect the engine(s) to determine the cause of the problem.

Caution: Under no circumstances bypass this breaker. Severe damage to the Electrical system and/or personal danger to the operator and other occupants of the boat could occur.

Battery

Specifications
12 Volt marine type
Tapered post connectors
Ratings for Batteries on Page 4

BATTERY SPECIFICATIONS

DELCO MODEL NO.	APPLICATION	COLD CRANK RATE @ 0°F (-18° C)	AMPS FOR LOAD TEST	25 AMP. RESERVE CAPACITY (MINUTES)
85-5	305 V-8 302 V-8 350 V-8 351 V-8	350 Amps	170	80
89-5	454 V-8	465 Amps	230	125

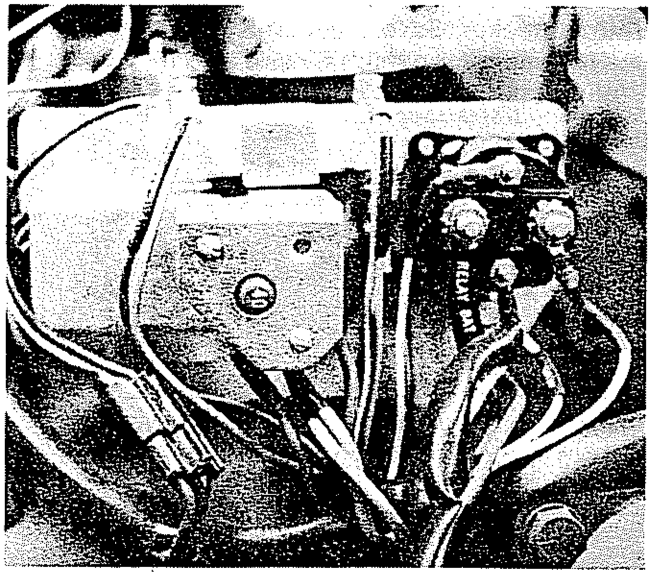


Fig. 22 — Electrical Accessory Bracket

3. IGNITION COIL AND RESISTOR

The coil used is designed for use with an external resistor (Item 4). If a coil is replaced, always be sure to use the exact replacement as supplied by PCM.

The function of the resistor is to control temperatures in the primary winding of the coil during prolonged periods of low speed or idle operation. The resistor must not be bypassed or eliminated, except for brief intervals during testing and diagnosis procedures. Two purple wires of the ignition circuit connect to the two resistor terminals. One is from the ignition switch, and the other to the primary (+) terminal of the coil.

It is essential that these wires connect to opposite terminals of the resistor, and that *no other wires* are installed on the terminal occupied by the coil wire.

Coils being tested for adequate performance should always be pre-warmed to normal operating temperatures before testing.

Resistors with cracked porcelain should always be replaced.

4. DISTRIBUTOR AND SPARK CABLES

ENGINE TIMING AND IGNITION:

PCM engines are equipped with Mallory Orprestolite marine distributors which incorporate a built-in, centrifugally operated, spark advance. Timing on all models should be set according to specifications at idle speed of 600 RPM's or less. The vibration damper on the front of the crankshaft is stamped with the necessary timing marks. The pointer is installed in the timing chain cover on the port side of the engine (approximately 2 o'clock position, facing front of engine).

DO NOT ATTEMPT TO "POWER TIME" ENGINES. Timing must always be set at idle speed, using a timing light. After initial timing has been established, the operation of the automatic advance may be checked by slowly increasing engine speed, and observing the timing change with the timing light. This method only determines that the advance mechanism is functioning. A complete check of the advance curve can be done only by a qualified distributor rebuilding shop, using specialized test equipment. *Total* maximum advance at maximum allowable RPM's should be according to specifications.

Engines must always be retimed after distributor points have been changed or adjusted.

For tune-up data, follow instructions on decal on valve cover, or in owner's manual.

FIRING ORDER — CYLINDER NUMBERING:

Viewing engine from flywheel end, counting front to rear:

	Ford Engine	Chevrolet Engine
Right side	1 - 2 - 3 - 4	2 - 4 - 6 - 8
Left side	5 - 6 - 7 - 8	1 - 3 - 5 - 7

FIRING ORDER — ENGINE ROTATION:

The first digit after the P in the engine model indicates crankshaft rotation, either L or R (Lefthand-Righthand).

A lefthand engine turns clockwise, viewed from the front (pulley) end. (Standard automotive rotation.) A righthand engine turns counter-clockwise viewed from the front (pulley) end.

All engines coupled to stern-drives or jet pumps are L.H. engines.

Warner gear models, or vee-drive models, may have either rotation.

Distributors on all models, regardless of engine rotation, turn counter-clockwise, viewed from the top on Ford engines and clockwise on Chevrolet engines. Firing order for each specific engine is stamped in the Engine Identification Plate which is fastened to the flywheel housing.

Firing orders for various models as follows:

Ford Engines	Chevrolet Engines
185-215-255—L.H. -	All L.H.
1-3-7-2-6-5-4-8 (WLB-WLC-WLD)	1-8-4-3-6-5-7-2
185-215-255—R.H. -	
1-8-4-5-6-2-7-3 (WRB-WRC-WRD)	
155-165—L.H. -	All R.H.
1-5-4-2-6-3-7-8 (WLA-WLE-WRF)	1-2-7-5-6-3-4-8

155-165—R.H. -
1-8-7-3-6-2-4-5 (WRA-WRE-WRF)

DISTRIBUTOR INSTALLATION, ALL MODELS:

Turn crankshaft unit #1 piston is at TDC on the compression stroke. Install distributor so the rotor is pointing straight to the rear, when the distributor is fully seated. (The helical cut of the drive gear will turn the distributor shaft as it is lowered. This must be compensated for when the gears are first starting to mesh.)

#1 spark plug wire will locate in the distributor cap terminal directly above the rear vent screen. Final positioning of the distributor will be accomplished by timing the engine.

NOTE: Do *not* force the distributor into a seated position, since the oil pump drive shaft must index into the lower end of the distributor shaft.

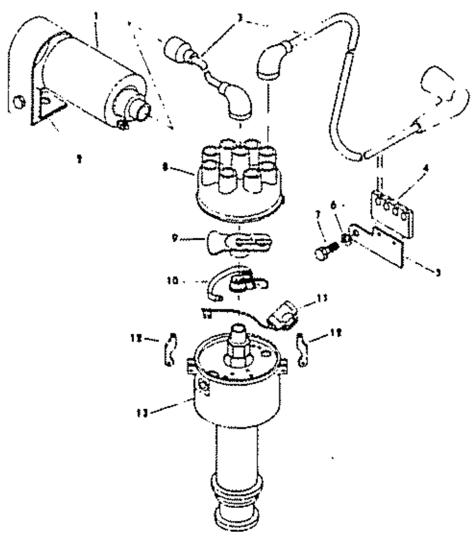


Fig. 23 — Coil and Distributor

PRESTOLITE DISTRIBUTORS (MARINE ENGINES) DESCRIPTION AND OPERATION

The centrifugal advance distributor is a straight mechanical-type unit. A governor-type centrifugal advance is located below the stationary breaker plate (Figure 18). Two centrifugal weights cause the cam to advance or move ahead with respect to the distributor drive shaft the rate of advance is controlled by two calibrated springs.

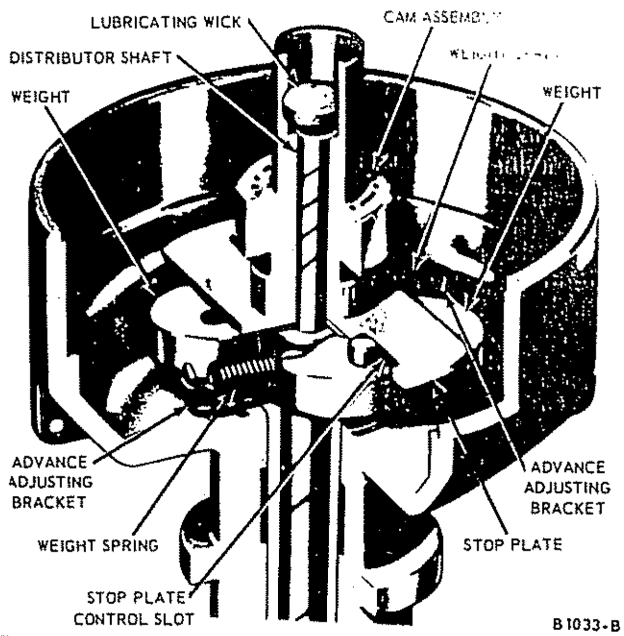


Fig. 18 — Centrifugal Advance Mechanism

ADJUSTMENTS AND REPAIRS BREAKER POINTS AND/OR CONDENSER

CAUTION: *This distributor when assembled is an ignition proofed unit in accordance with U.S. Coast Guard regulations. Use of parts other than approved PCM Replacement parts may destroy this ignition proofing.*

Removal

1. Remove the distributor cap and the rotor. **Be sure to loosen the distributor cap retaining screws before removing the cap.**
2. Disconnect the primary and the condenser wires from breaker point assembly.
3. Remove the breaker point assembly and condenser retaining screws. Lift the breaker point assembly and condenser out of the distributor.

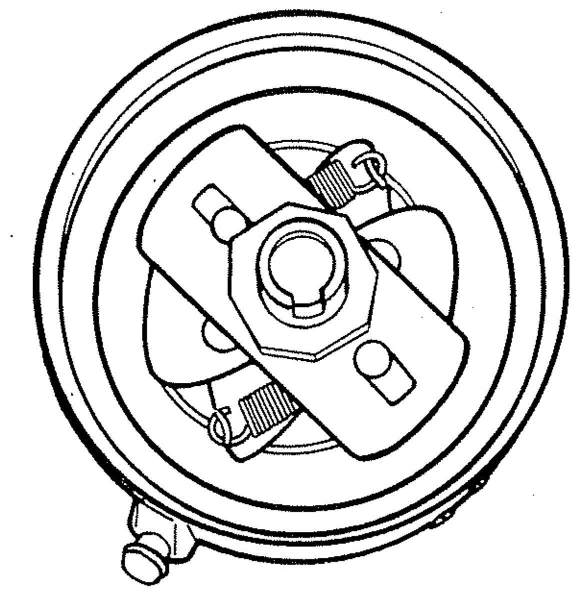


Fig. 19 — Weights, Spring, and Cam Installed.

Installation

1. Place the breaker point assembly and the condenser in position and install the retaining screws.
2. Align and adjust the breaker point assembly.
3. Connect the primary and condenser wires to the breaker point assembly.
4. Install the rotor and the distributor cap.

BREAKER PLATE AND SUB-PLATE

Removal

1. Remove the distributor cap and rotor.
2. Working from the inside of the distributor, pull the primary wire through the opening out of the distributor.
3. Remove the sub-plate attaching screws and lift the assembly from the distributor.

Installation

1. Place the breaker plate assembly in position in the distributor.
2. Install the sub-plate hold down screws.
3. Insert the primary wire in the distributor. Install the breaker points and the condenser. Connect the primary wire and the condenser wire to the breaker point terminal.
4. Install the rotor and the distributor cap.

CAM AND CENTRIFUGAL ADVANCE WEIGHTS

Removal

1. Remove the breaker plate and sub-plate from the distributor.
2. **Mark one of the distributor weight springs and its brackets. Also mark one of the weights and its pivot pin.**
3. Carefully unhook and remove the weight springs.
4. Lift the lubricating wick from the cam assembly. Remove the cam assembly retainer and lift the cam assembly off the distributor shaft. Remove the thrust washer.
5. Lift the weights out of the distributor.

Installation

1. If the weights were removed, fill the grooves in the weight pivot pins with distributor cam lubricant (C4AZ-19D530-A).
   Position the weights in the distributor (**the marked weight is placed on the marked pivot pin**) and install the weight retainers.
2. Place the thrust washer on the shaft.
3. Fill the grooves in the upper portion of the distributor shaft with distributor cam lubricant (C4AZ-19D530-A).
4. Install the cam assembly. **Be sure that the marked spring bracket on the cam assembly is near the marked spring bracket on the stop plate. Place a light film of distributor cam lubricant (C4AZ-19D530-A) on the distributor cam lobes. Install the retainer and the wick. Oil the wick with SAE-10W engine oil.**
5. Install the weight springs. **Be sure that the marked spring is attached to the marked spring brackets.**
6. Install the plate assembly.
7. Install the primary wire in the distributor. Connect the primary and condenser wires to the breaker point terminal.
8. Adjust the breaker point gap or dwell as required.

DISTRIBUTOR

Removal

1. Remove the air cleaner. Disconnect the primary wire from the coil. Remove the distributor cap.
2. Scribe a mark on the distributor body and the cylinder block indicating the position of the body in the block, and scribe another mark on the distributor body indicating the position of the rotor. These marks can be used as guides when installing the distributor in a correctly timed engine.
3. Remove the distributor hold down bolt and clamp. Lift the distributor out of the block.
   Do not rotate the crankshaft while the distributor is removed, or it will be necessary to time the engine.

Installation

1. If the crankshaft was rotated while the distributor was removed from the engine, it will be necessary to time the engine. Rotate the crankshaft until No. 1 piston is on TDC after the compression stroke. Align the TDC mark on the timing pointer with the timing pin on the crankshaft damper. Position the distributor in the block with the rotor at the No. 1 firing position.
   Make sure the oil pump intermediate shaft properly engages the distributor shaft. It may be necessary to crank the engine with the starter, after the distributor drive gear is partially engaged to engage the oil pump intermediate shaft.

   Install but do not tighten, the retaining clamp and bolt. Rotate the distributor to advance the timing to a point where the breaker points are just starting to open. Tighten the clamp.
2. If the crankshaft has not been moved, position the distributor in the block with the rotor aligned with the mark previously scribed on the distributor body and the marks on the distributor body and cylinder block in alignment.

3. Install the distributor cap.
4. Connect the primary wire to the coil.
5. Check the ignition timing with a timing light and adjust to specifications.
6. Install the air cleaner.

MAJOR REPAIR OPERATIONS

To perform the operations in this section, it will be necessary to remove the distributor from the engine and place it in a vise.

BENCH DISASSEMBLY

Refer to Figure 20 for the location of parts.

CONVENTIONAL IGNITION SYSTEM DISTRIBUTOR

1. Remove the rotor.
2. Disconnect the primary wire, the jumper strap, and the condenser wire from the breaker point assemblies.
3. Remove the retaining screws from the breaker point assemblies and condenser. Lift the breaker point assembly and the condenser out of the distributor.
4. Working from the inside of the distributor, pull the primary wire through the opening in the distributor.
5. Remove the breaker point and condenser plate retaining screws and lift the plate out of the distributor.
6. **Mark one of the distributor weight springs and its brackets. Also mark one of the weights and its pivot pin.**
7. **Carefully unhook and remove the weight springs.**
8. **Lift the lubricating wick from the cam assembly. Remove the cam assembly retainer and lift the cam assembly off the distributor shift. Remove the thrust washer.**
9. **Lift the weights out of the distributor.**
10. **If the gear and shaft are to be used again, mark the gear and the shaft so that the pin holes can be easily aligned for assembly.** Remove the gear roll pin and then remove the gear.
11. Remove the shaft collar roll pin.
12. Invert the distributor and place it on a support in a position that will allow the distributor shaft to clear the support plate and press the shaft out of the collar and the distributor housing.
13. Remove the distributor shaft upper bushing.
14. Remove the distributor shaft lower bushing.

BENCH ASSEMBLY

ORIGINAL SHAFT AND GEAR

1. Oil the new upper bushing, and install it on the bushing replacer tool. Then install the upper bushing. When the tool bottoms against the distributor base, the bushing will be installed to the correct depth.
2. Burnish the bushing to the proper size.
3. Invert the distributor and install the lower bushing in a similar manner.
4. Oil the shaft and slide it into the distributor body.
5. Place the collar in position on the shaft and align the holes in the collar and shaft, then install a new pin.
6. Check the shaft end play with a feeler gauge placed between the collar and the base of the distributor. If the end play is not within limits, replace the shaft and gear.
7. Press the gear on the shaft, using the marks made on the gear and shaft as guides to align the pin holes.
8. Remove the distributor from the press. Install the gear retaining pin.
9. Position the distributor in a vise. Fill the grooves in the weight pivot pins with distributor cam lubricant (C4AZ-19D530-A).
10. Position the weights in the distributor (**the marked weight is placed on the marked pivot pin**) and install the weight retainers.
11. Place the thrust washer on the shaft.
12. Fill the grooves in the upper portion of the distributor shaft with distributor cam lubricant (C4AZ-19D530-A).
13. Install the cam assembly. **Be sure that the marked spring bracket on the cam assembly is near the marked spring bracket on the stop plate.**
    Place a light film of distributor cam lubricant (C4AZ-19D530-A) on the distributor cam lobes. Install the retainer and the wick. Saturate the wick with SAE 10W engine oil.
14. Install the weight springs. **Be sure that the marked spring is attached to marked spring brackets.**
15. Place the breaker point and condenser plate in position and install the retaining screws.
16. Working from the inside of the distributor, push the primary wire through the opening in the distributor housing.
17. Place the breaker point assembly and the condenser in position and install the retaining screws.
18. Align and adjust the breaker point assembly.
19. Connect the primary wire and the condenser wire to the breaker point assembly.
20. Install the rotor and the distributor cap.
21. Check and adjust (if necessary) the centrifugal advance mechanism.

NEW SHAFT AND GEAR

The shaft and gear are replaced as an assembly.

One part should not be replaced without replacing the other.

1. Follow steps 1, 2, 3 and 4 under "Installing Original Shaft and Gear Conventional Ignition System Distributor."
2. Insert a .024-inch feeler gauge between the collar and distributor base. Slide the collar on the shaft. While holding the collar in place against the distributor base, drill a 1/8-inch hole through the shaft using the hole in the collar as a pilot. Remove the feeler gauge.
3. Position the gear on the end of the shaft. Install the assembly in a press.
4. With the backing screw on the support tool tightened enough to remove all end play, press the gear on the shaft to the specified distance from the bottom face of the gear to the bottom face of the distributor mounting flange (Figure 14). Drill a 1/8-inch hole through the shaft using the hole in the gear as a pilot.
5. Remove the distributor from the press. Install the collar retaining pin (Figure 6) and the gear retaining pin (Figure 4.)
6. On a conventional ignition system distributor, complete the assembly by following steps 10 through 21 under Original Shaft and Gear Bench Assembly.

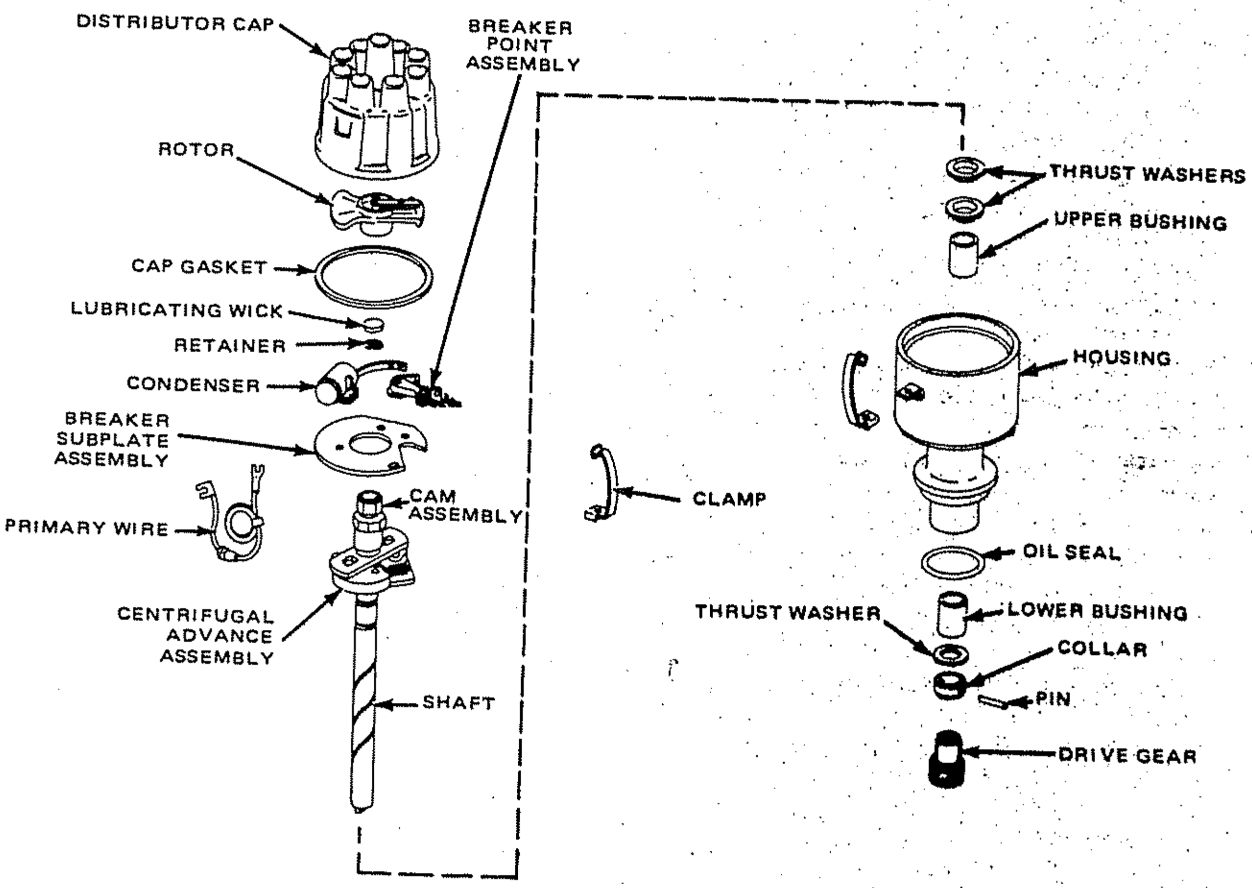


Fig. 20 — Distributor Assembly (Conventional)

5. OIL COOLERS

An engine oil cooler is used on some engines. Oil is taken from, and returned to, a special adapter between the oil filter and the block.

In the event of high oil consumption, this cooler should always be checked for leakage to preclude the possibility of oil being pumped into the cooling water and out through the exhaust system.

Since relatively high pressures are involved (engine oil pressure) a pinhole type of leak can cause rapid loss of oil. Therefore, it is advisable to check the cooler with air pressure of 30 to 35 lbs. PSI, and immerse the cooler in water while under pressure to check for air bubbles which would indicate leakage. Remove the cooler, pressurize either the water passage section or the oil passage section with air, immerse in water, and check for air bubbles escaping from the section which is not pressurized. Defective coolers should be replaced.

Always be certain that oil coolers are completely drained of water during lay-up periods (Fig. 28).

All models using Warner Velvet Drives and Warner Vee Drives are equipped with transmission oil coolers. A 5″ cooler is installed on the 1:1 Velvet Drive, a 9″ cooler on all reduction models except 2.1:1. All Vee Drives (Warner) and Warner Velvet Drive reduction 2.1:1 require 12″ coolers.

If coolers are being replaced, always use a new cooler of equal or greater size than the original.

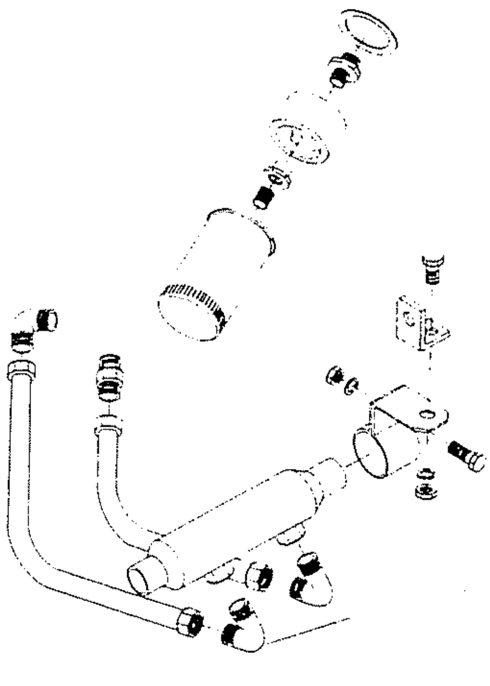


Fig. 24 — Engine Oil Filter and Cooler

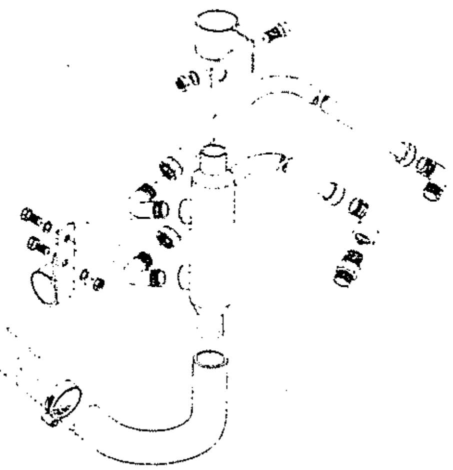


Fig. 25 — Oil Cooler, Warner Gear and Vee Drive

Inspect cooler tubes periodically to be sure the water flow is not restricted by blockage from weeds, shells, or other foreign matter (Fig. 26). A restriction in the water supply to the raw water pump can cause pump cavitation and impeller failure, as well as serious overheating conditions (Fig. 29).

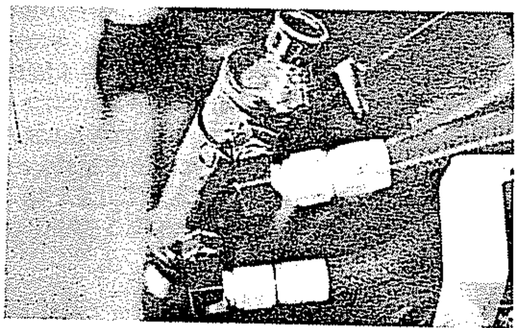
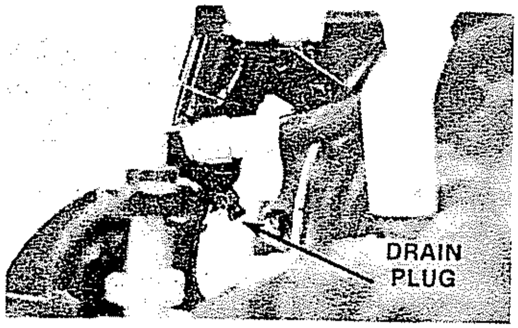
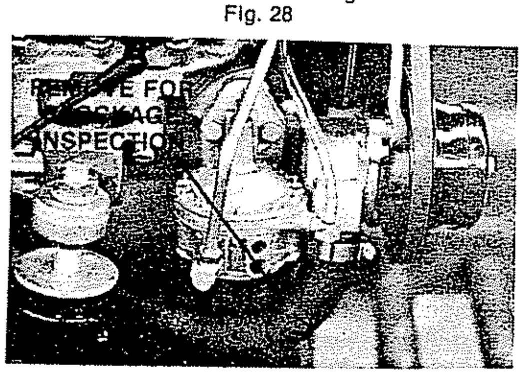


Fig. 26 — Transmission Oil Cooler



Hose or Drain Plug
Fig. 28



Chevy Water Pump
Fig. 29

6. STARTER AND RELAY

The starter relay (Item 7, Figure. 22) is mounted on the electrical accessory bracket at the rear of the intake manifold.

On Ford engines only one of the small terminals is used. Always be sure the wire from the starter switch connects to the left small terminal of the relay, with the relay mounted in the position illustrated.

NOTE: The empty terminal is provided for the installation of a bypass shunt to the coil, if required. A wire connected from this terminal to the + terminal of the coil provides full current to the coil while the starter is actuated, bypassing the primary resistor.

On all models shipped with a Warner Velvet Drive, or Warner Vee Drive, a neutral safety switch is incorporated to prevent starting in gear. This switch interrupts the starter switch circuit except when the shift selector is in *neutral.* Always test this switch if the starter fails to operate.

First, check the shift control linkage adjustment to be sure the shift selector is actually in neutral position, and the safety switch activated. *Leaving the shift selector in neutral,* remove both wires from the switch by removing the two screws which secure the wires. Install both wires on the same screw, and re-install the screw in the switch. If the starter operates, *replace the switch.* DO NOT LEAVE THE WIRES CONNECTED TO THE SAME TERMINAL—*THIS IS A SAFETY DEVICE.*

Check Warner Velvet Drive section 8—Extra Equipment, for assembly instructions.

On models other than those equipped with Warner gears and Vee Drives, always check to determine if there is a neutral start safety feature incorporated (usually in the control system) which may be the cause of an inoperative starter.

Diagnosis steps: (After battery condition is verified as acceptable).

If, when the starter switch is actuated, the starter does nothing (buzz, spin, click, etc.), check all terminals and ground connections relating to the starting circuit.

With ignition "off," disconnect the white starter switch wire from the starter relay, and install a remote starter switch between the relay terminal and the + battery terminal. If the starter functions when the remote switch is closed, check the starter switch and wiring harness for defects.

If the starter fails to operate when the remote switch is closed, connect a temporary jumper cable between the starter terminal and the battery + terminal. *(Connect starter end first. Because of the heavy sparking which may occur when the cable is touched to the battery terminal, be doubly certain there is no fuel vapor present. If the battery is equipped with vented caps, connect the jumper to the + cable terminal of the starter relay. Hydrogen Gas within a battery can explode if exposed to open sparks or flame.)* If the starter operates when the jumper cable is installed, check the relay and/or starter cable for defects.

If the starter does not operate when the jumper is installed, disconnect the jumper cable, and remove the starter for further repairs.

7. COOLING SYSTEM, RAW WATER COOLED MODELS.

The cooling system of all PCM engines provides full circulation of water through the running engine, at all times, even when the thermostat is closed.

Water is introduced into the thermostat housing cover by the raw water pump and is channeled to the intake side of the circulating pump through an internal passage in the thermostat housing. When the engine cooling system is filled with water, a pressure buildup occurs, and forces the raw water through a bypass orifice, out of the thermostat cover, and through hoses to the exhaust manifolds and risers dumping into the exhaust system and overboard. The circulating pump continues to recirculate the water within the engine until proper operating temperature is reached, and the thermostat opens. As soon as the thermostat opens, the pressure within the engine forces hot water to escape into the thermostat housing cover, where it mixes with the bypassed raw water and flows into the manifolds and risers. The water escape reduces pressure within the engine and allows the raw water pump to replace the escaped water. This is an extremely stable, simple, and reliable system with several distinct benefits, among which are:

1. Full volume and velocity at all times enables us to operate at temperatures above those normally used for salt water cooling systems, with better engine efficiency, engine life and less sludge formation.
2. Freedom from hot spots, and steam pockets, which occur in stagnant water systems, eliminating almost entirely the damage which results from heat distortion, warping, and cracks, common to such systems.
3. Lower service requirements and reduced diagnosis time due to simplification.
4. One-system cooling throughout, reducing the possibility of engine damage occurring unnoticed, as in the case of a dual pump, dual system setup.

TROUBLESHOOTING THE COOLING SYSTEM

Three basic types of cooling system problems exist, other than some of the obvious ones such as evident leaks, noisy pump, etc.

1. Overheating,
2. Internal Leaks,
3. External Leaks (not evident).

DIAGNOSTIC STEPS:

OVERHEATING: Be sure that genuine overheating exists before starting disassembly or parts replacement. Too often major repairs are undertaken to correct a problem which does not exist. A faulty water temperature gauge, or sender, or a ground in the circuit will cause an overheat condition to show on the gauge when the engine is *not overheating.* High voltage in the electrical system can also indicate readings higher than normal. Check system voltage.

Once assured that actual overheating is present, check the system methodically, using a step-by-step procedure starting with the water intake. DO NOT ATTEMPT TO START AN OVERHEATED ENGINE. Weeds, paper, leaves, plastic wrappings, etc., can block a water intake completely, but often will float away when the engine is stopped. Re-starting a hot engine under these conditions will almost certainly cause severe engine damage when the water supply is suddenly restored.

On engines which have an engine oil cooler, check the tubes in this cooler for restriction. Weeds, gravel, small shells, etc., can readily block off the cooler tubes.

All models with Warner Velvet Drive gears, or Vee drives have a transmission oil cooler. Always check the tubes of these coolers for obstruction.

Once assured that the intake system is open, remove the rear cover and impeller of the raw water pump, and check for wear or damage. Inspect the slots of the intake opening in the pump body for obstruction. Inspect impeller end surfaces and both wear plates for wear, galling, or burning. Replace any parts showing wear or damage. Be sure all broken pieces are out of the system before restarting engine.

If overheating persists, replace thermostat. Always check tension on the drive belts for both pumps, and adjust as necessary.

Failure of the circulating pump in such a manner as to create overheating is highly unlikely, although possible. As a last resort in overheating cases, remove the circulating pump, and check the impeller for breakage, wear, or looseness on the shaft. Repair or replace as necessary.

A final source of overheating would be an internal restriction within the block, heads, or manifolds, reducing water flow or escape. Stoppage of this nature is extremely unlikely, except in the case of bad castings or in a boat that has been aground or in shallow water and has filled the system with sand.

INTERNAL LEAKS:

If fresh water is leaking into one or more combustion chambers during normal engine operation, it will usually be noticed by the lack of carbon deposits on the piston head and spark plug. Salt water entry will rapidly build up a white or light gray salt deposit on plug and piston head.

In this situation, the big problem is to determine where the water is coming from. The most common source is from a defective exhaust manifold, riser, or riser gasket. These items should always be checked before further disassembly of the engine. The manifold and riser can be pressure tested to some degree. Remove from the engine, stuff the water jacket openings at the exhaust outlet end as tightly as possible with rags, stand the assembly in its normal position, and connect a water hose to the water inlet elbow. Slowly introduce water until pressure build-up is achieved, and watch the exhaust ports for water dripping out. Evidence of water dripping from any one of the exhaust ports indicates internal leakage.

Remove the riser from the manifold, after draining all water from jackets, and inspect visually to determine the source of the leak. If not evident, reassemble the riser and manifold together, using a thin metal plate between two gaskets, to block off the water flow from manifold to riser. Repressurize as before. If no leak is evident, consider the manifold to be sound, and the leak to be in the riser or at the original gasket. Remove the plate, and reassemble the riser to the manifold with a new gasket. If no leak, the problem was in the original gasket; if a leak is present, consider the riser defective and replace it.

Another means of isolating the location of a leak to either the engine or the manifold, when water is readily appearing on the spark plugs, is this:

> Remove the water inlet hose from the manifold and allow the manifold to drain completely. Tightly plug the water inlet elbow of the manifold with a good cork or a wooden plug, and reconnect and tighten the hose. (This will divert all water through the opposite manifold.) Dry the spark plugs and cylinders as well as possible, reinstall the plugs, and *idle* the engine for not more than 30 seconds. Stop the engine, and immediately remove the plugs. If water contamination is still evident, the leak is an internal one; if not, the evidence indicates the leak to be from the manifold, riser, or gasket. (This method can be also used to isolate a leak between two adjacent cylinders or to a given cylinder.)
>
> CAUTION: AFTER THIS TYPE OF TEST, ALLOW THE MANIFOLD AND RISER TO COOL BEFORE INTRODUCING WATER.
>
> If water appears in the two center cylinders of one side and the two end cylinders of the opposite side, check the intake manifolds and gaskets for water leakage into the fuel induction system.

WATER IN CRANKCASE:

If the crankcase oil shows evidence of water, but no evidence of water appears in the combustion chambers, inspect the flywheel housing to be sure that no water has accumulated inside. If water is present inside the flywheel housing, the annular nurling of the Ford crankshaft at the rear main bearing seal can force water into the crankcase.

If no water is present in the flywheel housing, the engine should be removed and suspended on a hoist. Block off the water tubes to the manifolds, remove the oil pan, and pressurize the cooling system to 10-15 lbs. PSI with a water hose. Visually inspect the inside of the block and crankcase for the source of leakage.

NOTE: After inspection of the flywheel housing, before removing engine, the oil and filter should be changed, and the engine operated for a reasonable period of time to positively ascertain the existence of a leak.

EXTERNAL LEAKS (NOT EVIDENT):

The type of leak referred to here is the situation where water appears in the boat while running, but does not accumulate while stopped. Leaks of this nature are not necessarily confined to the engine system, and can be due to the hull working and opening up while underway. However, careful inspection of the exhaust system is always advisable, since this is the most common source of this type of leak.

Stern-drive models may sometimes leak at the transom plate while thrust loads are imposed.

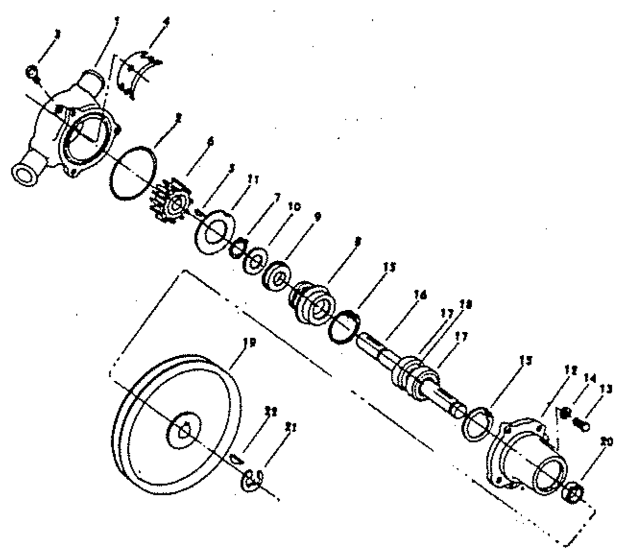


Fig. 38 — Sherwood Raw Water Supply Pump

8. COOLING SYSTEM — FRESH WATER COOLED MODELS

Factory installed fresh water cooling and factory supplied fresh water cooling kits are identical in content and in performance. This is a closed cooling system in which the engine and related parts except the exhaust manifolds and risers are cooled with a solution of permanent anti-freeze, providing better engine efficiency and longer life for the engine and related parts. The system is pressurized to allow higher operating temperatures without coolant loss.

If fresh water kits are being installed on an engine which has been operated on a raw water system, it is advisable to flush the system several times by running with fresh water, draining and refilling. Install a 50% solution of permanent anti-freeze and water after the final flushing. The anti-freeze used should be of high quality containing suitable rust inhibitors and water pump lubricants.

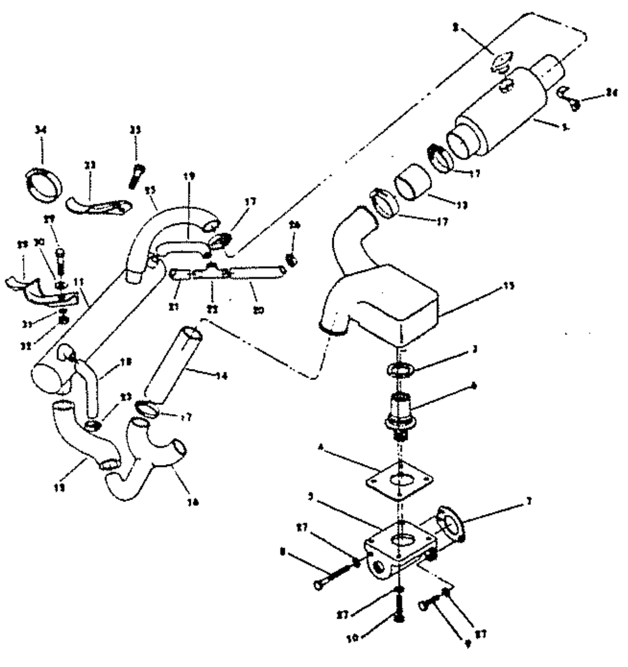


Fig. 41 — Fresh Water Cooling System

Coolant flow through the closed system is much the same as in raw water cooled models, circulating through the engine at full velocity and volume at all times the engine is running. After normal engine temperature is reached, thermostat action allows the heated coolant to flow through the heat exchanger, where it is cooled by the flow of water from the raw water pump. The heat loss from the coolant is transferred to the raw water, which flows through the exhaust manifolds and risers, and overboard through the exhaust system.

Check overheating problems in the same manner as a raw water cooled model, inspecting, in addition, the tubes of the heat exchanger for possible obstruction.

In the event of coolant loss, or evidence of water entry into the engine, it can sometimes be helpful to add a small amount of marker dye (as used with life rafts) to the fresh water cooling system. Evidence of dye in the water found in the engine would indicate an internal leak. Evidence of dye in the water being expelled from the exhaust system would indicate a leak into the raw water section of the heat exchanger.

Oil coolers on the engine, reverse gear or Vee Drive are cooled by raw water, exactly as on raw water cooled models.

9. WATER PUMP, CIRCULATING

Normally, a leaky or otherwise defective circulating pump can be more economically replaced than repaired. ALWAYS REPLACE WITH GENUINE PCM ASSEMBLIES.

Note in the Parts Manual that certain pump components and circulating pump assemblies are designed for specific engine rotation. Always double check engine rotation when ordering replacement pumps or parts.

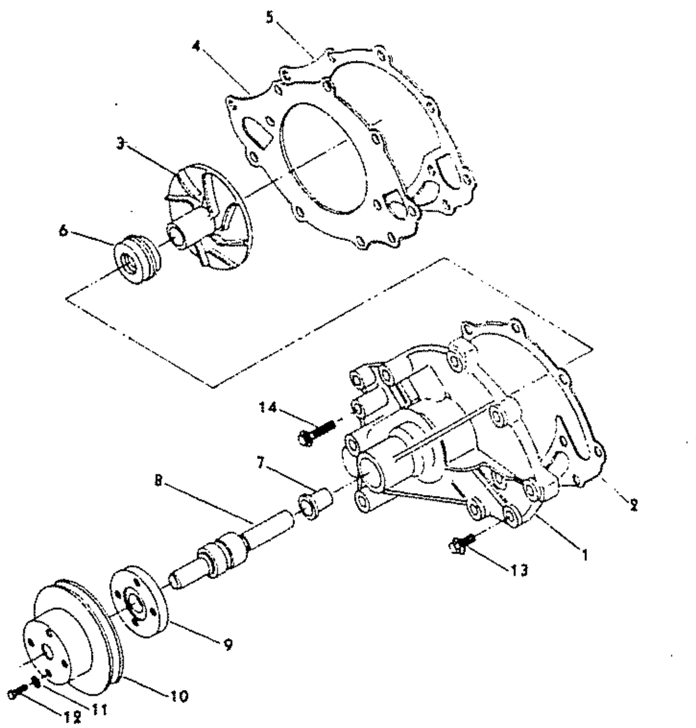


Fig. 42 — Circulating Pump

10. WATER PUMP, RAW WATER SUPPLY

For proper servicing, the raw water pump should be removed from the engine.

Impeller, wear plates, and gaskets may be serviced by simply removing the capscrews which assemble the pump body and components to the bearing housing. Bearing and shaft assembly and seals are replaced by removal of the snap ring and pressing the assembly forward out of the bearing housing. With the shaft assembly removed, pry the seal out of the housing, and press in the new seal. Always replace the O Ring and gaskets when the pump has been disassembled. Check forward and rear wear plates for wear or damage, and replace as necessary.

If the pump is to be filled with anti-freeze solution during lay-up periods, be sure the anti-freeze used does not contain any *petroleum base* rust inhibitors, pump lubricants, or other additives. Impeller swelling and damage will result.

Always check belt condition, tension, and alignment, when servicing the raw water pump. A belt failure can readily damage the engine beyond repair.

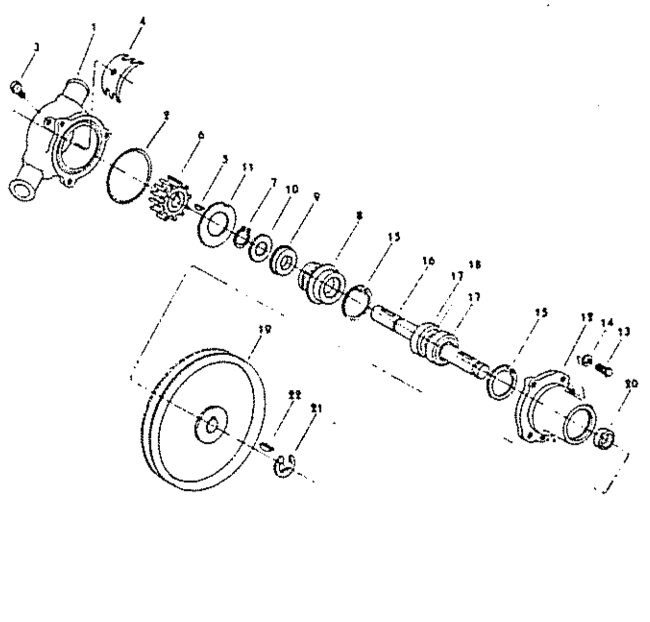


Fig. 43 — Raw Water Supply Pump

11. FLYWHEEL HOUSING, DRIVE DAMPER, FLYWHEEL

With the exception of jet models, power is transmitted from the engine to the drive train through the splined hub of the drive plate and damper assembly which bolts to the flywheel. The hub of this assembly is spring mounted in such a manner as to serve as a damper, smoothing out the variations in load and power, and "lash" action which may develop within the gear train. The damper action is utilized primarily during low speed operation. Low speed rattling or clatter (in gear operation) is usually indicative of rough engine idle performance, and can be usually eliminated by a tuneup to smooth out the engine power flow. If rattle persists, check the damper for broken springs, cracked hub, or worn splines, loose damper mounting bolts, or loose flywheel bolts. Defective dampers cannot be satisfactorily repaired, and should be replaced. If a cracked damper hub is found, check the flywheel runout as described in the engine overhaul section.

If worn splines are detected, check runout as above, and alignment of flywheel housing to flywheel face, as follows:

> Remove drive damper assembly, and re-install flywheel housing tightly, after checking flywheel runout. With a depth micrometer, measure from the drive adapter mounting face of the flywheel housing to the flywheel face at top, bottom, and on both sides. If variation is found, turn the crankshaft 1/4 turn and re-measure to be sure the variation is not in the flywheel face. If the variation is in the flywheel housing, and measurement is more than .010", the flywheel housing should be replaced, after examination of the mounting faces of the flywheel housing, adapter plate, and block face for burrs or nicks.

12. SENDERS, OIL PRESSURE & TEMPERATURE

Engines are shipped with senders installed. These senders are calibrated to the instruments used in the PCM instrument panel, and may or may not be compatible to instruments of other manufacture.

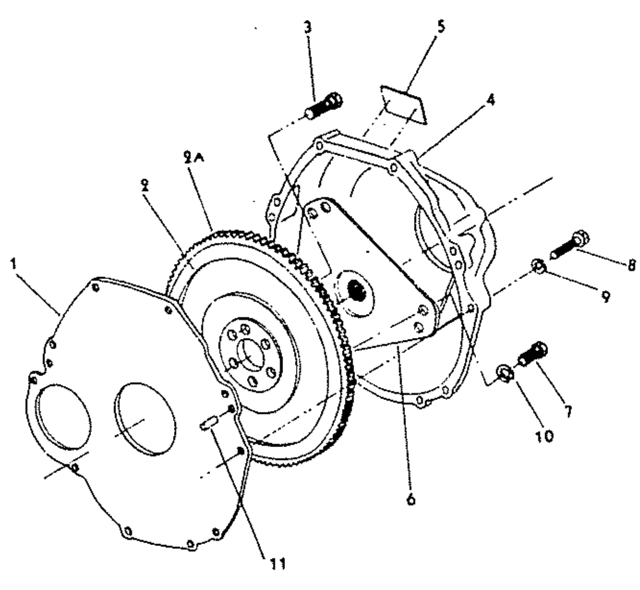


Fig. 44 — Flywheel Group

In checking out sender performance in the case of an instrument which shows no reading, disconnect the wire from the sender terminal, and with ignition "on," touch the wire terminal to a good ground on the engine. If the instrument shows a full reading with the wire terminal grounded, replace the sender. If no reading shows, replace the instrument, after testing the continuity of the instrumentation and wiring harness.

If high readings are encountered, check the instrument ground circuits, and check for high voltage output by the alternator.

If high or low instrument readings cannot be corrected, check for compatibility between the senders and the instruments in use. (Replace of *incompatible* senders will not be considered a warranty responsibility.)

Senders should always be installed with electrically conducive sealer on the threads.

PCM
marine engines

HOLLEY CARBURETOR REPAIR & DIAGNOSTIC PROCEDURES

TABLE OF CONTENTS

HOLLEY TWO-BARREL CARBURETORS — MODEL 2300

HOLLEY FOUR-BARREL CARBURETORS — MODELS 4150 AND 4160

HOLLEY TWO-BARREL CARBURETOR — MODEL 2300

DESCRIPTION

Four main assemblies make up the Holley 2300 two-barrel carburetor. They are: main body, metering block, fuel bowl, and throttle body (Fig. 1).

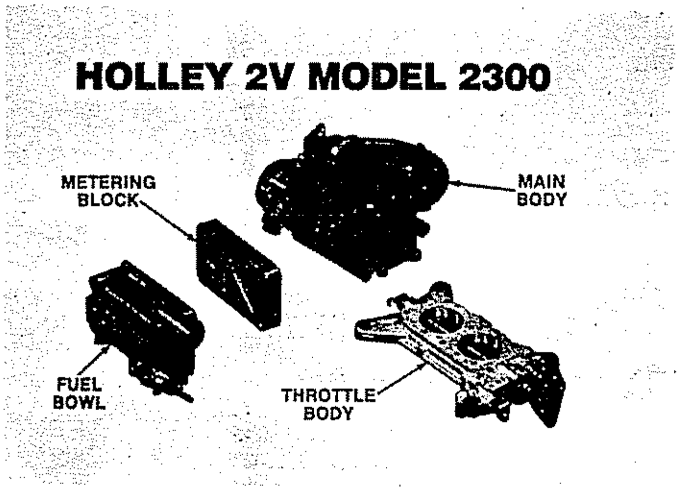


FIG. 1 — MODEL 2300-C TWO-BARREL CARBURETOR ASSEMBLIES

There are two areas of identification on the Holley Model 2300 two-barrel carburetor. An identification tag is connected to the electric choke assembly and an identification number is stamped on the carburetor air horn (Fig. 2). Do not remove the identification tag from the choke for any reason. Together with the air horn number, they identify the carburetor with a specific engine usage. They are used in finding specifications for carburetor adjustments and in ordering replacement parts.

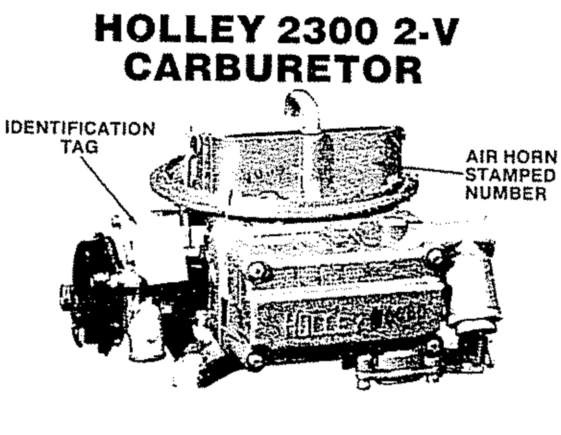


FIG. 2 — MODEL 2300 CARBURETOR IDENTIFICATION

The air horn assembly is part of the main body. On top of the air horn is the choke plate, and below the choke plate are the primary and booster venturis. Within the venturis are the main and accelerating pump discharge nozzles. On the side of the main body is the electric choke assembly (Fig. 3).

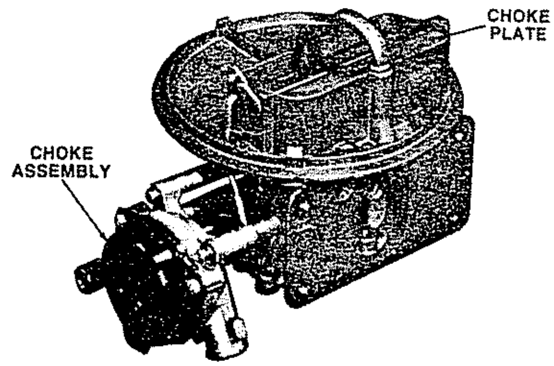


FIG. 3 — MODEL 2300 MAIN BODY

Found below the main body is a separate assembly called the throttle body. Located inside the throttle body are the throttle plates and throttle shaft. The throttle lever is connected to the throttle shaft. Connected to the throttle body is the accelerating pump operating lever and the idle speed adjustment screw (Fig. 4).

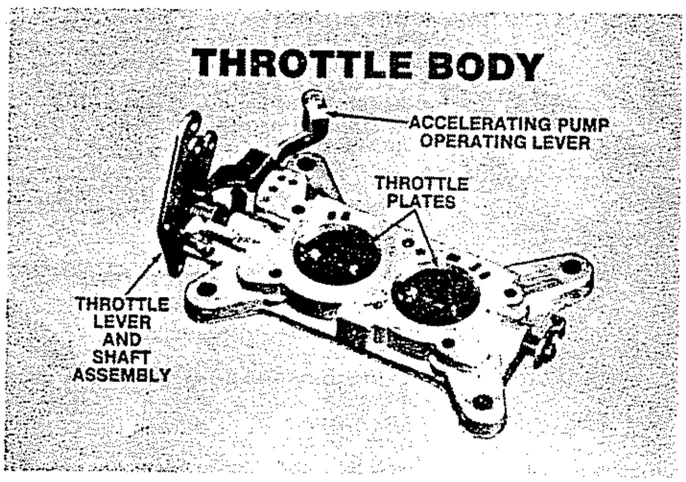


FIG. 4 — MODEL 2300 THROTTLE BODY

The metering block is connected to the side of the main body. Inside the metering block are the main jets, the power valve, and the various fuel and air passages and restrictions. The idle mixture adjusting screws are found on the side of the metering block (Fig. 5).

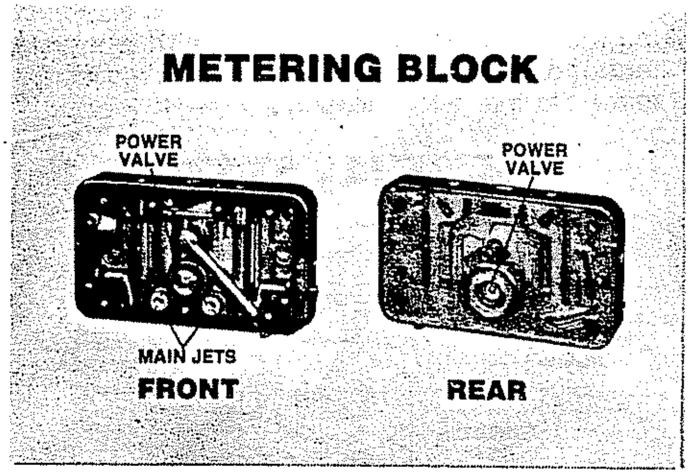


FIG. 5 — MODEL 2300 METERING BLOCK

Connected to the metering block on the main body is the fuel bowl assembly (Fig. 6). Inside the fuel bowl are the fuel inlet screen, fuel inlet needle and seat assembly, float and lever assembly, and accelerating pump. Found on some models are a sight plug and an adjusting nut for the float level.

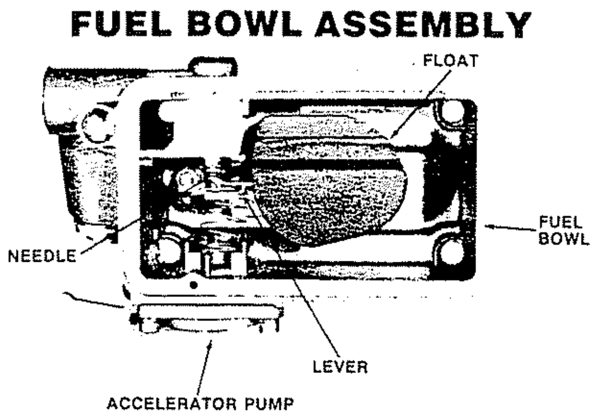


FIG. 6 — MODEL 2300 FUEL BOWL ASSEMBLY

CARBURETOR SYSTEMS

The Holley Model 2300 two-barrel carburetor uses four systems to provide carburetion.. Together these four systems vaporize and meter fuel into the proper air/fuel mixture for every mode of engine operation. The four systems are: idle, accelerating pump, main metering and power system. Two other systems, fuel inlet and choke, supplement these systems.

The two-barrel system can be thought of as two carburetors working for the same purpose. Each barrel can be thought of as a single carburetor by itself. Each system works identical to its counterpart in the other barrel.

The idle system provides a reasonably rich mixture for smooth engine idling speed and a transfer system that is in operation during low speeds. The main metering system provides the proper mixture for normal cruising conditions. The accelerator pump system mechanically supplies additional fuel during acceleration. The power enrichment system provides a richer mixture when high power output is desired. Each of these systems is constantly supplied with fuel by the fuel inlet system.

A choke system provides a rich mixture to start the engine when cold and a slightly richer than normal mixture for cold engine operation. The 2300 carburetor is equipped with an electrically heated automatic choke.

FUEL INLET SYSTEM

All fuel enters the fuel inlet through pressure supplied by the fuel pump. Fuel passes from the fuel inlet through the filter screen, past the needle and seat assembly, and into the fuel bowl. As the fuel level in the fuel bowl rises, so does the float assembly. But as the float rises it tends to close the needle and seat assembly, restricting the amount of fuel flowing into the fuel bowl. As the fuel is used, the float drops and the needle valve leaves the seat, allowing more fuel to enter the fuel bowl, but only enough fuel to raise the float to its proper level. A bumper spring is placed under the float hinge to stabilize the movement of the float assembly. The fuel bowl is vented internally through the vent tube (Fig. 7).

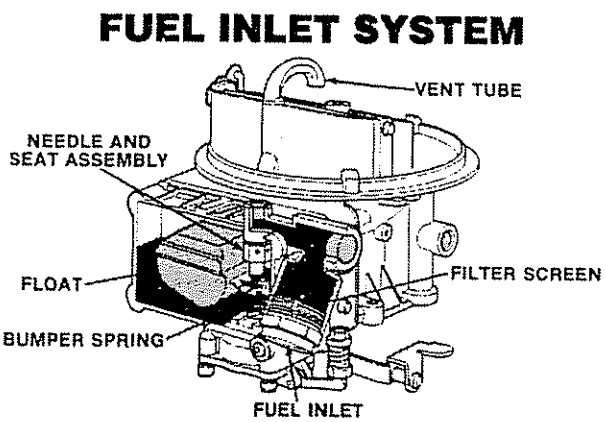


FIG. 7 — MODEL 2300 FUEL INLET SYSTEM

IDLE FUEL SYSTEM

From the fuel bowl, fuel flows through the main jet into a small, angular, horizontal idle feed passage that leads to a vertical idle well passage (Fig. 8). Flowing up this idle well passage, fuel passes through the idle feed restriction. After this passage, the fuel flows through another horizontal passage and at the end of this passage is mixed with incoming air from the idle air bleed. The air/fuel mixture then flows down another vertical passage to the bottom of the main body, where it splits into two directions. One direction goes to the idle discharge passage, the other to the idle transfer passage and constant feed port (Fig. 8). The mixture flowing down the passages leading to the idle discharge passage flows past the pointed tip of the idle mixture adjustment needle screw. From here, the air/fuel mixture goes down a short passage in the main body and down another passage into the throttle body, where it is discharged in the throttle bore below the closed throttle plate. In the passages leading to the idle transfer passage and constant feed port, the air/fuel mixture flows unrestricted. The mixture exits through the idle constant feed port. When the throttle plate is closed, no fuel is discharged through the idle transfer slot. At this point the function of the transfer slot is to act as an air bleed directly above the idle constant feed port and to further lean out the air/fuel mixture.

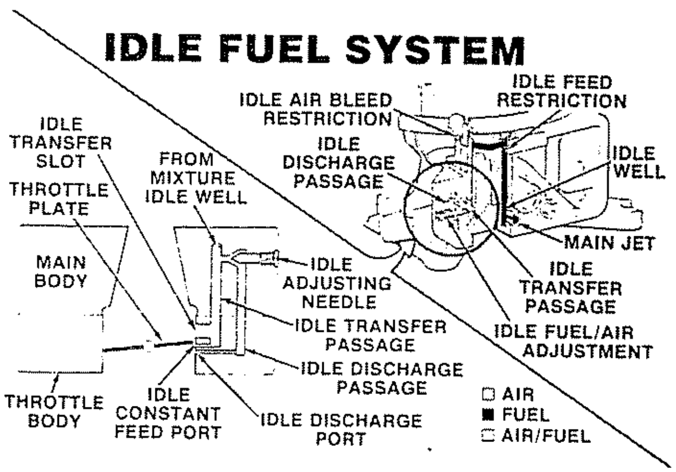


FIG. 8 — MODEL 2300 IDLE FUEL SYSTEM

As more engine speed is desired, the movement of the accelerator linkage causes the throttle plate to open. When the throttle plate is opening, the idle transfer slot is exposed to manifold vacuum, causing fuel to be discharged from the transfer slot. As the throttle plate opens more, engine speed increases, thus increasing the air flow through the carburetor. The air flow is increased further by the effect of the venturi. With the resulting increases in air flow, the main metering system comes into operation with idle system tapering off. Thus a smooth, gradual transition is made from idle to operating speeds (Fig. 9).

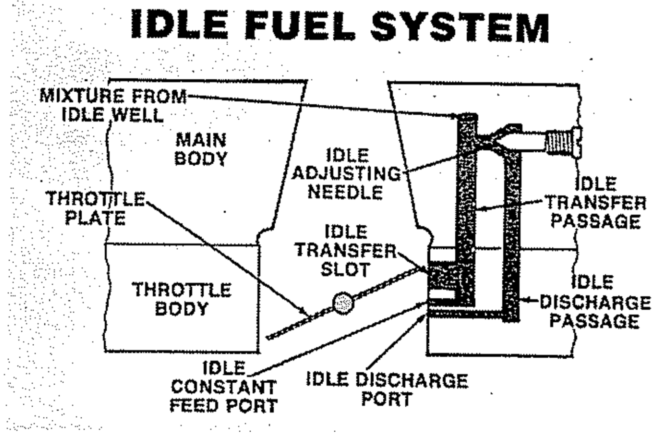


FIG. 9 — MODEL 2300 IDLE FUEL SYSTEM — TRANSFER

MAIN METERING SYSTEM

In the main metering system (Fig. 10), with the throttle partly opened, fuel flows from the fuel bowl through the main jet. The main jet meters the fuel into the main well. From the main well, fuel flows past the main well air bleeds, where it becomes mixed with air. The air/fuel mixture continues up the main well, passing through horizontal passages in the body, and exiting through a horizontal channel to the discharge nozzle in the booster venturi. The air/fuel mixture is now mixed with the incoming air.

Filtered air enters through the high speed air bleed in the air horn of the main body, and then enters the main metering body through interconnecting passages. Because the air/fuel mixture is lighter than liquid fuel, it responds faster to changes in venturi vacuum and vaporizes more easily when discharged into the airstream. The amount of air/fuel mixture flowing to the intake manifold is regulated by the throttle plate position, which also regulates the engine speed and power output.

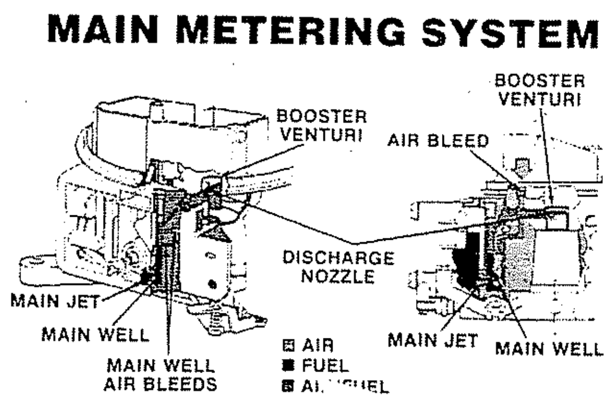


FIG. 10 — MODEL 2300 MAIN METERING SYSTEM

POWER FUEL SYSTEM

During high power operation, the increased air flow down the air horn tends to lean out the air/fuel mixture. Additional fuel is required to enrich the air/fuel mixture. The needed additional fuel is supplied by the power fuel system, which is regulated by manifold vacuum. Vacuum to actuate the power valve, found in the metering block, is supplied through passages in the throttle body and main body (Fig. 11). At idle speed or under normal load, the vacuum supplied to the power valve is sufficient to overcome the spring pressure acting on the power valve diaphragm; thus the vacuum holds the power valve closed. At high speed operation, manifold vacuum drops; thus the spring in the power valve forces the valve to open, allowing fuel to flow. The path of the fuel is through the power valve, then through the diagonal restrictions in the metering block, and finally into the main well, where it joins the main fuel flow and enriches the mixture.

When engine speed is reduced, manifold vacuum once again increases. This vacuum acts on the power valve diaphragm to overcome spring pressure. The power valve then shuts off the added supply of fuel which is no longer required.

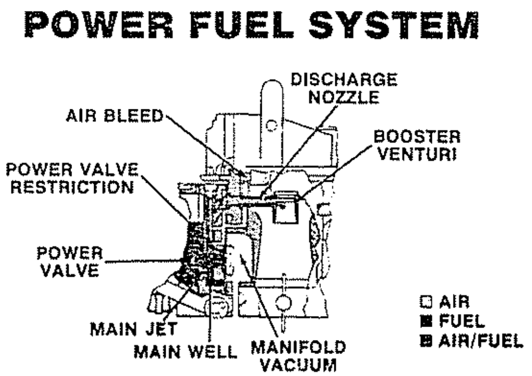


FIG. 11 — MODEL 2300 POWER FUEL SYSTEM

ACCELERATING PUMP SYSTEM

When the throttle plates are opened suddenly as during quick acceleration, the air flow down the venturi responds almost immediately and is rapidly increased. Fuel responds more slowly to this increased air flow since it is heavier than air. This difference in response must be compensated for or a too-lean mixture would result and the engine would hesitate. The accelerating pump system corrects this problem. It mechanically supplies fuel until the other metering systems are able to supply enough fuel to maintain a proper mixture.

The accelerating pump is a diaphragm-type pump which is located in the bottom of the fuel bowl (Fig. 12). When the throttle is opened, the pump linkage is actuated by a cam on the throttle lever, and forces the pump diaphragm upward. When the diaphragm moves up, fuel pressure forces the pump inlet check ball, or valve, onto its seat, preventing fuel flow back into the fuel bowl. The diaphragm pressure also forces fuel through a short passage in the fuel bowl, and into the long, diagonal passage in the metering body. It then flows into the main body passage to the pump discharged chamber. Fuel pressure causes the discharge needle to unseat and fuel is discharged into the venturi.

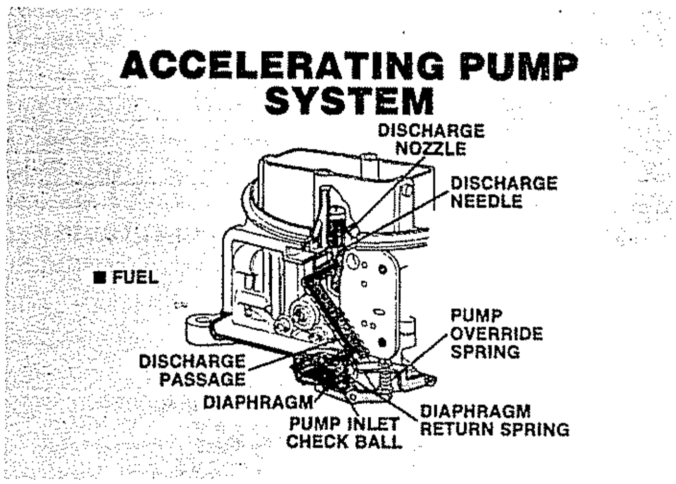


FIG. 12 — MODEL 2300 ACCELERATING PUMP SYSTEM

When the accelerator is moved rapidly the throttle plates go to the wide-open position, the pump override spring is compressed and allows the full pump travel, by applying pressure to maintain the pump discharge. Without this pump override spring, the pump linkage would be bent or broken because fuel, being a liquid, is essentially incompressible.

As the throttle moves to the closed position, the accelerating pump linkage returns to its original position and the diaphragm return spring pulls the diaphragm back to its original position. The pump inlet check ball is again unseated and fuel flows from the fuel bowl into the accelerating pump chamber.

ADJUSTMENTS

FLOAT OR FUEL LEVEL ADJUSTMENTS

Float or fuel level adjustments are of two types — dry and wet. The dry adjustment is made with the float bowl cover removed from the main body. It is performed on the internally adjusted float models as well as the externally adjusted float models.

With the wet adjustment, the fuel bowl cover is not removed from the carburetor assembly. It is performed on the externally adjusted float models only.

DRY ADJUSTMENT — EXTERNALLY ADJUSTED FLOAT

The dry level adjustment on the externally adjusted float model is basically a preliminary adjustment only. The wet level adjustment is the final adjustment. (This final adjustment must be performed with the carburetor installed on the intake manifold.)

To perform the dry level adjustment on the externally adjusted float model, remove the fuel bowl and float assembly from the carburetor main body (Fig. 13). (If the carburetor is installed on the intake manifold, place a pan or container under the carburetor to catch fuel that spills out. Be careful not to spill fuel on a hot engine or a fire may result.) Loosen the lock screw, invert the fuel bowl, and turn the fuel level adjusting nut until the float is parallel with the floor of the bowl. Reinstall the bowl.

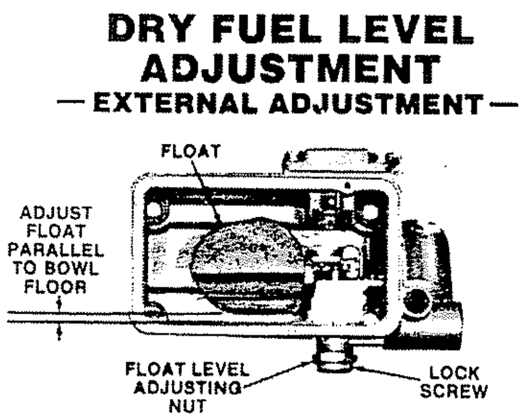


FIG. 13 — MODEL 2300 DRY ADJUSTMENT — EXTERNALLY ADJUSTED FLOAT

NOTE: When installing the fuel bowl cover assembly, the gasket must be installed properly. The accelerating pump passage is at the lower right of the metering block. The gasket must be installed with the hole over this passage to prevent blocking the passage.

WET ADJUSTMENT — EXTERNALLY ADJUSTED FLOAT

On externally adjusted carburetors, the wet float or fuel level adjustment is the final float or fuel level adjustment. The fuel system must be working properly, and the fuel pump pressure and volume must be up to specifications, before the final adjustment is to be made. The engine is to be run on a level surface so as not to affect the fuel level.

Start the engine and run it 5-10 minutes at a fast idle or until normal operating temperature is reached. Stop the engine. Place a container under the fuel bowl cover sight plug. The sight plug is found on the side of the fuel bowl. Remove the sight plug (Fig. 14). No fuel should run out and the fuel level should be up to the bottom of the sight hole. This is the correct fuel level.

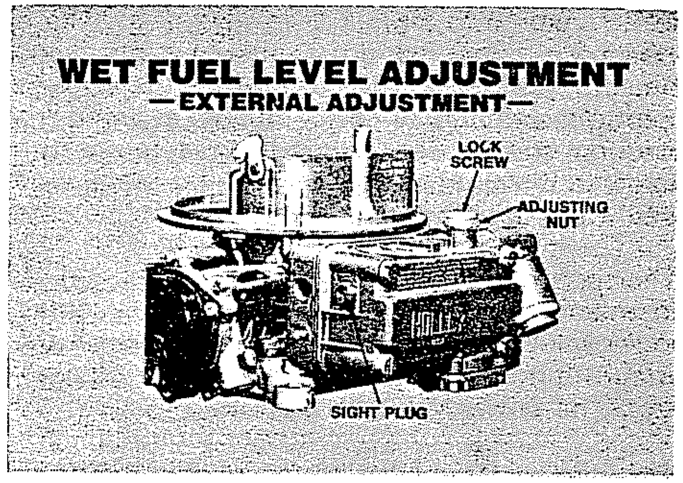


FIG. 14 — MODEL 2300 WET ADJUSTMENT-EXTERNALLY ADJUSTED FLOAT

If the fuel level is below the bottom of the hole; loosen the lock screw just enough to turn the adjusting nut. To raise fuel level, turn the adjusting nut one-sixth turn counterclockwise. Tighten the lock screw, reinstall the sight plug and start the engine. **Never run the engine with a loose or disconnected lock screw or sight plug, or fuel will be sprayed on a hot engine resulting in a fire.** Run the engine a few seconds until the fuel level stabilizes. Recheck fuel level. If further adjustment is required, turn the adjusting screw in one-sixth turn increments until the proper fuel level is attained.

If fuel level is too high, loosen the lock screw just enough to turn the adjusting nut. Turn the adjusting nut about one-half turn clockwise to lower the float. Tighten the lock screw, and reinstall the sight plug. Run the engine a few seconds until the fuel level stabilizes. **Never run the engine with a loose or disconnected lock screw or sight plug, or fuel will be sprayed on a hot engine resulting in a fire.** Recheck fuel level. If further adjustment is required, turn the adjusting nut in one-sixth turn increments counterclockwise to raise the level or clockwise to lower the level.

DRY ADJUSTMENT — INTERNALLY ADJUSTED FLOAT

The dry adjustment is the only float or fuel level adjustment performed on the internally adjusted float units. If making this adjustment with the carburetor installed on the vehicle, place a container under the fuel bowl cover assembly. This will collect fuel spillage when removing the cover assembly. Do not spill fuel on a hot engine as a fire may result. Remove the fuel bowl cover assembly and invert it. When inverted, the lower surface of the float should be parallel with the bottom of the fuel bowl cover (Fig. 15). Bend the tab on the float arm to adjust the float angle. Install fuel bowl cover assembly.

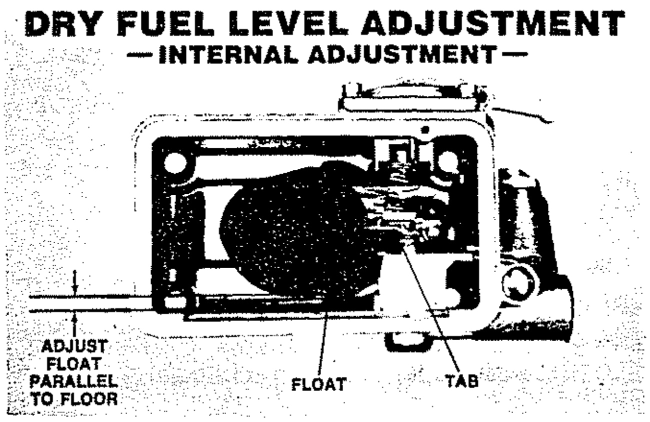


FIG. 15 — MODEL 2300 DRY ADJUSTMENT — INTERNALLY ADJUSTED FLOAT

NOTE: When installing the fuel bowl cover assembly the gasket between the metering block and cover must be installed properly. The accelerating pump passage is at the lower right of the metering block. The gasket must be installed with the hole in the gasket over this passage to prevent blocking the passage.

When installing the fuel bowl equipped with spring screws, lightly lubricate the bowl screws. Then tighten the screws, alternately from side to side. Tighten each screw until the screw assembly bottoms in the main body. When bottomed, the screw head will spring back a quarter of a turn when the screwdriver is removed. Do not overtighten or the springs on the screw assemblies may be damaged.

When connecting solid fuel lines to the fuel bowl, support the fuel bowl by using a wrench both on the fuel inlet fitting and on the fuel line nut to carry the torque loading when tightening the nut. Excessive twist loading on the fuel bowl will stretch the fuel bowl screw springs and cause loss of gasket sealing load.

CHECKING FUEL LEVEL — INTERNALLY ADJUSTED FLOAT

On internally adjusted floats, fuel level may be checked without removing the fuel bowl cover through the use of Kent-Moore wet level gauge number J10193 and a long screw, that is included in the kit. Install an O-ring on the long screw and install the screw through the hole in the gauge. Install O-rings on both ends of the spacer that comes with the gauge, and place the spacer on the screw. Place a container under the fuel bowl to catch any fuel spillage. Do not let any fuel spill on a hot engine as a fire may result. Remove either lower screw from the fuel bowl and quickly cover the hole to prevent excess spillage. Quickly install the long screw and gauge assembly (Fig. 16), to minimize spillage, and tighten the screw just enough to prevent spillage. Run the engine for a few seconds until the fuel level in the gauge stabilizes. Stop the engine and read the gauge. Compare to specifications and adjust if necessary.

NOTE: Be careful when removing the gauge and reinstalling the screw not to spill any fuel on a hot engine as a fire may result.

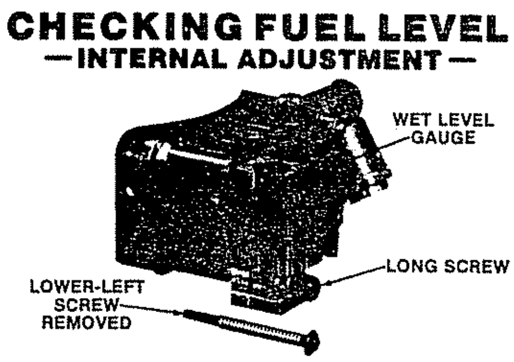


FIG. 16 — MODEL 2300 CHECKING FUEL LEVEL WITH KENT-MOORE GAUGE

ACCELERATING PUMP OVERRIDE SPRING ADJUSTMENT

To check the accelerating pump override spring adjustment, hold the throttle wide open and hold the pump lever in the fully compressed position. Insert a .015 inch feeler gauge between the adjusting nut and the arm of the pump lever (Fig. 17). Turn the adjusting screw until the proper clearance is attained. One-half turn of the adjusting screw is equal to approximately .015 inch. After adjusting, move the throttle lever from closed to open. Any movement of the throttle lever should be noticed in the pump operating lever.

ACCELERATING PUMP OVERRIDE SPRING ADJUSTMENT

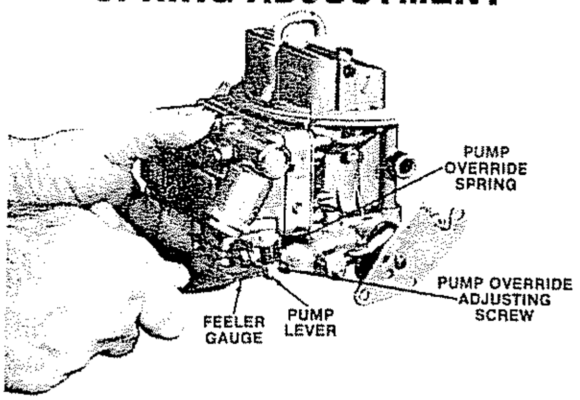


FIG. 17 — MODEL 2300 ACCELERATING PUMP OVERRIDE SPRING ADJUSTMENT

ACCELERATING PUMP STROKE ADJUSTMENT

The pump stroke is controlled by the position of the accelerating pump cam behind the throttle lever. The pump has two locating holes which vary the amount of fuel discharge and throttle movement for varying temperature conditions. In the standard application, the throttle lever screw is in hole number one (Fig. 18). In this position, the pump delivers a lesser quantity of fuel. Be sure to check specifications for the correct location for the accelerator pump cam.

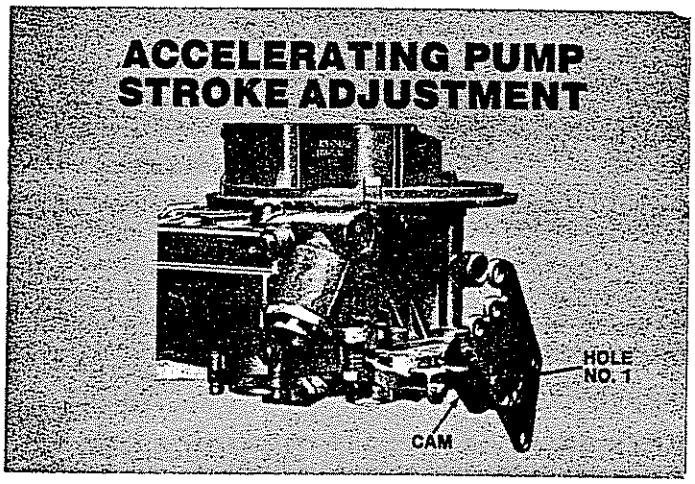


FIG. 18 — MODEL 2300 ACCELERATING PUMP STROKE ADJUSTMENT

ELECTRIC AUTOMATIC CHOKE PLATE CLEARANCE (PULLDOWN) ADJUSTMENT

To check the pulldown clearance, remove the thermostatic housing. To check if clearance adjustment is necessary, bend a paper clip. The paper clip should be .030" to .036" in diameter and the bent end should be no longer than ⅛ inch. Insert this bent end into the piston bore in the choke housing until the end of the bore slot is hooked by the paper clip (Fig. 19). Make sure that the bimetal lever is in contact with the piston lever adjusting tab. Move the piston and levers to close the choke until the edge of the piston slot engages the end of the paper clip. Measure the pulldown clearance by inserting a twist drill of the specified size between the choke plate and air horn (Fig. 19). If adjustments are necessary, bend the adjusting lever tang until specified measurement is attained.

ELECTRIC AUTOMATIC CHOKE PLATE CLEARANCE (PULLDOWN) ADJUSTMENT

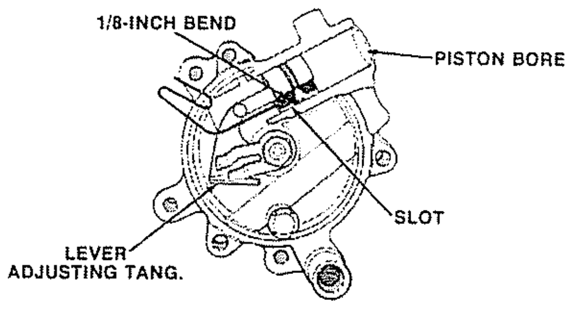


FIG. 19 — MODEL 2300 ELECTRIC AUTOMATIC CHOKE PLATE CLEARANCE (PULLDOWN) ADJUSTMENT

DECHOKE CLEARANCE ADJUSTMENT

To check dechoke clearance, hold the throttle plate in the wide-open position and the choke plate towards the closed position until the pawl on the fast idle speed lever contacts the fast idle cam (Fig. 20). Check the dechoke clearance by inserting a twist drill of the specified size between the upper edge of the choke plate and the wall of the air horn (Fig. 20). To adjust the clearance to specifications, bend the pawl on the fast idle lever forward to decrease the clearance or backward to increase the clearance.

DECHOKE CLEARANCE ADJUSTMENT

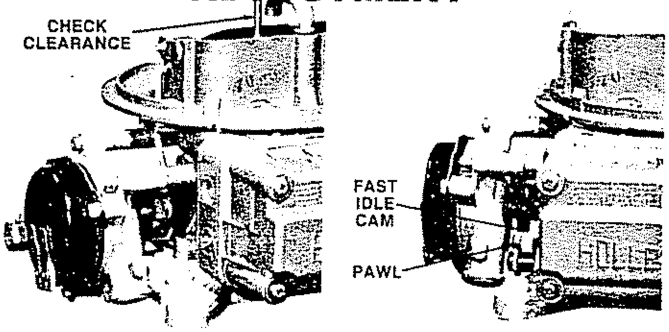


FIG. 20 — MODEL 2300 DECHOKE CLEARANCE ADJUSTMENT

AUTOMATIC CHOKE THERMOSTATIC SPRING HOUSING ADJUSTMENT

To adjust the spring housing, first remove the air cleaner. Loosen the three screws in the clamp that retains the spring housing. Turn the spring housing so the aligning mark on the housing lines up with the choke housing index mark (Fig. 21). Tighten the screws.

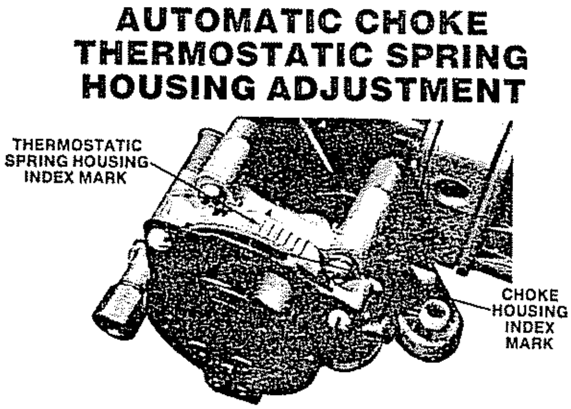


FIG. 21 — MODEL 2300 AUTOMATIC CHOKE THERMOSTATIC SPRING HOUSING ADJUSTMENT

IDLE SPEED ADJUSTMENT

To adjust idle speed, install a tachometer on the engine.Run the engine 5-10 minutes at a fast idle speed or until normal operating temperature is reached. Make sure the idle speed screw is in contact with the throttle lever tang. Turn the idle speed screw until the specified RPM is reached (Fig. 22). Turn the screw "in" to increase idle speed. Turn the screw "out" to decrease idle speed. After adjusting the idle speed screw, rapidly pull back on the throttle lever and release. Throttle speed should increase and return to normal. Adjust if necessary.

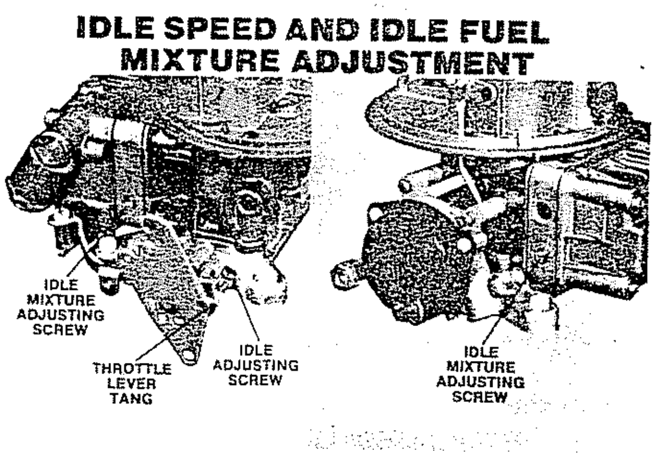


FIG. 22 — MODEL 2300 IDLE SPEED AND IDLE FUEL MIXTURE ADJUSTMENT

IDLE FUEL MIXTURE ADJUSTMENT

There are two idle mixture screws on the two-barrel carburetor. Each screw is found on opposite sides of the metering block (Fig. 22). Turn each screw "in" until it gently seats, then turn each screw out 1-1½ turns. This will provide a preliminary setting to start the engine. (The screws must be turned out an equal amount of turns on each side.) Turn the idle mixture screw "in" until the lean mixture causes the RPM to drop. Perform this on the other screw. Turn the screw "out" until the RPM drops due to a rich mixture. Perform this on the other screw. Turn the screw somewhere between the two extremes to a point of maximum engine smoothness and RPM. Always favor a rich setting over a lean one. Perform this on the other side. Recheck idle speed and adjust if necessary.

DISASSEMBLY AND ASSEMBLY

DISASSEMBLY

To facilitate working on the carburetor and to prevent damage to the throttle plates, install bolts about 2¼" long of the correct diameter through the carburetor attaching bolt holes with a nut above and below the flange (or install carburetor legs).

Use a separate container for the component parts of the various assemblies to facilitate cleaning, inspection and assembly.

The following is a step-by-step sequence of operations for completely overhauling the carburetor; however, certain components of the carburetor may be serviced without disassembling the entire unit. For a complete carburetor overhaul, follow all the steps. To partially overhaul the carburetor or to install a new gasket kit, follow only the applicable steps.

Many carburetors do not have all the hardware noted in the following steps.

Fuel Bowl and Metering Block

Refer to Fig. 23 for the correct location of the fuel bowl parts.

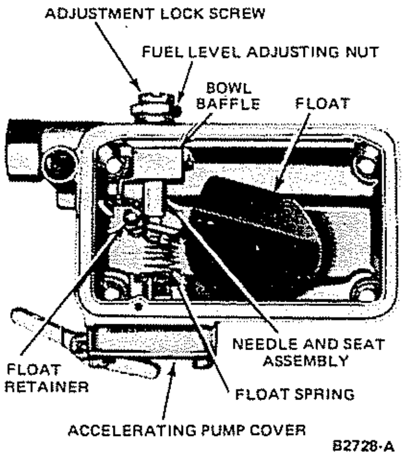


FIG. 23 — FUEL BOWL

1. Remove the fuel bowl and gasket, and the metering block and gasket. Discard the gaskets.

2. Using a socket wrench, remove the power valve and gasket (Fig. 24). Discard the gasket. Using a jet wrench, remove the main jets (Fig. 25).

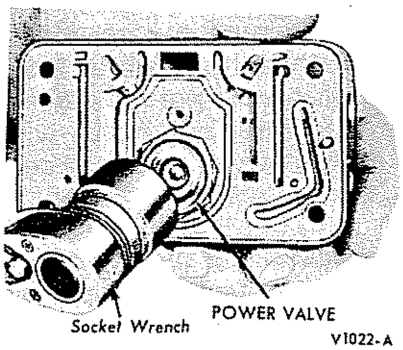


FIG. 24 — REMOVING OR INSTALLING POWER VALVE

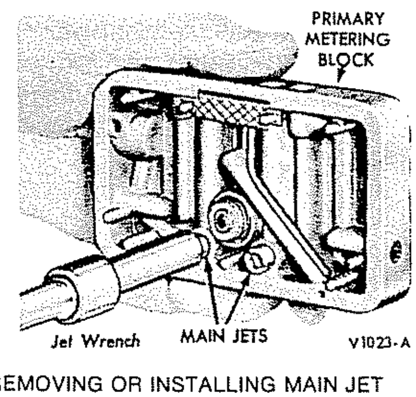


FIG. 25 — REMOVING OR INSTALLING MAIN JET

3. Externally Adjustable Needle and Seat: Remove the fuel inlet baffle and remove the retainer, float assembly and float spring (if spring is used). Remove the adjustment lock screw. Turn the adjustment nut counterclockwise. Remove the locknut, gasket and fuel inlet needle and seat.

   Internal Needle and Seat: Remove float retainer "E" clip, then slide float and spring out of float chamber. Remove baffle, fuel inlet valve and seat. Discard gasket.

4. Using needle-nose pliers, remove the float retainer.

5. Slide the float off the shaft. Remove the spring from the float.

6. Remove the fuel level sight plug and gasket. Remove the fuel inlet fitting, gasket, and filter screen.

7. Invert the fuel bowl and remove the accelerating pump cover, diaphragm, and spring. The accelerating pump inlet ball check is not removable.

Main Body

1. Invert the carburetor and remove the throttle body from the main body. Disconnect the choke rod from the choke control shaft lever assembly by pushing the rod toward the main body and releasing it from the lever. Discard the throttle body gasket.

2. Remove the elastic stop nuts from the choke plate and remove the screws, flat spring, spacers, choke plate and the choke plate poppet valve. Remove the choke rod from the choke plate shaft. Slide the choke rod out of the choke shaft as the shaft is removed from the housing. Remove the choke rod seal from the main body.

3. Remove the retainers, spring seats, and springs from the poppet valve on the front of the choke plate housing. **Use caution to avoid losing the springs as they are under compression.** Remove the pins and poppet valve.

4. Remove the accelerating pump discharge nozzle from the main body.

5. Invert the main body and let the accelerating pump discharge needle fall into the hand (Fig. 26). Remove the throttle operating shaft housing back-up plate and gasket.

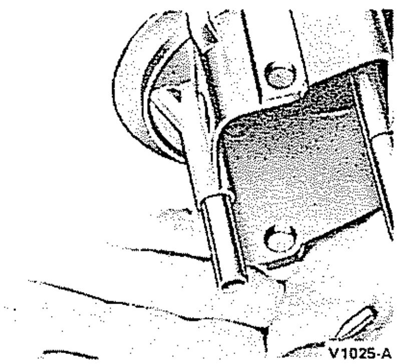


FIG. 26 — REMOVING ACCELERATING PUMP DISCHARGE NEEDLE

6. If it is necessary to remove the throttle plates, lightly scribe both throttle plates along the throttle shaft and mark each throttle plate and its corresponding barrel to insure proper installation. Remove the throttle plates. Remove the retainer from each end of the shaft. Slide the throttle shaft out of the throttle body.

Throttle Operating Shaft Housing

1. Remove the engine idle speed adjusting screw and spring. Remove the fast idle adjusting pin and screw.

2. Loosen the throttle lever screw. Remove the throttle lever retaining pin. Remove the throttle lever and the accelerating pump cam. Remove the throttle pick-up lever and swivel assembly.

3. Remove the throttle shaft retainer and slide the throttle shaft out of the housing.

ASSEMBLY

Make sure all holes in the new gaskets have been properly punched and that no foreign material has adhered to the gaskets. Make sure the accelerating pump diaphragm is not torn or cut. An exploded view of the carburetor is shown in Fig. 27.

Throttle Operating Shaft Housing

Refer to Fig. 42 of Holley 4V for the correct location of the parts.

1. Slide the throttle operating lever and shaft assembly into the housing. Install the accelerating pump cam in the throttle lever. Position the pick-up lever and swivel assembly on the shaft.

2. Aligning the retaining pin hole in the throttle lever and shaft, position the throttle lever on the shaft. **Be sure the throttle lever can be rotated from the full open position to the full closed position. Install the throttle lever retaining pin. Install the throttle lever screw.**

3. Install the engine idle speed adjusting screw and spring. Install the fast idle adjusting pin and screw.

Throttle Body

1. If the throttle plates were removed, position the bushings on the throttle shaft and slide them into the throttle body. Install the retainer on each end of the shaft. Referring to the lines scribed on the throttle plates, install the plates in their proper location with the screws snug, but not tight. Close the throttle plates and hold the throttle body up to the light. Little or no light should show between the throttle plates and the throttle bores. If the throttle plates are properly installed and there is no binding when the throttle shafts are rotated, tighten and stake the throttle plate screws.

2. Position the throttle operating shaft housing back-up plate assembly gasket and plate assembly on the throttle body by sliding them over the clutch lever on the throttle shaft.

3. Insert the throttle operating housing attaching screws in the housing. Slide the housing gasket over the screws.

4. Open the throttle plates and install the throttle operating housing on the throttle body. **If the housing is correctly installed, the throttle lever will close the throttle plates, but will not open them.**

5. Install the accelerating pump lever on the throttle body.

6. Install the idle adjusting needles and springs. Turn the needles in gently until they touch the seat, then back them out 1-1½ turns.

Main Body

1. Drop the accelerating pump discharge needle into the well. Seat the needle with a brass drift and a light hammer. Make sure it is free. Position the accelerating pump discharge nozzle gasket and nozzle in the main body; then install the attaching screw and gasket.

2. Place the choke rod seal in the groove located

on the underside of the carburetor air cleaner flange.

3. Working from the underside of the carburetor air cleaner flange, slide the choke rod (with the small upset end to the top) through the opening in the main body and rod seal.

4. Place the air horn poppet valve (if so equipped) in position on the main body. From inside the air horn, insert the pins through the main body and poppet valve, install the spring, spring seats, and retainers.

5. Position the choke plate shaft in the air horn. Position the choke rod in the choke plate shaft lever and over the spring.

6. Position the choke plate poppet valve over the retaining screws, then position the choke plate on top of the poppet valve.

7. Place the spacers over the screws, then position the flat spring over the screws so that the curved portion is down. Install the attaching nuts.

8. Invert the main body and position the gasket on the main body. Place the throttle body in position on the main body sliding the choke rod into the choke rod lever as the throttle body is placed into position. Install the throttle body to main body screws and lockwashers.

Fuel Bowl and Metering Block

1. Place the accelerating pump diaphragm spring and diaphragm in the accelerating pump chamber. The diaphragm must be positioned so that the large end of the lever disc will be against the operating lever. Install the cover with the screws finger tight. Make sure the diaphragm is centered, then compress the diaphragm with the pump operating lever and tighten the cover screws.

2. Install the fuel level sight plug and gasket.

3. Install the fuel inlet filter screen, gasket and fitting.

4. Slide the baffle plate on the ridges in the fuel bowl.

5. Install the float spring on the float, slide the float on the shaft and install the float retainer.

6. Apply petroleum jelly to a new O-ring seal and slide it on the fuel inlet needle and seat assembly.

7. Position the fuel inlet needle and seat assembly in the fuel bowl through the top of the bowl. Position the adjusting nut gasket and nut on the fuel inlet needle and seat. Align the flat on the ID of the nut with the flat on the OD of the fuel inlet needle and seat assembly.

8. Adjust the float so that the top of the float is parallel with the top of the fuel bowl with the fuel bowl inverted (see Adjustment).

9. Install the fuel level adjusting lock screw and gasket.

10. Using a socket wrench, install the power valve and a new gasket. **Be sure to install the correct power valve. Refer to the specifications for the correct identification number. The number is stamped on a flat on the base of the valve.** Using a jet wrench, install the main jets.

11. Position the metering block gasket on the dowels on the back of the metering block. Lay the metering block in place on the main body. Position the baffle on the metering block, then position the fuel bowl gasket on the metering block. Place the attaching screws and new compression gaskets in the fuel bowl. Lay the bowl in place on the metering block. Tighten the screws.

HOLLEY TWO-BARREL CARBURETOR — MODEL 2300

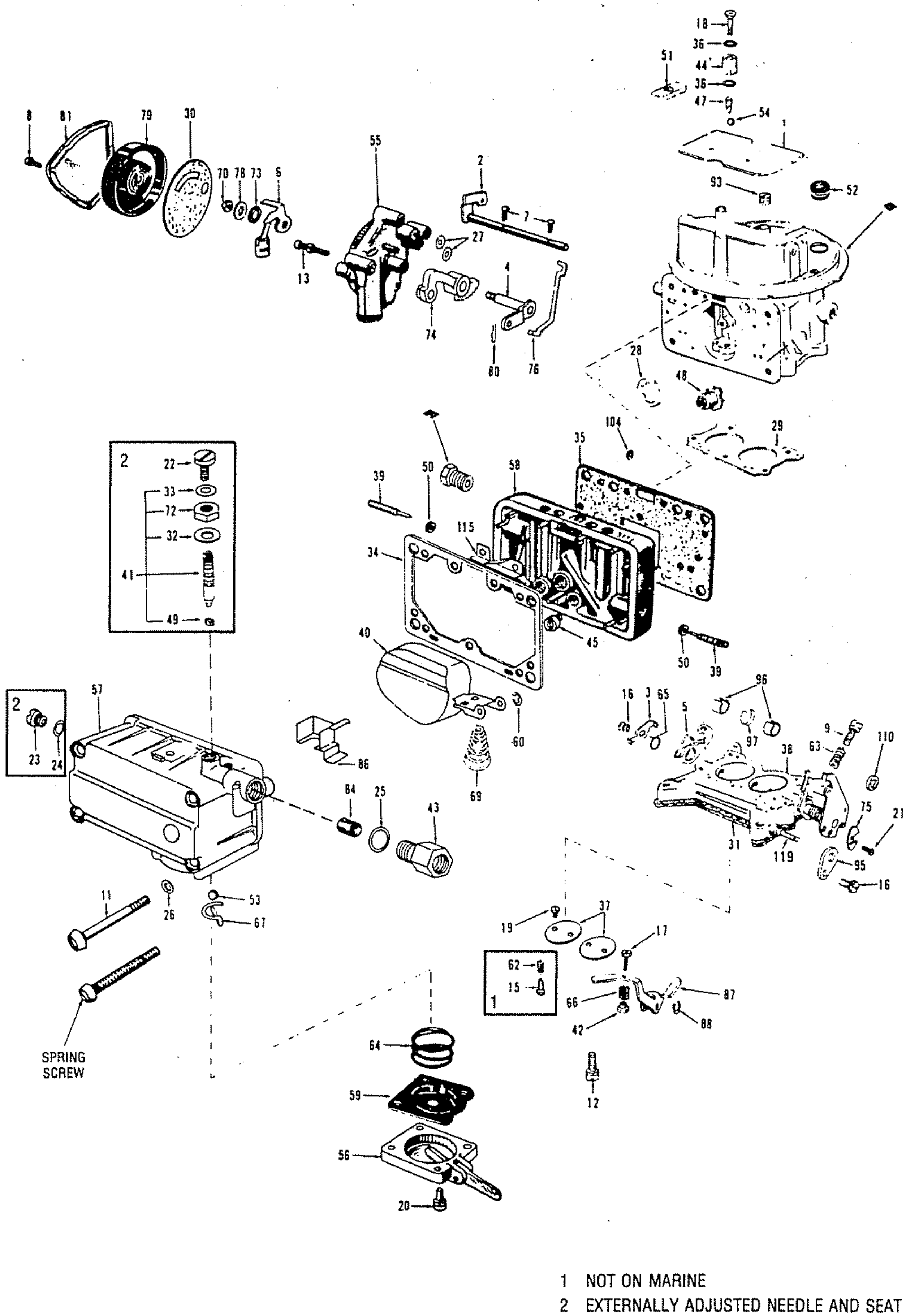


FIG. 27 — MODEL 2300C CARBURETOR — EXPLODED VIEW

HOLLEY TWO-BARREL CARBURETOR — MODEL 2300

TYPICAL NOMENCLATURE

Index Number	Part Name	Index Number	Part Name	Index Number	Part Name
1	Choke Plate	35	Metering Body Gasket	70	Choke Thermostat Shaft Nut
2	Choke Shaft Assembly	36	Pump Discharge Nozzle Gasket	72	Fuel Valve Seat Adj. Nut
3	Fast Idle Pick-up Lever	37	Throttle Plate	73	Choke Therm. Lever Spacer
4	Choke Hsg. Shaft & Lev. Assy.	38	Throt. Body & Shaft Assy.	74	Fast Idle Cam Assembly
5	Fast Idle Cam Lever	40	Float & Hinge Assy.	76	Choke Rod
6	Choke Therm. Lev., Link & Piston Assembly	41	Fuel Inlet Valve & Seat Assy.	78	Choke Therm. Shaft Nut L.W.
		42	Pump Oper. Lev. Adj. Scr. Fitting	79	Thermostat Housing Assembly
7	Choke Plate Screw	43	Fuel Inlet Fitting	80	Choke Rod Retainer
8	Therm. Hsg. Clamp Screw	44	Pump Discharge Nozzle	81	Thermostat Housing Clamp
9	Throttle Stop Screw	45	Main Jet	84	Filter Screen Assembly
11	Fuel Bowl to Main Body Screw	47	Pump Discharge Needle Valve or Check Ball Weight	86	Baffle Plate
12	Throt. Body Scr. & L.W.			87	Pump Operating Lever
13	Choke Hsg. Scr. & L.W.	48	Power Valve Assembly	88	Pump Operating Lev. Retainer
15	Fast Idle Cam Lever Screw	49	Fuel Valve Seat "O" Ring Seal or Gasket	93	Air Adapter Hole Plug
16	Fast Idle Cam Lev. & Throt. Lev. Screw & L.W.			95	Throttle Lever
		50	Idle Needle Seal	96	Throttle Shaft Bearing
17	Pump Oper. Lev. Adj. Screw	51	Choke Rod Seal	97	Throttle Shaft Brg. (center)
18	Pump Discharge Nozzle Screw	52	Choke Cold Air Tube Grommet	104	Diaphragm Link Retainer
19	Throttle Plate Screw	53	Pump Inlet Check Ball	105	Air Vent Rod Spg. Retainer
20	Fuel Pump Cov. Assy. Scr. & L.W.	54	Pump Discharge Check Ball	110	Throt. Link Connecor Pin Washer
21	Pump Cam Lock Scr. & L.W.	55	Choke Hsg. & Plugs Assy.	115	Metering Body Vent Baffle
22	Fuel Valve Seat Lock Screw	56	Fuel Pump Cover Assy.	119	Pump Oper. Lever Stud
23	Fuel Level Check Plug	57	Fuel Bowl & Plugs Assy.	•	Vent Tube
24	Fuel Level Check Plug Gasket	58	Main Metering Body & Plugs Assy.	•	Heat Tube Nut
25	Fuel Inlet Fitting Gasket	59	Pump Diaphragm Assembly	•	Heat Tube Ferrule
26	Fuel Bowl Screw Gasket	60	Float Spring Retainer	•	Fuel Tube Hose Clamp
27	Choke Housing Gasket	61	Air Vent Retainer	•	Retainer
28	Power Valve Body Gasket	62	Fast Idle Cam Lev. Scr. Spring	•	Air Cleaner Stud (Long)
29	Throttle Body Gasket	63	Throttle Stop Screw Spring	•	Air Cleaner Stud (Short)
30	Choke Therm. Housing Gasket	64	Pump Diaphragm Return Spring	•	Choke Heat Tube
31	Flange Gasket	65	Fast Idle Cam Lev. Spring	•	Fuel Line Hose
32	Fuel Valve Seat Adj. Nut Gskt.	66	Pump Oper. Lev. Adj. Spring	•	Fresh Air Hose
33	Fuel Valve Seat Lock Scr. Gskt.	67	Pump Inlet Check Ball Retainer	•	Spring
34	Fuel Bowl Gasket	69	Float Spring		

HOLLEY FOUR-BARREL CARBURETORS — MODELS 4150 AND 4160

There are two models of the Holley four-barrel carburetor, 4150 and 4160. The difference between the two models is in the design of the secondary metering body. In the 4150 model the secondary metering body is very similar to the primary metering body. In the 4160 the secondary metering body is a plate-type assembly.

DESCRIPTION

The four-barrel carburetor is a downdraft, two-stage carburetor (Fig. 1). It can be considered as two dual carburetors; one supplying an air/fuel mixture throughout the entire range of engine operation (primary stage), and the other functioning only when a greater quantity of air/fuel mixture is required (secondary stage).

The primary section (the section on which the fuel inlet is located) of the carburetor contains a fuel bowl, metering block and an accelerating pump assembly. The primary barrels each contain a primary and booster venturi, main fuel discharge nozzle, throttle plate and idle fuel passage. The choke plate, mounted in the air horn above the primary stage venturis, is manually controlled.

The secondary stage of the carburetor contains a fuel bowl, metering block, and secondary throttle operating diaphragm. The secondary barrels each contain a primary and booster venturi, idle fuel passages, main secondary discharge nozzle, throttle plate, and a transfer system fuel passage.

An identification tag is found on the carburetor. Do not remove this tag for any reason. This tag is used in finding specifications for adjustment and in ordering parts.

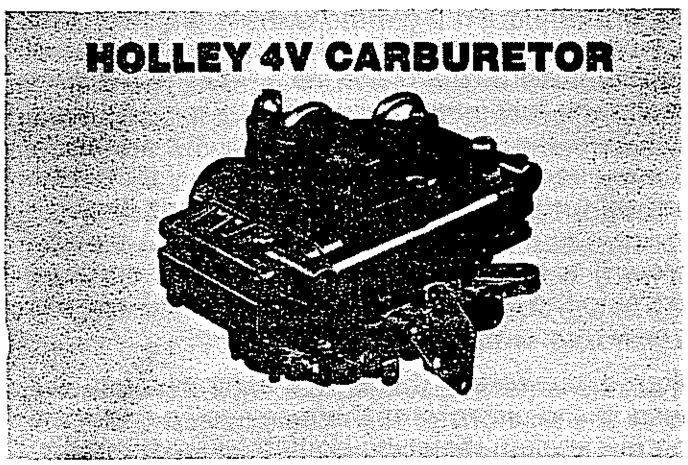


FIG. 1 — HOLLEY FOUR-BARREL CARBURETOR

CARBURETOR SYSTEMS

FUEL INLET SYSTEM

Primary

The fuel inlet system consists of a fuel bowl, fuel inlet fitting, fuel inlet needle, seat and a float assembly (Fig. 2). A fuel screen or inlet screen is usually installed in the inlet fitting. Where there is no filter in the inlet fitting, an inline filter must be used to prevent malfunction due to dirty fuel.

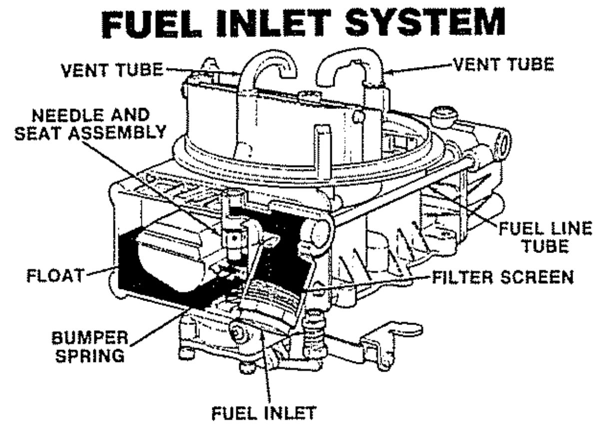


FIG. 2 — FUEL INLET SYSTEM

Fuel enters the fuel bowl through the inlet fitting, and through the inlet needle and seat assembly. As the fuel level in the bowl rises, so does the float. When the float rises to a specified level, pressure from the float and lever tends to seat the needle, allowing no more fuel to enter. As the fuel is used up, the fluid level drops allowing the float to drop with it. Pressure from the dropping float and lever assembly unseats the needle and fuel flows into the bowl once again.

The basic fuel metering systems are calibrated to deliver the proper mixture only when the float is adjusted to the correct level. A float bumper spring is installed under the float level in many applications to stabilize the float movement.

Float level can be adjusted in two ways, internally or externally, determined by the type of system on the carburetor. With an internal adjustment, the carburetor is removed from the intake manifold. On the external adjustment, the carburetor doesn't have to be removed from the intake manifold.

The fuel bowl is vented internally to the air horn by a vent tube in the carburetor body, releasing excess fuel vapor.

Fuel is transferred from the primary side to the secondary side by the transfer tube. The tube is connected to the inlet fitting of the primary side and to the secondary fuel bowl. Fuel pressure from the fuel pump forces the movement of the fuel.

Secondary

The secondary fuel inlet system is identical to the primary system in its operation and components.

IDLE FUEL SYSTEM

The idle fuel system supplies the air/fuel mixture to operate the engine at low and idle speeds.

The four-barrel Holley carburetor has identical idle fuel systems for both primary barrels and identical idle fuel systems for both secondary barrels. The two secondary systems are slightly different from the primary.

Primary

From the fuel bowl, fuel flows through the main jet into a small, angular, horizontal idle feed passage that leads to a vertical idle well passage (Fig. 3). Flowing up this idle well passage, fuel passes through the idle feed restriction. After this passage, the fuel flows through another horizontal passage and at the end of this passage is mixed with incoming air from the idle air bleed. The air/fuel mixture then flows down another vertical passage to the bottom of the main body, where it splits into two directions. One direction goes to the idle discharge passage, the other to the idle transfer passage and constant feed port (Fig. 3). The mixture flowing down the passages leading to the idle discharge passage flows past the pointed tip of the idle mixture adjustment needle screw. From here, the air/fuel mixture goes down a short passage in the main body and down another passage into the throttle body, where it is discharged in the throttle bore below the closed throttle plate. In the passages leading to the idle transfer passage and constant feed port, the air/fuel mixture flows unrestricted. The mixture exits through the idle constant feed port. When the throttle plate is closed, no fuel is discharged through the idle transfer slot. At this point the function of the transfer slot is to act as an air bleed directly above the idle constant feed port and to further lean out the air/fuel mixture.

As more engine speed is desired, the movement of the accelerator linkage causes the throttle plate to open. When the throttle plate is opening, the idle transfer slot is exposed to manifold vacuum, causing fuel to be discharged from the transfer slot. As the throttle plate opens more, engine speed increases, thus increasing the air flow through the carburetor. The air flow is increased further by the effect of the venturi. With the resulting increases in air flow, the main metering system comes into operation with idle system tapering off. Thus a smooth, gradual transition is made from idle to operating speeds.

IDLE FUEL SYSTEM

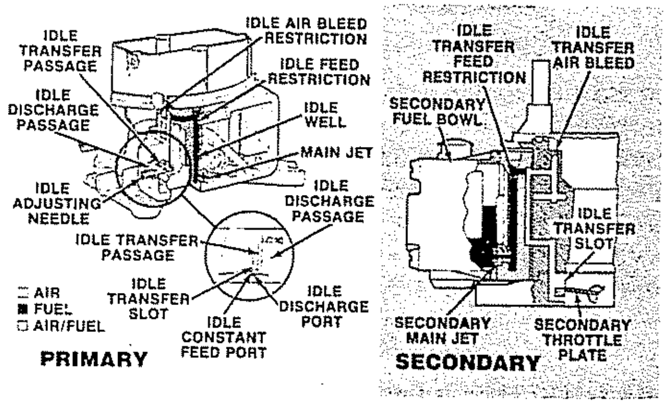


FIG. 3 — IDLE FUEL SYSTEM

Secondary

The secondary idle system is very similar to the primary system. One main difference is that there isn't any idle mixture adjusting screws in the secondary idle system. The main purpose of the secondary idle system is to keep a fresh bowl of fuel in the secondary fuel bowl. This is done by the idle constant feed port.

Fuel flows from the secondary fuel bowl, through the secondary main jet into the metering body. From here the fuel flows up the idle well and through the idle feed restriction. Here it is mixed with incoming air from the idle transfer air bleed to form the air/fuel mixture. The mixture flows down a number of passages to the throttle body. From here to a slot below the throttle plate. The transfer slot above it acts as an air bleed at idle.

MAIN METERING SYSTEM

Primary

In the primary main metering system (Fig. 4 and 5), with the throttle partly opened, fuel flows from the fuel bowl through the main jet. The main jet meters the fuel into the main well. From the main well, fuel flows past the main well air bleeds, where it becomes mixed with air. The air/fuel mixture continues up the main well, passing through horizontal passages in the body, and exiting through a horizontal channel to the discharge nozzle in the booster venturi. The air/fuel mixture is now mixed with the incoming air.

Filtered air enters through the high speed air bleed in the air horn of the main body, and then enters the main metering body through interconnecting passages. Because the air/fuel mixture is

MAIN METERING SYSTEM

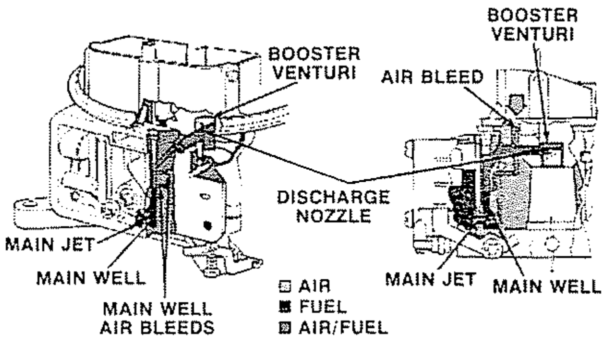


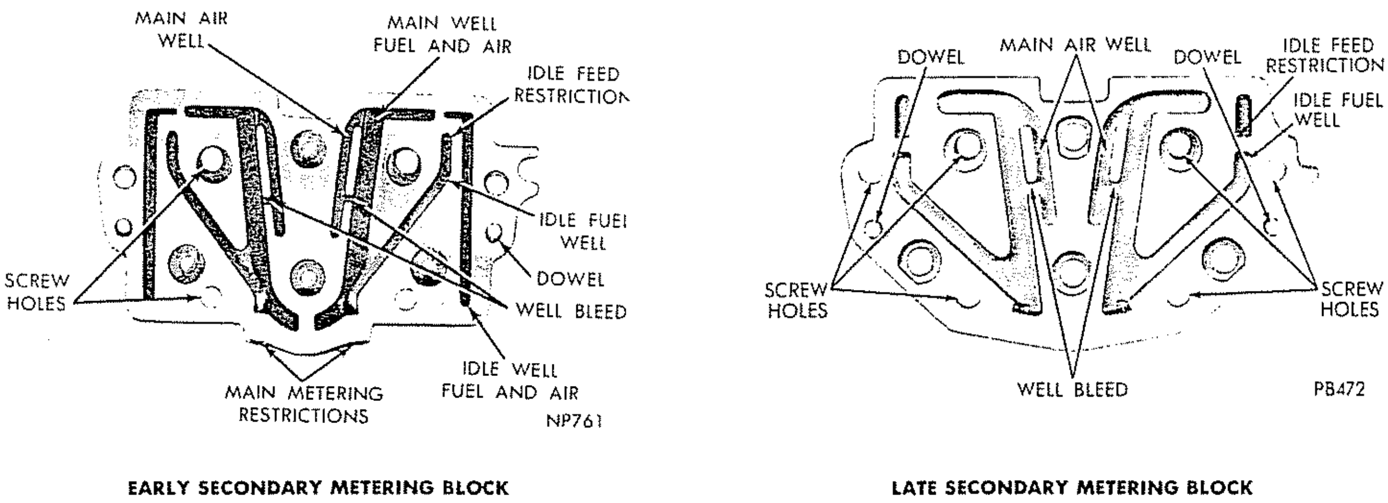
FIG. 4 — MAIN METERING SYSTEM

lighter than liquid fuel, it responds faster to changes in venturi vacuum and vaporizes more easily when discharged into the airstream. The amount of air/fuel mixture flowing to the intake manifold is regulated by the throttle plate position, which also regulates the engine speed and power output.

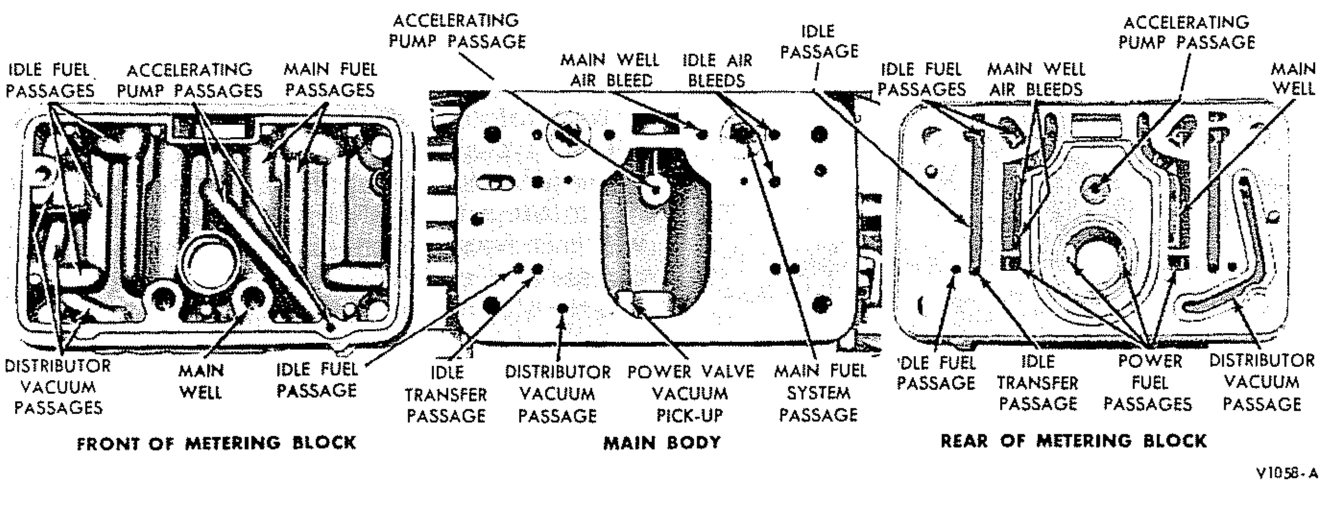
Secondary

The metering block in the 4150 carburetor is similar to the primary metering block. In the 4160 Model, the secondary metering body is a plate within the secondary fuel bowl (Fig. 5).

In the 4160, fixed main metering restrictions are located in the bottom of the metering body. Fuel



SECONDARY METERING BLOCK 4160



PRIMARY METERING BLOCK 4150, 4160
SECONDARY METERING BLOCK 4150

FIG. 5 — METERING BLOCK PASSAGES

for the idle and idle transfer system enters the main well through these restrictions. Idle fuel wells branch off each main well. Fuel travels up the idle well through an idle restriction, where it is mixed with the air entering through the secondary air bleeds. Air enters the main well through the secondary high speed air bleeds.

The air/fuel mixture is discharged out of the secondary nozzles located in the booster venturi. The secondary transfer and main metering system are only operative when the secondary throttle valves are opened.

POWER FUEL SYSTEM

During high power operation, the increased air flow down the air horn tends to lean out the air/fuel mixture. Additional fuel is required to enrich the air/fuel mixture. The needed additional fuel is supplied by the power fuel system. Vacuum to actuate the power valve, found in the metering block, is supplied through passages in the throttle body and main body. At idle speed or under normal load, the vacuum supplied to the power valve is sufficient to overcome spring pressure acting on the power valve diaphragm; thus vacuum holds the power valve closed. At high-speed operation manifold vacuum drops; thus the spring in the power valve forces the diaphragm to open, allowing fuel to flow (Fig. 6). The path of the fuel is through the power valve, then through the diagonal restrictions in the metering block, and finally into the main well, where it joins the main fuel flow and enriches the mixture.

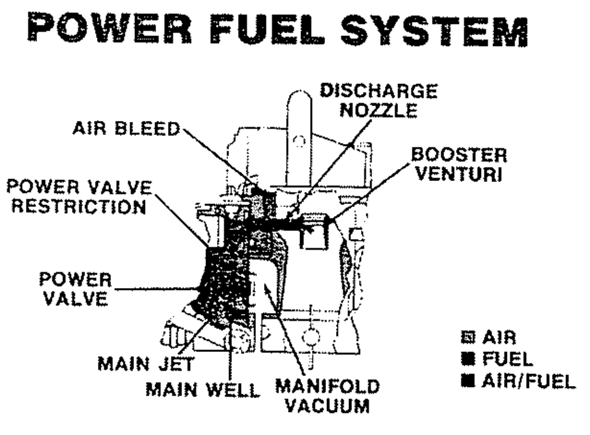


FIG. 6 — POWER FUEL SYSTEM

When engine speed is reduced, manifold vacuum once again increases. This vacuum acts on the power valve diaphragm to overcome spring pressure. The power valve then shuts off the added supply of fuel which is no longer necessary.

There are many power valve variations, differentiated by the sizes of valves and fuel passages, as well as a wide range of vacuum settings.

When servicing a carburetor, the power valve supplied in the kit should be used. Each power valve is stamped with the vacuum setting. (Example: 65 would indicate the valve would operate at 6.5 inches of vacuum.) A manufacturing code is also stamped on the valve.

It is very important that the proper gasket is used on the valve and torqued to 100 in-lbs. (Many valves are considered faulty because fuel leaks around the gasket and through the threads.) A sudden change in idle characteristics or sudden stalling due to idle richness can result from a leaking power valve diaphragm. The power valve diaphragm should be tested on a distributor test machine vacuum system, or with a hand vacuum pump equipped with a piece of rubber tubing that will cover the diaphragm side of the valve.

SECONDARY OPERATION — VACUUM SYSTEMS

At lower speeds and lower power requirements, the secondary throttle plates remain closed, allowing the engine to maintain the proper air/fuel mixture (Fig. 7). When engine speed increases to a point where additional air/fuel mixture is needed, the vacuum controlled secondary throttle plates begin to open automatically.

Vacuum from one of the primary venturi and one of the secondary venturi is channeled through the main body to the secondary vacuum diaphragm. The bottom of the diaphragm is open to atmospheric pressure. At higher speeds and higher primary venturi vacuum, the diaphragm, operating through a rod and secondary throttle lever, will commence to open the secondary throttle plates. This action will start to compress the secondary diaphragm spring.

As the secondary throttle plates are opening, a vacuum signal is created in the secondary venturi. This additional vacuum assists in opening the secondary throttle plates to the maximum designed opening. The secondary opening rate is controlled by the diaphragm spring and the size of the vacuum restrictions in the venturi.

When the engine speed is reduced, venturi vacuum decreases and the diaphragm spring starts to push the diaphragm down to start the closing of the secondaries. Closing the primary throttle plates moves the secondary throttle connecting link.

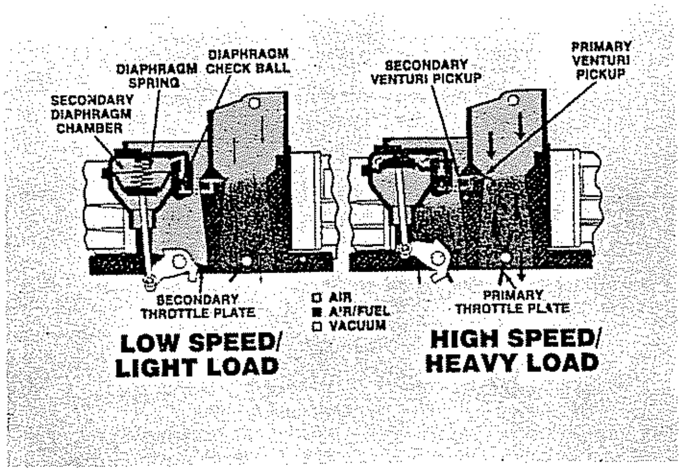


FIG. 7 — SECONDARY OPERATION — VACUUM SYSTEMS

Most production applications have a ball check and bypass bleed installed in the diaphragm passage. The ball permits a smooth, even opening of secondaries but lifts off the inlet bleed to cause rapid closing of secondaries when the primary throttle valves are closed.

No attempt should be made to convert vacuum operated secondaries to mechanical operation. Bolts or screws should never be installed in the slot in the secondary throttle lever.

ACCELERATOR PUMP

When the throttle plates are opened suddenly, as during quick acceleration, the air flow down the venturi responds almost immediately and is rapidly increased. Fuel responds more slowly to this increased air flow since it is heavier than air. The difference in response must be compensated for, or a too lean mixture would result and the engine would hesitate. The accelerating pump system corrects this problem. It mechanically supplies fuel until the other metering systems are able to supply enough fuel to maintain a proper mixture.

The accelerator pump is a diaphragm-type pump which is located in the bottom of the fuel bowl. When the throttle is opened, the pump linkage is actuated by a cam on the throttle lever, and forces the pump diaphragm upward. When the diaphragm moves up, fuel pressure forces the pump inlet check ball, or valve, onto its seat, preventing fuel flow back into the fuel bowl. The diaphragm pressure also forces fuel through a short passage in the fuel bowl, and into the long, diagonal passage in the metering body. It then flows into the main body passage to the pump discharge chamber (Fig. 8). Fuel pressure causes the discharge needle to unseat and fuel is discharged into the venturi.

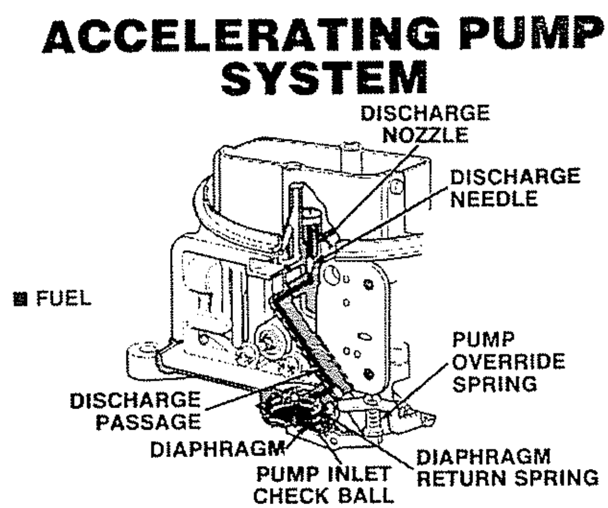


FIG. 8 — ACCELERATING PUMP SYSTEM

When the accelerator is moved rapidly, the throttle plates go to the wide open position, the pump override spring is compressed and allows the full pump travel, by applying pressure to maintain the pump discharge. Without this pump override spring, the pump linkage would be bent or broken because fuel, being a liquid, is essentially incompressible.

As the throttle moves to the closed position, the accelerating pump linkage returns the diaphragm to its original position, and the diaphragm return spring pulls the diaphragm back to its original position. The pump inlet check ball is again unseated and fuel flows from the fuel bowl into the accelerating pump chamber.

ADJUSTMENTS

FLOAT OR FUEL LEVEL ADJUSTMENTS

Float or fuel level adjustments are of two types — dry and wet. The dry adjustment is performed with the float bowl cover removed from the carburetor body. It is performed on the internally adjusted float models as well as the externally adjusted models. The dry adjustment on the externally adjusted models is only a preliminary float setting. The wet setting is performed as a final setting on the externally adjusted models.

DRY ADJUSTMENT — EXTERNALLY ADJUSTED FLOAT

To perform the dry level adjustment on the externally adjusted float model, remove the float bowl and float assembly from the carburetor body (if the carburetor is installed on the intake manifold, place a pan or container under the carburetor to catch fuel that spills out. Be careful not to spill fuel on a hot engine as a fire may result). Loosen the lock screw, invert the fuel bowl, and turn the fuel level adjusting nut until the float is parallel with the floor of the bowl. Reinstall the bowl (Fig. 9).

NOTE: When installing the fuel bowl cover assembly, the gasket must be installed properly. The accelerating pump passage is at the lower right of the metering block. The gasket must be installed with the hole over this passage to prevent blocking this passage.

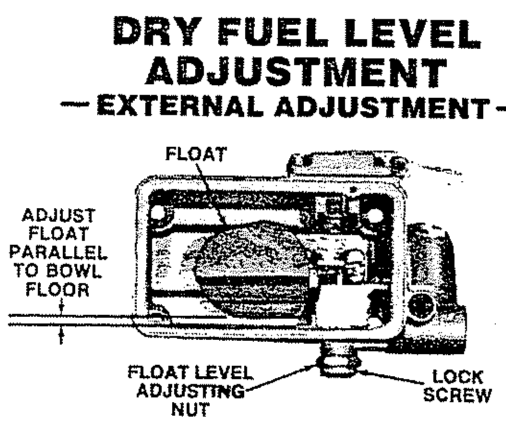


FIG. 9 — DRY ADJUSTMENT — EXTERNALLY ADJUSTED FLOAT

WET ADJUSTMENT — EXTERNALLY ADJUSTED FLOAT

The fuel system must be working properly and fuel pump pressure and volume up to specifications, before the final adjustment is to be made. The engine is to be run on a level surface so as not to affect the fuel level.

Start the engine and run it 5-10 minutes at a fast idle or until normal operating temperature is reached. Stop the engine. Place a container under the fuel bowl cover sight plug. The sight plug is found on the side of the fuel bowl. Remove the sight plug (Fig. 10). No fuel should run out and the fuel level should be up to the bottom of the sight hole. This is the correct fuel level.

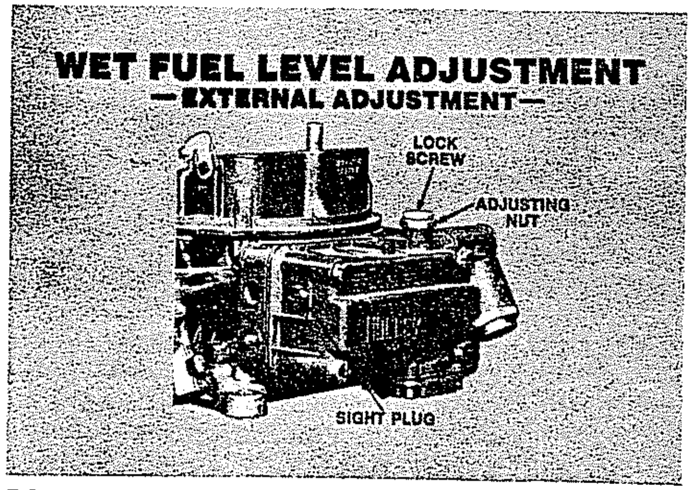


FIG. 10 — WET ADJUSTMENT — EXTERNALLY ADJUSTED FLOAT

If the fuel level is below the bottom of the sight glass hole; loosen the lock screw just enough to turn the adjusting nut. To raise fuel level, turn the adjusting screw one-sixth turn counterclockwise. Tighten the lock screw. Reinstall the sight plug and start the engine. **Never run the engine with a loose or disconnected lock screw or sight plug, or fuel may be sprayed on a hot engine resulting in a fire.** Run the engine a few seconds until the fuel level stabilizes. Recheck fuel level. If further adjustment is necessary, turn the adjusting screw in one-sixth turn increments until the proper fuel level is attained.

If the fuel level is too high, loosen the lock screw just enough to turn the adjusting nut. Turn the adjusting nut about one-half turn clockwise to lower the float. Tighten the lock screw and reinstall the sight plug. Run the engine a few seconds until the fuel level stabilizes. **Never run the engine with a loose or disconnected sight plug or lock screw, or fuel may be sprayed on a hot engine resulting in a fire.** Recheck fuel level. If further adjustment is required, turn the adjusting nut in one-sixth turn increments counterclockwise to raise the level or clockwise to lower the level.

DRY ADJUSTMENT — INTERNALLY ADJUSTED FLOAT

The dry adjustment is the only float or fuel level adjustment performed on the internally adjusted float units. If making this adjustment with the carburetor installed on the vehicle, place a container under the fuel bowl cover assembly. This will collect spillage when removing the cover assembly. Do not spill fuel on a hot engine as a fire may result. Remove the fuel bowl cover assembly and invert it. When inverted, the lower surface of the float should be parallel with the bottom of the fuel bowl cover (Fig. 11).Bend the tab on the float arm to adjust the float angle. Install fuel bowl cover assembly.

NOTE: When installing the fuel bowl cover assembly the gasket between the metering block and cover must be installed correctly. The accelerating pump passage is at the lower right of the metering block. The gasket must be installed with the hole in the gasket over this passage to prevent blocking the passage.

When installing the fuel bowl equipped with spring screws lightly lubricate the screws. Then tighten the screws alternately from side to side. Tighten each screw until the screw assembly bottoms in the main body. When bottomed, the screw head will spring back a quarter of a turn when the screwdriver is removed. Do not overtighten or the springs on the screw assemblies may be damaged.

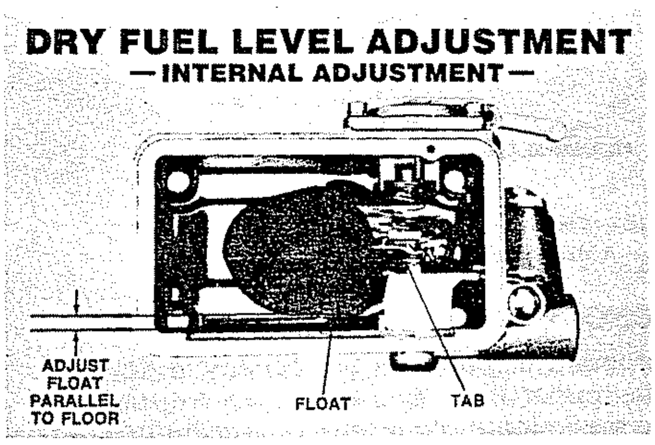


FIG. 11 — DRY ADJUSTMENT — INTERNALLY ADJUSTED FLOAT

CHECKING FUEL LEVEL — INTERNALLY ADJUSTED FLOAT

On internally adjusted floats, fuel level may be checked without removing the fuel bowl cover through the use of the Kent-Moore wet level gauge, number J10193 and a long screw that is included in the kit. Install an O-ring on the long screw and install the screw through the hole in the gauge. Install O-rings on both ends of the spacer that comes with the gauge, and place the spacer on the screw. Place a container under the fuel bowl to catch any spillage. Do not let any fuel spill on a hot engine as a fire will result. Remove either lower screw from the fuel bowl and quickly cover the hole to prevent excess spillage. Quickly install the long screw and gauge assembly to minimize spillage, and tighten the screw just enough to prevent spillage (Fig. 12). Run the engine for a few seconds until the fuel level in the gauge stabilizes. Stop the engine and read the gauge. Compare to specifications and adjust if necessary.

NOTE: Be careful when removing the gauge and reinstalling the screw not to spill any fuel on a hot engine as a fire may result.

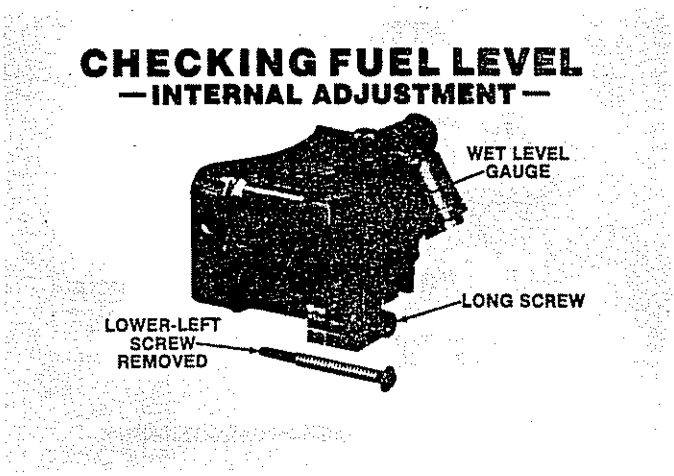


FIG. 12 — CHECKING FUEL LEVEL WITH KENT-MOORE GAUGE

ACCELERATING PUMP OVERRIDE SPRING ADJUSTMENT

To adjust the accelerating pump clearance, hold the throttle plates wide open and fully depress the pump lever. Install a .015" feeler gauge between the adjusting screw head and the pump arm (Fig. 13). Turn the adjusting screw "in" to increase the clearance or "out" to decrease the clearance. One-half turn of the screw equals .015".

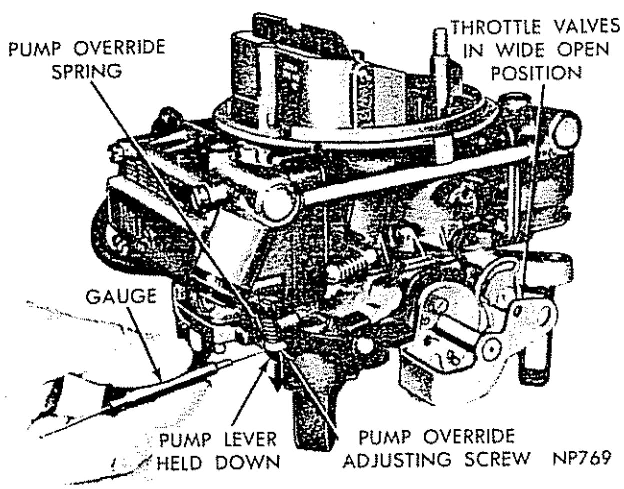


FIG. 13 — PUMP OVERRIDE SPRING ADJUSTMENT

ACCELERATING PUMP STROKE

The accelerating pump stroke adjustment is controlled by the position of the accelerating pump cam behind the primary throttle lever. The adjustment is made by placing the throttle screw in one of two numbered holes on the throttle lever (Fig. 14). Hole number two delivers maximum fuel through maximum pump stroke. Use the specified hole for carburetor application.

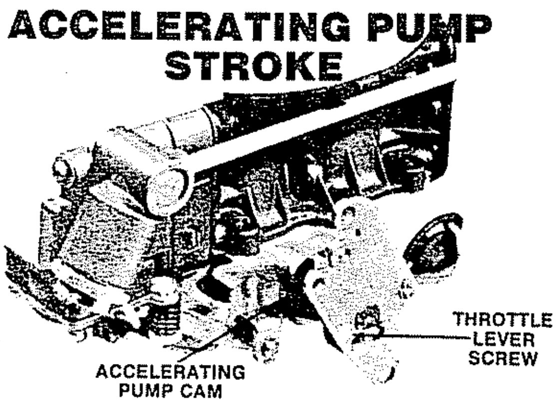


FIG. 14 — ACCELERATING PUMP STROKE ADJUSTMENT

SECONDARY THROTTLE STOP ADJUSTMENT

To adjust the secondary throttle stop, hold the secondary throttle plates fully closed and turn the throttle shaft lever adjusting screw counterclockwise until the secondary throttle plates seat in the throttle bore (Fig. 15). Turn the screw clockwise until it just contacts the secondary throttle shaft lever. Finally turn the screw clockwise one-quarter turn.

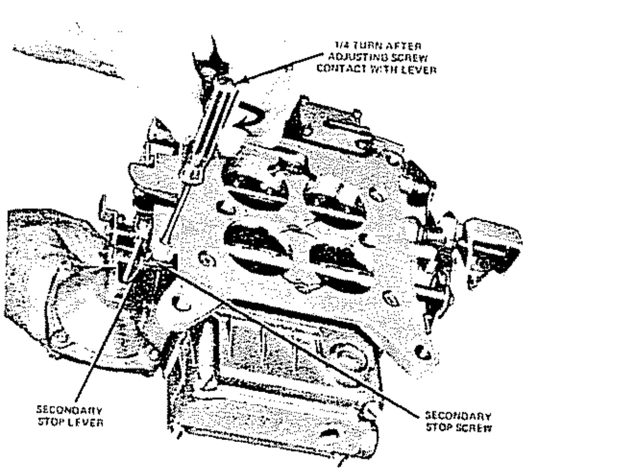


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FIG. 15 — SECONDARY THROTTLE STOP ADJUSTMENT

CHOKE PLATE CLEARANCE (PULLDOWN) ADJUSTMENT

To perform the choke plate clearance (pulldown) adjustment, first remove the plastic choke thermostat housing cover. To check if clearance adjustment is necessary, bend a paper clip. The paper clip should be .030" to .036" in diameter and the bent end should be no longer than 1/8". Insert this bent end into the piston bore in the choke housing until the end of the bore slot is hooked onto the paper clip (Fig. 16). Make sure that the bimetal lever is in contact with the piston lever adjusting tab. Move the piston and levers to close the choke until the edge of the piston slot engages the end of the paper clip. Measure the pulldown clearance by inserting a twist drill of the specified size between the choke plate and air horn. If adjustments are necessary, bend the adjusting lever tang until specified measurement is attained.

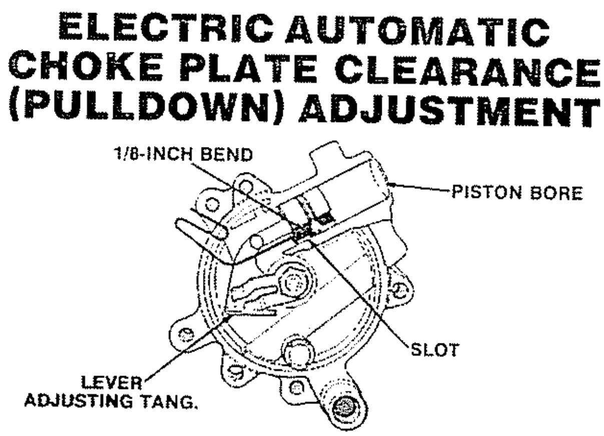


FIG. 16 — CHOKE PLATE CLEARANCE (PULLDOWN) ADJUSTMENT

DECHOKE CLEARANCE ADJUSTMENT

The choke unloader is a mechanical device to partially open the choke at wide open throttle. It is used to eliminate choke enrichment during cranking of an engine. Engines which have been flooded or stalled by excessive choke enrichment can be cleared by use of the unloader.

To check the dechoke clearance, hold the throttle plate in the wide open position. Move the choke towards the closed position until the pawl on the fast idle speed lever contacts the fast idle cam. Insert a twist drill of the specified diameter between the upper edge at the choke plate and the inner wall of the air horn (Fig. 17). A slight drag should be felt as the twist drill is withdrawn. If adjustment is necessary, bend the indicated throttle lever tang until the correct opening has been obtained.

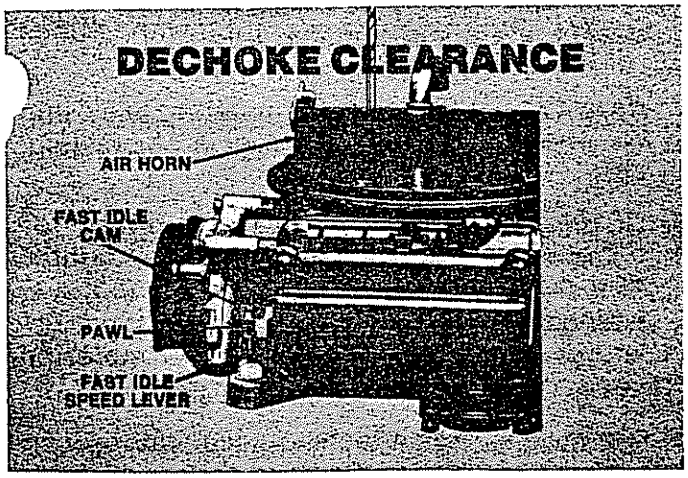


FIG. 17 — DECHOKE CLEARANCE ADJUSTMENT

AUTOMATIC CHOKE THERMOSTATIC SPRING HOUSING ADJUSTMENT

To adjust the spring housing, first remove the air cleaner, so the housing is accessible. Loosen the three screws in the clamp that retains the spring housing. Turn the spring housing so the aligning mark on the housing is in line with the choke housing index mark (Fig. 18). Tighten the screws.

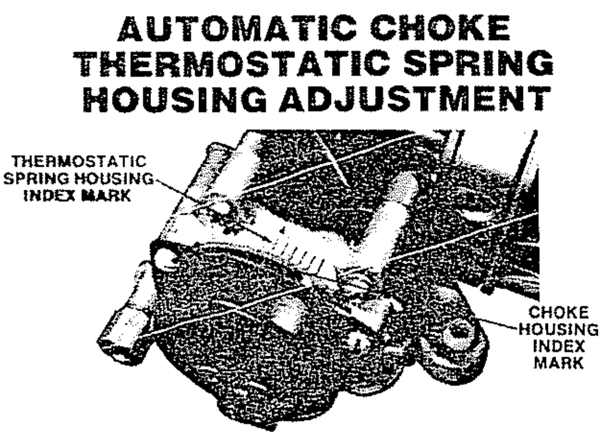


FIG. 18 — AUTOMATIC CHOKE THERMOSTATIC SPRING HOUSING ADJUSTMENT

IDLE SPEED ADJUSTMENT

To adjust idle speed install a tachometer on the engine. Run the engine 5-10 minutes at a fast idle or until normal operating temperature is reached. Make sure the idle speed screw is in contact with the throttle lever tang. Turn the idle speed screw until the specified RPM is reached (Fig. 19). Turn the idle speed screw "in" to increase idle speed. Turn the idle speed screw "out" to decrease idle speed. After adjusting the idle speed screw, rapidly pull back on the throttle lever and release. Throttle speed should increase and return to normal.

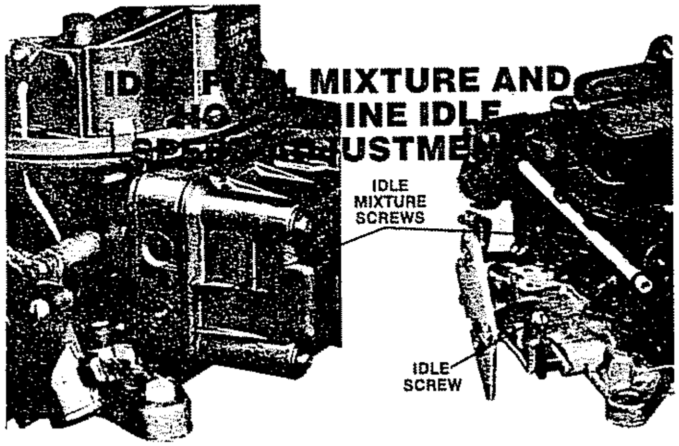


FIG. 19 — IDLE FUEL MIXTURE AND IDLE SPEED ADJUSTMENT

IDLE FUEL MIXTURE ADJUSTMENT

There are two idle mixture screws on the four-barrel carburetor. One needle is found on each side of the primary metering block (Fig. 19). Turn each screw "in" until it gently seats, then back each screw "out" 1½ turns. This will provide a preliminary setting, that can start the engine. Run the engine 5-10 minutes at a fast idle or until normal operating temperature is reached. Set the engine idle speed to specifications. Turn each idle mixture screw "in" until RPM drops from a lean mixture. Turn each screw "out" until RPM drops from a rich mixture. Finally turn each screw to a point somewhere between the two extremes where maximum engine smoothness and RPM is obtained. (Always try to keep each screw in proportion to the other in relation to the number of turns "out" or "in".) Always favor a rich setting over a lean one. Recheck idle speed and reset if necessary.

SERVICE PROCEDURES

Dirt, dust, water, gum and varnish deposits are some of the main causes of poor carburetor operation.

All parts **except** the diaphragms should be thoroughly cleaned in suitable solvent or commercial carburetor cleaner, then inspected for wear or damage.

All restrictions and channels should be blown out with air (see Figs. 20 and 35).

Experienced technicians develop their own order or method of disassembly. It is probably best for a beginner to break the carburetor down into subassemblies, keeping the related parts together. The most important tool or asset of any carburetor repairman is a keen sense of observation.

NOTE: Before disassembling any carburetor in this series place the carburetor on a suitable stand or legs. Legs can be made from four two-inch cap screws and eight nuts. Screw one nut on each cap screw about one inch from the end. Place in the mounting holes and install the other nut on the top. This procedure prevents nicks or damage to the throttle plates or shafts.

DISASSEMBLY

Many carburetors do not have all the hardward noted in the following steps.

1. Remove integral choke assembly and fast idle cam (if used) (Fig. 25).
2. Remove choke fast idle lever screw and lever, remove "E" clip, fast idle cam and lever (if used).
3. Remove secondary vacuum diaphgram assembly from carburetor body (Fig. 21).
4. Remove four fuel bowl screws and primary fuel bowl assembly by sliding straight off transfer tube (Fig. 26).
5. Remove primary metering body by sliding straight off dowels or balance tube.
6. Remove power valve using 1" wrench or power valve socket. Remove power valve gasket and pump transfer tube with O-rings (if used) from metering body (Fig. 28).
7. Remove gasket and main metering jets using ⅜" wide screwdriver or proper jet socket (Fig. 29).
8. Count and record exact number of "clockwise" turns to seat each screw lightly. The same number of turns must be maintained from the seat upon reinstallation. Remove screws and gaskets from metering body. Remove vent baffle (Fig. 29).
9. Remove screws attaching accelerator pump cover to fuel bowl. Remove cover and carefully remove pump diaphragm and spring (Fig. 30).
10. Remove fuel inlet fitting with screen or filter and gasket.
11. Externally Adjustable Needle and Seat: Remove the fuel inlet baffle and remove the retainer, float assembly and float spring (if spring is used). Remove the adjustment lock screw. Turn the adjustment nut counterclockwise. Remove the locknut, gasket, fuel inlet needle and seat.
12. Internal Needle and Seat: Remove float retainer "E" clip, then slide float and spring out of float chamber. Remove baffle, fuel inlet

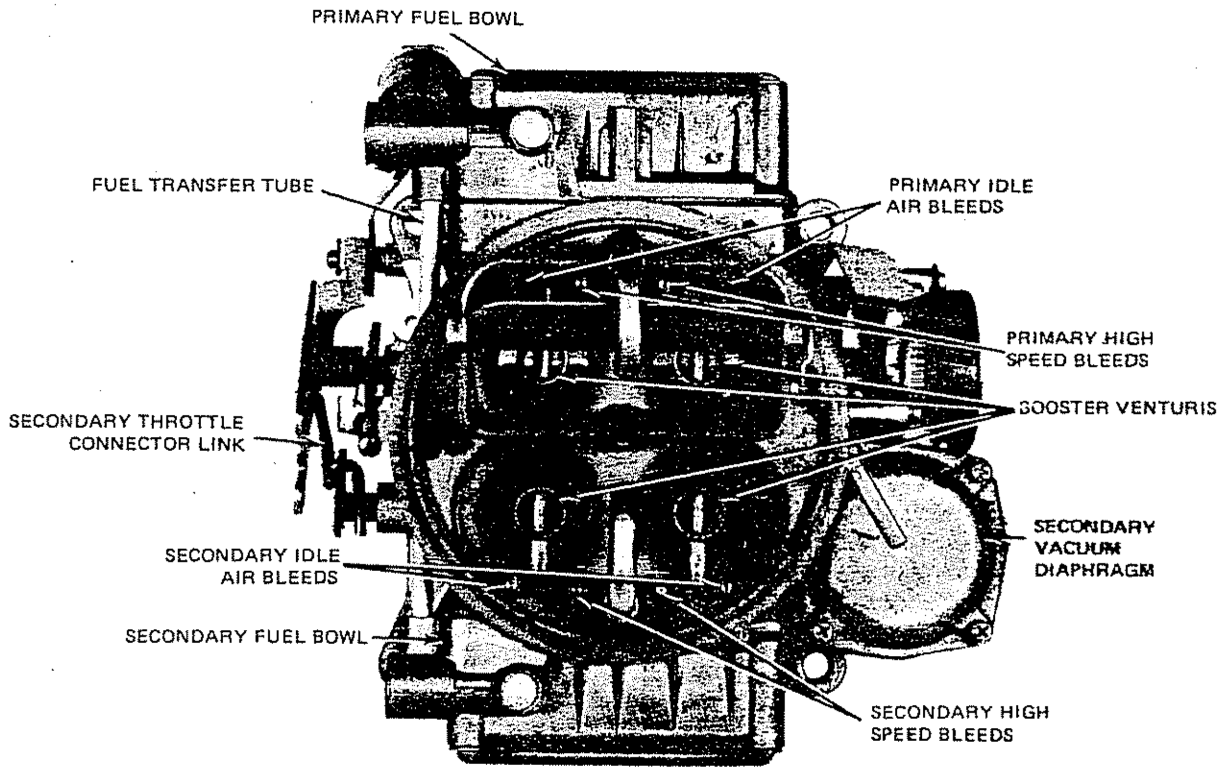


FIG. 20 — TOP VIEW, MODEL 4160, SHOWING IDLE AIR AND HIGH SPEED BLEEDS

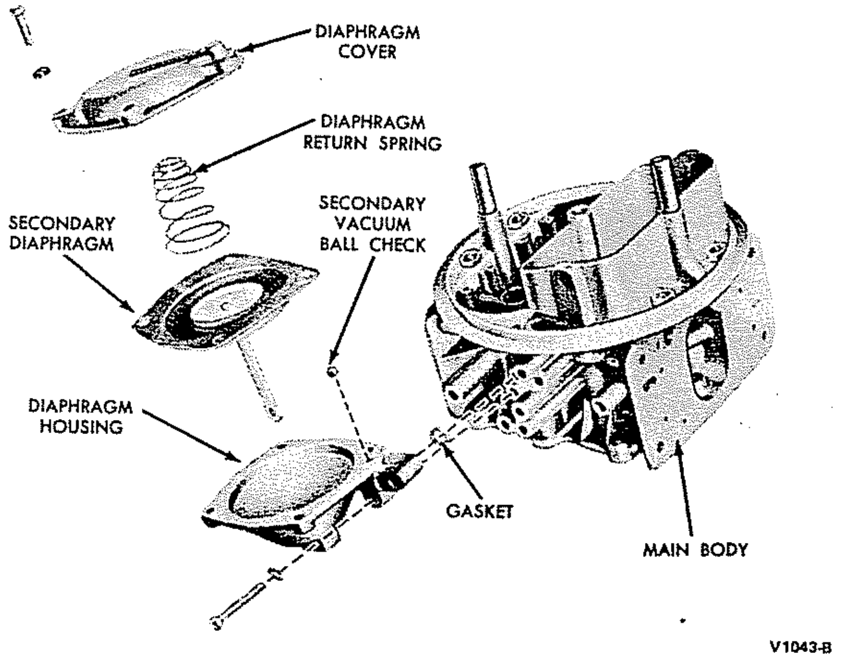


FIG. 21 — SECONDARY VACUUM DIAPHRAGM

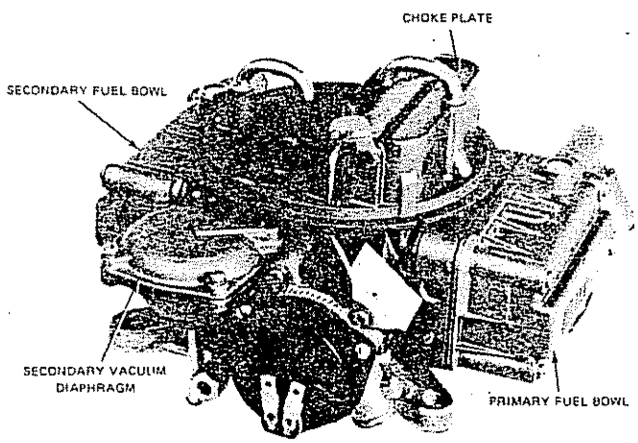


FIG. 22 — CHOKE HOUSING SIDE MODEL 4160, INTERNALLY ADJUSTED NEEDLE AND SEAT

valve and seat. Discard gasket (Fig. 32).

13. Remove the plastic accelerator pump inlet check valve (Fig. 31).
    NOTE: The ball type inlet check valve is not removable.
14. Remove secondary fuel bowl from carburetor body (Fig. 33).
    NOTE: Disassembly of the secondary fuel bowl is similar to the primary bowl.
    The fuel inlet baffles are not interchangeable.
15. Remove secondary metering body plate and gaskets from main body (Fig. 34).

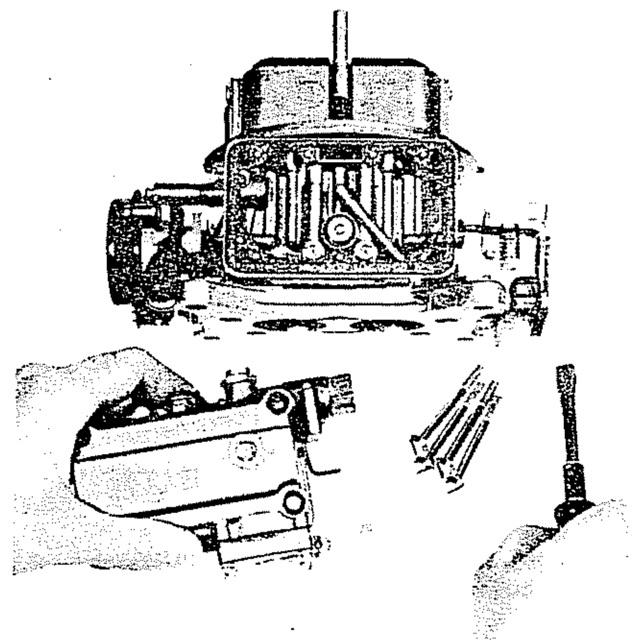


FIG. 23 — REMOVAL OR INSTALLATION OF PRIMARY FUEL BOWL

NOTE: A clutch head screwdriver must be used. Do not attempt to make one from a regular screwdriver. Remove balance tube washers and O-ring.

Model 4150 disassembly of the secondary metering body is similar to the disassembly of the primary metering body.

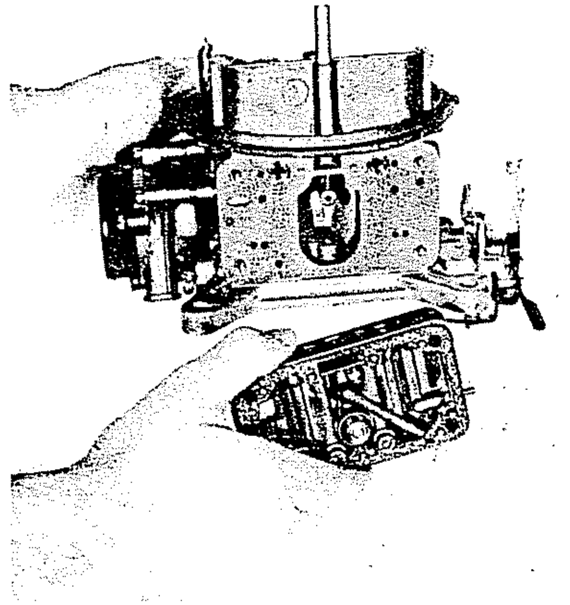


FIG. 24 — REMOVAL OR INSTALLATION OF PRIMARY METERING BODY

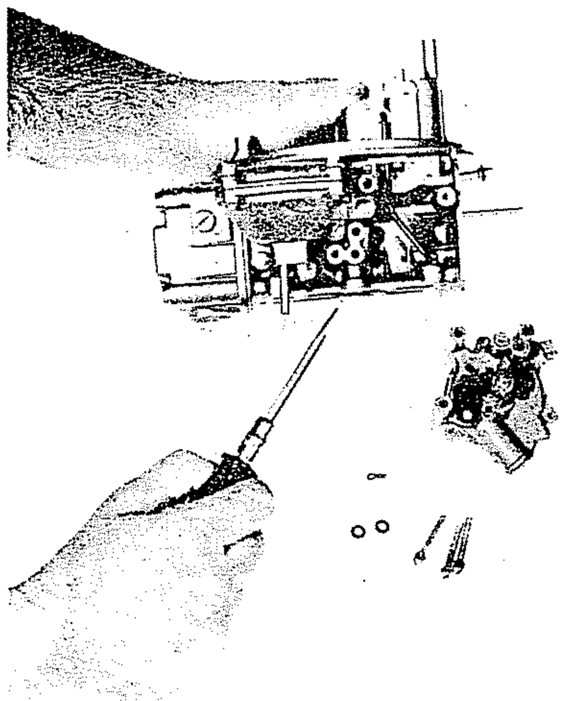


FIG. 25 — REMOVAL OR INSTALLATION OF INTERGAL AUTOMATIC CHOKE

16. Remove choke rod and seal. Unless the choke valve is bent or damaged, DO NOT remove.
NOTE: The choke plate screws are staked to prevent loosening and care is necessary to avoid breaking or stripping the threads in the choke shaft. If necessary to remove plate, remove staking with a file before loosening screws.

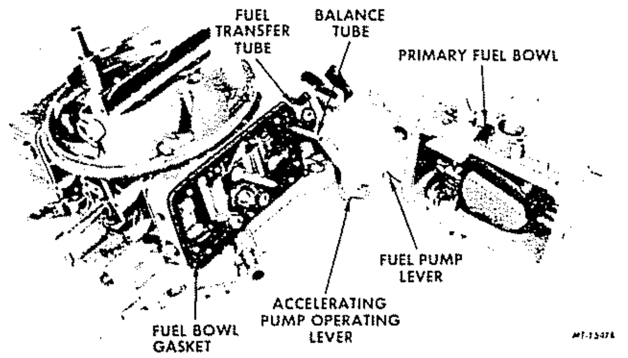


FIG. 26 — REMOVING OR INSTALLING PRIMARY FUEL BOWL

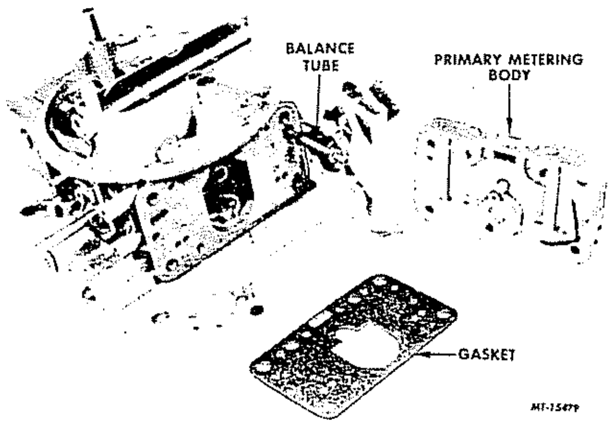


FIG. 27 — REMOVING OR INSTALLING PRIMARY METERING BODY (WITH PUMP TRANSFER TUBE)

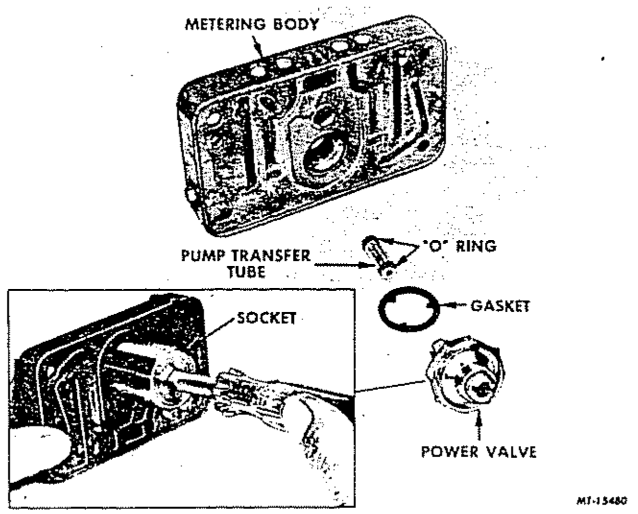


FIG. 28 — PRIMARY METERING BODY WITH ACCELERATION PUMP TRANSFER TUBE (DISASSEMBLED VIEW)

17. Remove pump discharge nozzle retaining screw, then lift out discharge nozzle. Remove gaskets from nozzle (top and bottom), invert carburetor and drop out pump discharge needle or check ball and weight from discharge passage.

18. Invert carburetor and remove the throttle body attaching screws. Remove the throttle body and gasket.
19. Disassemble the secondary diaphragm. *CAUTION: Loosen four screws carefully and free up cover to prevent catching edges of diaphragm in cover screws.*

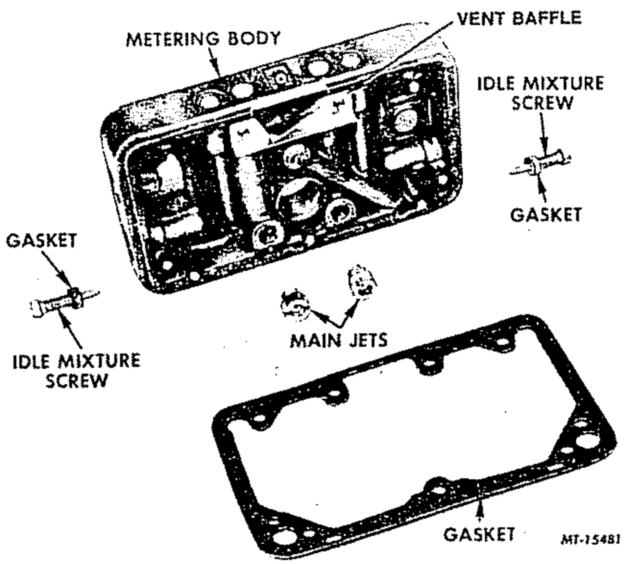


FIG. 29 — PRIMARY METERING BODY, FUEL BOWL SIDE (DISASSEMBLED VIEW)

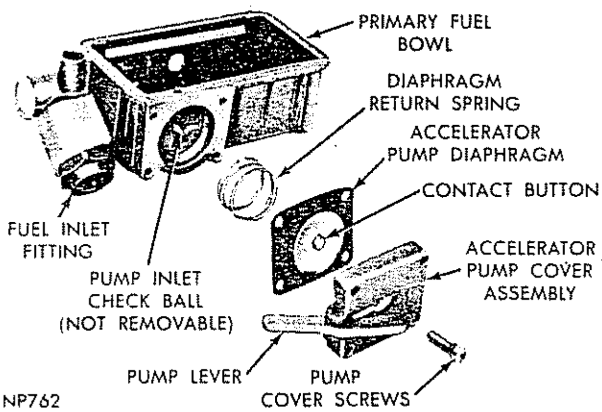


FIG. 30 — ACCELERATOR PUMP, DISASSEMBLED BALL CHECK VALVE

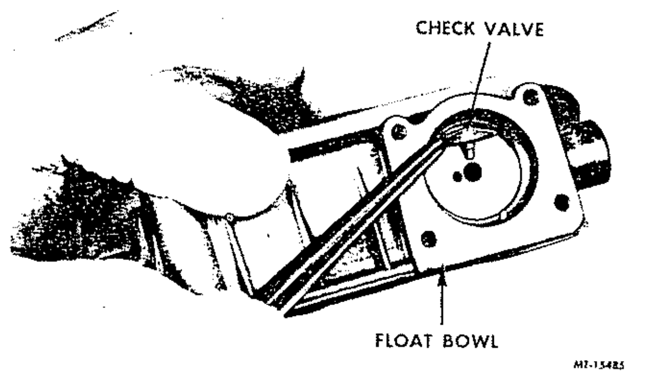


FIG. 31 — REMOVAL OR INSTALLATION OF THE PLASTIC PUMP INTAKE CHECK VALVE

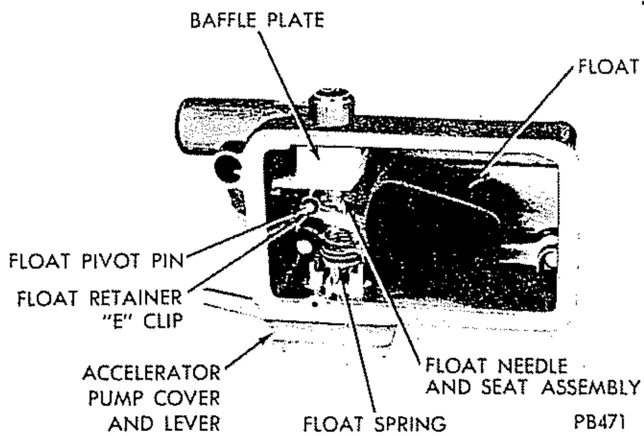


FIG. 32 — FUEL BOWL ASSEMBLY INTERNAL ADJUSTED NEEDLE AND SEAT

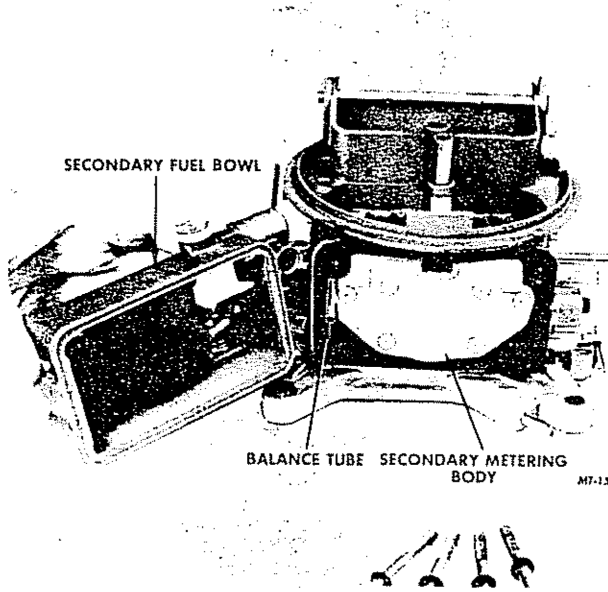


FIG. 33 — REMOVAL OR INSTALLATION OF SECONDARY FUEL BOWL (MODEL 4160)

ASSEMBLY

Make sure all holes in the new gaskets have been properly punched and that no foreign material has adhered to the gaskets. Make sure the accelerating pump diaphragm and the secondary operating diaphragm are not cut or torn.

ASSEMBLING PRIMARY METERING BODY

1. Install idle mixture screw gaskets in passages. Use head of screw to push into place.
   NOTE: Inspect mixture screws. If the tapered portion is grooved or ridged, a new mixture screw should be installed to insure ability to maintain the correct idle mixture. Turn screws in lightly against their seats. Back each screw out the exact number of turns recorded during disassembly (Fig. 29).

2. Install a new gasket on power valve and install with proper wrench or socket. Torque to 100 in-lbs. (Fig. 28).
3. Install main metering jets using proper screwdriver or jet wrench (Fig. 29).
4. Install fuel baffle (if used). Press metering body and fuel bowl gasket down firmly on the dowels (Fig. 29).
   CAUTION: Be sure you are using the correct metering body gasket and that bowl gasket is not covering the accelerator pump passage.

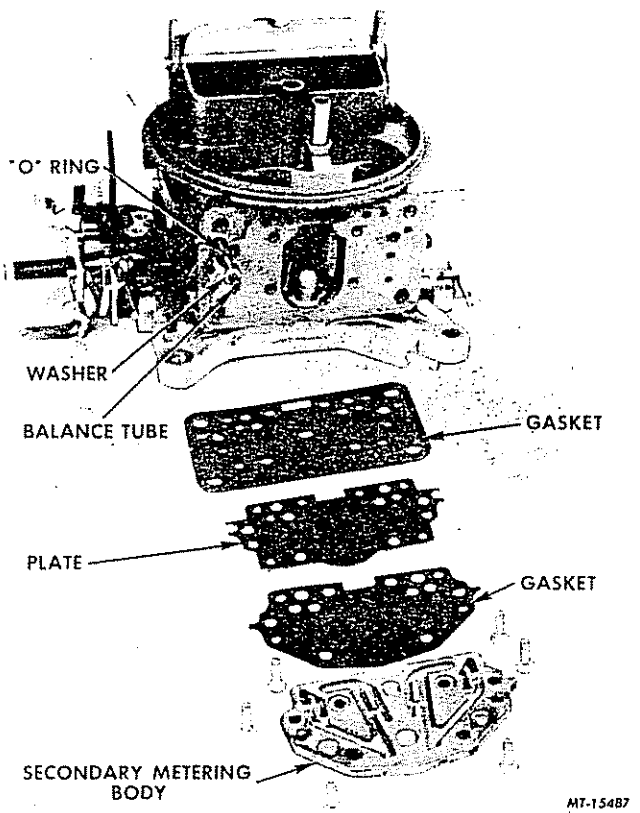


FIG. 34 — REMOVAL OR INSTALLATION OF SECONDARY METERING BODY (MODEL 4160)

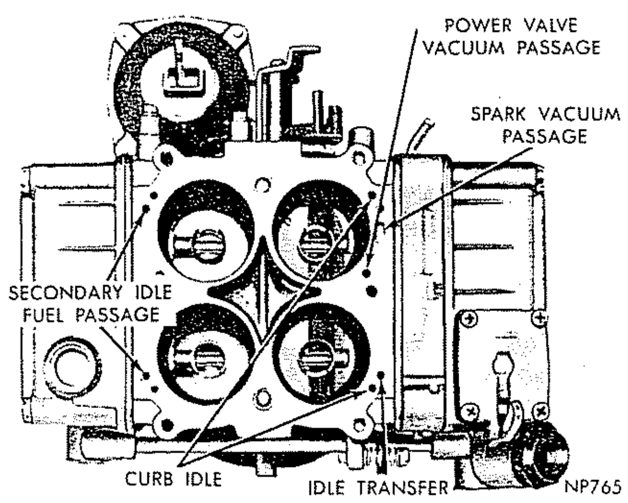


FIG. 35 — MAIN BODY PASSAGE IDENTIFICATION

ASSEMBLY FUEL BOWLS — (PRIMARY)

1. Install plastic accelerator pump check valve in fuel bowl (Fig. 31), (if used).
2. If ball type, check ball clearance under retaining bar is proper (Fig. 36).
3. Install pump diaphragm return spring, diaphragm and pump cover. Be sure diaphragm is centered and contact button is toward pump lever in cover. Install four attaching screws and tighten evenly.
4. External Adjusted Fuel Inlet Needle and Seat: Apply lubricating oil or petroleum jelly on a new O-ring seal and slide it on the needle and seat assembly.
5. Install the fuel inlet needle and seat assembly through the top of the fuel bowl. Then install the adjusting nut gasket. Align the flats of the seat and the adjusting nut and install the nut. Install the lock screw and gasket. Invert the bowl and turn the adjusting nut until top of float is parallel to top of bowl. This preliminary adjustment will run the engine until the fuel level can be properly checked through the sight plug hole after the carburetor has been installed on the engine (Fig. 37).
6. Slide the inlet baffle into the grooves (Fig. 37).
7. Install float spring (if used) on float lever and then install the assembly on the float shaft. Be sure spring is properly located on fuel bowl floor. Install the float retainer.
8. Install new gasket on fuel inlet fitting, install screen or filter element. Tighten fitting securely.

SECONDARY FUEL BOWL — (EXTERNAL NEEDLE AND SEAT)

Assemble the secondary fuel bowl by following Steps 4 through 8 under assembly primary fuel bowls.

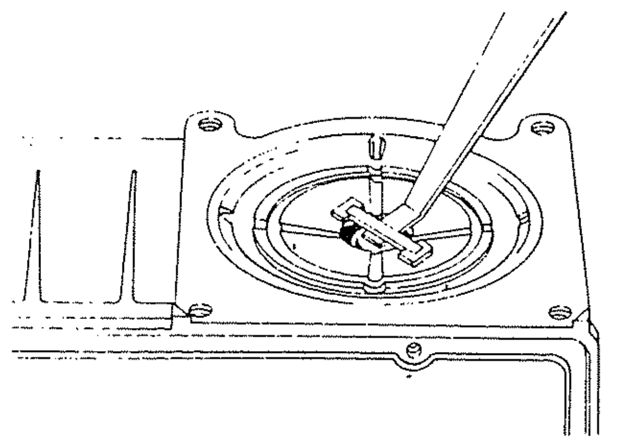


FIG. 36 — CHECKING PUMP INTAKE BALL VALVE CLEARANCE

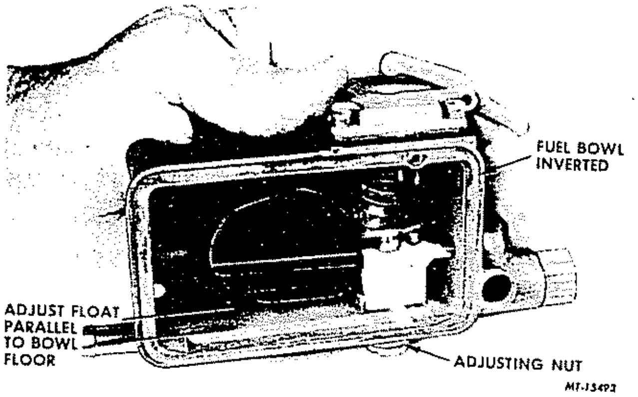


FIG. 37 — PRELIMINARY FLOAT ADJUSTMENT EXTERNALLY ADJUSTABLE FUEL INLET VALVE — INTERNALLY ADJUSTED FUEL INLET IS SIMILAR

FUEL BOWLS WITH INTERNAL FUEL INLET NEEDLE AND SEAT

Disregard Steps 4 and 5 under external adjusting needle and seats.

1. Install gasket on fuel inlet seat and install in fuel bowl.
2. Tighten securely with proper wrench.
3. Install fuel inlet needle.
4. Install float assembly as described under Step 7. To adjust the dry float setting (internal needle and seat), adjust float parallel to bowl floor as illustrated in (Fig. 37). If an adjustment is necessary, carefully bend float tang until proper adjustment has been obtained using care not to nick or damage portion of tang which contacts needle.

ASSEMBLING MAIN BODY

1. Place a new gasket on throttle body, then lower main body down on throttle body.
   NOTE: Be sure the gasket fits the throttle body and main body.
2. Hold assembly together, invert assembly and install attaching screws.
   CAUTION: Primary throttle bores must be on primary venturi side (choke side).
   Install levers, springs and screws into throttle body. Torque attaching screws evenly in stages to 50 in-lbs. (Fig. 38).
3. Install accelerator pump discharge needle or ball and weight (if used) in pump discharge passage under choke valve.
4. Install pump discharge nozzle gasket on nozzle screw, install nozzle, second gasket and install assembly in position. Tighten screw securely.

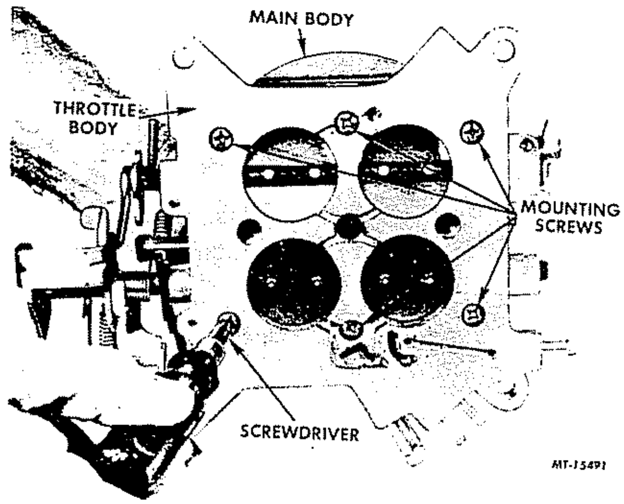


FIG. 38 — INSTALLING AND TORQUING THROTTLE BODY SCREWS

MODEL 4160 ASSEMBLY

1. Install balance tube into main body.
   CAUTION: Install new o-rings and washers at each end. Be sure O-rings and washers are seated in recesses on both primary and secondary side (Fig. 39); otherwise fuel leakage will occur.
2. Install a new secondary metering body (plate) to main body gasket followed by the metering body (plate) (Fig. 34). Install six clutch head screws. Tighten evenly and securely with a proper clutch head screwdriver.
3. Position balance tube (if so equipped) so that only 1" extends beyond the secondary metering body (Fig. 39).

PRIMARY BOWL AND METERING BODY ASSEMBLY

1. If metering body and bowl gaskets were not installed previously under No. 4, describing assembly primary metering body (also secondary on model 4150), do so now. Press gaskets down firmly on dowels, not only to hold them in place but to prevent bowl gasket from interfering with the float (Figs. 27 and 29).
2. Install eight bowl screw gaskets on the screws. NOT IN THE RECESSES.
   NOTE: This prevents shearing off gasket fibers which could enter the fuel bowl and partially stop up a main metering jet.
3. Carefully install primary metering body over balance tube (if used) and press firmly on dowels (Fig. 40).

4. Install fuel bowl on metering body, positioning pump lever in proper position over pump operating lever.

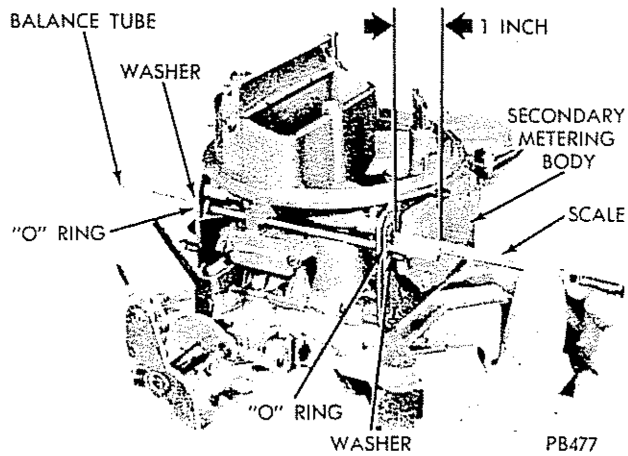


FIG. 39 — ADJUSTING BALANCE TUBE MODEL 4160

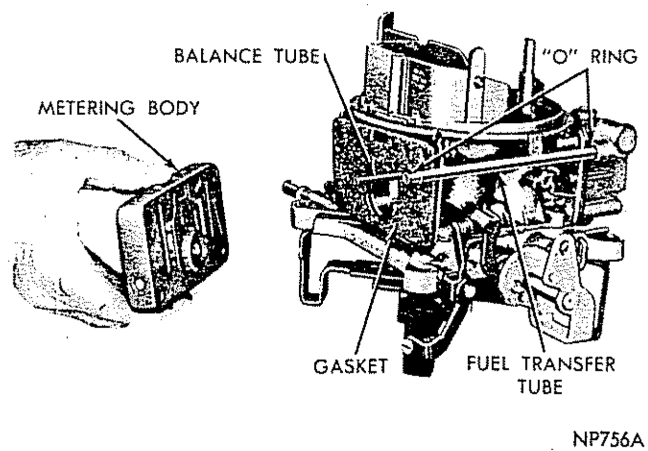


FIG. 40 — INSTALLING PRIMARY METERING BODY (MODEL 4160)

Carefully install four bowl screws and gaskets and torque all bowl screws evenly in stages to specification.

5. Install a new O-ring on the extreme end of each end of fuel transfer tube. Apply petroleum jelly lightly on O-ring and install transfer tube into opening in primary fuel bowl. The O-ring will roll into proper position as tube is installed (Fig. 27).

MODEL 4150 SECONDARY BOWL AND METERING BODY ASSEMBLY

The secondary metering body of the Model 4160 was installed under "2", Model 4160 assembly.

1. Install secondary metering jets, power valve (if used) and bowl vent (if used). Install metering body gaskets. Press firmly on metering body. Install bowl gasket on face of metering body. Press down firmly on the nine dowels, similar to the primary installation.
2. Carefully slide secondary fuel bowl on fuel transfer tube and seat on gasket. Install four bowl screws and gaskets and torque evenly in stages to specification.
3. Install accelerator pump discharge needle or ball and weight (if used) in pump discharge passage (in air horn).
4. Install pump discharge nozzle gasket on nozzle screw, install nozzle, second gasket and install assembly in position. Tighten screw securely.

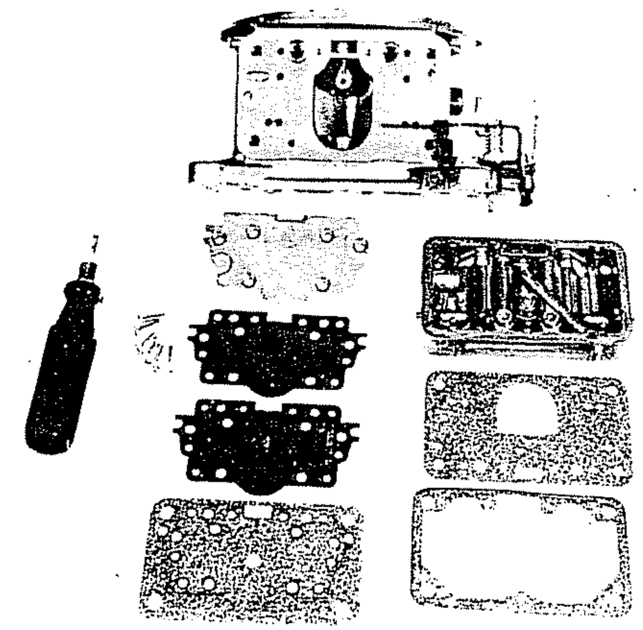
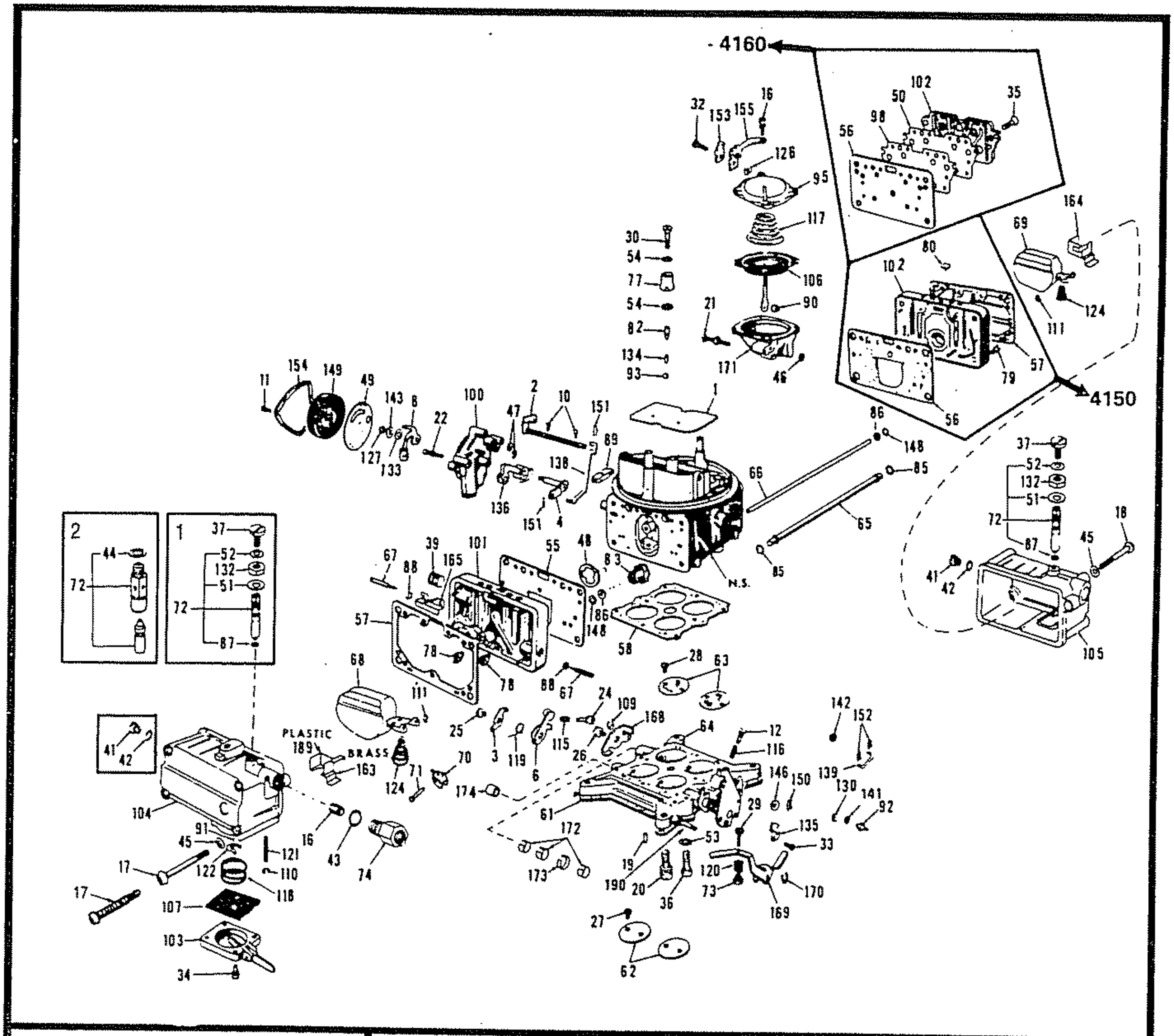
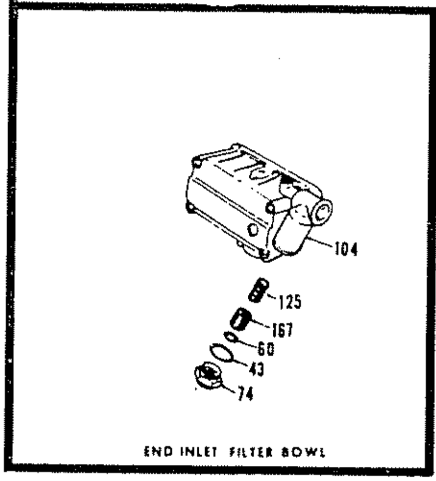


FIG. 41 — COMPARISON SECONDARY METERING BODIES MODEL 4160 LEFT — MODEL 4150 RIGHT

ASSEMBLING SECONDARY DIAPHRAGM (FIG. 21)

1. Position diaphragm in lower housing so that the diaphragm vacuum hole is aligned with vacuum hole in lower cover.
2. Install diaphragm return spring with small end snapped over botton in cover.
3. Stand diaphragm stem and lower housing in a socket or support to keep the diaphragm in position as the spring and cover are installed.
4. Align vacuum port in cover with port in housing. Install cover and four cover screws. Tighten securely.
5. Check diaphragm by pressing in on stem and placing finger over port. Diaphragm should stay in retracted position.
6. Install new gasket in vacuum passage recess in diaphragm housing. Engage diaphragm in secondary lever. Install housing on carburetor body, install screws and tighten securely.





1 EXTERNALLY ADJUSTED NEEDLE AND SEAT
2 INTERNAL NEEDLE AND SEAT

FIG. 45 — EXTERNALLY ADJUSTED NEEDLE AND SEAT

TYPICAL NOMENCLATURE

Index Number	Part Name
1	Choke Plate
3	Fast Idle Pick-up Lever
4	Choke Housing Shaft & Lever Assy.
8	Choke Therm. Lev., Link & Piston Assembly
10	Choke Plate Screw
11	Therm. Housing Clamp Screw
12	Throttle Stop Screw
16	Sec. Diaph. Assy. Cov. Scr. & L. W.
17	Fuel Bowl to Main Body Screw - Primary
18	Fuel Bowl to Main Body Screw - Secondary
19	Diaph. Lever Adjusting Screw
20	Throt. Body Screw & Lock Washer
21	Diaph. Hsg. Assy. Scr. & L. W.
22	Choke Housing Screw & L. W.
26	Diaph. Lev. Assy. Scr. & L. W.
27	Throt. Plate Screw - Primary
28	Throt. Plate Screw - Secondary
29	Pump Lever Adjusting Screw
30	Pump Discharge Nozzle Screw
33	Pump Cam Lock Screw
34	Fuel Pump Cov. Assy. Scr. & L. W.
35	Secondary Metering Body Screw
36	Throt. Body Screw - Special
37	Fuel Valve Seat Lock Screw
41	Fuel Level Check Plug
42	Fuel Level Check Plug Gasket
44	Fuel Valve Seat Gasket
45	Fuel Bowl Screw Gasket
46	Sec. Diaphragm Housing Gasket
47	Choke Housing Gasket
49	Choke Thermostat Housing Gasket
50	Sec. Metering Body Plate Gasket
51	Fuel Valve Seat Adj. Nut Gasket
52	Fuel Valve Seat Lock Screw Gasket
53	Throt. Body Screw Gasket
54	Pump Discharge Nozzle Gasket
55	Metering Body Gasket - Primary
56	Metering Body Gasket - Secondary
57	Fuel Bowl Gasket
58	Throttle Body Gasket
60	Fuel Inlet Filter Gasket

Index Number	Part Name
61	Flange Gasket
62	Throttle Plate - Primary
63	Throttle Plate - Secondary
64	Throt. Body & Shaft Assembly
65	Fuel Line Tube
67	Idle Adjusting Needle
68	Float & Hinge Assy. - Primary
69	Float & Hinge Assy. - Secondary
73	Pump Lever Adjusting Screw Fitting
77	Pump Discharge Nozzle
78	Main Jet - Primary
82	Pump Discharge Needle Valve
83	Power Valve Assy. - Primary
85	Fuel Line Tube "O" Ring Seal
87	Fuel Valve Seat "O" Ring Seal
88	Idle Needle Seal
89	Choke Rod Seal
90	Diaphragm Housing Check Ball-Sec.
91	Pump Inlet Check Ball
92	Throttle Lever Ball
93	Pump Discharge Check Ball
95	Sec. Diaphragm Housing Cover
98	Secondary Metering Body Plate
99	Air Vent Cap
100	Choke Hsg. & Plugs Assembly
101	Main Metering Body & Plugs Assy.- Primary
102	Main Metering Body & Plugs Assy.- Secondary
103	Fuel Pump Cover Assembly
104	Fuel Bowl & Plugs Assy.-Primary
106	Secondary Diaph. & Rod Assy.
107	Pump Diaphragm Assembly
109	Secondary Diaph. Link Retainer
110	Air Vent Rod Spring Retainer
111	Float Retainer
113	Choke Control Lever Retainer
115	Fast Idle Cam Lever Screw Spring
116	Throttle Stop Screw Spring
117	Secondary Diaphragm Spring
118	Diaphragm Return Spring
119	Fast Idle Cam Lever Spring
120	Pump Lev. Adj. Screw Spring
122	Pump Inlet Check Ball Ret. Spring
124	Float Spring - Pri. & Sec.
125	Fuel Inlet Filter Spring

Index Number	Part Name
127	Choke Thermostat Shaft Nut
	Throttle Lever Ball Nut
132	Fuel Valve Seat Adj. Nut
133	Choke Thermostat Lever Spacer
134	Pump Check Ball Weight
135	Pump Cam
138	Choke Rod
139	Throttle Connecting Rod
141	Throttle Lev. Ball Nut Washer
143	Choke Shaft Nut Lock Washer
149	Therm. Hsg. Assy. - Complete
150	Throt. Connector Pin Retainer
151	Choke Rod Retainer
152	Throt. Connecting Rod Cotter Pin
154	Thermostat Housing Clamp
161	Filter Screen
163	Baffle Plate - Primary (Brass)
164	Baffle Plate - Secondary
165	Metering Body Vent Baffle
167	Fuel Inlet Filter
168	Diaphragm Lever Assembly
169	Pump Operating Lever
170	Pump Operating Lever Retainer
171	Secondary Diaphragm Housing
172	Throt. Shaft Brg. Pri. & Sec. (Ribbon)
173	Throt. Shaft Brg. Pri. & Sec. (Ribbon)
174	Throt. Shaft Bearing - Pri. (Solid)
189	Baffle Plate - Primary (Plastic)
***	Fuel Valve Clip
190	Pump Oper. Lever Stud

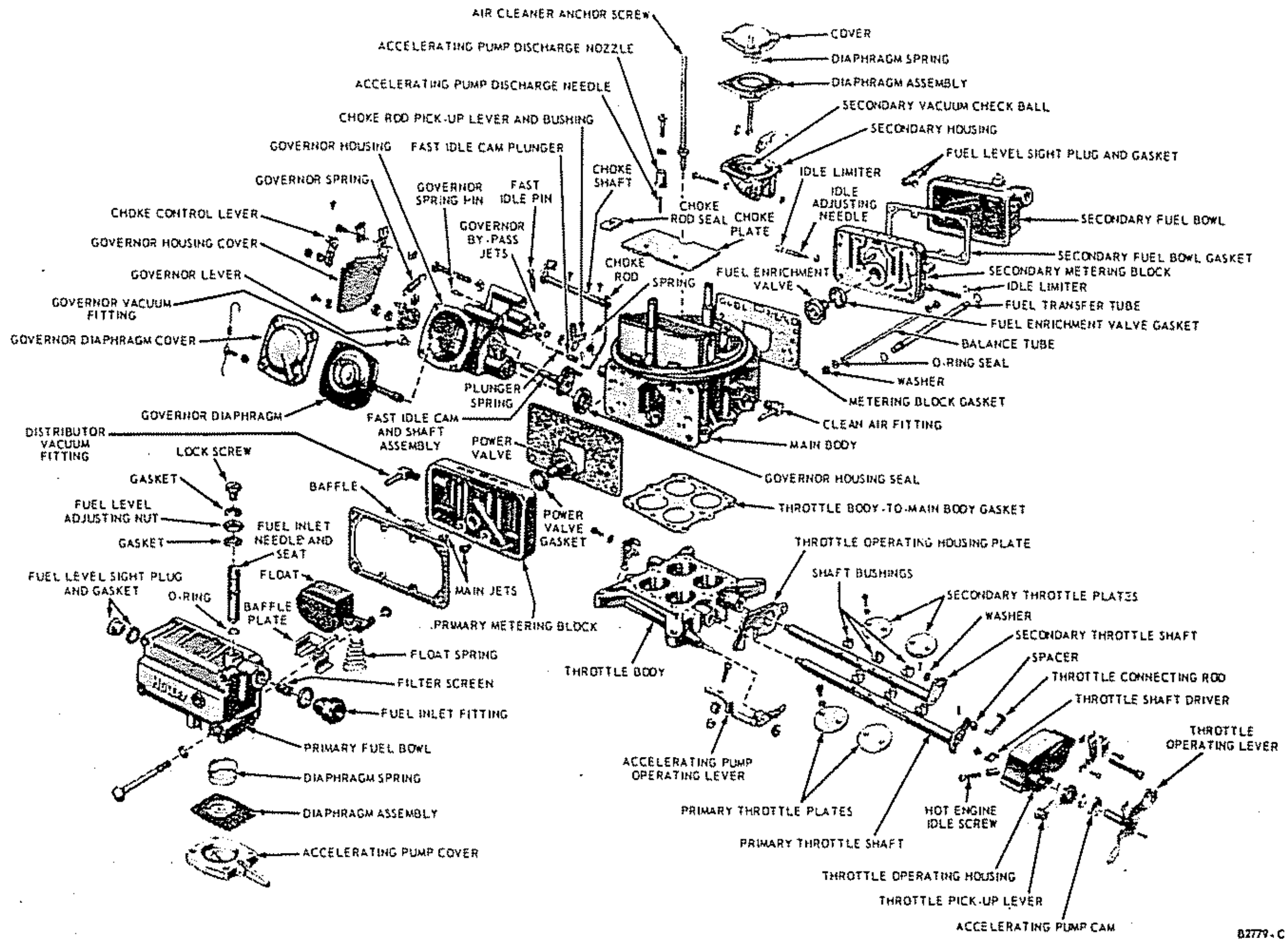


FIG. 46 — CARBURETOR ASSEMBLY — 4150 WITH GOVERNOR

TROUBLESHOOTING

Many problems attributed to the carburetor are caused by other vehiclé systems. Proper and careful diagnosis is a must.

If the problem seems to occur in one engine cylinder, the ignition system may be at fault. If the problem seems to occur in all engine cylinders, then the problem could be carburetion. When carburetion is thought to be at fault, check the fuel system first. Dirt or water in the gas tank often show the same sympthoms as carburetion problems. Pressure and volume tests, and observation will determine if the fuel system is the cause of the problem.

ıly disassemble the carburetor when positive that disassembly will correct the problem. Make sure all other causes have been eliminated. Often a simple solution is overlooked, and carburetor teardown results in wasted time and effort.

FLOODING

A simple cause of flooding is the use of an improper starting procedure on the part of the operator. Causes requiring a disassembly of the unit are; high fuel level or float setting, a fuel inlet needle not seating properly due to a worn needle or seat, a loose fuel inlet needle valve seat, or a sticking or restricted float operation.

HARD STARTING

Hard starting when attributed to the carburetor is often due to improper starting procedure causing a flooded engine. If used, check to see if the choke linkage is binding. Also check to see if the choke plate is binding. Observe if the setting on the thermostatic spring housing is correct. Check for the correct carburetor gasket or spacer combinations. On disassembly of the carburetor, check the fuel level or if the fuel inlet needle is sticking or incorrectly seating.

STALLING

Stalling can be caused by the following whether the engine is hot or cold: idle speed set too low, incorrect idle fuel mixture, dirt, water, or ice in the fuel filter, carburetor icing (cold, wet or humid weather) or a leaking manifold or carburetor gasket. On the carburetor body check for excessive looseness of the throttle shaft in the throttle body, or clogged air bleeds or idle passages.

ROUGH IDLE

Rough idle is caused by a number of items. On items not requiring disassembly of the carburetor check for: an improperly adjusted idle air/fuel mixture, an idle mixture adjustment needle screw that is grooved, worn or otherwise damaged or an air leak between the carburetor and intake manifold due to looseness or a leaking gasket.

On disassembly of the carburetor check for: an improper fuel level or float setting, restricted idle air bleeds or fuel passages, bent or damaged throttle plates or shaft, or a leaking power valve, power valve gasket or diaphragm.

SURGING ABOVE IDLE SPEED

The causes of surging not requiring carburetor disassembly are: low fuel pump pressure or volume, or a clogged fuel filter or filter screen.

The causes requiring carburetor disassembly are: low fuel level or float setting, a clogged main jet, or a main jet not suited to the engine application.

HESITATION ON ACCELERATION

Hesitation can be defined as when the engine hesitates or develops a flat spot upon acceleration. Hesitation can be caused by an air/fuel mixture that is either too lean or too rich.

Hesitation due to a lean mixture, not requiring carburetor disassembly can result from: an incorrect accelerating pump stroke adjustment, low fuel pump pressure, an air leak between the carburetor and intake manifold, or an air leak at the throttle shaft due to a worn throttle shaft.

Those causes corrected by carburetor disassembly are: sticking inlet needle, a restriction in the main fuel passage, defective accelerating pump diaphragm, accelerating pump fuel inlet valve not seating upon acceleration, accelerating pump discharge valve ball check or weight not fully coming off its seat or failing to seat properly on the reverse stroke of the pump diaphragm, an air leak at the accelerating pump cover caused by a damaged gasket or warped pump cover, a restriction in the accelerating pump discharge passage or a stuck power valve.

On hesitation due to a rich mixture the causes that do not require carburetor disassembly are: excessively dirty air filter, incorrect accelerating pump adjustment, a malfunctioning automatic choke, or excessive fuel pump pressure.

The causes of hesitation due to a rich mixture that are corrected by carburetor disassembly are: high fuel level or float setting, fuel inlet needle not seating properly due to a worn needle or seat, restriced air bleeds, power valve leakage, a broken power valve spring, an accelerating pump outlet ball that is not seating properly or a damaged main metering jet.

REDUCED TOP SPEED

Reduced top speed is the inability to operate at full capacity. The causes that do not require carburetor disassembly are: improper throttle linkage adjustment, faulty choke operation, or an excessively dirty air filter.

Those causes requiring carburetor disassembly are: an incorrect float level, a restriction in the main fuel passage, an improper size or restricted main jet, restricted air bleeds, or an inoperative power valve.

SECONDARIES DON'T OPEN

Secondaries not opening is a problem relating to four-barrel carburetors. It can be caused by sticking secondary throttle plates, a ruptured or leaking secondary diaphragm or plugged venturi vacuum ports.

SPECIAL TOOLS

Kent-Moore — For Model 1940 — J-10237-02 Staking Tool

Kent-Moore — For Two- and Four-Barrel Models — J-10193 Fuel Level Gauge

Tools available from:

Kent-Moore Corporation
1501 S. Jackson
Jackson, Michigan 49203
1-517-784-8561

TORQUE SPECIFICATION

Air Cleaner Studs (Flame Arrester)	30 in-lbs	Throttle Plate and Secondary Plate Screws	10 in-lbs
Air Horn/Main Body Screws	10 in-lbs	Fuel Inlet Seat	10 in-lbs
Choke Housing Screws	5 in-lbs	Main Jet	10 in-lbs
Choke Plate Screws	6 in-lbs	Power Valve Cover	10 in-lbs
Fast Idle Cam Nut	10 in-lbs	Pump Discharge Nozzle Screw	15 in-lbs
Fuel Inlet Screen Nut	60 in-lbs	Fuel Bowl Screws (Standard)	45 in-lbs
Idle Jet	10 in-lbs	(Spring Type)	1/4 Turn Return
Pump Diaphragm Cover Screws	5 in-lbs		
Secondary Shaft Nut	10 in-lbs		

CARBURETOR SPECIFICATIONS

CARBURETORS	D2JL C	D2JL E	D3JL S	D4JL F	D4JL G	D1FF TA	D4JL J
Carburetor Size							
Throttle Bore Diameter							
Primary —	1.5	1.5625	1.50	1.5	1.5610*	1.687	1.686
Secondary —	1.5	1.5625	—	1.5	1.5610	1.687	1.686
Venturi Diameter							
Primary —	1.094	1.250	1.187	1.094	1.250	1.375	1.375
Secondary —	1.094	1.3125	—	1.094	1.312	1.437	1.437
Fuel System							
Fuel Level (Wet)	①	①	③ ⑤	③ ⑤	④ ⑤	①	③ ⑤
Float Level (Dry)	②	②	②	②	②	②	②
Main Metering System							
Main Jet							
Primary —	#58	#64	#60	#582	#622	#72	#722
Secondary —	N/A	N/A	—	N/A	N/A	#84	N/A
Power Valve	85	50	50	85	25	85	85
Idle Mixture (Prelim. Setting)	1½	1½	1½	1½	1½	1½	1½
Accelerator Pump System							
Capacity — cc/10 Strokes	21-31	25-35	25-35	21-31	22-32	18-22	17-27
Pump Rod Location	#2	#1	#1	#2	#2	#2	#2
Override Spring Adjustment	.015"	.015"	.015"	.015"	.015"	.015"	.015"
Pump Cam Color	Red	Pink	Pink	Red	Pink	Red	Red
Idle Speed							
Curb Idle RPM	550-575	550-575	550-575	550-575	550-575	550-575	550-575
Choke Cover Setting	3 Lean	3 Lean	3 Lean	Index	Index	Index	Index
Dechoke	.300"	.300"	.300"	.300"	.270"	.300"	.300"
Choke Qualifying	.140"	.140"	.140"	.140"	.120"	.140"	.140"
Secondary Throttle Opening	¼-½	¼-½	—	¼-½	¼-½	¼-½	¼-½
Supplier	Holley	Holley	Holley	Holley	Holley	Holley	Holley
Supplier I.D. Number	6407	6576-A	7036	⑥	⑦	6361	⑧
Carburetor Model	4160	4160	2300	4160	4160	4150	4160

① Lower Edge of Sight Plug Hole.
② Parallel with Float Bowl Floor (bowl inverted).
③ ½" Primary ⅝" Secondary.
④ ½" Primary ¾" Secondary.
⑤ Use Kent Model Gauge #10193.
⑥ 7159, 9393, 50418, 80264
⑦ 7163, 9392, 50419, 50463, 80265
⑧ 7128, 9394, 50399, 80262

HOLLEY CARBURETOR PROBLEM DIAGNOSIS

Flooding or Leaking Carburetor

Cracked carburetor body, or fuel bowl.
Defective main body and/or fuel bowl gasket(s).
High fuel level or float setting.
Fuel inlet needle not seating properly or worn needle and/or seat.
Ruptured accelerating pump diaphragm.
Excessive fuel pump pressure.
Defective power valve gasket.
Ruptured power valve diaphragm.
Loose fuel inlet needle valve seat or seat gasket damaged or missing.
Sticking and/or restricted float operation.
Float tab surface rough.
Dirt or foreign material in fuel holds float needle valve open.

Hard Starting

Incorrect setting of choke thermostatic spring housing.
Improper starting procedure, causing a flooded engine.
Improper carburetor fuel level.
Improper idle adjustments.
Sticking or incorrectly seating fuel inlet needle.
Incorrect fuel pump pressure.
Improper carburetor gasket and/or spacer combination.
Choke linkage or plate binding.
Binding or broken manual choke linkage.
Restrictions or air leaks in the choke vacuum or hot air passages.
Dirty air cleaner element.

Stalling

ENGINE HOT OR COLD
Incorrect idle fuel mixture.
Engine idle speed too slow (fast or cold idle adjustments).
Dirt, water or ice in fuel filter.
Positive crankcase ventilation system malfunctioning or restricted.
Fuel lines restricted or leaking air.
Fuel tank vent restricted.
Leaking intake manifold or carburetor gaskets.
Carburetor icing (cold, wet or humid weather).
Incorrect throttle linkage adjustment to carburetor.
Clogged air bleeds or idle passages.
Defective fuel pump.
Excessive looseness of throttle shaft in bore(s) of throttle body.

Rough Idle

Improperly adjusted idle mixture screw.
Throttle plates and/or throttle shaft bent or damaged. Throttle plates misaligned.
Positive crankcase ventilation system malfunctioning or restricted.
Idle adjusting needle(s) grooved, worn or otherwise damaged.
Idle air bleeds restricted.
Idle air or fuel passages restricted.
Idle discharge holes not in proper relation to throttle plate(s).
Excessive dirt in air cleaner.
High or low fuel level or float setting.
Fuel inlet needle not seating properly, or worn needle or seat.
Power valve leaking.
Restricted air bleeds.
Plugged idle fuel channel restrictor.
Air leak at carburetor mounting or intake manifold gasket.
Plugged main metering jet.
Accelerating pump discharge ball check or needle and/or weight not seating properly.
Fuel pump pressure too low, or excessive.
Fuel siphoning from secondary main fuel system.
Restriction in main fuel passage.
Air leak below carburetor or at intake manifold gasket.

Poor Acceleration

Poor acceleration complaints fall under one of three headings: the engine is sluggish on acceleration, the engine stalls when accelerated, or the engine hesitates or developes a flat spot when accelerated. Poor acceleration is caused by either an excessively lean or rich mixture on acceleration and/or defects or improper adjustments in the ignition system.

A Lean Mixture on Acceleration Can Be Caused by:
Incorrect accelerating pump stroke adjustment.
Accelerating pump diaphragm defective.
Low fuel pump pressure.
Sticking fuel inlet needle.
Low fuel level or float setting.
Restriction in main fuel passage.

HOLLEY CARBURETOR PROBLEM DIAGNOSIS

Poor Acceleration (cont.)

Air leak between the carburetor and manifold caused by loose mounting bolts or defective gasket.
Air leak at the throttle shaft caused by a worn throttle shaft.
Accelerating pump fuel inlet valve not seating on acceleration.
Restriction in the accelerating pump discharge passage.
Accelerating pump discharge valve ball check or weight not coming fully off its seat, or failing to seat properly on the reverse stroke of the pump diaphragm.
Air leak at the accelerating pump cover caused by a defective gasket or warped pump cover.
Defective power valve spring.
Defective secondary diaphragm.
Air leak where secondary vacuum pick-up tube fits into air horn, between air horn and main body, or between the secondary diaphragm housing cover and housing.
Secondary throttle plates wedged in barrels.
Bent secondary throttle shaft.
Secondary throttle plates operating rod binding, or disconnected from secondary diaphragm or secondary throttle lever.
Secondary vacuum passage ball check stuck on its seat.
Secondary vacuum probe restricted or not properly positioned.
Restricted secondary fuel passages.
Power valve stuck.

A Rich Mixture on Acceleration Can Be Caused by:
Broken power valve spring.
Stuck or improperly adjusted secondary throttle air plates.
High fuel level or float setting.
Fuel inlet needle not seating properly or worn needle and/or seat.
Malfunctioning automatic choke.
Excessively dirty air cleaner.
Incorrect accelerating pump stroke adjustment.
Power valve leakage.
Restricted air bleeds.
Worn or damaged main metering jet.
Excessive fuel pump pressure.

Inconsistent Engine Idle Speed

Fast idle screw contacting low step of cam at curb idle.
Incorrect throttle linkage adjustment to carburetor.
Binding or sticking throttle linkage or accelerator pedal.
Sticking carburetor throttle shaft.
Excessive looseness of throttle shaft in bores of throttle body.
Sticking fuel inlet needle.
Defective power valve or gasket.
Air leak at carburetor mounting or intake manifold gasket.

Automatic Choke Slow Warm-Up, on Too Often or Long

Thermostatic choke setting too rich.
Choke linkage sticking or binding.
Incorrect choke linkage adjustment.
Choke plate misaligned or binding in air horn.

Surging (Cruising Speeds to Top Speeds)

Clogged main jets.
Improper size main jets.
Low fuel level or float setting.
Clogged filter or filter screen.
Defective power valve or gasket.
Distributor advance incorrect.
Low fuel pump pressure or volume.

Reduced Top Speed

Excessive dirt in air cleaner.
Improper size or obstructed main jets.
Float setting too high or too low.
Fuel pump pressure or volume too high or too low.
Power valve spring weak, or power valve restricted.
Restricted air bleeds.
Restriction in main fuel passages.
Throttle plates not fully open.
Faulty choke operation.
Improper throttle linkage adjustment.
Air leak where secondary vacuum pick-up tube fits into air horn and main body, or air leakage between the secondary diaphragm housing cover and housing or the air horn mounting gasket.
Secondary diaphragm return spring too stiff.
Secondary throttle plates wedged in barrels.
Bent secondary throttle shaft.
Secondary throttle plate operating rod binding.
Secondary vacuum passage ball check sticking on its seat.
Secondary damper linkage sticking.
Distributor advance incorrect.

PCM marine engines

ROCHESTER CARBURETOR REPAIR & DIAGNOSTIC PROCEDURES

TABLE OF CONTENTS

ROCHESTER 4MV CARBURETORS

MODEL 4MV CARBURETOR
GENERAL DESCRIPTION

The Model 4MV carburetor (Fig. 6C2,-2) is a two stage carburetor of downdraft design. The triple venturi system is used on the primary side of the carburetor with 1-3/8 inch throttle valve bores.

The secondary side has two 2-¼ inch bores. Using the air valve principle in the secondary side, fuel is metered in direct proportion to the air passing through the secondary bores. A baffle is attached to the secondary side of the air horn above the main well bleed tubes to deflect incoming air to improve secondary nozzle operation on heavy acceleration.

The float assembly is used along with a windowless type needle seat for better fuel handling in the float bowl. Also, a plastic filler block is used above the float chamber to reduce fuel slosh in this area.

The main metering system on all models uses separate main wells to feed each fuel nozzle for improved fuel flow in the venturi system.

An expander (garter) spring beneath the plunger cup on the accelerator pump assembly improves pump fuel delivery.

The choke shaft and some other parts of the choke system are Teflon coated to insure smooth choke operation.

The carburetor part number (Fig. 6C2-3) is stamped on a vertical section of the bowl, near the secondary throttle lever. Refer to the part number on the bowl when servicing this carburetor. When replacing the float bowl assembly, follow the instructions contained in the service package. Stamp or engrave the model number on the new float bowl.

The primary side of the carburetor has six systems of operation. They are float, idle, main metering, power, pump, and choke (Figs. 6C2-4 through 6C2-19). The secondary side has one metering system which supplements the primary main metering system and receives fuel from a common float chamber.

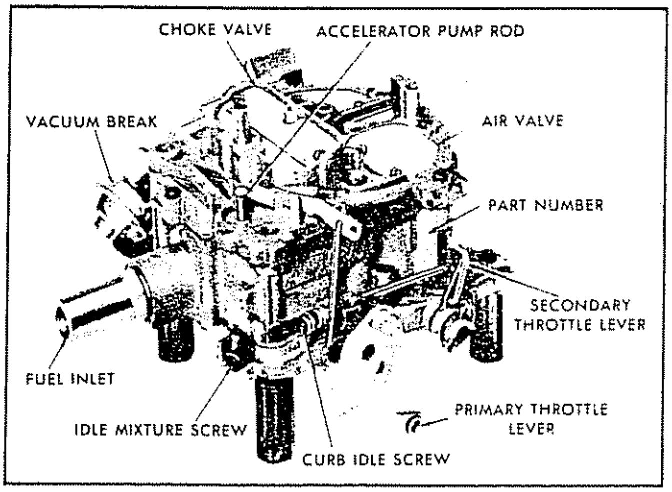


Fig. 6C2-2--Model 4MV Carbureto

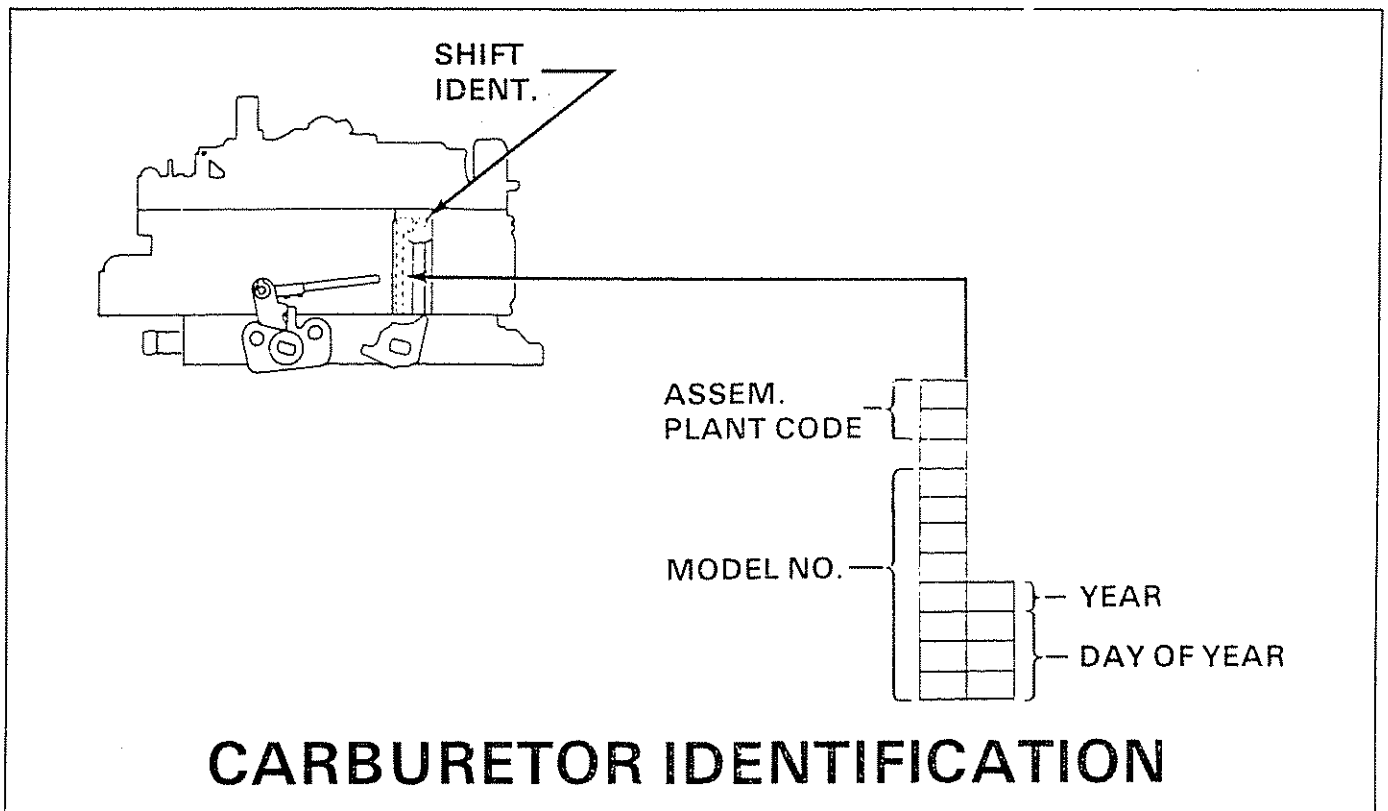


Fig. 6C2-3--Carburetor Identification

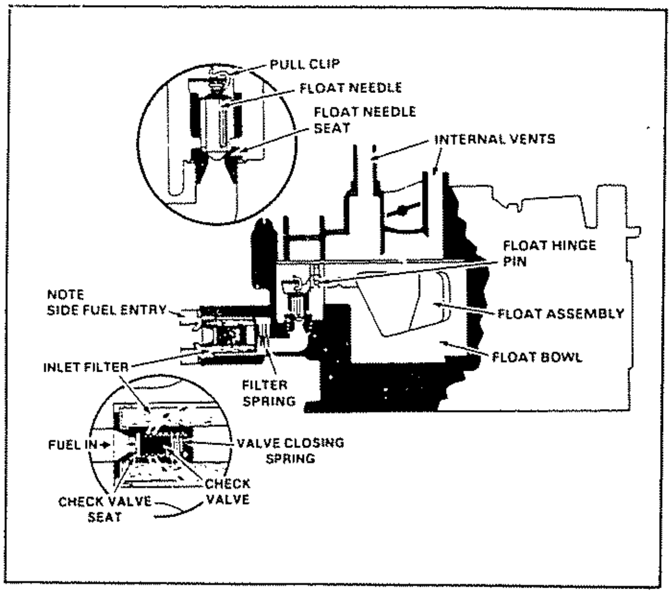


Fig. 6C2-5–Float System 4MV

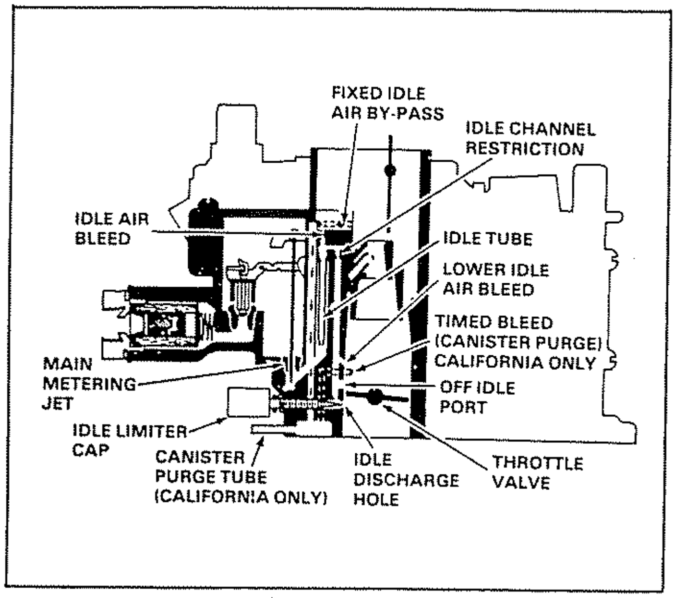


Fig. 6C2-8–Idle System 4MV

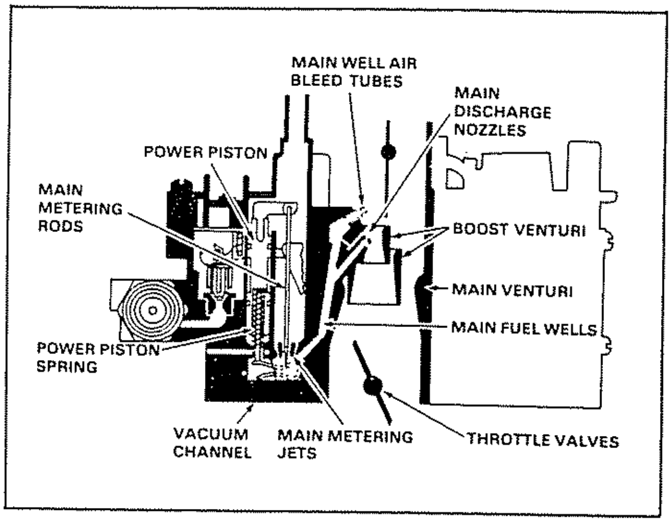


Fig. 6C2-11–Main Metering System-4MV

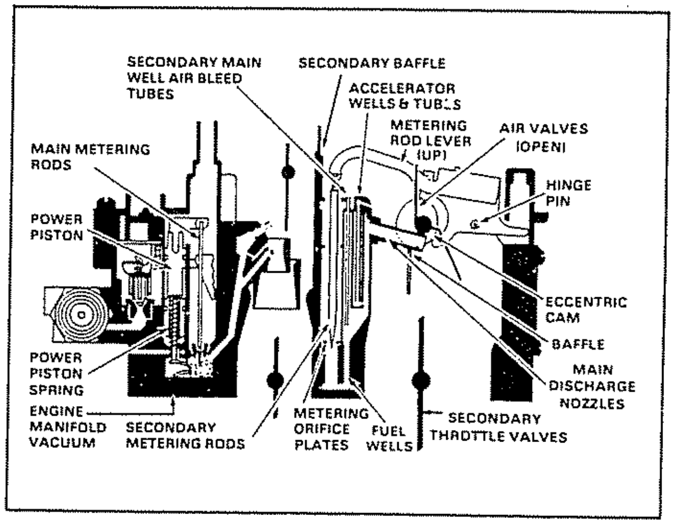


Fig. 6C2-15–Power System-4MV

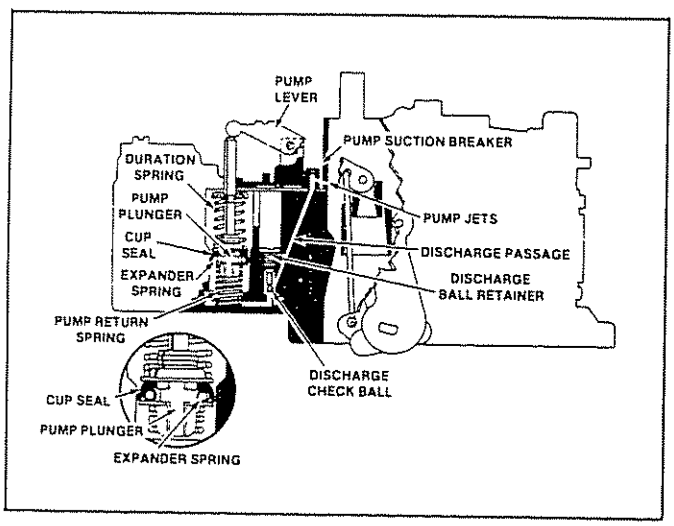


Fig. 6C2-17–Accelerating Pump System-4MV

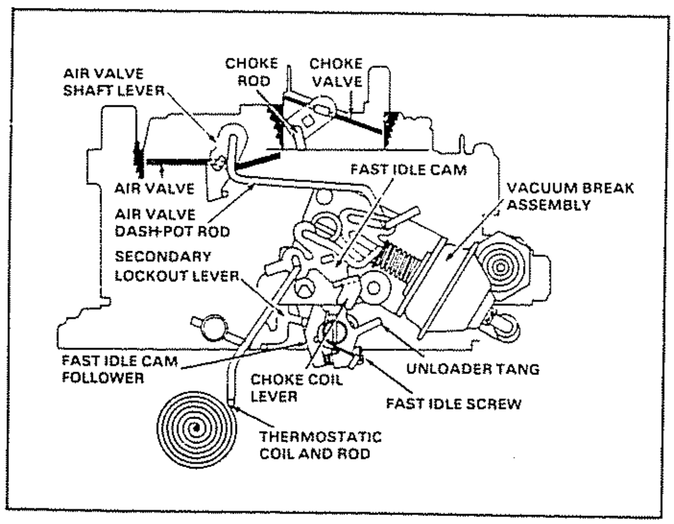
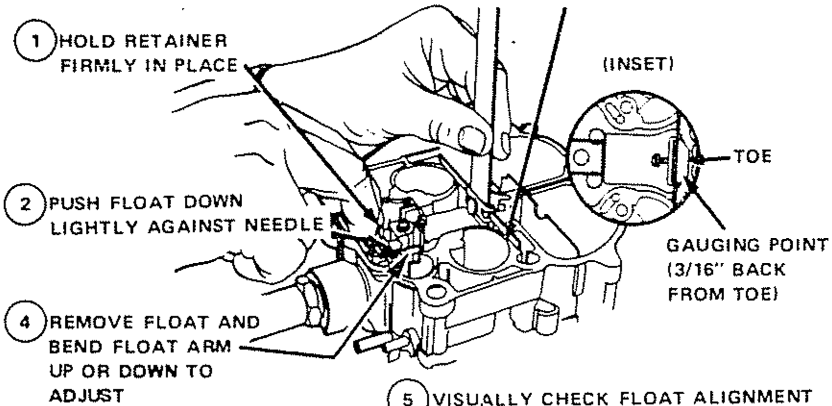


Fig. 6C2-19–Choke System-4MV

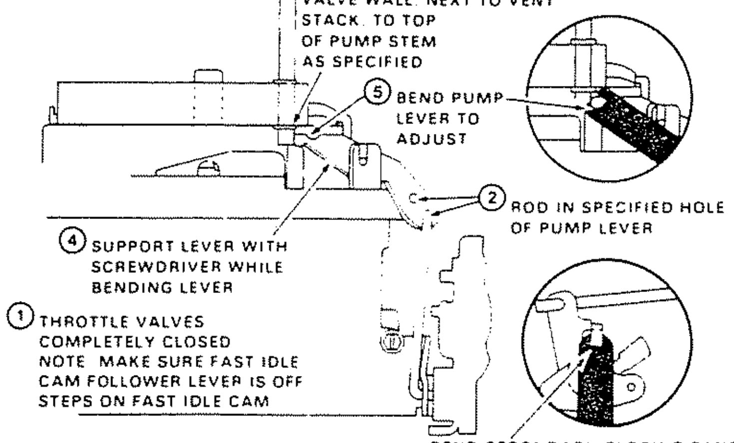
1



FLOAT LEVEL ADJUSTMENT

CARB. NO.		GAUGE
17058201	17058515	15/32
17058213	17058518	
17058215	17058519	
17058229	17058522	
17058503	17058523	
17058506	17058524	
17058508	17058527	
17058509	17058528	
17058510	17058529	
17058513	17058586	
17058514	17058588	
17058212	17058222	7/16
17058218	17058525	
17058219		
	17058520	3/8
17058501	17058521	
17058512		13/32

2



PUMP ADJUSTMENT

CARB. NO.	GAUGE	HOLE LOC.
ALL EXCEPT 17058509 17058510 17058586 17058588	9/32	INNER
17058509 17058510 17058586 17058588	11/32	OUTER

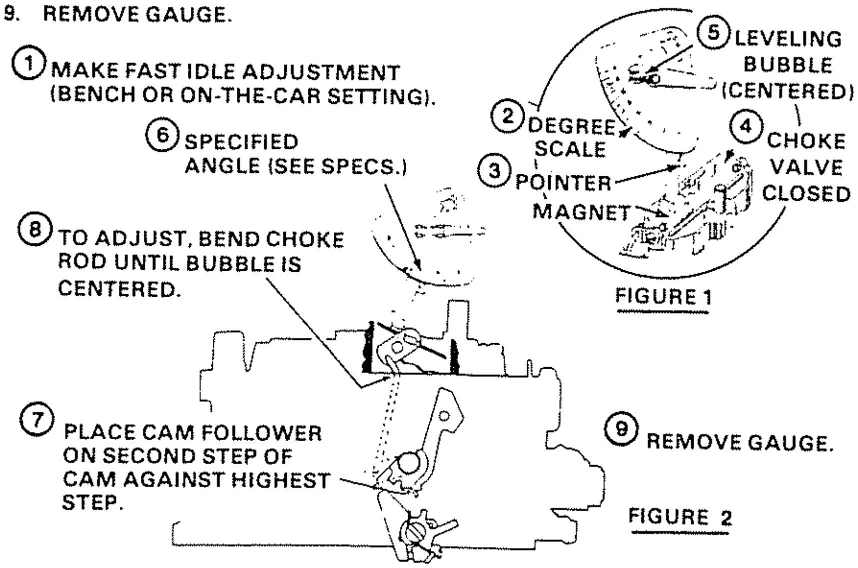
6

FIGURE 1

1. MAKE FAST IDLE ADJUSTMENT (BENCH OR ON-THE-CAR SETTING).
2. USE CHOKE VALVE MEASURING GAUGE J-26701. TOOL MAY BE USED WITH CARBURETOR ON OR OFF ENGINE. IF OFF ENGINE, PLACE CARBURETOR ON HOLDING FIXTURE SO THAT IT WILL REMAIN IN SAME POSITION WHEN GAUGE IS IN PLACE.
3. ROTATE DEGREE SCALE UNTIL ZERO (0) IS OPPOSITE POINTER.
4. WITH CHOKE VALVE COMPLETELY CLOSED, PLACE MAGNET SQUARELY ON TOP OF CHOKE VALVE.
5. ROTATE BUBBLE UNTIL IT IS CENTERED.

FIGURE 2

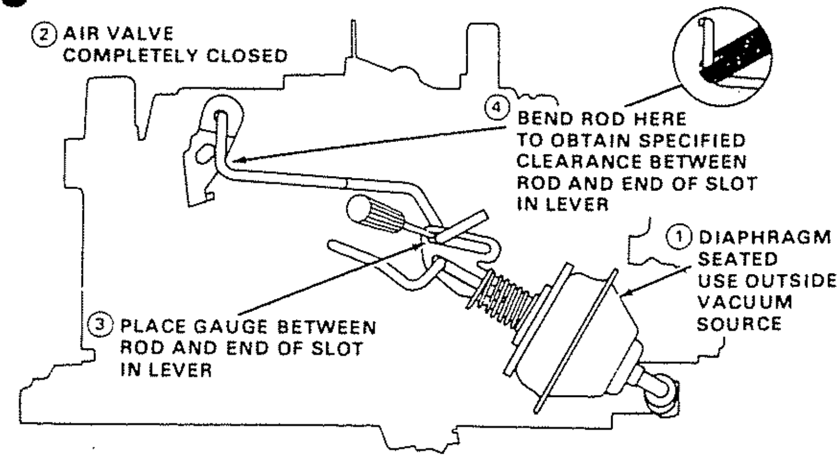
6. ROTATE SCALE SO THAT DEGREE SPECIFIED FOR ADJUSTMENT IS OPPOSITE POINTER.
7. PLACE CAM FOLLOWER ON SECOND STEP OF CAM AGAINST HIGHEST STEP.
8. TO ADJUST, BEND CHOKE ROD UNTIL BUBBLE IS CENTERED.
9. REMOVE GAUGE.



CHOKE ROD (FAST IDLE CAM) ADJUSTMENT - ANGLE GAUGE METHOD (4MV)

CARB. NO.	ANGLE GAUGE
ALL	42°

8



AIR VALVE ROD ADJUSTMENT (4MV)

CARB. NO.	PLUG GAUGE
ALL	.015"

10

FIGURE 1

1. USE CHOKE VALVE MEASURING GAUGE J-26701. TOOL MAY BE USED WITH CARBURETOR ON OR OFF ENGINE. IF OFF ENGINE, PLACE CARBURETOR ON HOLDING FIXTURE SO THAT IT WILL REMAIN IN SAME POSITION WHEN GAUGE IS IN PLACE.
2. ROTATE DEGREE SCALE UNTIL ZERO (0) IS OPPOSITE POINTER.
3. WITH CHOKE VALVE COMPLETELY CLOSED, PLACE MAGNET SQUARELY ON TOP OF CHOKE VALVE.
4. ROTATE BUBBLE UNTIL IT IS CENTERED.

FIGURE 2

5. ROTATE SCALE SO THAT DEGREE SPECIFIED FOR ADJUSTMENT IS OPPOSITE POINTER.
6. OPEN PRIMARY THROTTLE VALVES SO THAT FAST IDLE CAM FOLLOWER CLEARS STEPS ON FAST IDLE CAM.
7. SEAT DIAPHRAGM USING OUTSIDE VACUUM SOURCE. (PLUNGER MUST BE FULLY SEATED).
8. LIGHTLY ROTATE CHOKE COIL LEVER COUNTERCLOCKWISE UNTIL END OF ROD IS IN END OF SLOT IN LEVER.
9. TO ADJUST, BEND ROD UNTIL BUBBLE IS CENTERED
10. REMOVE GAUGE.

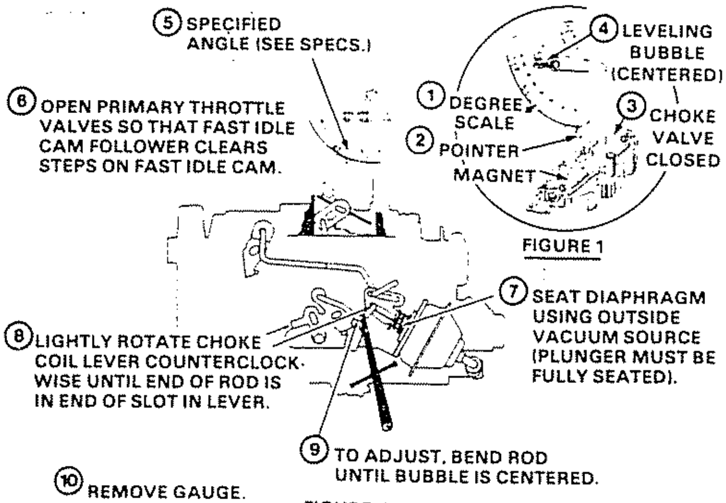
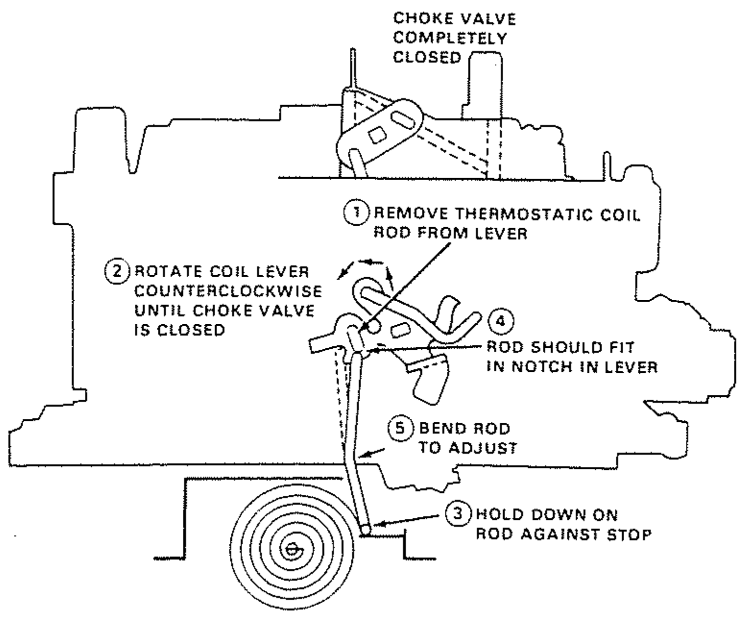


FIGURE 2

VACUUM BREAK ADJUSTMENT - ANGLE GAUGE METHOD (4MV)

CARB. NO.	ANGLE GAUGE
17058213 17058215 17058229	22°
17058212 17058513 17058514 17058515 17058525	26.5°
17058529	25°

12



AUTOMATIC CHOKE COIL ROD ADJUSTMENT (4MV)

Fig. 6C2-25--M4MC/4MV Carburetor Adjustments - 6 of 10

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FIGURE 1

1. USE CHOKE VALVE MEASURING GAUGE J-26701. TOOL MAY BE USED WITH CARBURETOR ON OR OFF ENGINE. IF OFF ENGINE, PLACE CARBURETOR ON HOLDING FIXTURE SO THAT IT WILL REMAIN IN SAME POSITION WHEN GAUGE IS IN PLACE.
2. ROTATE DEGREE SCALE UNTIL ZERO (0) IS OPPOSITE POINTER.
3. WITH CHOKE VALVE COMPLETELY CLOSED, PLACE MAGNET SQUARELY ON TOP OF CHOKE VALVE.
4. ROTATE BUBBLE UNTIL IT IS CENTERED.

FIGURE 2

5. ROTATE SCALE SO THAT DEGREE SPECIFIED FOR ADJUSTMENT IS OPPOSITE POINTER.
6. PUSH UP OR DOWN ON LEVER TOWARDS CLOSED CHOKE.
7. HOLD PRIMARY THROTTLE VALVES WIDE OPEN.
8. TO ADJUST, BEND TANG UNTIL BUBBLE IS CENTERED.
9. REMOVE GAUGE.

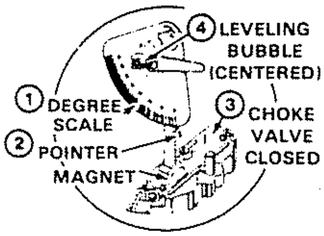


FIGURE 1

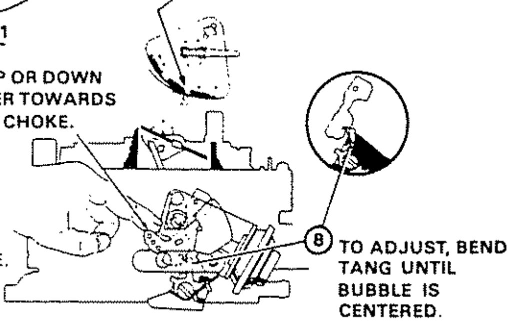
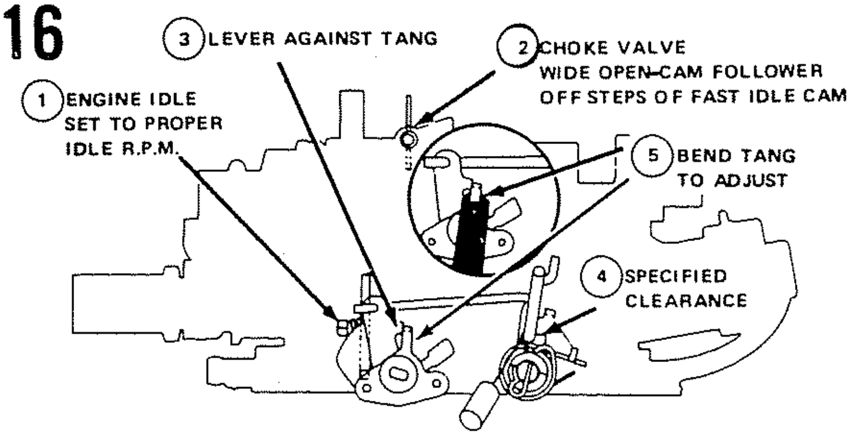


FIGURE 2

UNLOADER ADJUSTMENT - ANGLE GAUGE METHOD (4MV)

CARB. NO.	ANGLE GAUGE
17058213 17058215 17058229	40°
17058212 17058513 17058514 17058515	43°

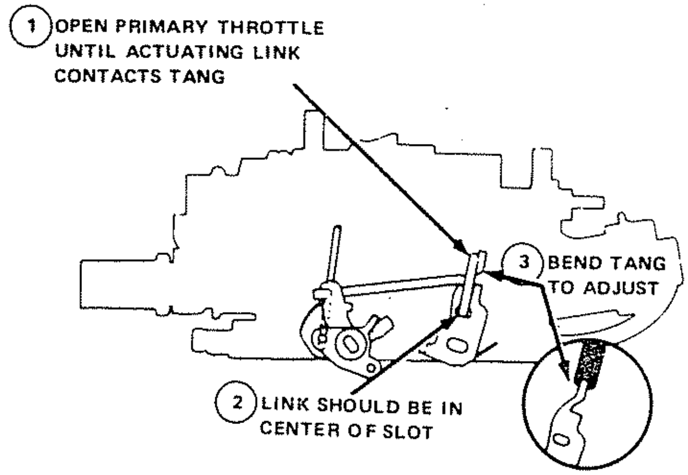
16



SECONDARY CLOSING ADJUSTMENT

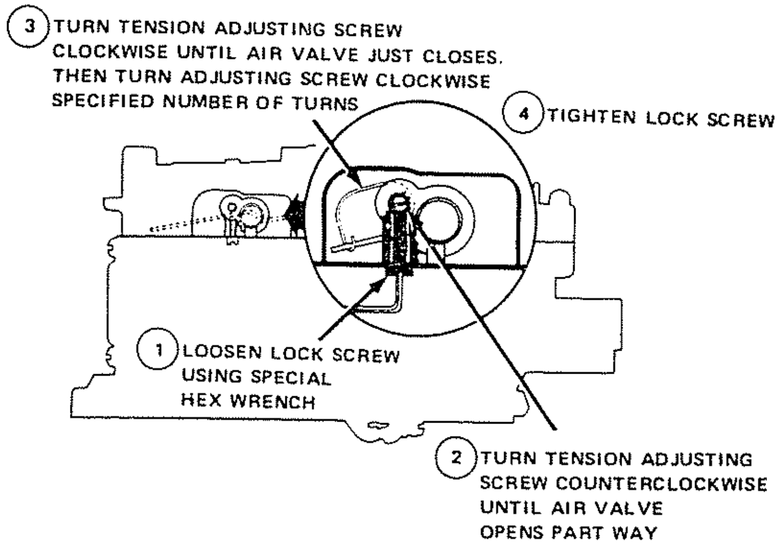
CARB. NO.	PLUG GAUGE
ALL	.020"

17



SECONDARY OPENING ADJUSTMENT

18



AIR VALVE SPRING ADJUSTMENT

CARB. NO.	NO TURNS
ALL EXCEPT 17058525	7/8
17058525	3/4

Fig. 6C2-28–M4MC/4MV Carburetor Adjustments-9 of 10

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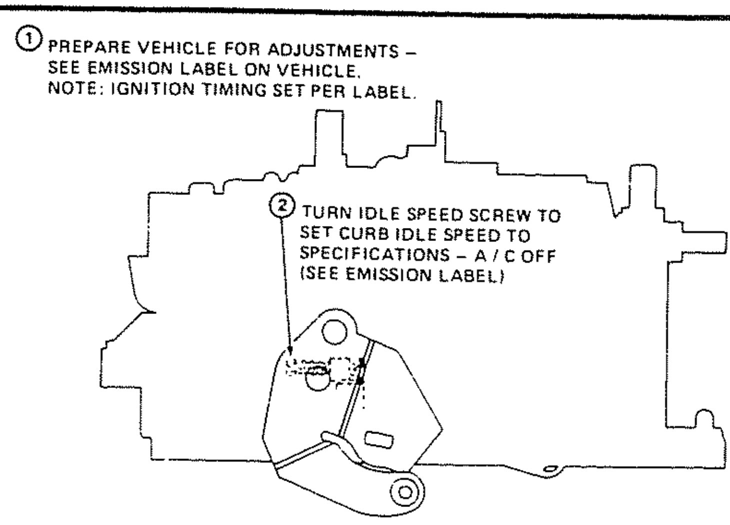


IDLE SPEED ADJUSTMENT - WITHOUT SOLENOID

SPECIFICATION
SEE: VEHICLE (ENGINE) EMISSION CONTROL INFORMATION LABEL

ANGLE DEGREE TO DECIMAL CONVERSION
MODEL 4MV CARBURETOR

THE RELATION BETWEEN DECIMAL AND ANGLE READINGS IS NOT EXACT DUE TO MANUFACTURING TOLERANCES OF THE COMPONENT PARTS. THIS CHART IS SUPPLIED FOR USE BY THE MECHANIC WHO HAS ACCESS TO PLUG GAUGES ONLY. THE RECOMMENDED TOOL IS AN ANGLE GAUGE FOR ACCURACY AND BEST OVERALL PERFORMANCE AND EMISSIONS.

ANGLE DEGREES	DECIMAL EQUIV. TOP OF VALVE	ANGLE DEGREES	DECIMAL EQUIV. TOP OF VALVE
5	.019	33	.158
6	.022	34	.164
7	.026	35	.171
8	.030	36	.178
9	.034	37	.184
10	.038	38	.190
11	.042	39	.197
12	.047	40	.204
13	.051	41	.211
14	.056	42	.217
15	.060	43	.225
16	.065	44	.231
17	.070	45	.239
18	.075	46	.246
19	.080	47	.253
20	.085	48	.260
21	.090	49	.268
22	.095	50	.275
23	.101	51	.283
24	.106	52	.291
25	.112	53	.299
26	.117	54	.306
27	.123	55	.314
28	.128	56	.322
29	.134	57	.329
30	.140	58	.337
31	.146	59	.345
32	.152	60	.353

4MV CARBURETOR ADJUSTMENTS

Refer to figure 6C2-20 for the following adjustments:

- Float
- Pump

Refer to figure 6C2-21 for the following adjustment:

- Fast Idle

Refer to figure 6C2-22 for the following adjustment:

- Choke Rod (Fast Idle Cam)-4MV

Refer to figure 6C2-23 for the following adjustment:

- Air Valve Rod-4MV

Refer to figure 6C2-24 for the following adjustment:

- Vacuum Break-4MV

Refer to figure 6C2-25 for the following adjustment:

- Automatic Choke Coil Rod-4MV

Checking Carburetor Choke

1. Remove flame arrestor. With engine off, hold throttle half open. Open and close choke several times. Watch linkage to be certain all links are connected and there are no signs of damage.

2. If choke or linkage binds, sticks or works sluggishly, clean with choke cleaner X-20-A or equivalent. Use cleaner as directed on can. Refer to disassembly instructions for additional direction if cleaning does not correct.

3. Visually inspect carburetor to be certain all vacuum hoses are connected. Inspect hoses for cracks, abrasions, hardness or other signs of deterioration. Replace or correct as necessary.

4. Make sure vacuum break diaphragm shaft is fully extended when engine is off. If shaft is not fully extended, replace vacuum break diaphragm shaft should fully retract within 10 seconds. If unit fails to retract, replace vacuum break assembly.

Refer to figure 6C2-26 for the following adjustment:

- Unloader

Refer to figure 6C2-28 for the following adjustments:

- Secondary Closing
- Secondary Opening
- Air Valve Spring

Refer to figure 6C2-29 for the following adjustment:

- Idle Speed-Without Solenoid.

Before suspecting the carburetor as the cause of poor engine performance or rough idle, check ignition system including distributor, timing, spark plugs and wires. Check air cleaner, PCV system, and engine compression. Also inspect intake manifold, vacuum hoses and connections for leaks and check torques of carburetor mounting bolts/nuts. If carburetor bolts are retorqued without carburetor removal retorque to 12 ft. lbs. maximum.

1. Engine must be at normal operating temperature, and choke open.

2. Connect an accurate tachometer to engine. Set idle speed to specification shown on Information Label.

3. Set timing to specification shown on the Information Label.

IDLE MIXTURE ADJUSTMENT

Turn one idle mixture screw in slowly until the RPM starts to drop. When drop occurs back out the screw counting the turns until the RPM's again start to drop. Turn the mixture screw in ½ the number of turns counted.

Repeat this procedure with the other mixture screw. Idle should be smooth and stable at the RPM listed on the Information Label. If RPM is too high or low adjust by changing the setting of the idle speed screw. If the speed screw is reset it is necessary to readjust the mixture screws as directed above. Always finish the carburetor adjustment by adjusting the mixture screws as the final adjustment.

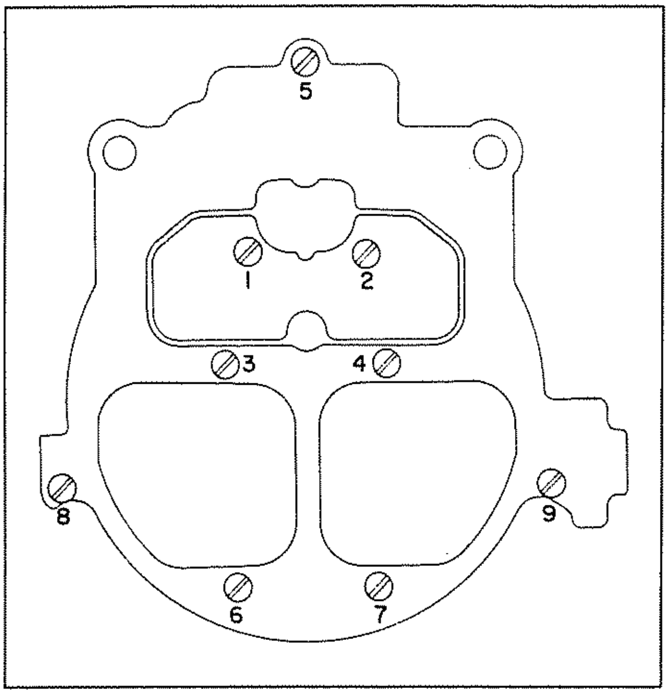


Fig. 6C2-52--Air Horn Screw Tightening Sequence

CARBURETOR REPLACEMENT

REMOVAL

Flooding, stumble on acceleration and other performance complaints are, in many instances, caused by presence of dirt, water, or other foreign matter in carburetor. To aid in diagnosis, carburetor should be carefully removed from engine witho'ıt draining fuel from bowl. Contents of fuel bowl may the' be examined for contamination as carbu. ›tor is . isassembled. Check filter.

1. Remove ame arrestor and gasket.
2. Disconne :t fuel and vacuum lines from carburetor.
3. Remove clip from choke linkage.
4. Di ,connect accelerator linkage.
5. Remove carburetor attaching bolts and remove carburetor.
6. Remove insulator.

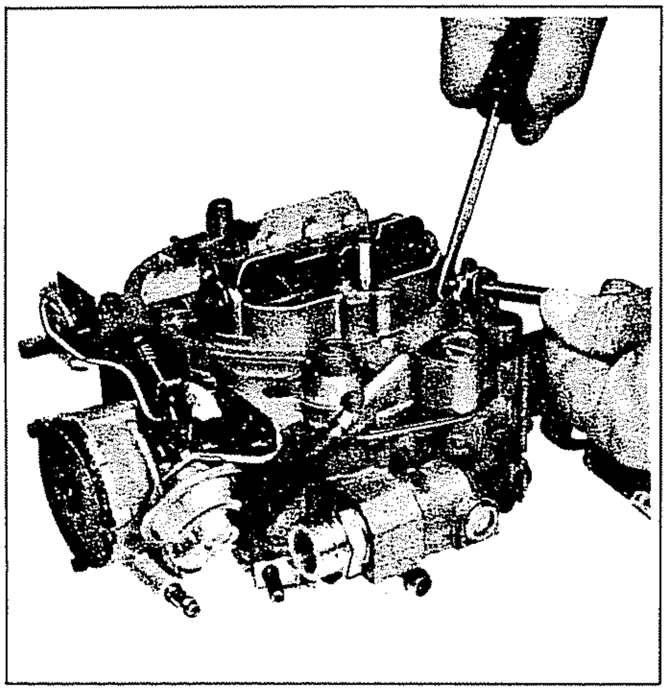


Fig. 6C2-53--Installing Pump Lever Pivot Pin

MODEL 4MV CARBURETOR

DISASSEMBLY

Place carbure.ɔr on a holding fixture to prevent damage to throttle plates.

Air Horn

1. Remove horseshoe clip from upper end of choke rod. Disconnect choke rod from upper choke shaft lever.

2. Remove choke rod from lower lever inside the float bowl casting by holding lower lever outward with small screwdriver and twisting rod counterclockwise.

3. Remove vacuum hose from vacuum break unit.

4. Remove secondary metering rods by removing the small screw in the top of the metering rod hanger. Lift upward on metering rod hanger until

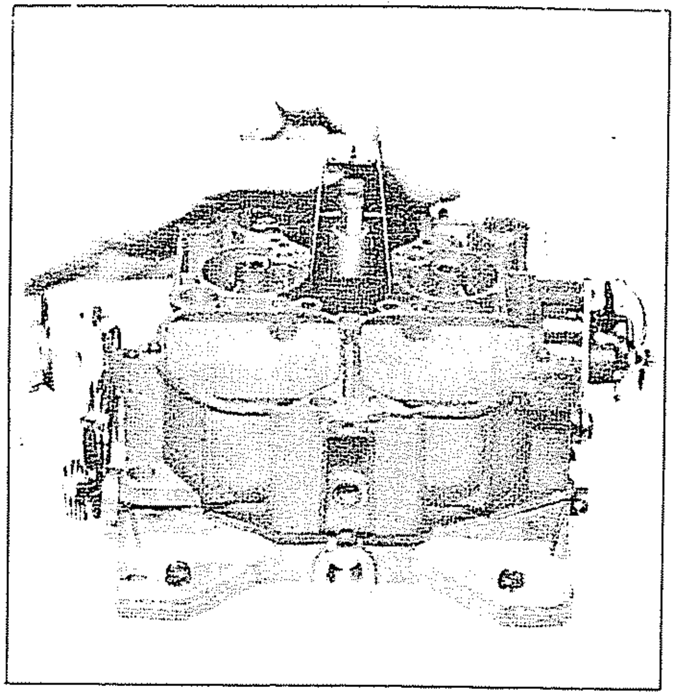


Fig. 6C2-55--Removing Secondary Metering Rods

the secondary metering rods are completely out of the air horn. Metering rods may be disassembled from the hanger by rotating ends out of the holes in the end of the hanger (Fig. 6C2-55).

5. Using special tool J-25322, drive small rod pin (pump lever pivot pin) inward just enough until pump lever can be removed from air horn. Then remove pump lever from pump rod (Fig. 6C2-56).

CAUTION: *Use care in removing small roll pin to prevent damage to pump lever casting boses in air horn.*

6. Remove nine air horn to bowl attaching screws; two attaching screws are located next to the venturi. (Two long screws, five short screws, and two countersunk screws) (Fig. 6C2-57).

7. Lift air horn off bowl and twist to disengage vacuum break rod from air valve shaft lever. Air

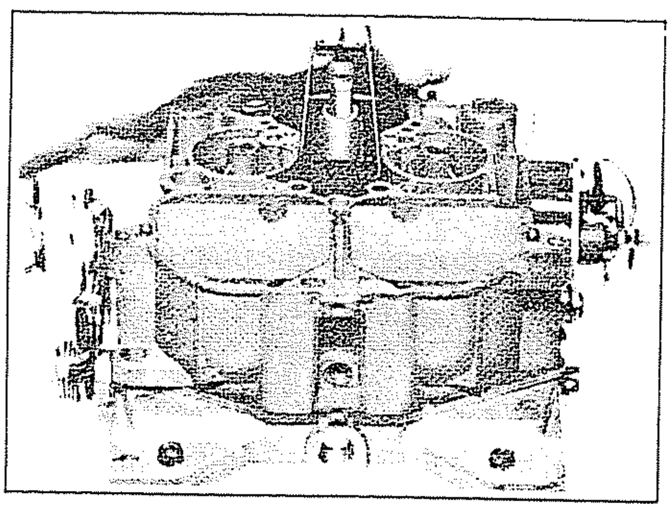


Fig. 6C2-56--Removing Pump Lever

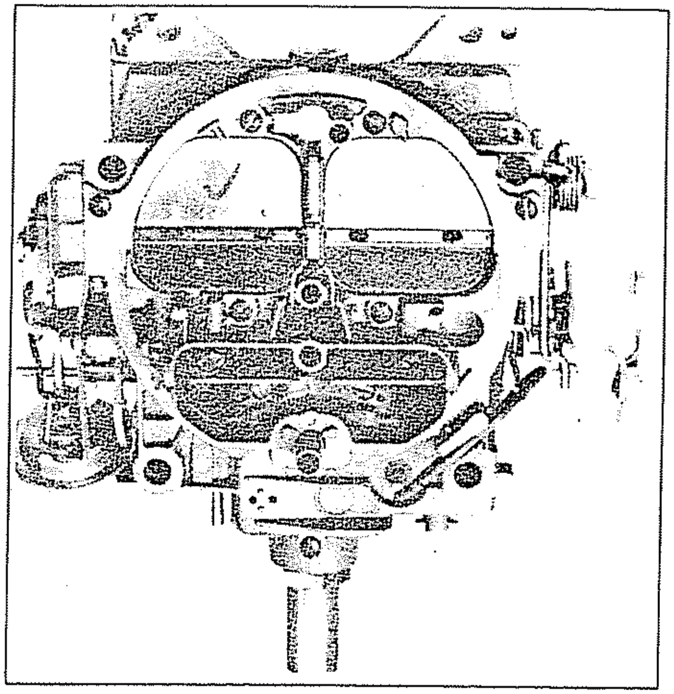


Fig. 6C2-57--Removing Air Horn Screws

horn gasket should remain on bowl for removal later. (Fig. 6C2-58).

8. Remove vacuum break rod from vacuum break diaphragm plunger.

CAUTION: *Care must be taken not to bend the small tubes protruding from air horn. These are permanently pressed into the casting. Do not remove.*

Air Horn Disassembly

NOTE: Further disassembly of the air horn is not required for cleaning purposes and is not recom-

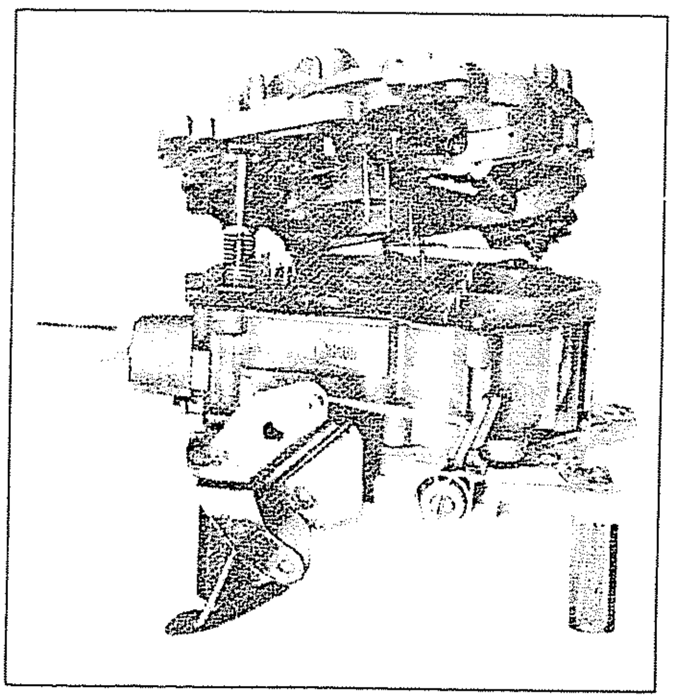


Fig. 6C2-58--Removing Air Horn

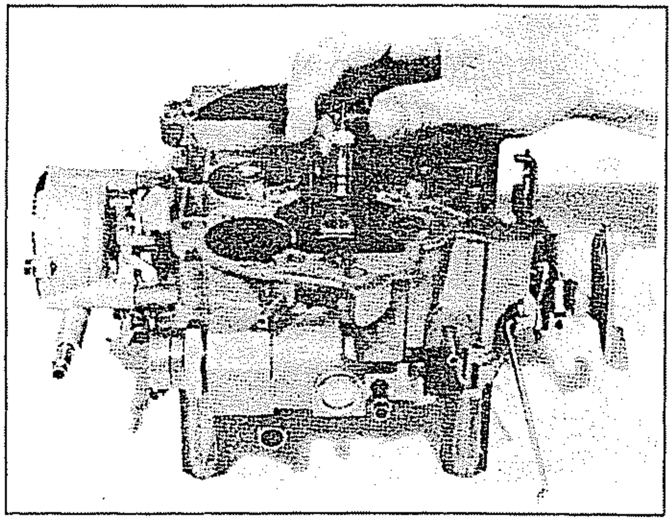


Fig 6C2-59–Removing Power Piston and Metering Rods

mended. If part replacement is required, proceed as follows:

1. Remove staking on two choke valve attaching screws and then remove choke valve and shaft.

2. Remove pump lever roll pin.

CAUTION: *Air valves and air valve shaft are calibrated and should not be removed. However, should it be necessary to replace the plastic air valve cam on the air valve shaft, a repair kit is available, which includes the plastic cam, closing spring, pin, screw and instructions.*

Float Bowl

1. Remove accelerator pump plunger from pump well.

2. Remove air horn gasket by lifting out of dowel locating pins and lifting tab of gasket from beneath the power piston hanger, being careful not to distort springs holding the main metering rods.

3. Remove pump return spring from pump well.

4. Remove plastic filler block over float valve.

5. Remove power piston and metering rods by depressing piston stem and allowing it to snap free (Fig. 6C2-59).

The power piston can be easily removed by pressing the piston down and releasing it with a snap. This will cause the power piston spring to snap the piston up against the retainer. This procedure may have to be repeated several times.

CAUTION: *Do not remove power piston by using pliers on metering rod hanger.*

6. Remove metering rods from power piston by disconnecting tension spring from top of each rod, then rotate rod to remove from hanger (Fig. 6C2-60).

CAUTION: *Use care when disassembling rods to prevent distortion of tension spring and/or metering rods. Note carefully position of tension spring for later reassembly.*

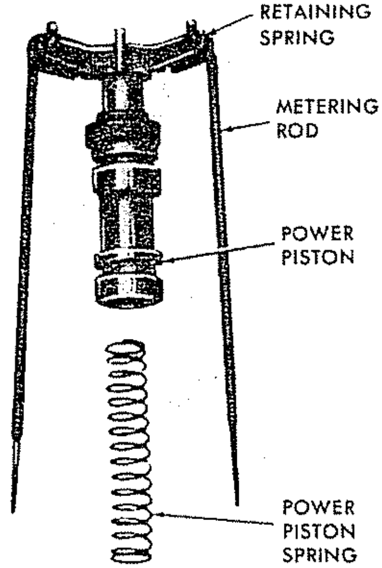


Fig. 6C2-60–Power Piston and Metering Rods

7. Remove float assembly and inlet needle by pulling up on retaining hinge pin. Do not remove inlet needle seat unless it is damaged, in which case it and fuel needle must be replaced as an assembly. If needle seat is to be removed, use fuel inlet needle seat remover, J-22769.

8. Do not remove primary metering jets, Figure 6C2-61 unless damaged or worn. No attempt

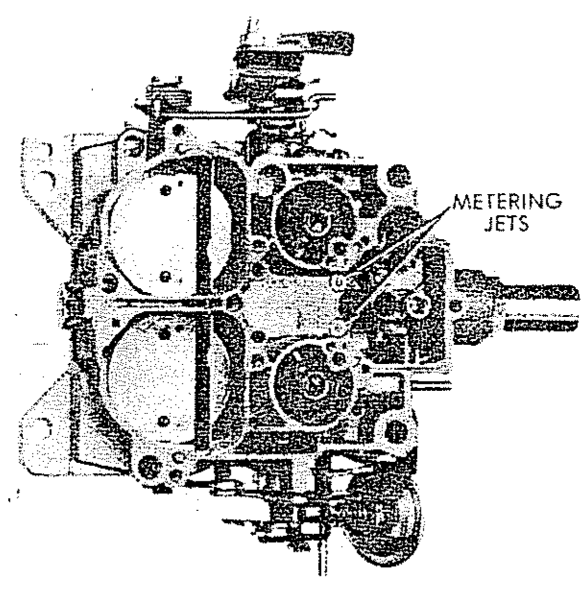


Fig. 6C2-61–Metering Jets

should be made to remove secondary metering plates. If jets are removed but not replaced, they should be installed in the same hole from which they were removed.

9. Remove pump discharge check ball retainer screw and check ball.

10. Remove vacuum hose from vacuum break assembly and from tube connection on bowl if not previously removed.

11. Remove retaining screw from vacuum break assembly and remove assembly from float bowl.

NOTE: If further disassembly of vacuum break mechanism is necessary, spread the retaining ears on bracket next to vacuum break assembly, then remove vacuum break assembly from bracket.

12. Remove choke rod actuating lever from inside of float bowl well.

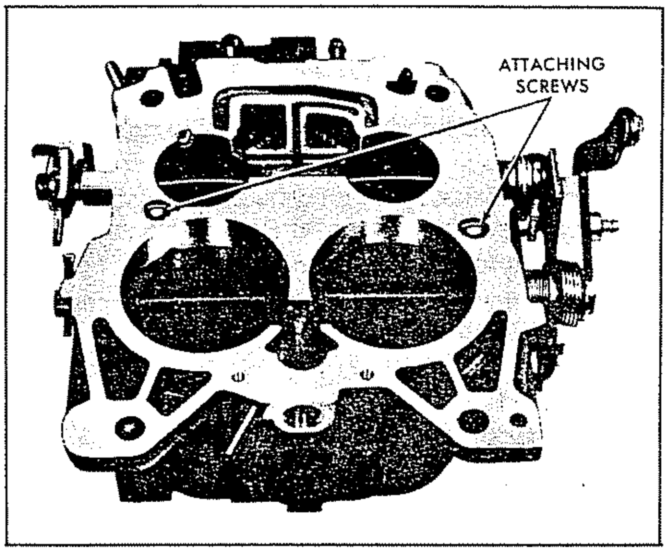


Fig. 6C2-63–Removing Throttle Body

Float Bowl Disassembly

1. Remove fuel inlet nut, gasket, filter and spring
2. Remove secondary air baffle, if replacement is required.
3. Remove primary main metering jets, if necessary.

NOTE: No attempt should be made to remove the A.P.T. metering screws, or secondary metering orifice plates. These items are fixed and, if damaged, float bowl replacement is required.

4. Turn bowl over and remove throttle body assembly by removing two throttle body to bowl attaching screws (Fig. 6C2-63).

NOTE: Be careful when inverting bowl assembly as smallest venturi protrudes beyond the gasket surface.

5. Remove throttle body to bowl insulator gasket.

Throttle Body Disassembly

1. Remove pump rod from throttle lever by rotating rod out of lever. Remove the idle mixture needles.

CAUTION: *Extreme care must be taken to avoid damaging throttle valves.*

No further disassembly of the throttle body is required.

CLEANING AND INSPECTION

The carburetor parts should be cleaned in cold immersion type cleaner.

The plastic cam on the air valve shaft (where used) and bushing in bowl will withstand normal cleaning. Rinse thoroughly after cleaning.

1. Thoroughly clean all metal parts and blow dry with compressed air. Make sure all fuel passages and metering parts are free of burrs and dirt.
2. Check, repair or replace the following parts if the following problems were encountered.

a. Flooding

1. Inspect float needle seat for dirt, deep wear grooves, scores and proper seating.
2. Inspect float, float arms and hinge pin for distortion, binds and burrs. Check float for leaks and/or being loaded (heavier than normal).

b. Hesitation

1. Inspect pump plunger for cracks, scores or cup, excessive wear. A used pump cup will shrink when dry. Soak in fuel for 8 hours before testing if dried out.
2. Inspect pump duration and return spring for being weak or distorted.
3. Check all pump passages and jets for dirt, improper seating inlet or discharge balls, scores in pump well.
4. Check pump linkage for excessive wear, repair or replace as necessary.

c. Hard Starting - Poor cold operation

1. Check choke valve and linkage for excessive wear, binds or distortion.
2. Inspect choke vacuum diaphragms for leaks.
3. Clean or replace carburetor filters.
4. Inspect needle for sticking, dirt, etc.
5. Examine fast idle cam for wear or damage.
6. Also check items under "flooding".

d. Poor Performance - Poor Gas Mileage

1. Power piston, power valve, metering rods for dirt, sticking, binding, damaged parts or excessive wear.
2. (If used) Check air valve for binds and damage. If air valve is damaged, the air horn assembly must be replaced. A torsion spring kit is available for repairs to air valve closing spring. A new plastic secondary metering rod cam is included in kit.

3. Clean all fuel and vacuum passages in castings.

e. Rough Idle

1. Inspect idle needle for ridges, burrs or being bent.

2. Inspect gasket mating surfaces on castings for damage to sealing beads, nicks and burrs.

3. Clean all idle fuel passages.

4. Check throttle levers and valves for binds, nicks and other damage.

ASSEMBLY

Throttle Body

1. If removed, install idle mixture needles and springs until lightly seated. Back out the mixture needles 4 turns as a preliminary idle adjustment. Final adjustment must be made on the engine using the procedures described under idle adjustment.

2. Install lower end of pump rod in throttle lever by aligning tang on rod with slot in lever. End of rod should point outwards toward throttle lever.

Float Bowl

1. Install new throttle body to bowl gasket over two locating dowels on bowl.

2. Install throttle body making certain throttle body is properly located over dowels on float bowl, then install throttle body to bowl screws and tighten evenly and securely (Fig. 6C2-63).

3. Place carburetor on proper holding fixture J-8328.

4. Install fuel inlet filter spring, filter, new gasket and inlet nut and tighten nut securely (18 ft. lbs.).
CAUTION: *Tightening beyond specified torque can damage nylon gasket.*

5. If vacuum break diaphragm was removed from bracket, slide vacuum break diaphragm between retaining ears and bend ears down slightly to hold securely.

6. Install fast idle cam on vacuum break assembly. Be sure arm of choke connecting lever is located beneath the tail of the fast idle cam.

7. Install vacuum hose to connection on bowl and vacuum break assembly.
NOTE: Do not attach vacuum hose to inlet on vacuum break diaphragm until after vacuum break adjustment is complete. (Refer to adjustment procedure).

8. Connect choke rod (plain end) to choke rod actuating lever, then holding choke rod with grooved end pointing inward - position choke rod actuating lever in well of float bowl and install choke assembly, engaging shaft with hole in actuating lever. Install retaining screw and tighten securely. Remove choke rod from lever for installation later.

9. If removed, install air baffle in secondary side

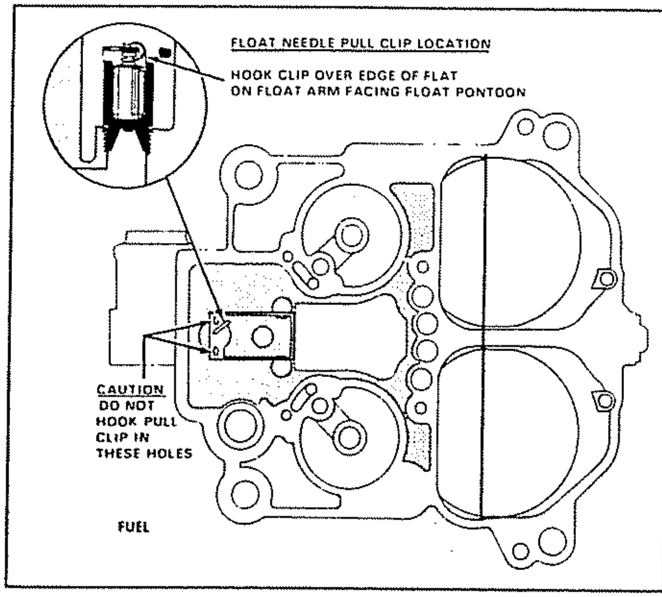


Fig. 6C2-64–Pull Clip Location

of float bowl with notches toward the top. Top edge of baffle must be flush with bowl casting.

10. Install pump discharge check ball and retainer screw in passage next to pump well. Tighten retainer securely.

11. Install main metering jets. If removed, the jets should be installed in the same hole from which they were removed.

12. If fuel inlet needle seat was removed, use new needle seat gasket and position new seat on Fuel Inlet Needle Seat Remover and Installer, J-22769. Carefully thread needle seat into float bowl. Tighten securely.

13. To make adjustment easier, bend float arm upward at notch in arm before assembly.

14. Install needle by sliding float lever under needle pull clip — correct installation of the needle pull clip is to hook the clip over the edge of the flat on the float arm facing the float pontoon (Fig. 6C2-64).

With float lever in pull clip, hold float assembly at toe and install retaining hinge pin from A.P.T. metering side (ends of retaining pin face the accelerating pump well).
CAUTION: *Do not install float needle pull clip into holes in float arm. Severe flooding will result.*
15. Adjust Float Level:

FLOAT LEVEL (Fig. 6C2-65)

a. Hold float retainer firmly in place.
b. Push float down lightly against needle.
c. With adjustable T-scale, gage from top of float bowl casting (air horn gasket removed) to top of float - gauging point is 3/16" back from end of float at toe (See inset - Fig. 6C2-65).
d. Bend float arm as necessary for proper adjust-

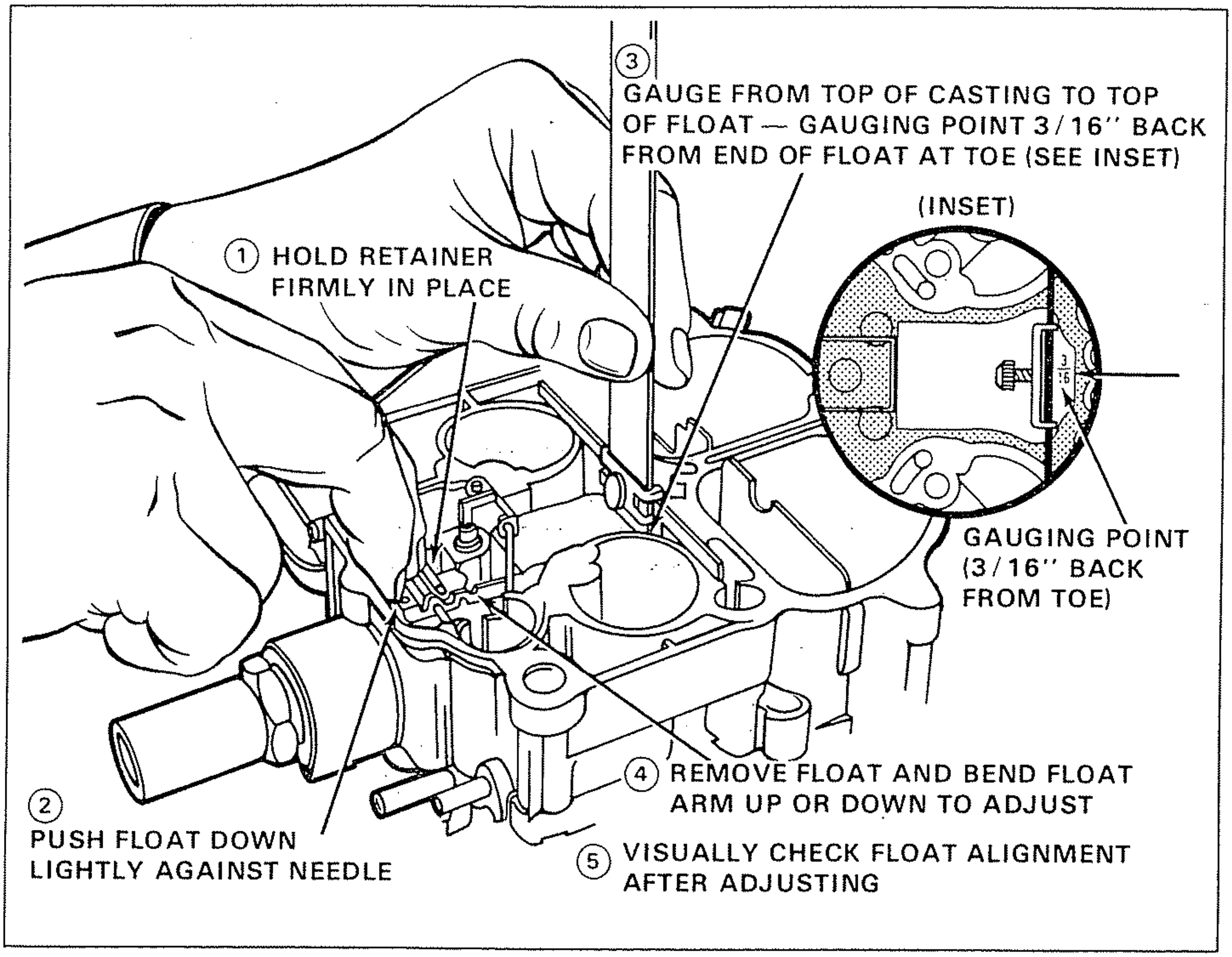


Fig. 6C2-65--Float Level Adjustment

ment by pushing on pontoon. Refer to Service Manual for specification.

e. Visually check float alignment after adjustment.

17. Install power piston spring in power piston well. If main metering rods were removed from hanger, reinstall making sure tension spring is connected to top of each rod. Install power piston assembly in well with metering rods properly positioned in metering jets. Press down firmly on plastic power piston retainer to make sure the retainer is seated in recess in bowl and the top is flush with the top of the bowl casting. If necessary, using a drift punch and small hammer, tap retainer lightly in place.

18. Install plastic filler block over fuel inlet needle, pressing downward until seated properly.

19. Install pump return spring in pump well.

20. Install air horn gasket around primary metering rods and piston. Position gasket over two dowels on secondary side of bowl.

21. Install pump plunger in pump well to complete float bowl assembly.

Air Horn

1. Install the following, if removed: choke shaft, choke valve and two attaching screws. Check for free operation.

The choke valve screws have a special sealing compound to hold them in place. If removed, they should be lightly staked after tightening.

Air Horn to Bowl Assembly

1. Install vacuum break rod into vacuum break diaphragm plunger. Secure with clip.

2. Insert vacuum break rod in slot of air valve shaft and twist air horn into position.

3. Lower air horn assembly to bowl carefully, positioning vent tubes and accelerating well tubes through air horn gasket.

CAUTION: *Do not force the air horn assembly onto the bowl but rather lightly lower in place.*

4. Install two long air horn screws, five short screws, and two countersunk screws into primary venturi area.

All air horn screws must be tightened evenly and securely. See Figure 6C2-52 for proper tightening sequence.

5. Connect choke rod in lower choke lever and retain in upper lever with horseshoe clip.

6. Connect upper end of pump rod to pump lever by placing rod in specified hole in lever. Align hole in pump lever with hole in air horn casting using J-25322. Using small screwdriver, push pump lever roll pin back through casting until end of pin is flush with casting bosses in air horn.

CAUTION: *Use care installing the small roll pin to prevent damage to pump lever casting bosses.*

7. Install two secondary metering rods into the secondary metering rod hanger (upper end of rods point toward each other). Install secondary metering rod holder, with rods, onto air valve cam follower. Install retaining screw end tighten securely. Work air valves up and down several times to make sure they are free in all positions.

TORQUE SPECIFICATIONS

4MV CARBURETOR

SCREW	TORQUE (IN. LBS.)
AIR HORN TO BOWL 10-32	46
AIR HORN TO BOWL 8-32	26
AIR HORN TO THROTTLE BODY	46
THROTTLE BODY TO BOWL	46
VACUUM BREAK UNIT	26
FUEL INLET NUT	400
METERING JET	40
NEEDLE SEAT	45

ROCHESTER CARBURETOR DIAGNOSIS

The following diagnostic procedures are for carburetor related problems and their effects on engine performance. Other systems of the engine can also cause similar problems and should be checked when listed on the chart. The problem areas described are:

1. Engine cranks normally. Will not start.
2. Engine starts and stalls.
3. Engine starts hard.
4. Engine idles abnormally and/or stalls.
5. Inconsistent engine idle speeds.
6. Engine diesels (after-run) upon shut off.
7. Engine hesitates on acceleration.
8. Engine has less than normal power at low speeds.
9. Engine has less than normal power on heavy acceleration or at high speed.
10. Engine surges.
11. Excessive fuel consumption.

CONDITION	POSSIBLE CAUSE	CORRECTION
Engine Cranks Normally — Will Not Start	Improper starting procedure used.	Check Owner's Manual.
	Choke valve not operating properly.	Adjust the choke thermostatic coil to specification. Check the choke valve and/or linkage as necessary. Replace parts if defective. If caused by foreign material and gum, clean with suitable non-oil base solvent. NOTE: After any choke system work, check choke vacuum break settings and correct as necessary.
	No fuel in carburetor.	Remove fuel line at carburetor. Connect hose to fuel line and run into metal container. Remove the wire from the "bat" terminal of the distributor. Crank over engine - if there is no fuel discharge from the fuel line, test fuel pump. If fuel supply is okay, check the following: a. Inspect fuel inlet filter. If plugged, replace. b. If fuel filter is okay, remove air horn and check for a bind in the float mechanism or a sticking inlet needle. If okay, adjust float as specified.
	Engine flooded. To check for flooding, remove the flame arrestor with the engine immediately shut off and look into the carburetor bores. Fuel will be dripping off nozzles.	Remove the air horn. Check fuel inlet needle and seat for proper seal. If a needle and seat tester is not available, apply vacuum to the needle seat with needle installed. If the needle is leaking, replace. Check float for free movement, bent float hanger or binds in the float arm. If foreign material is in fuel system, clean the system and replace fuel filters as necessary. If excessive foreign material is found, completely disassemble and clean.
Engine Starts — Will Not Keep Running	Fuel pump.	Check fuel pump pressure and volume, replace if necessary.
	Idle speed.	Adjust idle to specifications

CARBURETOR DIAGNOSIS CONT'D.

CONDITION	POSSIBLE CAUSE	CORRECTION
Engine Starts — Will Not Keep Running (Continued)	Choke heater system malfunctioning (may cause loading).	Check vacuum supply at hot air inlet to choke housing. Should be not less than manifold vacuum minus 3" Hg. with engine running at idle. (Exc. IMV) Check for plugged, restricted, or broken heat tubes. Check routing of all hot air parts.
	Loose, broken or incorrect vacuum hose routing.	Check condition and routing of all vacuum hoses — correct as necessary.
	Choke vacuum break units are not adjusted to specification or are defective.	Adjust both vacuum break assemblies to specification. If adjusted okay, check the vacuum break units for proper operation as follows: To check the vacuum break units, apply a constant vacuum source of at least 10" Hg., plungers should slowly move inward and hold vacuum. If not, replace the unit. Always check the fast idle cam adjustment when adjusting vacuum break units.
	Choke valve sticking and/or binding.	Clean and align linkage or replace if necessary. Readjust all choke settings, see Section 6M, if part replacement or realignment is necessary.
	Insufficient fuel in carburetor.	Check fuel pump pressure and volume. Check for partially plugged fuel inlet filter. Replace if contaminated. Check the float level adjustment for binding condition. Adjust as specified.
Engine Starts Hard (Cranks Normally)	Loose, broken or incorrect vacuum hose routing.	Check condition and routing of all vacuum hoses — correct as necessary.
	Incorrect starting procedure.	Check to be sure customer is using the starting procedure outlined in Owner's Manual.
Engine Starts Hard (Cranks Normally)	Malfunction in accelerator pump system.	Check accelerator pump adjustment and operation. Check pump discharge ball for sticking or leakage.
	Choke valve not closing.	Adjust choke thermostatic coil. Check choke valve and linkage for binds and alignment. Clean and repair or replace as necessary.
	Vacuum breaks misadjusted or malfunctioning.	Check for adjustment and function of vacuum breaks. Correct as necessary.
	Insufficient fuel in bowl.	Check fuel pump pressure and volume. Check for partially plugged fuel inlet filter. Replace if dirty. Check float mechanism. Adjust as specified.
	Flooding.	Check float and needle and seat for proper operation.
	Slow engine cranking speed.	Refer to starting circuit diagnosis.

CARBURETOR DIAGNOSIS CONT'D.

CONDITION	POSSIBLE CAUSE	CORRECTION
Engine Idles Abnormally (Too fast or too slow)	Incorrect idle speed.	Reset idle speed per instructions on engine label.
	Air leaks into carburetor bores beneath throttle valves, manifold leaks, or vacuum hoses disconnected or installed improperly.	Check all vacuum hoses and restrictors leading into the manifold or carburetor base for leaks or being disconnected. Install or replace as necessary.
		Torque carburetor to manifold bolts to 10 ft. lbs. Using a pressure oil can, spray light oil or kerosene around manifold to head surfaces and carburetor throttle body. NOTE: Do not spray at throttle shaft ends. If engine RPM changes, tighten or replace the carburetor or manifold gaskets as necessary.
	Clogged or malfunctioning PCV system.	Check PCV system. Clean and/or replace as necessary.
	Carburetor flooding.	Remove air horn and check float adjustments.
	Check by using procedure outlined under "Engine Flooded".	Check float needle and seat for proper seal. If a needle and seat tester is not available, apply vacuum to the needle seat with needle installed. If the needle is leaking or damaged, replace.
		Check float for free movement. Check for bent float hanger or binds in the float arm.
		If foreign material is found in the carburetor, clean the fuel system and carburetor. Replace fuel filters as necessary.
	Restricted air cleaner element.	Replace as necessary.
	Idle system plugged or restricted.	Clean carburetor.
	Incorrect idle mixture adjustment.	Readjust per specified procedure.
	Throttle blades or linkage sticking and/or binding.	Check throttle linkage and throttle blades (primary and secondary) for smooth and free operation. Correct problem areas.
Engine Diesels (After Run) upon Shut Off	Loose, broken or improperly routed vacuum hoses.	Check condition and routing of all vacuum hoses. Correct as necessary.
	Incorrect idle speed.	Reset idle speed per instructions on label in engine compartment.
	Fast idle cam not fully off.	Check fast idle cam for freedom of operation. Clean, repair, or adjust as required. Check choke heated air tubes for routing, fittings being tight or tubes plugged. Check choke linkage for binding. Clean and correct as necessary.

CARBURETOR DIAGNOSIS CONT'D.

CONDITION	POSSIBLE CAUSE	CORRECTION
Engine Diesels (After Run) upon Shut Off (Continued)	Excessively lean condition caused by maladjusted carburetor idle mixture.	Adjust carburetor idle mixture.
	Ignition timing retarded.	Set to specifications.
Engine Hesitates On Acceleration	Loose, broken or incorrect vacuum hose routing	Check condition and routing of all vacuum hoses — correct or replace.
	Accelerator pump not adjusted to specification or inoperative.	Adjust accelerator pump, replace.
	Inoperative accelerator pump system.	Remove air horn and check pump cup. If cracked, scored or distorted, replace the pump plunger.
	NOTE: A quick check of the pump system can be made as follows: With the engine off, look into the carburetor bores and observe pump nozzles while quickly opening throttle lever. A full stream of fuel should emit from each pump nozzle.	Check the pump discharge ball for proper seating and location.
	Foreign matter in pump passages.	Clean and blow out with compressed air.
	Float level too low.	Check and reset float level to specification.
	Front vacuum break diaphragm not functioning properly.	Check adjustment and operation of vacuum break diaphragm.
	Air valve malfunction.	Check operation of secondary air valve. Check spring tension adjustment.
	Power enrichment system not operating correctly.	Check for binding or stuck power piston(s) — correct as necessary.
	Fuel filter dirty or plugged.	Replace filter and clean fuel system as necessary.
	Distributor mechanical advance malfunctioning.	Check for proper operation.
	Timing not to specifications.	Adjust to specifications.
	Choke coil misadjusted (cold operation).	Adjust to specifications.
Engine Has Less Than Normal Power At Normal Accelerations.	Loose, broken or incorrect vacuum hose routing.	Check condition and routing of all vacuum hoses.
	Clogged or defective PCV system.	Clean or replace as necessary.
	Choke sticking.	Check complete choke system for sticking or binding. Clean and realign as necessary. Check adjustment of choke thermostatic coil.
		Check connections and operation of choke hot air system.
		Check jets and channels for plugging; clean and blow out passages.
	Clogged or inoperative power system.	Remove air horn and check for free operation of power pistons.

CARBURETOR DIAGNOSIS CONT'D.

CONDITION	POSSIBLE CAUSE	CORRECTION
Engine Has Less Than Normal Power At Normal Accelerations. (Continued)	Ignition system malfunction.	Check ignition system.
	Exhaust system.	Check for restrictions. Correct as required.
Less Than Normal Power On Heavy Acceleration Or At High Speed	Carburetor throttle valves not going wide open. Turn off engine and check by pushing accelerator pedal to floor.	Correct throttle linkage to obtain wide open throttle in carburetor.
	Secondary throttle lockout not allowing secondaries to open.	Check for binding or sticking lockout lever.
		Check for free movement of fast idle cam.
		Check choke heated air system for proper and tight connections plus flow through system.
		Check adjustment of choke thermostatic coil.
		Make necessary corrections and adjustments.
	Spark plugs fouled, incorrect gap.	Clean, regap, or replace plugs.
	Plugged flame arrestor element.	Replace element.
	Plugged fuel inlet filter.	Replace with a new filter element.
	Insufficient fuel to carburetor.	Check fuel pump and system, run pressure and volume test.
	Power enrichment system not operating correctly.	Remove the air horn and check for free operation of both power piston(s), clean and correct as necessary.
	Choke closed or partially closed.	Free choke valve or linkage.
		Check for loose jets.
	Float level too low.	Check and reset float level to specification.
	Ignition system malfunction.	Check ignition system.
	Fuel metering jets restricted.	If the fuel metering jets are restricted and an excessive amount of foreign material is found in the fuel bowl, the carburetor should be completely disassembled and cleaned.
	Fuel pump.	Check fuel pump pressure and volume, inspect lines for leaks and restrictions.
	Exhaust system.	Check for restrictions. Correct as required.
Engine Surges	Loose, broken or incorrect vacuum hose routing.	Check condition and routing of all vacuum hoses. Correct as necessary.
	PCV system clogged or malfunctioning.	Check PCV system. Clean or replace as necessary.
	Loose carburetor intake manifold bolts and/or leaking gaskets.	Torque carburetor to manifold bolts to 10 ft. lbs. Using a pressure oil can, spray light oil or kerosene around manifold to head mounting surface and carburetor base. If engine RPM changes, tighten or replace the carburetor or manifold gaskets as necessary.

CARBURETOR DIAGNOSIS CONT'D.

CONDITION	POSSIBLE CAUSE	CORRECTION
Engine Surges (Continued)	Low or erratic fuel pump pressure.	Check fuel delivery and pressure.
	Contaminated fuel.	Check for contaminants in fuel. Clean system if necessary.
	Fuel filter plugged.	Check and replace as necessary.
	Float level too low.	Check and reset float level to specification.
	Malfunctioning float and/or needle and seat.	Check operation of system. Repair or replace as necessary.
	Power piston stuck or binding.	Check for free movement of power piston(s). Clean and correct as necessary.
	Fuel jets or passages plugged or restricted.	Clean and blow out with compressed air.
	Ignition system malfunction.	Check ignition system.
	Exhaust system.	Check for restrictions. Correct as necessary.
Excessive Fuel Consumption	Customer operating habits.	Run mileage test with customer driving if possible.
	Loose, broken or improperly routed vacuum hoses.	Check condition of all vacuum hose routings. Correct as necessary.
	Engine in need of service.	Check engine compression, e.amine spark plugs; if fouled or improperly gapped, clean and regap or replace. Check ignition wire condition and check and reset ignition timing. Replace air cleaner element if dirty. Check for restricted exhaust system and intake manifold for leakage. Check carburetor mounting bolt torque. Check vacuum and mechanical advance.
	Fuel leaks.	Check fuel tank, fuel lines and fuel pump for any fuel leakage.
	High fuel level in carburetor.	Check fuel inlet needle and seat for proper seal. Test, using suction from a vacuum source. If needle is leaking, replace. Check for loaded float. Reset float level to specification. If excessive foreign material is present in the carburetor bowl, the carburetor should be cleaned.
	Power system in carburetor not functioning properly. Power piston(s) sticking or metering rods out of jets.	Remove air horn and check for free movement of power piston(s). Clean and correct as necessary.
	Choke system.	Check choke heated air tubes for routing and/or plugging which would restrict hot air flow to choke housing. Check choke linkage for binding. Clean or repair as required. Check adjustment of thermostatic coil. Readjust to specification as required.
	Plugged flame arrestor element.	Replace element.
	Exhaust system.	Check for restrictions. Correct as required.

CARBURETOR DIAGNOSIS CONT'D.

CONDITION	POSSIBLE CAUSE	CORRECTION
Engine feels like it is running out of gas — surging occurs in mid-speed range	Plugged fuel filters.	Remove and replace filters.
	Faulty fuel pump.	Perform fuel pump test. Remove and replace fuel pump as required.
	Foreign material in fuel system or kinked fuel pipes or hoses.	Inspect pipes, and hoses for kinks and bends, blow out to check for plugging. Remove and replace as required.
Engine starts but will not continue to run or will run but surges and backfires.	Faulty fuel pump.	Perform fuel pump test. Remove and replace fuel pump as required.
Engine will not start	Faulty fuel pump.	Perform diagnostic tests on the fuel pump. Remove and replace fuel pump as required.
GASOLINE ODOR	Tank overfilled.	Do not "pack" tank. Fill to automatic shut-off.
	Leak in fuel tank.	Purge tank and repair or replace tank as required.
	Disconnected fuel tank vent lines or hoses.	Connect lines or hoses as required.
	Faulty fill cap.	Install new cap.
FUEL STARVATION	Tank filter plugged.	Replace filter.
	Fuel line pinched, plugged or mis-routed.	Check open or re-route as required.
	Fuel pump not operating.	See FUEL PUMP TEST.
	Plugged or restrictive anti syphon valve.	Replace valve.
	Plugged tank vent	Clean or replace vent.

PCM

marine engines

FORD ENGINE STARTING SYSTEM REPAIR & DIAGNOSTIC PROCEDURES

FORD ENGINE STARTING SYSTEM

DESCRIPTION AND OPERATION

The function of the starting system is to crank the engine at a speed fast enough to permit the engine to start. Heavy cables, connectors, and switches are used in the starting system because of the large current required by the starter while it is cranking the engine. The amount of resistance in the starting circuit must be kept to an absolute minimum to provide maximum current for the starter operation. Loose or corroded connections, relay contacts, or partially broken cables will result in slower than normal cranking speeds, and may even prevent the starter from cranking the engine.

POSITIVE ENGAGEMENT STARTER

The starter used on these engines is the positive engagement starter. The starting system includes the starter motor with an integral positive-engagement drive, the battery, a remote control starter switch, the starter relay, and heavy circuit wiring.

Turning the ignition key to the START position or pressing the start button actuates the starter relay through the starter control circuit. The starter relay then connects the battery to the starter.

When the starter is not in use, one of the field coils is connected directly to ground through a set of contacts (Figure 1). When the starter is first connected to the battery, a large current flows through the grounded field coil, actuating a movable pole shoe. The pole shoe is attached to the starter drive plunger lever and thus the drive is forced into engagement with the flywheel.

When the movable pole shoe is fully seated, it opens the field coil grounding contacts and the starter is then in normal operation. A holding coil is used to maintain the movable pole shoe in the fully seated position during the time that the starter is turning the engine.

SOLENOID ACTUATED STARTER

Major assembly components of the solenoid actuated starter are the frame and field coil assembly, armature assembly, brush plate assembly, drive assembly, shift lever assembly, drive housing assembly and starter solenoid assembly (Figure 1).

The motor is a four-brush, four-field, four-pole wound unit.

The solenoid assembly is mounted to a flange on the starter drive housing. The entire shift lever mechanism and the solenoid plunger are enclosed in the drive housing, thus protecting them from exposure to contamination.

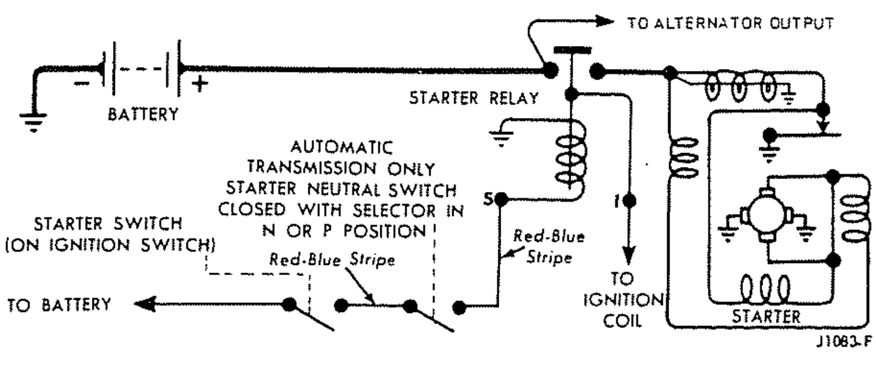


Fig. 1 — Starting Circuit Positive Engagement

A metal heat shield protects the solenoid from heat radiated by the engine. Without this shield, plastic parts of the solenoid could be damaged by excessively high temperatures, and the solenoid could fail.

Always install a heat shield whenever a starter has been removed and repaired or replaced, or whenever the shield has fallen off or has been damaged. Service Kit D3AF-11K138-AA contains the attaching screws and a universal shield for use on all engines with solenoid starters.

The solenoid incorporates two windings: a pull-in winding and hold-in winding. Together they provide the magnetic attraction to pull the solenoid plunger into the solenoid.

SOLENOID OPERATION

Engine cranking occurs when the solenoid on the starter is energized through the starter control (ignition) switch. When energized, the solenoid shifts the starting motor pinion into mesh with the engine flywheel ring gear.

Simultaneously, the main contacts of the solenoid are closed and battery current is directed to the starting motor, causing the armature to rotate.

After the engine starts, the starter drive is disengaged only when the ignition switch is turned from the START to the ON position. This opens the circuit to the starter solenoid and the solenoid return spring causes the shift lever to disengage the starter drive from the engine flywheel ring gear.

The starting motor is protected from short duration excessive speed by an overrunning clutch incorporated in the starter drive. The overrunning clutch permits the drive pinion gear to rotate faster than the armature as the engine starts and picks up speed, thus protecting the armature from being driven by the engine.

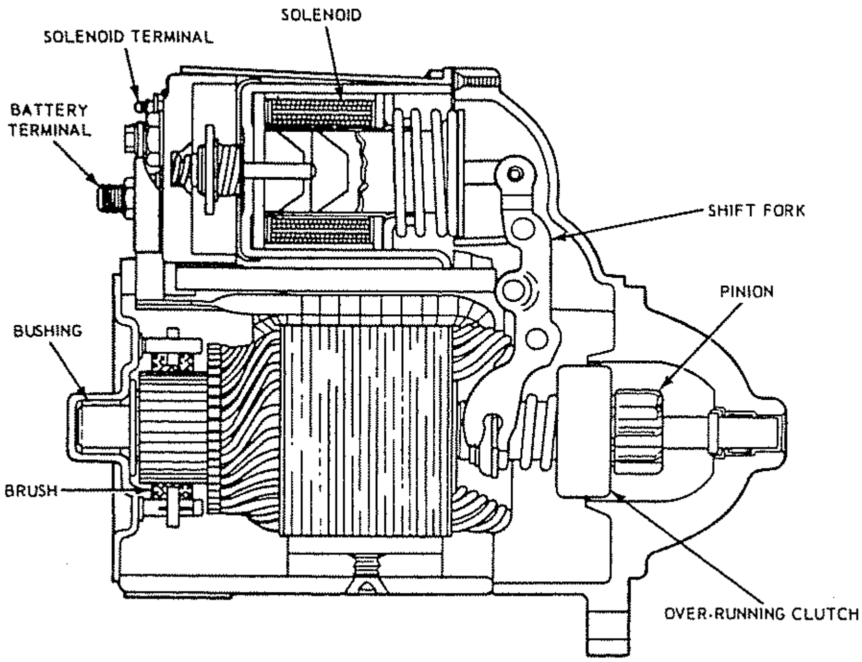


Fig. 1 — Solenoid Actuated Starter Cross Section

CONNECTOR LINK

In the solenoid actuated starter heavy battery current is carried to the starter windings by contacts in the solenoid.

If the solenoid actuated starter is installed on engines with a starter relay, a special "connector link" is installed on the solenoid (Figure 2). This link connects the battery terminal with the solenoid operating windings. Thus, when the key is turned to the START position, the starter relay is actuated, sending battery current to the starter solenoid. The current operates the solenoid and then the starter through solenoid internal contacts.

When replacing starters or starter solenoids, be sure to replace the link. If a link is not used on a starter relay equipped engine, the engine will not start.

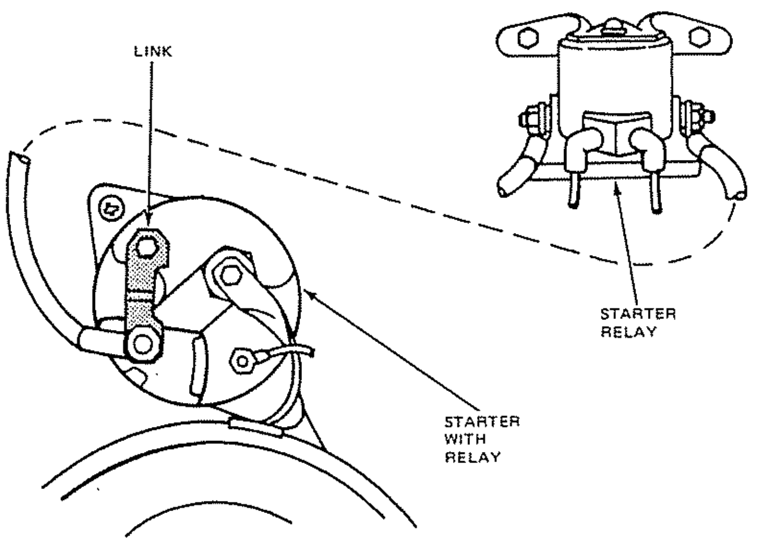


Fig. 2 — Solenoid Connector Link

TESTING

BOOSTER BATTERY

You should connect a booster battery to the starting system for cases of a starter that will not crank the engine or a starter that cranks the engine very slowly, for you may have run your battery down while trying to get the engine started.

If the starter does not turn the engine over, even with a booster battery attached, refer to the following tests. **Be certain that correct battery polarity is obsreved when using a booster battery; positive-to-positive and negative-to-negative connection of the auxiliary cables.**

ON VEHICLE TESTING SOLENOID STARTER

STARTER CRANKING CIRCUIT TEST

These tests will determine whether or not there is excessive resistance in the cranking circuit. Make each test connection as shown in Figure 3. While cranking the engine, observe the voltage drop reading for each test. **Disconnect and ground the high tension lead from the ignition coil to prevent the engine from starting. Connect a remote control switch between the battery terminal of the starter relay and the S terminal of the relay.** The voltage drop in the circuit will be indicated by the voltmeter (0 to 2 volt range). Maximum allowable voltage drop should be:

1. 0.5 volt with the voltmeter negative lead connected to the starter terminal and the positive lead connected to the battery positive terminal (Figure 3, connection 1).
2. 0.3 volt with the voltmeter negative lead connected to the starter terminal and the positive lead connected to the battery terminal of the starter solenoid (Figure 3, connection 2).
3. 0.2 volt with the voltmeter negative lead connected to the battery terminal of the starter solenoid and the positive lead connected to the positive terminal of the battery (Figure 3, connection 3).

4. 0.1 volt with the voltmeter negative lead connected to the negative terminal of the battery and the positive lead connected to the engine ground (Figure 3, connection 4).

STARTER LOAD TEST

Connect the test equipment as shown in Figure 4. Be sure that no current is flowing through the ammeter and heavy-duty carbon pile rheostat portion of the circuit (rheostat at maximum counterclockwise position).

Crank the engine with the ignition OFF, and determine the exact reading on the voltmeter. This test is accomplished by disconnecting and grounding the high tension lead from the ignition coil, and by connecting a jumper from the battery terminal of the starter solenoid to the ignition switch "S" terminal of the solenoid.

Stop cranking the engine, and reduce the resistance of the carbon pile until the voltmeter indicates the same reading as that obtained while the starter cranked the engine. The ammeter will indicate the starter current draw under load.

STARTER SOLENOID TEST

If the solenoid does not pull in (starter load test) measure the voltage between the starter mounted solenoid switch terminal and ground with the ignition switch closed. If the reading is 10 volts or more, a worn or damaged solenoid is indicated. Remove the starter assembly for solenoid replacement.

BENCH TESTS

STARTER NO-LOAD TEST

This test will uncover such faults as open or shorted windings, rubbing armature, and bent armature.

Make the test connections as shown in Figure 5. The starter will run at no load. Be sure that no current is flowing through the ammeter (rheostat at maximum counterclockwise position). Determine the exact reading on the voltmeter.

Disconnect the starter from the battery, and reduce the resistance of the rheostat until the voltmeter indicates the same reading as that obtained while the starter was running. The ammeter will indicate the starter no-load current draw.

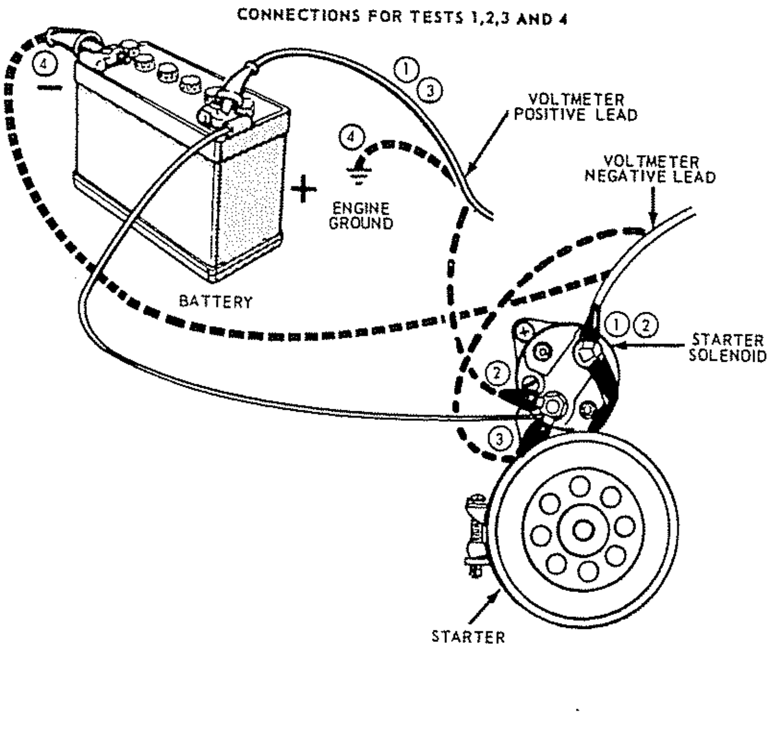


Fig. 3 — Starter Cranking Circuit Test—Solenoid Starter

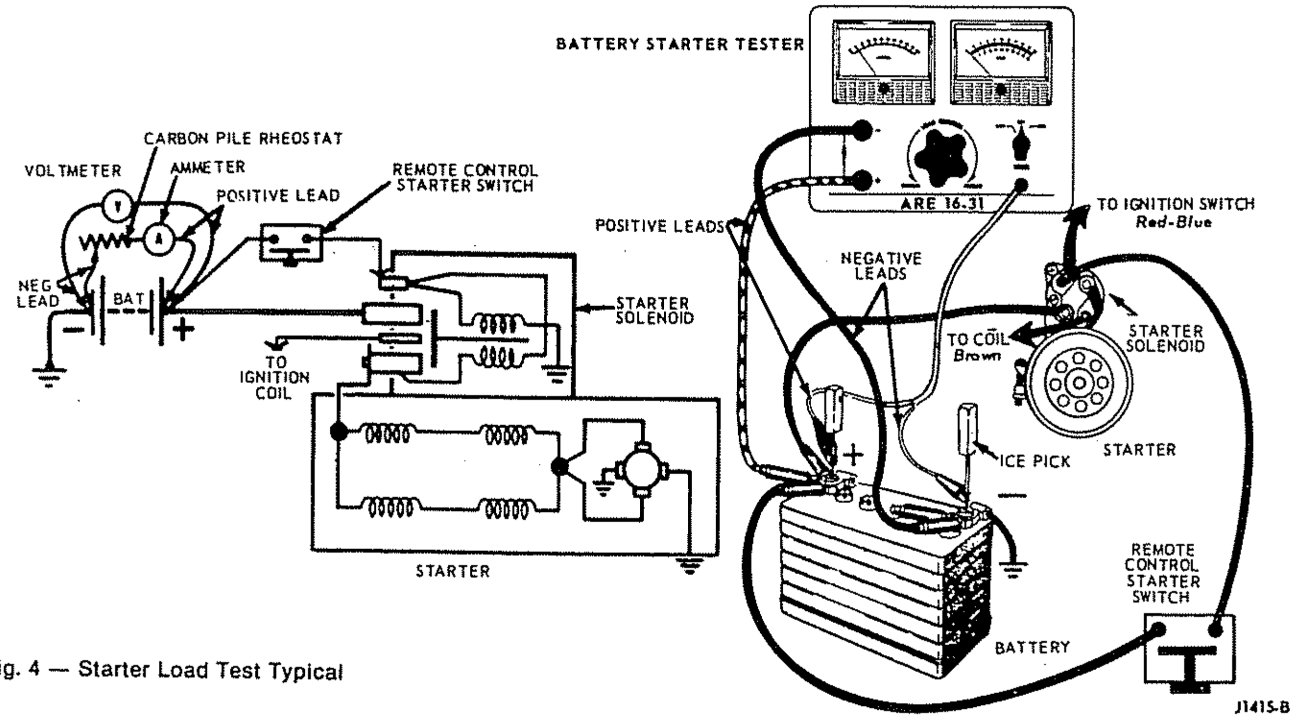


Fig. 4 — Starter Load Test Typical

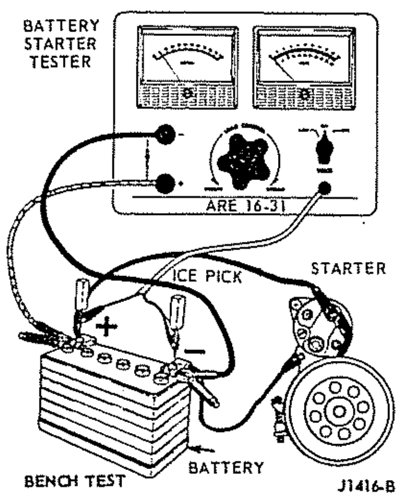


Fig. 5 — Starter No-Load Test on Test Bench

ARMATURE OPEN CIRCUIT TEST

An open circuit armature may sometimes be detected by examining the commutator for evidence of burning. A spot burned on the commutator is caused by an arc formed every time the commutator segment, connected to the open circuit windings, passes under a brush.

ARMATURE AND FIELD GROUNDED CIRCUIT TEST

This test will determine if the winding insulation has failed, permitting a conductor to touch the frame or armature core:

To determine if the armature windings are grounded, make the connections as shown in Figure 6. If the voltmeter indicates any voltage, the windings are grounded.

Grounded field windings can be detected by making the connections as shown in Figure 7. If the voltmeter indicates any voltage, the field windings are grounded.

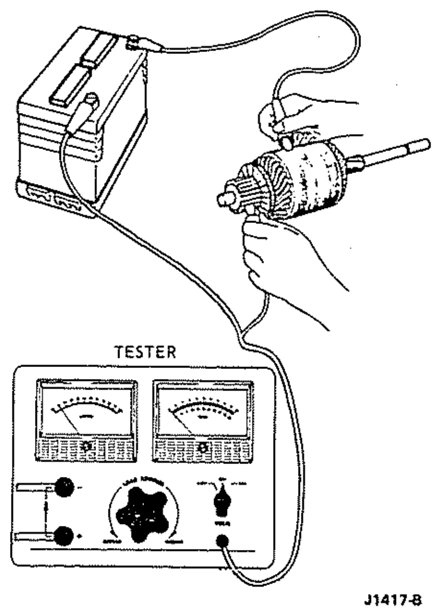


Fig. 6 — Armature Grounded Circuit Test

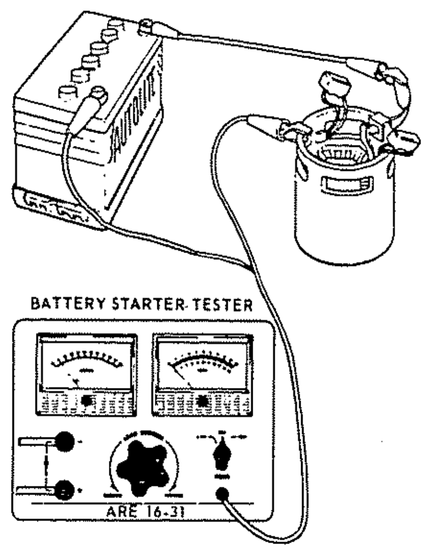


Fig. 7 — Field Grounded Circuit Test

ON VEHICLE TESTING

STARTER DRIVE AND STARTER TEST

Flood the engine by pumping the throttle eight to ten times. Turn the ignition key to start and hold it in the start position. The engine should fire immediately, but should not start and run. The starter should continue to crank the engine. This indicates a normal, acceptable starter drive. If the engine stops turning and the starter spins at high speed, the drive is not operating properly and should be replaced. Whenever possible, remove the plunger cover to observe if the plunger pole is operating while the starter is on the vehicle. **Do not damage the exposed switch during starter removal or installation.**

ALTERNATE STARTER DRIVE TEST

1. Pull the push-on connector from the ignition coil primary terminal. Place the connector loosely on the coil terminal.
2. Connect a remote control starter switch to the starter relay.
3. Turn the ignition switch key to the ON position and depress the remote control starter switch. As soon as the engine begins to run, pull the push-on connector from the coil terminal while holding the remote control switch in the **start** position. Pulling the wire off the coil **kills** the ignition, and the **dead** engine should now be cranked by the starter.
4. Observe to see if the starter begins to crank the **dead** engine and if it continues to crank the engine until the remote control switch is released. If the starter does not crank the **dead** engine, the drive assembly is slipping.
5. Repeat the test at least three times in succession to detect intermittent operation.

POSITIVE ENGAGEMENT

STARTER CRANKING CIRCUIT TEST

Excessive resistance in the starter circuit can be determined from the results of this test. Make the test connections as shown in Figure 4. Crank the engine with the ignition OFF. This is accomplished by disconnecting a grounding the high tension lead from the ignition coil and by connecting a jumper from the battery terminal of the starter relay to the S terminal of the relay.

The voltage drop in the circuit will be indicated by the voltmeter (0 to 2 volt range). Maximum allowable voltage drop should be:

1. With the voltmeter negative lead connected to the starter terminal and the positive lead connected to the battery positive terminal (Figure 2, connection (2)...0.5 volt.
2. With the voltmeter negative lead connected to the battery terminal of the starter relay and the positive lead connected to the positive terminal of the battery (Figure 2, connection (2)...0.1 volt.
3. With the voltmeter negative lead connected to the starter terminal of the starter relay and the positive lead connected to the positive terminal of the battery (Figure 2, connection (3)...0.3 volt.
4. With the voltmeter negative lead connected to the negative terminal of the battery and the positive lead connected to the engine ground (Figure 2, connection (4)) ...0.1 volt.

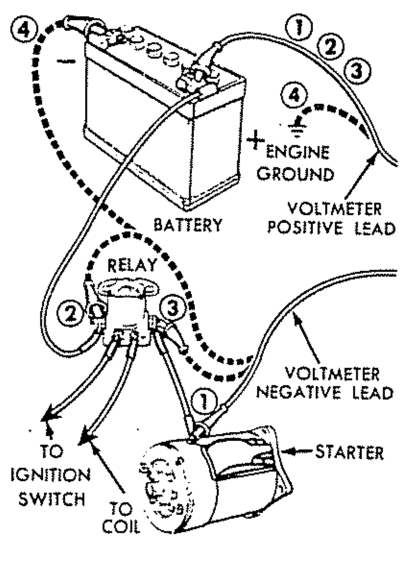


Figure 8 — Starting Cranking Circuit Test

STARTER LOAD TEST

Connect the test equipment as shown in Figure 4. Be sure that no current is flowing through the ammeter and heavy-duty carbon pile rheostat portion of the circuit (rheostat at maximum counterclockwise position).

Crank the engine with the ignition OFF, and determine the exact reading on the voltmeter. This test is accomplished by disconnecting and grounding the high tension lead from the ignition coil, and by connecting a jumper from the battery terminal of the starter relay to the ignition switch terminal of the relay.

Stop cranking the engine. Then reduce the resistance of the carbon pile until the voltmeter indicates the same reading as that obtained while the starter cranked the engine. The ammeter will indicate the starter current draw under load.

BENCH TESTS

STARTER NO-LOAD TEST

The starter no-load test will uncover open or shorted windings, rubbing armature, and bent armature shaft. The starter can be tested, at no-load, on the test bench only.

Make the test connections as shown in Figure 9. The starter will run at no-load. Be sure that no current is flowing through the ammeter (rheostat at maximum counterclockwise position). Determine the exact reading on the voltmeter.

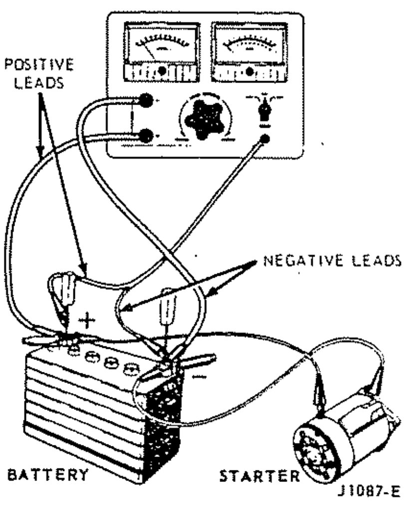


Fig. 9 Starter No-Load Test on Test Bench

Disconnect the starter from the battery. Then, reduce the resistance of the rheostat until the voltmeter indicates the same reading as that obtained while the starter was running. The ammeter will indicate the starter no-load current draw.

ARMATURE OPEN CIRCUIT TEST—ON TEST BENCH

An open circuit armature may sometimes be detected by examining the commutator for evidence of burning. A spot burned on the commutator is caused by an arc formed every time the commutator segment, connected to the open circuit winding, passes under a brush.

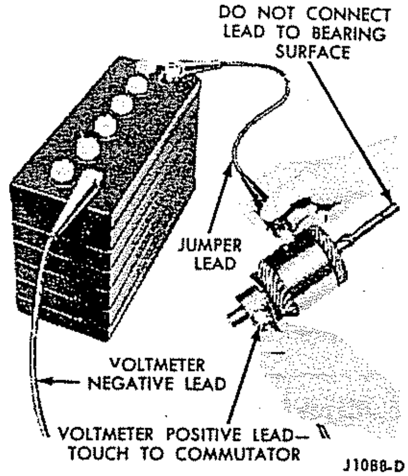


Fig. 10

ARMATURE AND FIELD GROUNDED CIRCUIT TEST—ON TEST BENCH

This test will determine if the winding insulation has been damaged, permitting a conductor to touch the frame or armature core.

To determine if the armature windings are grounded, make the connections as shown in Figure 5. If the voltmeter indicates any voltage, the windings are grounded.

Grounded field windings can be detected by making the connections as shown in Figure 6. If the voltmeter indicates any voltage, the field windings are grounded.

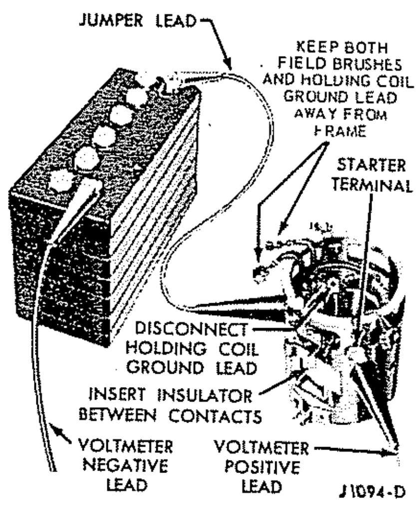


Fig. 11 — Field Grounded Circuit Test

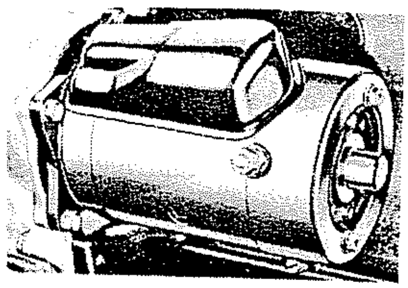


Fig. 12 — Starter Mounting

REMOVAL AND INSTALLATION

STARTER

Removal

1. Disconnect the starter cable and wires at the starter terminal.
2. Remove the starter mounting bolts. Remove the starter assembly (Figure 12).

INSTALLATION

1. Position the starter assembly to the flywheel housing, and start the mounting bolts.
2. Snug all bolts while holding the starter squarely against its mounting surface and fully insert into the pilot hole. Torque the bolts to specification.
3. Connect the starter cable and wires.
4. Check the operation of the starter.

OVERHAUL POSITIVE ENGAGEMENT

STARTER

Use the following procedures when it becomes necessary to completely overhaul the starter. Figure 13 illustrates a partially disassembled starter.

DISASSEMBLY

1. Loosen the brush cover band retaining screw and remove the brush cover band and the starter drive plunger lever cover. Observe the lead positions for assembly and then remove the commutator brushes from the brush holders.
2. Remove the through bolts, starter drive end housing, and the starter drive plunger lever return spring.
3. Remove the pivot pin retaining the starter gear plunger lever and remove the lever and the armature.

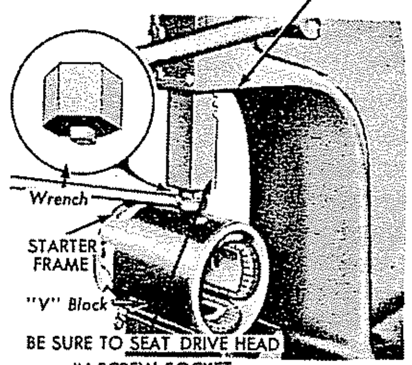


Fig. 14 — Pole Shoe Screw Removal

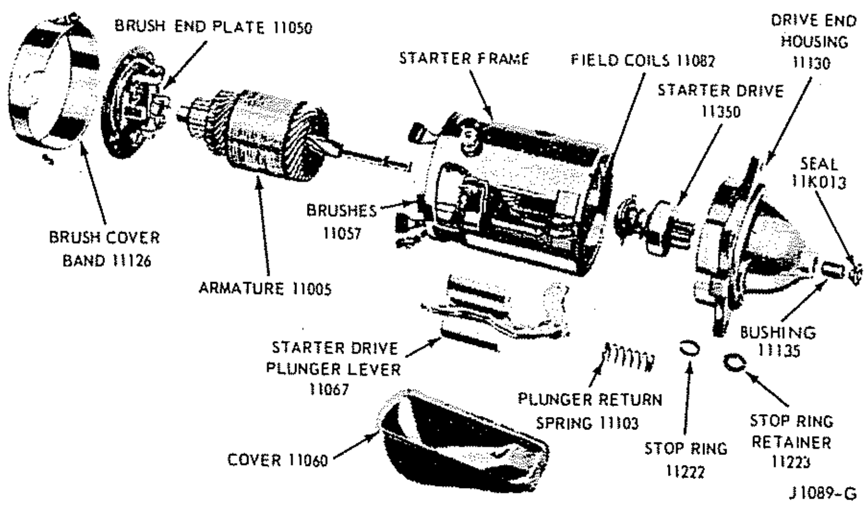


Fig. 8 — Starter Disassembled Positive Engagement Type

4. Remove the stop ring retainer. Remove and discard the stop ring retaining the starter drive gear to the end of the armature shaft, and remove the starter drive gear assembly.
5. Remove the brush end plate.
6. Remove the two screws retaining the ground brushes to the frame.
7. On the field coil that operates the starter drive gear actuating lever, bend the tab up on the field coil retaining sleeve and remove the sleeve.
8. Remove the three coil-retaining screws, using Tool 10044-A and an arbor press (Figure 14). The arbor press prevents the wrench from slipping out of the screw. Unsolder the field coil leads from the terminal screw, and remove the pole shoes and coils from the frame. Use a 300-watt solder iron.
9. Cut (or unsolder) the insulated brush leads from the field coils, as close to the field connection point as possible.
10. Remove the starter terminal nut, washer, insulator, and terminal from the starter frame. Remove any excess solder from the terminal slot.

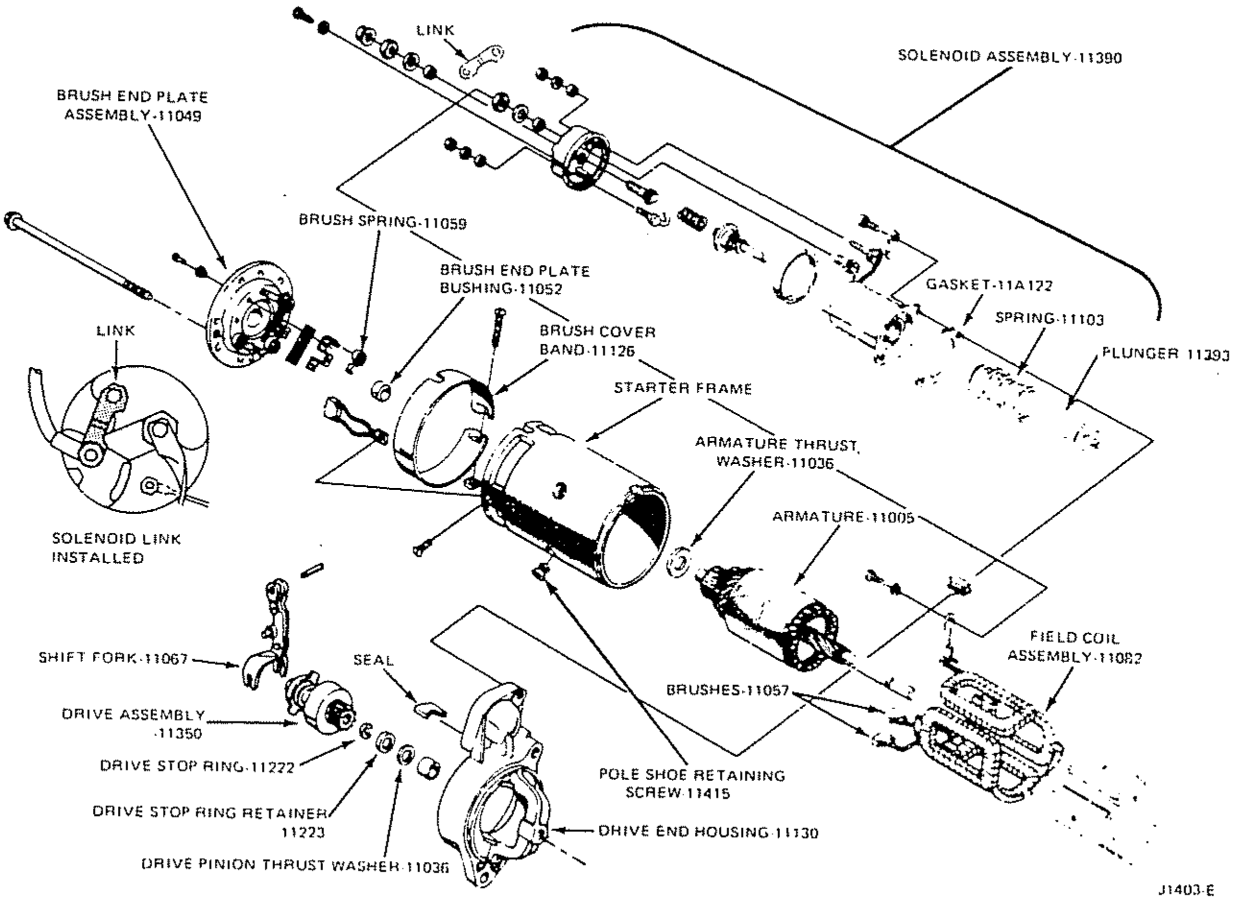


Fig. 15 - Starter Disassembled Solenoid Type

OVERHAUL

SOLENOID ACTUATED STARTER

Disassembly

1. Disconnect the copper strap from the starter terminal on the solenoid, remove the retaining screws and remove the solenoid from the drive housing (Figure 15).
2. Loosen the retaining screw and slide the brush cover band back on the starter frame for access to the brushes.
3. Remove the commutator brushes from their holders. Hold each spring away from the brush with a hook, while sliding the brush out of the holder.
4. Remove the through-bolts and separate the drive-end housing, starter frame and brush end plate assemblies.
5. Remove the solenoid plunger and shift fork assembly. If either the plunger or fork is to be replaced, they can be separated by removing the roll pin.
6. Remove the armature and drive assembly from the frame. Remove the drive stop ring and slide the drive assembly off the armature shaft.
7. Remove the drive stop ring retainer from the drive housing.

CLEANING AND INSPECTION (ALL STARTERS)

1. Do not wash the drive because **the solvent will wash out the lubricant causing the drive to slip.** Use a brush or compressed air to clean the drive, field coils, armature, commutator, armature shaft front end plate, and rear end housing. Wash all other parts in solvent and dry the parts.
2. Inspect the armature windings for broken or burned insulation and unsoldered connections.
3. Check the armature for open circuits and grounds.
4. Check the commutator for runout (Figure 17). Inspect the armature shaft and the two bearings for scoring and excessive wear. On a starter with needle bearings apply a small amount of grease to the needles. If the commutator is rough, or more than 0.005 inch out-of-round, turn it down.
5. Check the brush holders for broken springs and the insulated brush holders for shorts to ground. Tighten any rivets that may be loose. Replace the brushes if worn to 1/4 inch in length.
6. Check the brush spring tension. Replace the springs if the tension is not within specified limits (40 ounces minimum).
7. Inspect the field coils for burned or broken insulation and continuity. Check the field brush connections and lead insulation. A brush kit and a contact kit are available. All other assemblies are to be replaced rather than repaired.
8. Examine the wear pattern on the starter drive teeth. The pinion teeth must penetrate to a depth greater than 1/2 the ring gear tooth depth (Figure 16), to eliminate premature ring gear and starter drive failure.
9. Replace starter drives and ring gears with milled, pitted or broken teeth or that show evidence of inadequate engagement (Figure 16).

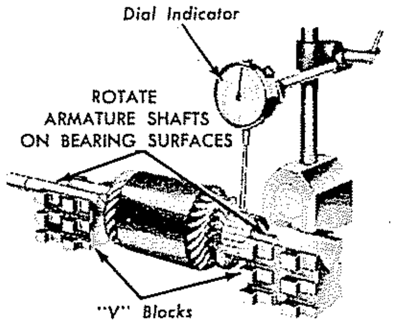


Fig. 17 — Checking Commutator Runout

ASSEMBLY POSITIVE ENGAGEMENT STARTER

1. Install the starter terminal, insulator, washers, and retaining nut in the frame (Figure 18). Be sure to position the slot in the screw perpendicular to the frame end surface.
2. Position the coils and pole pieces, with the coil leads in the terminal screw slot, and then install the retaining screws (Figure 14). As the pole shoe screws are tightened, strike the frame several sharp blows with a soft-faced hammer to seat and align the pole shoes, then stake the screws.
3. Install the solenoid coil and retainer and bend the tabs to retain the coils to the frame.
4. Solder the field coils and solenoid wire to the starter terminal using rosin core solder. Use a 300-watt iron.
5. Check for continuity and grounds in the assembled coils.

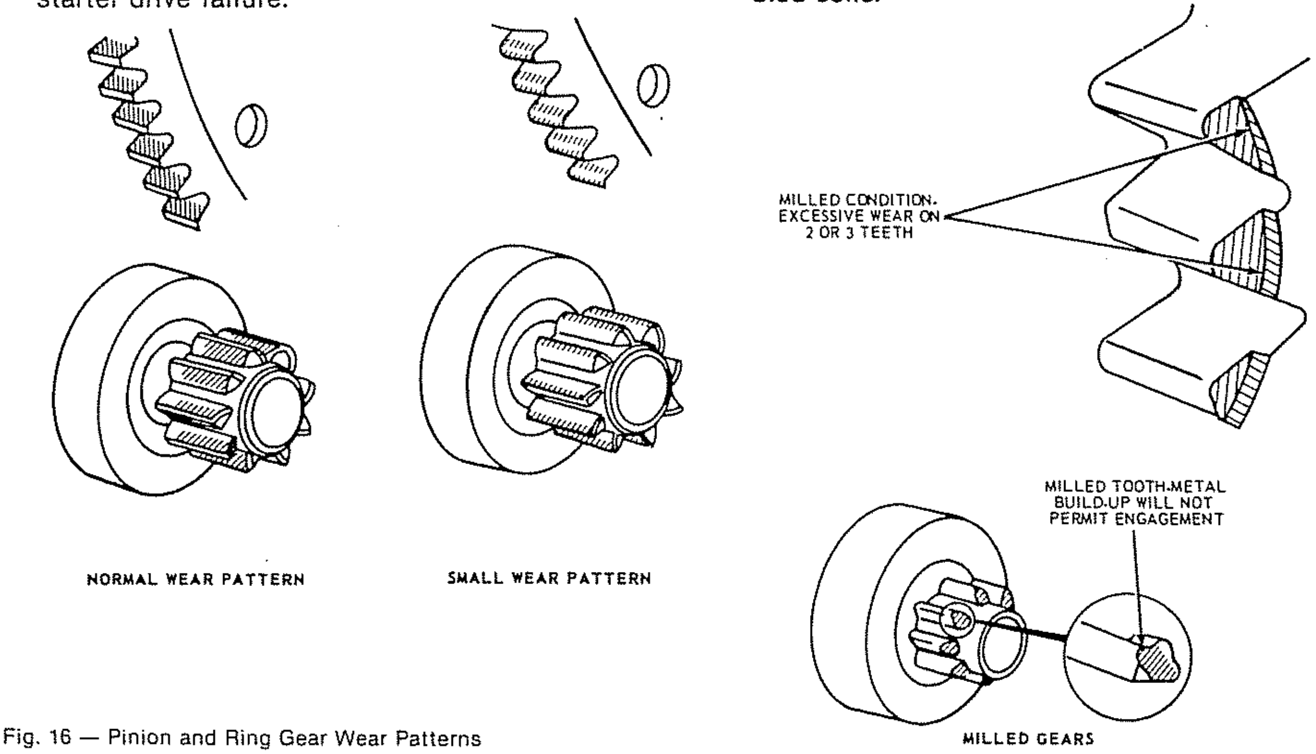


Fig. 16 — Pinion and Ring Gear Wear Patterns

6. Position the new insulated field brushes lead on the field coil terminal. Install the clip provided with the brushes to hold the brush lead to the terminal. Solder the lead, clip, and terminal together, using rosin core solder (Figure 18). Use a 300-watt iron.
7. Position the solenoid coil ground terminal over the nearest ground screw hole.
8. Position the ground brushes to the starter frame and install the retaining screws (Figure 18).
9. Position the starter brush end plate to the frame with the end plate boss in the frame slot.
10. Apply a thin coating of Lubriplate 777 on the armature shaft splines. Install the starter motor drive gear assembly to the armature shaft and install a new retaining stop ring. Install a new stop retainer.
11. Position the fiber thrust washer on the commutator end of the armature shaft and position the armature in the starter frame.
12. Partially fill the drive end housing bearing bore with grease (approximately 1/4 full). Position the starter drive gear plunger lever to the frame and starter drive assembly, and install the pivot pin.
13. Position the starter drive plunger lever return spring and the drive end housing to the frame and install and tighten the through bolts to specification (55-75 inch pounds). **Do not pinch the brush leads between the brush plate and the frame.** Be sure that the stop ring retainer is seated properly in the drive housing.
14. Install the brushes in the brush holders. **Be sure to center the brush springs on the brushes.**
15. Position the drive gear plunger lever cover on the starter and install the brush cover band with a gasket. Tighten the band retaining screw.
16. Check the starter no-load current draw.

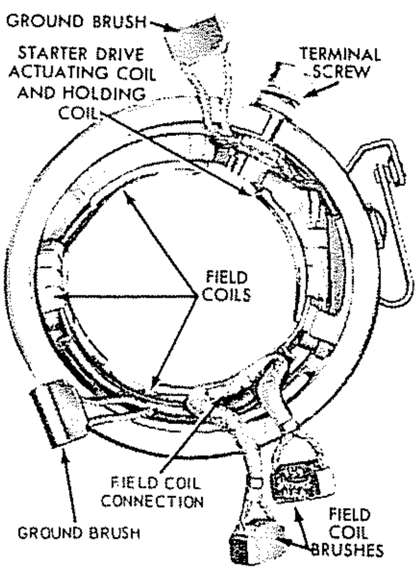


Fig. 18 — Coil Assembly

ASSEMBLY SOLENOID STARTER

1. Install a small amount of lubriplate on the armature shaft splines. Install the drive assembly on the armature shaft and install a new stop ring (Figure 15).
2. Apply a small amount of lubriplate on the shift lever pivot pin. Position the solenoid plunger and shift lever assembly in the drive housing.
3. Place a new retainer in the drive housing. Apply a small amount of lubriplate to the drive end of the armature shaft. Place the armature and drive assembly into the drive housing. Be sure that the shift lever tangs properly engage the drive assembly.
4. Apply a small amount of lubriplate on the commutator end of the armature shaft.
5. Position the frame and field assembly to the drive housing. Be sure that the frame is properly indexed to the drive housing assembly.
6. Position the brush plate assembly to the frame assembly. Be sure that the brush plate is properly indexed to the frame. Install the through-bolts and tighten to 45 to 85 in-lbs.
7. Place the brushes in their holders. Pull each spring away from the holder with a hook to allow entry of the brush. Center the brush springs on the brushes. Press the insulated brush leads away from all other interior components to prevent possible shorts.
8. Position the rubber gasket between the solenoid mounting and the upper outside surface of the frame. Position the starter solenoid with metal gasket (if used), and install the solenoid mounting screws.
9. Connect the copper strap to the starter terminal on the solenoid.
10. Position the cover band and tighten the retaining screw.
11. Connect the starter to a battery to check its operation.

STARTER DRIVE REPLACEMENT

1. Loosen and remove the brush cover band and the starter drive plunger lever cover.
2. Loosen the through bolts enough to allow removal of the drive end housing and the starter drive plunger lever return spring.
3. Remove the pivot pin retaining the starter drive plunger lever and remove the lever.
4. Remove the drive gear stop ring retainer and stop ring from the end of the armature shaft and remove the drive gear assembly.
5. Apply a thin coating of Lubriplate 777 on the armature shaft splines. Install the drive gear assembly on the armature shaft and install a new stop ring.

6. Position the starter gear plunger lever on the starter frame and install the pivot pin. **Be sure that the plunger lever properly engages the starter drive assembly.**
7. Install a new stop-ring retainer. Partially fill the drive end housing bearing bore with grease (approximately 1/4 full). Position the starter drive plunger lever return spring and drive end housing to the starter frame, and then tighten the through bolts to specifications 55-75 inch pounds).
8. Position the starter drive plunger lever cover and the brush cover band, with its gasket, on the starter. Tighten the brush cover band retaining screw.

BRUSH REPLACEMENT POSITIVE ENGAGEMENT STARTER

Replace the starter brushes when they are worn to 1/4 inch. Always install a complete set of new brushes.

1. Loosen and remove the brush cover band, gasket, and starter drive plunger lever cover. Remove the brushes from their holders.
2. Remove the two through bolts from the starter frame.
3. Remove the drive end housing, and the plunger lever return spring.
4. Remove the starter drive plunger lever pivot pin and lever, and remove the armature.
5. Remove the brush end plate.
6. Remove the ground brush retaining screws from the frame and remove the brushes.
7. Cut the insulated brush leads from the field coils, as close to the field connection point as possible.
8. Clean and inspect the starter motor.
9. Replace the brush end plate if the insulator between the field brush holder and the end plate is cracked or broken.
10. Position the new insulated field brushes lead on the field coil connection. Position and crimp the clip provided with the brushes to hold the brush lead to the connection. Solder the lead, clip, and connection together, using rosin core solder (Figure 18). Use a 300-watt iron.
11. Install the ground brush leads to the frame with the retaining screws.
12. Clean the commutator with 00 or 000 sandpaper.
13. Position the brush end plate to the starter frame, with the end plate boss in the frame slot.
14. Install the armature in the starter frame.
15. Install the starter drive gear plunger lever to the frame and starter drive assembly, and install the pivot pin.
16. Partially fill the drive end housing bearing bore with grease (approximately 1/4 full). Position the return spring on the plunger lever, and the drive end housing to the starter frame. Install the through bolts and tighten to specified torque (55-75 inch pounds). Be sure that the stop ring retainer is seated properly in the drive end housing.
17. Install the commutator brushes in the brush holders. Center the brush springs on the brushes.
18. Position the plunger lever cover and the brush cover band, with its gasket on the starter. Tighten the band retaining screw.
19. Connect the starter to a battery to check its operation.

BRUSH REPLACEMENT SOLENOID STARTER

Replace the starter brushes when they are worn to 1/4 inch. Always install a complete set of new brushes.

1. Disconnect the copper strap from the starter terminal on the solenoid.
2. Loosen the retaining screw and slide the brush cover band back on the starter frame for access to the brushes.
3. Remove the commutator brushes from their holders. Hold each spring away from the brush with a hook, while sliding the brush out of the holder.
4. Remove the through-bolts and separate the drive end housing, starter frame and brush end plate assemblies.
5. Remove the ground brush retaining screws from the frame and remove the brushes.
6. Cut the insulated brush leads from the field coils, as close to the field connection point as possible.
7. Clean and inspect the starter motor.
8. Replace the brush end plate, if the insulator between the field brush holder and the end plate is cracked or broken.
9. Position the new insulated field brushes lead on the field coil connection. Position and crimp the clip provided with the brushes to hold the brush lead to the connection. Solder the lead, clip, and connection together, using rosin core solder. Use a 300-watt iron.
10. Install the ground brush leads to the frame with the retaining screws.
11. Clean the commutator with 00 or 000 sandpaper.
12. Apply a small amount of lubriplate on the commutator end of the armature shaft.
13. Position the rubber gasket over the solenoid plunger lever, then position the frame to the end housing so that the wide slot in the frame clears the plunger lever and the end housing dowel is indexed with its frame slot.
14. Position the brush plate assembly to the frame assembly. Be sure that the brush plate is

properly indexed to the frame. Install the through-bolts, making certain that the insulated brush lead is not between the through-bolt and the frame, and tighten to 45 to 85 in-lbs.

15. Place the brushes in their holders. Pull each spring away from the holder with a hook to allow entry of the brush. Center the brush springs on the brushes. Press the insulated brush leads away from all other interior components to prevent possible shorts.
16. Slide the cover band into position and tighten the retaining screw.
17. Connect the copper strap to the starter terminal on the solenoid.
18. Connect the starter to a battery to check its operation.

ARMATURE REPLACEMENT

1. Loosen the brush cover band retaining screw and remove the brush cover band, gasket, and the starter drive plunger lever cover. Remove the brushes from their holders.
2. Remove the through bolts, the drive end housing, and the drive plunger lever return spring.
3. Remove the pivot pin retaining the starter gear plunger lever, and remove the lever.
4. Remove the armature. If the starter drive gear assembly is being reused, remove the stop ring retainer, and the stop ring from the end of the armature shaft, and remove the drive.
5. Place the drive gear assembly on the new armature with a new stop ring.
6. Install the armature in the starter frame.
7. Position the drive gear plunger lever to the frame and drive gear assembly and install the pivot pin.
8. Partially fill the drive end housing bearing bore with grease (approximately 1/4 full). Position the drive plunger lever return spring, the drive end housing and the front end plate to the starter frame, and then install and tighten the through bolts to specification. Be sure that the stop ring retainer is seated properly in the drive housing.
9. Place the brushes in the holders, and center the brush springs on the brushes.
10. Position the plunger lever cover and the brush cover band, with its gasket, and then tighten the retaining screw.
11. Connect the starter to a battery to check its operation.

STARTER TERMINAL

REMOVAL

1. Loosen the brush cover band retaining screw and remove the brush cover band and the starter drive plunger lever cover. Observe the lead positions for assembly and then remove the commutator brushes from the brush holders.
2. Remove the through bolts, starter drive end housing, starter drive plunger lever return spring, and the brush end plate.
3. Remove the pivot pin retaining the starter gear plunger lever and remove the lever and the armature assembly.
4. Unsolder the field coil and solenoid wire leads from the terminal screw. Use a 300-watt soldering iron.
5. Remove the starter terminal nut, washer, insulator and terminal from the starter frame.

INSTALLATION

1. Install the new starter terminal, insulator, washers, and retaining nut in the frame. Be sure to position the slot in the screw perpendicular to the frame end surface.
2. Solder the field coils and solenoid wire to the starter terminal using rosin core solder. Use a 300-watt iron.
3. Check for continuity and grounds in the assembled coils.
4. Position the starter brush end plate to the frame with the end plate boss in the frame slot.
5. Position the armature in the starter frame.
6. Position the starter drive gear plunger lever to the frame and starter drive assembly, and install the pivot pin.
7. Partially fill the drive end housing bearing bore with grease (approximately 1/4 full). Position the starter drive plunger lever return spring and the drive end housing to the frame and install and tighten the through bolts to specifications (55-75 in-lbs.). **Do not pinch the brush leads between the brush plate and the frame.** Be sure that the stop ring retainer is seated properly in the drive housing.
8. Install the brushes in the brush holders. **Be sure to center the brush springs on the brushes.**
9. Position the drive gear plunger lever core on the starter and install the brush cover band with a gasket. Tighten the band retaining screw.
10. Check the starter no-load current draw.

SPECIFICATIONS

CURRENT DRAW (Under Normal Load)
BENDIX INERTIA . . . . 180-250 amps (max. 380)
POSITIVE ENGAGEMENT
4" diameter . . . . 150-200 amps
4½" diameter . . . . 150-180 amps
SOLENOID ACTUATED
4½" diameter . . . . 180-210 amps

NORMAL ENGINE CRANKING SPEED
BENDIX INERTIA . . . . 140-170 rpm
POSITIVE ENGAGEMENT
4" diameter . . . . 180-250 rmp
4½" diameter . . . . 150-290 rpm
SOLENOID ACTUATED
4½" diameter . . . . 140-170 rpm

MAXIMUM LOAD
BENDIX INERTIA . . . . 380 amps
POSITIVE ENGAGEMENT
4" diameter . . . . 460 amps
4½" diameter . . . . 670 amps
SOLENOID ACTUATED
4½" diameter . . . . 400 amps

NO-LOAD
BENDIX INERTIA . . . . 60 amps
POSITIVE ENGAGEMENT
4" diameter . . . . 70 amps
4½" diameter . . . . 80 amps
SOLENOID ACTUATED . . . . 70 amps

MAXIMUM COMMUTATOR RUNOUT
BENDIX INERTIA . . . . 0.005 inches
POSITIVE ENGAGEMENT . . . . 0.005 inches
SOLENOID ACTUATED . . . . 0.005 inches

MAXIMUM STARTING CIRCUIT VOLTAGE DROP
(Battery positive terminal to starter terminal)
BENDIX INERTIA . . . . 0.5 volt
POSITIVE ENGAGEMENT . . . . 0.5 volt
SOLENOID ACTUATED . . . . 0.5 volt
RELAY W/SOLENOID . . . . 0.5 volt

MAXIMUM CABLE VOLTAGE DROP
(Battery to relay resistance)
BENDIX INERTIA . . . . 0.1 volt
POSITIVE ENGAGEMENT . . . . 0.1 volt
SOLENOID ACTUATED . . . . 0.3 volt
RELAY W/SOLENOID . . . . 0.1 volt

MAXIMUM RELAY AND CABLE VOLTAGE DROP
(Resistance across relay or solenoid)
BENDIX INERTIA . . . . 0.3 volt
POSITIVE ENGAGEMENT . . . . 0.3 volt
SOLENOID ACTUATED . . . . 0.5 volt
RELAY W/SOLENOID . . . . 0.3 volt

MAXIMUM GROUND CABLE VOLTAGE DROP
(Ground circuit resistance)
BENDIX INERTIA . . . . 0.1 volt
POSITIVE ENGAGEMENT . . . . 0.1 volt
SOLENOID ACTUATED . . . . 0.1 volt
RELAY W/SOLENOID . . . . 0.1 volt

STARTER BRUSHES (Mfg. length)
BENDIX INERTIA . . . . 0.50 inches
POSITIVE ENGAGEMENT
4" diameter . . . . 0.50 inches
4½" diameter . . . . 0.50 inches
SOLENOID ACTUATED
4½" diameter . . . . 0.50 inches

WEAR LIMIT
BENDIX INERTIA 0.25
POSITIVE ENGAGEMENT
4" diameter 0.25
4½" diameter 0.25
SOLENOID ACTUATED
4½" diameter 0.25

SPRING TENSION
BENDIX INERTIA . . . . 40 ounces
POSITIVE ENGAGEMENT
4" diameter . . . . 40 ounces
4½" diameter . . . . 40 ounces
SOLENOID ACTUATED
4½" diameter . . . . 40 ounces

THROUGH BOLT TORQUE
BENDIX INERTIA . . . . 45-85 in-lbs.
POSITIVE ENGAGEMENT
4" diameter . . . . 55-75 in-lbs.
4½" diameter . . . . 55-75 in-lbs.
SOLENOID ACTUATED
4½" diameter . . . . 45-85 in-lbs.

MOUNTING BOLT TORQUE
BENDIX INERTIA . . . . 15-20 ft-lbs.
POSITIVE ENGAGEMENT
4"diameter . . . . 15-20 ft-lbs.
4½" diameter . . . . 15-20 ft-lbs
SOLENOID ACTUATED
4½" diameter . . . . 15-20 ft-lbs

SPECIAL TOOLS
Tool 10044-A Generator Pole Screw Wrench

DELCO STARTER SYSTEMS REPAIR & DIAGNOSTIC PROCEDURES

DELCO
STARTER SYSTEM
GENERAL DESCRIPTION

The function of the starting system, composed of the starting motor, solenoid and battery, is to crank the engine. The battery supplies the electrical energy, the solenoid completes the circuit to the starting motor, and the motor then does the actual work of cranking the engine.

The starting motor (Fig. 6D-1s) consists primarily of the drive mechanism, frame, armature, brushes, and field windings. The starting motor is a pad mounted 12-volt extruded frame type, having four pole shoes and four fields, connected with the armature. The aluminum drive end housing is extended to enclose the entire shift lever and plunger mechanism, protecting them from dirt, splash, and icing. The drive end frame also includes a grease reservoir to provide improved lubrication of the drive end bearing. The flange mounted solenoid switch operates the overrunning clutch drive by means of a linkage to the shaft lever. The Diesel starter utilizes a center bearing. (Figure 6D-1s).

The starting system is made up of the cranking motor with its drive mechanism, the starter motor solenoid and the battery. These units are connected together and work as a team to crank the engine. The simplified diagram (Fig. 6D-2s) shows the electrical components in a typical starting system. Although modern day applications use more circuitry and controls than shown in Figure 6D-1s, the function of the components is always the same — to convert electrical energy from the battery into mechanical energy at the starter motor to crank the engine.

STARTER MOTOR

Construction

A cross-sectional view of a typical starter motor with a solenoid is shown in Figure 6D-1s.

The starting motor assembly is made up of field coils placed over pole pieces which are attached to the inside of a heavy iron frame, an armature, an overrunning clutch-type drive mechanism, and a solenoid.

The diesel starter is illustrated in Figure 6D-1s.

The iron frame and pole shoes not only provide a place for the field coils, but also provide a path for the magnetic lines produced by the field coil windings.

Armature

The armature assembly (Fig. 6D-3s), consists of a stack of iron laminations placed over a steel shaft, a commutator assembly and the armature winding. The windings are heavy copper ribbon that are assembled into slots in the iron laminations. The winding ends are soldered or welded to the commutator bars which are electrically insulated from each other and from the iron shaft.

The armature is supported by bushings in the end frames. A center bearing is used on the 20MT motor. Brushes are supported on the field frame and ride on the commutator bars.

Drive Mechanism

The starting motor drive mechanism (Fig. 6D-4s) is a roll-type overrunning clutch that is assembled onto the armature shaft. Through this drive component power is transmitted from the armature to the engine during the starting cycle.

The overrunning clutch drive contains a pinion which is made to move along the shaft by means of a shift lever to engage the engine ring gear for cranking. A gear reduction is provided between the pinion and ring gear to meet the cranking requirements of the engine. With this gear reduction, the motor operates to crank the engine at speeds required for starting.

The overrunning clutch drive has a shell and sleeve assembly which is splined internally to match the spiral splines on the armature shaft. The pinion is located inside the shell along with spring-loaded rollers that are wedged against the pinion and a taper inside the shell. The springs may be either a helical or accordion type. Four rolls are used. A collar and spring, located over the sleeve, are the other major clutch components.

When the shift lever is operated by the solenoid, it moves the collar endwise along the shaft. The spring pushes the pinion into mesh with the ring gear. If a tooth abutment occurs, the spring compresses until the switch is closed, at which time the armature rotates and the tooth abutment is cleared. The compressed spring then pushes the pinion into mesh and cranking begins.

Torque is transmitted from the shell to the pinion by the rolls which are wedged tightly between the pinion and taper cut into the shell.

When the engine starts, the ring gear drives the pinion faster than the armature and the rolls move away from the taper, allowing the pinion to overrun the shell. The start switch should be opened immediately when the engine starts to avoid prolonged overrun. When the shift lever is moved back by the return spring, the pinion moves out of mesh and the cranking cycle is completed.

SOLENOID

A sectional view of a typical solenoid is shown in Figure 6D-5s. It performs two functions in the starting system. First, it is used to provide a circuit of short length and low resistance between the battery and motor. Since the motor may draw several hundred amperes during operation, heavy cables of short length are needed to reduce the voltage drop in the circuit.

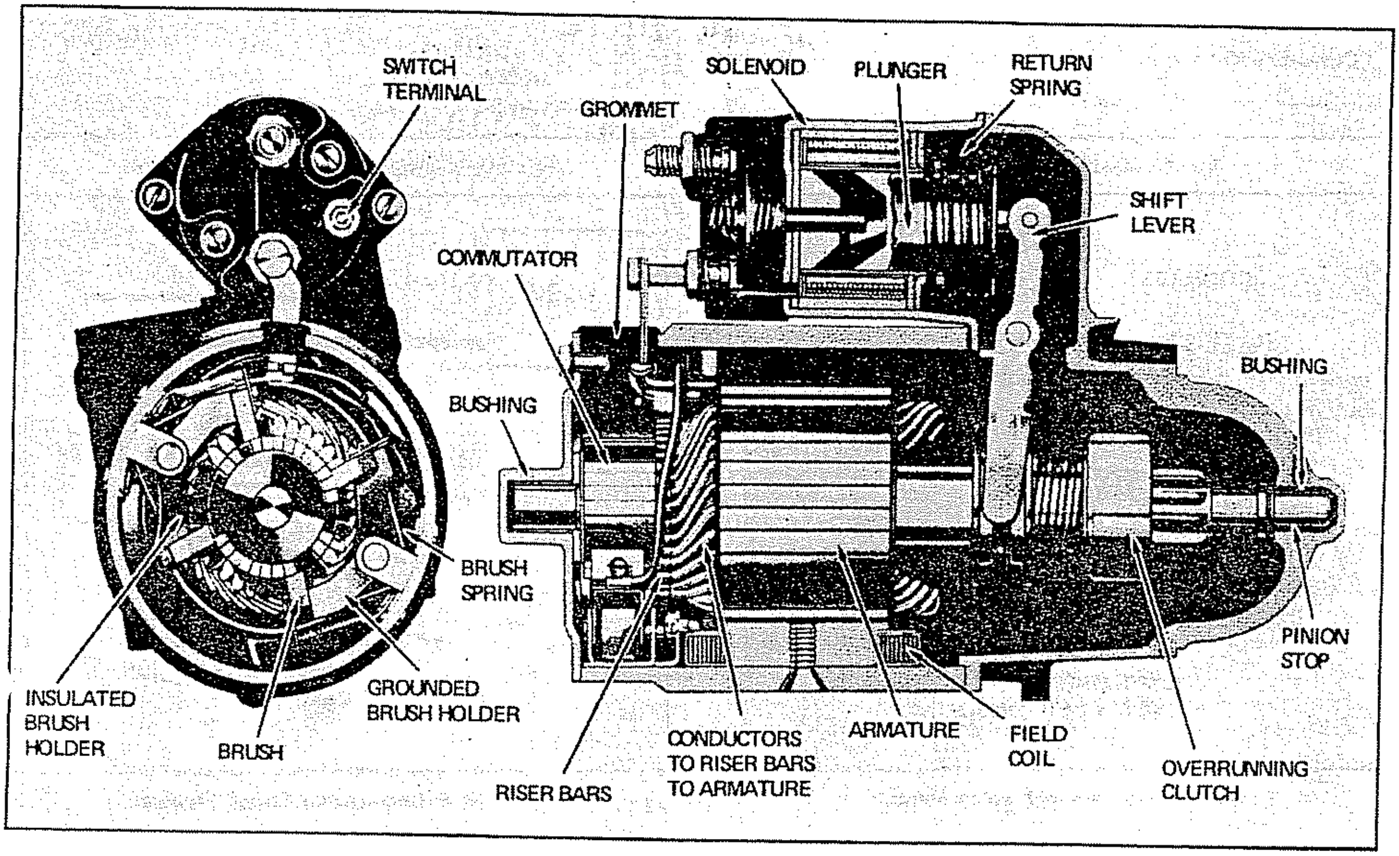


Fig. 6D-1s–Starting Motor Cross Section (Typical)

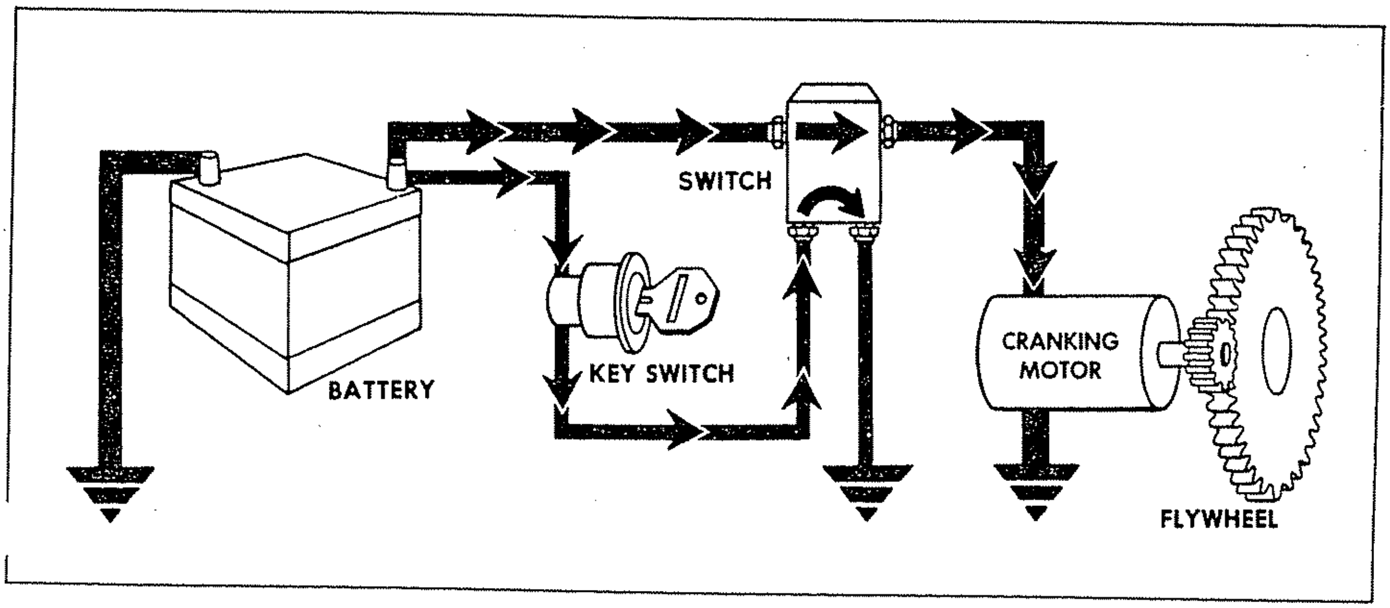


Fig. 6D-2s–Typical Cranking System

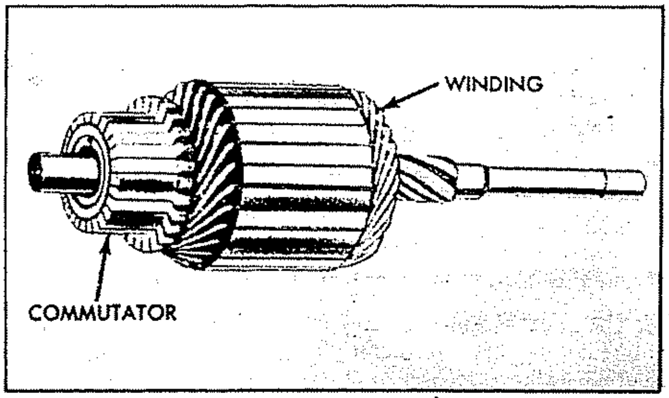


Fig. 6D-3s–Armature Assembly

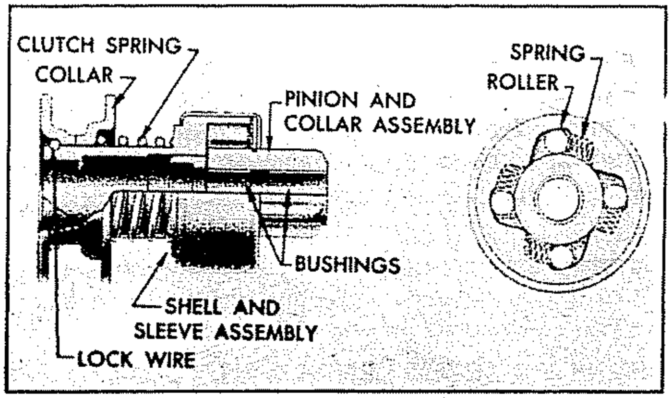


Fig. 6D-4s–Overrunning Clutch Assembly

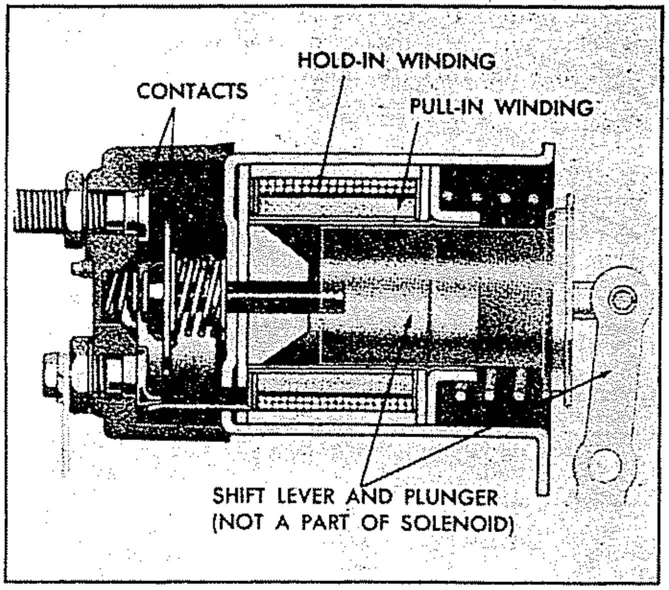


Fig. 6D-5s–Solenoid Cross Section

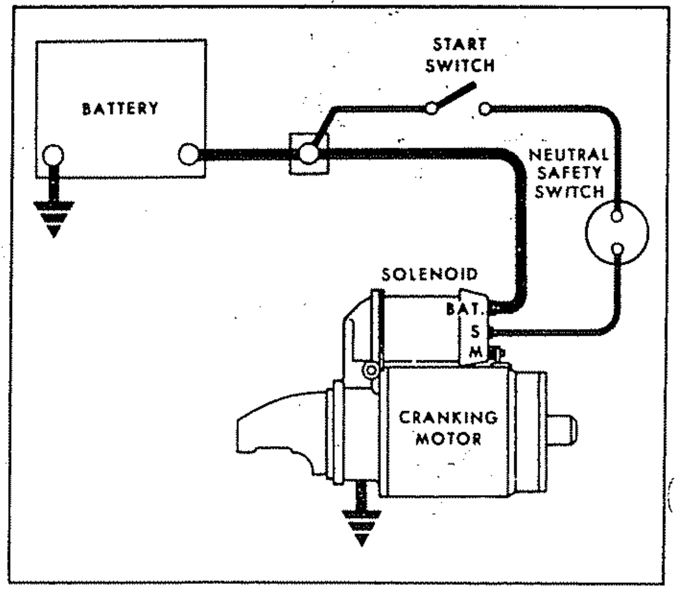


Fig. 6D-6s–Start Switch Circuit (Typical)

DIAGNOSIS

NO CRANKING ACTION

1. Make sure that control lever is neutral (N).
2. Make quick check of battery and cables. If battery is low, the solenoid usually will produce a clattering noise, because a nearly discharged battery will not sustain the voltage required to hold solenoid plunger in after solenoid switch has been closed.
3. If starter motor spins and drive pinion engages ring gear but does not drive it, overrunning clutch is slipping. Remove motor to replace drive assembly.
4. If starter motor does not operate, note whether solenoid plunger is pulled into solenoid when solenoid circuit is closed. Ordinarily the plunger makes a loud click when it is pulled in. If plunger is pulled in, solenoid circuit is okay and trouble is in solenoid switch, cranking motor, or cranking motor circuit. The starter motor must be removed for repairs to switch or motor.
5. If plunger does not pull into solenoid when ignition switch is turned to "START", the solenoid circuit is open, or solenoid is at fault.
6. To find reason why plunger does not pull into solenoid, connect jumper between solenoid battery terminal and terminal on solenoid switch to which control wire is connected. If cranking motor operates, solenoid is okay; trouble is in ignition switch, neutral start switch, or in wires and connections between these units.
7. If starter motor still does not operate, remove motor for inspection and test of solenoid switch.

CRANKING SPEED ABNORMALLY LOW

Abnormally low cranking speed may be caused by low battery or defective cables, defective solenoid switch, defective cranking motor, or an internal condition of engine.

1. Make quick check of battery. If low battery is indicated, test battery. If defective cables are indicated, test cables.

NOTE: Check alternator belt tension for cause of low battery.

2. If battery and cables are okay, test cranking motor and solenoid switch.

3. If starter motor and solenoid switch test okay, the trouble is due to an internal condition of engine. This may be due to use of engine oil which is too heavy for prevailing temperatures.

VOLTAGE TEST OF STARTING SYSTEM AND SOLENOID SWITCH

The voltage across the starter motor and switch while cranking the engine gives a good indication of any excessive resistance.

NOTE: Engine must be at normal operating temperature when test is made.

1. Inspect battery and cables to make certain that battery has ample capacity for cranking and ignition.

2. Connect jumper wire to distributor terminal of coil and to ground on engine, so that engine can be cranked without firing.

3. Connect voltmeter positive lead to the motor terminal on solenoid switch; connect voltmeter negative lead to ground (Fig. 6D-7s).

4. Turn ignition switch on, crank engine and take voltmeter reading as quickly as possible. If cranking motor turns engine at normal cranking speed with voltmeter reading 9 or more volts, the motor and switch are satisfactory. If cranking speed is below normal and voltmeter reading is 9 volts or greater, the cranking motor is defective.

CAUTION: *Do not operate starter motor more than 30 seconds at a time without pausing to allow motor to cool for at least two minutes; otherwise, overheating and damage to motor may result.*

5. If starter motor turns engine at low rate of speed with voltmeter reading less than 9 volts, test solenoid switch contacts as follows:

6. With voltmeter switch turned to any scale above 12 volts, connect voltmeter negative lead to the motor terminal of solenoid switch, and connect positive lead to battery terminal of switch (Fig. 6D-8s).

7. Turn ignition switch on and crank engine. Immediately turn voltmeter switch to low scale and take reading as quickly as possible, then turn switch back to higher scale and stop engine.

The voltmeter will read not more than 2/10 volt if switch contacts are satisfactory. If voltmeter reads more than 2/10 volt, switch should be repaired or replaced.

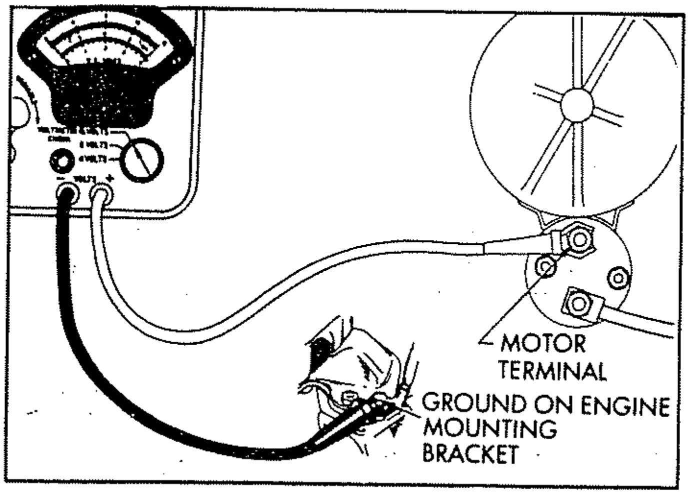


Fig. 6D-7s–Cranking Voltage Test Connections

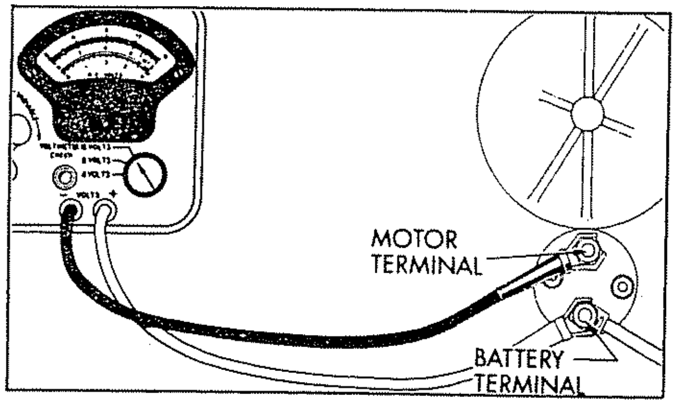


Fig. 6D-8s–Solenoid Switch Contact Test Connections

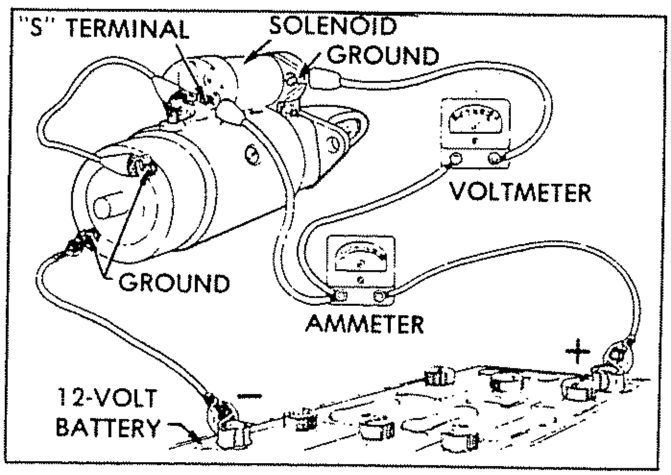


Fig. 6D-9s–Amperage Test of Solenoid

AMPERAGE TEST OF SOLENOID SWITCH WINDINGS

(1) Current draw of both windings in parallel.

(2) Current draw of hold-in winding alone.

1. Remove screw from solenoid motor terminal and bend field leads slightly until clear of terminal. Then ground solenoid motor terminal with a heavy jumper wire (Fig. 6D-9s).

2. Connect a 12-volt battery, a variable resistance, and an ammeter of 100 amperes capacity in series with solenoid "S" terminal. Connect a heavy jumper wire from solenoid base to ground post of battery.

3. Connect a voltmeter between base of solenoid and small solenoid "S" terminal.

4. Slowly adjust resistance until voltmeter reads 10 volts and note ammeter reading. This shows current draw of both windings in parallel. Refer to Delco-Remy bulletin for specifications on the starter being tested.

5. Remove jumper wire from solenoid motor terminal and re-adjust resistance until voltmeter reads 10 volts, then note ammeter reading. This shows current draw of hold-in winding alone. Refer to Delco-Remy bulletin for specifications.

6. If solenoid windings do not test within specifications given, solenoid switch assembly should be replaced.

ON VEHICLE SERVICE

MAINTENANCE AND ADJUSTMENTS

Lubrication

No periodic lubrication of the starting motor or solenoid is required. Since the starting motor and brushes cannot be inspected without disassembling the unit, no service is required on these units between overhaul periods.

COMPONENT PART REPLACEMENT

Starting Motor

Replacement

The following procedure is a general guide for all engines and will vary slightly depending on series and model.

1. Disconnect battery ground cable at battery.
2. Disconnect all wires at solenoid terminals.

NOTE: Reinstall the nuts as each wire is disconnected as thread size is different but may be mixed and stripped.

3. Remove attaching bolts and starter.
4. Reverse the removal procedure to install. Tighten the mount bolts.
5. Check operation of starter on vehicle.

CHECKING PINION CLEARANCE

Whenever the starter motor is disassembled and reassembled, the pinion clearance should be checked. This is to make sure that proper clearance exists between the pinion and pinion stop retainer when pinion is in cranking position. Lack of clearance would prevent solenoid starter switch from closing properly; too much clearance would cause improper pinion engagement in ring gear.

1. Connect a source of approximately 6 volts (3 battery cells or a 6 volt battery) between the solenoid "S" terminal and ground.

CAUTION: *Do not use more than 6 volts or the motor will operate. As a further precaution to prevent motoring, connect a heavy jumper wire from the solenoid motor terminal to ground.*

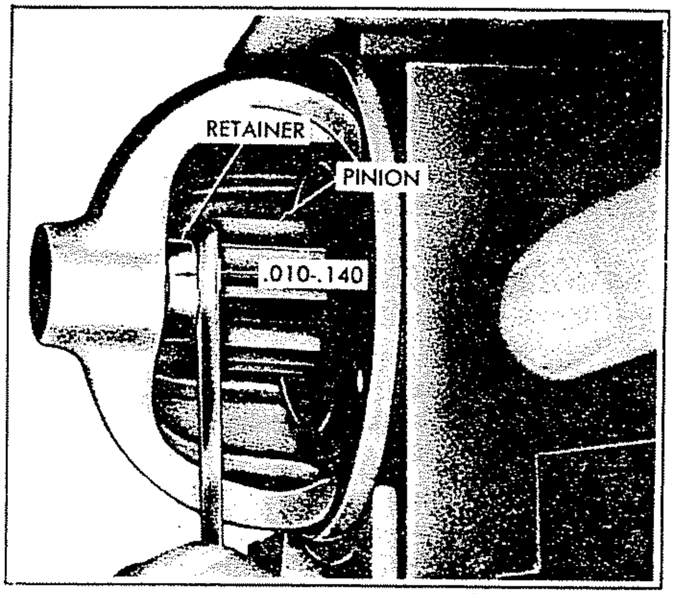


Fig. 6D-10s--Checking Pinion Clearance

2. After energizing the solenoid, push the pinion away from the stop retainer as far as possible and use feeler gauge to check clearance between pinion and retainer (Fig. 6D-10s).

3. If clearance is not between .010" and .140" it indicates excessive wear of solenoid linkage, shift lever mechanism, or improper assembly of these parts.

NOTE: Pinion clearance cannot be adjusted. If clearance is not correct, motor must be disassembled and checked for the above mentioned defects. Any defective parts must be replaced.

BENCH TEST OF STARTING MOTOR

To obtain full performance data on a cranking motor, or to determine the cause of abnormal operation, the motor should be removed from the engine and be submitted to a no-load test with equipment designed for such tests. A high current carrying variable resistance should be connected into the circuit so that the specified voltage at the starter motor may be obtained, since a small variation in the voltage will produce a marked difference in the current draw.

(a) No-Load Test. Connect the starter motor in series with a 12-volt battery and an ammeter capable of indicating several hundred amperes. If an RPM indicator is available, set it up to read armature RPM. Check current draw and armature RPM at the specified voltage.

1. Low no-load speed and high current draw may result from:

(a) Tight, dirty, or worn bearings, bent armature shaft or loose field pole screws which would allow the armature to drag.

(b) Shorted armature. Check armature further on growler.

(c) A grounded armature or field.

Check for grounds by raising the grounded brushes and insulating them from the commutator. If the starter motor has shunt field coils which are grounded to the field frame, disconnect these fields from ground. Then check with a test lamp between the insulated terminal and the frame. If lamp lights, raise other brushes from commutator and check fields separately to determine whether it is the fields or armature that is grounded:

2. Failure to operate with high current draw may result from:

(a) A direct ground in the terminal or fields.

(b) Frozen shaft bearings which prevent the armature from turning.

3. Failure to operate with no current draw may result from:

(a) Open field circuit. Inspect internal connections and trace circuits with test lamp.

(b) Open armature coils. Inspect the commutator for badly burned bars.

(c) Broken or weakened brush springs, worn brushes, high mica on the commutator, or other causes which would prevent good contact between the brushes and commutator. Any of these conditions will cause burned commutator bars.

4. Low no-load speed with low current draw indicates:

(a) An open field winding. Raise and insulate ungrounded brushes from commutator and check fields with test lamp.

(b) High internal resistance due to poor connections, defective leads, dirty commutator and causes listed under item 3 (c).

5. High no-load speed with high current draw indicates shorted fields. There is no easy way to detect shorted fields, since the field resistance is already low. If shorted fields are suspected, replace the fields and check for improvement in performance.

UNIT REPAIR

DISASSEMBLY-EXCEPT DIESEL (Fig. 6D-1s and 6D-11s)

1. Disconnect the field coil connector(s) from the motor solenoid terminal.

2. Remove through bolts.

3. Remove commutator end frame, field frame assembly and armature assembly from drive housing.

4. Remove overrunning clutch from armature shaft as follows:

a. Slide two piece thrust collar off end of armature shaft.

b. Slide a standard half-inch pipe coupling or other metal cylinder of suitable size (an old pinion of suitable size can be used if available) onto shaft so end of coupling or cylinder butts against edge of retainer (Fig. 6D-12s). Tap end of coupling with hammer, driving retainer towards armature end of snap ring.

c. Remove snap ring from groove in shaft using pliers or other suitable tool. If the snap ring is too badly distorted during removal, it may be necessary to use a new one when reassembling clutch.

d. Slide retainer and clutch from armature shaft.

5. Disassemble brush rigging from field frame.

a. Release "V" spring from slot in brush holder support.

b. Remove support pin.

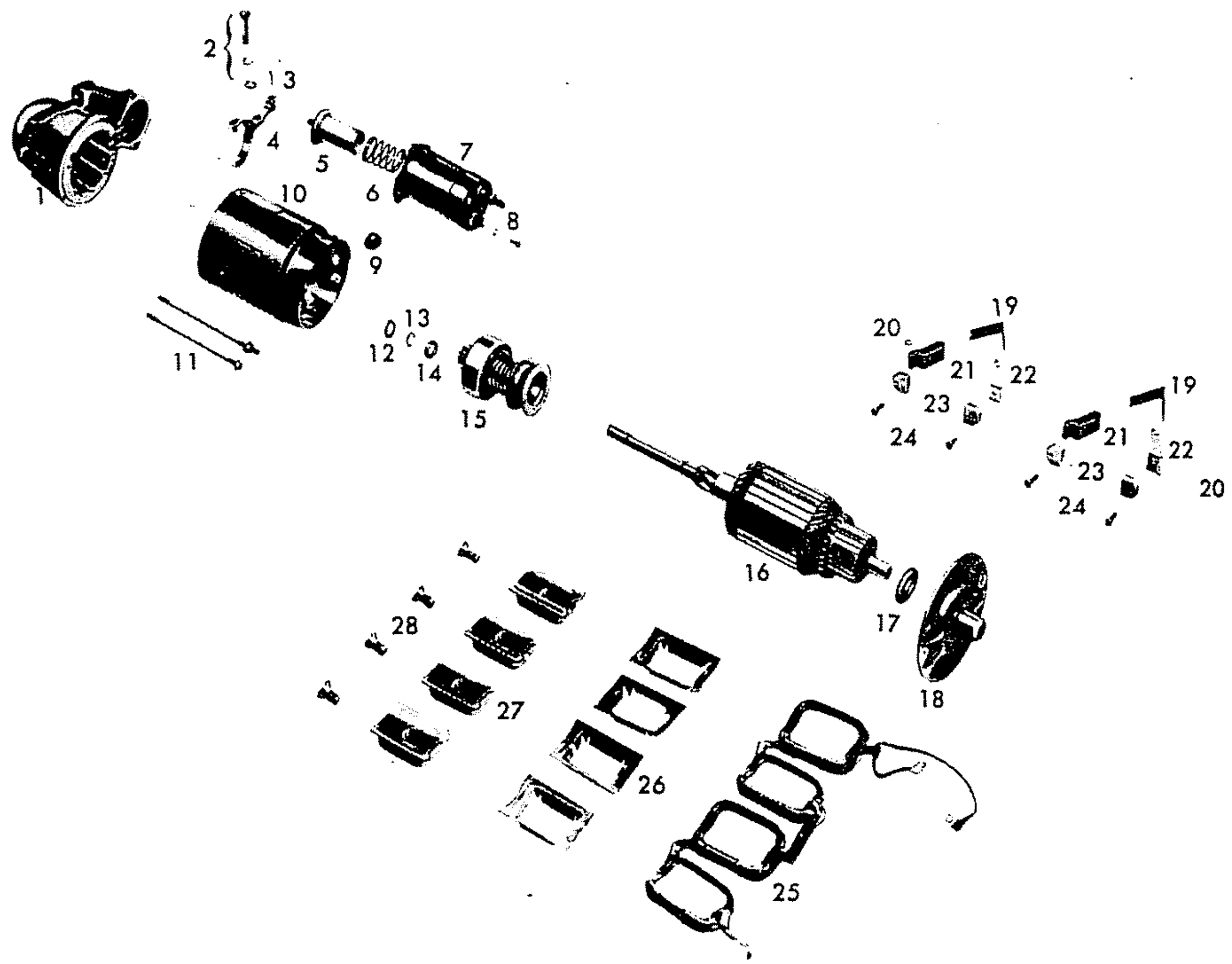
c. Lift brush holders, brushes and spring upward as a unit.

d. Disconnect leads from each brush.

e. Repeat operation for other set of brushes.

CLEANING AND INSPECTION

With the starting motor completely disassembled except for removal of field coils, the component



1. Drive Housing
2. Shift Lever Bolt, Nut and Lock Washer
3. Pin
4. Shift Lever
5. Solenoid Plunger
6. Solenoid Return Spring
7. Solenoid Case
8. Screw and Lock Washer
9. Grommet
10. Field Frame
11. Through Bolts
12. Thrust Collar
13. Snap Ring
14. Retainer
15. Overrunning Clutch Assembly
16. Armature
17. Braking Washing
18. Commutator End Frame
19. Brush Springs
20. Washer
21. Insulated Brush Holders
22. Grounded Brush Holders
23. Brushes
24. Screws
25. Field Coils
26. Insulators
27. Pole Shoes
28. Screws

Fig. 6D-11s–Starting Motor Parts Layout

parts should be cleaned and inspected as described below. Field coils need be removed only where defects in the coils are indicated by the tests described in this section.

1. Clean all starting motor parts, but do not use grease dissolving solvent for cleaning the overrunning clutch, armature, and field coils since such a solvent would dissolve the grease packed in the clutch mechanism and would damage armature and field coil insulation.

2. Test overrunning clutch action. The pinion should turn freely in the overrunning direction and must not slip in the cranking direction. Check pinion teeth to see that they have not been chipped, cracked, or excessively worn. Check the spring for normal tension and drive collar for wear. If necessary, the spring or collar can be replaced by forcing the collar toward the clutch and removing lock ring from end of tube.

3. Check brush holders to see that they are not deformed or bent, but will properly hold brushes against the commutator.

4. Check the condition of the brushes and if pitted or worn to one-half their original length, they

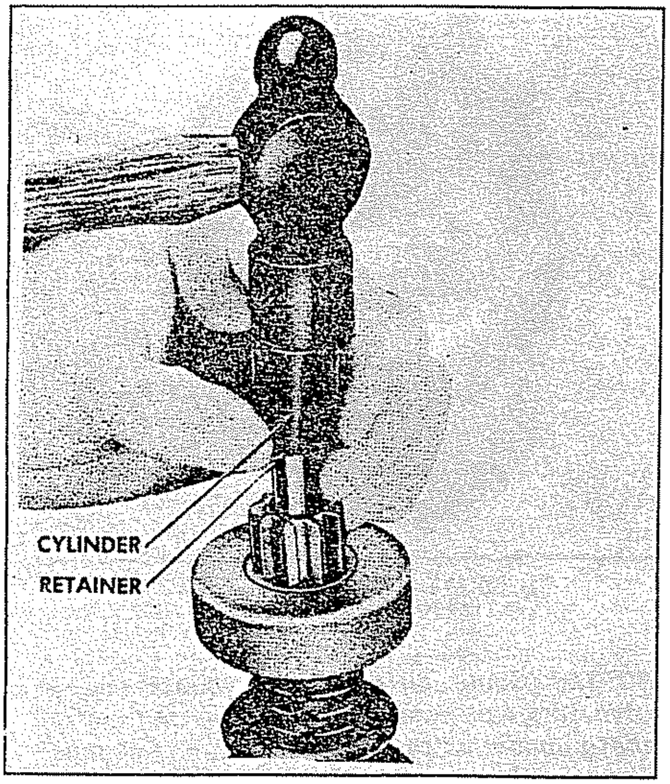


Fig. 6D-12s–Driving Retainer Off Snap Ring

should be replaced.

5. Check fit of armature shaft in bushing of drive housing. Shaft should fit snugly in the bushing. If the bushing is worn, it should be replaced. Apply a silicone lubricant to this bushing before reassembly. Avoid excessive lubrication.

6. Check fit of bushing in commutator end frame. If this bushing is damaged or worn excessively, the end frame assembly must be replaced. Apply a silicone lubricant to this bushing before reassembly. Avoid excessive lubrication. Lubricant forced onto the commutator would gum and cause poor commutation with a resulting decrease in cranking motor performance.

CAUTION: *Some starter motor models use a molded armature commutator design and no attempt to undercut the insulation should be made or serious damage may result to the commutator. Undercutting reduces the bonding of the molding material which holds the commutator bars and since the molding material is softer than the copper bars, it is not necessary to undercut the material between the bars of the molded commutator.*

7. Inspect armature commutator. If commutator is rough or out of round, it should be turned down and undercut. Inspect the points where the armature conductors join the commutator bars to make sure that it is a good firm connection. A burned commutator bar is usually evidence of a

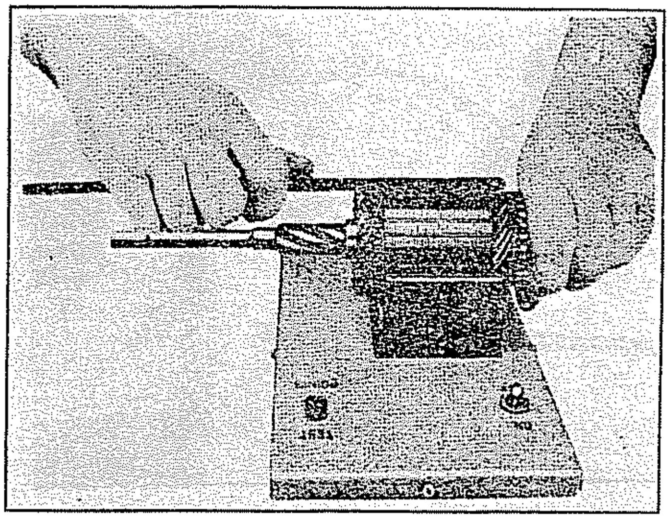


Fig. 6D-13s–Armature Short Circuit Test

poor connection. See "Turning the Commutator," described under Testing and Repairs.

TESTING AND REPAIRS

Armature Test For Shorts

Check the armature for short circuit by placing on growler and holding hack saw blade over armature core while armature is rotated (Fig. 6D-13s). If saw blade vibrates, armature is shorted. Recheck after cleaning between the commutator bars. If saw blade still vibrates, replace the armature.

Armature Test For Ground

Place one lead on the armature core or shaft and the other on the commutator (Fig. 6D-14s). If the lamp lights, the armature is grounded and must be replaced.

Field Coil Test For Open Circuit

Place one lead on the insulated brush and the other to the field connector bar (Fig. 6D-15s). If the lamp does not light, the field coils are open and will require replacement.

Field Coil Test For Ground

NOTE: Be sure to disconnect the shunt coil before performing this test (when applicable).

Place one lead on the connector bar and the other on the grounded brush (Fig. 16s). If the lamp lights, the field coils are grounded.

Field Coil Replacement

Field coils may be removed from the field frame using a pole shoe screwdriver and a pole shoe spreader. The spreader prevents distortion of the field frame. Careful installation of field coils is necessary to prevent shorting or grounding of the field coils as the pole shoe screws are tightened

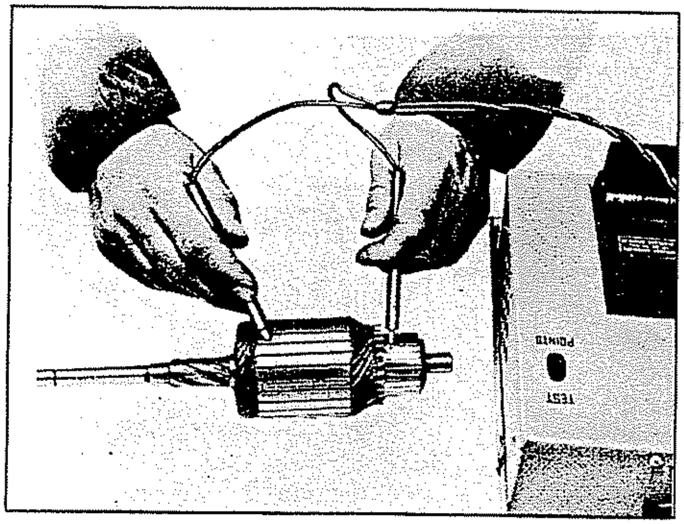


Fig. 6D-14s--Armature Ground Test

in place. Formed insulators are used to protect the field leads from grounding to the frame and must be replaced with assembly.

Loose Electrical Connections

When an open soldered connection of the armature to commutator leads is found during inspection, it may be resoldered provided resin flux is used for soldering. Acid flux should never be used on electrical connections.

When inspection shows commutator roughness, it should be cleaned as follows:

Turning The Commutator

1. Turn down commutator in a lathe until it is thoroughly cleaned.

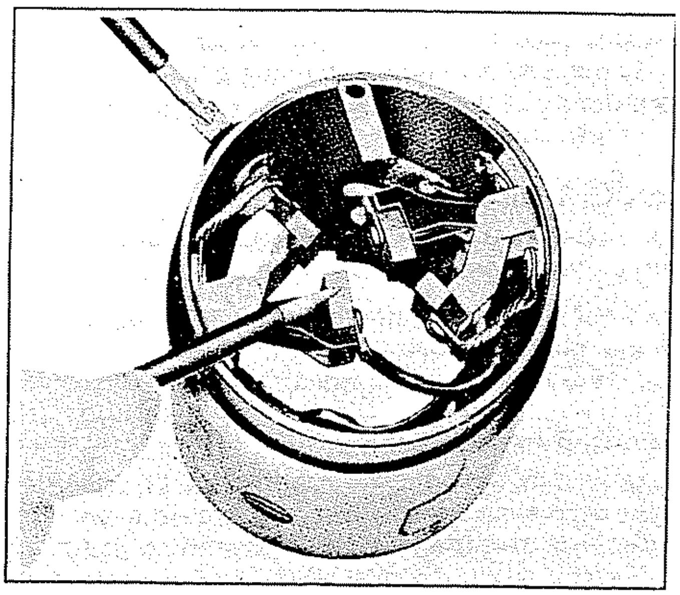


Fig. 6D-15s--Field Coil Open Circuit Test

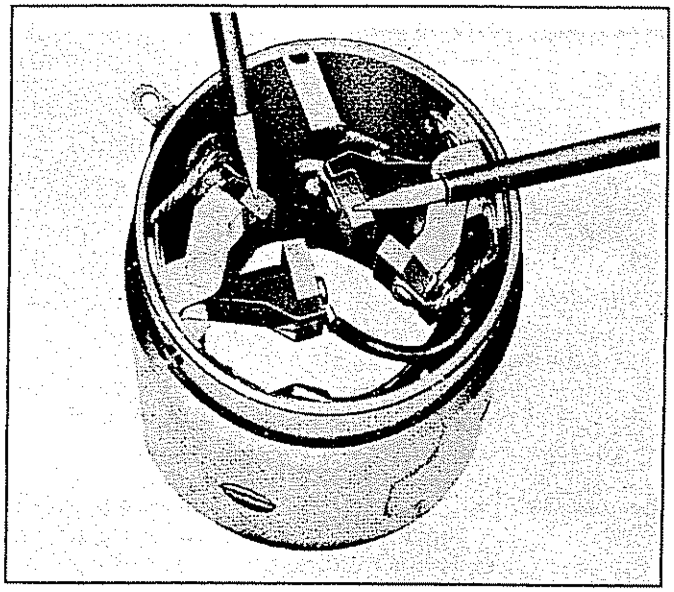


Fig. 6D-16s--Field Coil Ground Test

CAUTION: *Some starter motor models use a molded armature commutator design and no attempt to undercut the insulation should be made or serious damage may result to the commutator. Undercutting reduces the bonding of the molding material which holds the commutator bars and since the molding material is softer than the copper bars, it is not necessary to undercut the material between the bars of the molded commutator.*

2. Undercut insulation between commutator bars 1/32". This undercut must be the full width of insulation and flat at the bottom; a triangular groove will not be satisfactory. After undercutting, the slots should be cleaned out carefully to remove any dirt and copper dust.

3. Sand and the commutator lightly with No. 00 sandpaper to remove any slight burrs left from undercutting.

4. Recheck armature on growler for short circuits.

Brush Holder Replacement

If brush holders are damaged, they can be replaced by special service units.

Overrunning Clutch

The overrunning clutch (roll clutch design) used in the various starting motors is (Fig. 6D-17s) designed to be serviced as a complete unit.

ASSEMBLY

After all parts have been thoroughly tested and inspected and worn or damaged parts replaced, the starter should be reassembled.

1. Assemble brush rigging to field frame.

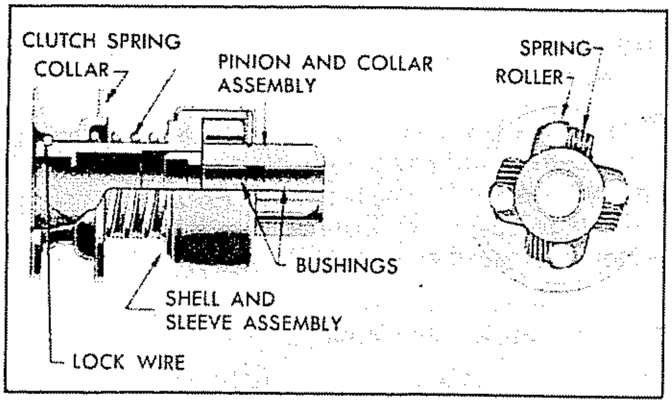


Fig. 6D-17s–Roll Type Clutch Cross-Section

a. Assemble brushes to brush holders.

b. Assemble insulated and grounded brush holder together with the "V" spring and position as unit on the support pin. Push holders and spring to bottom of support and rotate spring to engage the "V" in slot in support.

c. Attach ground wire to grounded brush and field lead wire to insulated brush.

d. Repeat for other set of brushes.

2. Assemble overrunning clutch assembly to armature shaft.

a. Lubricate drive end of armature shaft with silicone lubricant.

b. Slide clutch assembly onto armature shaft with pinion outward.

c. Slide retainer onto shaft with cupped surface facing end of shaft (away from pinion).

d. Stand armature on end of wood surface with commutator down. Position snap ring on upper end of shaft and hold in place with block of wood. Tap wood block with hammer forcing snap ring over end of shaft (Fig. 6D-19s). Slide snap ring down into groove.

e. Assemble thrust collar on shaft with shoulder next to snap ring.

f. Place armature flat on work bench, and position retainer and thrust collar next to snap ring. Then using two pair of pliers at the same time (one pair on either side of shaft), grip retainer and thrust collar and squeeze until snap ring is forced into retainer (Fig. 6D-19s).

3. Lubricate the drive housing bushing with a silicone lubricant. Make sure thrust collar is in place against snap ring and retainer and slide armature and clutch assembly into place in drive housing engaging shift lever with clutch.

4. Position field frame over armature and apply special sealing compound between frame and solenoid case. Position frame against drive housing using care to prevent damage to the brushes.

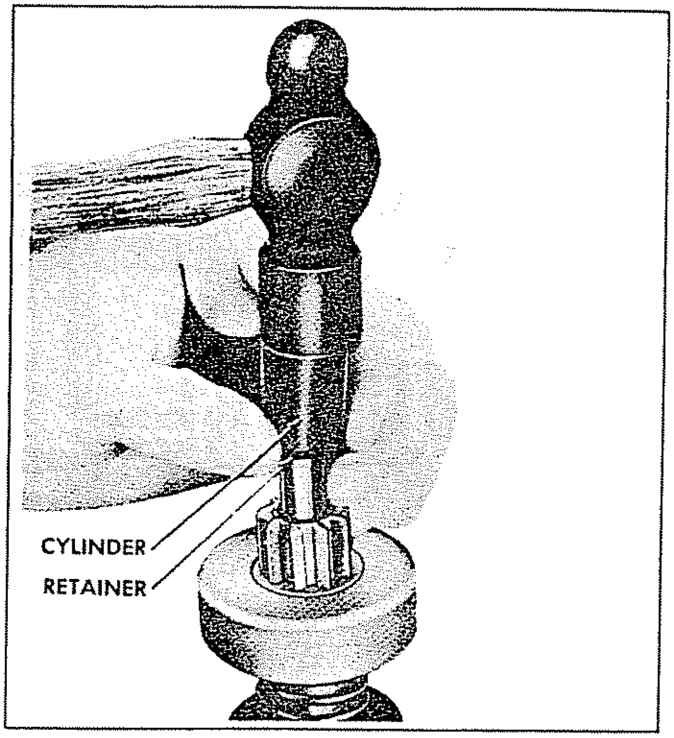


Fig. 6D-18s--Forcing Snap Ring Over Shaft

5. Lubricate the bushing in the commutator end frame with a silicone lubricant. Place leather brake washer on armature shaft and slide commutator end frame onto shaft.

6. Reconnect the field coil connectors to the "motor" solenoid terminal.

7. After overhaul is completed, perform "Pinion Clearance Check".

PINION CLEARANCE CHECK

1. Connect a battery, of the same voltage as the solenoid, from the solenoid switch terminal to the

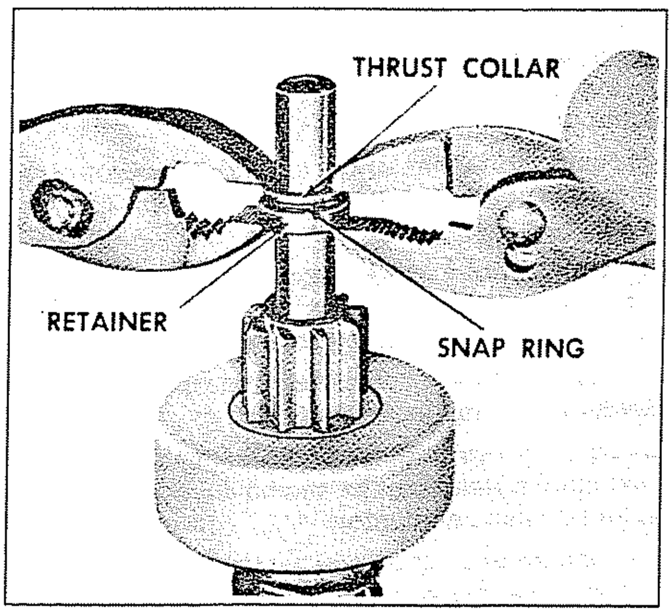


Fig. 6D-19s--Forcing Snap Ring Into Retainer

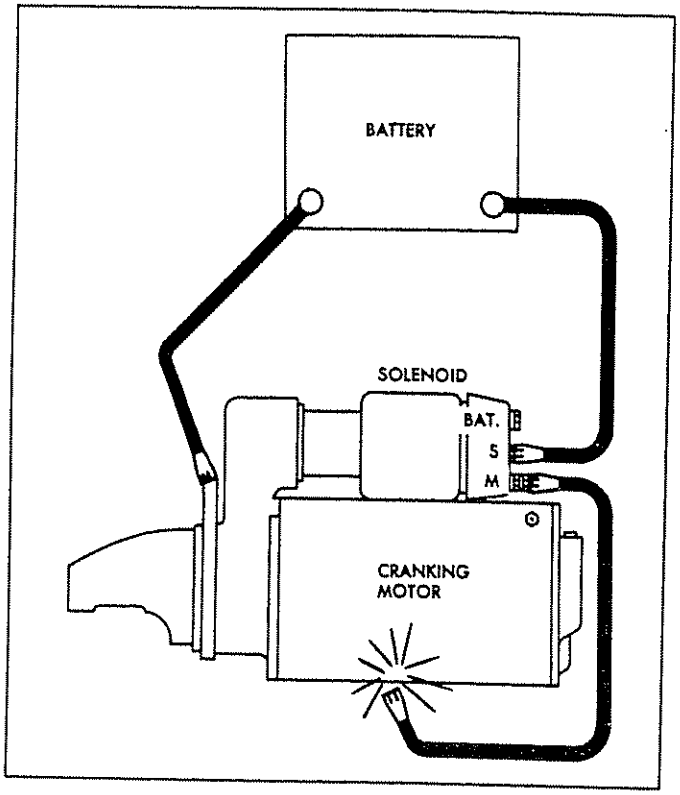


Fig. 6D-20s–Circuit for Checking Pinion Clearance

solenoid frame or ground terminal (Fig. 6D-20s).

NOTE: Disconnect the motor field coil connector for this test.

2. Momentarily flash a jumper lead from the solenoid motor terminal to the solenoid frame or ground terminal. The pinion will now shift into cranking position and will remain there until the jumper lead is disconnected.

3. Push the pinion back towards the commutator end to eliminate slack movement.

4. Measure the distance between the pinion and pinion stop (Fig. 6D-15s). If clearance is not within specified limits (.010-.140) it may indicate excessive wear of solenoid linkage shift lever yoke buttons or improper assembly of the shift lever mechanism. Worn or defective parts should be replaced.

STARTING SOLENOID

Removal

1. Remove the outer screw and washer from the motor connector strap terminal.

2. Remove the two screws retaining solenoid housing to end frame assembly.

3. Twist solenoid clockwise to remove flange key from keyway slot in housing; then remove solenoid assembly.

Replacement of Contacts (Fig. 6D-21s)

1. With solenoid removed from motor, remove nuts and washers from switch and motor connector strap terminals.

2. Remove the two solenoid end cover retaining screws and washers and remove end cover from solenoid body.

3. Remove nut and washer from battery terminal on end cover and remove battery terminal. Remove resistor by-pass terminal and contactor.

4. Remove motor connector strap terminal and solder new terminal in position.

5. Using a new battery terminal, install terminal washer and retaining nut to end cover. Install by-pass terminal and contactor.

6. Position end cover over switch and motor terminals and install end cover retaining screws. Also install washers and nuts on the solenoid switch and starting motor terminals.

7. Bench test solenoid for proper operation.

Installation

1. With solenoid return spring installed on plunger, position solenoid body to drive housing and turn counterclockwise to engage the flange key in the keyway slot.

2. Install two screws retaining solenoid housing to end frame.

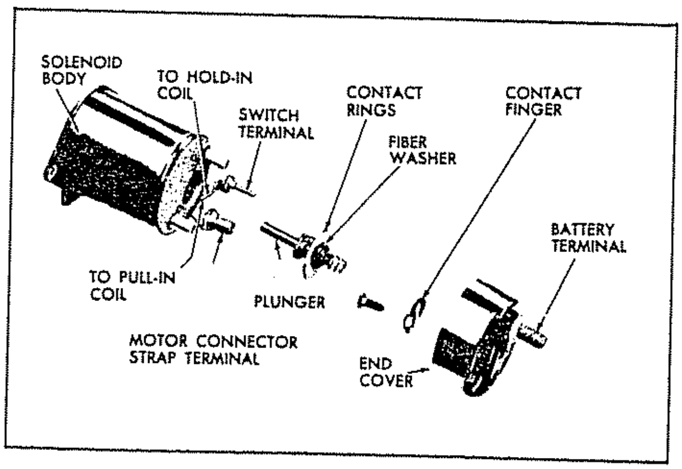


Fig. 6D-21s–Exploded View of Solenoid

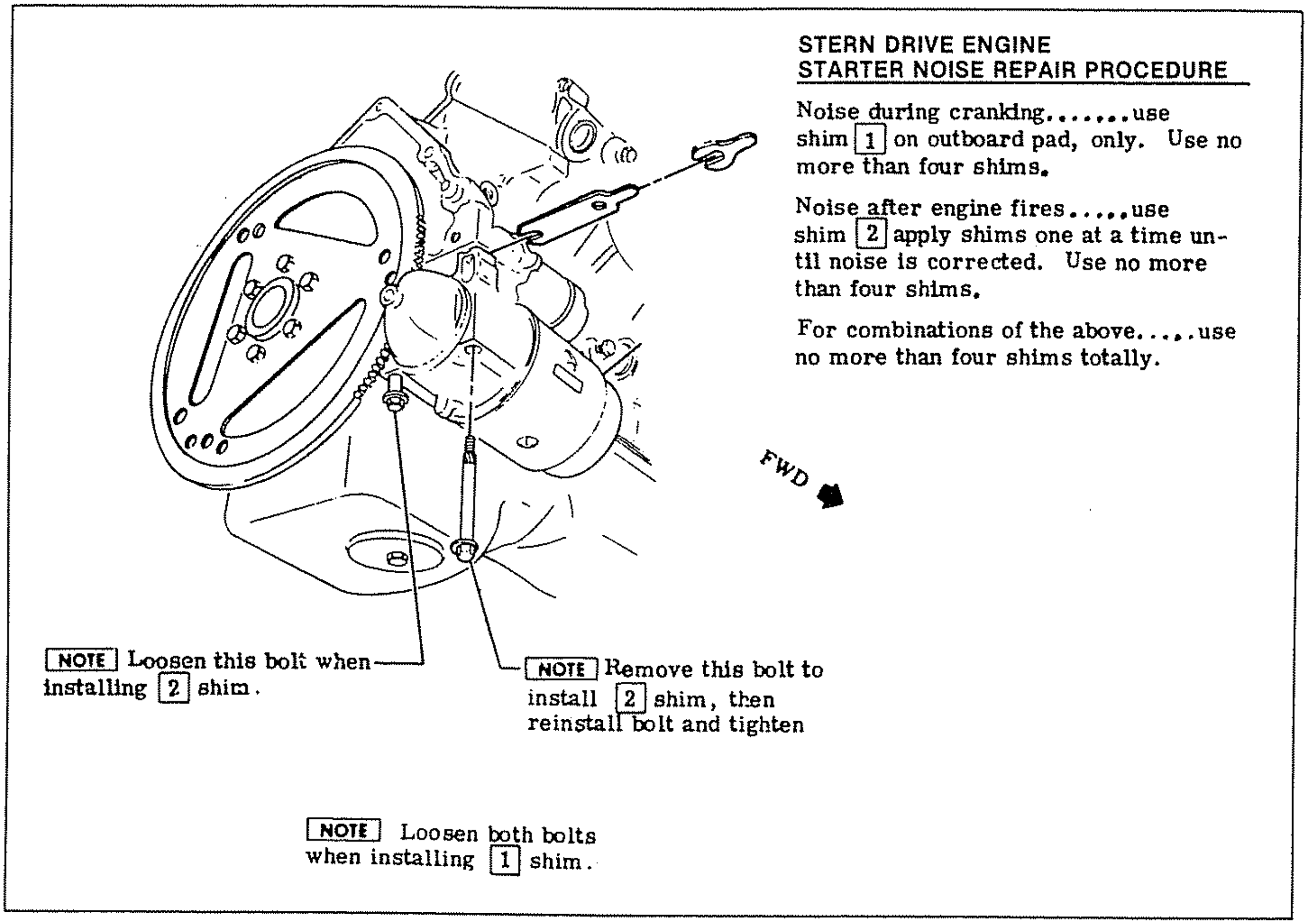


Fig. 6D-22s--Starter Motor Shimming (Exc LF9)

3. Install outer screw and washer securing motor connector strap terminal.

4. Install starter motor as previously described.

STARTERS

Starter motor shimming procedures for Stern Drive engines (except Diesel) are illustrated in Figure 6D-22s.

STARTER-DIESEL ENGINE (FIG. 6D-23s)

Starter Disassembly (Fig. 6D-23s)

1. Remove screw from field coil connector and solenoid mounting screws. Rotate solenoid 90° and remove along with plunger return spring.

NOTE: Solenoid may be removed and serviced without further starter disassembly at this time.

2. Remove 2 through bolts, then remove commutator end frame and washer.

3. Remove field frame assembly from drive gear housing. (On diesel starter armature remains in drive end frame.)

4. Remove shift lever pivot bolt.

5. Remove center bearing screws and remove drive gear housing from armature shaft. Shift lever and plunger assembly will now fall away from starter clutch. (Fig. 6D-24s).

6. If necessary to remove overrunning clutch from armature shaft, proceed as follows: (Fig. 25sD-6)

a. Remove thrust washer or collar from armature shaft.

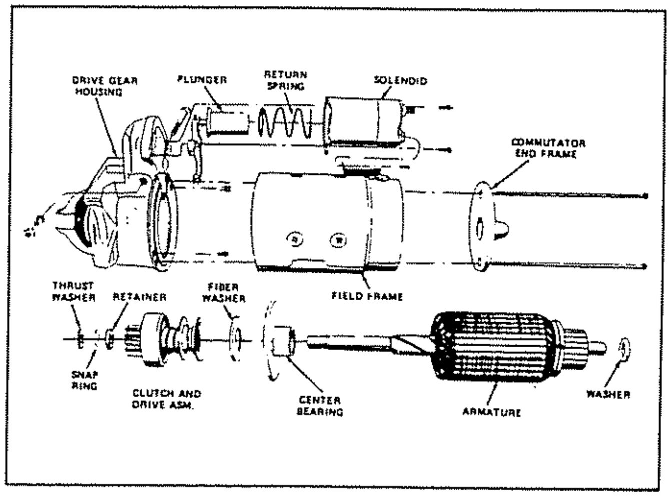


Fig. 6D-23s--Diesel Starter

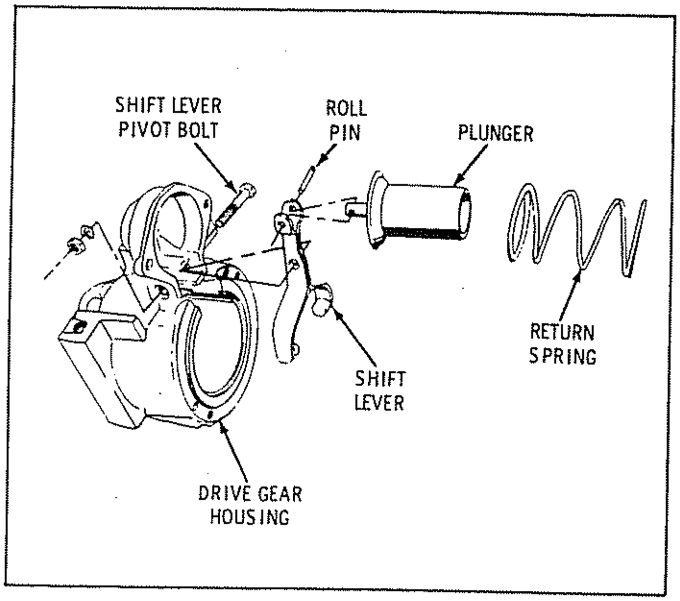


Fig. 6D-24s--Remove Shift Lever

b. Slide a 5/8" deep socket or piece of pipe of suitable size over shaft against retainer as a driving tool. Tap tool to move retainer off snap ring.

c. Remove snap ring from groove in shaft. If snap ring is distorted, it will be necessary to use a new one on reassembly. (Fig. 6D-26s).

d. Remove retainer, clutch assembly, (also fiber washer and center bearing on diesel) from armature shaft.

7. The shift lever and plunger may be disassembled at this time by removing the roll pin.

8. If necessary to replace brush holder parts, proceed as follows:

a. Remove brush holder pivot pin which positions one insulated and one grounded brush. (Fig. 6D-27s).

b. Remove brush spring.

c. Replace brushes as necessary.

Cleaning, Inspection and Tests

Refer to Section 6D of the 1977 service manual for starter cleaning, inspection and tests.

NOTE: If necessary to remove field coils or pole shoes, care must be taken during reassembly not to break through insulation material on the field coils. Be sure long lip on pole shoes is in direction of armature rotation.

Solenoid Switch

The starter solenoid switch is serviced as an assembly only. The cover can be removed to inspect the contacts and contact disc if necessary. (Fig. 6D-28s).

Starter Assembly

1. Assemble the armature and clutch as follows:

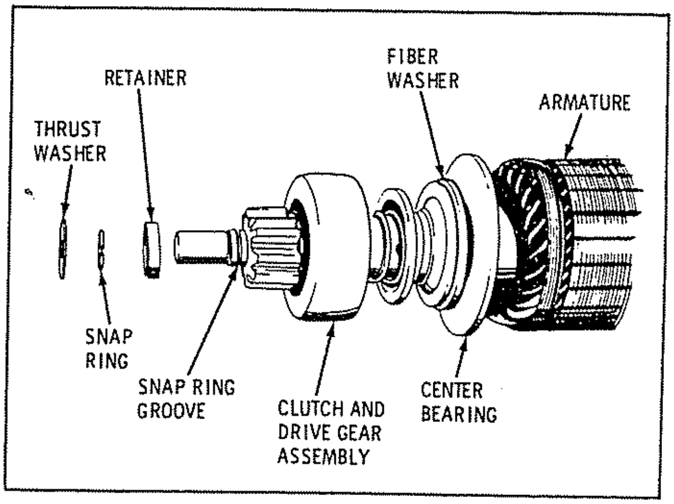


Fig. 6D-25s--Remove Thrust Collar

a. Lubricate drive end of armature shaft with lubricant GM #1960954 or equivalent.

b. Install center bearing with bearing toward the armature winding. Then install the fiber washer on the armature shaft. Refer to Fig. 6D-26s.

c. Slide clutch assembly onto armature shaft with pinion away from armature.

d. Slide retainer onto shaft with cupped side facing the end of shaft.

e. Install snap ring into groove on armature shaft.

f. Install thrust washer on shaft.

g. Position retainer and thrust washer with snap ring in between. Using two pliers, grip retainer and thrust washer or collar and squeeze until snap ring is forced into retainer and is held securely in groove in armature shaft. (Fig. 6D-29s).

2. Lubricate drive gear housing bushing with lubricant GM #1960954 or equivalent.

3. Engage shift lever yoke with clutch and slide complete assembly into drive gear housing.

NOTE: Shift lever may be installed in drive gear

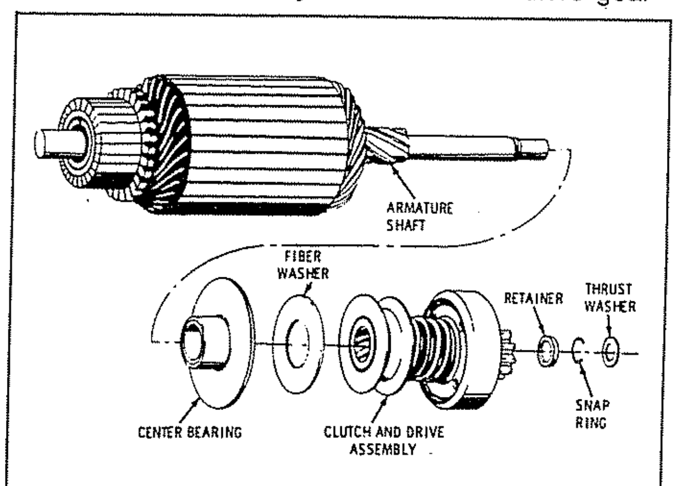


Fig. 6D-26s--Remove Starter Drive

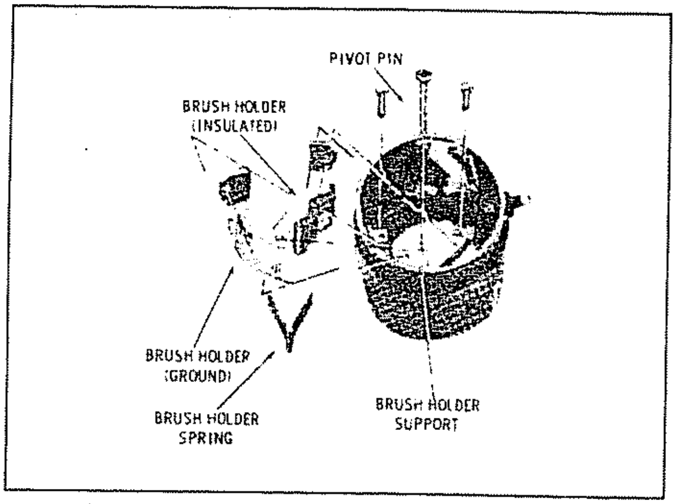


Fig. 6D-27s–Brush Replacement

housing first.

4. Install the center bearing screws (diesel only) and the shift lever pivot bolt. Tighten securely.

5. Install solenoid assembly on drive gear housing.

6. Apply sealer, No. 1050026 or equivalent to solenoid flange where field frame against drive gear housing on alignment pin using care to prevent damage to brushes.

7. Position field frame against drive gear housing on alignment pin using care to prevent damage to brushes.

8. Lubricate commutator end-frame bushing with lubricant 1960954 or equivalent.

9. Install washer on armature shaft and slide end frame onto shaft, then install and tighten through-bolts.

10. Connect the field coil connector to the solenoid terminal.

11. Check pinion clearance as outlined under PINION CLEARANCE.

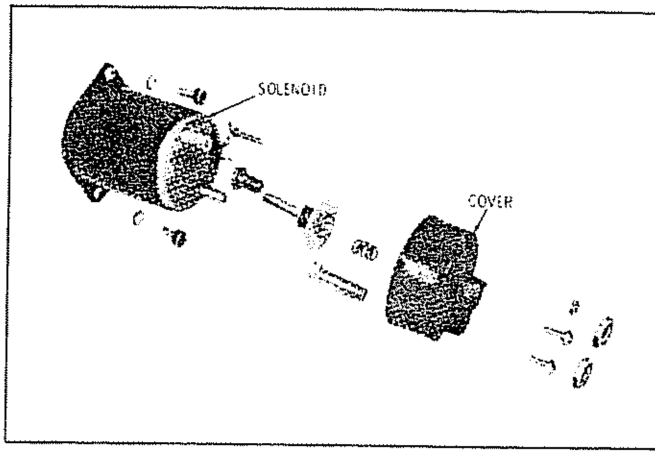


Fig. 6D-28s--Solenoid Switch

Pinion Clearance

When the starter motor has been disassembled or the solenoid has been replaced, it is necessary to check the pinion clearance. Pinion clearance must be correct to prevent the buttons on the shift lever yoke from rubbing on the clutch collar during cranking.

1. Disconnect the motor field coil connector from the solenoid motor terminal and insulate it carefully.

2. Connect one 12-volt battery lead to the solenoid switch terminal and the other to the starter frame.

3. Flash a jumper lead momentarily from the solenoid motor terminal to the starter frame. This will shift the pinion into cranking position and will remain so until the battery is disconnected.

4. Push the pinion back as far as possible to take up any movement, and check the clearance with a feeler gage. (Fig. 6D-30s). The clearance should be .010" to .140".

Means for adjusting pinion clearance is not provided on the starter motor. If the clearance does not fall within limits, check for improper installation and replace all worn parts.

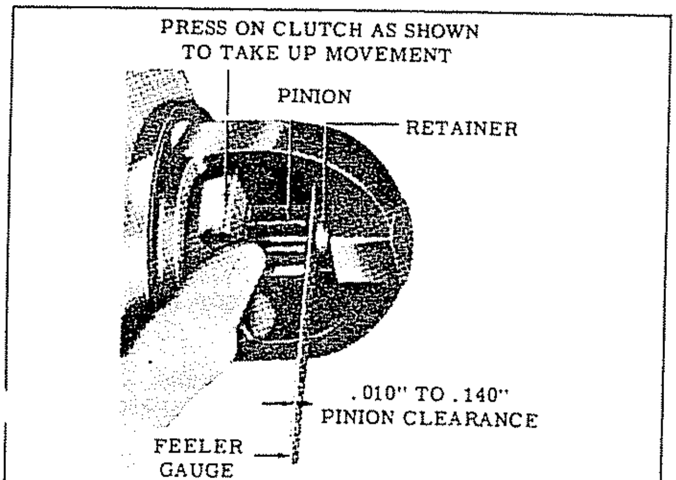


Fig. 6D-30s–Check Pinion Clearance

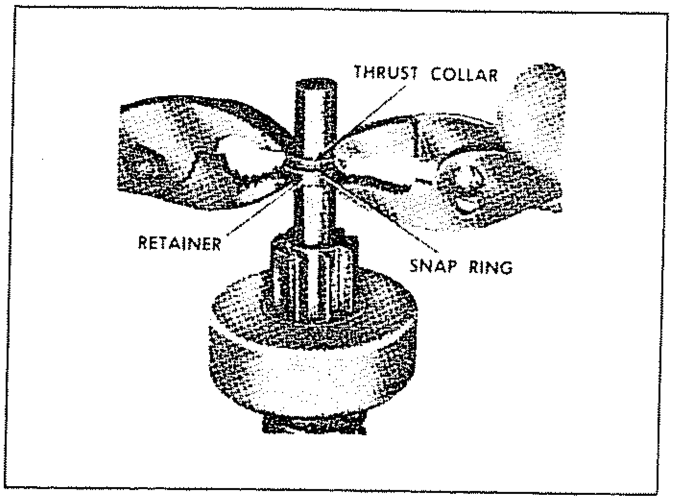


Fig. 6D-29s--Install Snap Ring and Retainer

Delco-Remy

Date 9-1-77
Supersedes Bulletins Dated 1-1-67, 3-1-68

Reference: 1B-115, 116
1M-180, 185, 186, 187
1S-180, 186, 187

Enclosed Shift Lever Type

CRANKING MOTORS

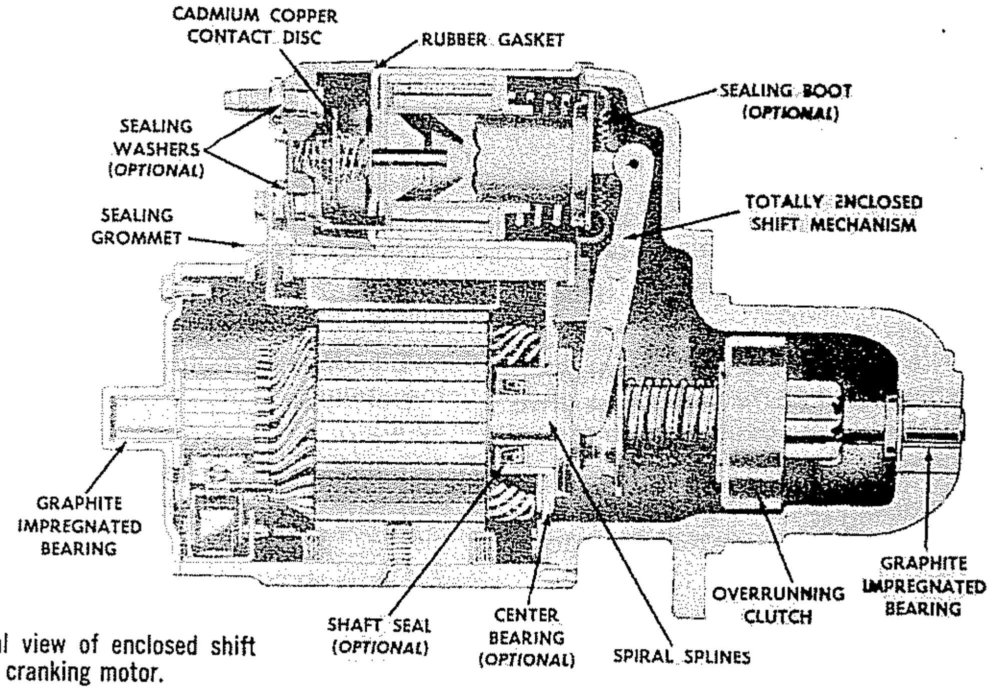


Figure 1—Sectional view of enclosed shift lever type cranking motor.

Enclosed shift lever cranking motors have the shift lever mechanism and the solenoid plunger enclosed in the drive housing protecting them from exposure to dirt, icing conditions and splash. A typical motor is shown in Figure 1. The assist spring is not used on some models.

In the basic circuit shown in Figure 2, the solenoid windings are energized when the switch is closed. The resulting plunger and shift lever movement causes the pinion to engage the engine flywheel ring gear and the solenoid main contacts to close, and cranking takes place. When the engine starts, pinion overrun protects the armature from excessive speed until the switch is opened, at which time the return spring causes the pinion to disengage. To prevent excessive overrun, the switch should be opened immediately when the engine starts.

CRANKING MOTOR LUBRICATION

Motors do not require lubrication except during overhaul.

When the motor is disassembled for any reason, lubricate as follows:

1. The armature shaft and drive end and commutator end bushings should be coated with Delco-Remy Lubricant No. 1960954.

2. The roll type overrunning clutch requires no internal lubrication. However, the drive assembly should be wiped clean. CAUTION: Do not clean in any degreasing tank or with grease dissolving solvents; this will dissolve the lubricant in the clutch mechanism. Use silicone grease General Electric CG321, or Dow Corning 33 medium, or equivalent, on the shaft underneath the overrunning clutch assembly.

3. Avoid excessive lubrication.

TROUBLESHOOTING THE CRANKING CIRCUIT

Before removing any unit in a cranking circuit for repair, the following checks should be made:

Battery: To determine the condition of the battery, follow the testing procedure

Enclosed Shift Lever Type CRANKING MOTORS

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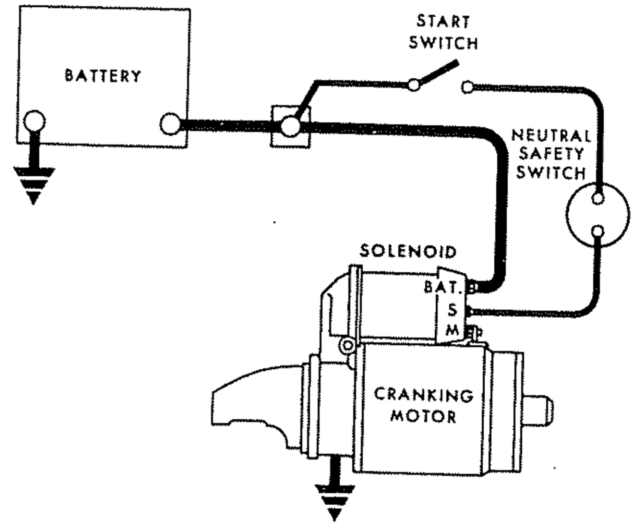


Figure 2—Basic wiring circuit.

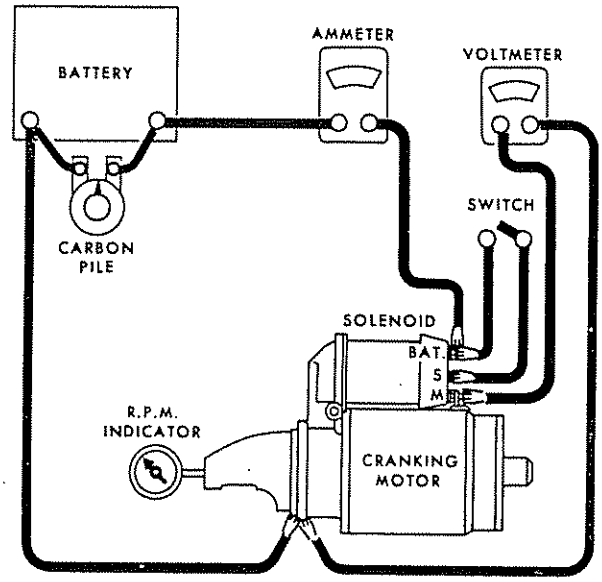


Figure 3—No-load test hookup.

outlined in Service Bulletin 1B-115 or 1B-116. Insure that the battery is fully charged.

Wiring: Inspect the wiring for damage. Inspect all connections to the cranking motor, solenoid or magnetic switch, ignition switch or any other control switch, and battery, including all ground connections. Clean and tighten all connections as required.

Magnetic Switch or Solenoid and Control Switches: Inspect all switches to determine their condition. Connect a jumper lead around any switch suspected of being defective. If the system functions properly using this method, repair or replace the bypassed switch.

Motor: If the battery, wiring and switches are in satisfactory condition, and the engine is known to be functioning properly, remove the motor and follow the test procedures outlined below.

Regardless of the construction, never operate the cranking motor more than 30 seconds at a time without pausing to allow it to cool for at least two minutes. Overheating, caused by excessive cranking will seriously damage the cranking motor.

CRANKING MOTOR TESTS

With the cranking motor removed from the engine, the pinion should be checked for freedom of operation by turning it on the screw shaft. The armature should be checked for freedom of rotation by prying the pinion with a screwdriver. Tight bearings, a bent armature shaft, or a loose pole shoe screw will cause the armature to not turn freely. If the armature does not turn freely the motor should be disassembled immediately. However, if the armature does rotate freely, the motor should be given a no-load test before disassembly.

No-Load Test (Fig. 3)

Connect a voltmeter from the motor terminal to the motor frame, and use an r.p.m. indicator to measure armature speed. Connect the motor and an ammeter in series with a fully charged battery of the specified voltage, and a switch in the open position from the solenoid battery terminal to the solenoid switch terminal. Close the switch and compare the r.p.m., current, and voltage readings with the specifications in Service Bulletins 1M-180, 1M-185, 1M-186, or 1M-187. It is not necessary to obtain the exact voltage specified in these bulletins, as an accurate interpretation can be made by recognizing that if the voltage is slightly higher the r.p.m. will be proportionately higher, with the current remaining essentially unchanged. However, if the exact voltage is desired, a carbon pile connected across the battery can be used to reduce the voltage to the specified value. If more than one 12-volt battery is used in series, connect the carbon pile across only one of the 12-volt batteries. If the specified current draw does not include the solenoid, deduct from the ammeter reading the specified current draw of the solenoid hold-in winding. Make disconnections only with the switch open. Interpret the test results as follows:

1. Rated current draw and no-load speed indicates normal condition of the cranking motor.
2. Low free speed and high current draw indicates·
   a. Too much friction—tight, dirty, or worn bearings, bent armature shaft or loose pole shoes allowing armature to drag.
   b. Shorted armature. This can be further checked on a growler after disassembly.
   c. Grounded armature or fields. Check further after disassembly.
3. Failure to operate with high current draw indicates:
   a. A direct ground in the terminal or fields.
   b. "Frozen" bearings (this should have been determined by turning the armature by hand).
4. Failure to operate with no current draw indicates:

a. Open field circuit. This can be checked after disassembly by inspecting internal connections and tracing circuit with a test lamp.

b. Open armature coils. Inspect the commutator for badly burned bars after disassembly.

c. Broken brush springs, worn brushes, high insulation between the commutator bars or other causes which would prevent good contact between the brushes and commutator.

5. Low no-load speed and low current draw indicates:

a. High internal resistance due to poor connections, defective leads, dirty commutator and causes listed under Number 4.

6. High free speed and high current draw indicate shorted fields. If shorted fields are suspected, replace the field coil assembly and check for improved performance.

DISASSEMBLY

If the motor does not perform in accordance with published specifications, it may need to be disassembled for further testing of the components. Normally the cranking motor should be disassembled only so far as is necessary to make repair or replacement of the defective parts. As a precaution, it is suggested that safety glasses be worn when disassembling or assembling the cranking motor. Following are general instructions for disassembling a typical overruning clutch drive cranking motor:

1. Disconnect the field coil connections from the solenoid motor terminal.

2. Remove the thru-bolts.

3. Remove the commutator end frame and field frame assembly.

4. Remove the armature assembly from the drive housing. On some models it will be necessary to remove the solenoid and shift lever assembly from the drive housing before removing the armature assembly.

5. Remove the thrust collar from the armature shaft.

6. Remove the clutch from the armature by sliding a metal cylinder onto the shaft; with a hammer striking the metal cylinder against the retainer, drive the retainer toward the armature core and off the snap ring (Fig. 4).

7. Remove the snap ring from the groove in the armature shaft.

8. Roller type clutches are designed to be serviced as a complete unit, therefore do not disassemble. Replace if necessary.

COMPONENT INSPECTION AND REPAIR

A. **Brushes and Brush Holders**—Inspect the brushes for wear. If they are worn excessively when compared with a new brush, they should be replaced. Make sure the brush holders are clean and the brushes are not binding in the holders. The full brush surface should ride on the commutator to give proper performance. Check by hand to insure that the brush springs are giving firm contact between the brushes and commutator. If the springs are distorted or discolored, they should be replaced.

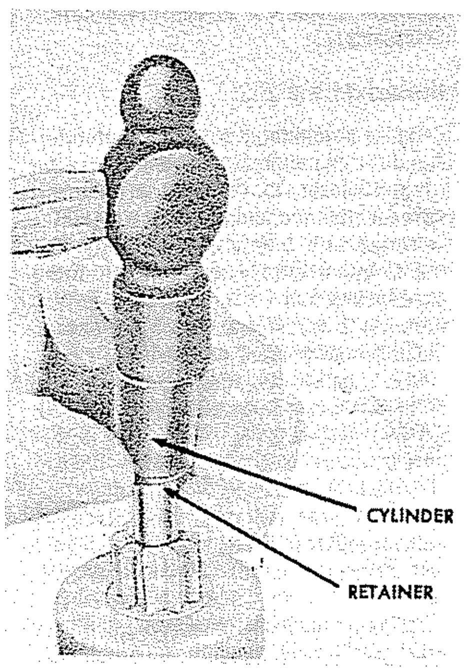


Figure 4—Removing retainer from snap ring.

B. **Armature**—Do not turn the commutator or undercut the insulation on these motors. Use No. 240 grit emery paper to clean the commutator. If the commutator cannot be cleaned, replace the armature. The armature should be checked for short circuits, opens, and grounds:

1. Short circuits are located by rotating the armature in a growler with a steel strip such as a hacksaw blade held on the armature. The steel strip will vibrate on the area of the short circuit. Shorts between bars are sometimes produced by brush dust or copper between the bars.

2. Opens may be located by inspecting the points where the conductors are joined to the commutator for loose connections. Poor connections cause arcing and burning of the commutator. If the bars are not badly burned, leads originally soldered to the riser bars can be resoldered.

3. Grounds in the armature can be detected by the use of a test lamp. If the lamp lights when one test prod is placed on the commutator and the other test prod on the armature core or shaft, the armature is grounded.

C. **Field Coils**—The field coils should be checked for grounds and opens using a test lamp. Typical circuits are shown in Figure 5.

1. Grounds—Disconnect field coil ground connections. Connect one test prod to the field frame and the other to the field connector.

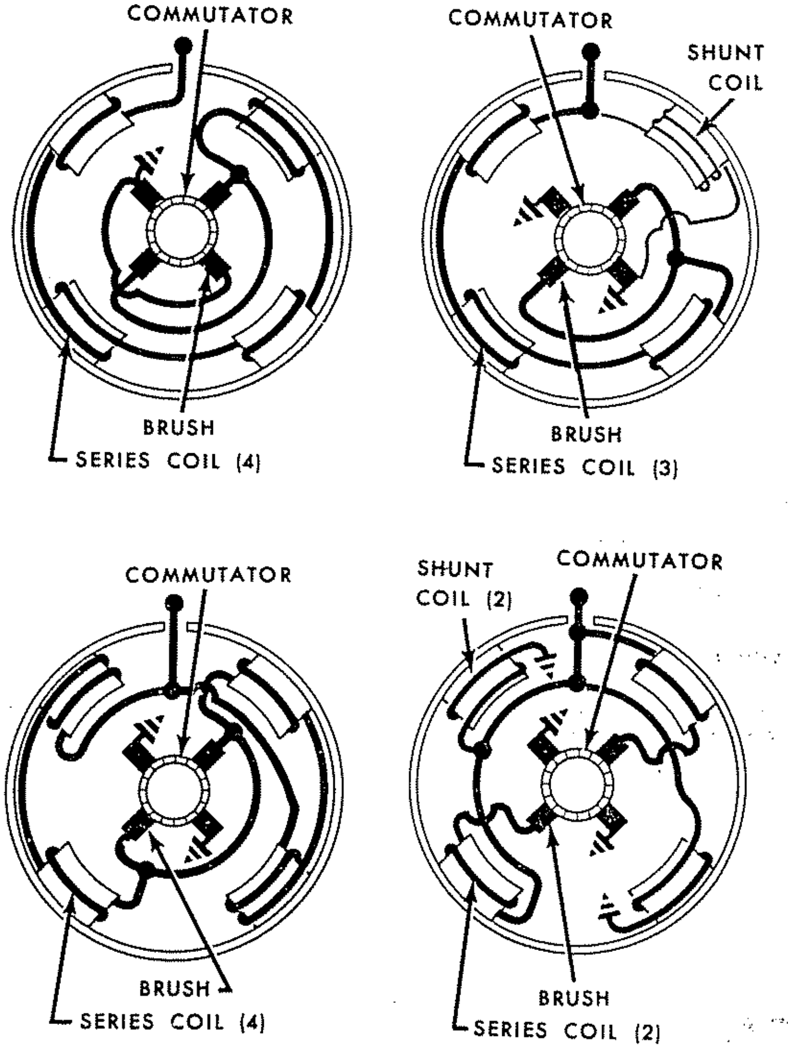


Figure 5—Typical motor circuits.

If the lamp lights, the field coils are grounded and must be repaired or replaced. This check cannot be made if the ground connection cannot be disconnected.

2. Opens—Connect test lamp prods to ends of field coils. If lamp does not light, the field coils are open.

If the field coils need to be removed for repair or replacement, a pole shoe spreader and pole shoe screwdriver should be used. Care should be exercised in replacing the field coils to prevent grounding or shorting them as they are tightened into place. Where the pole shoe has a long lip on the side, it should be assembled in the direction of armature rotation.

D. **Solenoid**—A basic solenoid circuit is shown in Figure 6. Solenoids may differ in appearance, but can be checked electrically by connecting a battery of the specified voltage, a switch, and an ammeter to the two solenoid windings. With all leads disconnected from the solenoid, make test connections as shown to the solenoid switch (S or SW) terminal and to ground, (G) or to the second switch terminal, if present, to check the hold-in winding. (Fig. 7) Use the carbon pile across the battery to decrease the battery voltage to the value specified in Service Bulletins 1S-180, 1S-186, or 1S-187, and compare the ammeter reading with specifications. A high reading indicates a shorted or grounded hold-in winding, and a low reading excessive resistance. To check the pull-in winding, connect from the solenoid switch terminal (S or SW), and to the solenoid motor (M or MOT) terminal. NOTE: If needed to reduce the voltage to the specified value, connect the carbon

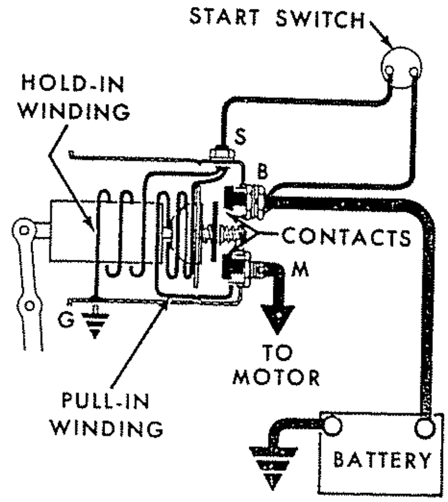


Figure 6—Basic solenoid circuit.

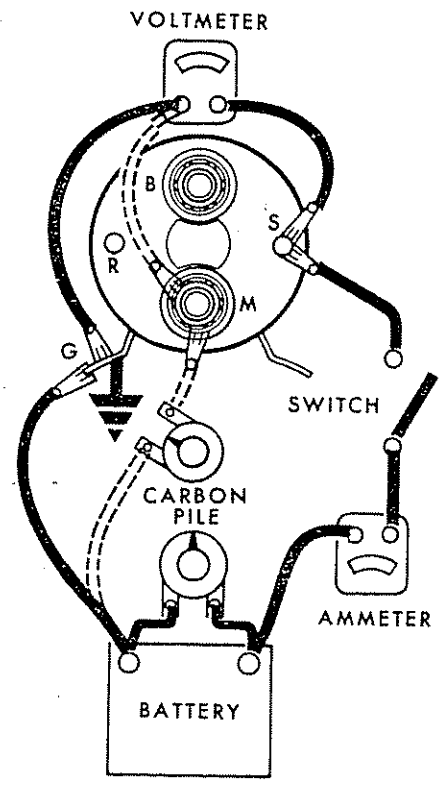


Figure 7—Connections for checking solenoid (note: terminal locations may vary).

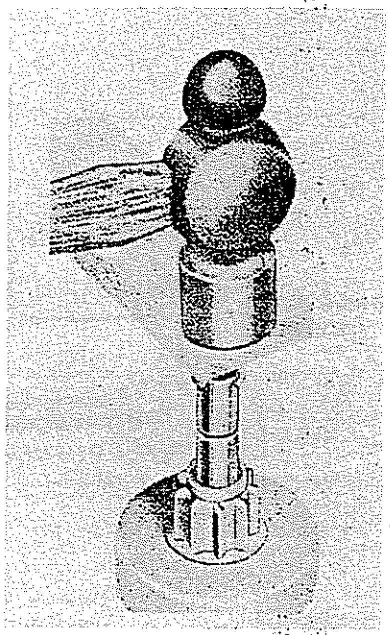


Figure 8—Forcing snap ring over shaft.

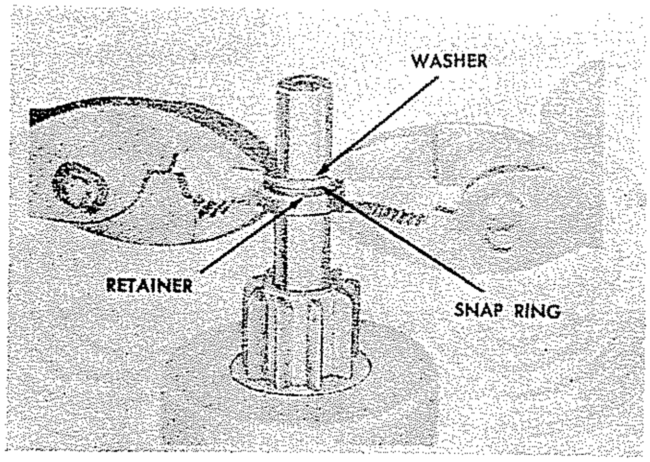


Figure 9—Forcing retainer over snap ring.

pile between the battery and "M" terminal as shown in dashed red lines instead of across the battery as shown in solid red lines. If not needed, connect a jumper directly from the battery to the "M" terminal as shown in dashed red lines. CAUTION: To prevent overheating, do not leave the pull-in winding energized more than 15 seconds. The current draw will decrease as the winding temperature increases.

The purpose of the "R" terminal is to short out the ignition resistor during cranking, and thereby provide higher ignition coil output. (Fig. 7)

REASSEMBLY

1. Place the clutch assembly on the armature shaft. To facilitate replacing the snap ring and retainer onto the armature:

   a. Place the retainer on the armature shaft with the cupped surface facing the snap ring groove.
   b. Place the snap ring on the end of the shaft. With a piece of wood on top of it, force the ring over the shaft with a light hammer blow (Fig. 8), then slide the ring down into the groove.
   c. To force the retainer over the snap ring, place a suitable washer over

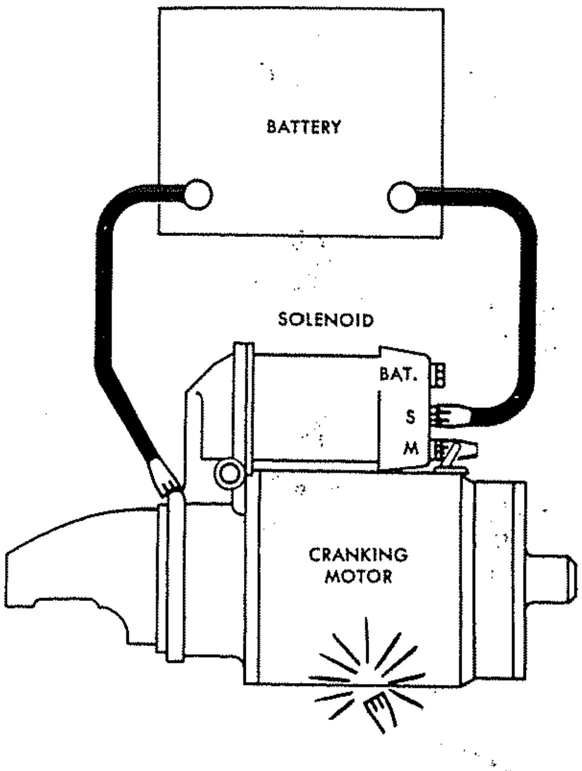


Figure 10—Circuit for checking pinion clearance.

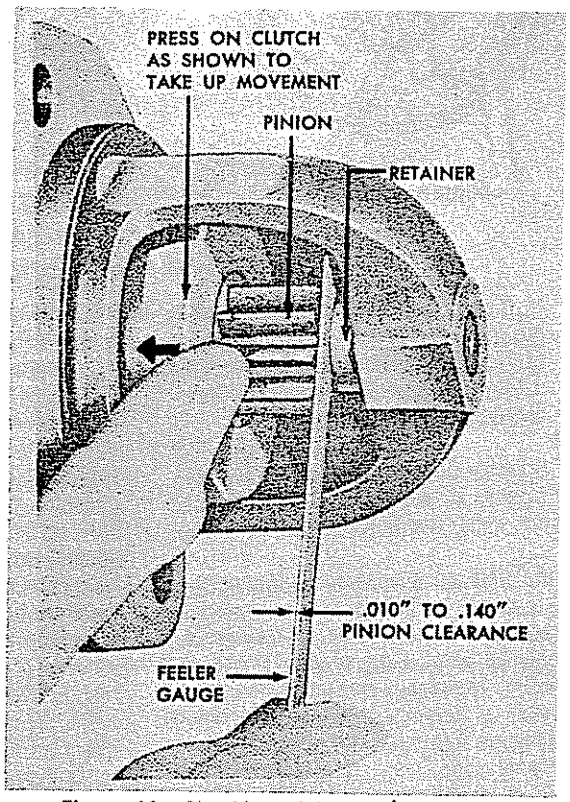


Figure 11—Checking pinion clearance.

the shaft and squeeze retainer and washer together with pliers (Fig. 9).

d. Remove the washer.

e. Assemble collar over shaft.

2. Refer to the disassembly procedure and follow in reverse to complete the reassembly.

3. When the solenoid is reinstalled, apply sealing compound between field frame, flange, and solenoid junction.

PINION CLEARANCE

The pinion clearance cannot be adjusted but should be checked after reassembly of the motor to insure proper clearance. Improper clearance is an indication of worn parts.

To check pinion clearance, follow the steps listed below:

1. Disconnect the motor field coil connector from the solenoid motor terminal and INSULATE IT CAREFULLY.

2. Connect a battery, of the same voltage as the solenoid, from the solenoid switch terminal to the solenoid frame (Fig. 10).

3. MOMENTARILY flash a jumper lead from the solenoid motor terminal to the solenoid frame. This will shift the pinion into cranking position and it will remain so until the battery is disconnected.

4. Push the pinion back towards the commutator end to eliminate slack movement.

5. Measure the distance between pinion and pinion stop (Fig. 11).

CRANKING MOTORS AND MISCELLANEOUS D.C. MOTORS

Specifications contained in this bulletin are for the purpose of testing the performance of Delco-Remy cranking and miscellaneous d.c. motors in the service field and apply only when tests are conducted as recommended in the applicable service bulletin.

To obtain full performance data on a motor, or to determine the cause of abnormal operation, the motor should be subjected to a "no-load" test. This test is performed, as described below, with the motor removed from the engine.

No-Load Test

Be sure switch is OPEN before connections or disconnections are made.

To perform the no-load test, connect the cranking motor in series with a fully charged battery of the specified voltage as illustrated in Figure 1 or Figure 2. An r.p.m. indicator is necessary to measure armature speed. Obtain the specified voltage by varying the carbon pile. Then read the current draw and the armature speed and compare these readings with the values listed in the published specifications. CAUTION: Do not apply voltage above what is specified. Excessive voltage may cause the armature to throw windings.

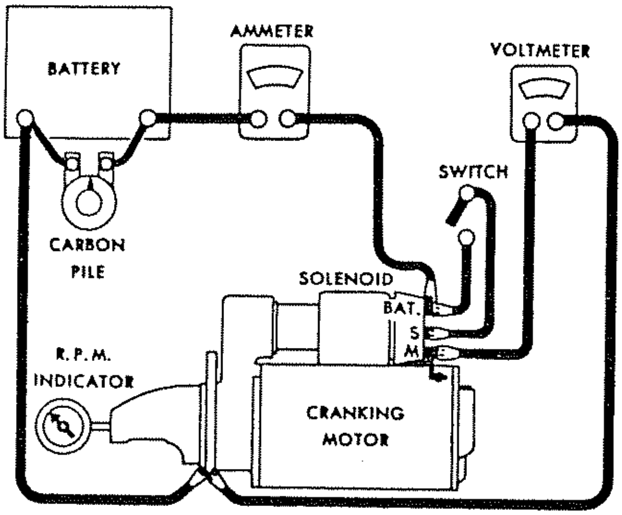


Fig. 1—No-Load test hookup with solenoid

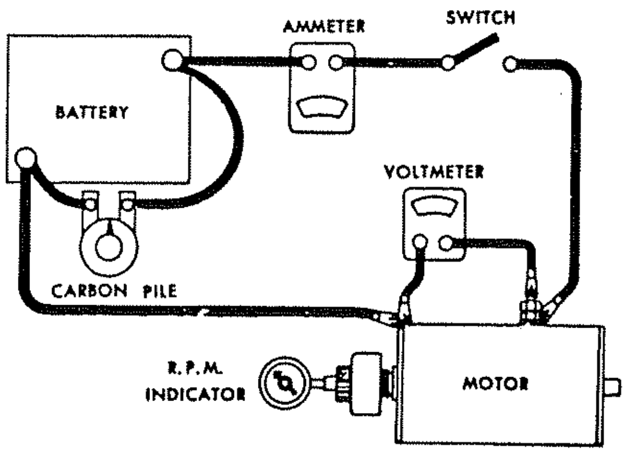


Fig. 2—No-Load test hookup without solenoid

STARTING MOTOR SPECIFICATIONS

Motor Model	Series	Type	Service Bulletin	Rotation Viewing D. E.	Spec. No.	NO LOAD TEST Volts	Min. Amps	Max. Amps	Min. RPM	Max. RPM
(Specifications Are For Basic Motor Only Unless Otherwise Indicated)										
1109484(a)	10MT	110	1M-151	CW	3563	9	65*	95*	7500	10500
1109485(a)	10MT	110	1M-151	CCW	3563	9	65*	95*	7500	10500

* Includes Solenoid
(a) Pinion Clearance — .010" to .140"
(b) Pinion Clearance — 23/64" ± 1/32"
(f) Pinion Clearance — .25 to 3.56 millimeters

PCM

marine engines

FORD ENGINES REPAIR & DIAGNOSTIC PROCEDURES

FORD ENGINE INDEX

460 ENGINES
DESCRIPTION AND OPERATION

The 460 V-8 engine is a lightweight cast iron design with a bore of 4.36 inches and a stroke of 3.85 inches. Piston displacement is 460 cubic inches and the compression ratio is 8.5 to 1.

MANIFOLDS

The cast iron intake manifold is an exhaust gas heated design with eight mounting bolts per side. Coolant is discharged from the engine through the outlet housing at the right front of the intake manifold.

The intake manifold contains two sets of air-fuel mixture passages which have round ports. All passages are of nearly equal length to assure more even mixture distribution to the cylinders. The upper set of passages feeds cylinders 1, 4, 6 and 7 from the right primary and secondary bores of the carburetor. Exhaust gases flow through the crossover passage below the carburetor mounting pad to provide the initial heat for vaporization of the air-fuel mixture.

CYLINDER HEADS

Cylinder head assemblies have rail type rocker arms individually mounted on threaded studs. Combustion chambers are cast in an advanced wedge (quench) design with more rounded contours. Valves are canted at angles so their heads will conform to these contours. Intake and exhaust ports are round in cross section. The valve arrangement from front to rear is E-I-E-I-E-I-E-I for the left cylinder head, and I-E-I-E-I-E-I-E for the right cylinder head.

The cylinder head gasket used on all marine engines is the asbestos binder-type with a stainless steel core and should be installed dry, that is, without any sealer.

CYLINDER BLOCK

The cast iron cylinder block is a skirtless design with five main bearings. All oil passages are closed with pipe plugs. Main bearings are of intermediate copper-lead material with an oil groove only in the upper half. Crankshaft end thrust is controlled by the flanges of the center main bearing.

Cylinders are numbered from front to rear with 1 through 4 on the right bank and 5 through 8 on the left bank. Firing order is 1-5-4-2-6-3-7-8. Each slipper skirt autothermic piston has two compression rings and an oil control ring. The upper compression ring has a moly-filled groove and the lower compression ring has a scraper groove. The oil control ring assembly consists of a stainless steel expander spacer separating chrome-plated steel rails. Pressed-in piston pins and strap-type caps with overplated copper-lead alloy bearings are used with the connecting rods.

All 460 marine engines are available in either standard or reverse rotation, except for the "Ski Boat." The 460 Ski Boat engine is standard rotation only. The firing order is different between reverse and standard rotation. Standard rotation is 1-5-4-2-6-3-7-8. Reverse rotation is 1-8-7-3-6-2-4-5.

Two crankshaft assemblies are used on marine engines depending upon whether the engine is standard or reverse rotation. The knurling must throw oil toward the slinger.

A two-piece split lip-type rear oil seal is used for service on marine engines. They are color coded, yellow for use with a standard rotation crankshaft and red for use with a reverse rotation crankshaft.

The 460 engines have cast pistons with the notch, for assembly

The standard marine 460 engines use a cast iron front cover while the "Ski Boat" engines use the aluminum front cover. Mounted on it are the water pump (all marine engines except the 460 "Ski Boat" engine use a marine bi-rotational water pump with a stainless steel external bypass tube, left hand water inlet, and no heater inlet. The "Ski Boat" engine uses a standard automotive water pump) with bonded ceramic seal contact face. The oil pump is mounted at the lower left front of the block and is driven by the distributor through an intermediate 5/16 inch hex driveshaft.

VALVE TRAIN

The camshaft is supported by five bearings pressed into the block. It is driven at one-half crankshaft speed by the timing chain sprockets. The camshaft sprocket is positioned by a dowel in the forward face of the front camshaft bearing journal. Camshaft end play is controlled by a thrust plate attached to the front of the cylinder block. An excentric cam for fuel pump actuation is attached to the front face of the sprocket. A helical accessory drive gear is machined in the camshaft directly behind the front journal to drive the distributor and oil pump. There are two camshafts available for the 460 marine engines depending upon whether the engine is standard rotation or reverse rotation. The camshaft for the standard rotation engine can be identified by a white color band painted on the body diameter between the gear and the number one intake cam lobe. There is no color code used on the reverse-rotation camshaft.

Hydraulic valve lifters ride directly on the camshaft lobes and transmit the thrust of the lobes to the push rods which actuate the valve train. Two types of hydraulic valve lifters are used in the 460 V-8 engines. Although both types may be used interchangeably in an engine, their component parts are not interchangeable. Type II hydraulic valve lifters have three circumferential ribs on the barrel near the oil hole, while Type I hydraulic valve lifters have no ribs in that area. In a Type II lifter, an upper metering valve retainer with a tensioning finger is used. The metering valve in a Type I lifter is flat.

When a valve is closed, the related push rod is in its lowest position and the lifter assembly is on the base circle of the cam lobe. The valve lifter plunger spring expands, forcing the plunger upward. This force is transmitted to the rocker arm through the push rod, causing solid contact between the valve end of the rocker arm and the valve stem.

As the valve lifter plunger spring expands to move the plunger upward, the volume of the compression chamber in the bottom of the lifter body is increased. Oil, supplied at full lubrication system pressure through the oil gallery passages in the cylinder block unseats the disc type check valve in the bottom of the lifter and enters the compression chamber to fill the increased volume. The check valve closes when the chamber is filled.

As the camshaft rotates, the lifter body is raised by the cam lobe. The oil in the compression chamber, being incompressible, acts as a solid member and transfers the lifting force to the plunger and push rod. Because of the load imposed on the plunger by the push rod, the oil in the compression chamber is subjected to increased pressure. This causes a slight leakage out of the chamber past the walls of the plunger. The leakage flow is known as the calibrated leak-down rate and is controlled by precise matching of valve body and plunger during original assembly of the valve lifter. Consequently, individual hydraulic valve lifter components are not interchangeable.

When the high point of the cam rotates past the foot of the valve lifter body, the lifter is forced downward by the push rod as the valve (intake or exhaust) returns to its seat in the cylinder head. This reduces the force on the lifter plunger and allows the plunger to be raised once again by the plunger spring. Engine oil is forced into the compression chamber to replace that which leaked out, priming the lifter for its next operating cycle.

Hydraulic force and plunger spring action in the valve lifter take up all clearances in the valve train mechanism to maintain zero valve lash.

The push rods are tubular steel with ball ends. Each push rod receives oil from a disc-type metering valve in the push rod cup at the top of the valve lifter. The oil enters and leaves the push rod through holes in both ball ends to independently lubricate each rocker arm.

The rail type rocker arms each have a hole in their push rod end for lubrication. Each rocker arm is individually mounted on a stud that is threaded into the cylinder head. The rocker arm pivots on a spherical fulcrum seat on the stud. A nut retains the rocker arm and fulcrum seat on the stud, and provides a means of adjusting valve clearance.

Intake valves are of forged alloy steel. Exhaust valves are of cast austenitic steel. Marine engines use heavy duty valves with chrome plated stems. Both intake and exhaust valves are the free turning type. The valves of all engines except the low output version use valve spring dampers. Valves with oversize stems are available for all marine engines. All valves have chromed stems and tips. Because the valves are canted, they open obliquely into the combustion chambers, in the direction of gas flow, to improve engine breathing. Pockets are cast in the piston heads to provide clearance at top dead center for full valve opening.

The valve springs for the standard marine and "Ski Boat" engines are identified by four red stripes. The low output version valve springs are blue.

LUBRICATION SYSTEM

Oil from the bottom of the sump in the front of the oil pan is drawn into the oil pump through the pump inlet tube and screen assembly. The positive displacement rotor type oil pump is driven by an intermediate drive shaft from the distributor. The pump forces the oil through the engine's lubrication system. A spring-loaded relief valve in the pump limits the maximum pump output pressure, returning any excess oil flow to the intake side of the pump.

The pressurized oil flow from the pump passes through a full-flow, two-stage oil filter before it enters the engine lubrication galleries. A relief valve in the filter permits oil to bypass the filter if the high capacity element becomes clogged.

From the filter, the oil flows through a passage to the right main oil gallery. Before reaching the right main oil gallery, some oil is diverted into a narrower vertical cross passage leading up to the No. 1 camshaft bearing and down to the No. 1 main bearing. Oil from the top of the cross passage flows through the oil hole in the camshaft bearing to lubricate the bearing surfaces. Some oil is conveyed through a groove in the bearing to a passage that lubricates the distributor shaft pilot bearing. The rest of the oil is squeezed out between the front and rear edges of the camshaft bearing and journal. Oil from the front of the bearing is directed through slots in the hub of the camshaft sprocket and drips onto the timing chain and fuel pump eccentric cam for lubrication. It then drains into the forward end of the oil pan.

Oil reaching the No. 1 main bearing from the lower end of the vertical cross passage lubricates the front crankshaft journal. A groove in the upper bearing half conveys oil to a lengthwise notch formed in the ends of the bearing shell, from where the oil is discharged. Oil coming out of the front of this notch drips onto the crankshaft sprocket and timing chain for lubrication, then drains into the forward end of the oil pan.

Oil in the right main oil gallery is routed to the main bearings, the hydraulic valve lifters for the right cylinder bank of the engine, and through a crossover passage to the left main oil gallery which supplies the hydraulic valve lifters for the left cylinder bank of the engine. A passage at the rear of the right main oil gallery leads to the sending unit for the low oil pressure warning light on the instrument panel.

Oil passages are drilled in the cylinder block from each main bearing to the camshaft bearing above it. After lubricating the camshaft bearings, the oil drains into the oil pan.

In addition to supplying oil for the camshaft bearings, the main bearing lubrication system also lubricates the connecting rod bearings through grooves in the upper halves of the main bearings and passages drilled in the crankshaft.

Oil enters each hydraulic valve lifter when the valve is closed and the oil hole in the lifter is exposed to the oil gallery passage. The oil is then metered through the disc valve in the head of the lifter and into the tubular push rod. From the upper end of the push rod, the oil is discharged into a hole drilled in the rocker arm to lubricate the upper valve train bearing areas. The oil returns to the oil pan through drain back holes at each end of the cylinder heads and cylinder block. A reservoir in each valve lifter bore retains oil for immediate valve lifter lubrication as the engine is started.

The level of the engine oil in the crankcase is indicated on a dipstick inserted in a tube extending downward. The lower portion of the dipstick enters the surface of the oil of the oil pan.

POSITIVE CRANKCASE VENTILATION SYSTEM

The 460 V-8 engine has a closed type, positive ventilation system. This system draws blow-by vapors from the crankcase and discharges them into the intake manifold to be burned in the combustion chambers of the engine, eliminating a major source of engine oil contamination. The closed positive crankcase ventilation system also prevents the discharge of any crankcase fumes to the atmosphere, as an air pollution control measure.

Ventilating air, taken from the carburetor flame arrestor flows through a hose to the oil filler cap on the front of the left valve rocker arm cover. The oil filler cap contains a filtering element which cleans the incoming air. The filter element and the narrow hose fittings slightly restrict air flow to help maintain a small vacuum in the crankcase when the engine is operating. The oil filler cap is sealed at the filler opening to prevent the entrance of atmospheric air.

From the oil filler cap, the air enters the left rocker arm chamber. Then it moves down past the push rods into the crankcase and also into the timing chain chamber. From these spaces, the ventilating air flows to the rear of the crankcase and up to the rear section of the right valve rocker arm cover, sweeping any combustion by-product fumes along with it. The vapor-laden air enters a spring-loaded regulator valve in the top rear portion of the right valve rocker arm cover. This "jiggle pin" valve regulates the amount of airflow to meet changing operating conditions. The air is then drawn to the intake manifold through the crankcase vent hose and the carburetor spacer passage.

The regulator valve operates by sensing intake manifold vacuum through the carburetor spacer passage and crankcase vent hose. At idle, intake manifold vacuum is high, overcoming the pressure of the valve spring. The valve "jiggle pin" moves to the low-speed operation position where only a minimum of ventilating airflow passes between the valve pin and outlet port in the valve body. As manifold vacuum decreases with an increase in engine speed and/or power output, the spring forces the pin to the full open position to increase the flow of ventilating air.

CARBURETORS

The 460 engines use either a Holley Model 4150 or Model 4160 carburetor. The 460 low output marine engines use a Holley Marine Model 4160 carburetor while the 460 Standard Marine and "Ski Boat" engines use a Holley Marine Model 4150C carburetor with a center pivot float bowl design.

DISTRIBUTORS

All 460 marine engines use a Prestolite centrifugal advance distributor.

302 & 351 ENGINES DESCRIPTION AND OPERATION

The Ford 302 CID and 351W CID 8-cylinder gasoline engines are available as engine assemblies and are available in industrial or marine versions. In addition, optional equipment is available to custom tailor each engine to individual requirements.

The Ford 302 CID 8-cylinder engine and the Ford 351W CID 8-cylinder engine are designed by Ford Motor Company to incorporate many features for smooth, powerful operation, long life and service. The cylinder block is cast iron for maximum strength and rigidity. They have five main bearings and full-length, full-circle water jackets. These full-length, full-circle water jackets help eliminate hot spots and provide more uniform cylinder wall expansion under heavy-duty operation. The cylinders are numbered from front to rear, on the right bank 1, 2, 3, 4 and on the left bank 5, 6, 7, 8. All marine engines are available in either standard or reverse rotation of the camshaft and crankshaft depending upon the engine installation. The firing order for the standard rotation is 1-3-7-2-6-5-4-8 and the reverse rotation is 1-8-4-5-6-2-7-3, except the 302 low output engine. The firing order for the 302 low output engine is 1-5-4-2-6-3-7-8 for the standard rotation and 1-8-7-3-6-2-4-5 for the reverse rotation.

The crankshaft is carried in five replaceable copper-lead alloy main bearings. Crankshaft end thrust is controlled by the center bearing. Marine engines use four crankshaft assemblies, two for the 302 including the 302 low output engine and two for the 351W. Standard or reverse rotation is the determining factor on which crankshaft is used. A different damper assembly is used for each crankshaft and can be identified by the part number stamped on the face of the damper and the direction of rotation as indicated by the timing marks on the damper.

The camshaft is supported by five bearings pressed into the block. It is driven by a timing chain from the crankshaft. There are six different camshafts available for marine engines, two for the 302 low output engine, depending upon standard or reverse rotation and four for the other engines depending upon whether a two or four venturi carburetor is used and whether the engine is standard or reverse rotation. The camshafts are color coded as per the chart which follows.

Camshaft end play is controlled by a plate bolted to the front of the block. The distributor is driven by a gear at the front end of the camshaft. Distributors used on marine engines may vary. The parts are not interchangeable between different makes of distributors, but complete distributors can be interchanged. The 302 marine engines use a Prestolite or Mallory distributor. The 351W marine engines use a Prestolite, GPD or Mallory distributor.

The cylinder head assemblies contain the fuel intake and exhaust passages, the valves, and the valve rocker arm assemblies. Valve guides are an integral part of the head. Hard-faced intake and exhaust valve seat inserts are standard. The intake and exhaust valves are actuated through hydraulic-type valve lifters, tubular push rods and individual rocker arms. The large intake and exhaust valves are the free-turning type which rotate slightly each time the valve opens and closes. Rotation promotes self-cleaning and long life.

The self-adjusting valve lifters are housed in bores located in the cylinder block valve lifter chamber. The valve lifters operate directly on the camshaft, thereby transmitting the thrust of the camshaft lobes, by means of hydraulic pressure, to the push rods which actuate the valve train.

All marine engines use heavy duty valves and all have free rotating intake and exhaust valves, except the low output 302 engines. Free rotating valves rotate slightly each time the valve opens and closes.

On the low output 302 marine engines, the intake valves are free rotating while the exhaust valves are the positive rotating type. A positive rotating spring retainer produces a definite amount of rotation each time the valve opens and closes.

The low output 302 marine engines use the regular 302 cylinder head while all the other marine engines use a 351W engine cylinder head. The intake and exhaust valve parts of the 351W cylinder head are larger than those of the 302 head. Accordingly, the diameter of the intake and exhaust valves of all engines using the 351W head are larger and the length of the stems slightly longer. Valves with oversize stems are available for all marine engines.

The same spring is used for intake and exhaust valves of all marine engines except the low output 302 engine. These springs are identified by color coding. The color code for all springs other than those for the low output 302 is three green stripes. The intake valve spring for the low output 302 is light red while the exhaust valve spring is color coded purple.

The cylinder head gasket used on all marine engines is the composition type with a stainless steel core and should be installed dry, that is, without any sealer.

The intake manifold has two sets of fuel passages, each with its own separate inlet connection to the carburetor. A heat crossover passage permits exhaust gases to circulate through the intake manifold, thereby providing the initial heat necessary to assist in vaporizing the incoming fuel charge.

Oil from the oil pan sump, located in the front of the oil pan, is forced through the pressure lubrication system by a rotor-type oil pump mounted in the front of the crankcase. A spring-loaded relief valve in the pump maintains the maximum pressure in the system. A full-flow filter is used which filters the entire output of the pump before the oil enters the engine. A valve integral with the filter permits oil flow if the filter ever becomes clogged. From the filter, the oil flows to an oil gallery and through passages to the various bearings and engine components.

The pistons have two compression rings and one oil control ring. The top compression ring is chrome-plated steel and the lower compression ring is phosphate-coated. The oil control ring consists of a serrated spring expander and two chrome-plated steel rails. The connecting rods are forged steel and use selective fit replaceable copper-lead alloy bearings.

A two-piece split lip-type rear main oil seal is used for service on marine engines. They are color coded yellow for use with a standard rotation crankshaft and red for use with a reverse rotation crankshaft.

The engine is equipped with a positive crankcase system that directs the crankcase vapors through an emission valve to the intake manifold, where they are mixed with the incoming fuel charge and burned in the cylinders.

Marine engines use a different water pump depending upon whether the engine is standard or reverse rotation.

The reverse rotation engines use a bi-rotational water pump assembly. The bi-rotational pump only is identified by a number D3JE-AA, on the housing.

Marine engines use Holley marine carburetors Model 4160 for four venturi applications and 2300 for two venturi applications.

SECTION C - ENGINE OVERHAUL

I. DIAGNOSIS AND TESTING

Manifold Vacuum:

A manifold vacuum test aids in determining the condition of an engine and in helping to locate the cause of poor engine performance. To check manifold vacuum:

1. Operate the engine for a minimum of 30 minutes at 1200 rpm or until the engine is at normal operating temperature.
2. Connect an accurate, sensitive vacuum gauge to the intake manifold vacuum fitting.
3. Operate the engine at the recommended idle rpm, with the shift control lever in neutral.
4. Check the vacuum reading on the gauge.

Test Conclusions

Manifold vacuum is affected by the carburetor adjustment, valve timing, ignition timing, condition of the valves, cylinder compression, condition of the positive crankcase ventilation system and leakage of the manifold, carburetor, carburetor spacer or cylinder head gaskets.

Because abnormal gauge readings may indicate that more than one of the above factors are at fault, exercise caution in analyzing an abnormal reading. For example, if the vacuum is low, the correction of one item may increase the vacuum enough so as to indicate that the trouble has been corrected. It is important, therefore, that each cause of an abnormal reading be investigated and further tests conducted, where necessary, to arrive at the correct diagnosis of the trouble.

Fig. 1, lists various types of readings and their possible causes.

Allowance should be made for the effect of altitude on the gauge reading. The engine vacuum will decrease with an increase in altitude.

Gauge Reading	Engine Condition
All models 16 inches or more	NORMAL
Low and steady.	Loss of power in all cylinders possibly caused by late ignition or valve timing, or loss of compression due to leakage around the piston rings.
Very low.	Intake manifold, carburetor, spacer or cylinder head gasket leak.
Needle fluctuates steadily as speed increases.	A partial or complete loss of power in one or more cylinders caused by a leaking valve, cylinder head or intake manifold gasket, a defect in the ignition system, or a weak valve spring.
Gradual drop in reading at engine idle.	Excessive back pressure in the exhaust system.
Intermittent fluctuation.	An occasional loss of power possibly caused by a defect in the ignition system or a sticking valve.
Slow fluctuation or drifting of the needle.	Improper idle mixture adjustment or carburetor, spacer or intake manifold gasket leak, or restricted crankcase ventilation system.

Fig. 1 - Manifold Vacuum Gauge Readings

COMPONENT IDENTIFICATION CHART

CAMSHAFT IDENTIFICATION

Engine	Identification
302 351W 4V Standard	White color band painted on body diameter between gear and No. 1 intake cam lobe. Also, a yellow color band painted on body diameter between gear and No. 1 journal.
302 351W 4V Reverse	White color band painted on body diameter between gear and No. 1 intake cam lobe. Also, bronze color band painted on body between gear and No. 1 journal.
302 351W 2V Low Output Standard	No color code used. Ford Part Number is stamped on face of rear journal.
302 351W 2V Low Output Reverse & 460 Reverse	No color code used. Fort Part Number is stamped on face of rear journal.
302 351W 2V Standard	Green color band both sides of gear.
302 351W 2V Reverse & 460 Standard	White color band painted around the body diameter between the gear and the No. 1 intake cam.

FIG. 5 Marine Engine Camshaft Identification
5 Chart

VALVE SPRING COLOR CODE

	Intake	Exhaust
Derated 302	Light Red	Purple
302 Std. & 351	3 Green Stripes All Valves	
460 Engines	4 Red Stripes All Valves	
Derated 460	Blue All Valves	

REAR MAIN SEAL COLOR CODE — ALL ENGINES

Standard Rotation Engines (LH)	Yellow
Reverse Rotation Engines (RH)	Red

ENGINE WATER PUMP IDENTIFICATION

Reverse Rotation Engine (RH) Water Pump identified by the number D3JE-AA on the housing. This Pump is bi-rotational and can be used on either the RH or LH engine. All 460 water pumps are bi-rotational.

	Carburetor Models
302 2/V	Holley 2300 Marine
302 & 351 4V	Holley 4160 Marine
460	Holley 4150C Marine

DIAGNOSIS AND TESTING

CAMSHAFT LOBE LIFT

Check the lift of each lobe in consecutive order and make a note of the readings.

1. Remove the air cleaner. Remove valve rocker arm cover.
2. Remove the valve rocker arm assembly(ies) and install a solid, tappet-type push rod in the push rod bore of the camshaft lobe to be checked or use the adapter for ball end push rods shown in Figure 6.
3. Make sure the push rod is in the valve lifter socket. Install a dial indicator so that the actuating point of the indicator is in the push rod socket (or the indicator ball socket adapter is on the end of the push rod) and in the same plane as the push rod movement.
4. Connect an auxiliary starter switch in the starting circuit. Crank the engine with the ignition switch OFF. Bump the crankshaft over until the tappet or lifter is on the base circle of the camshaft lobe. At this point, the push rod will be in its lowest position.
5. Zero the dial indicator. Continue to rotate the crankshaft slowly until the push rod is in the fully raised position.
6. Compare the total lift recorded on the indicator with specification.
7. To check the accuracy of the original indicator reading, continue to rotate the crankshaft until the indicator reads zero. **If the lift on any lobe is below specified wear limits, the camshaft and the valve lifters operating on the worn lobe(s) must be replaced.**
8. Remove the dial indicator and auxiliary starter switch.
9. Install the valve rocker arm assembly as detailed under Removal and Installation.
10. Install the valve rocker arm cover and the air cleaner.

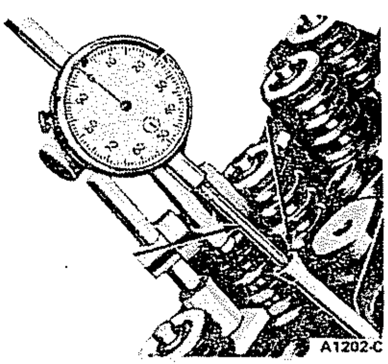


FIG. 6 Typical Camshaft Lobe Lift Hydraulic Valve Lifters—V-8 Engine

COMPRESSION TEST

Compression Gauge Check

1. Be sure the crankcase oil is of the correct viscosity and make sure that the battery is properly charged. Operate the engine for a minimum of 30 minutes at 1200 rpm, or until the engine is at normal operating temperature. Turn the ignition switch off; then remove all the spark plugs.
2. Set the carburetor throttle plates in the **wide open position.**
3. Install a compression gauge in No. 1 cylinder.
4. Install an auxiliary starter switch in the starting circuit. Using the auxiliary starter switch, crank the engine (with the ignition switch OFF) at least five compression strokes and record the highest reading. Note the approximate number of compression strokes required to obtain the highest reading.
5. Repeat the test on each cylinder as was required to obtain the highest reading on the No. 1 cylinder.

Test Conclusion

The indicated compression pressures are considered normal if the lowest reading cylinder is within 75% of the highest. Refer to the following example.

Seventy-five percent of 140, the highest cylinder reading, is 105. Therefore, cylinder No. 7 being less than 75% of cylinder No. 3 indicates an improperly seated valve or worn or broken piston rings.

If one or more cylinders read low, squirt approximately one (1) tablespoon of engine oil on top of the pistons in the low reading cylinders. Repeat compression pressure check on these cylinders.

1. If compression improves considerably, the piston rings are at fault.
2. If compression does not improve, valves are sticking or seating poorly.
3. If two adjacent cylinders indicate low compression pressures and squirting oil on the pistons does not increase the compression, the cause may be a cylinder head gasket leak between the cylinders. Engine oil and/or coolant in the cylinders could result from this problem.

Example

After checking the compression pressures in all cylinders, it was found that the highest reading obtained was 196 psi. The lowest pressure reading was 155 psi. The engine is within specifications and the compression is considered satisfactory.

HYDRAULIC VALVE LIFTER

Dirt, deposits of gum, varnish and air bubbles in the lubricating oil can cause hydraulic valve lifter failure or malfunction.

Dirt, gum and varnish can keep a check valve from seating and cause a loss of hydraulic pressure. An open valve disc will cause the plunger to force oil back into the valve lifter reservoir during the time the push rod is being lifted to force the valve from its seat.

Air bubbles in the lubricating system can be caused by too much oil in the system or too low an oil level. Air may also be drawn into the lubricating system through an opening in a damaged oil pick-up tube. Air in the hydraulic system can cause a loss of hydraulic pressure.

Assembled valve lifters can be tested with Tool 6500-E to check the leak-down rate. The leak-down rate specification is the time in seconds for the plunger to move the length of its travel while under a 50 lb. load. Test the valve lifters as follows:

1. Disassemble and clean the lifter to remove all traces of engine oil. Lifters cannot be checked with engine oil in them. Only the testing fluid can be used.
2. Place the valve lifter in the tester with the plunger facing upward. Pour hydraulic tester fluid into the cup to a level that will cover the valve lifter assembly. The fluid can be purchased from the manufacturer of the tester. Do not use kerosene, for it will not provide an accurate test.
3. Place a 5/16 inch steel ball in the plunger cup (Figure 8).
4. Adjust the length of the ram so that the pointer is 1/16 inch below the starting mark when the ram contacts the valve lifter plunger (Figure 9) to facilitate timing as the pointer passes the start timing mark.

   Use the center mark on the pointer scale as the stop timing point instead of the original stop timing mark at the top of the scale.

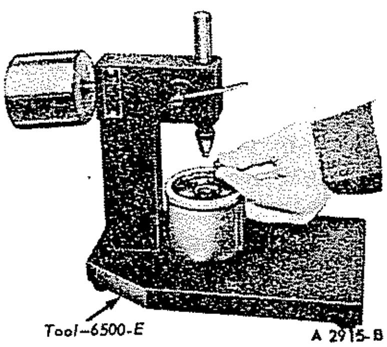


FIG. 8 Placing Steel Ball in Valve Lifter Plunger.

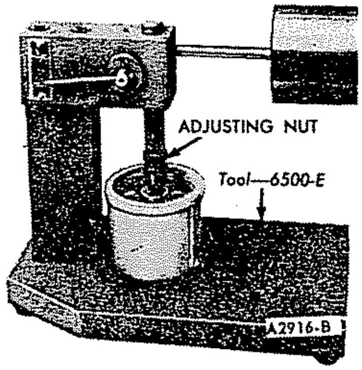


FIG. 9 Adjusting Ram Length

5. Work the valve lifter plunger up and down until the lifter fills with fluid and all traces of air bubbles have disappeared.
6. Allow the ram and weight to force the valve lifter plunger downward. Measure the exact time it takes for the pointer to travel from the start timing to the stop timing marks on the tester.
7. A valve lifter that is satisfactory must have a leak-down rate (time in seconds) within the minimum and maximum limits specified.
8. If the valve lifter is not within specifications, replace it with a new lifter. It is not necessary to test a new lifter before installing it in the engine.

POSITIVE CLOSED-TYPE VENTILATION SYSTEM

A malfunctioning closed crankcase ventilation system may be indicated by loping or rough engine idle. Do not attempt to compensate for this idle condition by disconnecting the crankcase ventilation system and making carburetor adjustments. **The removal of the crankcase ventilation system from the engine will adversely affect the fuel economy and engine ventilation with resultant shortening of engine life.** To determine whether the loping or rough idle condition is caused by a malfunctioning crankcase ventilation system, perform either of the following tests.

AIR INTAKE TEST

This test is performed with the crankcase ventilation tester C8AZ-6B627-A (Figure 10) which is operated by the engine vacuum through oil fill opening. Follow the procedures described below to install the tester and check the crankcase ventilation system for faulty operation.

1. With the engine at **normal operating temperature,** remove the oil filler cap.
2. Hold the tester C8AZ-6B627-A over the opening in the valve cover. Make sure the surface is flat to form a seal between the cover and tester. If the cover is distorted, shape it as required to make an air tight seal. An air leak

between the cover and tester will render the tester inoperative.

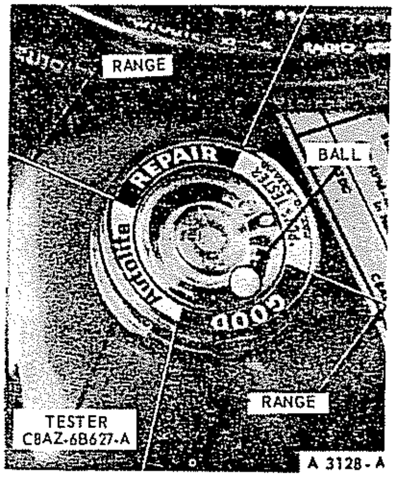


FIG 10 Crankshaft Ventilation System Tester

3. Start the engine and allow it to operate at the recommended idle speed.
4. Hold the tester over the oil filler cap opening making sure that there is a positive seal between the tester and cover.
5. If the ball settles in the **GOOD** (green) area, the system is functioning properly. If the ball settles in the **REPAIR** (red) area, clean or replace the malfunctioning components as required.
6. Repeat the test **AFTER** repairs are made to make sure that the crankcase ventilation system is operating satisfactorily.

Clean and replace the malfunctioning components as required. Repeat the test to ensure that the crankcase ventilation system is operating satisfactorily.

CRANKCASE VENTILATION REGULAR VALVE TEST

Install a known good regulator valve (PCV) in the crankcase ventilation system.

Start the engine and compare the engine idle condition to the prior idle condition.

If the idle condition is found to be satisfactory, use the new regulator valve and clean the hoses, fittings, etc.

If the loping or rough idle condition remains when the good regulator valve is installed, the crankcase ventilation regulator valve is not at fault. Check the crankcase ventilation system for restriction at the intake manifold or carburetor spacer. If the system is not restricted, further engine component diagnosis will have to be conducted to find the malfunction.

CRANKSHAFT END PLAY

1. Force the crankshaft toward the rear of the engine.
2. Install a dial indicator so that the contact point rests against the crankshaft flange and the indicator axis is parallel to the crankshaft axis (Figure 11).
3. Zero the dial indicator. Push the crankshaft forward and note the reading on the dial.
4. If the end play exceeds the wear limit, replace the thrust washers. If the end play is less than the minimum limit inspect the thrust bearing faces for scratches, burrs, nicks, or dirt.

FLYWHEEL FACE RUNOUT

Install a dial indicator so that the indicator point bears against the flywheel face. Turn the flywheel making sure that it is full forward or rearward so that crankshaft end play will not be indicated as flywheel runout.

If the clutch face runout exceeds specifications, remove the flywheel and check for burrs between the flywheel and the face of the crankshaft mounting flange. If no burrs exist, check the runout of the crankshaft mounting flange. Replace the flywheel or machine the crankshaft-flywheel mounting face sufficiently to true up the surface if the mounting flange runout exceeds specifications. Replace it or reinstall it on the flywheel.

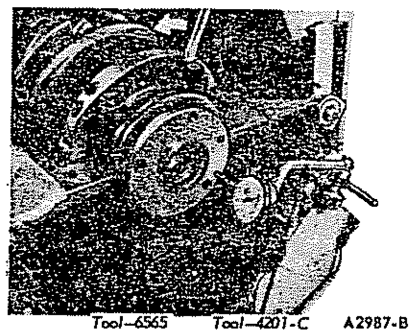


FIG. 11 Checking Crankshaft End Play

CAMSHAFT END PLAY

Prying against the aluminum-nylon camshaft sprocket, with the valve train load on the camshaft, can break or damage the sprocket. Therefore, the rocker arm adjusting nuts must be backed off, or the rocker arm and shaft assembly must be loosened sufficiently to free the camshaft. After checking the camshaft end play, adjust the valve clearance.

Push the camshaft toward the rear of the engine. Install a dial indicator so that the indicator point is on the camshaft sprocket attaching screw (Figure 12). Zero the dial indicator. Position a large screwdriver between the camshaft gear and the block. Pull the camshaft forward and release it. Compare the dial indicator reading with the specifications.

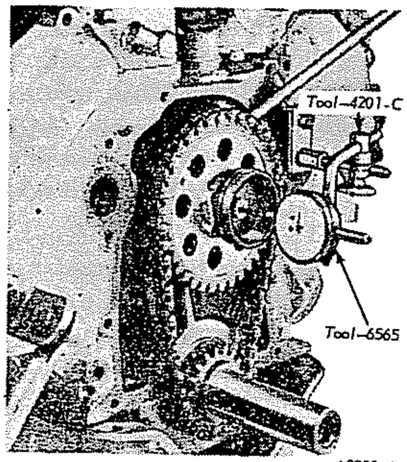


FIG. 12 Checking Camshaft End Play

If the end play is excessive, check the spacer for correct installation before it is removed. If the spacer is correctly installed, replace the thrust plate.

Remove the dial indicator.

TIMING CHAIN DEFLECTION

1. Rotate the crankshaft in a counterclockwise position (as viewed from the front) to take up the slack on the left side of the chain.

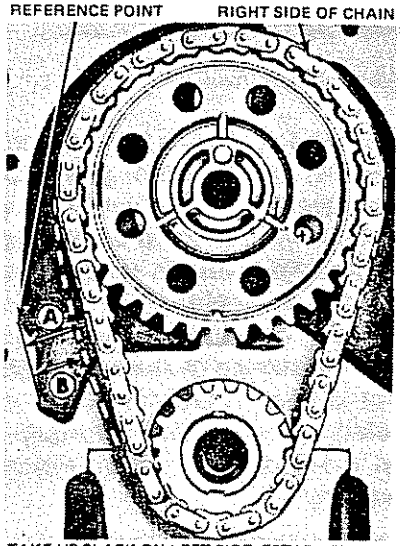


FIG. 13 Checking Timing Chain Deflection

2. Establish a reference point on the block and measure from this point to the chain.
3. Rotate the crankshaft in the opposite direction to take up the slack on the right of the chain. Force the left side of the chain out with the fingers and measure the distance between the reference point and the chain. The deflection is the difference between the two measurements.

If the deflection exceeds specifications, replace the timing chain and sprockets.

CLEANING AND INSPECTION

The cleaning and inspection procedures are for a complete engine overhaul; therefore, for partial engine overhaul or parts replacement, follow the pertinent cleaning or inspection procedure.

INTAKE MANIFOLD

Cleaning

Remove all gasket material from the machined surfaces of the manifold. Clean the manifold in a suitable solvent and dry it with compressed air.

Inspection

Inspect the manifold for cracks, damaged gasket surfaces, or other defects that would make it unfit for further service. Replace all studs that are stripped or otherwise damaged. **Remove all filings and foreign matter that may have entered the manifold as a result of repairs.**

EXHAUST MANIFOLDS

Cleaning

Remove all gasket material from the manifolds.

Inspection

Inspect the cylinder head joining flanges of the exhaust manifold for evidence of exhaust gas leaks.

Inspect the manifolds for cracks, damaged gasket surfaces, or other defects that would make them unfit for further service.

VALVE ROCKER ARM ASSEMBLY

Cleaning

Clean all the parts thoroughly. Make sure all oil passages are open.

Make sure the oil passage in the push rod end of the rocker arm is open.

Inspection

On rocker arm assemblies, inspect the pad at the valve end of the rocker arm for indications of scuffing or abnormal wear. If the pad is grooved, replace the rocker arm. **Do not attempt to true this surface by grinding.**

Check the push rod end of the rocker arms for scratches or excessive wear.

PUSH RODS

Cleaning

Clean the push rods in a suitable solvent.

Inspection

Check the ends of the push rods for nicks, grooves, roughness or excessive wear.

The push rods can be visually checked for straightness while they are installed in the engine by rotating them with the valve closed. They also can be checked with a dial indicator (Figure 14).

If the push rod is visibly bent, it should be replaced.

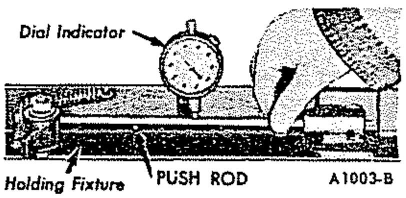


FIG. 14 Checking Push Rod Runout

CYLINDER HEADS

Cleaning

With the valves installed to protect the valve seats, remove deposits from the combustion chambers and valve heads with a scraper and a wire brush. Be careful not to damage the cylinder head gasket surface. After the valves are removed, clean the valve guide bores with a valve guide cleaning tool. Use cleaning solvent to remove dirt, grease and other deposits. Clean all bolt holes; be sure the oil transfer passage is clean. Remove all deposits from the valves with a fine wire brush or buffing wheel.

Inspection

Check the cylinder head for cracks and inspect the gasket surface for burrs and nicks. Replace the head if it is cracked.

The following inspection procedures are for a cylinder head that is to be completely overhauled. For individual repair operations, use only the pertinent inspection procedure.

When a cylinder head is removed because of gasket leaks, check the flatness of the cylinder head gasket surface (Figure 15) for conformance to specifications. If necessary to refinish the cylinder head gasket surface, **do not plane or grind off more than 0.010 inch.**

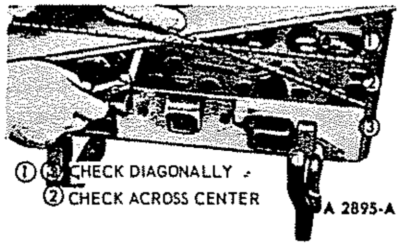


FIG. 15 Typical Cylinder Head Flatness

Check the valve seat runout with an accurate gauge (Figure 16). Follow the instructions of the gauge manufacturer. If the runout exceeds the wear limit, reface the valve and valve seat. Measure the valve seat width (Figure 30). Reface any valve seat whose width **is not within specifications.**

Inspect the valve face and the edge of the valve head for pits, grooves, scores or other damage. Inspect the stem for a bent condition and the end of the valve head for pits, grooves, scores or other wear. Inspect the stem for a bent condition and the end of the stem for grooves or scores.

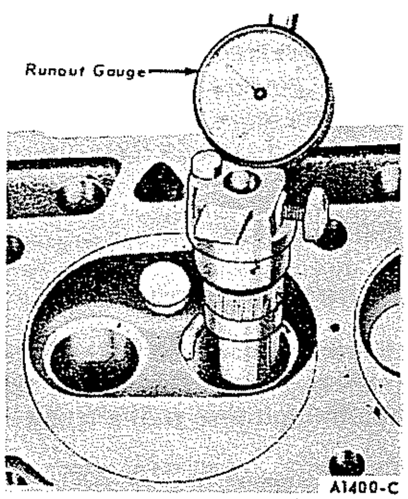


FIG. 16 Checking Valve Seat Runout

Check the valve head for signs of burning, erosion, warpage and cracking. Minor pits, grooves, etc., may be removed. Discard valves that are severely damaged. **Do not discard sodium-cooled valves with other scrap metal in scrap bins. If a sodium-cooled valve is accidentally broken and the sodium exposed, it will react violently upon contact with water resulting in fire and explosion due to chemical action. Therefore, these valves should be handled with care and disposed of by being buried in the ground in an area not subjected to excavation.**

Inspect the valve spring, valve spring retainers, locks and sleeves for wear or damage. Discard any visually damaged parts.

Check the valve stem to valve guide clearance of each valve in its respective valve guide with the tool shown in Figure 17 or its equivalent. Use a flat end indicator point.

Install the tool on the valve stem until it is fully seated, and tighten the knurled set screw firmly. Permit the valve to drop away from its seat until the tool contacts the upper surface of the valve guide.

Position the dial indicator with its flat tip against the center portion of the tool's spherical section at approximately 90 degrees to the valve stem axis. Move the tool back and forth in line with the indicator stem. Take a reading on the dial indicator without removing the tool from the valve guide upper surface. Divide the reading by two, the division factor for the tool.

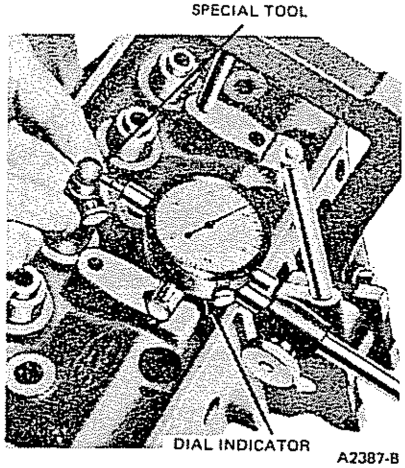


FIG. 17 Checking Valve Stem Clearance

Check the springs for proper pressure (Figure 18) at the specified spring lengths (Tool 6513-DD). **Manually rotating the valve spring assemblies while installed in the engine must not be used to determine good and/or bad valve springs.** Weak valve springs cause poor engine performance. Replace any spring not within specifications.

Check each spring for squareness using a steel square and a flat surface (Figure 19). Stand the spring and square on end on the flat surface. Slide the spring up to the square. Revolve the spring slowly and observe the space between the top coil of the spring and the square. The out-of-square limits are 5/64 inch.

Follow the same procedure to check new valve springs before installation. **Make certain the proper spring (color coded) is installed.**

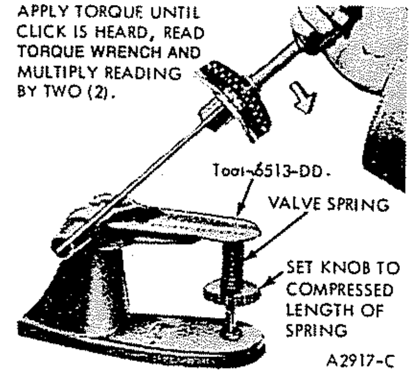


FIG. 18 Checking Valve Spring Pressure

HYDRAULIC VALVE LIFTERS

The valve lifter assemblies should be kept in proper sequence so that they can be installed in their original position. Inspect and test each lifter separately so as not to intermix the internal parts. **If any part of the lifter assembly needs replacing, replace the entire assembly.**

Cleaning

Thoroughly clean all the parts in cleaning solvent and wipe them with a clean, lint-free cloth.

Inspection

Inspect the parts and discard the entire lifter assembly if any part shows pitting, scoring, galling or evidence of nonrotation. Replace the entire assembly if the plunger is not free in the body. The plunger should drop to the bottom of the body by its own weight when assembled dry.

Assemble the lifter assembly and check for freeness of operation by pressing down on the push rod cup. The lifters can also be checked with a hydraulic tester to test the leak-down rate. Follow the instructions of the test unit manufacturer.

CRANKSHAFT VIBRATION DAMPER AND SLEEVE

Cleaning

Clean the oil seal contact surface on the crankshaft damper or sleeve with solvent to remove any corrosion, sludge or varnish deposits. Excess deposits that are not readily removed with solvent may be removed with crocus cloth. Use crocus cloth to remove any sharp edges, burrs or other inperfections which might damage the oil seal during installation or cause premature seal wear. **Do not use crocus cloth to the extent that the seal surface becomes polished. A finely polished surface may produce poor sealing or cause premature seal wear.**

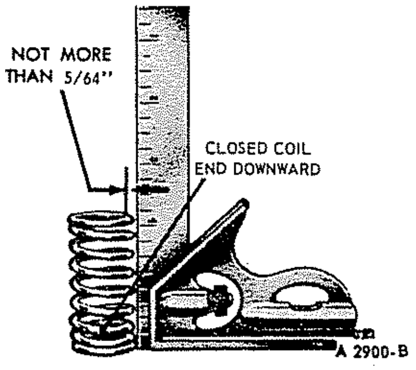


FIG. 19 Checking Valve Spring Squareness

Inspection

Inspect the crankshaft damper or sleeve oil seal surface for nicks, sharp edges or burrs that might damage the oil seal during installation or cause premature seal wear.

TIMING CHAIN AND SPROCKETS

Cleaning

Clean all parts in solvent and dry them with compressed air.

Lubricate the timing chain with engine oil before installing it on the engine.

Inspection

Inspect the chain for broken links. Inspect the sprockets for cracks and worn or damaged teeth. Replace all the components of the timing chain and sprocket assembly if any one item needs replacement.

Inspect the fuel pump drive eccentric for scores, nicks and excessive wear. If the eccentric is scored, replace it.

CAMSHAFT

Cleaning and Inspection

Clean the camshaft in solvent and wipe it dry. Inspect the camshaft lobes for scoring and signs of abnormal wear. Lobe wear characteristics may result in pitting in the general area of the lobe toe. This pitting is not detrimental to the operation of the camshaft; therefore, the camshaft should not be replaced unless the lobe lift loss has exceeded 0.005 inch.

The lift of the camshaft lobes can be checked with the camshaft installed in the engine or on centers. Refer to Camshaft Lobe Lift.

Check the distributor drive gear for broken or chipped teeth. Replace the camshaft if this condition exists.

CRANKSHAFT

Cleaning

Handle the crankshaft with care to avoid possible fractures or damage to the finished surfaces. Clean the crankshaft with solvent, then blow out all oil passages with compressed air.

Inspection

Inspect the main and connecting rod journals for cracks, scratches, grooves or scores. Inspect the crankshaft oil seal surface for nicks, sharp edges or burrs that might damage the oil seal during installation or cause premature seal wear.

Measure the diameter of each journal in at least four places to determine an out-of-round, taper or undersize condition (Figure 20).

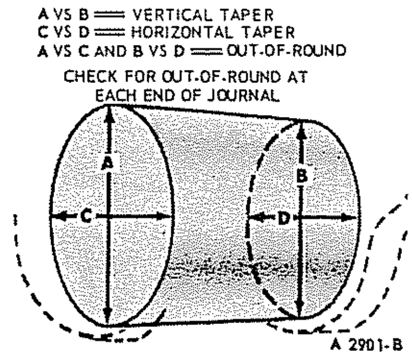


FIG. 20 Crankshaft Journal Measurement

Check the fit of the clutch pilot bushing in the bore of the crankshaft. The bushing is pressed into the crankshaft and should not be loose. Inspect the inner surface of the bushing for wear or a bell-mouth condition. Check the ID of the bushing (Figure 21). Replace the bushing if it is worn or damaged or the ID is not within specifications.

Inspect the pilot bearing (ball bearing), when so equipped, for roughness, evidence of overheating or loss of lubricant. Replace it if any of these conditions are found.

FIG. 21 Checking Clutch Pilot Bushing Wear

FLYWHEEL

Inspection

Inspect the flywheel for cracks, heat check, or other damage that would make it unfit for further service. Machine the friction surface of the flywheel if it is scored or worn. If it is necessary to remove more than 0.045 inch of stock from the original thickness, replace the flywheel.

Inspect the ring gear for worn, chipped, or cracked teeth. If the teeth are damaged, replace the ring gear.

With the flywheel installed on the crankshaft, check the flywheel face runout, following the procedure under Diagnosis and Testing.

CONNECTING RODS

Cleaning

Remove the bearings from the rod and cap. Identify the bearings if they are to be used again. Clean the connecting rod in solvent, including the rod bore and the back of the inserts. **Do not use a caustic cleaning solution.** Blow out all passages with compressed air.

Inspection

The connecting rods and related parts should be carefully inspected and checked for conformance to specifications. Various forms of engine wear caused by these parts can be readily identified.

A shiny surface on either pin boss side of the piston usually indicates that a connecting rod is bent.

Abnormal connecting rod bearing wear can be caused by either a bent connecting rod, worn or damaged crankpin, or a tapered connecting rod bore.

Twisted connecting rods will not create an easily identifiable wear pattern, but badly twisted rods will disturb the action of the entire piston, rings, and connecting rod assembly and may be the cause of excessive oil consumption.

Inspect the connecting rods for signs of fractures and the bearing bores for out-of-round and taper. If the bore exceeds the recommended limits and/or if the connecting rod is fractured, it should be replaced. Check the ID of the connecting rod piston pin bore. If the pin bore in the connecting rod is larger than specifications, install a 0.002 inch oversize piston pin. First, prefit the oversize piston pin to the piston pin bore by reaming or honing the piston. Then, assemble the piston, piston pin and connecting rod following the procedures for assembly. **It is not necessary to ream or hone the pin bore in the connecting rod. Replace damaged connecting rod nuts and bolts. Check the connecting rods for bend or twist on a suitable alignment fixture. Follow the instructions of the fixture manufacturer. If the bend and/or twist exceeds specifications, the connecting rod must be straightened or replaced.**

PISTONS, PINS AND RINGS

Cleaning

Remove deposits from the piston surfaces. Clean gum or varnish from the piston skirt, piston pins and rings with solvent. **Do not use a caustic cleaning solution or a wire brush to clean pistons.**

Clean the ring grooves with a ring groove cleaner (Figure 22). Make sure the oil ring slots (or holes) are clean.

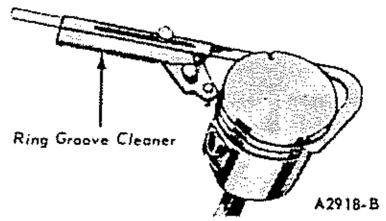


FIG. 22 Cleaning Piston Ring Grooves

Inspection

Carefully inspect the pistons for fractures at the ring lands, skirts and pin bosses, and for scuffed, rough or scored skirts. If the lower inner portion of the ring grooves has a high step, replace the piston. The step will interfere with ring operation and cause excessive ring side clearance.

Spongy, eroded areas near the edge of the top of the piston are usually caused by detonation or pre-ignition. A shiny surface on the thrust surface of the piston, offset from the centerline between the piston pin holes, can be caused by a bent connecting rod. Replace pistons that show signs of excessive wear, wavy ring lands or fractures or damage from detonation or pre-ignition.

Check the piston to cylinder bore clearance by measuring the piston and bore diameters. Refer to the specifications for the proper clearance. Refer to Cylinder Block Inspection for the bore measurement procedure. **Measure the OD of the piston with micrometers approximately 2¼ inches below the dome and at 90 degrees to the piston pin bore.** Check the ring side clearance following the procedure under Fitting Piston Rings in this section.

Replace piston pins showing signs of fracture, etching or wear. Check the piston pin fit in the piston and rod. Refer to Piston and Connecting Rod Assembly.

Check the OD of the piston and the ID of the pin bore in the piston. Replace any piston pin or piston that is not within specifications.

Replace all rings. Check the end gap and side clearance. **Rings should not be transferred from one piston to another regardless of mileage or hours.**

MAIN AND CONNECTING ROD BEARINGS

Cleaning

Clean the bearing inserts and caps thoroughly in solvent, and dry them with compressed air. **Do not scrape gum or varnish deposits from the bearing shells.**

Inspection

Inspect each bearing carefully. Bearings that have a scored, chipped, or worn surface should be replaced. Typical examples of unsatisfactory bearings and their causes are shown in Figure 23. The copper-lead bearing base may be visible through the bearing overlay. This does not mean that the bearing is worn. It is not necessary to replace the bearing if the bearing clearance is within recommended limits. Check the clearance of bearings that appear to be satisfactory with Plastigage as detailed under Main and Connecting Rod Bearings.

CYLINDER BLOCK

Cleaning

After any cylinder bore repair operation, such as honing or deglazing, clean the bore(s) with soap or detergent and water. Then, thoroughly rinse the bore(s) with clean water to remove the soap or detergent, and wipe the bore(s) dry with a clean, lint-free cloth. Finally, wipe the bore(s) with a clean cloth dipped in engine oil. If these procedures are not followed, rusting of the cylinder bore(s) may occur.

If the engine is disassembled, thoroughly clean the block with solvent. Remove old gasket material from all machined surfaces. Remove all pipe plugs that seal oil passages; then clean out all the passages. Blow out all passages, bolt holes, etc., with compressed air. Make sure the threads in the cylinder head bolt holes are clean. Dirt in the threads may cause binding and result in a false torque reading. Use a tap to true up threads and to remove any deposits. Thoroughly clean the grooves in the crankshaft bearings and bearing retainers.

Inspection

After the block has been thoroughly cleaned, check it for cracks. Minute cracks not visible to the naked eye may be detected by coating the suspected area with a mixture of 25% kerosene and 75% light engine oil. Wipe the part dry and immediately apply a coating of zinc oxide dissolved in wood alcohol. If cracks are present, the coating will become discolored at the defective area. Replace the block if it is cracked.

Check all machined gasket surfaces for burrs, nicks, scratches and scores. Remove minor imperfections with an oil stone.

Replace all expansion-type plugs that show evidence of leakage.

Inspect the cylinder walls for scoring, roughness, or other signs of wear. Check the cylinder bore for out-of-round and taper. Measure the bore with an accurate bore gauge following the instructions of the manufacturer. Measure the diameter of each cylinder bore at the top, middle and bottom with the gauge placed at right angles and parallel to the centerline of the engine (Figure 24). **Use only the measurements obtained at 90 degrees to the engine centerline when calculating the piston to cylinder bore clearance.**

Refinish cylinders that are deeply scored and/or when out-of-round and/or taper exceed the wear limits. If the cylinder walls have minor surface imperfections, but the out-of-round and taper are within limits, it may be possible to remove the imperfections by honing the cylinder walls and installing new service piston rings providing the piston clearance is within specified limits.

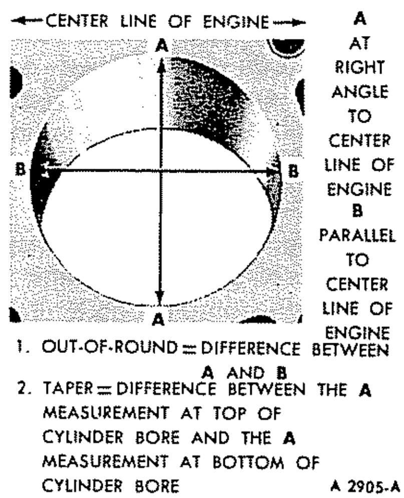


FIG. 24 Cylinder Bore Out-of-Round and Taper

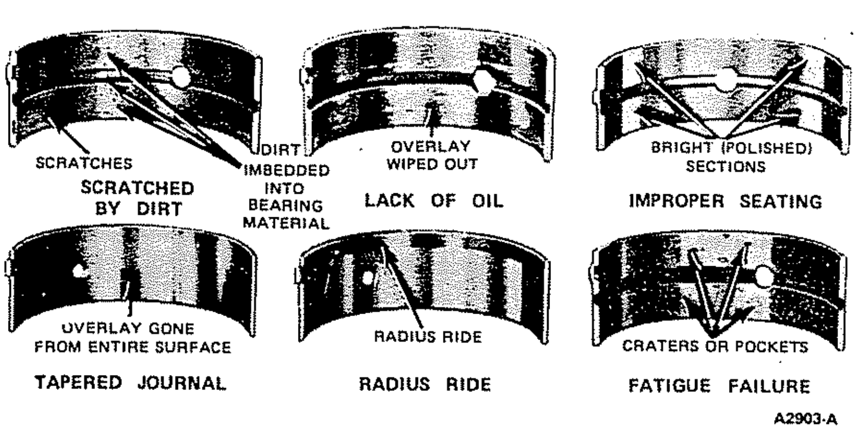


FIG. 23 Typical Bearing Failures

OIL PAN

Cleaning

Scrape any dirt or metal particles from the inside of the pan. Scrape all old gasket material from the gasket surface. Wash the pan in a solvent and dry it thoroughly. Be sure all foreign particles are removed from below the baffle plate.

Inspection

Check the pan for cracks, holes, damaged drain plug threads, and a loose baffle or a damaged gasket surface.

Inspect for damage (uneven surface) at the bolt holes caused by over-torquing the bolts. Straighten surfaces as required. Repair any damage, or replace the pan if repairs cannot be made satisfactorily.

OIL PUMP

Cleaning

Wash all parts in a solvent and dry them thoroughly with compressed air. Use a brush to clean the inside of the pump housing and the pressure relief valve chamber. Be sure all dirt and metal particles are removed.

Inspection

Refer to the specifications for clearances and wear limits.

Check the inside of the pump housing and the outer race and rotor for damage or excessive wear.

Check the mating surface of the pump cover for wear. If the cover mating surface is worn, scored or grooved, replace the cover.

Measure the outer race to housing clearance (Figure 25). Then check the clearance between the outer race and the rotor lobes.

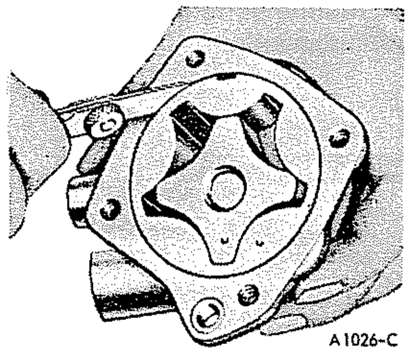


FIG. 25 Checking Outer Race to Housing Clearance

With the rotor assembly installed in the housing, place a straight edge over the rotor assembly and the housing. Measure the clearance (rotor end play) between the straight edge and the rotor and outer race (Figure 26). **The outer race, shaft and rotor are replaceable only as an assembly.** Check the drive shaft to housing bearing clearance by measuring the OD of the shaft and the ID of the housing bearing. Inspect the relief valve spring for a collapsed or worn condition. Check the relief valve spring tension. If the spring tension is not within specifications and/or the spring is worn or damaged, replace the spring. Check the relief valve piston for scores and free operation in the bore.

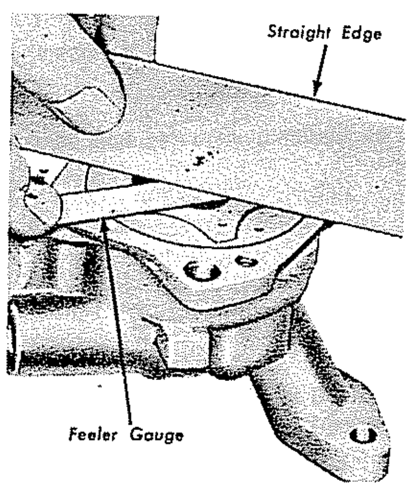


FIG. 26 Checking Rotor End Play

POSITIVE CLOSED-TYPE CRANKCASE VENTILATION SYSTEM

Cleaning

Do not attempt to clean the crankcase ventilation regulator valve (Figure 27); it should be replaced at the specified maintenance interval. The oil filler cap and oil separator should be cleaned at the proper maintenance interval. Remove the cap and the oil separator and wash them in a low-volatility, petroleum-base solvent. Shake the cap dry and install them. Clean the crankcase ventilation system connection(s) on the intake manifold by probing with a flexible wire or bottle brush. Clean the hoses, fittings, tubes and associated hardware with a low-volatility, petroleum-base solvent and dry with compressed air.

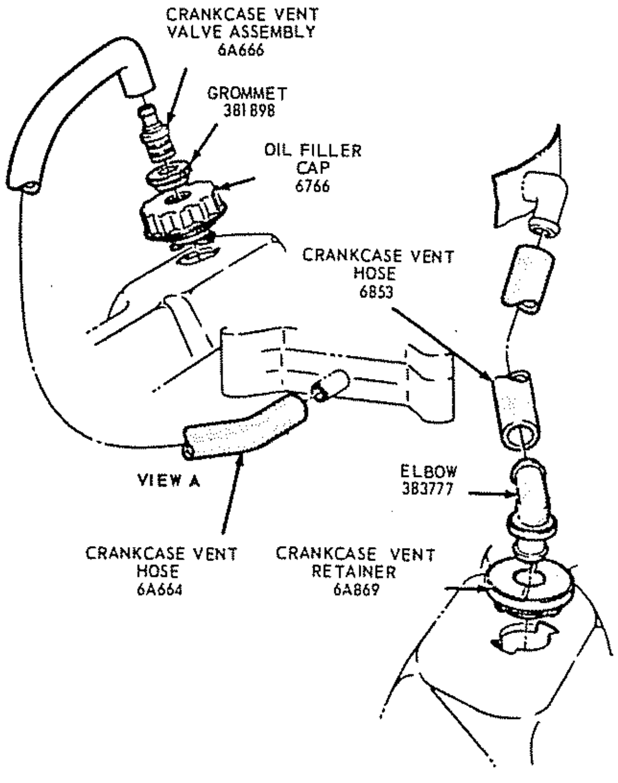


FIG. 27 Crankcase Ventilation System Regulator Valve Installed

OVERHAUL

CYLINDER HEAD

Replace the head if it is cracked. **Do not plane or grind more than 0.010 inch from the cylinder head gasket surface.** Remove all burrs or scratches with an oil stone.

REAMING VALVE GUIDES

If it becomes necessary to ream a valve guide (Figure 28) to install a valve with an oversize stem, a reaming kit is available which contains the following reamer and pilot combinations: a 0.003-inch OS reamer with a standard diameter pilot, a 0.015-inch OS reamer with a 0.003-inch OS pilot, and a 0.030-inch reamer with a 0.015-inch OS pilot.

When going from a standard size valve to an oversize valve always use the reamer in sequence. **Always reface the valve seat after the valve guide has been reamed, and use a suitable scraper to break the sharp corner (ID) at the top of the valve guide.**

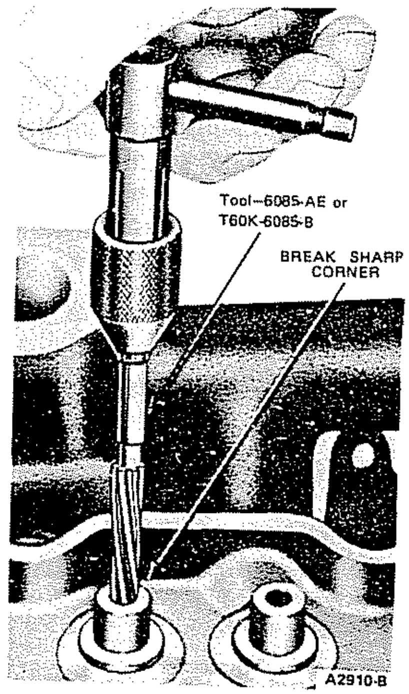


FIG. 28 Reaming Valve Guides

REFACING VALVE SEATS

Refacing the valve seat should be closely coordinated with the refacing of the valve face so that the finished seat and valve face will be concentric and the specified interference fit will be maintained. This is important so that the valve and seat will have a compression-tight fit. Be sure that the refacer grinding wheels are properly dressed.

Grind the valve seats of all engines to a true 45 degree angle (Figure 29). Remove only enough stock to clean up pits and grooves or to correct the valve seat runout. After the seat has been refaced, use a seat width scale or a machinist scale to measure the seat width (Figure 30). Narrow the seat, if necessary, to bring it within specifications, and center it on the valve face.

If the valve seat width exceeds the maximum limit, remove enough stock from the top edge and/or bottom edge of the seat to reduce the width to specifications, and center.

On the valve seats of all engines, use a 60 degree angle grinding wheel to remove stock from the bottom of the seats (raise the seats) and use a 30 degree angle wheel to remove stock from the top of the seats (lower the seats).

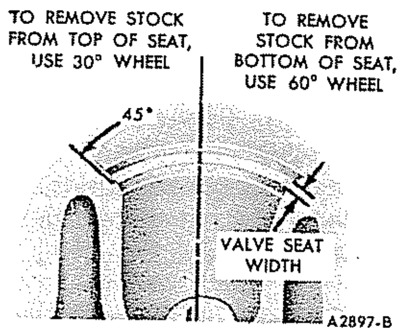


FIG. 29 Refacing Valve Seat

The finished valve seat should contact the approximate center of the valve face. It is good practice to determine where the valve seat contacts the face. To do this, coat the seat with Prussian blue and set the valve in place. Rotate the valve with light pressure. If the blue is transferred to the center of the valve face, the contact is satisfactory. If the blue is transferred to the top edge of the valve face, lower the valve seat. If the blue is transferred to the bottom edge of the valve face, raise the valve seat.

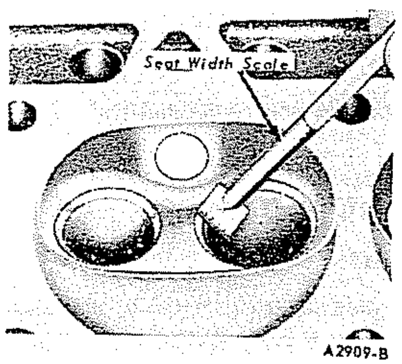


FIG. 30 Checking Valve Seat Width

VALVES

Minor pits, grooves, etc., may be removed. Discard valves that are severely damaged, if the face runout cannot be corrected by refinishing or stem clearance exceeds specifications. **Discard any excessively worn or damaged valve train parts.**

Refacing Valves

The valve refacing operation should be closely coordinated with the valve seat refacing operations so that the finished angles of the valve face and of the valve seat will be to specifications and provide a compression-tight fit. Be sure that the refacer grinding wheels are properly dressed.

Under no circumstances should the faces of aluminized intake valves be ground or the valves lapped in as this will remove the diffused aluminum coating and reduce the valve's wear and heat resistant properties. If the valve faces are worn or pitted it will be necessary to install new valves and to resurface the valve seats or, alternatively, lap the seats using dummy valves. The exhaust valves may be lapped in or the faces ground if required.

If the valve face runout is excessive and/or to remove pits and grooves, reface the valves to a true 44 degree angle. Remove only enough stock to correct the runout or to clean up the pits and grooves. If the edge of the valve head is less than 1/32 inch thick after grinding (Figure 31), replace the valve as the valve will run too hot in the engine. **The interference fit of the valve and seat should not be lapped out. Remove all grooves or score marks from the end of the valve stem, and chamfer it as necessary. Do not remove more than 0.010 inch from the end of the valve stem.**

If the valve and/or valve seat has been refaced, it will be necessary to check the clearance between the rocker arm pad and the valve stem with the valve train assembly installed in the engine.

Select Fitting Valves

If the valve stem to valve guide clearance exceeds the wear limit, ream the valve guide for the **next** oversize valve stem. Valves with oversize stem diameters of 0.003, 0.015 and 0.030 inch are available for service. **Always reface the valve seat after the valve guide has been reamed. Refer to Reaming Valve Guides.**

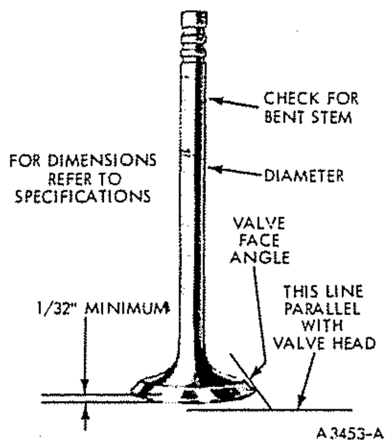


FIG. 31 Critical Valve Dimensions

CAMSHAFT REPAIR

Remove light scuffs, scores or nicks from the camshaft machined surfaces with a smooth oil stone.

CRANKSHAFT

Dress minor scores with an oil stone. If the journals are severely marred or exceed the wear limit, they should be refinished to size for the next undersize bearing.

REFINISHING JOURNALS

Refinish the journals to give the proper clearance with the next undersize bearing. If the journal will not clean up to maximum undersize bearing available, replace the crankshaft.

Always reproduce the same journal shoulder radius that existed originally. Too small a radius will result in fatigue failure of the crankshaft. Too large a radius will result in bearing failure due to radius ride of the bearing.

After refinishing the journals, chamfer the oil holes; then polish the journal with a No. 320 grit polishing cloth and engine oil. Crocus cloth may also be used as a polishing agent.

FITTING MAIN OR CONNECTING ROD BEARINGS WITH PLASTIGAGE

1. Clean crankshaft journals. Inspect journals and thrust faces (thrust bearing) for nicks, burrs or bearing pickup that would cause premature bearing wear. **When replacing standard bearings with new bearings, it is good practice to fit the bearing to minimum specified clearance.** If the desired clearance cannot be obtained with a standard bearing, try a 0.002 inch undersize in combination with a standard bearing to obtain the proper clearance.
2. If fitting a main bearing in the chassis, **position a jack under counterweight adjoining bearing which is being checked. Support crankshaft with jack so its weight will not compress Plastigage and provide an erroneous reading.**
3. Place a piece of Plastigage on bearing surface across full width of bearing cap and about 1/4 inch off center (Figure 32).
4. Install cap and torque bolt to specifications. Do not turn crankshaft while Plastigage is in place.
5. Remove cap. Using Plastigage scale, check width of Plastigage at widest point to get minimum clearance. Check at narrowest point to get maximum clearance. Difference between readings is taper of journals.
6. If clearance exceeds specified limits, on the connecting rod bearings, try a 0.002 inch undersize bearing in combination with the standard bearings. Bearing clearance must be within specified limits. If 0.002 undersize main bearings are used on more than one journal, be sure they are all installed in cylinder block side of bearing. If standard and 0.002 inch undersize bearings do not bring clearance within desired limits, refinish crankshaft journal, then install undersize bearings.
7. After bearing has been fitted, remove Plastigage and apply light coat of engine oil to journal and bearings. Install bearing cap. Torque cap bolts to specifications.
8. Repeat procedure for remaining bearings that require replacement.

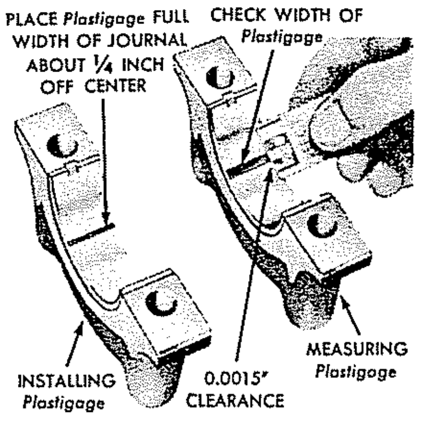


FIG. 32 Installing and Measuring Plastigage

PISTONS, PINS AND RINGS

Fitting Pistons

Pistons are available for service in standard sizes and the oversizes shown in the parts book.

The standard size pistons are color coded red or blue, or have .0025 O.S. stamped on the dome. Refer to the Specifications for standard size piston dimensions.

Measure the cylinder bore and select the piston to assure the proper clearance. When the bore diameter is in the lower one-third of the specified range, a red piston should be used. When the bore diameter is in the middle one-third a blue piston should be used. When the bore diameter is in the upper one-third, the 0.0025 O.S. piston should be used.

Measure the piston diameter to ensure that the specified clearance is obtained. It may be necessary periodically to use another piston (red or blue) that is either slightly larger or smaller to achieve the specified clearance. **If none can be fitted, refinish the cylinder to provide the proper clearance for the piston. When a piston has been fitted, mark it for assembly in the cylinder to which it was fitted. If the taper, out-of-round and piston to cylinder bore clearance conditions of the cylinder bore are within specified limits, new piston rings will give satisfactory service. If new rings are to be installed in a used cylinder that has not been refinished, remove the cylinder wall glaze (refer to Cylinder Block, Refinishing Cylinder Walls). Be sure to clean the cylinder bore thoroughly.**

1. Calculate the size piston to be used by taking a cylinder bore check. Follow the procedures outlined under Cleaning and Inspection.
2. Select the proper size piston to provide the desired clearance (refer to the specifications). The piston should be measured 2¼ inches below the dome and at 90° to the piston pin bore.
3. Make sure the piston and cylinder block are at room temperature (70 degrees F.). **After any refinishing operation allow the cylinder bore to cool, and make sure the piston and bore are clean and dry before the piston fit is checked.**

Fitting Piston Rings

1. Select the proper ring set for the size cylinder bore.
2. Position the ring in the cylinder bore in which it is going to be used.
3. Push the ring down into the bore area where normal ring wear is not encountered.
4. Use the head of a piston to position the ring in the bore so that the ring is square with the cylinder wall. **Use caution to avoid damage to the ring or cylinder bore.**
5. Measure the gap between the ends of the ring with a feeler gauge (Figure 33). If the ring gap is less or greater than the specified limits, try another ring set.
6. Check the ring side clearance of the compression rings with a feeler gauge inserted between the ring and its lower land (Figure 34). The gauge should slide freely around the entire ring circumference without binding. Any wear that occurs will form a step at the inner portion of the lower land. **If the lower lands have high steps, the piston should be replaced.**

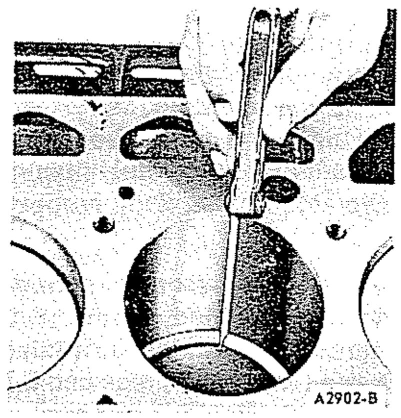


FIG. 33 Checking Piston Ring Gap

Fitting Piston Pins

The piston pins are selected to give the correct fit in the piston pin bore and bushing in the connecting rod. Pistons are only supplied in service complete with the piston pin, to ensure the correct fit. The piston pins should not be interchanged.

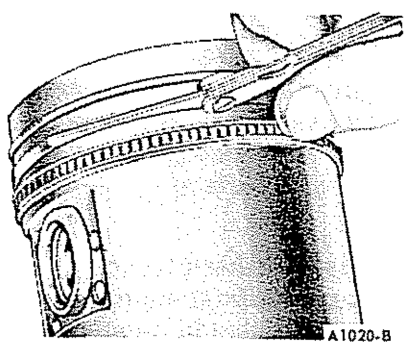


FIG. 34 Checking Piston Ring Side Clearance

VALVE ROCKER ARM

If the pad at the valve end of the rocker arm has a grooved radius, replace the rocker arm. **Do not attempt to true this surface by grinding.**

PUSH RODS

Following the procedures under Push Rod Inspection, check the push rods for straightness.

If the runout exceeds the maximum limit at any point, discard the rod. **Do not attempt to straighten push rods.**

CYLINDER BLOCK

Refinishing Cylinder Walls

Honing is recommended for refinishing cylinder walls **only** when the walls have minor scuffs or scratches, or for fitting pistons to the specified clearance. The grade of hone to be used is determined by the amount of metal to be removed. Follow the instructions of the hone manufacturer. If coarse stones are used to start the honing operation, leave enough material so that all hone marks can be removed with the finishing hone which is used to obtain the proper piston clearance.

Cylinder walls that are severely marred and/or worn beyond the specified limits should be refinished. **Before any cylinder is refinished, all main bearing caps must be in place and tightened to the proper torque so that the crankshaft bearing bores will not become distorted from the refinishing operation.**

Refinish only the cylinder or cylinders that require it. All pistons are the same weight, both standard and oversize; therefore, various sizes of pistons can be used without upsetting engine balance.

Refinish the cylinder with the most wear first to determine the maximum oversize. If the cylinder will not clean up when refinished for the maximum oversize piston recommended, replace the block.

Refinish the cylinder to within approximately 0.0015 inch of the required oversize diameter. This will allow enough stock for the final step of honing so that the correct surface finish and pattern are obtained.

For the proper use of the refinishing equipment, follow the instructions of the manufacturer. Only experienced personnel should be allowed to perform this work.

Use a motor-driven, spring pressure-type hone at a speed of 300-500 rpm. Hones of grit sizes 180-220 will normally provide the desired bore surface finish of 15/32 RMS. When honing the cylinder bores, use a lubricant mixture of equal parts of kerosene and SAE No. 20 motor oil. Operate the hone in such a way as to produce a cross-hatch finish on the cylinder bore. The cross-hatch pattern should be at an angle of approximately 30 degrees to the cylinder bore. After the final operation in either of the two refinishing methods described and prior to checking the piston fit, thoroughly clean and oil the cylinder walls. Mark the pistons to correspond to the cylinders in which they are to be installed. When the refinishing of all cylinders that require it has been completed and all pistons are fitted, thoroughly clean the entire block and oil the cylinder walls.

REPAIRING SAND HOLES OR POROUS ENGINE CASTINGS

Porosity or sand hole(s) which will cause oil seepage or leakage can occur with modern casting processes. A complete inspection of engine and transmission should be made. If the leak is attributed to the porous condition of the cylinder block or sand hole(s), repairs can be made with metallic plastic (Part No. C6AZ-19554-A). **Do not repair cracks with this material.** Repairs with this metallic plastic must be confined to those cast iron engine component surfaces where the inner wall surface is not exposed to engine coolant pressure or oil pressure, for example:

1. Cylinder block surfaces extending along the length of the block, upward from the oil pan rail to the cylinder water jacket but not including machined areas.
2. Lower rear face of the cylinder block.
3. Intake manifold casting.
4. Cylinder head, along the rocker arm cover gasket surface.

The following procedure should be used to repair porous areas or sand holes in cast iron:

a. Clean the surface to be repaired by grinding or rotary filing to a clean bright metal surface. Chamfer or undercut the hole or porosity to a greater depth than the rest of the cleaned surface. Solid metal must surround the hole. Openings larger than 1/4 inch should not be repaired using metallic plastic. Openings in excess of ¼ inch can be drilled, tapped and plugged using common tools. Clean the repair area thoroughly. Metallic plastic will not stick to a dirty or oily surface.
b. Mix the metallic plastic base and hardener as directed on the container. Stir thoroughly until uniform.
c. Apply the repair mixture with a suitable clean tool (putty knife, wood spoon, etc.) forcing the epoxy into the hole or porosity.
d. Allow the repair mixture to harden. This can be accomplished by two methods: heat cure with a 250 degree watt lamp placed 10 inches from the repaired surface or air dry for 10-12 hours at temperatures above 50 degrees F.
e. Sand or grind the repaired area to blend with the general contour of the surrounding surface.
f. Paint the surface to match the rest of the block.

ADJUSTMENTS

VALVE CLEARANCE

The valve arrangement on the left bank is E-I-E-I-E-I-E-I and on the right bank is I-E-I-E-I-E-I-E.

A 0.060-inch shorter push rod or a 0.060-inch longer push rod are available for service to provide a means of compensating for dimensional changes in the valve mechanism. Refer to the Master Parts List or the specifications for the pertinent color code.

Valve stem to valve rocker arm clearance should be within specifications with the hydraulic lifter completely collapsed. Repeated valve reconditioning operations (valve and/or valve seat refacing) will decrease the clearance to the point that, if not compensated for, the hydraulic valve lifter will cease to function and the valve will be held open.

To determine whether a shorter or a longer push rod is necessary, make the following check:

D-302 CID V-8 Engine & 460 V-8 Engine

1. Install an auxiliary starter switch. Crank the engine with the ignition switch OFF until the No. 1 piston is on TDC after the compression stroke.
2. With the crankshaft in the positions designated in Steps 3, 4 and 5, position the hydraulic lifter compressor tool on the rocker arm. Slowly apply pressure to bleed down the hydraulic lifter until the plunger is completely bottomed (Figure 35). Hold the lifter in this position and check the available clearance between the rocker arm and the valve stem tip with a feeler gauge. The feeler gauge width must not exceed 3/8 inch.

   If the clearance is less than specifications, install a shorter push rod.

   If the clearance is greater than specifications, install a longer push rod.
3. With the No. 1 piston on TDC at the end of the compression stroke, POSITION 1 in Figure 36, check the following valves:
   No. 1 Intake, No. 1 Exhaust
   No. 7 Intake, No. 5 Exhaust
   No. 8 Intake, No. 4 Exhaust
4. Rotate the crankshaft to POSITION 2 in Figure 36 and check the following valves:
   No. 5 Intake, No. 2 Exhaust
   No. 4 Intake, No. 6 Exhaust
5. Rotate the crankshaft to POSITION 3 in Figure 36 and check the following valves:
   No. 2 Intake, No. 7 Exhaust
   No. 3 Intake, No. 3 Exhaust
   No. 6 Intake, No. 8 Exhaust

Engine With Positive Stop Rocker Arm Studs

The positive stop rocker arm stud eliminates the necessity of adjusting the valve clearance. However, to obtain the specified valve clearance, it is important that all valve components be in a serviceable condition and installed and torqued properly. **Each stud nut should be removed and inspected for conditions shown in Figure 37 when adjusting valve clearance.**

With the crankshaft in the positions designated in Steps 1, 2 and 3, remove and inspect the stud nut for conditions shown in Figure 37. Install and turn the stud nut clockwise until it contacts the stop. Tighten the nut to specifications.

6. With the No. 1 piston on TDC at the end of the compression stroke, POSITION 1 in Figure 36, set the valve clearance on the following valves:
   No. 1 Intake, No. 1 Exhaust
   No. 7 Intake, No. 5 Exhaust
   No. 8 Intake, No. 4 Exhaust
7. Rotate the crankshaft to POSITION 2 in Figure 36 and set the valve clearance on the following valves:
   No. 5 Intake, No. 2 Exhaust
   No. 4 Intake, No. 6 Exhaust
8. Rotate the crankshaft to POSITION 3 in Figure 36 and set the valve clearance on the following valves:
   No. 2 Intake, No. 7 Exhaust
   No. 3 Intake, No. 3 Exhaust
   No. 6 Intake, No. 8 Exhaust

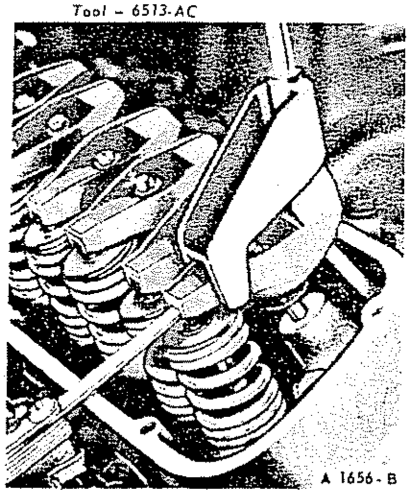


FIG. 35 Checking Valve Clearance Hydraulic Valve Lifters

351 C.I.D. V-8 Engine

1. Install an auxiliary starter switch. Crank the engine with the ignition switch OFF.
2. Position the crankshaft as outlined in Figure 36. Position a hydraulic lifter compressor tool on the rocker arm and slowly apply

pressure to bleed down the hydraulic lifter until the plunger is completely bottomed (Figure 35). Hold the lifter in the fully collapsed position and insert a low-limit (see Specifications) clearance gauge between the valve stem and the rocker arm of the valve being checked. If the clearance is less than specified, install a 0.060 inch longer push rod. If the gauge enters, the old push rod may be used. If a high-limit gauge enters, the operating range of the lifter is excessive which indicates severe wear has occured at the push rod ends, rocker arm, or valve stem. In this case, it will be necessary to determine the area of discrepancy and the worn part(s) should be replaced. If all the valve train components except the push rod are within limits, install a 0.060 inch longer push rod.

3. With the No. 1 piston on TDC at the end of the compression stroke, POSITION No. 1 in Figure 36, check the following valves:
   No. 1 Intake, No. 1 Exhaust
   No. 4 Intake, No. 3 Exhaust
   No. 8 Intake, No. 7 Exhaust
4. Rotate the crankshaft to POSITION No. 2 in Figure 36 and check the following valves:
   No. 3 Intake, No. 2 Exhaust
   No. 7 Intake, No. 6 Exhaust

With No. 1 at TDC at end of compression stroke make a chalk mark at points 2 and 3 approximately 90 degrees apart.

POSITION 1 - No. 1 at TDC at end of compression stroke.
POSITION 2 - Rotate the crankshaft 180 degrees (one half revolution) clockwise from POSITION 1.
POSITION 3 - Rotate the crankshaft 270 degrees (three quarter revolution) clockwise from POSITION 2.

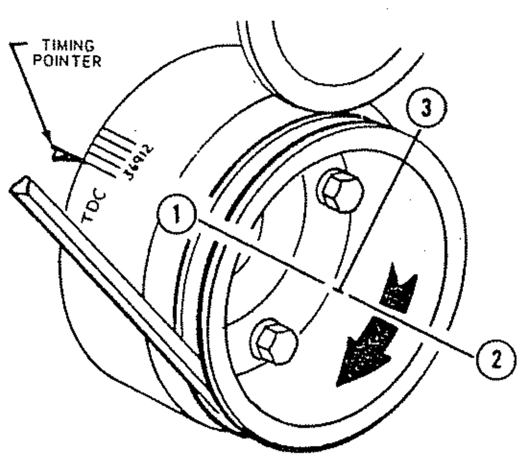


FIG. 36 Position of Crankshaft for Checking and Adjusting Valve Clearance

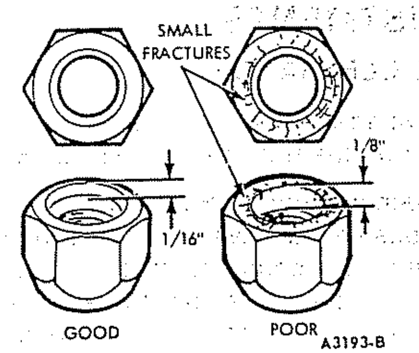


FIG. 37 Inspection of Rocker Arm Stud Nut

5. Rotate the crankshaft to POSITION No. 3 in Figure 36 and check the following valves:
   No. 2 Intake, No. 4 Exhaust
   No. 5 Intake, No. 5 Exhaust
   No. 6 Intake, No. 8 Exhaust

Engines With Positive Stop Rocker Arm Studs

The positive stop rocker arm stud eliminates the necessity of adjusting the valve clearance. However, to obtain the specified valve lash, it is important that all valve components be in a serviceable condition and installed and torqued properly. **Each stud nut should be removed and inspected for conditions shown in Figure 37 when adjusting valve clearance.**

6. With the crankshaft in the positions designated in Steps 2, 3 and 4, remove the stud nut and inspect it for conditions shown in Figure 37.

   Install the stud nuts on the stud and turn the nut clockwise until it contacts the stop. Torque the stud nut to specifications.
7. With the No. 1 piston on TDC at the end of the compression stroke, POSITION No. 1 in Figure 36, inspect the stud nut and install the stud nut on the following valves:
   No. 1 Intake, No. 1 Exhaust
   No. 4 Intake, No. 3 Exhaust
   No. 8 Intake, No. 7 Exhaust
8. Rotate the crankshaft to POSITION No. 2 in Figure 36. Inspect and install the stud nut on the following valves:
   No. 3 Intake, No. 2 Exhaust
   No. 7 Intake, No. 6 Exhaust
9. Rotate the crankshaft to POSITION No. 3 in Figure 36. Inspect and install the stud nut on the following valves:
   No. 2 Intake, No. 4 Exhaust
   No. 5 Intake, No. 5 Exhaust
   No. 6 Intake, No. 8 Exhaust

REMOVAL AND INSTALLATION

CRANKCASE VENTILATION SYSTEM

Removal

1. Remove ventilation system air intake hose from flame arrestor and the left valve cover.
2. Disconnect the crankcase vent hose from the carburetor spacer.
3. Pull the regulator valve out of the oil filler cap in the left valve cover.

Installation

1. Insert the regulator valve into the grommet on the right valve cover.
2. Connect the vent hose to the regulator valve; install the hose on the carburetor spacer.
3. Install the ventilation system air intake hose to the flame arrestor and left valve cover fitting.
4. Start the engine and check for leaks.

VALVE ROCKER ARM COVER AND ROCKER ARM

The valve rocker arm assembly sequence is shown in Figure 39.

Removal

1. To remove a valve rocker arm from the cylinder head.
   Disconnect the spark plug wires from the spark plugs using Tool No. T68P-6666-A. Do not pull on wire. Remove the wires from the bracket on the valve rocker arm cover(s) and position the wires out of the way.
2. On a right side rocker arm cover, remove the wire harness from the retaining clips. Remove the valve rocker arm cover attaching bolts and remove the cover.

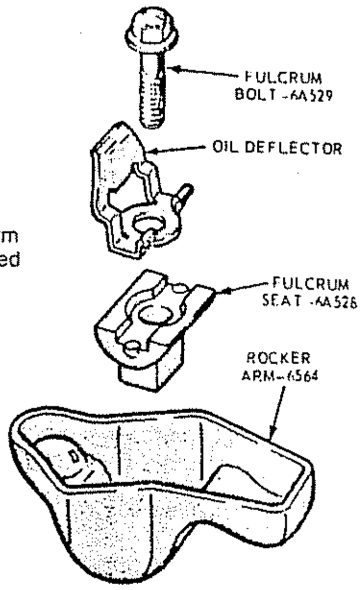


FIG. 39A Rocker Arm and Related Parts

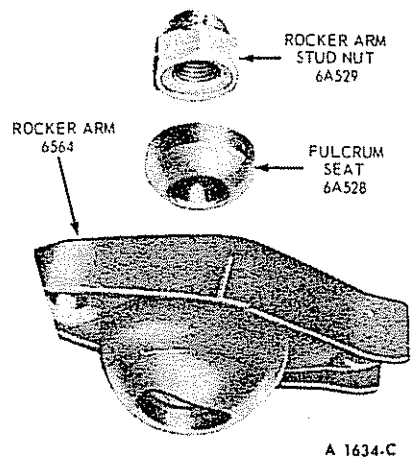


FIG. 39 Valve Rocker Arm Assembly

3. Remove the valve rocker arm stud nut, or bolt fulcrum seat and rocker arm.

If removal of the rocker arm stud is necessary, refer to the procedure under Cylinder Head Repairs.

Installation 302 & 351 Engs

All rocker arms and fulcrum seats are to be lubricated with heavy engine oil SE before installation.

1. Apply Lubriplate, or equivalent, to the top of the valve stem and underside of the fulcrum seats.
2. Inspect the stud nut for damage. The chamfer on the nut should not be over 1/16-inch wide. A nut with a chamfer larger than 1/16-inch can cause the valves to be held open.
3. Install the rocker arm, fulcrum seat and stud nut.
4. Clean the valve rocker arm cover(s) and the cylinder head gasket surface(s). Position the valve rocker cover gasket in each cover, making sure that the tabs engage the notches in the cover.
5. Position the cover(s) on the cylinder head(s). Make sure the gasket seats evenly all around the head. Install the bolts and wire loom clips on left hand cover. The cover is tightened in two steps. Torque the bolts to specifications. Two minutes later, torque the bolts to the same specifications.

   Install the crankcase ventilation hoses in the covers.
6. Install the spark plug wires in the bracket on the valve rocker arm cover(s). Connect the spark plug wires.

Installation 460 Engine

1. Apply Lubriplate or equivalent to the top of the valve stems, the rocker arm and fulcrum seats.
2. Position the No. 1 piston on TDC at the end of the compression stroke, Position 1 in Figure 33, and install the rocker arm, fulcrum seat, oil deflector and bolt on the following valves:
   No. 1 Intake, No. 1 Exhaust
   No. 7 Intake, No. 5 Exhaust
   No. 8 Intake, No. 4 Exhaust

Position the crankshaft in Position 2 in Figure 33 and install the rocker arm, fulcrum seat, oil deflector and bolt on the following valves:
No. 4 Intake, No. 2 Exhaust
No. 5 Intake, No. 6 Exhaust

Position the crankshaft in Position 3 in Figure 33 and install the rocker arm, fulcrum seat, oil deflector and bolt on the following valves:
No. 2 Intake, No. 3 Exhaust
No. 3 Intake, No. 7 Exhaust
No. 6 Intake, No. 8 Exhaust

Be sure that the fulcrum seat base is inserted in its slot on the cylinder head before tightening the fulcrum bolts. Tighten the fulcrum bolt to specification. Check the valve clearance following the procedures under Valve Clearance Checking Procedure.

3. Clean the valve rocker arm cover(s) and the cylinder head gasket surface(s). Position the gasket in the cover, making sure that the gasket tangs are secured in the notches in the cover.
4. Position the cover(s) on the cylinder head(s). Make sure the gasket seats evenly all around the head. Install the bolts. The cover is tightened in two steps. Tighten the bolts to specifications. Two minutes later, tighten the bolts to the same specifications.
   If the right cover was removed, install PCV valve. Install the air cleaner and intake duct assembly.
5. Install the spark plug wires in the bracket on the valve rocker arm cover(s). Connect the spark plug wires.
6. Start the engine and check for leaks.

VALVE SPRING, RETAINER AND STEM SEAL

Removal

Broken valve springs or damaged valve stem seals and retainers may be replaced without removing the cylinder head, provided damage to the valve or valve seat has not occurred.

1. Refer to Valve Rocker Arm Cover in this section for the cover removal and installation.
2. Remove the applicable spark plug and bring the piston to the top of the bore to prevent accidental loss of the valve into the cylinder.
3. Remove the valve rocker arm stud nuts, fulcrum seats, valve rocker arms and push rods from the applicable cylinder. Remove the exhaust valve stem cap.
4. Install an air line with an adapter in spark plug hole and apply air pressure to the cylinder. Failure of the air pressure to hold the valve(s) in the closed position is an indication of valve seat damage and required removal of the cylinder head.
5. Install the stud nut and position the compressor tool as shown in Figure 40. Compress the valve spring and remove the retainer locks, spring retainer, sleeve and valve spring

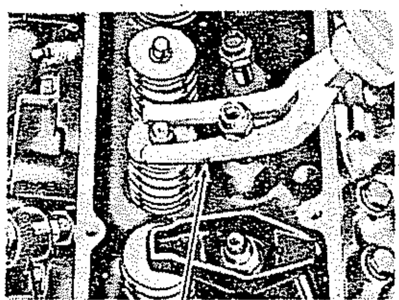


FIG. 40 Compressing Valve Spring—In Chassis

6. Remove and discard the valve stem seal (Figure 41).
7. **If air pressure has forced the piston to the bottom of the cylinder, any removal of air pressure will allow the valve(s) to fall into the cylinder. A rubber band, tape or string wrapped around the end of the valve stem will prevent this condition and will still allow enough travel to check the valve for binds.**
8. Inspect the valve stem for damage. Rotate the valve and check the valve stem tip for eccentric movement during rotation. Move the valve up and down through normal travel in the valve guide and check the stem for binds. **If the valve has been damaged, it will be necessary to remove the cylinder head for repairs.**

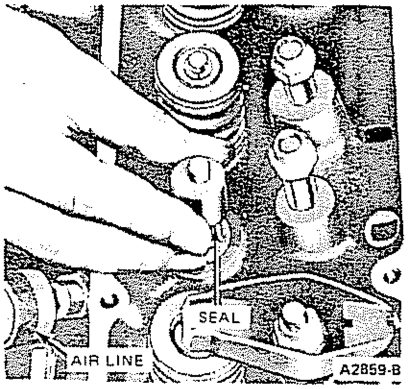


FIG. 41 Removing or Installing Valve Stem Seal

Installation

1. If the condition of the valve proved satisfactory, lubricate the valve stem with heavy engine oil SE. Hold the valve in the closed position and apply air pressure within the cylinder.
2. Install a new valve stem seal (Figure 41). Place the spring in position over the valve and install the valve spring retainer and sleeve. Compress the valve spring and install the valve spring retainer locks. Remove the compressor tool and stud nut.
3. Turn off the air and remove the air line and adapter. Install the spark plug and connect the spark plug wire.
4. Lubricate the push rod ends with Lubriplate or equivalent and install the push rod. Apply Lubriplate or equivalent to the tip of the valve stem. Install the exhaust valve stem cap.
5. Apply Lubriplate or equivalent to the rocker arms and fulcrum seats. Inspect the stud nuts for conditions shown in Figure 37. Install the valve rocker arms, fulcrum seats and stud nuts.
6. Clean and install the rocker arm cover.

INTAKE MANIFOLD

The intake manifold assembly is shown in Figure 42.

Removal

1. Drain cooling system. Remove flame arrestor, including the crankcase ventilation hose.
2. Disconnect the throttle cable and choke wires from the carburetor.
3. Disconnect the high-tension lead and wires from the coil, temperature & oil sender.
4. Disconnect the spark plug wires from the spark plugs by grasping, twisting and pulling the moulded cap using Tool No. T68P-6666-A. Remove the wires from the harness brackets on the valve rocker arm covers. Remove the distributor cap and spark plug wires as an assembly.
5. Remove the carburetor fuel inlet line.
6. Remove the distributor hold down bolt and remove the distributor.
7. Disconnect the hose's from the coolant outlet housing.
8. Loosen the clamp on the water pump by-pass hose at the coolant outlet housing and slide the hose off the outlet housing.
9. Disconnect the crankcase vent hose at the valve rocker arm cover.
10. Remove the intake manifold and carburetor as an assembly. **It may be necessary to pry the intake manifold away from the cylinder heads. Remove the intake manifold gaskets and seals. Discard the intake manifold attaching bolt sealing washers.**
11. If the manifold assembly is to be disassembled, remove the coolant outlet housing gasket and thermostat. Remove the carburetor, spacer, gasket, and other stems no supplied with a new manifold.

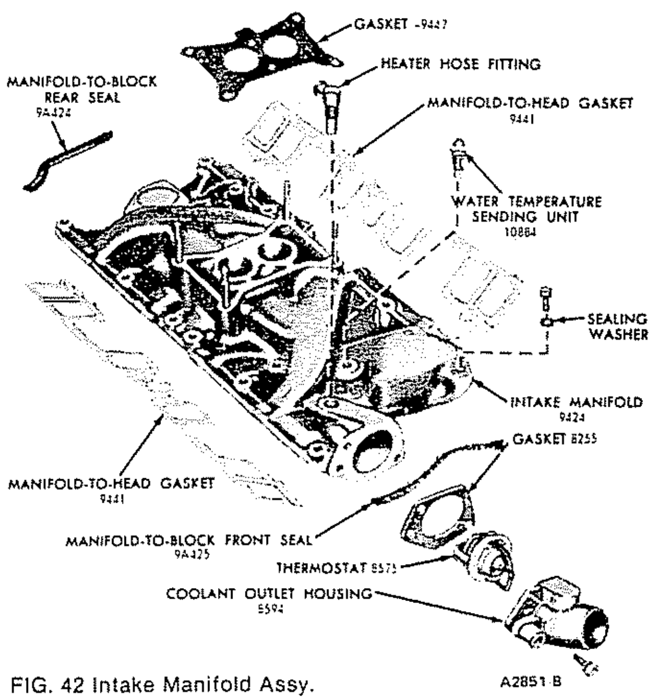


FIG. 42 Intake Manifold Assy.

Installation

1. If intake manifold assembly was disassembled, install the temperature sending unit (threads coated with electrical conductive sealer), ignition and coil, carburetor, spacer, gaskets. Install the coolant outlet housing and other removed components
2. Clean the mating surfaces of the intake manifold, cylinder heads and cylinder block using a solvent such as Ford Spot Remover

(B7A-19521-A) or equivalent. Apply a 1/8 inch bead of RTV sealer, (C3AZ-19526-A or B) at the points shown in Figure 43.

3. Apply a 1/16 inch bead of RTV sealer to the outer end of each intake manifold seal for the full width of the seal (4 places). See Figure 43.

NOTE: This sealer sets-up in 15 minutes, so it is important that assembly be completed promptly. Do not drip any sealer into the engine valley. Position the seals on the cylinder block and new gaskets on the cylinder heads with the gaskets interlocked with the seal tabs. Be sure the holes in the gaskets are aligned with the holes in the cylinder heads.

4. Carefully lower intake manifold into position on the cylinder block and cylinder heads. **After the intake manifold is in place, run a finger around the seal area to make sure the seals are in place. If the seals are not in place, remove the intake manifold and position the seals.**
5. Be sure the holes in the manifold gaskets and manifold are in alignment. Install the intake manifold attaching nuts and bolts. Tighten the nuts and bolts in two steps (Figure 44 or Figure 15). Tighten all nuts and bolts in sequence to specifications.

After completing the remaining assembly steps, operate the engine until it reaches normal operating temperature, then retighten the manifold nuts and bolts in sequence to specifications.

6. Install water pump by-pass hose on the coolant outlet housing. Slide the clamp into position and tighten the clamp.
7. Connect the upper hose's
8. Install the carburetor fuel inlet line.
9. Rotate the crankshaft damper until the No. 1 piston is on TDC at the end of the compression stroke. Position the distributor in the block with the rotor at the No. 1 firing position and the points just open. Install the holddown clamp.
10. Install the distributor cap. Position the spark plug wires in the harness brackets on the valve rocker arm covers and connect the wires to the plugs.
11. Connect crankcase vent hose. Connect the high-tension lead and coil wires.
12. Connect the accelerator cable. Connect the choke wires
13. Fill and bleed the cooling system if fresh water system.
14. Start the engine and check and adjust the ignition timing
15. Operate the engine at fast idle and check all hose connections and gaskets for leaks. Operate the engine until engine temperatures have stabilized and adjust the engine idle speed and idle fuel mixture. Retighten the intake manifold bolts to specifications.

VALVE LIFTER

Before replacing a hydraulic valve lifter for noisy operation, be sure the noise is not caused by improperly adjusted valve to rocker arm clearance or by worn rocker arms or push rods.

Removal

1. Remove the intake manifold and related parts following procedures given in Intake Manifold Removal.
2. Remove the valve rocker arm cover, then loosen the valve rocker arm stud nut and rotate the rocker arms to the side.
3. Remove the valve push rods in sequence so that they can be installed in their original positions.

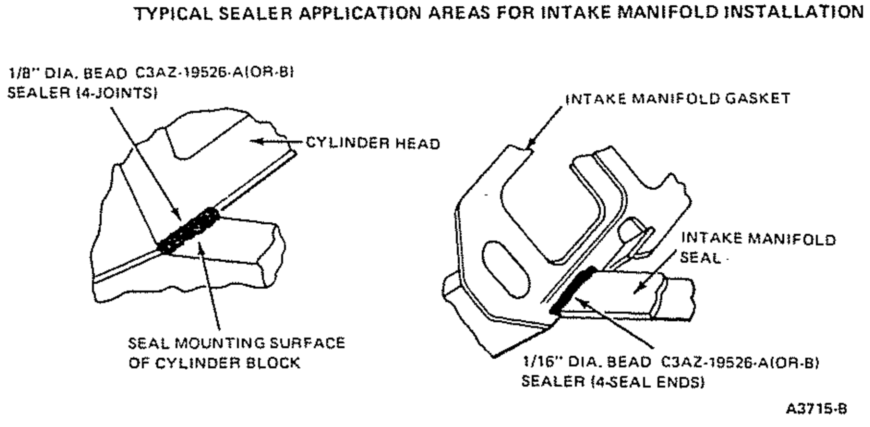


FIG. 43 RTV Sealer Installation Intake Manifold

4. Using Tool T70L-6500-A shown in Figure 46, remove the valve lifters and place them in a rack so that they can be installed in their original bores.
   If necessary to disassemble a lifter, refer to Valve Lifter Disassembly and Assembly in this Part.

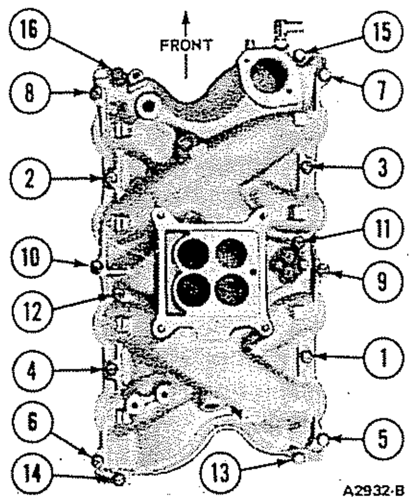


FIG. 45-A Intake Manifold Torque Sequence 460 Engine

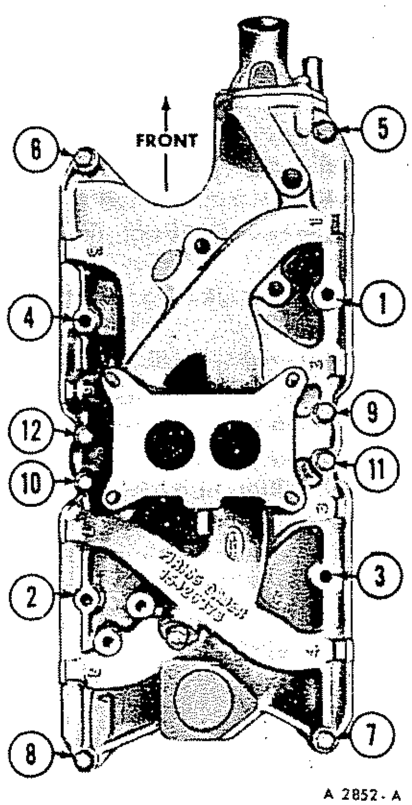


FIG. 44 Intake Manifold Bolts Tightening Sequence—302 CID Engine

Installation

Valve lifters and bores are to be lubricated with heavy engine oil SE before installation.

1. Clean the external surfaces and install the valve lifters in the bores from which they were removed, using Tool T70L-6500-A. If a new lifter(s) is being installed, check the new lifter(s) for a free fit in the bore in which it is to be installed. Lubricate the lifter(s) and bore(s) with heavy engine oil before inserting the lifter.
2. Lubricate the ends of the push rods with Lubriplate or equivalent and install the push rods in their original positions. Apply Lubriplate or equivalent to the valve stem tip.
3. Lubricate the rocker arms and fulcurm seats with Lubriplate or equivalent and position the rocker arms over the push rods.
4. Install the valve rocker arm covers.
5. Install the intake manifold following instructions given under Intake Manifold Installation.

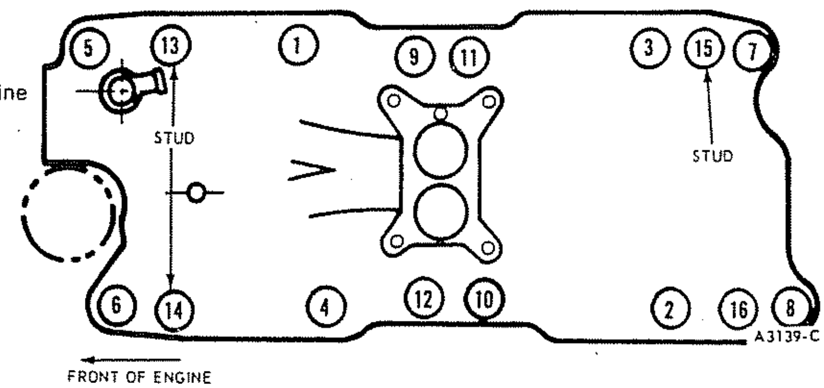


FIG. 45 Intake Manifold Bolt Tightening Sequence—351W Engine

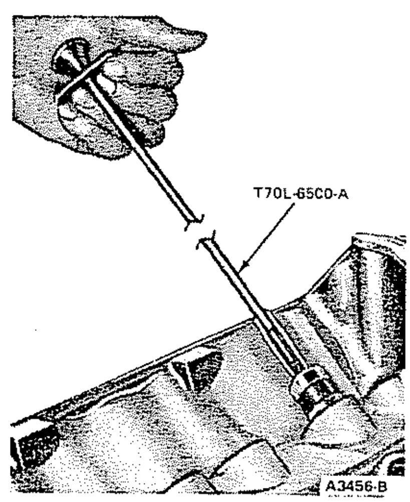


FIG. 46 Removing Valve Lifter

CYLINDER HEADS

If a cylinder head is to be replaced, follow the procedures under Cylinder Head Disassembly and Assembly in this Part, and transfer all valves, springs, spark plugs, etc., to the new cylinder head. Clean and inspect all parts, reface the valves and check all assembly clearances before assembling the new or used parts to the new cylinder head.

Removal

1. Remove the intake manifold and carburetor as an assembly, following the procedure under Intake Manifold Removal.
2. Remove the rocker arm cover(s).
3. Remove exhaust, manifold & other components attached to the heads.
4. Loosen the rocker arm stud nuts so that the rocker arms can be rotated to the side. Remove the push rods in sequence (Figure 47) so that they may be installed in their original positions.
5. On 302 engines, remove the exhaust valve stem caps.
6. Install the cylinder head holding fixtures (Figure 48). Remove the cylinder head attaching bolts and lift the cylinder head off the block. Remove and discard the cylinder head gasket.

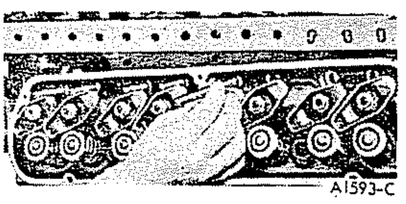


FIG. 47 Removing Valve Push Rods

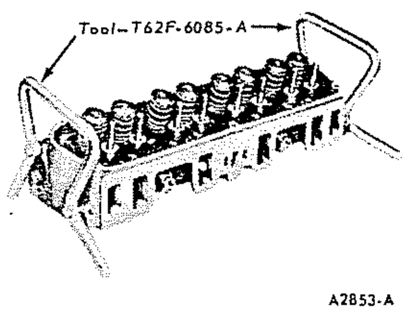


FIG. 48 Cylinder Head Holding Fixtures

Installation

1. Clean the cylinder head, intake manifold, valve rocker arm cover and cylinder head gasket surfaces. If the cylinder head was removed for a cylinder head gasket replacement, check the flatness of the cylinder head and block gasket surfaces.
2. On 302 and 351 V-8 engines, a specially treated composition gasket is used. **Do not apply sealer to a composition gasket. Position the new cylinder head gasket over the cylinder dowels on the block. Position the cylinder head on the block and install the attaching bolts. Remove the holding fixtures.**
3. The cylinder head bolts are tightened in three progressive steps. Tighten all the bolts in sequence (Figure 49) to specifications. When cylinder head bolts have been tightened following this procedure, it is not necessary to retighten the bolts after extended operation. However, the bolts may be checked and retightened if desired.
4. Clean the push rods in a suitable solvent. Blow out the oil passage in the push rod with compressed air. Check the ends of the push rods for nicks, grooves, roughness or excessive wear. Visually check the push rods for straightness or check push rod runout with a dial indicator. If runout exceeds the maximum limit at any point, discard the rod. **Do not attempt to straighten push rods.**
5. Lubricate the end of the push rods with Lubriplate or equivalent and install them in their original positions. Apply Lubriplate or equivalent to the valve stem tips. Install the exhaust valve stem cap on 302 engines.
6. Lubricate the rocker arms and fulcrum seats with Lubriplate or equivalent, then install the rocker arms.
7. Position a new gasket(s) on the exhaust manifolds & install.
8. Install removed components and adjust the drive belt tension to specifications.
9. Clean the valve rocker arm cover and cylinder head gasket surfaces. Place the new gaskets in the covers making sure that the tabs of the gasket engage the notches provided in the cover. Install the valve rocker arm cover(s).
10. Install the intake manifold and related parts, following the procedure under Intake Manifold Installation.

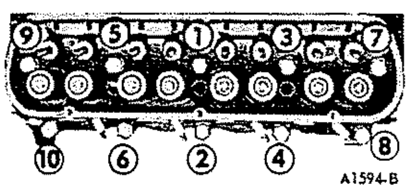


FIG. 49 Cylinder Head Bolt Tightening Sequence

EXHAUST MANIFOLDS

Removal

1. Remove exhaust and cooling hoses from manifold
2. Support exhaust hoses or tie up to prevent water entry
3. Disconnect exhaust manifold(s) from cylinder head.
4. Remove the exhaust manifold.

Installation

1. Clean the mating surfaces of the exhaust manifold(s) and cylinder head(s). Clean the mounting flange of the exhaust manifold(s).
2. Position the exhaust manifold(s) on the cylinder head(s) and install the attaching bolts. Working from the center to the ends, tighten the bolts to specifications.
3. Install and tighten exhaust and cooling hoses.
4. Position the oil dipstick tube bracket on the left exhaust manifold. Install and tighten attaching bolts to specifications.

WATER PUMP

Removal

1. Drain the cooling system.
2. Remove the alternator drive belt.

Remove all accessory brackets which attach to the water pump. Remove water pump pulley.

3. Disconnect the lower hose and water pump bypass hose at the water pump.
4. Remove the bolts that attach the pump to the cylinder front cover.
   Remove the pump and gasket.
   Discard the gasket.

Installation

1. Remove all gasket material from the mounting surfaces of the cylinder front cover and water pump.
2. Position a new gasket, coated on both sides with sealer, on the cylinder front cover; then install the pump.
3. Install the attaching bolts and torque them to specifications.
4. Connect the hose, and water pump bypass hose at the water pump.
5. Install all the accessory brackets which attach to the water pump. Place the water pump pulley on the water pump shaft.
6. Install the alternator and drive belt.
7. Adjust the drive belts to the specified belt tension.
8. Fill and bleed the cooling system. Operate the engine until normal operating temperatures have been reached and check for leaks.

CYLINDER FRONT COVER AND TIMING CHAIN

Removal

1. Refer to Water Pump Removal. Perform all steps except removal of the pump. Leave it attached to the front cover.
2. Drain the crankcase.
3. Remove the crankshaft pulley from the crankshaft vibration damper. Remove the damper attaching screw and washer. Install the puller on the crankshaft vibration damper (Figure 50) and remove the vibration damper.
4. Disconnect the fuel pump outlet line from the fuel pump. Remove the fuel pump attaching bolts and lay the pump to one side with the flexible fuel line still attached.
5. Remove the oil level dipstick if in chain cover.
6. Remove the oil pan to cylinder front cover attaching bolts. Use a thin blade knife to cut the oil pan gasket flush with cylinder block face prior to separating the cover from the cylinder block. Remove the cylinder front cover and water pump as an assembly.

If a new cylinder front cover is to be installed, remove the water pump and dipstick tube from the old cylinder front cover and install them on the new cover.

7. Discard the cylinder front cover gasket. Remove the crankshaft front oil slinger.
8. Check the timing chain deflection.
9. Crank the engine until the timing marks on the sprockets are positioned as shown in Figure 51.
10. Remove the camshaft sprocket cap screw, washers and fuel pump eccentric. Slide both sprockets and the timing chain forward, and remove them as an assembly (Figure 52).

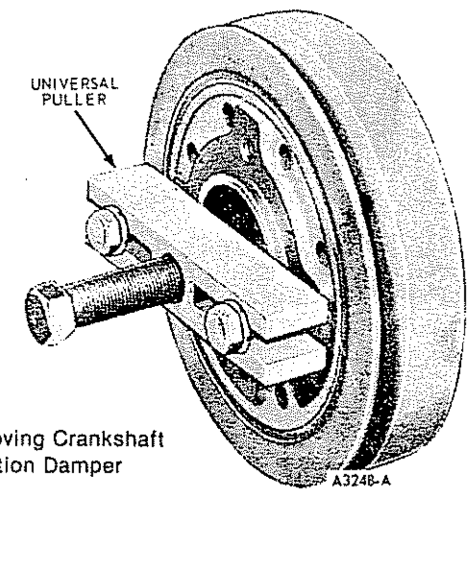


FIG. 50 Removing Crankshaft Vibration Damper

Installation

1. Position the sprockets and timing chain on the camshaft and crankshaft simultaneously (Figure 52). Be sure the timing marks on the sprockets are positioned as shown in Figure 51.
2. Install the fuel pump eccentric, washers and camshaft sprocket cap screw. Torque the sprocket cap screw to specifications. Install the crankshaft front oil slinger (Figure 53).
3. Clean the cylinder front cover, oil pan and the block gasket surfaces.
4. Install a new oil seal in the cylinder front cover following the procedures under Front Oil Seal Removal and Installation.

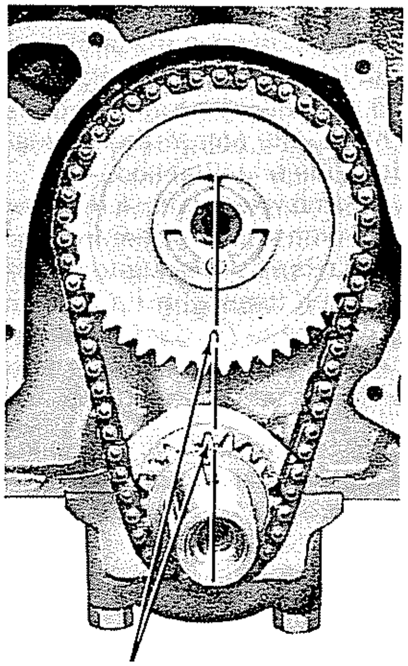


FIG. 51 Aligning Timing Marks

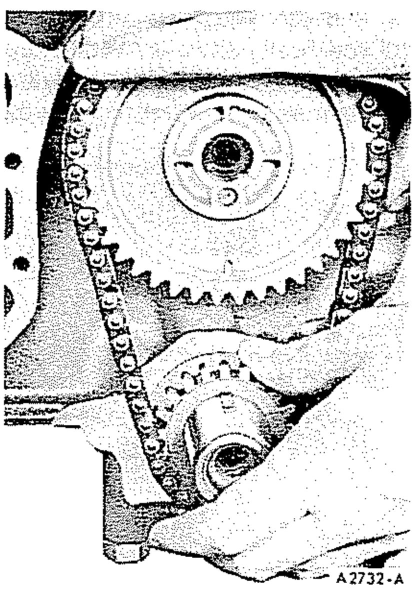


FIG. 52 Removing or Installing Timing Marks

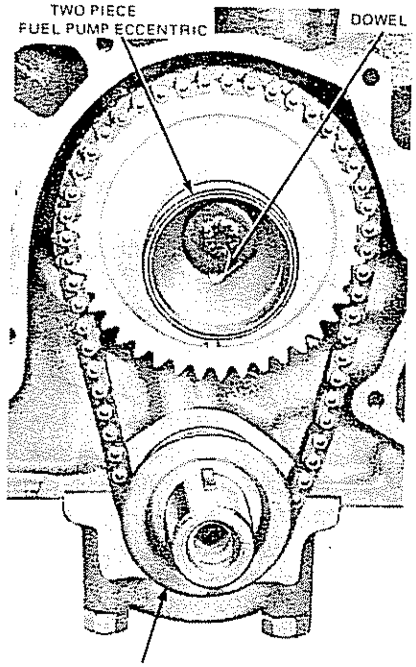


FIG. 53 Fuel Pump Eccentric and Front Oil Slinger Installed

5. Lubricate the timing chain with engine oil.
6. Coat the gasket surface of the oil pan with sealer, cut and position the required sections of a new gasket on the oil pan, apply sealer at the corners. Install pan seal as required.

Coat the gasket surfaces of the block and cover with sealer, and position a new gasket on the block.

7. Position the cylinder front cover on the cylinder block. Use care when installing the cover to avoid seal damage or possible gasket mislocation.
8. Install the cylinder front cover to seal alignment tool into proper position.
9. It may be necessary to force the cover downward to slightly compress the pan gasket. This operation can be facilitated by using a suitable tool at the front attaching hole locations.
10. Coat the threads of the attaching screws with oil resistant sealer and install the screws. While pushing in on the alignment tool, tighten the oil pan to cover attaching screws to specifications (Figure 54). Tighten the cover to block attaching screws to specifications. Remove the pilot.
11. Apply Lubriplate or equivalent to the oil seal rubbing surface of the vibration damper inner hub to prevent damage to the seal. Apply a white lead and oil mixture to the front of the crankshaft for damper installation.

12. Line up the crankshaft vibration damper keyway with the key on the crankshaft. Install the vibration damper on the crankshaft (Figure 55). Seal bolt & washer contact surface and install the cap screw and washer. Tighten the screw to specifications. Install the crankshaft pulley.
13. Install the fuel pump using a new gasket. Connect the fuel pump outlet line.
14. Install the oil level dipstick if used in cover.
15. Refer to Water Pump Installation. Perform all the required steps except installation of the pump.
16. Fill the crankcase with the proper grade and quantity of engine oil.
17. Fill and bleed the cooling system.
18. Operate the engine at fast idle and check for coolant and oil leaks. Check and adjust the ignition timing.

FRONT OIL SEAL

Removal

1. Remove the cylinder front cover following the procedure under Cylinder Front Cover and Timing Chain Removal.
2. Drive out the old seal with the pin punch. Clean out the recess in the cover.

Installation

1. Coat a new seal with grease, then install the seal in the cover. Drive the seal in until it is fully seated in the recess (Figure 56). Check the seal after installation to be sure the spring is properly positioned in the seal.
2. Replace the cylinder front cover following the procedure under Cylinder Front Cover and Timing Chain Installation.

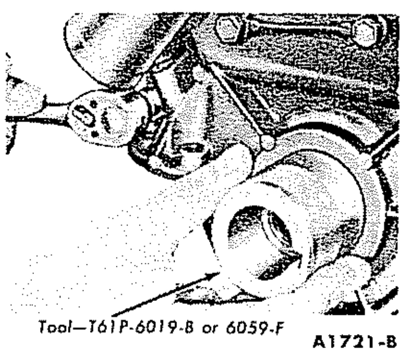


FIG. 54 Aligning Cylinder Front Cover

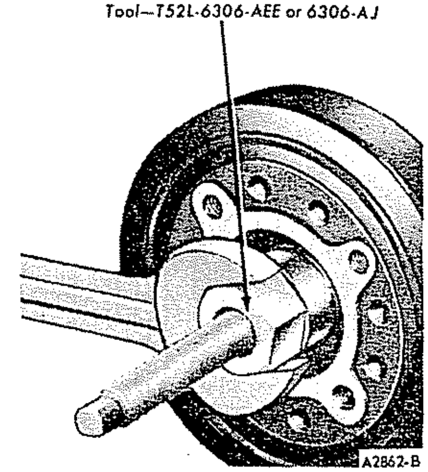


FIG. 55 Installing Crankshaft Vibration Damper

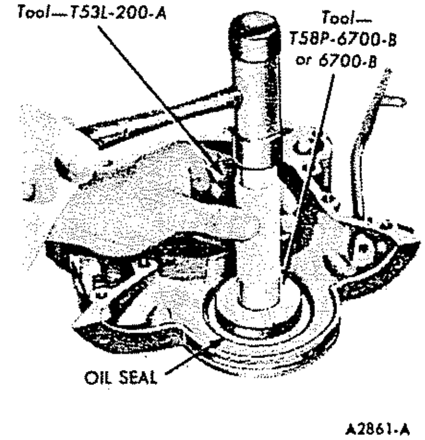


FIG. 56 Installing Crankshaft Front Oil Seal

CORE PLUGS

Removal

To remove a large core plug, drill a 1/2-inch hole in the center of the plug and remove with a clutch pilot bearing puller (Tool T59L-100-B and T58L-101-A) or pry it out with a large drift punch. On a small core plug, drill a ¼-inch hole in the center of the plug and pry it out with a small pin punch. Clean and inspect the plug bore.

Prior to installing a core plug the plug bore should be inspected for any damage that would interfere with the proper sealing of the plug. If the bore is damaged it will be necessary to true the surface by boring for the next specified oversize plug.

Oversize (OS) plugs are identified by the OS stamped in the flat located on the cup side of the plug.

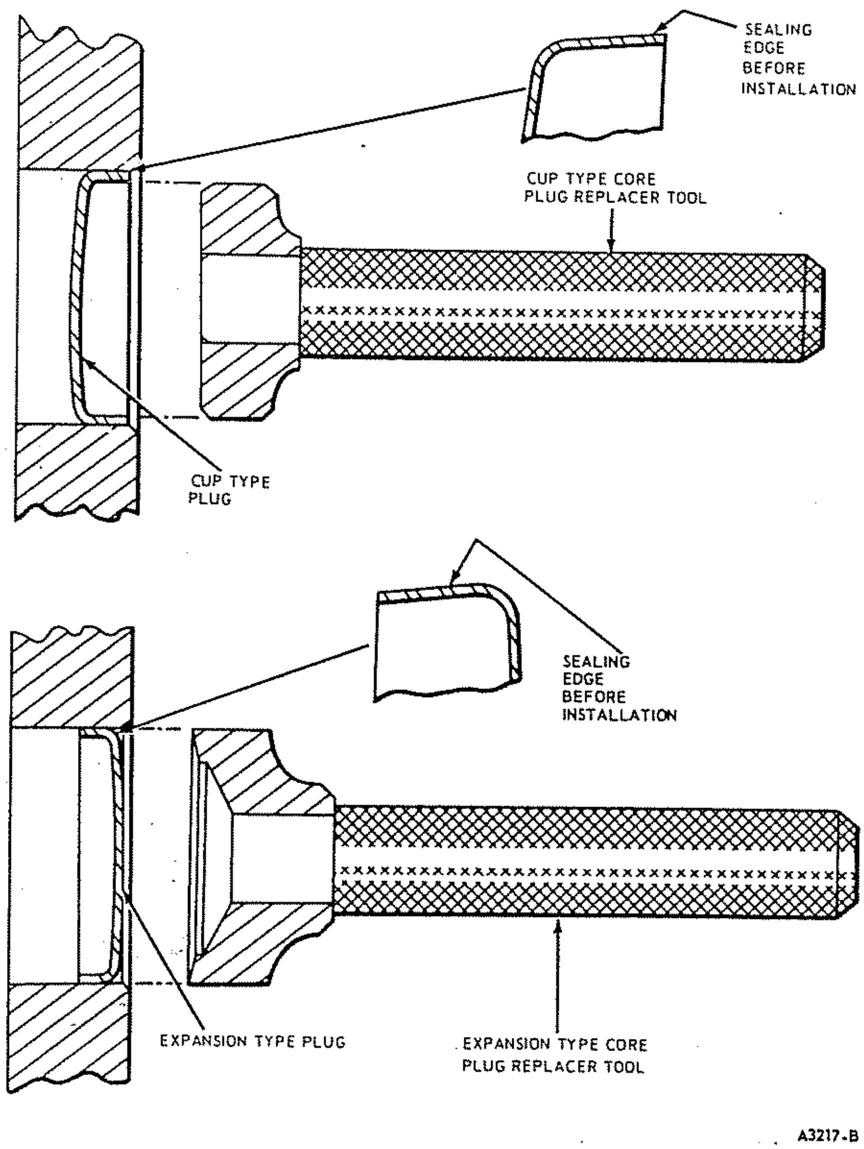


FIG. 57 Typical Core Plugs and Installation Tools

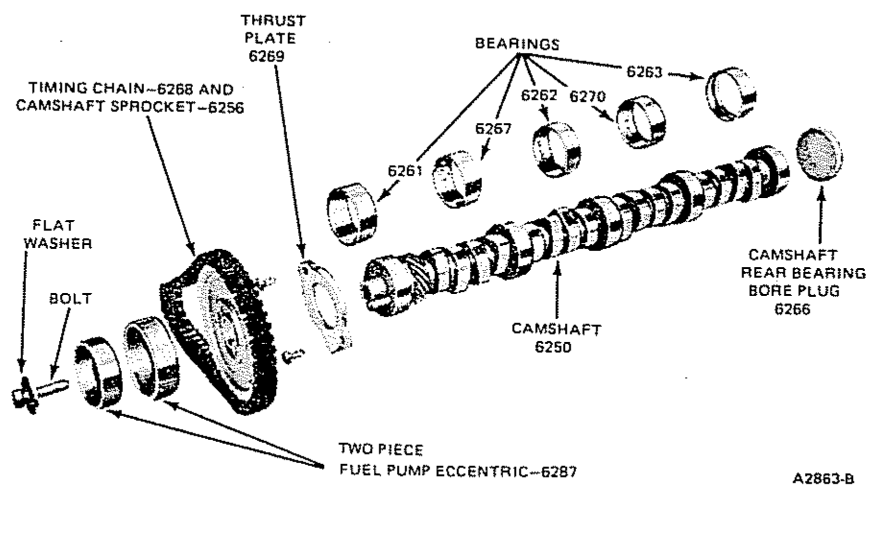


FIG. 58 Camshaft and Related Parts

Coat the plug and/or bore lightly with an oil-resistant (oil galley) or water-resistant (cooling jacket) sealer and install it following the procedure for cup type or expansion type below:

Installation

Cup Type

Cup-type core plugs (Figure 57) are installed with the flanged edge outward. The maximum diameter of this plug is located at the outer edge of the flange. The flange on cup-type plugs flares outward with the largest diameter at the outer (sealing) edge.

It is imperative to install the plug in the machined bore by using a properly designed tool. Under no circumstances is the plug to be driven into the bore using a tool that contacts the flange. This method will damage the sealing edge and will result in leakage and/or plug blow out. The flanged (trailing) edge must be below the chamfered edge of the bore to effectively seal the plug bore. If the core plug replacing tool has a depth seating surface, do not seat the tool against a nonmachined (casting) surface.

Expansion-Type

Expansion-type core plugs (Figure 57) are installed with the flanged edge inward. The maximum diameter of this plug is located at the base of the flange with the flange flaring inward.

It is imperative to push or drive the plug into the machined bore using a properly designed tool. Under no circumstances is the plug to be driven using a tool that contacts the crowned portion of the plug. This method will expand the plug prior to installation and may damage the plug and/or plug bore. When installed, the trailing (maximum) diameter must be below the chamfered edge of the bore to effectively seal the plugged bore. If the core plug replacing tool has a depth seating surface, do not seat the tool against a non-machined (casting) surface.

CAMSHAFT

The camshaft and related parts are shown in Figure 58.

Removal

1. Remove the cylinder front cover and the timing chain following the procedure under Cylinder Front Cover and Timing Chain Removal.
2. Remove the intake manifold and related parts by following procedures under Intake Manifold Removal.
3. Remove the crankcase ventilation valve and tubes from the valve rocker arm covers. Remove the valve rocker arm covers. Loosen the valve rocker arm stud nuts and rotate the rocker arms to the side.
4. Remove the valve push rods and identify them so that they can be installed in their original positions.
5. Using a magnet, remove the valve lifters and place them in a rack so that they can be installed in their original bores (Figure 46).

If necessary to disassemble a lifter, refer to Valve Lifter Disassembly and Assembly.

If the valve lifters are stuck in their bores by excessive varnish, etc., it may be necessary to use a plier-type tool (T52T-6500-DJD or 6500-D) or a claw type tool to remove the lifters. Rotate the lifter back and forth to loosen it from the gum or varnish that may have formed at the lifter.

6. Remove the camshaft thrust plate. Carefully remove the camshaft by pulling toward the front of the engine. **Use caution to avoid damaging the camshaft bearings.**

Installation

1. Oil the camshaft journals with heavy engine oil SE and apply Lubriplate or equivalent to the lobes. Carefully slide the camshaft through the bearings. Install camshaft thrust plate with groove towards the cylinder block. Check camshaft end play.
2. Lubricate the lifters and bores with heavy engine oil SE. Install the valve lifters in the bores from which they were removed.
3. Apply Lubriplate or equivalent to each end of the push rod and install the push rods in their original positions. Apply Lubriplate or equivalent to the valve stem tips. Lubricate the rocker arms and fulcrum seats with heavy engine oil SE. Position the rocker arms over the push rods.
4. Install the intake manifold and related parts by following procedures under Intake Manifold Installation.
5. Connect the throttle and retracting spring.
6. Position and connect the fuel line.
7. Replace the crankshaft front oil seal following procedures under Front Oil Seal Removal and Installation. Install the timing chain, cylinder front cover and related parts following procedures under Cylinder Front Cover and Timing Chain Installation.
8. With No. 1 piston on TDC at the end of the compression stroke, position the distributor in the block with the rotor at the No. 1 firing position and the points just open. Install the hold down clamp.

9. If any valve train components have been replaced, perform a Valve Clearance Adjustment as outlined under Hydraulic Valve Lifters.
10. Clean the valve rocker arm covers and the cylinder head gasket surface. Position the valve rocker cover gasket in each cover, making sure that the tabs engage the notches in the cover.
11. Position the covers on the cylinder heads. Make sure the gasket seats evenly all around the head. Install the bolts. The cover is tightened in two steps. Torque the bolts to specifications. Two minutes later, torque the bolts to the same specifications.
12. Clean and install the crankcase ventilation system.
13. Install the distributor cap. Position the spark plug wires in the harness brackets on the valve rocker arm covers and connect the wires to the plugs. Connect the high tension lead at the coil.
14. Fill and bleed the cooling system. Fill the crankcase with the proper grade and quantity of engine oil.
15. Start the engine and check and adjust the ignition timing.
16. Operate the engine at fast idle and check all hoses connections and gaskets for leaks. When the engine temperature has stabilized adjust the engine idle speed and idle fuel mixture. Retorque intake manifold bolts and nuts.

CAMSHAFT REAR BEARING BORE PLUG

Removal

1. Remove the transmission, clutch drive plate.
2. Remove the flywheel attaching bolts and remove the flywheel. Remove the engine rear cover plate.
3. Remove the bore plug.

Installation

1. Install the bore plug.
2. Coat the flywheel attaching bolts with oil-resistant sealer. Position the engine rear cover plate on the cylinder block dowels. Position the flywheel on the crankshaft flange. Install and torque the attaching bolts in sequence across from each other to specifications.

Install the clutch drive plate, and the transmission.

OIL PAN

Removal

1. Disconnect the battery ground cable.
2. Drain the crankcase.
3. Remove the oil pan attaching bolts and remove the pan.
4. Refer to cleaning and inspection procedures. Check the gasket surface for damage caused by over-tightened bolts. Straighten the surface as required to restore original flatness

Installation

1. Clean the gasket surfaces of the block and oil pan. Coat the block surface and the oil pan gasket surface with oil-resistant sealer. Position the oil pan gaskets on the cylinder block.
2. Position the oil pan front seal on the cylinder front cover. **Be sure that the tabs on the seal are over the oil pan gasket.**
3. Position the oil pan rear seal on the rear main bearing cap. **Be sure that the tabs on the seal are over the oil pan gasket.**
4. Hold the oil pan in place against the block and install a bolt, finger tight, on each side of the oil pan. Install the remaining bolts. Tighten the bolts from the center outward in each direction to specifications.
5. Install a new oil filter.
6. Connect the battery ground cable.
7. Fill the crankcase. Start the engine and check for leaks.

OIL PUMP

Removal

1. Remove the oil pan and related parts as outlined under Oil Pan Removal.
2. Remove the oil pump inlet tube and screen assembly.
3. Remove the oil pump attaching bolts (Figure 59), and remove the oil pump gasket and intermediate drive shaft.

Installation

1. Prime the oil pump by the inlet port with engine oil. Rotate the pump shaft to distribute the oil within the pump body.
2. Position the intermediate drive shaft into the distributor socket. With the shaft firmly seated in the distributor socket, the stop on the shaft should touch the roof of the crankcase. Remove the shaft and position the stop as necessary.
3. With the stop properly positioned, insert the intermediate drive shaft into the oil pump. Install the pump and shaft as an assembly. **Do not attempt to force the pump into position if**

it will not seat readily. The drive shaft hex may be misaligned with the distributor shaft. To align, rotate the intermediate drive shaft into a new position. Tighten the oil pump attaching screws to specifications.

4. Clean and install the oil pump inlet tube and screen assembly.
5. Install the oil pan and related parts.

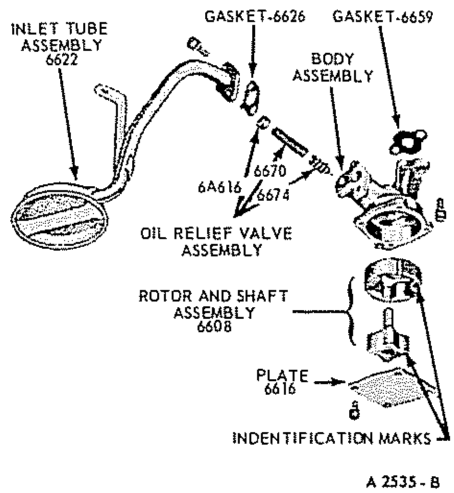


FIG. 59 Oil Pump and Inlet Tube Installed

CRANKSHAFT REAR OIL SEAL

Replacement of a crankshaft rear oil seal to correct for oil leaks requires replacement of both the upper and lower seals, as follows:

Removal

1. Remove the oil pan and oil pump.
2. Loosen all the main bearing cap bolts, thereby lowering the crankshaft slightly but not to exceed 1/32 inch.
3. Remove the rear main bearing cap, and remove the oil seal from the bearing cap and cylinder block. On the block half of the seal, install a small metal screw in one end of the seal and pull on the screw to remove the seal. **Exercise caution to prevent scratching or damaging the crankshaft seal surfaces.**

Installation

1. Carefully clean the seal grooves in the cap and block with a brush and solvent.
2. Dip the seal halves in clean engine oil.
3. Carefully install the upper seal (cylinder block) into its groove with the lip of seal toward the FRONT of the engine (Figure 60) by rotating it on the seal journal of the crankshaft until the seal protrudes approximately 1/8 inch below the parting surface. **Be sure no rubber has been shaved from the outside diameter of the seal by the bottom edge of the groove.**
4. Tighten the remaining bearing cap bolts and torque to specifications.
5. Install the lower seal in the rear main bearing cap with undercut side of seal toward the FRONT of the engine (Figure 60). Allow the seal to protrude approximately 1/8 inch above the parting surface to mate with the upper seal when the cap is installed.
6. Apply a thin coating of oil-resistant sealer to the rear main bearing cap at the rear of the top mating surface. **Do not apply sealer to the area forward of the side seal groove. Install the rear main bearing cap. Torque the cap bolts to specifications.**
7. Install the oil pump and oil pan. Install the oil level dipstick. Fill the crankcase with the proper amount and viscosity oil. Install the spark plugs.
8. Operate the engine and check for oil leaks.

MAIN BEARING

The main bearing inserts are selective fit. Refer to the procedures under Fitting Main and Connecting Rod Bearings.

Removal

1. Drain the crankcase. Remove the oil level dipstick. Remove the oil pan and related parts, following the procedure under Oil Pan Removal in this section.
2. Remove the oil pump inlet tube assembly and the oil pump.
3. Replace one bearing at a time, leaving the other bearings securely fastened. Remove the main bearing cap to which new bearings are to be installed.
4. Insert the upper bearing removal tool (Tool 6331) in the oil hole in the crankshaft.
5. Rotate the crankshaft in the direction of engine rotation to force the bearing out of the block.
6. Clean the crankshaft journal. Inspect journals and thrust faces (thrust bearing) for nicks, burrs or bearing pick-up that would cause premature bearing wear.
7. If the rear main bearing is being replaced, remove and discard the rear oil seal from the bearing cap.
8. Remove the block half of the rear oil seal following the procedures given under Crankshaft Rear Oil Seal Removal.

Installation

1. If the rear main bearing is being replaced, clean the rear oil seal groove in the block with a brush and solvent.

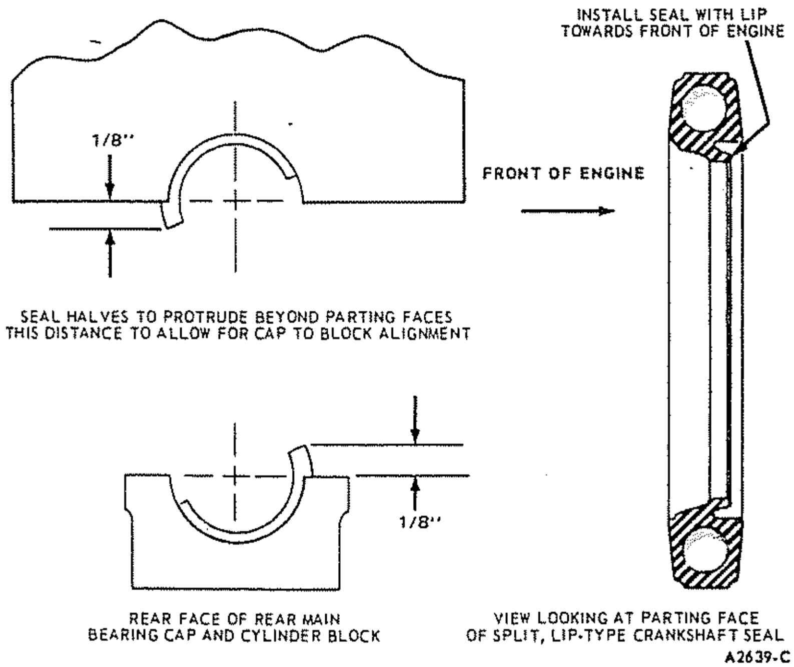


FIG. 60 Installing Crankshaft Rear Seal

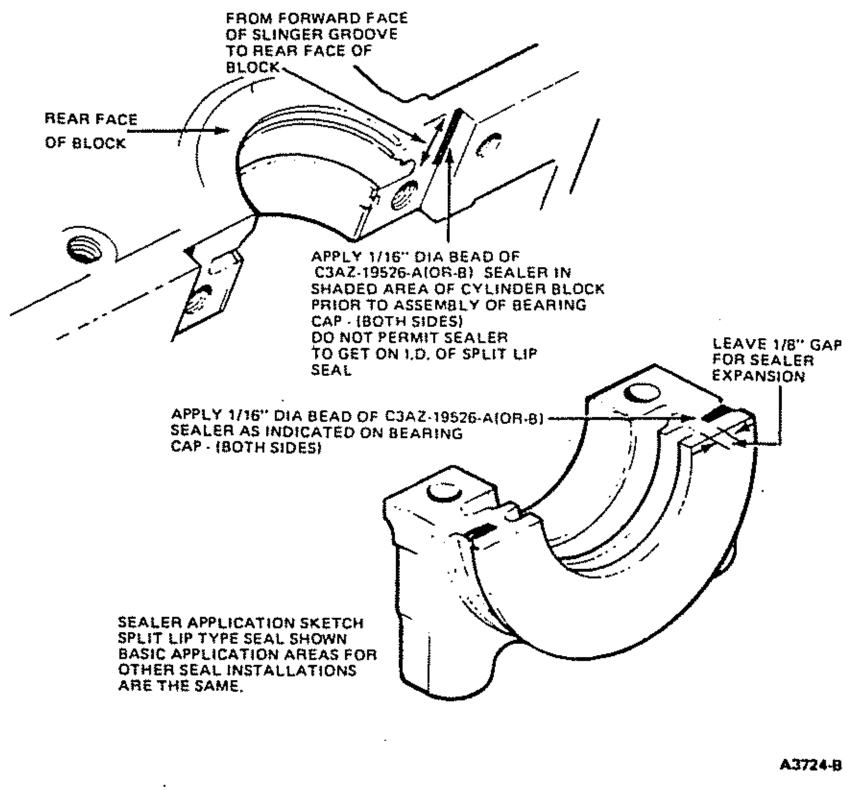


FIG. 61 Applying RTV Sealer to Main Bearing Cap and Block—
Typical for 6 and 8-Cylinder Engines

2. Install the block half of the rear oil seal following the procedure given under Crankshaft Rear Oil Seal Installation.
3. To install an upper main bearing, place the plain end of the bearing over the shaft on the locking tang side of the block and partially install the bearing so that Tool 6331 can be inserted in the oil hole in the crankshaft. With Tool 6331 positioned in the oil hole in the crankshaft, rotate the crankshaft in the opposite direction of engine rotation until the bearing seats itself. Remove the tool.
4. Install the bearing cap.
5. Select fit the bearing for proper clearance, following the procedures under Fitting Main and Connecting Rod Bearings in Part 21-01.
6. If the bearing is being replaced on journal number 1, 2 or 4, apply a coat of heavy engine oil SE to the journal and bearings and install the bearing cap. Tighten the cap bolts to specifications.
7. If the rear main bearing is to be replaced, remove the rear main oil seal retaining pin from the lower bearing cap seal groove. The pin is not used with the split, lip-type seal. Clean the oil seal groove with a brush and solvent.
8. Install the lower seal in the rear main bearing cap with the undercut side of the seal toward the FRONT of the engine. Allow the seal to protrude approximately 1/8 inch above the parting surface to mate with the upper seal when the cap is installed.
9. Apply RTV sealer to the rear main bearing cap as shown in Figure 61. Lubricate the journal with heavy engine oil SE and install the rear main bearing cap. Tighten the cap bolts to specifications.
10. If the thrust bearing cap (No. 3 main bearing) has been removed, install it as follows:

Lubricate the journal with heavy engine oil SE and install the thrust bearing cap with the bolts finger tight. Pry the crankshaft forward against the thrust surface of the upper half of the bearing. Hold the crankshaft cap to the rear. This will align the thrust surfaces of both halves of the bearing. Retain the forward pressure on the crankshaft. Tighten the cap bolts to specifications (Figure 62).

11. Clean the oil pump inlet tube screen. Prime the oil pump by filling the inlet opening with oil and rotating the pump shaft until oil emerges from the outlet opening. Install the oil pump and inlet tube assembly.
12. Position the oil pan gaskets on the oil pan. Position the oil pan front seal on the cylinder front cover. Position the oil pan rear seal on the rear main bearing cap. Install the oil pan and related parts, following the procedure under Oil Pan Installation in this section. Install the oil level dipstick.
13. Fill the crankcase. Start the engine and check for oil pressure. Operate the engine at fast idle and check for oil leaks.

CONNECTING ROD BEARINGS

The connecting rod bearings are selective fit. Refer to the procedures under Fitting Main and Connecting Rod Bearings.

Removal

1. Drain the crankcase. Remove the oil level dipstick. Remove the oil pan and related parts, following the procedure under Oil Pan Removal.
2. Remove the oil pump inlet tube assembly and the oil pump.
3. Turn the crankshaft until the connecting rod to which new bearings are to be fitted is down. Remove the connecting rod cap. Remove the bearing inserts from the rod and cap.

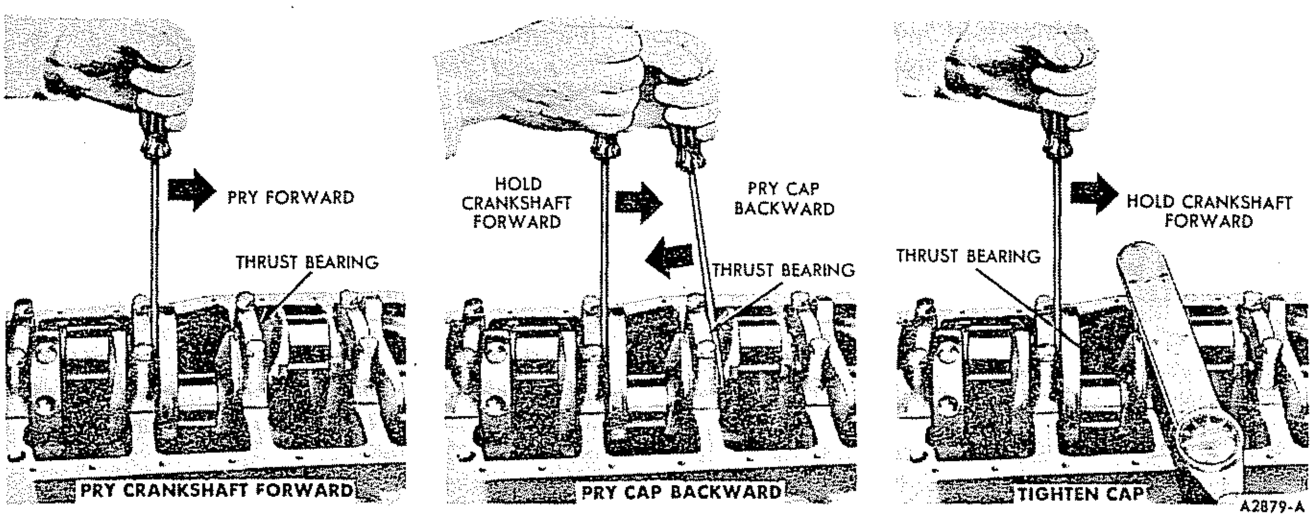


FIG. 62 Aligning Thrust Bearing

Installation

1. Be sure the bearing inserts and the bearing bore in the connecting rod and cap are clean. Foreign material under the inserts will distort the bearing and cause a failure.
2. Clean the crankshaft journal.
3. Install the bearing inserts in the connecting rod and cap with the tangs fitting in the slots provided.
4. Pull the connecting rod assembly down firmly on the crankshaft journal.
5. Select fit the bearing, following procedures under Fitting Main and Connecting Rod Bearings.
6. After the bearing has been fitted, clean and apply a coat of heavy engine oil SE to the journal and bearings. Install the connecting rod cap. Tighten the nuts to specifications.
7. Repeat the procedure for the remaining connecting rods that require new bearings.
8. Clean the oil pump inlet tube screen. Prime the oil pump by filling the inlet opening with oil and rotating the pump shaft until oil emerges from the outlet opening. Install the oil pump and inlet tube assembly.
9. Position the oil pan gaskets on the oil pan. Position the oil pan front seal on the cylinder front cover. Position the oil pan rear seal on the rear main bearing cap. Install the oil pan and related parts, following the procedure under Oil Pan Installation in this section. Install the oil level dipstick.
10. Fill the crankcase. Start the engine and check for oil pressure. Operate the engine at fast idle and check for oil leaks.

PISTONS AND CONNECTING RODS

Removal

1. Drain the cooling system and crankcase. Remove the intake manifold, cylinder heads, oil pan and oil pump, following the procedures in this section.
2. Remove any ridges and/or deposits from the upper end of cylinder bores as follows:

Turn the crankshaft until the piston to be removed is at the bottom of its travel, then place a cloth on the piston head to collect the cuttings. Remove the cylinder ridge with a ridge cutter. Follow instructions furnished by tool manufacturer. **Never cut into ring travel area in excess of 1/32 inch when removing ridges.**

3. Make sure all connecting rod caps are marked so they can be installed in their original positions.
4. Turn the crankshaft until the connecting rod being removed is down.
5. Remove the connecting rod nuts and cap.
6. Push the connecting rod and piston assembly out the top of the cylinder with the handle end of a hammer. **Avoid damage to the crankshaft journal or the cylinder wall when removing the piston and rod.**
7. Remove the bearing inserts from the connecting rod and cap.
8. Install the cap on the connecting rod from which it was removed.

Installation

1. If new piston rings are to be installed, remove the cylinder wall glaze. Follow the instructions of the tool manufacturer.
2. Oil the piston rings, pistons and cylinder walls with heavy engine oil. **Be sure to install pistons in the same cylinders from which they were removed or to which they were fitted.** Connecting rod and bearing caps are numbered from 1 to 4 in the right bank and from 5 to 8 in the left bank, beginning at the front of the engine. The numbers on the connecting rod and bearing cap must be on the same side when installed in the cylinder bore. If a connecting rod is ever transferred from one block or cylinder to another, new bearings should be fitted and the connecting rod should be numbered to correspond with the new cylinder number.

When installing the piston and connecting rod assembly, the largest chamfer at the bearing end of the rod should be positioned towards the crank pin thrust face of the crankshaft.

3. Make sure that ring gaps are properly spaced around circumference of piston (Figure 63).
4. Install piston ring compressor on the piston and push the piston in with hammer handle until it is slightly below top of the cylinder (Figure 64). Be sure to guide connecting rods to avoid damaging the crankshaft journals. Install the piston with indentation notch in piston head toward the front of the engine.
5. Check the clearance of each bearing, following the procedure under Fitting Main and Connecting Rod Bearings.
6. After the bearings have been fitted, apply a light coat of engine oil to the journals and bearings.
7. Turn the crankshaft throw to the bottom of its stroke. Push the piston all the way down until the connecting rod bearing seats on the crankshaft journal.
8. Install the connecting rod cap. Tighten the nuts to specifications.

9. After the piston and connecting rod assemblies have been installed, check the side clearance between the connecting rods on each shaft journal (Figure 65).
10. Disassemble, clean and assemble the oil pump. Clean the oil pump inlet tube screen, and oil pan and block gasket surfaces.
11. Prime the oil pump by filling the inlet port with engine oil and rotating the pump shaft to distribute oil within the housing. Install the oil pump and the oil pan, following the procedure under Oil Pan Installation in this section.
12. Install the cylinder heads, following the steps under Cylinder Head Installation.
13. Install the intake manifold, following the steps under Intake Manifold Installation.
14. Fill and bleed the cooling system. Fill the crankcase with the proper grade and quantity of engine oil.
15. Start the engine, then check and adjust the ignition timing.
16. Operate the engine at fast idle and check for oil and coolant leaks. Operate the engine until engine temperatures have stabilized, then adjust the engine idle speed and idle fuel mixture.

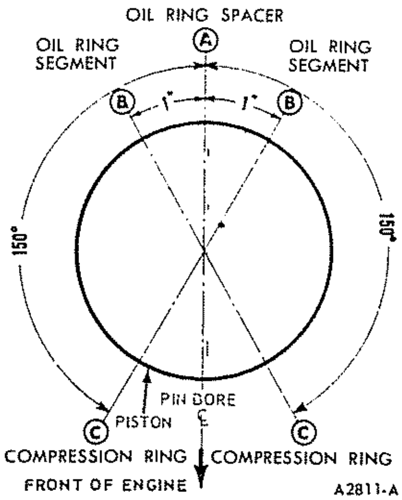


FIG. 63 Piston Ring Spacing

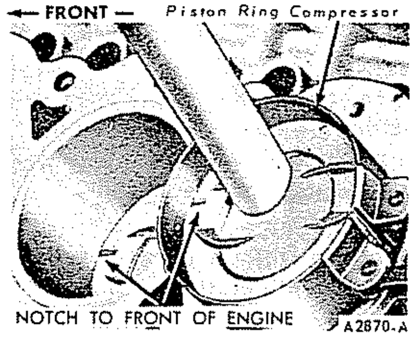


FIG. 64 Installing Piston

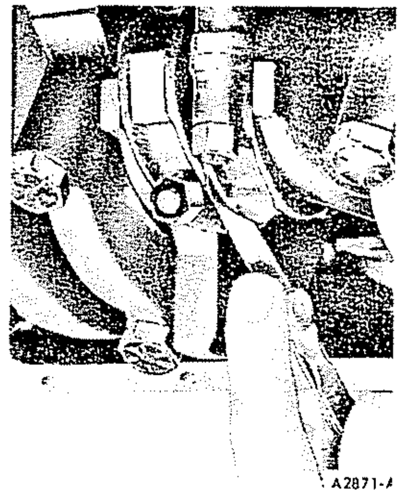


FIG. 65 Checking Connecting Rod Side Clearance

CRANKSHAFT

The crankshaft and related parts are shown in Figure 66.

Removal

1. With the engine placed in a work stand, drain oil disconnect the spark plug wires at the spark plugs by hand only and remove the wires from the ignition harness brackets on the valve rocker arm covers. Disconnect the coil to distributor high-tension lead at the coil. Remove the distributor cap and spark plug wires as an assembly. Remove the spark plugs to allow easy rotation of the crankshaft.
2. Remove the fuel pump and the oil filter. Slide the water pump by-pass hose clamp toward the water pump. Remove the alternator and mounting brackets.
3. Remove the crankshaft pulley from the crankshaft vibration damper. Remove the capscrew and washer from the end of the crankshaft. Install the puller on the crankshaft vibration damper (Figure 50) and remove the damper.
4. Remove the cylinder front cover and water pump as an assembly.
5. Remove the crankshaft front oil slinger. Check the timing chain deflection, then remove the timing chain and sprockets by following steps under Cylinder Front Cover and Timing Chain Removal.
6. Invert the engine on a work stand. Remove the flywheel and engine rear cover plate. Remove the oil pan and gasket. Remove the oil pump.
7. **Make sure all bearing caps (main and connecting rod) are marked so that they can be installed in their original locations.** Turn the

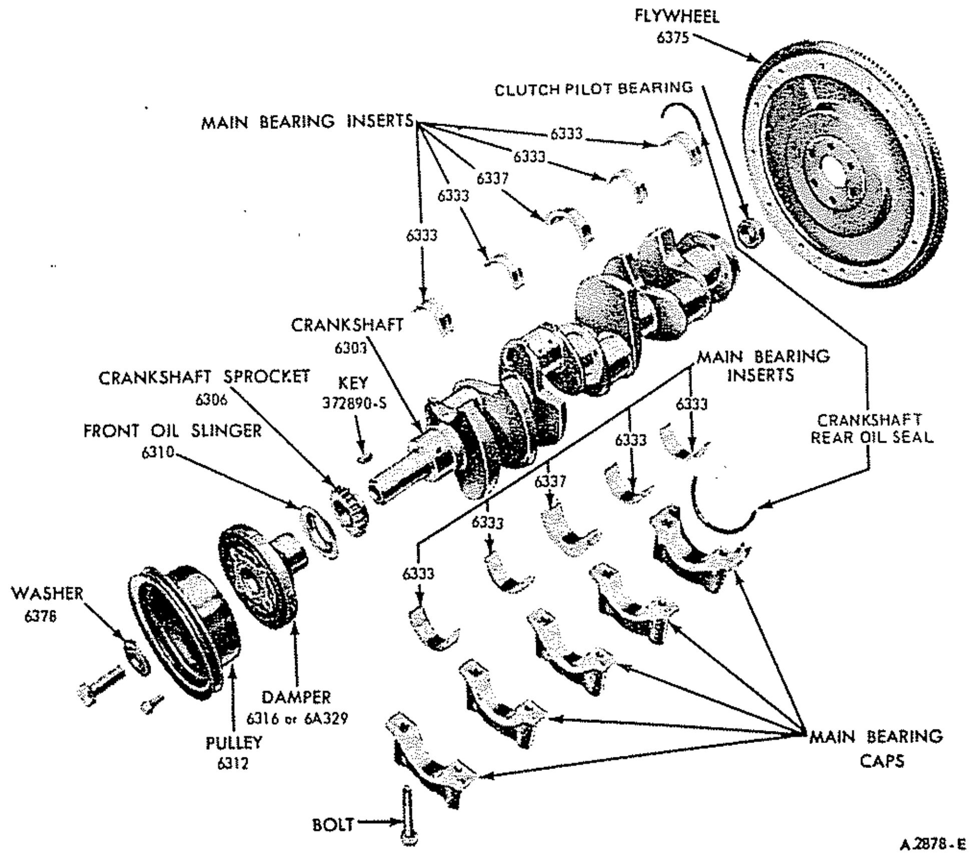


FIG. 66 Crankshaft and Related Parts

crankshaft until the connecting rod from which the cap is being removed is down, then remove the bearing cap. Push the connecting rod and piston assembly up into the cylinder. Repeat this procedure until all connecting rod bearing caps are removed.

8. Remove the main bearing caps.
9. Carefully lift the crankshaft out of the block so that the thrust bearing surfaces are not damaged. **Handle the crankshaft with care to avoid possible fracture or damage to finished surfaces.** Refer to cleaning and inspection sections for cleaning and inspection instructions.

Installation

1. Remove rear journal oil seal from the block and rear main bearing cap.
2. Remove the main bearing inserts from the block and bearing caps.
3. Remove the connecting rod bearing inserts from the connecting rods and caps.
4. If the crankshaft main bearing journals have been refinished to a definite undersize, install the correct undersize bearings. Be sure the bearing inserts and bearing bores are clean. Foreign material under inserts will distort the bearing and cause failure.
5. Place the upper main bearing inserts in position in bores with tang fitting in the slot provided.
6. Install lower main bearing inserts in the bearing caps.
7. Clean the rear journal oil seal groove and the mating surfaces of the block and rear main bearing cap with Ford Spot Remover (B7A-19521-A). Remove the rear oil seal retainer pin from the rear main bearing cap seal groove. The pin is not used with the split, lip-type seal.
8. Dip the lip-type seal halves in clean engine oil. Install the seals in the bearing cap and block with the undercut side of the seal toward the FRONT of the engine.
9. Carefully lower the crankshaft into place. **Be careful not to damage the bearing surfaces.**
10. Check the clearance of each main bearing by following the procedure under Fitting Main and Connecting Rod Bearings.
11. After the bearings have been fitted, check for special instructions in applying RTV sealer to the rear main bearing cap.
12. Apply heavy engine oil SE to the journals and bearings.
13. Install all the bearing caps, except the thrust bearing cap (No. 3 bearing). **Be sure that the**

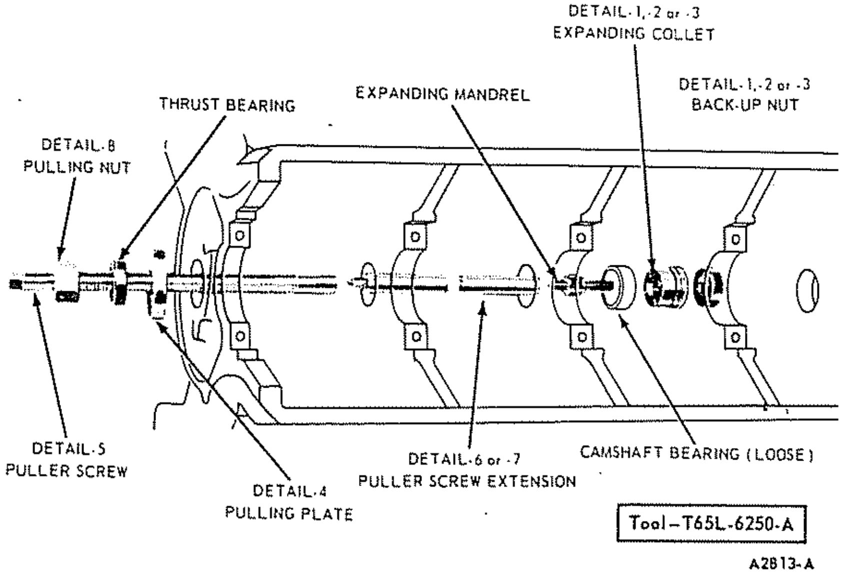


FIG. 67 Camshaft Bearing Replacement

main bearing caps are installed in their original locations. Tighten the bearing cap bolts to specifications.

14. Install the thrust bearing cap with the bolts finger-tight.
15. Pry the crankshaft forward against the thrust surface of the upper half of the bearing.
16. Hold the crankshaft forward and pry the thrust bearing cap to the rear. This will align the thrust surfaces of both halves of the bearing.
17. Retain the forward pressure on the crankshaft. Tighten the cap bolts to specification.
18. Force the crankshaft toward the rear of the engine.
19. Check the crankshaft end play.
20. Install new bearing inserts in the connecting rods and caps. Check the clearance of each bearing, following the procedure under Fitting Main and Connecting Rod Bearings.
21. After the connecting rod bearings have been fitted, apply a light coat of engine oil SE to the journals and bearings.
22. Turn the crankshaft throw to the bottom of its stroke. Push the piston all the way down until the rod bearing seats on the crankshaft journal.
23. Install the connecting rod cap. Tighten the nuts to specifications.
24. After the piston and connecting rod assemblies have been installed, check the side clearance between the connecting rods on each connecting rod crankshaft journal (Figure 65).
25. Install the timing chain and sprockets, cylinder front cover and crankshaft pulley and adapter, following steps under Cylinder Front Cover and Timing Chain Installation.
26. Coat the threads of the flywheel attaching bolts with oil-resistant sealer. Position the flywheel on the crankshaft flange. Install and tighten the bolts to specifications.

Install the drive plate. Tighten the attaching bolts.

27. Clean the oil pan, oil pump and oil pump screen. Prime the oil pump by filling the inlet port with engine oil and rotating the pump shaft to distribute oil within the housing. Install the oil pump and oil pan by following the procedures under Oil Pan and Oil Pump Installation.
28. Install the oil filter, fuel pump and connect the fuel lines. Install the alternator, shield and mounting bracket.
29. Install the spark plugs, distributor cap and spark plug wires. Connect the spark plug wires and high-tension lead.

CAMSHAFT BEARINGS

Camshaft bearings are available prefinished to size for standard and 0.015 inch undersize journal diameters. The bearings are not interchangeable from one bore to another.

Removal

1. Remove the camshaft, flywheel, and crankshaft, following the appropriate procedures in this Section. Push the pistons to the top of the cylinders.
2. Remove the camshaft rear bearing bore plug. Remove camshaft bearings (Figure 67).

3. Select the proper size expanding collet and back-up nut and assemble on the expanding mandrel. With the expanding collet collapsed, install the collet assembly in the camshaft bearing, and tighten the back-up nut on the expanding mandrel until the collet fits the camshaft bearing.
4. Assemble the puller screw and extension (if necessary) as shown and install on the expanding mandrel. Wrap a cloth around the threads of the puller screw to protect the front bearing or journal. Tighten the pulling nut against the thrust bearing and pulling plate to remove the camshaft bearing. Be sure to hold a wrench on the end of the puller screw to prevent it from turning.
5. Repeat the procedure for each bearing. To remove the front bearing, install the puller screw from the rear of the cylinder block.

Installation

1. Select the proper size expanding collet and back-up nut and assemble on expanding mandrel. With the expanding collet collapsed, install the collet in the camshaft bearing and tighten back-up nut on expanding mandrel until collet fits camshaft bearing.
2. Assemble the puller screw and extension (if necessary) as shown in Figure 67 and install on expanding mandrel. Wrap a cloth around threads of the puller screw to protect the front bearing or journal. Tighten pulling nut against the thrust bearing and pulling plate to remove camshaft bearing. Hold a wrench on the end of puller screw to prevent it from turning.
3. Repeat the procedure for each bearing. To remove the front bearing, install puller screw from rear of cylinder block.
4. Position new bearings at bearing bores, and press in place with the tool shown in Figure 67. Be sure to center the pulling plate and puller screw to avoid bearing damage. **Failure to use correct expanding collet can cause severe bearing damage.** Align oil holes in bearings with oil holes in cylinder block before pressing them into block. Be sure front bearing is installed specified distance below front face of cylinder block (Figure 68).
5. Install core plug.
6. Install the camshaft, crankshaft, flywheel and related parts, following appropriate procedures in this part, except do not check connecting rod and main bearing clearances.

OIL FILTER

SPIN-ON TYPE

The spin-on oil filter assembly is shown in Figure 69.

Removal

1. Place a drip pan under the filter.
2. Unscrew the filter from the adapter fitting. Clean the adapter filter recess.

Installation

1. Coat the gasket on a new filter with oil. Place the filter in position on the adapter. Hand tighten the filter until the gasket contacts the adapter face, then advance it ½ turn.

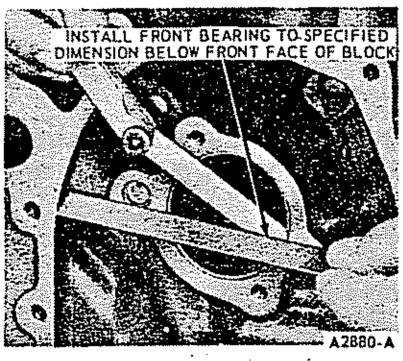


FIG. 68 Camshaft Front Bearing Replacement

2. Operate the engine at fast idle and check for leaks. If oil leaks are evident, perform the necessary repairs to correct the leakage. Check the oil level and fill the crankcase if necessary.

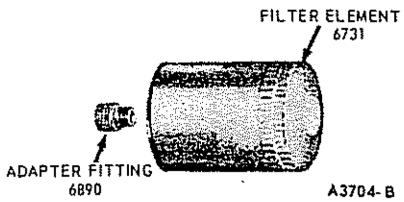


FIG. 69 Typical Oil Filter Assy.—Spin-On Type

DISASSEMBLY AND ASSEMBLY

When installing nuts or bolts that must be tightened (refer to torque specifications), oil the threads with lightweight engine oil. **Do not oil threads that require oil-resistant or water-resistant sealer.**

Refer to Page 1-08 for the cleaning and inspection procedures.

VALVE LIFTER

The internal parts of each hydraulic valve lifter assembly are matched sets. Do not intermix the parts. Keep the assemblies intact until they are to be cleaned.

Valve lifters should always be tested after assembly; refer to the test procedures covered on page 1-06.

Disassembly

Disassemble and assemble each lifter separately. Keep the lifter assemblies in proper sequence so that they can be installed in their original bores.

1. Grasp the lock ring with needle nose pliers to release it from the groove. It may be necessary to depress the plunger to fully release lock ring.
2. Remove the push rod cup, metering valve (disc), plunger and spring.
3. Remove the plunger assembly, the check valve retainer and plunger spring. Carefully remove the plunger spring, the check valve retainer, and the check valve disc from the plunger.

Assembly

Hydraulic valve lifter assembly is shown in Figure 70.

1. Place the plunger upside down on a clean work bench.
2. Place the check valve (disc or ball check) in position over the oil hole on the bottom of the plunger. Set the check valve spring on top of the check valve (disc or ball check).

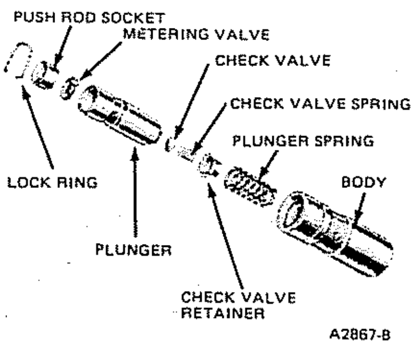


FIG. 70 Hydraulic Valve Lifter Assy.

3. Position the check valve retainer over the check valve and spring then push the retainer down into place on the plunger.
4. Place the plunger spring, and then the plunger (open end up) into the lifter body.
5. Position the metering valve (disc) in the plunger, and then place the push rod cup in the plunger.
6. Depress the plunger, and position the closed end of the lock ring in the groove of the lifter body. With the plunger still depressed, position the open ends of the lock ring in the groove. Release the plunger, and then depress it again to fully seat the lock ring.
7. Use a hydraulic valve lifter leakdown tester to fill the lifters with test fluid.

CYLINDER HEADS

Disassembly

1. Remove the exhaust manifolds and spark plugs.
2. Clean the carbon out of the cylinder head combustion chambers before removing the valves.
3. Compress the valve spring (Figure 71). Remove the spring retainer locks and release spring.

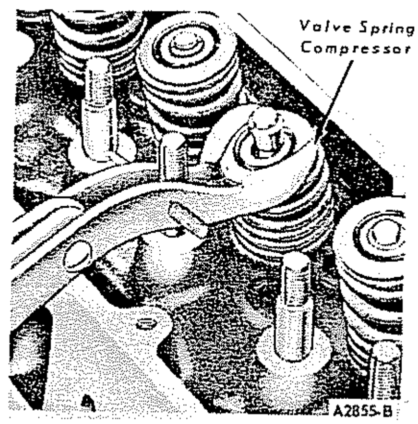


FIG. 71 Compressing Valve Spring on Bench

4. Remove the spring retainer, sleeve, spring, stem seal and valve. Discard the valve stem seals. Identify all valve parts.
5. Clean, inspect and repair the cylinder head as required, or transfer all usable parts to a new cylinder head.

Assembly

1. Install each valve (Figure 72) in the port from which it was removed or to which it was fitted. Install a new stem seal on each valve.
2. Install the valve spring over the valve, and then install the spring retainer and sleeve. Compress the spring (Figure 71) and install the retainer locks (Figure 72).
3. Measure the assembled height of the valve spring from the surface of the cylinder head spring pad to the underside of the spring retainer with dividers (Figure 73). Check the dividers against a scale. If the assembled height is greater than specifications, install the necessary 0.030 inch thick spacer(s) be-

tween the cylinder head spring pad and the valve spring to bring the assembled height to the recommended height.

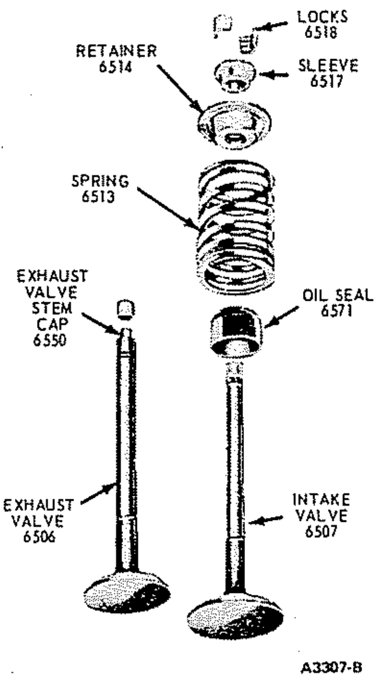


FIG. 72 Valve Assembly.

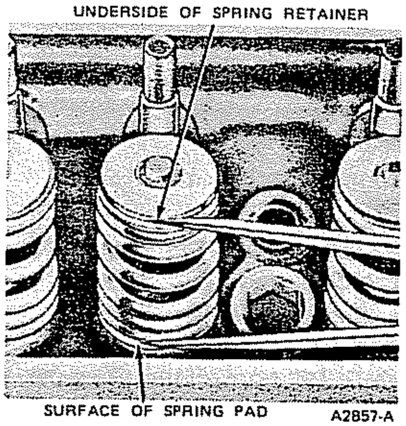


FIG. 73 Checking Valve Spring Assembled Height

Do not install the spacers unless necessary. Use of spacers in excess of recommendations will result in overstressing the valve springs and overloading the camshaft lobes which could lead to spring breakage and worn camshaft lobes.

4. Coat the fulcrum seats and sockets with Lubriplate. Make certain that the rocker arm bolts are in a serviceable condition before installing them. Install rocker arms, fulcrum seats, oil deflectors and bolts as detailed under Valve Rocker Arm Installation.
5. Install exhaust manifolds and spark plugs.

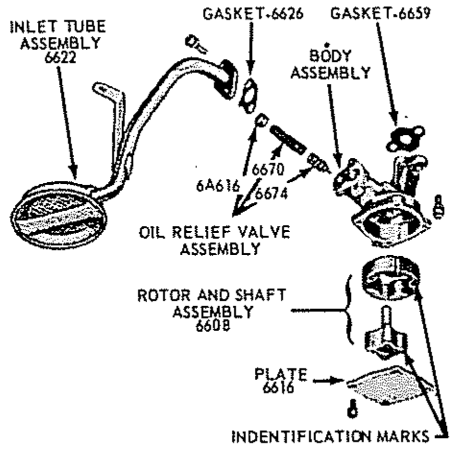


FIG. 74 Oil Pump—Disassembled A 2535-B

OIL PUMP

Disassembly

1. Remove the four screws and washers securing the oil pump cover to the oil pump.
2. Remove the oil pump outer rotor and rotor shaft assembly from the oil pump housing.
3. Remove the cotter pin that secures the relief valve plug in the oil pump housing. To remove the plug, drill a small hole and insert a self-tapping screw in the relief valve plug. Use pliers to remove plug from oil pump housing (Figure 74A). **Use care to prevent the loss of the relief valve spring.**
4. Remove the spring and relief valve from the oil pump housing.

Refer to Page 1-13 for cleaning and inspection procedures.

Assembly

1. Install the relief valve, spring and the relief valve plug in the oil pump housing. Press the plug inward until it seats; then, install the cotter pin.
2. Install the outer rotor and rotor shaft in the housing. **Be sure that the identification mark on the outer rotor is on the same side as the identification mark on the inner rotor. These parts are matched sets and should only be replaced as an assembly. Fill the housing with engine oil for priming purposes.**

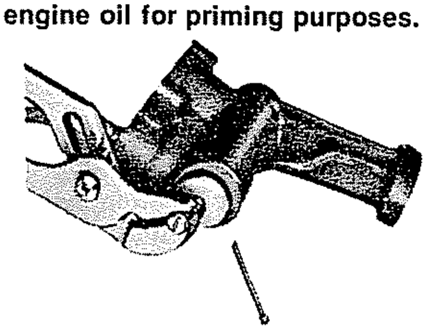


FIG. 74A Removing Oil Pump Relief Valve Plug

3. Install the outer race and the inner rotor and shaft assembly. **Be sure the dimple (identification mark) on the outer race is facing outward and on the same side as the identification mark on the rotor. The inner rotor and shaft and the outer race are serviced as an assembly. One part should not be replaced without replacing the other.** Install the cover and tighten the cover attaching bolts to specifications.
4. Install the attaching bolts.

PISTONS AND CONNECTING RODS

Disassembly

1. Remove the bearing inserts from the connecting rod and cap.
2. Mark the pistons to assure assembly with same rod and installation in the same cylinders from which they were removed.
3. Using an Arbor press and the tool shown in Figure 75, press the piston pin from the piston and connecting rod. Remove the piston rings.

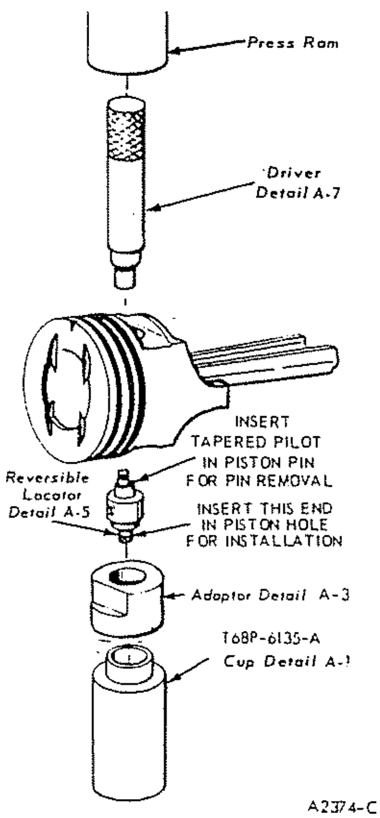


FIG. 75 Removing or Installing Pistion Pin

Assembly

The piston, connecting rod and related parts are shown in Figure 76. Check the fit of a new piston in the cylinder bore before assembling the piston and piston pin to the connecting rod.

The piston pin bore of a connecting rod and the diameter of the piston pin must be within specifications.

1. Apply a light coat of engine oil SE to all parts. **Assemble the piston to the connecting rod with the indentation in the piston positioned as shown in Figure 77.**

On replacement connecting rods, install the large-chamfered side of the connecting rod bearing bore towards the crankshaft cheek; facing towards front of engine on the right bank rods, and facing towards rear of engine on left bank rods.

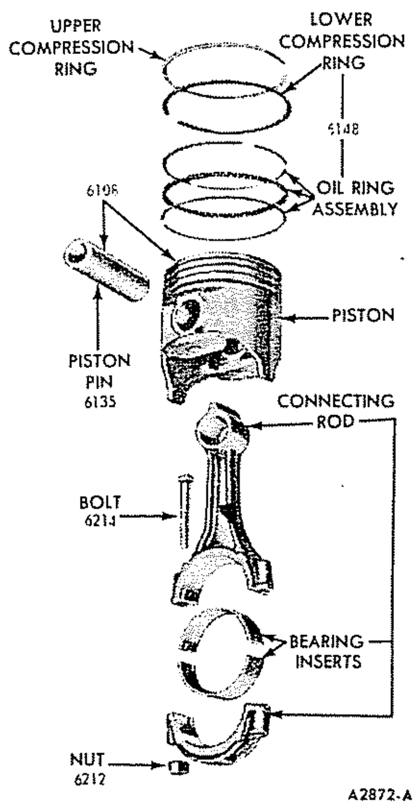


FIG. 76 Piston, Connecting Rod and Related Parts

2. Start the piston pin in the piston and connecting rod (this may require a very light tap with a mallet). Using an Arbor Press, press the piston pin through the piston and connecting rod until the pin is centered in the piston (Figure 77).
3. Check the end gap of all piston rings. It must be within specifications. Follow the instructions contained on piston ring package and install the piston rings.

4. Check the ring side clearance of the compression rings with a feeler gauge inserted between the ring and its lower land. The gauge should slide freely around the entire ring circumference without binding. Any wear that occurs will form a step at the inner portion of the lower land. **If the lower lands have high steps, the piston should be replaced.**
5. Be sure the bearing inserts and bearing bore in the connecting rod and cap are clean. Foreign material under the inserts will distort the bearing and cause failure. Install the bearing inserts in the connecting rod and cap with the tangs fitting in the slots provided.

CYLINDER ASSEMBLY

Disassembly

1. Mount the old engine in a work stand and remove all parts not furnished with the new cylinder assembly; following the procedures given in the Removal and Installation Section of this Part.
2. Remove the old cylinder assembly from the work stand.

Assembly

1. Clean the gasket and seal surfaces of all serviceable parts and assemblies.
2. Position the new cylinder assembly in a work stand.
3. Transfer all serviceable parts removed from the old cylinder assembly, following the procedures given in the Removal and Installation Section of this Part.
4. Check all assembly clearances and correct as necessary.

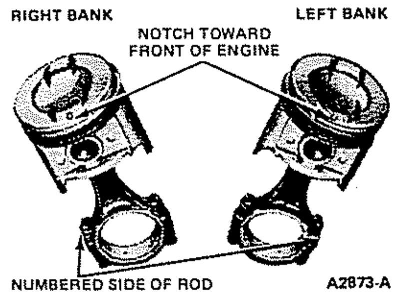


FIG. 77 Correct Piston and Rod Positions

CYLINDER BLOCK

Before replacing a cylinder block, determine if it is repairable. If so, make the necessary repairs, following the procedures given earlier in this part.

Disassembly

1. Completely disassemble the old engine, following the procedures given in the Removal and Installation Section of this Part.
2. Remember to ridge-ream the cylinder bores before removing piston assemblies.

Assembly

1. Clean the gasket and seal surfaces of all serviceable parts and assemblies.
2. Position the new cylinder block in a work stand.
3. Transfer all serviceable parts removed from the old cylinder block, following the procedures given in the Removal and Installation Section of this Part.
4. Check all assembly clearances and correct as necessary.

SPECIFICATIONS — FORD ENGINES

Model	351/4	302/2, 302/4
Bore	4.00″	4.00″
Stroke	3.50″	3.00″
Cubic Displacement	351 cubic inches	302 cubic inches
Horsepower	240 @ 4400 RPM	175 @ 4400 302 2/V 220 @ 4400 302 4/V
Maximum RPM's		
Intermittent Service	4400	4400
Continuous Cruise	3600	3600

NOTE: Do not cruise at high limits of above range unless propped to turn at or near maximum RPM's at full throttle.

Idle Speed, in forward gear	600 RPM	600 RPM
Timing	6 degrees BTC @ 600 RPM	6 degrees BTC @ 600 RPM or lower
Breaker Point Gap	.018″	.018″
Breaker Point Dwell	24 to 29 degrees	24 to 29 degrees
Spark Plug Gap	.035	.035
Spark Plug Type	Autolite BTF3M or Champion F10. 18MM Autolite ARF32M or Champion RBL11Y. 14MM	Autolite BTF3M or Champion F10. 18MM Autolite ARF32M or Champion RBL11Y. 14MM
Firing Order	See engine identification tag.*	See engine identification tag.
Recommended Fuel	Regular grade, leaded 93 octane minimum (Research method)	Regular grade, leaded 93 octane minimum (Research method)

NOTE: Low lead fuel of proper octane rating may be used intermittently. Unleaded fuel should not be used.

Recommended Oil-See Engine Lubrication Section for further information.

Engine	10W30 or 10W40 premium grade	10W30 or 10W40 premium grade
Warner Drives and Vee Drives	Automatic Transmission Fluid (ATF), Type A, Suffix A. Dexron	Automatic Transmission Fluid (ATF), Type A, Suffix A. Dexron
Carburetor	Holley 4 bbl	175-2 bbl Holley 220-4 bbl Holley
Fuel Pump	Marine approved, double diaphragm, with safety sight tube	Marine approved, double diaphragm, with safety sight tube
Electrical System	12 Volt, Negative ground	12 Volt, Negative ground

WARNING: DO NOT reverse battery cables on battery terminals. DO NOT spark battery cables against terminals to check polarity. Damage to charging system components may result if these precautions are not observed.

Alternator	Marine approved, 35 AMP.	Marine approved, 35 AMP.
Regulator	Sealed solid state transistorized	Sealed solid state transistorized
Battery Recommended	Marine type of 70 AMP. hr. minimum	Marine type of 70 AMP. hr. minimum
Oil Capacity	4 quarts and 1 for filter	4 quarts and 1 for filter

***L.H. Rotation**
Firing Order
1-3-7-2-6-5-4-8 LB, LC & LD
1-5-4-2-6-3-7-8 LE

R.H. Rotation
Firing Order
1-8-4-5-6-2-7-3 RB, RC & RD
1-8-7-3-6-2-4-5 RE

SPECIFICATIONS — FORD ENGINE'S

Model	460	460S
Bore	4.362"	4.362"
Stroke	3.85"	3.85"
Cubic Displacement	460 cubic inches	460 cubic inches
Horsepower	340 @ 4600 RPM	320 @ 4600
Maximum RPM's		
Intermittent Service	4600	4600
Continuous Cruise	3600	3600

NOTE: Do not cruise at high limits of above range unless propped to turn at or near maximum RPM's at full throttle.

Idle Speed, in forward gear	600 RPM	600 RPM
Timing	10 degrees BTC @ 600 RPM	10 degrees BTC @ 600 RPM or lower
Breaker Point Gap	.020"	.020"
Breaker Point Dwell	24 to 29 degrees	24 to 29 degrees
Spark Plug Gap	.035	.035
Spark Plug Type	Autolite ARF32M or Champion RBL11Y. 14MM	Autolite ARF32M or Champion RBL11Y. 14MM
Firing Order	See engine identification tag.*	See engine identification tag.*
Recommended Fuel	Regular grade, leaded 93 octane minimum (Research method)	Regular grade, leaded 93 octane minimum (Research method)

NOTE: Low lead fuel of proper octane rating may be used intermittently. Unleaded fuel should not be used.

Recommended Oil-See Engine Lubrication Section for further information.

Engine	SAE40 "SE" Rating	SAE40 "SE" Rating
Warner Drives and Vee Drives	Automatic Transmission Fluid (ATF), Type A, Suffix A. Dexron	Automatic Transmission Fluid (ATF), Type A, Suffix A. Dexron
Carburetor	Holley 4 bbl	4bbl Holley
Fuel Pump	Marine approved, with safety sight tube	Marine approved, with safety sight tube
Electrical System	12 Volt, Negative ground	12 Volt, Negative ground

WARNING: DO NOT reverse battery cables on battery terminals. DO NOT spark battery cables against terminals to check polarity. Damage to charging system components may result if these precautions are not observed.

Alternator	Marine approved, 35 AMP.	Marine approved, 35 AMP.
Regulator	Sealed solid state transistorized	Sealed solid state transistorized
Battery Recommended	Marine type of 100 AMP. hr. minimum	Marine type of 100 AMP. hr. minimum
Oil Capacity	5 quarts and 1 for filter	5 quarts and 1 for filter

***L.H. Rotation**
Firing Order
1-5-4-2-6-3-7-8

R.H. Rotation
Firing Order
1-8-7-3-6-2-4-5

Specifications

Specifications not listed under 460 column are the same as the 302-351 Specifications

General	302 & 351	460
Displacement (Cubic Inches)	302 351W	460
Bore and Stroke		
302	4.00 x 3.00	4.36 x 3.850
351W	4.00 x 3.50	
Oil Pressure — Hot @ 2000 rpm		
302	40-60 psi	35 - 65 psi
351W	40-65 psi	
Firing Order		
302	1-5-4-2-6-3-7-8	15426378 Std.
351W	1-3-7-2-6-5-4-8	18736245 Rev.
Oil Capacity (Qts.)— (add 1 qt. with filter change)	Marine 4	5 qt. sk 7 qt. Marine
Cylinder Head		
Combustion Chamber Volume (cc)		
302-2V	56.7-59.7	94.7-97.7
351W	58.9-61.9	
Valve Guide Bore Diameter	0.3433-0.3443	
Valve Seat Width — Intake and Exhaust	0.060-0.080	
Valve Seat Angle — Intake and Exhaust	45°	
Valve Seat Runout — Maximum	0.0020	
Surface Flatness	0.003 inch in any 6 inches or 0.007 inch overall	
Valve Arrangement (Front to Rear)	Right I-E-I-E-I-E-I-E Left E-I-E-I-E-I-E-I	
Rocker Arm Stud Bore Diameter — Standard	0.3680-0.3695	
Gasket Surface Flatness	0.003 inch in any 6 inches or 0.007 inch overall	
Gasket Surface Finish RMS	60-150	
Valve Rocker Arms, Push Rods and Lifters		
Rocker Arm Lift Ratio	1.61:1	1.73:1
Valve Push Rod Runout — Maximum	0.015	
Rocker Arm Stud Diameter		N/A
Standard	0.3714-0.3721	
0.006 Oversize	0.3774-0.3781	
0.010 Oversize	0.3814-0.3821	
0.015 Oversize	0.3864-0.3871	
Hydraulic Lifter Leakdown Rate	5-50 seconds maximum measured at 1/16 inch plunger travel.	
Hydraulic Lifter Standard Diameter	0.8740-0.8745	
Hydraulic Lifter Clearanc to Bore	0.0007-0.0027 Wear Limit — 0.005	
Hydraulic Lifter Collapsed Gap		
302		
Allowable	0.090-0.190	0.075-0.175
Desirable	0.115-0.130	0.100-0.150
351		
Allowable	0.106-0.206	
Desired	0.131-0.181	

VALVES	302 & 351	460
Valve Stem Diameter		
Intake		
Standard	0.3416-0.3423	Intake & Exhaust
0.003 Oversize	0.3446-0.3453	0.3416-0.3423
0.015 Oversize	0.3566-0.3573	Oversize as listed
0.030 Oversize	0.3716-0.3723	for 302 & 351 Intake
Exhaust		
Standard	0.3411-0.3418	
0.003 Oversize	0.3441-0.3448	
0.015 Oversize	0.3561-0.3568	
0.030 Oversize	0.3711-0.3718	
Valve Face Angle	44°	
Valve Stem to Valve Guide Clearance—		
Intake	0.0010-0.0027	
Exhaust	0.0015-0.0032	0.0010-0.0027
Wear Limit	0.0055	
Valve Head Diameter		
Intake	1.773-1.791	
Exhaust	1.453-1.468	2.075-2.090
Valve Face Runout (Maximum)	0.0020	1.6461-1.661
Valve Spring Free Length — Approximate		All 2.07
302		
Exhaust	1.87	All 2.07
Intake	1.94	
351		
Exhaust	1.87	
Intake	2.06	
Valve Spring Out-of-Square - Maximum	5/64 (0.078)	
Valve Spring Pressure — Lbs. at Specified Length		
302	76-84 @ 1.69	76-84 @ 1.81
	190-210 @ 1.31	300-330 @ 1.32
351	71-79 @ 1.79	
	190-210 @ 1.31	
Service Limit	10% Pressure Loss @ Spec. Length	
Valve Spring Assembled Height — Pad to Retainer		
302 — Intake	1-21/32 — 1-23/32	1-51/64 — 1-53/64
Exhaust	1-19/32 — 1-5/8	
351 — Intake	1-49/64 — 1-13/16	
Exhaust	1-19/32 — 1-5/8	
CAMSHAFT AND BEARINGS		
Camshaft Journal Diameter Standard		
No. 1 Bearing	2.0805-2.0815	All 2.1238-2.1248
No. 2 Bearing	2.0655-2.0665	
No. 3 Bearing	2.0505-2.0515	
No. 4 Bearing	2.0355-2.0365	
No. 5 Bearing	2.0205-2.0215	
Camshaft Journal to Bearing Clearance	0.001-0.003	
	Wear Limit — 0.006	
Camshaft End Play	0.001-0.007	
	Wear Limit — 0.009	
Camshaft Lobe Lift		
302		
Intake	0.2303	0.2530
Exhaust	0.2474	0.2780
351		
Intake	0.2600	
Exhaust	0.2600	

CAMSHAFT AND BEARINGS (Cont'd)	302 & 351	460
Maximum Allowable Lobe Lift Loss	0.005	
Bearing Inside Diameter		
Bearing No. 1	2.0825-2.0835	All
Bearing No. 2	2.0675-2.0685	2.1258-2.1268
Bearing No. 3	2.0525-2.0535	
Bearing No. 4	2.0375-2.0385	
Bearing No. 5	2.0225-2.0235	
Camshaft Journal Diameter — Standard		
Bearing No. 1	2.0805-2.0815	
Bearing No. 2	2.0655-2.0665	
Bearing No. 3	2.0505-2.0515	
Bearing No. 4	2.0355-2.0365	
Bearing No. 5	2.0205-2.0215	
Camshaft Journal Maximum Runout	0.005	
Camshaft Journal Maximum Out-of-Round	0.005	
Camshaft Bearing Location — No. 1 Bearing	0.0050-0.0200*	0.040-0.060*
Timing Chain Deflection — Maximum	0.500	

*Distance in inches that the front edge of the bearing is installed toward the rear from the front face of the cylinder block.

CRANKSHAFT AND FLYWHEEL	302 & 351	460
Main Bearing Journal Diameter		
302	2.2482-2.2490	2.9994-3.0002
351	2.9994-3.0002	
Main Bearing Journal Out-of-Round — Maximum	0.0006	
Connecting Rod Journal Diameter		
302	2.1228-2.1236	
351	2.3103-2.3111	
Connecting Rod Journal Out-of-Round — Maximum	0.0006	
Main Bearing Journal Taper — Maximum	0.0006 per inch	
Connecting Rod Journal Taper — Maximum	0.0006 per inch	
Connecting Rod Journal Diameter		
302	2.1228-2.1236	2.4992-2.5000
351	2.3103-2.3111	
Thrust Bearing Journal Length	1.137-1.139	1.124-1.126
Main Bearing Journal Thrust Face Runout	0.001	
Crankshaft to Rear Face of Block Runout TIR - Maximum	0.005	
Crankshaft Free End Play	0.004-0.008 Wear Limit — 0.012	
Flywheel Clutch Face Runout — Maximum	0.010	
Assembled Flywheel Ring Gear Lateral Runout TIR		
Standard	0.030	
Automatic	0.060	

MAIN BEARINGS	302 & 351	460
Journal Clearance		
302 No. 1 Bearing		
Desired	0.0001-0.0015	0.0008-0.0015
Allowable	0.0001-0.0020	0.0004-0.0020
All others		
Desired	0.0005-0.0015	0.0008-0.0015
Allowable	0.0005-0.0024	0.0008-0.0026

MAIN BEARINGS (Cont'd)	302 & 351	460
351		
Desired	0.0008-0.0015	
Allowable	0.0008-0.0026	
Wall Thickness		Std.
302 No. 1 Bearing	0.0961-0.0966	0.0955-0.0960
All Others	0.0957-0.0962	
351	0.0957-0.0960	0.002 undersized
All Others	0.0957-0.0962	0.0965-0.0970
CONNECTING ROD		
Piston Pin Bore I.D. — Standard	0.9096-0.9112	1.0386-1.0393
Bearing Bore Diameter		
302	2.2390-2.2398	2.6522-2.6530
351	2.4265-2.4273	
Bearing Bore Out-of-Round and Taper	0.0004	
Connecting Rod Length — Center to Center		
302	5.0885-5.0915	6.6035-6.6065
351	5.9545-5.9575	
Twist Total Difference — Maximum	0.024*	
Bend Total Difference — Maximum	0.012*	
Connecting Rod Assembly — Assembled to Crankshaft — Side Clearance	0.010-0.020 Wear Limit — 0.023	
*Pin bushing and crankshaft bearing bore must be parallel and in the same vertical plane within the specified total difference at ends of an 8-inch long bar measured 4 inches on each side of rod.		
CONNECTING ROD BEARINGS		
Bearing to Crankshaft Clearance		
Allowable	0.0008-0.0025	
Desired	0.0008-0.0015	
Wall Thickness — Standard	0.0572-0.0577	0.0756-0.0761
0.002 Undersize	0.0582-0.0587	0.0766-0.0771
PISTONS		
Piston Diameter — Coded Red		
302	3.9984-3.9990	4.3585-4.3591
351	3.9978-3.9984	
Coded Blue		
302	3.9996-4.0002	4.3597-4.3603
351	3.9990-3.9960	
0.003 Oversize		
302	4.0008-4.0014	4.3609-4.3615
351	4.0002-4.0008	
Piston to Cylinder Bore Clearance	0.0018-0.0026	0.0022-0.0032
Piston Pin Bore Diameter		
302	0.9122-0.9126	1.0402-1.0405
351	0.9124-0.9127	
Ring Groove Width, Compression —		
Top	0.077-0.078	0.080-0.0815
Bottom	0.077-0.078	0.080-0.0815
Oil Ring	0.1880-0.1890	

PISTON PIN	302 & 351	460
Piston Pin Diameter — Standard	0.9120-0.9123	1.0398-1.0403
0.001 Oversize	0.9130-0.9133	1.0410-1.0413
0.002 Oversize	0.9140-0.9143	N/A
Piston Pin Length	3.010-3.040	3.290-3.320
Piston Pin to Piston Clearance		
302	0.0002-0.0004	0.0002-0.0004
351	0.0003-0.0005	
	Wear Limit — 0.0008	
Piston Pin to Connecting Rod		
Bushing Clearance	Interference Fit	
PISTON RINGS		
Top Compression Ring Width	0.077-0.078	
Bottom Compression Ring Width	0.077-0.078	
Top Compression Ring Side Clearance	0.002-0.004	
Bottom Compression Ring Side Clearance	0.002-0.004	
	Wear Limit — 0.002 max. increase in total clearance	0.006 Wear Limit
Oil Ring Side Clearance	Snug	
Top Compression Ring — Ring Gap	0.010-0.020	
Bottom Compression Ring — Ring Gap	0.010-0.020	
Oil Ring (Steel Rail) — Ring Gap	0.015-0.055	
CYLINDER BLOCK		
Cylinder Bore Diameter		
302	4.0004-4.0052	4.3600-4.3636
351	4.0000-4.0048	
Maximum Out-of-Round	0.0015	
	Wear Limit — 0.005	
Maximum Taper	0.001	
	Wear Limit — 0.010	
Crankshaft to Rear Face of Block Runout		
TIR Maximum	0.005	
Lifter Bore Diameter	0.8752-0.8767	
Main Bearing Bore Diameter		
302	2.4412-2.4420	3.1922-3.1930
351	3.1922-3.1930	
Distributor Shaft Bearing Bore Diameter		
302	0.4525-0.4541	0.5160-0.5175
351	0.5155-0.5171	
Head Gasket Surface Flatness	0.003 inch in any 6 inches or 0.006 inch overall	
Head Gasket Surface Finish RMS	60-150	
Cylinder Bore Surface Finish RMS	18-38	
OIL PUMP		
Relief Valve Spring Tension (Lbs. @ Specified Length)		
302	10.6-12.2 @ 1.704	20.6-22.6 @ 2.490
351	18.2-20.2 @ 2.49	
Drive Shaft to Housing Bearing Clearance	0.0015-0.0029	
Relief Valve Clearance	0.0015-0.0029	
Rotor Assembly End Clearance	0.001-0.004	
Outer Race to Housing Clearance (Radial)	0.001-0.013	

CARBURETORS

CARBURETORS	D2JL C 302	D2JL E 351	D3JL S 302-351	D4JL F 302	D4JL G 351	D1FF TA 460	D4JL J 460
Carburetor Size							
Throttle Bore Diameter							
Primary —	1.5	1.5625	1.50	1.5	1.5610	1.687	1.686
Secondary —	1.5	1.5625	-	1.5	1.5610	1.687	1.686
Venturi Diameter							
Primary —	1.094	1.250	1.187	1.094	1.250	1.375	1.375
Secondary —	1.094	1.3125	-	1.094	1.312	1.437	1.437
Fuel System							
Fuel Level (Wet)	1	1	3	3 5	4 5	1	3 5
Float Level (Dry)	2	2	2	2	2	2	2
Main Metering System							
Main Jet							
Primary —	#58	#64	#60	#582	#622	#72	#722
Secondary —	N/A	N/A	-	N/A	N/A	#84	N/A
Power Valve Timing	8.5	5.0	5	8.5	2.5	8.5	8.5
Idle Mixture (Prelim. Setting)	1½	1½	1½	1½	1½	1½	1½
Accelerator Pump System							
Capacity — cc/10 Strokes	21-31	25-35	25-35	21-31	22-32	18-22	17-27
Pump Rod Location	#2	#1	#1	#2	#2	#2	#2
Override Spring Adjustment	.015"	.015"	.015"	.015"	.015"	.015"	.015"
Pump Cam Color	Red	Pink	Pink	Red	Pink	Red	Red
Idle Speed							
Curb Idle RPM	550-575	550-575	550-575	550-575	550-575	550-575	550-575
Fast Idle RPM	1500	1500	1500	1500	1500	1500	1500
Choke Cover Setting	3 Lean	3 Lean	3 Lean	Index	Index	Index	Index
Dechoke	.300"	.300"	.300"	.300"	.270"	.300"	.300"
Choke Qualifying	.140"	.140"	.140"	.140"	.120"	.140"	.140"
Secondary Throttle Opening	¼-½	¼-½	-	¼-½	¼-½	¼-½	¼-½
Supplier	Holley	Holley	Holley	Holley	Holley	Holley	Holley
Supplier I.D. Number	6407	6576-A	7036	7159	7163	6361	7128
Carburetor Model	4160C	4160C	2300C	4160C	4160C	4150C	4160C

1 Lower Edge of Sight Plug Hole.
2 Parallel with Float Bowl Floor (bowl inverted.)
3 1/2" Primary 5/8" Secondary
4 1/2" Primary 3/4" Secondary
5 Use Kent Model Gauge #10193

TORQUE LIMITS — FT.-LBS.

	302 & 351	460
Cylinder Head Bolts		
302		
Step 1	50	70-80
Step 2	60	100-110
Step 3	65-70	130-140
351		
Step 1	90	
Step 2	100	
Step 3	112	
Oil Pan to Cylinder Block		
5/16-18	8-11	
1/4-20	7-9	

TORQUE LIMITS — FT.-LBS. (Cont'd)	302 & 351	460
Intake Manifold Bolts	23-25	22-32
Exhaust Manifold Bolts	18-24	28-33
Water Outlet Housing	10-15	
Flywheel to Crankshaft	75-85	
Main Bearing Cap		
302	60-70	95-105
351	95-105	
Oil Pan Drain Plug	15-25	
Oil Pump to Cylinder Block	22-32	
Oil Inlet Tube to Oil Pump	10-15	Press Fit
Oil Pump Cover Plate	6-9	
Oil Filter Insert to Block	20-30	
Oil Filter to Block Cartridge Type — With grease on gasket surface, hand-tighten until gasket contacts adapter face then tighten ½ turn more.		
Cylinder Front Cover	12-18	
Water Pump Bolts	12-18	12-15
Camshaft Sprocket to Camshaft	40-45	
Camshaft Thrust Plate to Block	9-12	
Vibration Damper to Crankshaft	70-90	
Crankshaft Pulley to Vibration Damper	35-50	
Connecting Rod Nuts		
302	19-24	
351	40-45	40-45
Valve Rocker Arm Cover	3-5	5-6
Fuel Pump to Cylinder Front Cover	19-27	
Rocker Arm Stud Nut	17-23 After nuts contact shoulder	Stud 18-25

TORQUE LIMITS FOR VARIOUS SIZE BOLTS FT.-LBS.

CAUTION: If any of the torque limits listed in this table disagree with any of those listed in the preceding tables, the limits in the preceding tables prevail.

Size (Inches)	Torque (Ft.-Lbs.)
1/4-20	6-9
5/16-18	12-18
3/8-16	22-32
3/8-24	27-38
7/16-14	45-57
1/2-13	55-80
9/16-18	85-120

IGNITION SYSTEM

	302 & 351	460
Initial Spark Advance — BTDC	6°	10°
Breaker Arm Spring Tension (ounces)	17-21	
Contact Spacing		
Marine:		
GPD	0.014-0.019	0.014-0.019
Mallory	0.019-0.021	
Prestolite	0.014-0.019	
Dwell Angle at Idle Speed		
Marine		
GPD	26°	
Mallory	26°	
Prestolite	31°	31°
Gear Location Dimension — Distributor (Distance from bottom of mounting flange to bottom of gear)	4.031-4.038	

IGNITION SYSTEM (Cont'd)

	302 & 351	460
Shaft End Play Clearance — Distributor	0.024-0.025	0.024-0.035
Condenser		
Capacity — Microfarads	0.21-0.25	
Minimum Leakage — Megohms	10	
Maximum Series Resistance Ohms	1	
Coil		
Primary Resistance Wire — Ohms	1.40-1.54 (75°F)	
Secondary Resistance — Ohms	7600-8800 (75°F)	
Amperage Draw		
Engine Stopped	4.5	
Engine Idling	2.5	
Primary Circuit Resistance — Ohms	1.30-1.40 (75°F)	
Spark Plugs		
Plugs (Motorcraft)		
Marine	BRF-3 or ARF-32	ARF-32
Size		
Marine	14mm or 18mm	14mm
Torque (Ft.-Lbs.)	15-20	

Distributor RPM's	Advance (in degrees) 302 & 351	460
0-550	0	0
900	9	8
2000	13.5	15

FUEL SYSTEM

	302 & 351	460
Fuel Pump Static Pressure @ 500 rpm	5.0-7.0	5.7-7.7
Minmum Feed Pump Volume Flow: @ 500 rpm	1 pint/20 sec.	
Eccentric Total Lift	0.630-0.710	0.890-0.910

POSITIVE ENGAGEMENT STARTER

Positive Engagement Starter Motor					
Dia. (Inches)	Current Draw Under Normal Load (Amps)	Normal Engine Cranking Speed (rpm)	Min. Stall Torque @ 5 Volts (Ft-Lbs)	Max. Load (Amps)	No. Load (Amps)
4	150-200	180-250	9.0	460	70
4½	150-180	150-290	15.5	670	80

Starter Brushes				
Mfg. Length (Inches)	Wear Limit (Inches)	Spring Tension (Ounces)	Through Bolt Torque (In-Lbs)	Mounting Bolt Torque (Ft-Lbs)
0.50	0.25	40	55-75	15-20
0.50	0.25	40	55-75	15-20

Maximum Commutator runout is 0.005 inch. Maximum starting circuit voltage drop (battery positive terminal to starter terminal) at normal engine temperature is 0.5 volt.

PCM

marine engines

CHEVROLET ENGINES
REPAIR & DIAGNOSTIC
PROCEDURES

CHEVROLET "V" BLOCK

SECTION 6A2

5.0 (U) 305 cu. in. V-8
5.7 (L) 350 cu. in. V-8
7.4 (S) 454 cu. in. V-8

Contents

GENERAL DESCRIPTION

CYLINDER BLOCK

The cylinder block is made of cast iron and has 8 cylinders (6 on V-6) arranged in a "V" shape with 4 cyl (3 on V-6) inders in each blank. Five main bearings (4 on V-6) support the crankshaft which is retained by bearing caps that are machined with the block for proper alignment and clearances. Cylinders are completely encircled by coolant jackets.

CYLINDER HEAD

The cast iron cylinder heads provide a compression ratio of 8.5:1 (8.2:1 on V-6). They are cast with individual intake and exhaust ports for each cylinder. Valve guides are integral, and rocker arms are retained on individual pressed studs.

CRANKSHAFT AND BEARINGS

The crankshaft is cast nodular iron and is supported by five main bearings (4 on V-6). Number five (#4 on V-6) is the end thrust bearing.

V8 ONLY

Main bearings are lubricated from oil holes which intersect the camshaft bearings. The camshaft bearings are fed oil by the main oil gallery which is rifle drilled down the center of the block, above the camshaft. Two additional oil gallerys are on either side of the main oil gallery to provide an oil supply for the hydraulic lifters.

V6 ONLY

Main bearings are lubricated from oil holes which intersect the camshaft bearings. The camshaft bearings are fed oil by the left bank oil gallery which is rifle drilled in the block, above the camshaft.

The V-6 engine crankshaft has splayed crankpins for a more even firing and smoother idle. A torsional damper on the forward end of the crankshaft dampens any engine torsional vibrations.

CAMSHAFT AND DRIVE

The cast iron camshaft is supported by five bearings (4 on V-6) and is chain driven. A steel crankshaft sprocket drives the timing chain which in turn drives the camshaft through a cast iron sprocket on left hand engines. Right hand engines use gears only no chain to turn the camshaft.

Cam lobes are ground, hardened and tapered with the high side toward the rear. This, coupled with a spherical face on the lifter, causes the valve lifters to rotate.

Camshaft bearings are lubricated through oil holes which intersect the main oil gallery. The main oil gallery is rifle drilled down the center of the block, above the camshaft.

NOTE: The V6 has only two (2) oil galleries. The main gallery is on the left hand side.

PISTONS AND CONNECTING RODS

The pistons are made of cast aluminum alloy using two compression rings and one oil control ring. Piston pins are offset 1/16" toward the thrust side (right hand side) to provide a gradual change in thrust pressure against the cylinder wall as the piston travels its path. Pins are Chromium steel and have a floating fit in the pistons. They are retained in the connecting rods by a press fit.

Connecting rods are made of forged steel. Full pressure lubrication is directed to the connecting rods by drilled oil passages from the adjacent main bearing journal.

VALVE TRAIN

A very simple ball pivot-type train is used. Motion is transmitted from the camshaft through the hydraulic lifter and push rod to the rocker arm. The rocker arm pivots on its ball and transmits the camshaft motion to the valve. The rocker-arm ball is retained by a nut.

HYDRAULIC VALVE LIFTERS

Hydraulic Valve Lifters are used to keep all parts of the valve train in constant contact.

The hydraulic lifter assembly consists of: the lifter body, which rides in the cylinder block boss, a plunger, a push rod seat, a metering valve, a plunger spring, a check ball and spring, a check ball retainer and a push rod seat retainer.

When the lifter is riding on the low point of the cam, the plunger spring keeps the plunger and push rod seat in contact with the push rod.

When the lifter body begins to ride up the cam lobe, the check ball cuts off the transfer of oil from the reservoir below the plunger. The plunger and lifter body then rise as a unit, pushing up the push rod and opening the valve.

As the lifter body rides down the other side of the cam, the plunger follows with it until the valve closes. The lifter body continues to follow the cam to its low point, but the plunger spring keeps the plunger in contact with the push rod. The ball check valve will then move off its seat and the lifter reservoir will remain full.

INTAKE MANIFOLD

The intake manifold is of cast iron double level design for efficient fuel distribution. (The V6 intake manifold is of single level design.) The carburetor pad is centrally located with an Early Fuel Evaporation (E.F.E.) passage running underneath the pad through which exhaust gases are forced to promote faster fuel vaporization when the engine is cold.

EXHAUST MANIFOLDS

Two cast iron exhaust manifolds are used to direct exhaust gases from the combustion chambers to the exhaust system.

COMBUSTION CHAMBERS

Combustion Chambers are cast to insure uniform shape for all cylinders. Spark plugs are located between the intake and exhaust valves.

The contoured wedge shape of the combustion chamber minimizes the possibility of detonation, facilitates breathing and provides swirling turbulence for smooth, complete combustion.

ENGINE LUBRICATION

Full pressure lubrication through a full flow oil filter, is furnished by a gear-type oil pump. The distributor, driven by a helical gear on the camshaft, drives the oil pump. The main oil gallery (center on V8, left hand side on V6) feeds oil, through drilled passages, to the camshaft and crankshaft to lubricate the bearings. The valve lifter oil gallery feeds the valve lifters which, through hollow push rods, feed the individually mounted rocker arms (fig. 6A2-1 & 6A2-2).

We recommend that the filter & engine oil be changed after the first 25 hours of engine operation and every 50 hours of operation thereafter. If the required number of hours of operation per year are not accumulated the oil should be changed at

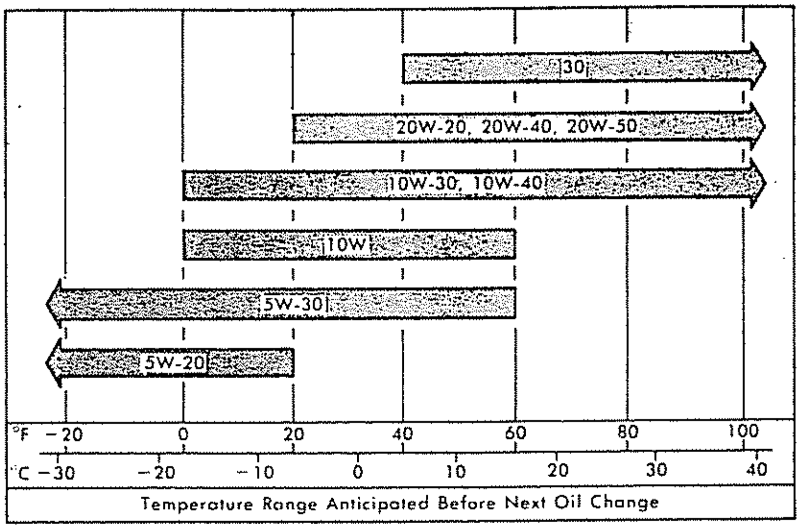


Fig. OB-3 — Oil Viscosity Chart Gasoline

least once each season at lay up time.

The above recommendations apply to the first change as well as subsequent oil changes. The oil change interval for the engine is based on the use of recommended oils and quality oil filters. Oil change intervals longer than those listed above will seriously reduce engine life and may affect the manufacturer's obligation under the provisions of the New Engine Warranty.

A high quality SE oil (SE/CD for Diesel) was installed in the engine at the factory. It is not necessary to change this factory-installed oil prior to the recommended normal change period. However, check the oil level more frequently during the break-in period since higher oil consumption is normal until the piston rings become seated.

NOTE: Non-detergent and other low quality oils are specifically not recommended.

OIL FILTER TYPE AND CAPACITY

- Throwaway type, 1 quart U.S. measure, .75 quart Imperial measure.
- 305, 350, 400 and 454 cu. in., AC Type PF-35.

CRANKCASE CAPACITY (Does Not Include Filter)

- All engines; 4 quarts U.S. measure, 3.25 quarts Imperial measure.

RECOMMENDED VISCOSITY

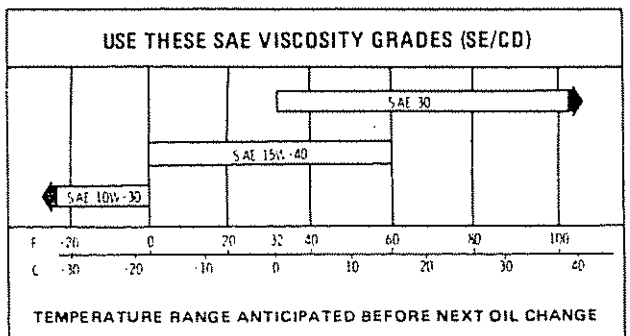
To help assure good cold and hot starting, as well as maximum engine life, fuel economy, and oil economy, select the proper oil viscosity for the temperature range anticipated from the chart in Fig. OB-3 and Fig. OB-4.

NOTE: SAE 5W-20 oils are not recommended for sustained high-speed.

NOTE: For gasoline engine only use single viscosity grade SAE-30 oil when prevailing temperatures will allow. Use multi-viscosity oils only when necessary for starting at low temperature ranges in above chart. (It may be necessary to use an optional engine block heater for starting when ambient temperature is approximately −10°F (−23°C) or lower).

CHECKING OIL LEVEL

The engine oil should be maintained at proper level. The best time to check it is before operating the engine or as the last step in a fuel stop. This will allow the oil accumulation in the engine to drain back in the crankcase.



NOTICE: Use SAE 30 SE/CD oil when prevailing temperatures are above 32°F (0°C). Use SAE 15W-40 SE/CD oil when prevailing temperatures drop below 32°F (0°C). At temperatures below 0°F (-18°C), use the block heater. If circumstances do not allow you to use a block heater, use SAE 10W-30 SE/CD oil. If SE/CD oil is not available, you may use SAE 10W-30 SE/CC oil. HOWEVER, we recommend using the block heater and SAE 15W-40 SE/CD if at all possible. If you must use 10W-30 oil (either SE/CD or SE/CC), switch back to the appropriate oil when prevailing temperatures rise above 0°F (-18°C).

Fig. OB-4 — Oil Viscosity Chart Diesel

INTAKE MANIFOLD

Removal

1. Drain engine and remove flame arrestor
2. Disconnect:
   - Battery negative cable at battery.
   - All hoses attached to the manifold
   - Accelerator linkage at carburetor.
   - Fuel line at carburetor.
   - Crankcase ventilation lines.
3. Remove distributor cap and mark rotor position with chalk, then remove distributor.
4. Remove manifold attaching bolts, then remove manifold and carburetor as an assembly. Discard gaskets.
5. If manifold is to be replaced, transfer:
   - Carburetor and carburetor attaching bolts.
   - Temperature sending unit.
   - Thermostat with housing (use new gasket or RTV, as applicable).
   - Choke spring assembly (where applicable).

Installation

1. Clean gasket and seal surfaces on manifold, block, and cylinder heads.
2. Install manifold seals on block and gaskets on cylinder heads. Use sealer at water passages and where seals butt to gaskets.

   NOTE: On those engines not having front and rear manifold seals, place a 3/16" bead of RTV on the front and rear ridges of the cylinder case. Extend the bead 1/2" up each cylinder head to seal and retain the manifold side gaskets.

3. Install manifold and torque bolts to specifications in the sequence outlined in Fig. 6A2-8 & 6A2-10.
4. Install distributor, positioning rotor at chalk mark, then install distributor cap.
5. Connect:
   - Crankcase ventilation lines.
   - Fuel line at carburetor.
   - Accelerator linkage at carburetor.
   - Battery negative cable at battery.
6. Install flame arrestor.
7. Fill with coolant, start engine, adjust ignition timing and carburetor idle speed and check for leaks.

EXHAUST MANIFOLD

Removal

1. Remove spark plug wires from plugs.
2. Disconnect exhaust hose from riser and hang exhaust hose from hull with wire.

   Caution: If boat is in the water be certain to plug the exhaust hose as well as hanging it from the hull. If the hanger should fail the boat will sink if the hose is not plugged.

3. Remove drain plugs from manifold & disconnect hose.
4. Remove riser from manifold to decrease weight or remove after manifold has been removed.

Installation

1. Clean mating surfaces on manifold and head, then install manifold in position and install bolts (fingertight).
2. Using a new gasket torque manifold bolts to specifications.
3. Clean riser gasket surface. Position riser gasket on manifold so that protrusion on gasket points away from the riser outlet. Install riser attaching bolts & torque to specifications.
4. Connect exhaust hose to riser.
5. Install plug and attach hose to manifold. Tighten all clamps.
6. Connect spark plug wires.
7. Start engine and check for leaks.

ROCKER ARM COVER

Removal

1. Loosen manifold attaching bolts & back off manifold from engine until access can be achieved.
2. Disconnect crankcase ventilation hoses at rocker arm covers.
3. Disconnect electrical wiring harness from rocker arm clips.
4. Remove rocker arm cover to head attaching bolts and remove rocker arm cover.

   CAUTION: *Do not pry rocker arm cover loose. Sealer (or gaskets) adhering to cylinder head and rocker arm cover may be sheared by bumping end of rocker arm cover rearward with palm of hand or a rubber mallet.*

Installation

NOTE: On disassembly, if engine had gaskets on rocker arm covers then gaskets MUST be used for reassembly. DO NOT USE RTV. Conversely, an engine having RTV on disassembly MUST be reassembled with RTV. DO NOT USE GASKETS.

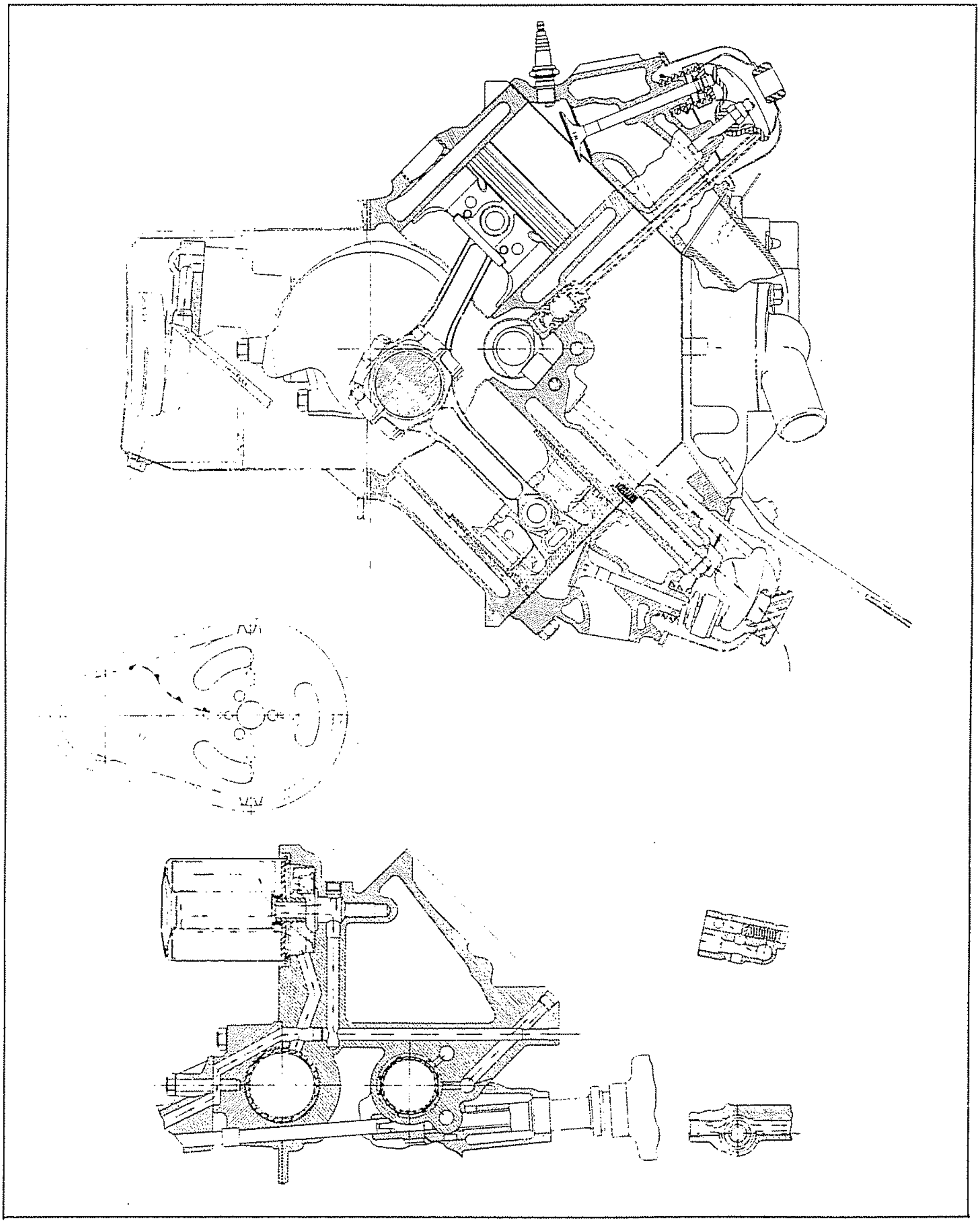


Fig. 6A2-1–Small V-8 Engine Lubrication

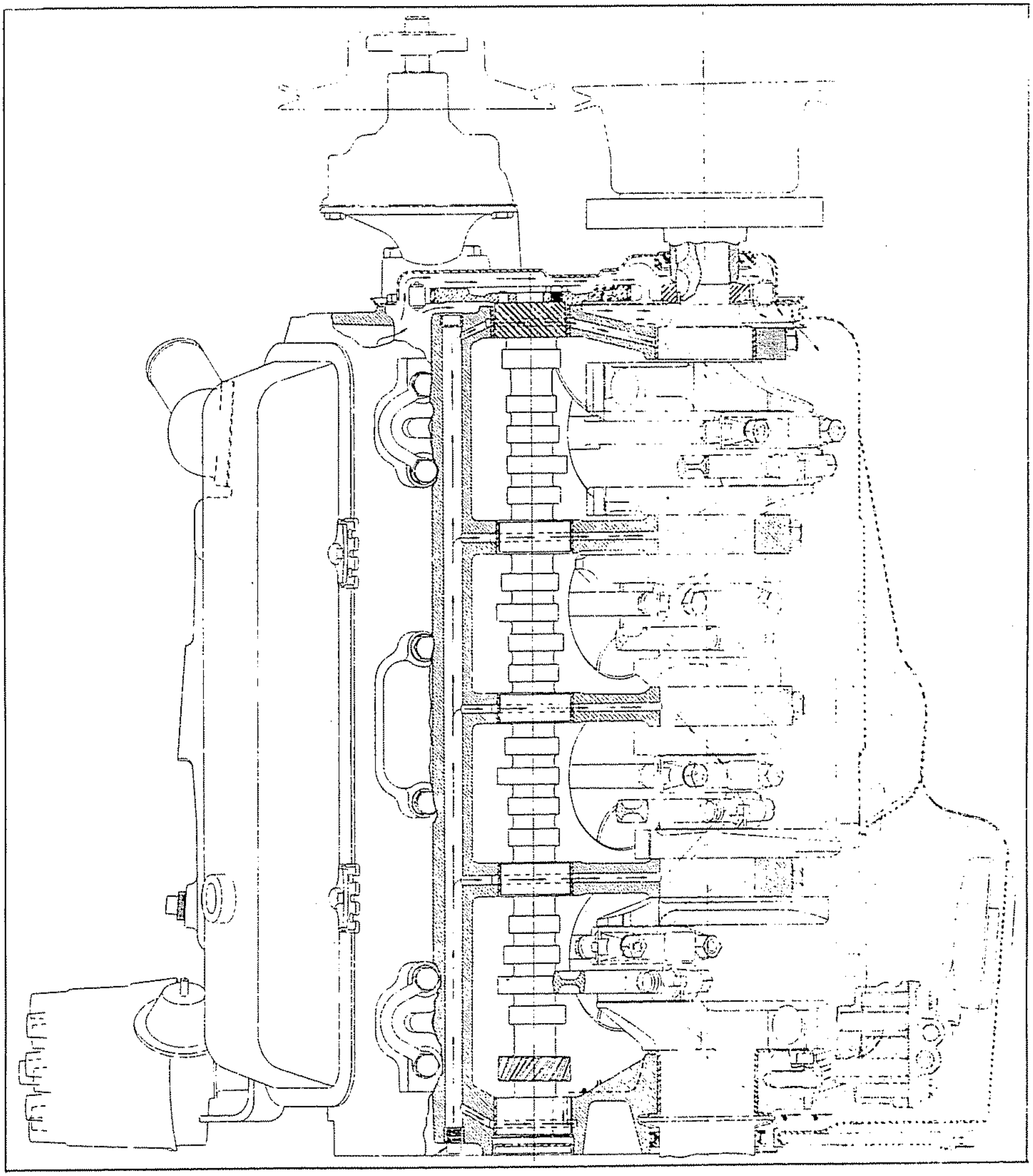


Fig. 6A2-2–Small V-8 Engine Lubrication

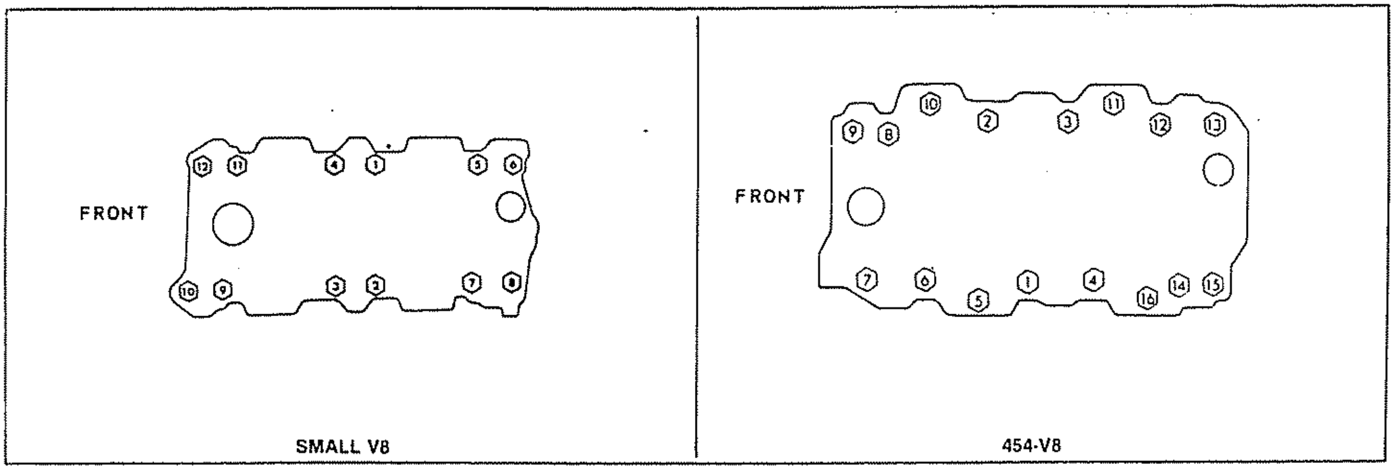


Fig. 6A2-10–Intake Manifold Torque Sequence

1. Clean sealing surfaces on cylinder head and rocker arm cover with degreaser then, using a new gasket or RTV, as applicable, place rocker arm cover on the head, install retaining bolts and torque to specifications.

   NOTE: When using RTV, a 1/8" bead of RTV sealer should be placed all around the rocker cover sealing surface of the cylinder head. (When going around attaching bolt holes, always go around the inboard side of the holes). Install cover and torque bolts while RTV is still wet (within 10 minutes).

2. Connect electrical wiring harness at clips on rocker arm cover.
3. Connect crankcase ventilation hoses.

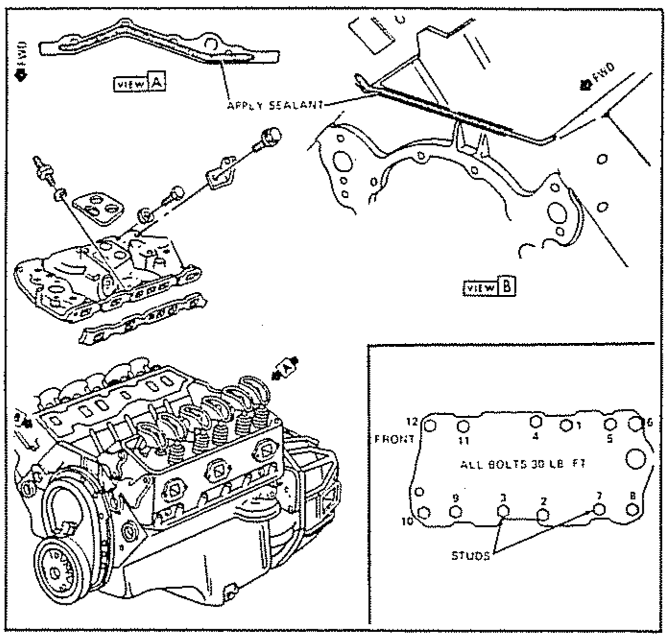


Fig. 6A2-8–Intake Manifold Torque Sequence – V-6

4. Tighten manifold bolts to specifications. Start engine & check for leaks.

VALVE MECHANISM

Removal

1. Remove rocker arm covers as previously outlined.
2. Remove rocker arm nuts, rocker arm balls, rocker arms and push rods.

   NOTE: Place rocker arms, rocker arm balls and push rods in a rack so they may be reinstalled in the same locations.

INSTALLATION AND ADJUSTMENT

NOTE: Whenever new rocker arms and/or rocker arm balls are being installed, coat bearing surfaces of rocker arms and rocker arm balls with "Molykote" or its equivalent.

1. Install push rods. Be sure push rods seat in lifter socket.
2. Install rocker arms, rocker arm balls and rocker arm nuts. Tighten rocker arm nuts until all lash is eliminated.
3. Adjust valves when lifter is on base circle of camshaft lobe as follows:
   a. Crank engine until mark on torsional damper lines up with center of "O" mark on the timing tab fastened to the crankcase front cover and the engine is in the number 1 firing position. This may be determined by placing fingers on the number 1 valve as the mark on the damper comes near the "O" mark on the crankcase front cover. If the valves are not moving, the engine is in the number 1 firing position. If the valves move as the mark comes up to the timing tab, the engine is in number 6 (Number 4 on V6) firing position and should be turned over

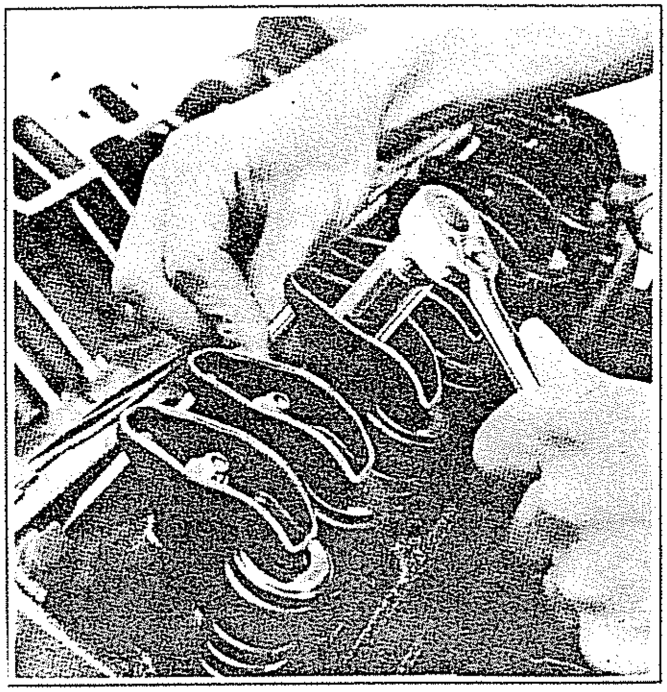


Fig. 6A2-10–Valve Adjustment - Typical

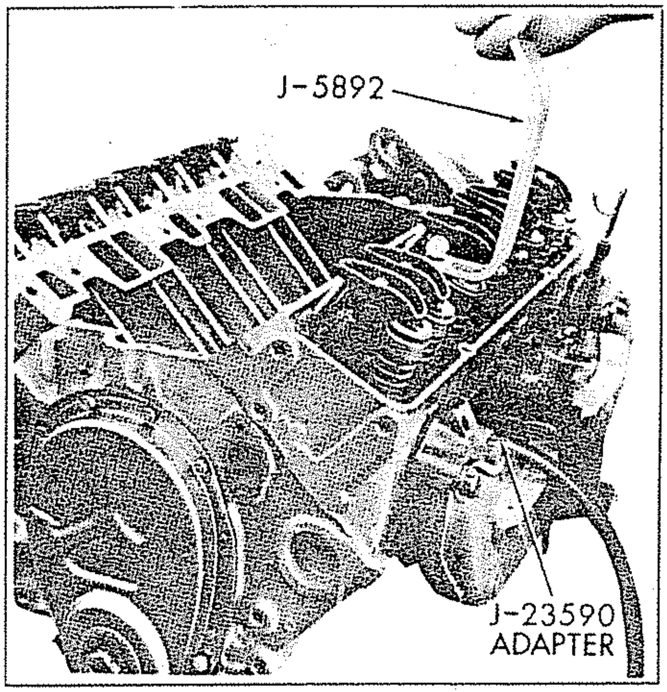


Fig. 6A2-11–Compressing Valve Spring

one more time to reach the number 1 position.

b. With the engine in the number 1 firing position as determined above, the following valves may be adjusted.

- V8-Exhaust—1, 3, 4, 8
- V6-Exhaust—1, 5, 6
- V8-Intake—1, 2, 5, 7
- V6-Intake—1, 2, 3

c. Back out adjusting nut until lash is felt at the push rod then turn in adjusting nut until all lash is removed. This can be determined by rotating push rod while turning adjusting nut (Fig. 6A2-10). When play has been removed, turn adjusting nut in one full additional turn (to center lifter plunger).

d. Crank the engine one revolution until the pointer "O" mark and torsional damper mark are again in alignment. This is number 6 (number 4 on V6) firing position. With the engine in this position the following valves may be adjusted.

- V8-Exhaust—2, 5, 6, 7
- V6-Exhaust—2, 3, 4
- V8-Intake—3, 4, 6, 8
- V6-Intake—4, 5, 6

4. Install rocker arm covers as previously outlined.
5. Start engine and adjust carburetor idle speed.

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1. Install new valve stem oil seal (coated with oil) in position over valve guide.

NOTE: Seal installation instructions are supplied with each service kit. Install seal following procedures outlined on the supplied instruction sheet.

2. Set the valve spring and damper and valve cap in place.
3. Compress the spring with Tool J-5892 and install the valve locks then release the compressor tool, making sure the locks seat properly in the groove of the valve stem.

   NOTE: Grease may be used to hold the locks in place while releasing the compressor tool.
4. Install spark plug, and torque to specifications.
5. Install and adjust valve mechanism as previously outlined.

VALVE STEM OIL SEAL and/or VALVE SPRING

Removal

1. Remove rocker arm cover as previously outlined.
2. Remove spark plug, rocker arm and push rod on the cylinder(s) to be serviced.
3. Install air line adapter Tool J-23590 to spark plug port and apply compressed air to hold the valves in place.
4. Using Tool J-5892 to compress the valve spring, remove the valve locks, valve cap and valve spring and damper (Fig. 6A2-11).
5. Remove the valve stem oil seal.

Installation

1. Set the valve spring and damper, valve shield and valve cap in place. Compress the spring

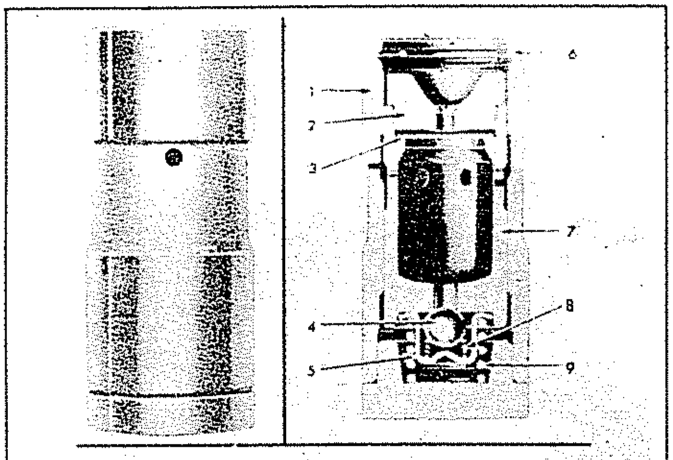

Fig. 6A2-12–Hydraulic Valve Lifter

with Tool J-5892 and install oil seal in the lower groove of the stem, making sure the seal is flat and not twisted.

NOTE: A light coat of oil on the seal will help prevent twisting.

2. Install the valve locks and release the compressor tool making sure the locks seat properly in the upper groove of the valve stem.

   NOTE: Grease may be used to hold the locks in place while releasing the compressor tool.

3. Using tool J-23994, apply vacuum to the valve cap to make sure no air leaks past the seal.
4. Install spark plug and torque to 22 lb. ft. (30N•m).
5. Install and adjust valve mechanism as previously outlined.

454 ENGINE

1. Install new valve stem oil seal (coated with oil) in position over valve guide.

   NOTE: Seal installation instructions are supplied with each service kit. Install seal following procedures outlined on the supplied instruction sheet.

2. Set the valve spring and damper and valve cap in place.
3. Compress the spring with Tool J-5892 and install the valve locks then release the compressor tool, making sure the locks seat properly in the groove of the valve stem.

   NOTE: Grease may be used to hold the locks in place while releasing the compressor tool.

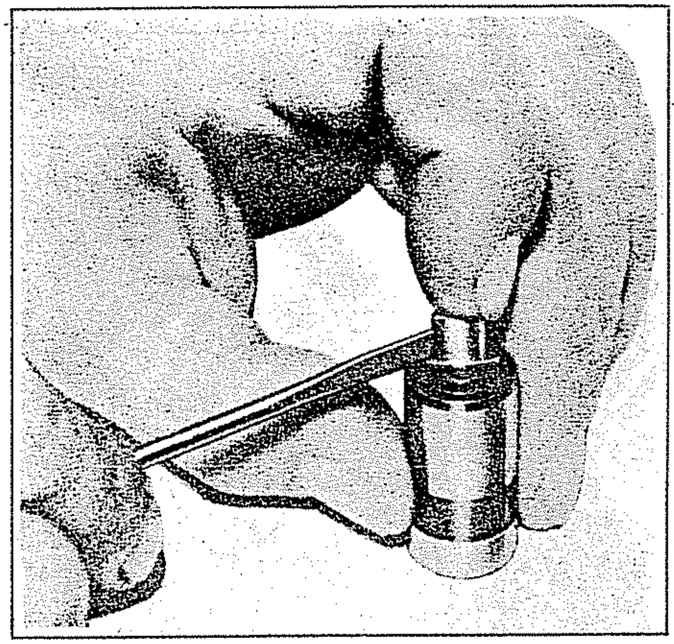

Fig. 6A2-13–Removing Ball Check Valve

4. Install spark plug, and torque to specifications.
5. Install and adjust valve mechanism as previously outlined.

VALVE LIFTERS

Hydraulic valve lifters very seldom require attention. The lifters are extremely simple in design, readjustments are not necessary, and servicing of the lifters requires only that care and cleanliness be exercised in the handling of parts.

Locating Noisy Lifters

Locate a noisy valve lifter by using a piece of garden hose approximately four feet in length. Place one end of the hose near the end of each intake and exhaust valve with the other end of the hose to the ear. In this manner, the sound is localized making it easy to determine which lifter is at fault.

Another method is to place a finger on the face of the valve spring retainer. If the lifter is not functioning properly, a distinct shock will be felt when the valve returns to its seat.

The general types of valve lifter noise are as follows:

1. Hard Rapping Noise—Usually caused by the plunger becoming tight in the bore of the lifter body to such an extent that the return spring can no longer push the plunger back up to working position. Probable causes are:
   a. Excessive varnish or carbon deposit causing abnormal stickiness.
   b. Galling or "pick-up" between plunger and bore of lifter body, usually caused by an abrasive piece of dirt or metal wedging

between plunger and lifter body.

2. Moderate Rapping Noise—Probable causes are:

   a. Excessively high leakdown rate.
   b. Leaky check valve seat.
   c. Improper adjustment.

3. General Noise Throughout the Valve Train—This will, in most cases, be caused by either insufficient oil supply or improper adjustment.
4. Intermittent Clicking—Probable causes are:

   a. A microscopic piece of dirt momentarily caught between ball seat and check valve ball.
   b. In rare cases, the ball itself may be out-of-round or have a flat spot.
   c. Improper adjustment.

In most cases where noise exists in one or more lifters all lifter units should be removed, disassembled, cleaned in a solvent, reassembled, and reinstalled in the engine. If dirt, corrosion, carbon, etc. is shown to exist in one unit, it more likely exists in all the units, thus it would only be a matter of time before all lifters caused trouble.

Removal

1. Remove intake manifold as previously outlined.
2. Remove valve mechanism as previously outlined.
3. Remove valve lifters.

   NOTE: Place valve lifters in a rack so that they may be reinstalled in the same location.

Installation

1. Install valve lifters.

   NOTE: Whenever new valve lifters are being installed, coat foot of valve lifters with "Molykote" or its equivalent. Make sure lifter foot is convex.

2. Install intake manifold as previously outlined.
3. Install and adjust valve mechanism as outlined.

Dissassembly

1. Hold the plunger down with a push rod, and using the blade of a small screw driver, remove the push rod seat retainer.
2. Remove the push rod seat and metering valve (Fig. 6A2-12).
3. Remove the plunger, ball check valve assembly and the plunger spring.
4. Remove the ball check valve and spring by prying the ball retainer loose from the plunger with the blade of a small screw driver (Fig. 6A2-13).

Cleaning and Inspection

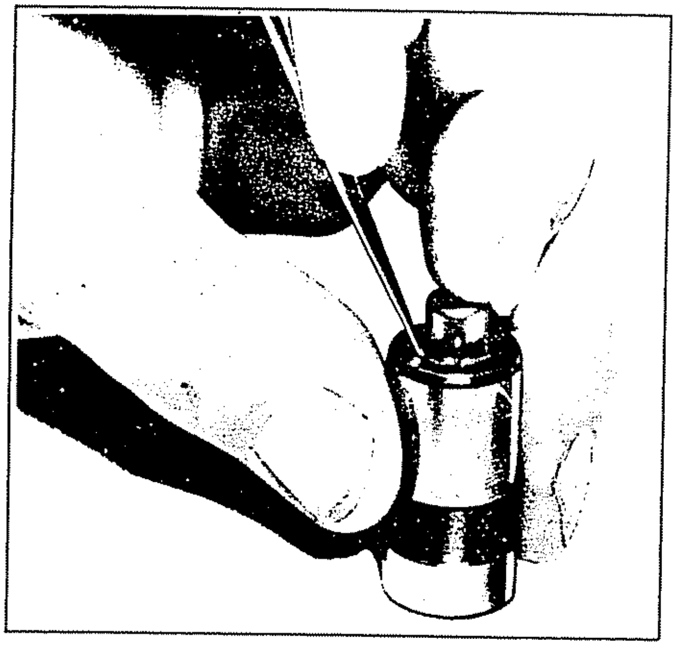

Fig. 6A2-14--Installing Ball Check Valve

Thoroughly clean all parts in cleaning solvent, and inspect them carefully. If any parts are damaged or worn, the entire lifter assembly should be replaced. If the lifter body wall is scuffed or worn, inspect the cylinder block lifter bore. If the bottom of the lifter is scuffed or worn, inspect the camshaft lobe. If the push rod seat is scuffed or worn, inspect the push rod. An additive containing EP lube, such as EOS, should always be added to crankcase oil for run-in when any new camshaft or lifters are installed. All damaged or worn lifters should be replaced.

NOTE: For proper lifter rotation during engine operation, lifter foot must be convex.

Assembly

1. Place the check ball on small hole in bottom of the plunger.
2. Insert check ball spring on seat in ball retainer and place retainer over ball so that spring rests on the ball. Carefully press the retainer into position in plunger with the blade of a small screw driver (Fig. 6A2-14).
3. Place the plunger spring over the ball retainer and slide the lifter body over the spring and plunger, being careful to line up the oil feed holes in the lifter body and plunger.
4. Fill the assembly with SAE-10 oil, then insert the end of a 1/8" drift pin into the plunger and press down solid. At this point, oil holes in the lifter body and plunger assembly will be aligned (Fig. 6A2-15).

   CAUTION: *Do not attempt to force or pump the plunger.*

5. Insert a 1/16" drift pin through both oil holes to hold the plunger down against the lifter spring

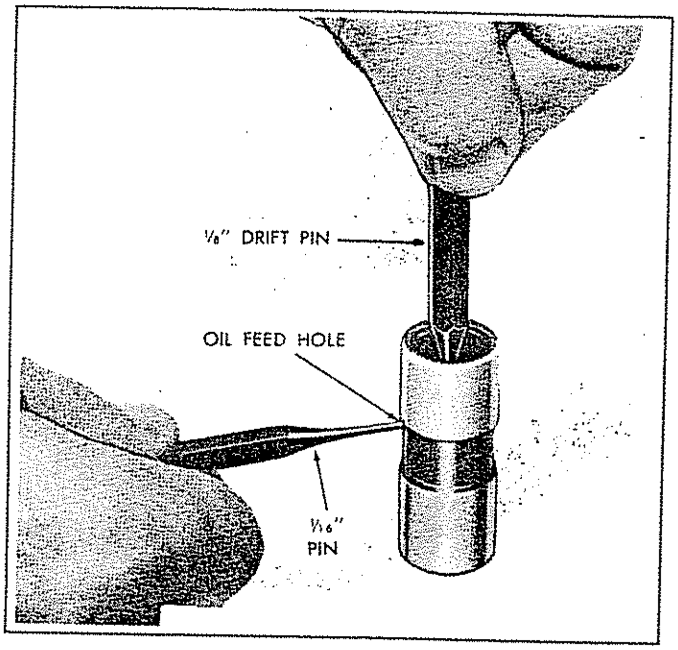

Fig. 6A2-15–Assembling Hydraulic Lifter

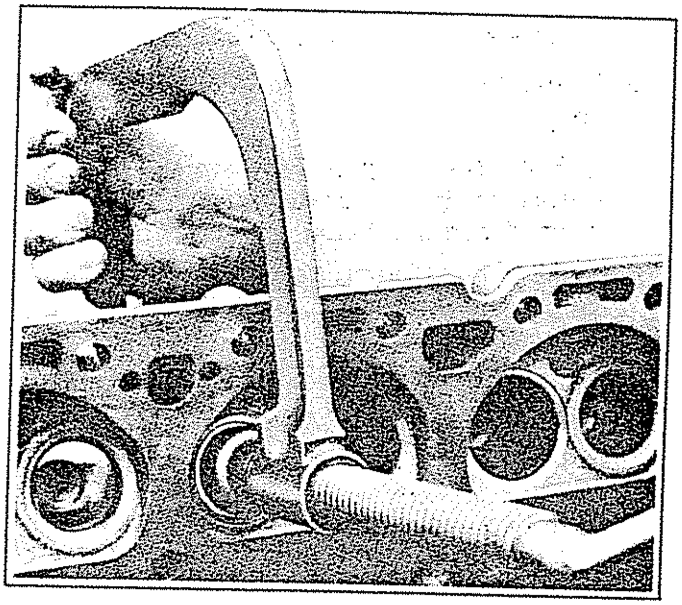

Fig. 6A2-16–Compressing Valve Spring-Typical

tension (Fig. 6A2-15).

6. Remove the 1/8" drift pin, refill assembly with SAE-10 oil.
7. Install the metering valve and push rod seat (Fig. 6A2-12).
8. Install the push rod seat retainer, press down on the push rod seat and remove the 1/16" drift pin from the oil holes. The lifter is now completely assembled, filled with oil and ready for installation.

NOTE: Before installing lifters, coat the bottom of the lifter with "Molykote" or its equivalent.

CYLINDER HEAD ASSEMBLY

Removal

1. Remove intake manifold as previously outlined.
2. Remove alternator mounting bracket and lay unit aside.
3. Remove exhaust manifolds as previously outlined.
4. Remove valve mechanism as previously outlined.
5. Drain cylinder block of coolant.
6. Remove cylinder head bolts, cylinder head and gasket. Place cylinder head on two blocks of wood to prevent damage.

Disassembly

1. With cylinder head removed, remove valve rocker arm nuts, balls and rocker arms (if not previously done).
2. Using Tool J-8062, compress the valve springs (Fig. 6A2-16) and remove valve keys. Release the compressor tool and remove rotators or spring caps, oil shedders (if so equipped) springs and spring damper, then remove oil seals and valve spring shims (if used).
3. Remove valves from cylinder head and place them in a rack in their proper sequence so that they can be assembled in their original positions.

Cleaning

1. Clean all carbon from combustion chambers and valve ports using Tool J-8089 (Fig. 6A2-17).
2. Thoroughly clean the valve guides using Tool J-8101 (Fig. 6A2-18).
3. Clean all carbon and sludge from push rods, rocker arms and push rod guides.
4. Clean valve stems and heads on a buffing wheel.
5. Clean carbon deposits from head gasket mating surface.

Inspection

1. Inspect the cylinder heads for cracks in the exhaust ports, combustion chambers, or external cracks to the water chamber.
2. Inspect the valves for burned heads, cracked faces or damaged stems.

NOTE: Excessive valve stem to bore clearance will cause excessive oil consumption and may cause valve breakage. Insufficient clearance will result in noisy and sticky functioning of the valve and disturb engine smoothness.

3. Measure valve stem clearance (Fig. 6A2-19) as follows: Clamp a dial indicator on one side of the cylinder head rocker arm cover gasket rail, locating the indicator so that movement of the

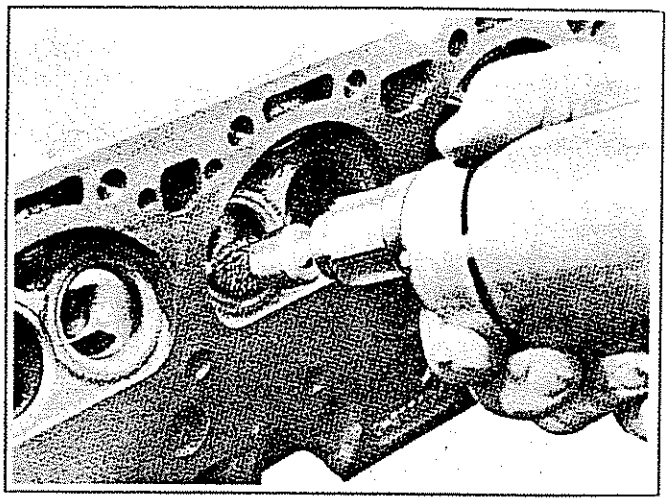

Fig. 6A2-17--Cleaning Combustion Chambers-Typical

valve stem from side to side (crosswise to the head) will cause a direct movement of the indicator stem. The indicator stem must contact the side of the valve stem just above the valve guide. With the valve head dropped about 1/16" off the valve seat; move the stem of the valve from side to side using light pressure to obtain clearance reading. If clearance exceeds specifications it will be necessary to ream valve guides for oversize valves.

NOTE: Service valves are available in standard, .003", .015" and .030" oversize.

4. Check valve spring tension with Tool J-8056 spring tester (Fig. 6A2-20).

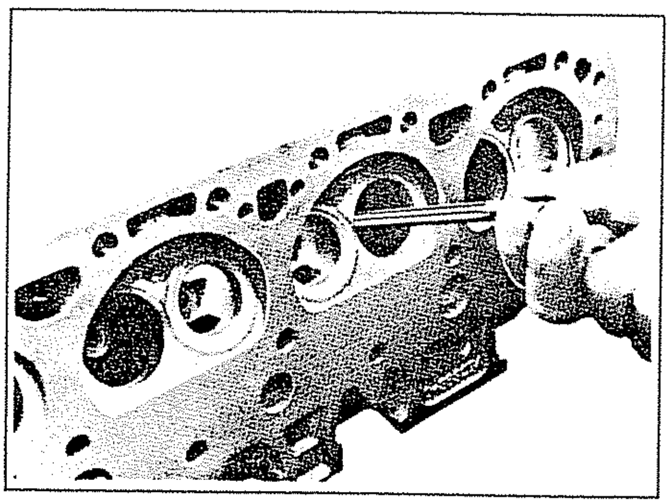

Fig. 6A2-18--Cleaning Valve Guides-Typical

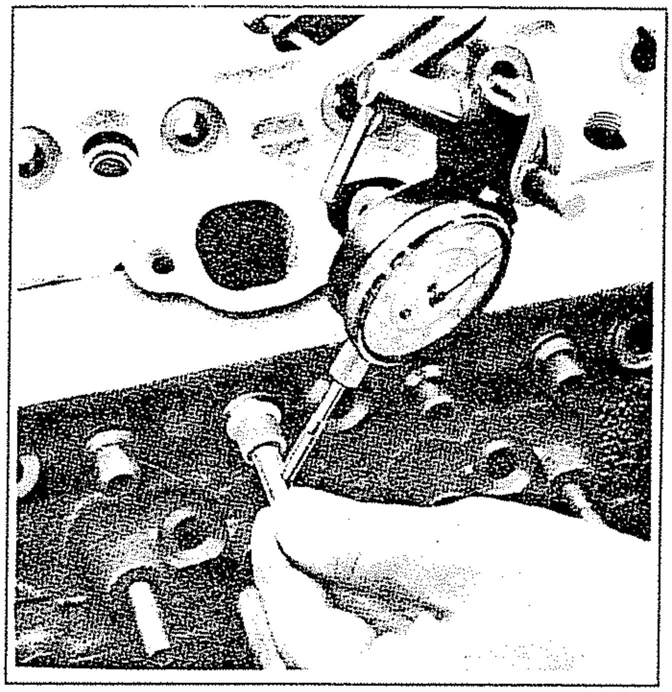

Fig. 6A2-19--Measuring Valve Stem Clearances-Typical

NOTE: Springs should be compressed to the specified height and checked against the specifications chart. Springs should be replaced if not within 10 lbs. of the specified load (without dampers).

5. Inspect rocker arm studs for wear or damage. On 454 engines inspect push rod guides for wear or damage.

Assembly

1. Insert a valve in the proper port.

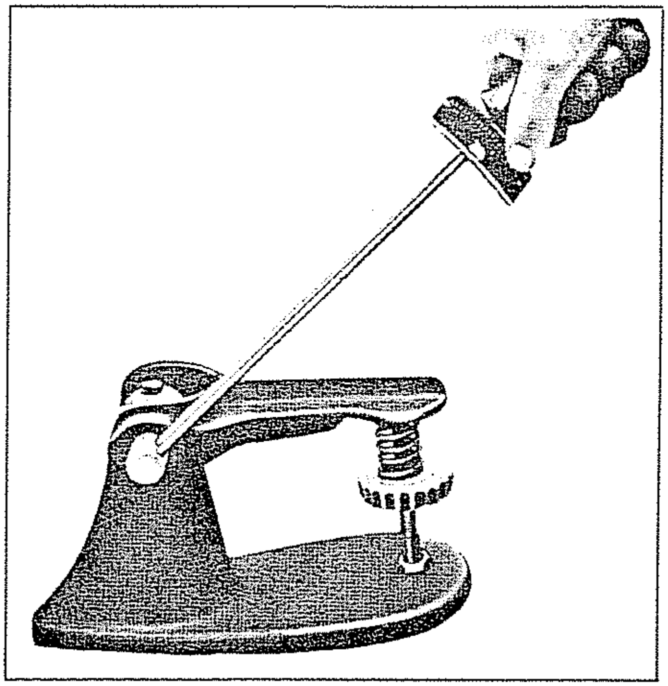

Fig. 6A2-20--Checking Valve Spring Tension

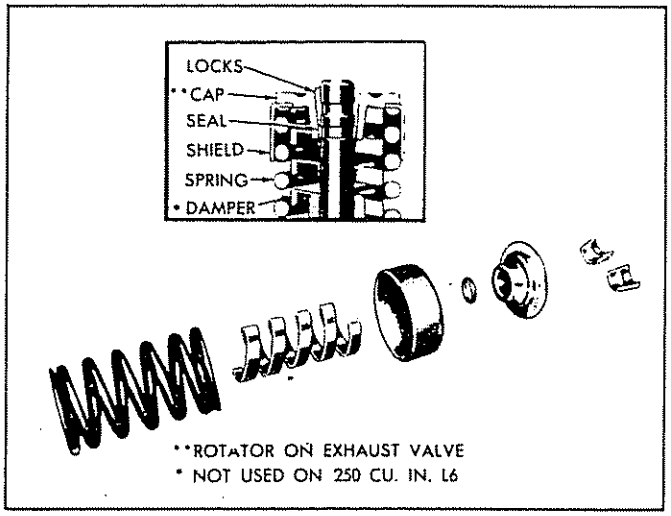

Fig. 6A2-26–Valve Spring Installation – Small V-8

2. Assemble the valve spring and related parts as follows:
   a. Set the valve spring shim (if used), valve spring (with damper if used), oil shedder and valve cap or rotator in place.
   b. Compress the spring with Tool J-8062.
   c. Install oil seal in the lower groove of the stem, making sure that the seal is flat and not twisted.
   d. Install the valve locks and release the compressor tool making sure that the locks seat properly in the upper groove of the valve stem.

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   a. Install valve spring shim on valve spring seat then install a new valve stem oil seal over valve and valve guide.
   b. Set the valve spring (with damper); and valve cap in place (Fig. 6A2-27).
   c. Compress the spring with Tool J-8062.
   d. Install the valve locks and release the compressor tool, making sure the locks seat properly in the groove of the valve stem.

   NOTE: Grease may be used to hold the locks in place, while releasing the compressor tool.

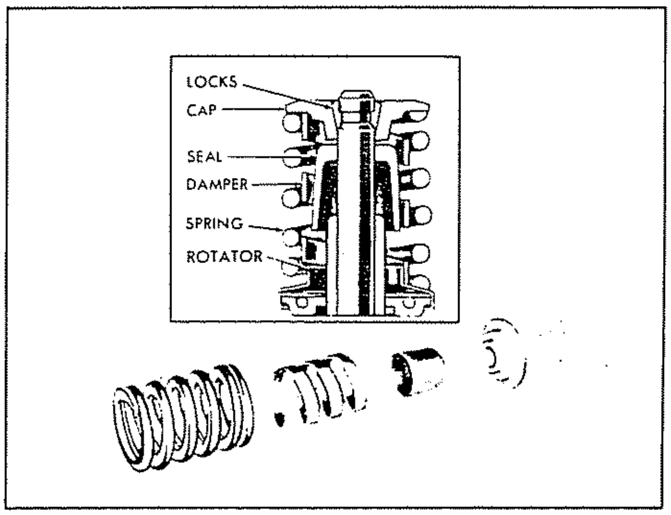

Fig. 6A2-27 - Valve Spring Installation — 454

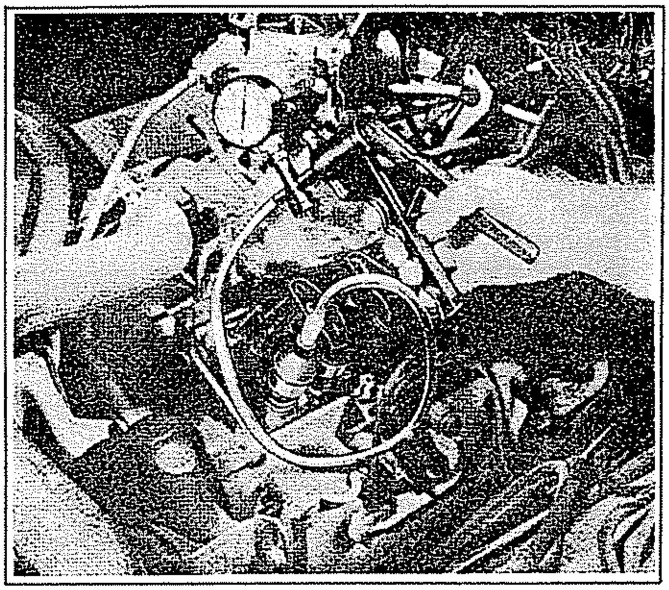

Fig. 6A2-21 — Checking Valve Stem Oil Seals — Small V-8

3. Install the remaining valves.
4. Check each valve stem oil seal by placing Valve Seal Leak Detector (Tool J-23994) over the end of the valve stem and against the cap. Operate the vacuum pump and make sure no air leaks past the seal (Fig. 6A2-21).
5. Check the installed height of the valve springs, using a narrow thin scale. A cutaway scale will help (Fig. 6A2-22). Measure from the top of the shim or the spring seat to the top of the valve spring or oil shedder. If this is found to exceed the specified height, install a valve spring seat shim approximately 1/16" thick. At no time should the spring be shimmed to give an installed height under the minimum specified.

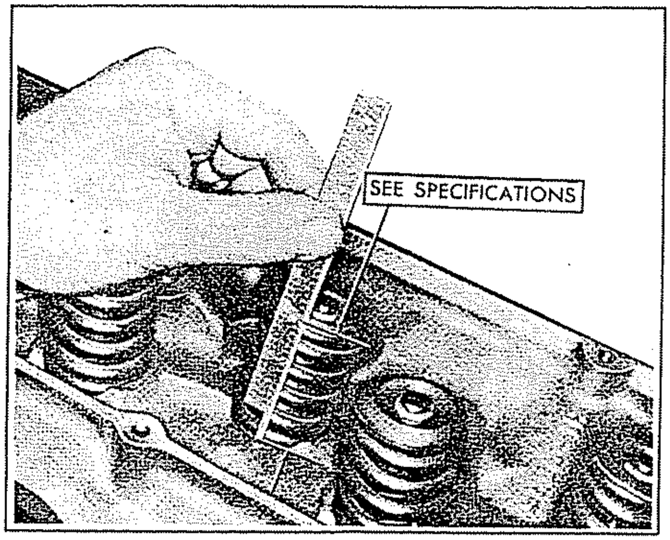

Fig. 6A2-22 — Measuring Valve Spring Installed Height

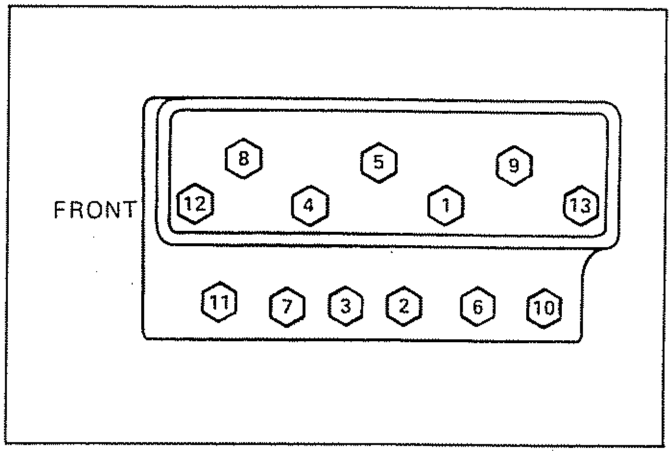

Fig. 6A2-23--Cylinder Head Torque Sequence--V-6

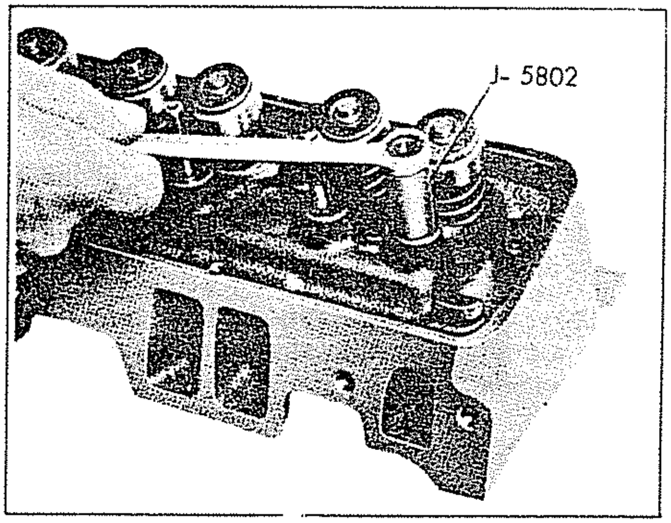

Fig. 6A2-24--Removing Rocker Arm Stud

Installation

CAUTION: *The gasket surfaces on both the head and the block must be clean of any foreign matter and free of nicks or heavy scratches. Cylinder bolt threads in the block and threads on the cylinder head bolts must be clean. (Dirt will affect bolt torque).*

1. On engines using a STEEL gasket, coat both sides of a new gasket with a good sealer. Spread the sealer thin and even. One method of applying the sealer that will assure the proper coat is with the use of a paint roller. Too much sealer may hold the gasket away from the head or block.

   CAUTION: *Use no sealer on engines using a composition STEEL ASBESTOS gasket.*

2. Place the gasket in position over the dowel pins with the bead up.
3. Carefully guide the cylinder head into place over the dowel pins and gasket.
4. Coat threads of cylinder head bolts with sealing compound and install bolts finger tight.
5. Tighten each cylinder head bolt a little at a time until the specified torque is reached (Fig. 6A2-23).
6. Install exhaust manifolds as previously outlined.
7. Install intake manifolds as previously outlined.
8. Install and adjust valve mechanism as previously outlined.

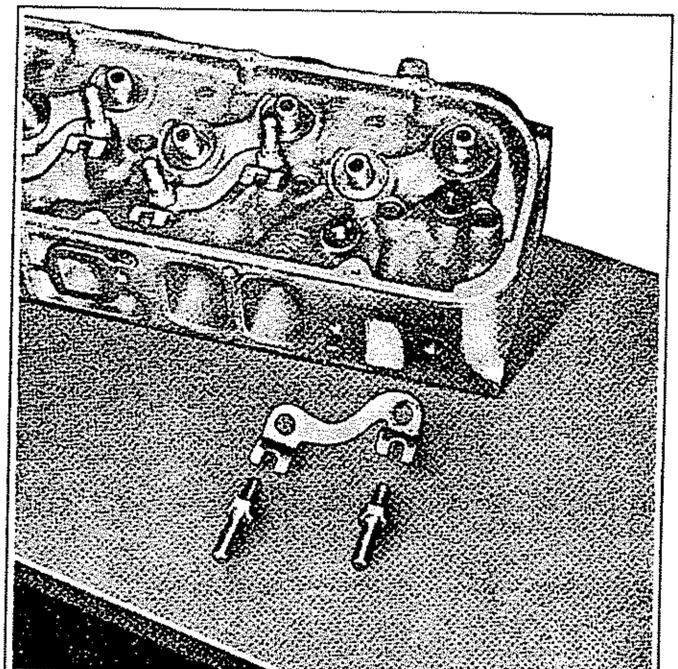

Fig. 6A2-31--Rocker Arm Stud & Push Rod Guide

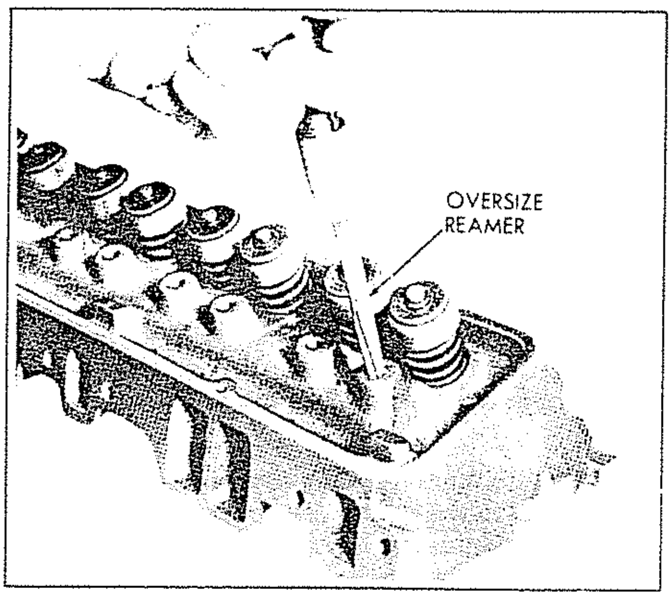

Fig. 6A2-25--Reaming Rocker Arm Stud Bore

ROCKER ARM STUDS

Replacement

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The push rod guides are related to the cylinder head by the rocker arm studs. (Fig. 6A2-31). Replace where necessary and torque rocker arm studs to specifications.

NOTE: Coat Threads on cylinder head end of rocker arm studs with sealer before assembly to cylinder head.

OTHER ENGINES

Replacement

Rocker arm studs that have damaged threads or are loose in cylinder heads should be replaced with new studs available in .003" and .013" oversize. Studs may be installed after reaming the holes as follows:

1. Remove old stud by placing Tool J-5802-1 over the stud, installing nut and flat washer and removing stud by turning nut (Fig. 6A2-24).
2. Ream hole for oversize stud using Tool J-5715 for .003" oversize or Tool J-6036 for .013" oversize (Fig. 6A2-25).

   CAUTION: *Do not attempt to install an oversize stud without reaming stud hole.*

3. Coat press-fit area of stud with hypoid axle lubricant. Install new stud, using Tool J-6880 as a guide. Gage should bottom on head.

VALVE GUIDE BORES

Valves with oversize stems are available (see specifications). To ream the valve guide bores for oversize valves use Tool Set J-5830 or J-7049 for 454 Engines.

VALVE SEATS

Reconditioning the valve seats is very important, because the seating of the valves must be perfect for the engine to deliver the power and performance built into it.

Another important factor is the cooling of the valve heads. Good contact between each valve and its seat in the head is imperative to insure that the heat in the valve head will be properly carried away.

Several different types of equipment are available for reseating valves seats. The recommendations of the manufacturer of the equipment being used should be carefully followed to attain proper results.

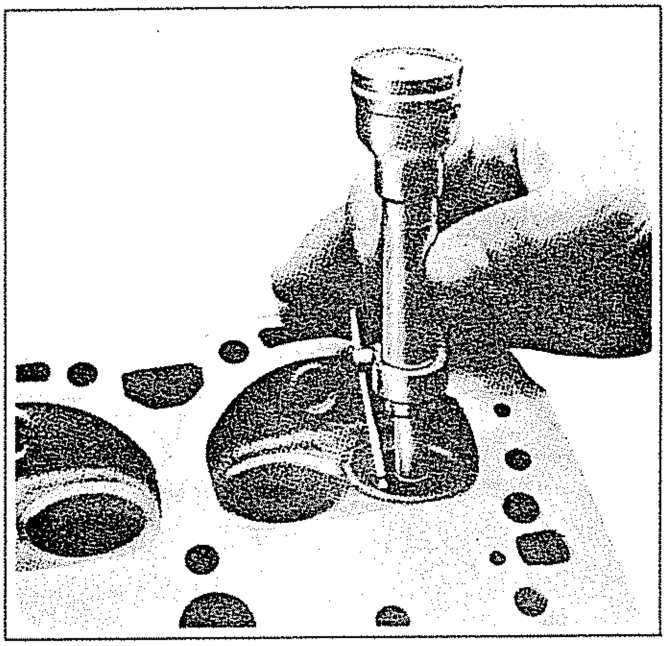


Fig. 6A2-27--Measuring Valve Seat Concentricity

Regardless of what type of equipment is used, however, it is essential that valve guide bores be free from carbon or dirt to ensure proper centering of pilot in the guide.

Reconditioning

1. Install expanding pilot in the valve guide bore and expand pilot.
2. Place roughing stone or forming stone over pilot and just clean up the valve seat. Use a stone cut to specifications.
3. Remove roughing stone or forming stone from pilot, place finishing stone, cut to specifications, over pilot and cut just enough metal from the seat to provide a smooth finish. Refer to specifications.
4. Narrow down the valve seat to the specified width.

   NOTE: This operation is done by grinding the port side with a 30 degree stone to lower seat and a 60 degree stone to raise seat.

5. Remove expanding pilot and clean cylinder head carefully to remove all chips and grindings from above operations.
6. Measure valve seat concentricity (Fig. 6A2-27).

   NOTE: Valve seats should be concentric to within .002" total indicator reading.

VALVES

Valves that are pitted can be refaced to the proper angle, insuring correct relation between the head and stem on a valve refacing mechanism. Valve stems which show excesisive wear, or valves that are warped excessively should be replaced. When a valve head which is warped excessively is refaced, a knife edge will be ground on part or all of the valve head due to the amount of metal that must be removed to completely reface. Knife edges lead to breakage, burning or pre-ignition due to heat localizing on this knife edge. If the edge of the valve head is less than 1/32" thick after grinding, replace the valve.

Several different types of equipment are available for refacing valves. The recommendation of the manufacturer of the equipment being used should be carefully followed to attain proper results.

Reconditioning

1. If necessary, dress the valve refacing machine grinding wheel to make sure it is smooth and true. Set chuck at angle specified for valve. Refer to specifications.
2. Clamp the valve stem in the chuck of the machine.
3. Start the grinder and move the valve head in line with the grinder wheel.
4. Turn the feed screw until the valve head just contacts wheel. Move valve back and forth across the wheel and regulate the feed screw to provide light valve contact.
5. Continue grinding until the valve is true and smooth all around the valve. If this makes the valve head thin (1/32" min.) the valve must be replaced as the valve will overheat and burn.
6. Remove valve from chuck and place stem in "V" block. Feed valve squarely against grinding wheel to grind any pit from rocker arm end of stem.

   NOTE: Only the extreme end of the valve stem is hardened to resist wear. Do not grind end of stem excessively.

7. After cleaning valve face and cylinder head valve seat of grinding particles, make pencil marks about 1/4" apart across the valve face, place the valve in cylinder head and give the valve 1/2 turn in each direction while exerting firm pressure on head of valve.
8. Remove valve and check face carefully. If all pencil marks have not been removed at the point of contact with the valve seat, it will be necessary to repeat the refacing operation and again recheck for proper seating.
9. Grind and check the remaining valves in the same manner.

TORSIONAL DAMPER

Removal

1. Remove drive belts and pulley.
2. Remove accessory drive pulley then remove damper retaining bolt.
3. Install Tool J-23523 on damper then, turning puller screw, remove damper.

   NOTE: Tool J-23523 has holes forming two patterns—a two bolt and a three bolt pattern. The holes for the two bolt pattern must be elongated for use on the 454 V8 engines.

Installation

CAUTION: *The inertial weight section of the torsional damper is assembled to the hub with a rubber type material. The installation procedures (with proper tool) must be followed or movement of the inertia weight section on the hub will destroy the tuning of the torsional damper.*

1. Coat front cover seal contact area (on damper) with engine oil.
2. Place damper in position over key on crankshaft.
3. Pull damper onto crankshaft as follows:
   a. Install appropriate threaded end of Tool J-23523 into crankshaft.

   CAUTION: *Install tool in crankshaft so that at least 1/2" of thread engagement is obtained.*

   b. Install plate, thrust bearing and nut to complete tool installation.
   c. Pull damper into position as shown in Figure 6A2-28.
   d. Remove tool from crankshaft then install damper retaining bolt and torque to specifications.
4. Install accessory drive pulley.
5. Install drive belts and adjust to specifications

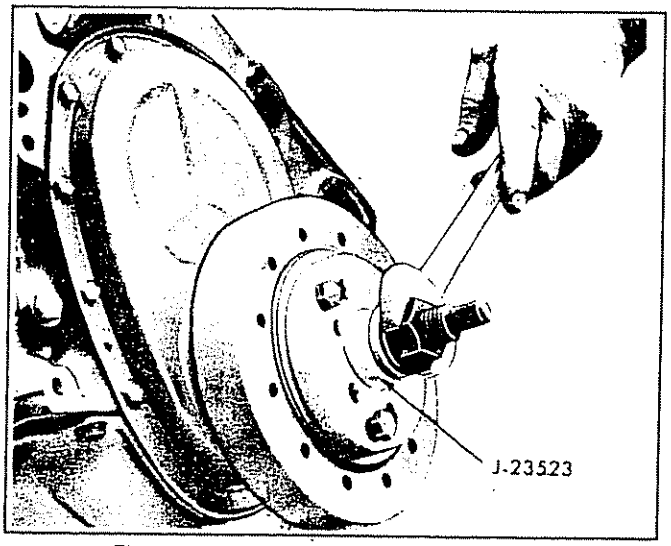


Fig. 6A2-28 — Installing Torsional Damper

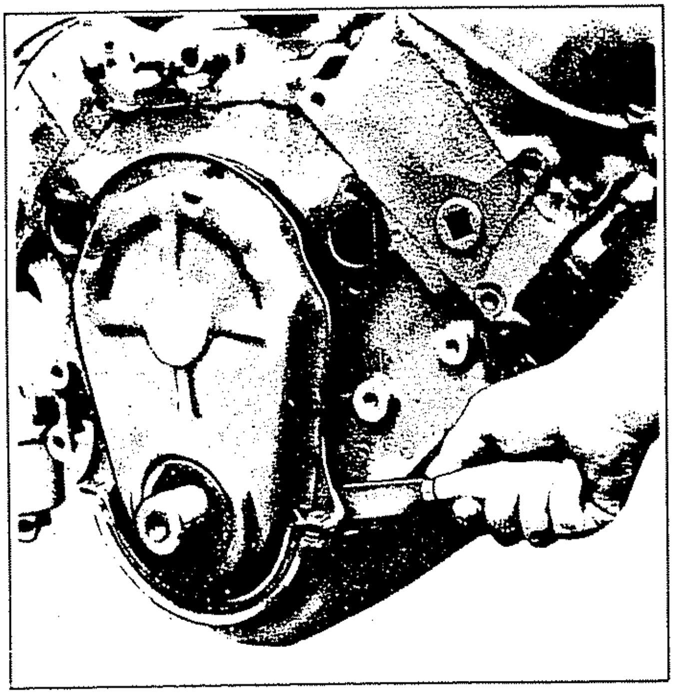


Fig. 6A2-38--Cutting Tabs on Oil Pan Front Seal

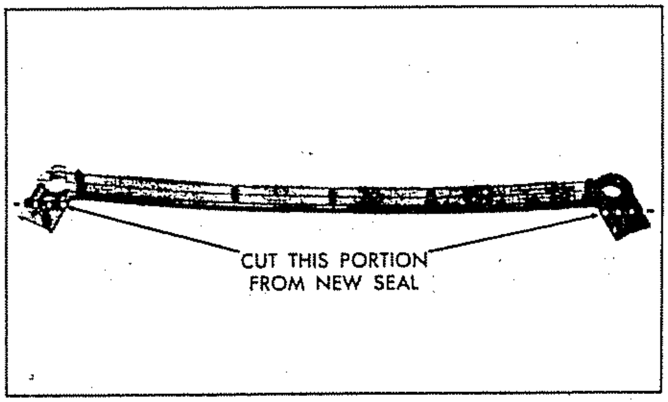


Fig. 6A2-39--Oil Pan Front Seal Modification

using strand tension gage.

6. Fill cooling system, start engine and check for leaks.

CRANKCASE FRONT COVER

Removal

1. Remove torsional damper as previously outlined.
2. Remove water pump.
3. Remove crankcase front cover attaching screws and remove front cover and gasket then discard gasket.

454 V8 ENGINE

1. Remove torsional damper and water pump as outlined.
2. Remove the two, oil pan-to-front cover attaching screws.
3. Remove the front cover-to-block attaching screws.
4. Pull the cover slightly forward only enough to permit cutting of oil pan front seal.
5. Using a sharp knife or other suitable cutting tool, cut oil pan front seal flush with cylinder block at both sides of cover (Fig. 6A2-38).
6. Remove front cover and attaching portion of oil pan front seal. Remove front cover gasket.

Installation

1. Clean gasket surface on block and crankcase front cover.
2. Use a sharp knife or other suitable cutting tool, to remove any excess oil pan gasket material that may be protruding at the oil to engine block junction.
3. Apply a 1/8 inch bead of silicone rubber sealer, part #1051435 (or equivalent) to the joint formed at the oil pan and cylinder block.
4. Coat the cover gasket with gasket sealer and place in position on cover.
5. Install cover-to-oil pan seal, lightly coat bottom of seal with engine oil, and position cover over crankshaft end.
6. Loosely install the cover-to-block, upper attaching screws.
7. Tighten screws alternately and evenly while pressing downward on cover so that dowels in block are aligned with corresponding holes in cover.

   NOTE: Position cover so that dowels enter holes in cover without binding. Do not force cover over dowels so that cover flange or holes are distorted.

8. Install remaining cover screws and torque to specifications.
9. Install torsional damper and water pump as previously outlined.

454 V8 Engine

1. Clean gasket surface on block and crankcase front cover.
2. Cut tabs from the new oil pan front seal (Fig. 6A2-39). Use a sharp instrument to ensure a clean cut.
3. Install seal to front cover, pressing tips into holes provided in cover.
4. Coat the gasket with gasket sealer and place in position on cover.
5. Apply a 1/8 inch bead of silicone rubber sealer, part #1051435 (or equivalent) to the joint formed at the oil pan and cylinder block (Fig. 6A2-40).
6. Position crankcase front cover over crankshaft.

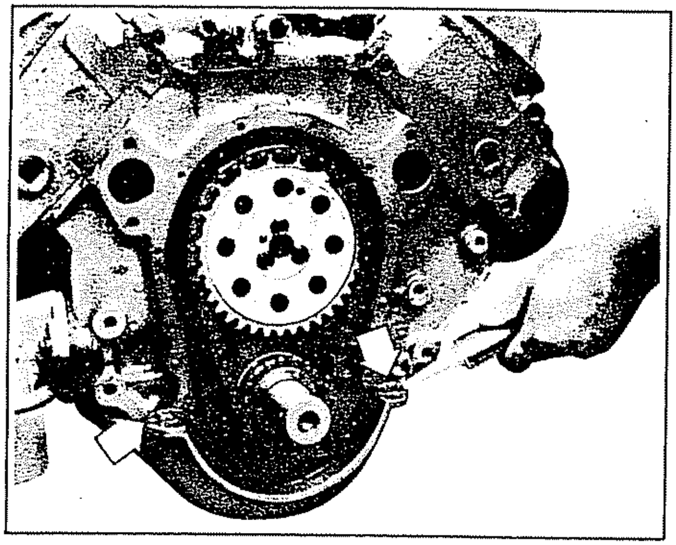


Fig. 6A2-40--Applying Front Cover Sealer

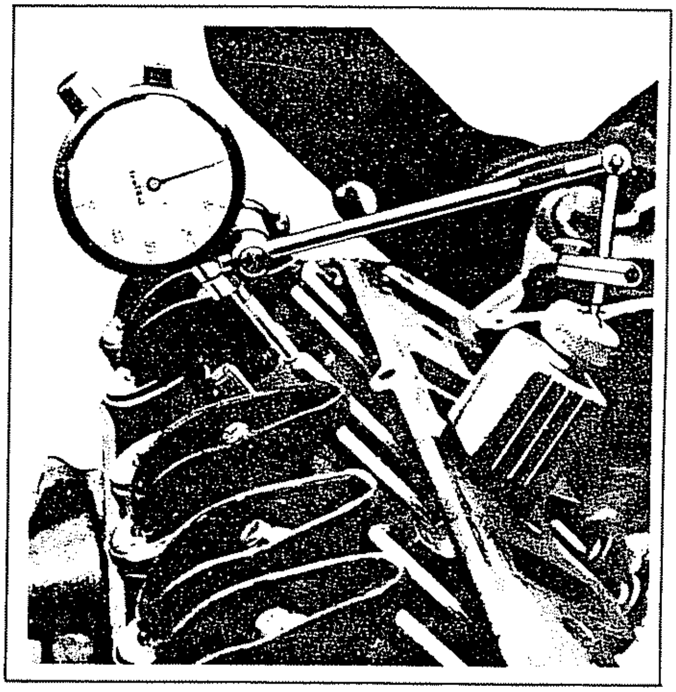


Fig. 6A2-30--Measuring Camshaft Lobe Lift

7. Press cover downward against oil pan until cover is aligned and installed over dowel pins on block.
8. Install and partially tighten the two, oil pan-to-front cover attaching screws.
9. Install the front cover-to-block attaching screws.
10. Torque all screws to specifications.
11. Install torsional damper and water pump as previously outlined.

OIL SEAL (FRONT COVER)

Replacement

With Cover Removed

1. With cover removed, pry oil seal out of cover from the front with a large screw driver.
2. Install new seal so that open end of the seal is toward the inside of cover and drive it into position with Tool J-23042 or Tool J-221002 on 454 Engine.

CAUTION: *Support cover at seal area. (Tool J-971 may be used as support).*

With Cover Installed

1. With torsional damper removed, pry seal out of cover from the front with a large screw driver, being careful not to damage the surface on the crankshaft.
2. Install new seal so that open end of seal is toward the inside of cover and drive it into position with Tool J-23042 or Tool J-221002 on 454 Engine.

CAMSHAFT

Measuring Lobe Lift

NOTE: Procedure is similar to that used for checking valve timing. If improper valve operation is indicated, measure the lift of each push rod in consecutive order and record the readings.

1. Remove the valve mechanism as previously outlined.
2. Position indicator with ball socket adapter (Tool J-8520) on push rod (Fig. 6A2-30).

NOTE: Make sure push rod is in the lifter socket.

3. Rotate the crankshaft slowly in the direction of rotation until the lifter is on the heel of the cam lobe. At this point, the push rod will be in its lowest position.
4. Set dial indicator on zero, then rotate the crankshaft slowly, or attach an auxiliary starter switch and "bump" the engine over, until the push rod is fully raised position.

CAUTION: *Whenever the engine is cranked remotely at the starter, with a special jumper cable or other means, the distributor primary lead must be disconnected from the coil*

5. Compare the total lift recorded from the dial indicator with specifications.

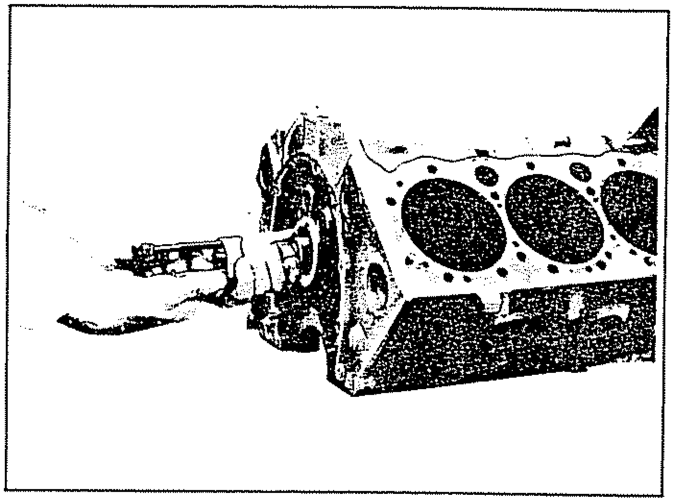


Fig. 6A2-31–Removing Camshaft

6. If camshaft readings for all lobes are within specifications, remove dial indicator assembly.
7. Install and adjust valve mechanism as outlined.

Removal

1. Remove valve lifters as previously outlined.
2. Remove crankcase front cover as previously outlined.
3. Remove fuel pump push rod as outlined in Section 6C.
4. Complete camshaft removal as follows:

   NOTE: Sprocket is a light fit on camshaft. If sprocket does not come off easily a light blow on the lower edge of sprocket (with a plastic mallet) should dislodge the sprocket.

5. Install two 5/16" × 18 × 4" bolts in camshaft bolt holes then remove camshaft (Fig. 6A2-31).

   CAUTION: *All camshaft journals are the same diameter and care must be used in removing camshaft to avoid damage to bearings.*

Inspection

The camshaft bearing journals should be measured with a micrometer for an out-of-round condition. If the journals exceed .001" out-of-round, the camshaft should be replaced.

Installation

NOTE: Whenever a new camshaft is installed coat camshaft lobes with "Molykote" or its equivalent.

Whenever a new camshaft is installed, replacement of all valve lifters is recommended to insure durability of the camshaft lobes and lifter feet.

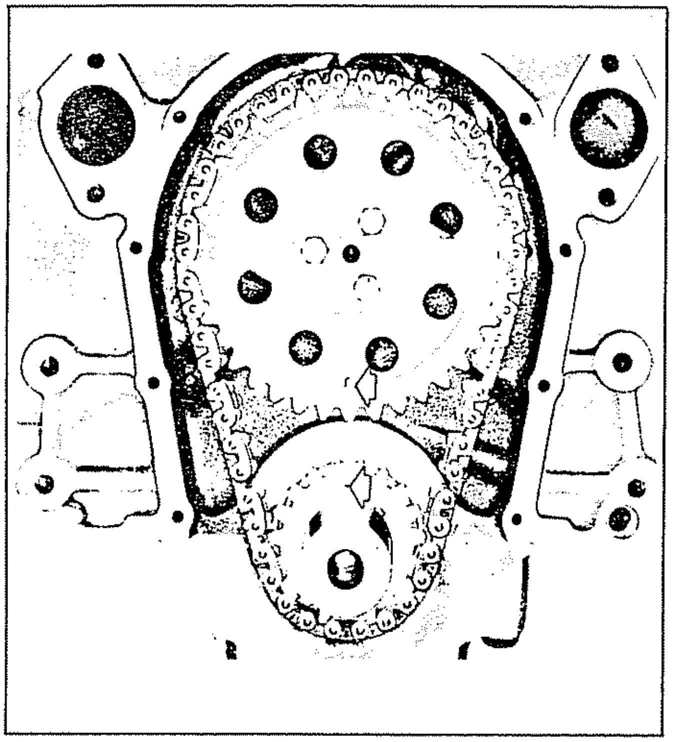


Fig. 6A2-32–Timing Sprocket Alignment Marks

1. Lubricate camshaft journals with engine oil and install camshaft.
2. Install timing chain on camshaft sprocket. Hold the sprocket vertically with the chain hanging down and align marks on camshaft and crankshaft sprockets. (Refer to Fig. 6A2-32). For right hand engines index timing gears to align sprocket marks.
3. Align dowel in camshaft with dowel hole in camshaft sprocket then install sprocket on camshaft.
4. Draw the camshaft sprocket onto camshaft using the mounting bolts. Torque to specifications.
5. Lubricate timing chain with engine oil.
6. Install fuel pump push rod and fuel pump.
7. Install crankcase front cover as previously outlined.
8. Install valve lifters as previously outlined.

CAMSHAFT BEARINGS

Removal

Camshaft bearings can be replaced while engine is disassembled for overhaul or without complete disassembly of the engine. To replace bearings without complete disassembly remove the camshaft and crankshaft leaving cylinder heads attached and pistons in place. Before removing crankshaft, tape threads of connecting rod bolts to prevent damage to crankshaft. Fasten connecting rods against sides of engine so they will not be in the way while replacing camshaft bearings.

1. With camshaft and crankshaft removed, drive camshaft rear plug from cylinder block.

   NOTE: This procedure is based on removal of the bearings nearest center of the engine first. With this method a minimum amount of turns are necessary to remove all bearings.

2. Using Tool J-6098, with nut and thrust washer installed to end of threads, index pilot in camshaft front bearing and install puller screw through pilot.
3. Install remover and installer tool with a shoulder toward bearing, making sure a sufficient amount of threads are engaged.
4. Using two wrenches, hold puller screw while turning nut. When bearing has been pulled from bore, remove remover and installer tool and bearing from puller screw.
5. Remove remaining bearings (except front and rear) in the same manner. It will be necessary to index pilot in camshaft rear bearing to remove the rear intermediate bearing.
6. Assemble remover and installer tool on driver handle and remove camshaft front and rear bearings by driving towards center of cylinder block.

Installation

The camshaft front and rear bearings should be installed first. These bearings will act as guides for the pilot and center the remaining bearings being pulled into place.

1. Assemble remover and installer tool on driver handle and install camshaft front and rear bearings by driving towards center of cylinder block.
2. Using Tool Set J-6098, with nut then thrust washer installed to end of threads, index pilot in camshaft front bearing and install puller screw through pilot.
3. Index camshaft bearing in bore (with oil hole aligned as outlined below), then install remover and installer tool on puller screw with shoulder toward bearing.
   a. Small V8 Engines—Number one cam bearing oil hole must be positioned so that oil holes are equidistant from 6 o'clock position. Number two through number four bearing oil holes must be positioned at 5 o'clock position (toward left side of engine, and at a position even with bottom of cylinder bore). Number five bearing oil hole must be in 12 o'clock position.
   b. 454-V8 Engines — Number one through number four cam bearing oil hole must be aligned with oil holes in cam bearing bore. The number five bearing bore is annulus, and cam bearing must be positioned at or near the 6 o'clock position.
4. Using two wrenches, hold puller screw while turning nut. After bearing has been pulled into bore, remove the remover and installer tool from puller screw and check alignment of oil hole in camshaft bearing.
5. Install remaining bearings in the same manner. It will be necessary to index pilot in the camshaft rear bearing to install the rear intermediate bearing.
6. Install a new camshaft rear plug.

   NOTE: Plug should be installed flush to 1/32" deep and be parallel with rear surface of cylinder block.

OIL PAN

Removal

1. Drain Oil from oil pan in a suitable container.
2. Turn engine over so pan is facing up.
3. Remove oil pan bolts and pan from engine block.

Installation

1. Clean sealing surfaces on cylinder case and oil pan.
2. Install oil pan with new gaskets and seals and torque retaining bolts to 80 lbs. in. (9N•m) or 135 lb. in (15 N•m for 454 engine).
3. Turn engine upright and fill crankcase with proper oil to the proper level.
4. Start engine and check for leaks.

OIL PUMP

Removal

1. Remove oil pan as previously outlined.
2. Remove pump to rear main bearing cap bolt and remove pump and extension shaft.

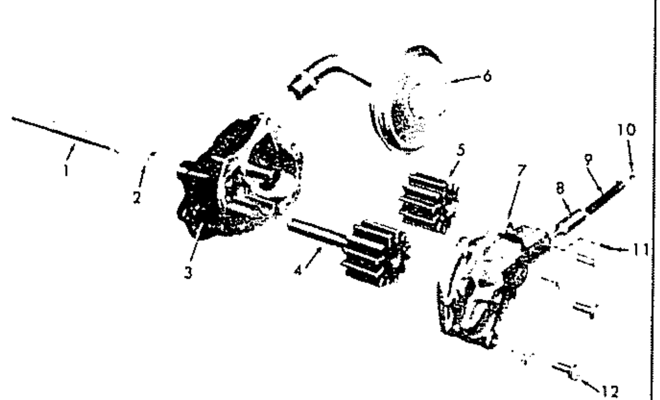
Disassembly (Figure 6A2-33)

1. Remove the pump cover attaching screws and the pump cover.

   NOTE: Mark gear teeth so they may be reassembled with the same teeth indexing.

2. Remove the idler gear and the drive gear and shaft from the pump body.
3. Remove the pressure regulator valve retaining pin, pressure regulator valve and related parts.
4. If the pickup screen and pipe assembly need replacing, mount the pump in a soft-jawed vise and extract pipe from pump.

   CAUTION: *Do not disturb the pickup screen on the pipe. This is serviced as an assembly.*



1. Shaft Extension
2. Shaft Coupling
3. Pump Body
4. Drive Gear and Shaft
5. Idler Gear
6. Pickup Screen and Pipe
7. Pump Cover
8. Pressure Regulator Valve
9. Pressure Regulator Spring
10. Washer
11. Retaining Pin
12. Screws

Fig. 6A2-33 — Oil Pump — Mark IV

Cleaning and Inspection

1. Wash all parts in cleaning solvent and dry with compressed air.
2. Inspect the pump body and cover for cracks or excessive wear.
3. Inspect pump gears for damage or excessive wear.
4. Check the drive gear shaft for looseness in the pump body.
5. Inspect inside of pump cover for wear that would permit oil to leak past the ends of the gears.
6. Inspect the pickup screen and pipe assembly for damage to screen, pipe or relief grommet.
7. Check the pressure regulator valve for fit.

NOTE: The pump gears and body are not serviced separately. If the pump gears or body are damaged or worn, replacement of the entire oil pump assembly is necessary.

Assembly (Figure 6A2-33)

1. If the pickup screen and pipe assembly was removed, it should be replaced with a new part. Loss of press fit condition could result in an air leak and loss of oil pressure. Mount the pump in a soft-jawed vise, apply sealer to end of pipe, and using Tool J-8369 (Fig. 6A2-34) tap the pipe in place with a plastic hammer. On 454 engine use Tool J-22144.

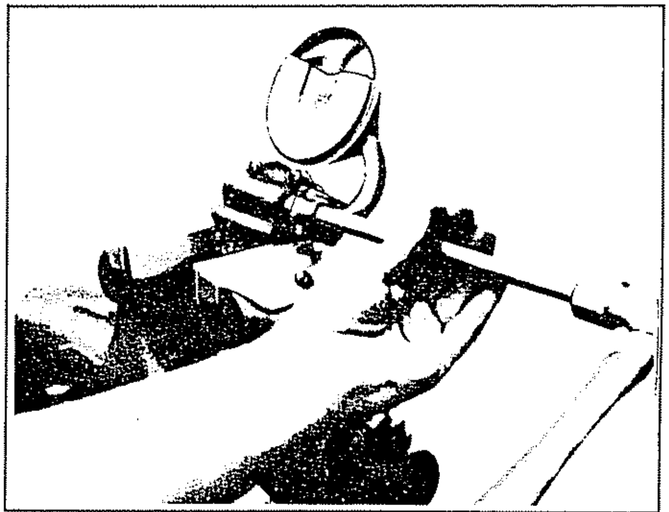


Fig. 6A2-34 — Installing Screen — Small V8

CAUTION: *Be careful of twisting, shearing or collapsing pipe while installing in pump.*

2. Install the pressure regulator valve and related parts.
3. Install the drive gear and shaft in the pump body.
4. Install the idler gear in the pump body with the smooth side of gear towards pump cover opening.
5. Install the pump cover and torque attaching screws to specifications.
6. Turn drive shaft by hand to check for smooth operation.

Installation

1. Assemble pump and extension shaft to rear main bearing cap, aligning slot on top end of extension shaft with drive tang on lower end of distributor drive shaft.
2. Install pump to rear bearing cap bolt and torque to specifications.

   NOTE: Installed position of oil pump screen is with bottom edge parallel to oil pan rails.

3. Install oil pan previously outlined.

CONNECTING ROD BEARINGS

Connecting rod bearings are of the precision insert type and do not utilize shims for adjustment. DO NOT FILE RODS OR ROD CAPS. If clearances are found to be excessive a new bearing will be required. Service bearings are available in standard size and .001" and .002" undersize for use with new and used standard size crankshafts, and in .010" and .020" undersize for use with reconditioned crankshafts.

NOTE: On removing a connecting rod cap, it is

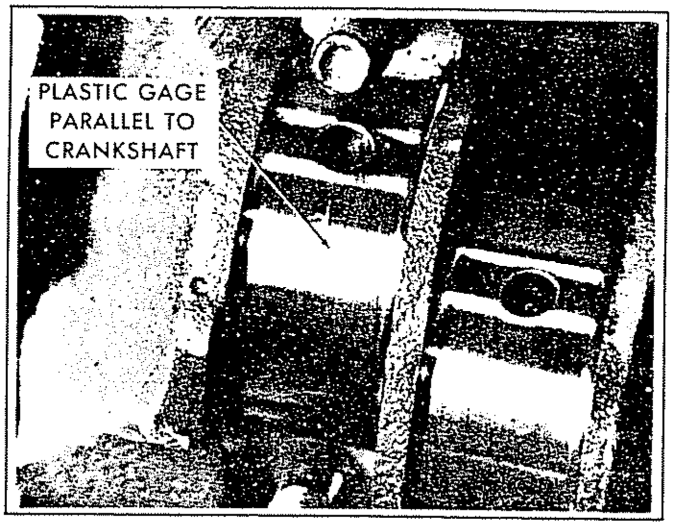


Fig. 6A2-35--Gaging Plastic On Crankpin-Typical (V6 Shown)

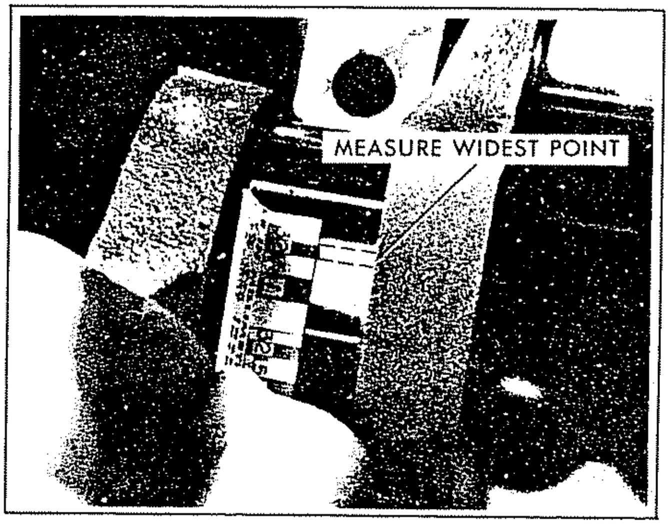


Fig. 6A2-36--Measuring Gaging Plastic-Typical (V6 Shown)

possible to find a .009" undersize bearing. These are used in manufacturing for selective fiting.

Inspection and Replacement

1. With oil pan and oil pump removed, remove the connecting rod cap and bearing.
2. Inspect the bearing for evidence of wear or damage. (Bearings showing the above should not be installed.)
3. Wipe both upper and lower bearing shells and crankpin clean of oil.
4. Measure the crankpin for out-of-round or taper with a micrometer. If not within specifications replace or recondition the crankshaft. If within specifications and a new bearing is be installed, measure the maximum diameter of the crankpin to determine new bearing size required.
5. If within specifications measure new or used bearing clearances with Plastigage or its equivalent.

   NOTE: If a bearing is being fitted to an out-of-round crankpin, be sure to fit to the maximum diameter of the crankpin. If the bearing is fitted to the minimum diameter and the crankpin is out-of-round .001" interference between the bearing and crankpin will result in a rapid bearing failure.

   a. Place a piece of gaging plastic the full width of the crankpin as contacted by the bearing (parallel to the crankshaft) (fig. 6A2-35).
   b. Install the bearing in the connecting rod and cap.
   c. Install the bearing cap and evenly torque nuts to specifications.

   CAUTION: *Do not turn the crankshaft with the gaging plastic installed.*

   d. Remove the bearing cap and using the scale on the gaging plastic envelope, measure the gaging plastic width at the widest point (Fig. 6A2-36).
6. If the clearance exceeds specifications, select a new, correct size bearing and remeasure the clearance.

   NOTE: Be sure to check what size bearing is being removed in order to determine proper replacement size bearing.

   If clearance cannot be brought to within specifications, the crankpin will have to be ground undersize. If the crankpin is already at maxi-

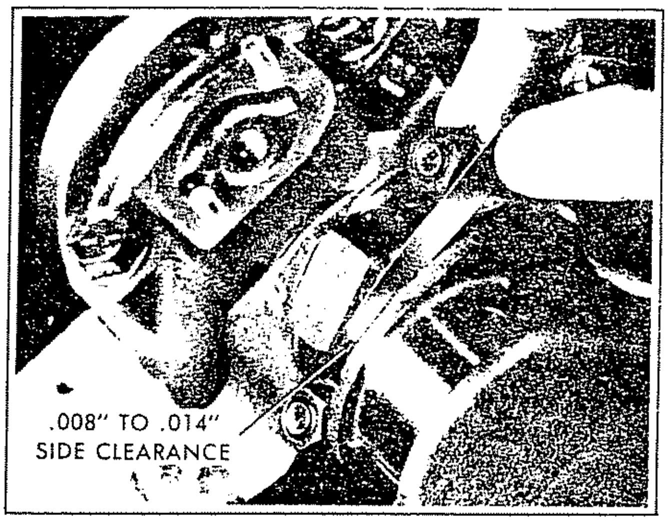


Fig. 6A2-37--Measuring Connecting Rod Side Clearance-Typical (V6 Shown)

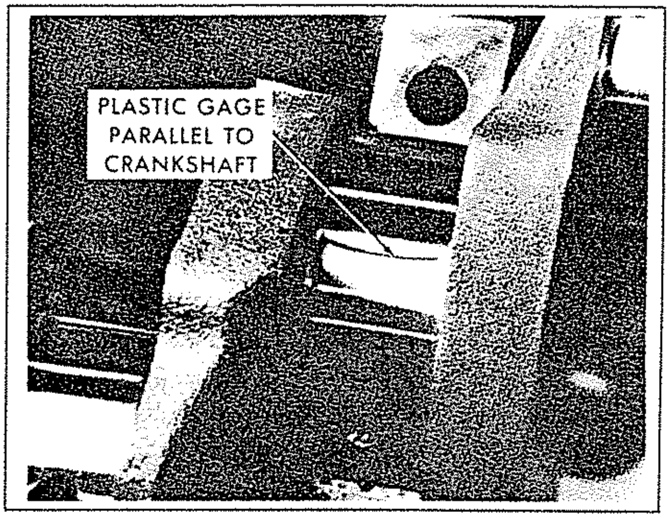


Fig. 6A2-38--Gaging Plastic on Journal-Typical

8. When all connecting rod bearings have been installed tap each rod lightly (parallel to the crankpin) to make sure they have clearance.
9. Measure all connecting rod side clearances (see specifications) between connecting rod caps (Fig. 6A2-37).

MAIN BEARINGS

Main bearings are of the precision insert type and do not utilize shims for adjustment. If clearances are found to be excessive, a new bearing, both upper and lower halves, will be required. Service bearings are available in standard size and .001", .002", .009", .010" and .020" undersize.

Selective fitting of both rod and main bearing inserts is necessary in production in order to obtain close tolerances. For this reason you may find one half of a standard insert with one half of a .001" undersize insert which will decrease the clearance .0005" from using a full standard bearing.

When a production crankshaft cannot be precision fitted by this method, it is then ground .009" undersize **ON ONLY THOSE MAIN JOURNALS THAT CANNOT BE PROPERLY FITTED. ALL JOURNALS WILL NOT NECESSARILY BE GROUND.** A .009" undersize bearing and .010" undersize bearing may be used for precision fitting in the same manner as previously described.

NOTE: If, for any reason, main bearing caps are

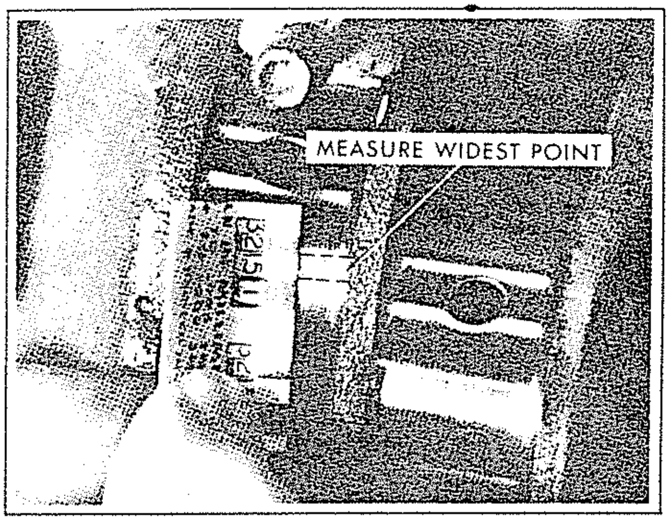


Fig. 6A2-39--Measuring Gaging Plastic-Typical

mum undersize, replace crankshaft.

7. Coat the bearing surface with oil, install the rod cap and torque nuts to specifications.

replaced, shimming may be necessary. Laminated shims for each cap are available for service. Shim requirement will be determined by bearing clearance.

Inspection

In general, the lower half of the bearing (except No. 1 bearing) shows a greater wear and the most distress from fatique. If upon inspection the lower half is suitable for use, it can be assumed that the upper half is also satisfactory. If the lower half shows evidence of wear or damage, both upper and lower halves should be replaced. Never replace one half without replacing the other half.

Checking Clearance

To obtain the most accurate results with "Plastigage", (or its equivalent) a wax-like plastic material which will compress evenly between the bearing and journal surfaces without damaging either surface, certain precautions should be observed.

If the engine is out of the vehicle and upside down, the crankshaft will rest on the upper bearings and the total clearance can be measured between the lower bearing and journal. If the engine is to remain in the vehicle, the crankshaft should be supported both front and rear (damper and flywheel) to remove the clearance from the upper bearing. The total clearance can then be measured between the lower bearing and journal.

NOTE: To assure the proper seating of the crankshaft, all bearing cap bolts should be at their specified torque. In addition, preparatory to checking fit of bearings, the surface of the crankshaft journal and bearing should be wiped clean or oil.

1. With the oil pan and oil pump removed, and starting with the rear main bearing, remove bearing cap and wipe oil from journal and bearing cap.
2. Place a piece of gaging plastic the full width of the bearing (parallel to the crankshaft) on the journal (Fig. 6A2-38).

   CAUTION: *Do not rotate the crankshaft while the gaging plastic is between the bearing and journal.*

3. Install the bearing cap and evenly torque the retaining bolts to specifications.

   NOTE: Bearing cap MUST be torqued to specification in order to assure proper reading. Variations in torque affect the compression of the plastic gage.

4. Remove bearing cap. The flattened gaging plastic will be found adhering to either the bearing shell or journal.
5. On the edge of gaging plastic envelope there is a graduated scale which is correlated in thousandths of an inch. Without removing the gaging plastic, measure its compressed width (at the widest point) with the graduations on the gaging plastic envelope (fig. 6A2-39).

   NOTE: Normally main bearing journals wear evenly and are not out-of-round. However, if a bearing is being fitted to an out-of-round (.001" max.), be sure to fit to the maximum diameter of the journal: If the bearing is fitted to the minimum diameter and the journal is out-of-round .001", interference between the bearing and journal will result in rapid bearing failure. If the flattened gaging plastic tapers toward the middle or ends, there is a difference in clearance indicating taper, low spot or other irregularity of the bearing or journal. Be sure to measure the journal with a micrometer if the flattened gaging plastic indicates more than .001" difference.

6. If the bearing clearance is within specifications, the bearing insert is satisfactory. If the clearance is not within specifications, replace the insert. Always replace both upper and lower inserts as a unit.

   NOTE: If a new bearing cap is being installed and clearance is less than .001", inspect for burrs or nicks; if none are found then install shims as required.

7. A standard, .001" or .002" undersize bearing may produce the proper clearance. If not, it will be necessary to regrind the crankshaft journal for use with the next undersize bearing.

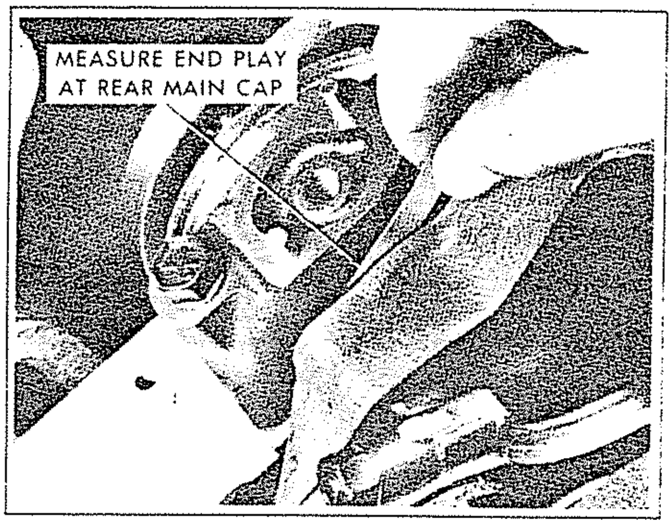


Fig 6A2-40--Measuring Crankshaft End Play - Typical (V6 Shown)

   NOTE: After selecting new bearing, recheck clearance.

8. Proceed to the next bearing. After all bearings have been checked rotate the crankshaft to see that there is no excessive drag.

   NOTE: When checking #1 main bearing, loosen accessory drive belts so as to prevent tapered reading with plastic gage.

9. Measure crankshaft end play (see specifications) by forcing the crankshaft to the extreme front position. Measure at the front end of the rear main bearing with a feeler gage (Fig. 6A2-40).
10. Install a new rear main bearing oil seal in the cylinder block and main bearing cap.

Replacement

NOTE: Main bearings may be replaced with or without removing the crankshaft.

With Crankshaft Removal

1. Remove and inspect the crankshaft.
2. Remove the main bearings from the cylinder block and main bearing caps.
3. Coat bearing surfaces of new, correct size, main bearings with oil and install in the cylinder block and main bearing caps.
4. Install the crankshaft.

Without Crankshaft Removal

1. With oil pan, oil pump and spark plugs removed, remove cap on main bearing requiring replacement and remove bearing from cap.
2. Install a main bearing removing and installing tool in oil hole in crankshaft journal.

   NOTE: If such a tool is not available, a cotter pin may be bent as required to do the job.

3. Rotate the crankshaft clockwise as viewed

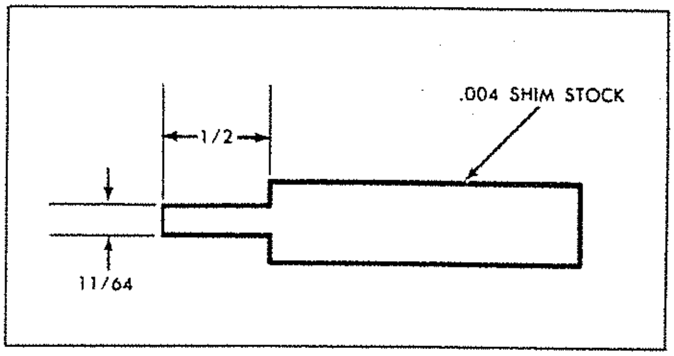


Fig. 6A2-41--Oil Seal Installation Tool

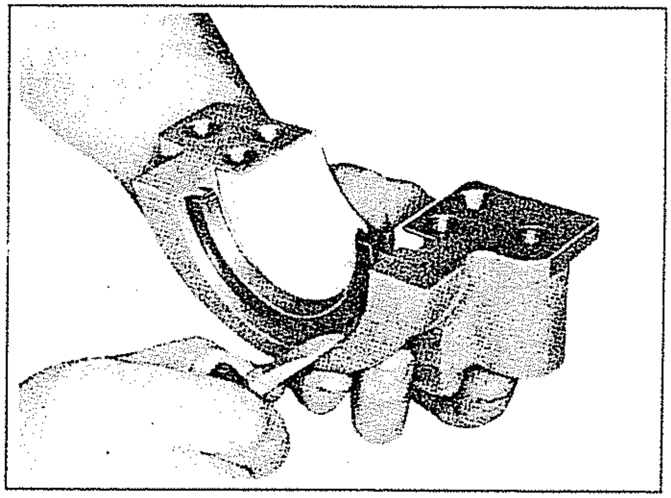


Fig. 6A2-42--Removing Oil Seal - Lower Half

from the front of engine. This will roll upper bearing out of block.

4. Oil new selected size upper bearing and insert plain (unnotched) end between crankshaft and indented or notched side of block. Rotate the bearing into place and remove tool from oil hole in crankshaft journal.
5. Oil new lower bearing and install in bearing cap.
6. Install main bearing cap with arrows pointing toward front of engine.
7. Torque all main bearing caps, EXCEPT THE REAR MAIN CAP, to specifications. Torque rear main bearing cap to 10-12 lb. ft. (14-16N•m) then tap end of crankshaft, first rearward then forward with a lead hammer. This will line up rear main bearing and crankshaft thrust surfaces. Retorque all main bearing caps to specifications.

OIL SEAL (REAR MAIN)

Replacement

NOTE: Always replace the upper and lower seal as a unit. Install seal with lip facing front of engine.

The rear main bearing oil seal can be replaced (both halves) without removal of the crankshaft. Extreme care should be exercised when installing this seal to protect the sealing bead located in the channel on the outside diameter of the seal. An installation tool (Fig. 6A2-41) can be used to protect the seal bead when positioning seal as follows:

1. With the oil pan and oil pump removed, remove the rear main bearing cap.
2. Remove oil seal from the bearing cap by prying from the bottom with a small screw driver (Fig. 6A2-42).
3. To remove the upper half of the seal, use a small hammer to tap a brass pin punch on one end of seal until it protrudes far enough to be removed with pliers (fig. 6A2-43).
4. Clean all sealant and foreign material from cylinder case bearing cap and crankshaft, using a non-abrasive cleaner.
5. Inspect components for nicks, scratches, burrs and machining defects at all sealing surfaces, case assembly and crankshaft.
6. Coat seal lips and seal bead with light engine oil—keep oil off seal mating ends.
7. Position tip of tool between crankshaft and seal seat in cylinder case.
8. Position seal between crankshaft and tip of tool so that seal bead contacts tip of tool.

   NOTE: Make sure that oil-seal lip is positioned toward front of engine (Fig. 6A2-44).

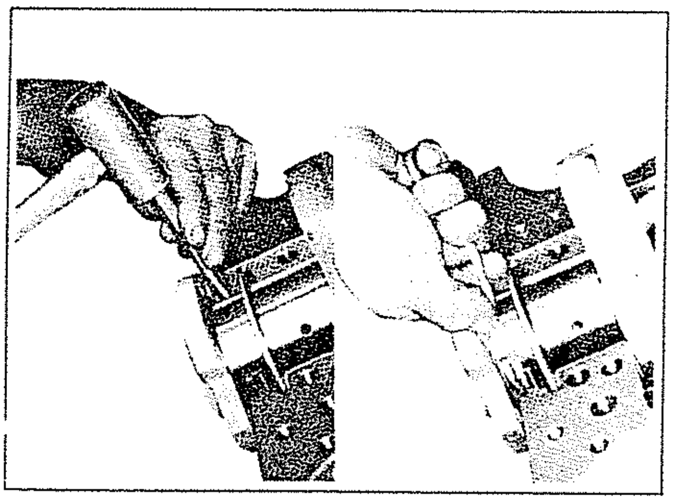


Fig. 6A2-43--Removing Oil Seal - Upper Half

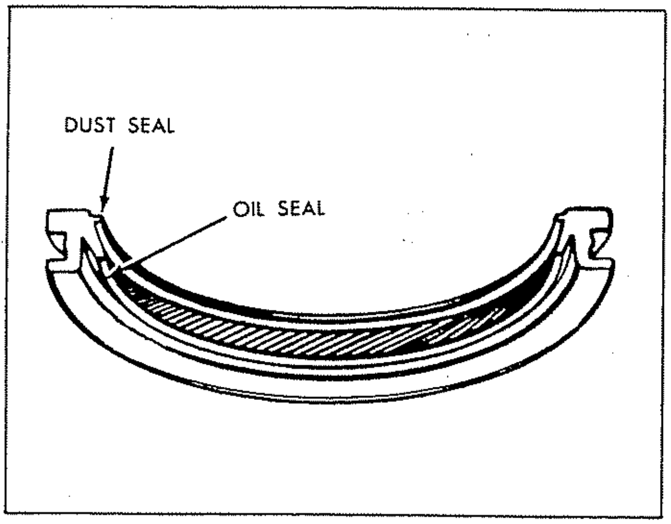


Fig. 6A2-44--Crankshaft Oil Seal - Rear Main

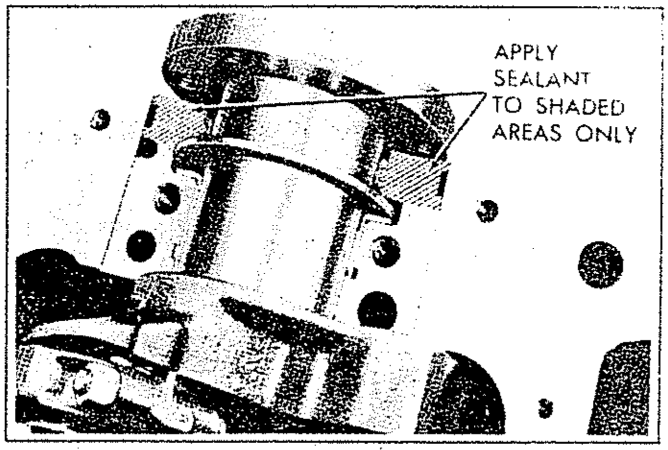


Fig 6A2-45--Sealing Bearing Cap

9. Roll seal around crankshaft using tool as a "shoe-horn" to protect seal bead from sharp corner of seal seat surface in cylinder case.

   CAUTION: *Installation tool must remain in position until seal is properly positioned with both ends flush with block.*

10. Remove tool, being careful not to withdraw seal.
11. Install seal half in bearing cap, again using tool as a "shoe-horn", feeding seal into cap using light pressure with thumb and finger.
12. Install bearing cap to case with sealant applied to the cap-to-case interface being careful to keep sealant off the seal split line (Fig. 6A2-45).
13. Install the rear main bearing cap (with new seal) and torque to 10-12 lb. ft. (14-16N•m). Tap end of crankshaft first rearward then forward with lead hammer. This will line up thrust surfaces. Retorque bearing cap to specification.

CONNECTING ROD AND PISTON ASSEMBLIES

Removal

1. With oil pan, oil pump and cylinder head removed, use a ridge reamer to remove any ridge and/or deposits from the upper end of the cylinder bore.

   NOTE: Before ridge and/or deposits are removed, turn crankshaft until piston is at the bottom of stroke and place a cloth on top of piston to collect the cuttings. After ridge and/or deposits are removed, turn crankshaft until piston is at top of stroke and remove cloth and cuttings.

2. Inspect connecting rods and connecting rod caps for cylinder identification. If necessary mark them.
3. Remove connecting rod cap and install Tool J-5239 (3/8") or J-6305 (11/32") on studs. Push connecting rod and piston assembly out of top of cylinder block.

   NOTE: It will be necessary to turn the crankshaft slightly to disconnect some of the connecting rod and piston assemblies and push them out of the cylinder.

Disassembly

1. Remove connecting rod bearings from connecting rods and caps.

   NOTE: If connecting rod bearings are being reused, place them in a rack so they may be reinstalled in their original rod and cap.

2. Remove piston rings by expanding and sliding them off the pistons. Tools J-8020 (3-9/16"), J-8021 (3-7/8"), J8032 (4"), J-22249 (3-15/16"), J-22147 (4-3/32"), and J-22250 (4-1/4") are available for this purpose.
3. Place connecting rod and piston assembly on Tool J-24086-20. Using an arbor press and piston pin remover, J-24086-8, press the piston pin out of connecting rod and piston (Fig. 6A2-46).

Cleaning and Inspection

Connecting Rods

Wash connecting rods in cleaning solvent and dry with compressed air.

Check for twisted or bent rods and inspect for nicks or cracks. Replace connecting rods that are damaged.

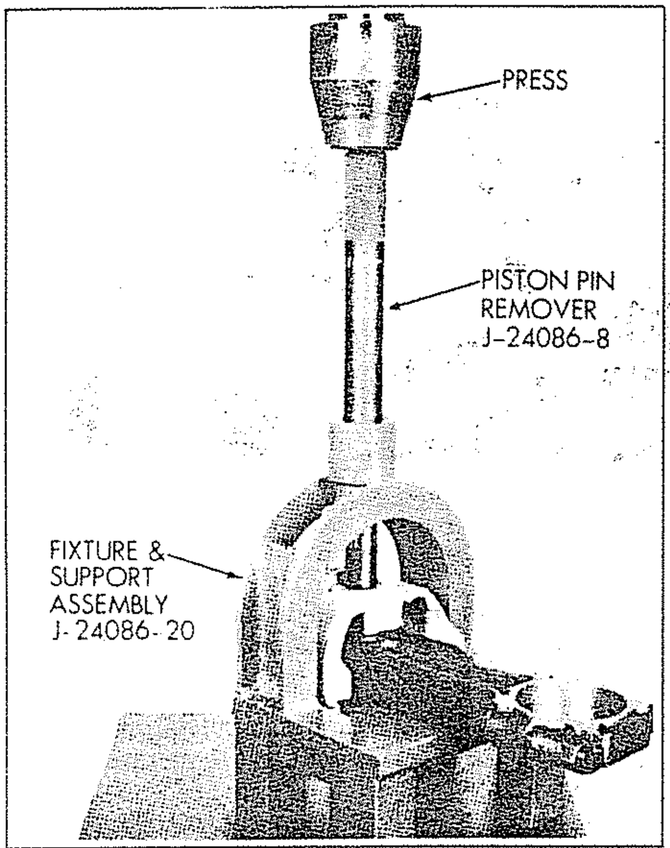


Fig 6A2-46--Removing Piston Pin

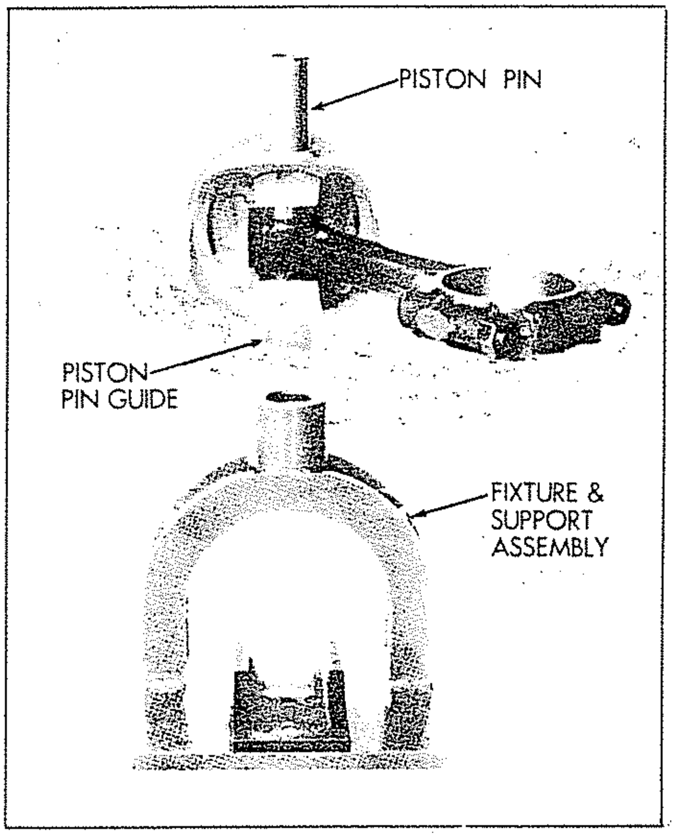


Fig. 6A2-47--Piston Pin Ready for Installation

Pistons

Clean varnish from piston skirts and pins with a cleaning solvent. **DO NOT WIRE BRUSH ANY PART OF THE PISTON.** Clean the ring grooves with a groove cleaner and make sure oil ring holes and slots are clean.

Inspect the piston for cracked ring lands, skirts or pin bosses, wavy or worn ring lands, scuffed or damaged skirts, eroded areas at top of the piston. Replace pistons that are damaged or show signs of excessive wear.

Inspect the grooves for nicks or burrs that might cause the rings to hang up.

Measure piston skirt (across center line of piston pin) and check clearance as outlined under "Piston Selection".

Piston Pins

The piston pin clearance is designed to maintain adequate clearance under all engine operating conditions. Because of this, the piston and piston pin are a matched set and not serviced separately.

Inspect piston pin bores and piston pins for wear. Piston pin bores and piston pins must be free of varnish or scuffing when being measured. The piston pin should be measured with a micrometer and the piston pin bore should be measured with a dial bore gage or an inside micrometer. If clearance is excess of the .001" wear limit, the piston and piston pin assembly should be replaced.

Assembly

1. Lubricate piston pin holes in piston and connecting rod to facilitate installation of pin.
2. Place connecting rod in piston and hold in place with piston pin guide and piston pin. Place assembly on fixture and support assembly (Fig. 6A2-47).
3. Using piston pin installer, J-24086-9, press the piston pin into the piston and connecting rod (Fig. 6A2-48).

NOTE: The piston pin installer is a variable insertion length tool designed to be applicable to all GM Piston assemblies.

The insertion length is varied by rotating the hub on the shaft much like adjusting a micrometer. An alpha-numeric scale is used to determine the desired length for a given piston pin assembly.

CAUTION: *After installer hub bottoms on support assembly, do not exceed 5000 psi pressure, as this could cause structural damage to the tool.*

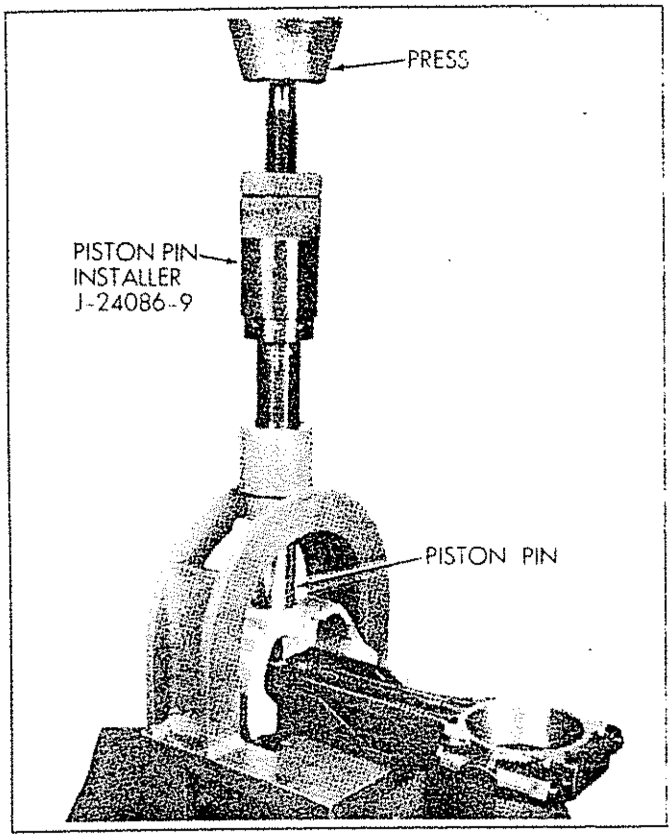


Fig 6A2-48--Installing Piston Pin

4. Remove piston and connecting rod assembly from tool and check piston for freedom of movement on piston pin.

Piston Rings

All compression rings are marked on the upper side of the ring. When installing compression rings, make sure the marked side is toward the top of the piston. The top ring is chrome faced, or treated with molybdenum for maximum life.

The oil control rings are of three piece type, consisting of two segments (rails) and a spacer.

1. Select rings comparable in size to the piston being used.
2. Slip the compression ring in the cylinder bore; then press the ring down into the cylinder bore about 1/4 inch (above ring travel). Be sure ring is square with cylinder wall.
3. Measure the space or gap between the ends of the ring with a feeler gage (Fig. 6A2-49).
4. If the gap between the ends of the ring is below specifications, remove the ring and try another for fit.
5. Fit each compression ring to the cylinder in which it is going to be used.
6. If the pistons have not been cleaned and inspected as previously outlined, do so.
7. Slip the outer surface of the top and second compression ring into the respective piston ring groove and roll the ring entirely around the groove (Fig. 6A2-50) to make sure that the ring is free. If binding occurs at any point the cause should be determined, and if caused by ring groove, remove by dressing with a fine cut file. If the binding is caused by a distorted ring, check a new ring.
8. Install piston rings as follows:

NOTE: Tools J-8020 (3-9/16"), J-8021 (3-7/8"), J8032 (4"), J-22249 (3-15/16"), J-22147 (4-3/32"),

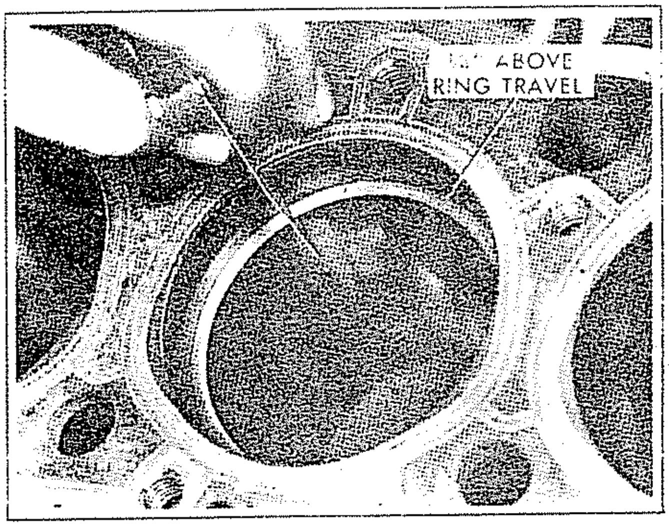


Fig 6A2-49--Measuring Ring Gap

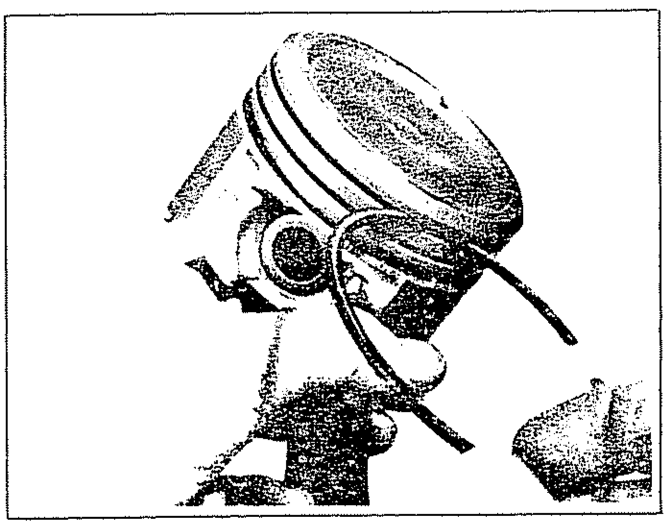


Fig 6A2-50--Checking Ring in Groove

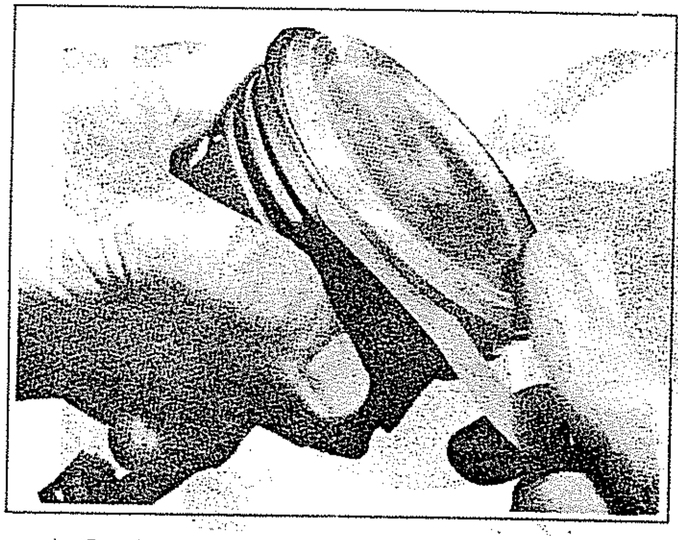


Fig 6A2-51--Measuring Ring Groove Clearance

and J-22250 (4-1/4") are available for this purpose.

a. Install oil ring spacer in groove and insert antirotation tang in oil hole.
b. Hold spacer ends butted and install lower steel oil ring rail with gap properly located.
c. Install upper steel oil ring rail with gap properly located.
d. Flex the oil ring assembly to make sure ring is free. If binding occurs at any point the cause should be determined, and if caused by ring groove, remove by dressing groove with a fine cut file. If binding is caused by a distorted ring, check a new ring.
e. Install second compression ring expander then ring with gaps properly located.
f. Install top compression ring with gap properly located.

9. Proper clearance of the piston ring in its piston ring groove is very important to provide proper ring action and reduce wear. Therefore, when fitting new rings, the clearances between the surfaces of the ring and groove should be measured (Fig. 6A2-51). (See Specifications).

Installation

NOTE: Cylinder bores must be clean before piston installation. This may be accomplished with a hot water and detergent wash or with a light honing as necessary. After cleaning, the bores should be swabbed several times with light engine oil and a clean dry cloth.

1. Lubricate connecting rod bearings and install in rods and rod caps.
2. Lightly coat pistons, rings and cylinder walls with light engine oil.
3. With bearings caps removed, install Tool J-5239 (3/8") or J-6305 (11/32") on connecting rod bolts.

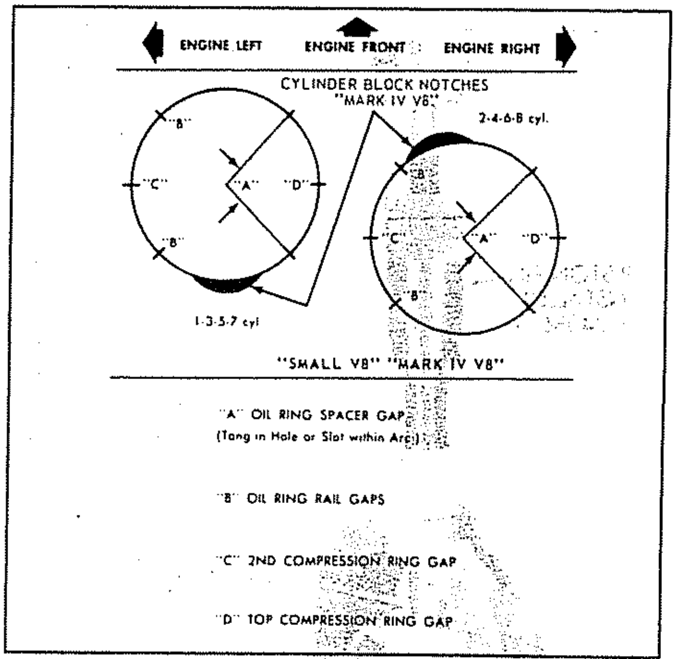


Fig. 6A2-70--Ring Gap Location

CAUTION: *Be sure ring gaps are properly positioned as previously outlined (Fig. 6A2-70).*

4. Install each connecting rod and piston assembly in its respective bore. Install with connecting rod bearing tang slots on side opposite camshaft. Use Tool J-8037 to compress the rings. Guide the connecting rod into place on the crankshaft journal with Tool J-5239 (3/8") or J-6305 (11/32"). Use a hammer handle and light blows to install the piston into the bore. Hold the ring compressor firmly against the cylinder block until all piston rings have entered the cylinder bore.
5. Remove Tool J-5239 or J-6305.
6. Install the bearing caps and torque nuts to specifications.

NOTE: If bearing replacement is required refer to "Connecting Rod Bearings".

Be sure to install new pistons in the same cylinders for which they were fitted, and used pistons in the same cylinder from which they were removed. Each connecting rod and bearing cap should be marked, beginning at the front of the engine. On V8 engines 1, 3, 5 and 7 in the left bank and, 2, 4, 6 and 8 in the right bank. On V6 engines, 1, 3 and 5 in the left bank and 2, 4 and 6 in the right bank. The numbers on the connecting rod and bearing cap must be on the same side when installed in the cylinder bore. If a connecting rod is ever transposed from one block or cylinder to another, new bearings should be fitted and the connecting rod should be numbered to correspond with the new cylinder number.

CYLINDER BLOCK

Cleaning and Inspection

1. Wash cylinder block thoroughly in cleaning solvent and clean all gasket surfaces.
2. Remove oil gallery plugs and clean all oil passages.

   NOTE: These plugs may be removed with a sharp punch or they may be drilled and pried out.

3. Clean and inspect water passages in the cylinder block.
4. Inspect the cylinder block for cracks in the cylinder walls, water jacket, value lifter bores and main bearing webs.
5. Measure the cylinder walls for taper, out-of-round or excessive ridge at top of ring travel. This should be done with a dial indicator. Set the gage so that the thrust pin must be forced in about 1/4" to enter gage in cylinder bore. Center gage in cylinder and turn dial to "O". Carefully work gage up and down cylinder to determine taper and turn it to different points around cylinder wall to determine the out-of-round condition. If cylinders were found to exceed specifications, honing or boring will be necessary.

Conditioning

The performance of the following operation is contingent upon engine condition at time of repair.

If the cylinder block inspection indicated that the block was suitable for continued use except for out-of-round or tapered cylinders, they can be conditioned by honing or boring.

If the cylinders were found to have less than .005" taper or wear, they can be conditioned with a hone and fitted with the high limit standard size piston. A cylinder bore of less than .005" wear or taper may not entirely clean up when fitted to a high limit piston. If it is desired to entirely clean up the bore in these cases, it will be necessary to rebore for an oversize piston. If more than .005" taper or wear, they should be bored and honed to the smallest oversize that will permit complete resurfacing of all cylinders.

When pistons are being fitted and honing is not necessary, cylinder bores may be cleaned with a hot water and detergent wash. After cleaning, the cylinder bores should be swabbed several times with light engine oil and a clean cloth and then wiped with a clean dry cloth.

Boring

1. Before using any type boring bar, the top of the cylinder block should be filed off to remove any dirt or burrs. This is very important. Otherwise, the boring bar may be tilted which would result in the rebored cylinder wall not being at right angles to the crankshaft.
2. The piston to be fitted should be measured with a micrometer, measuring at the center of the piston skirt and at right angles to the piston pin. The cylinder should be bored to the same diameter as the piston and honed to give the specified clearance.

   NOTE: Hone cylinders as outlined under "Cylinder Honing and Piston Fitting".

3. The instructions furnished by the manufacturer of the equipment being used should be carefully followed.

Honing

1. When cylinders are to be honed follow the hone manufacturer's recommendation for the use of the hone and cleaning and lubrication during honing.
2. Occasionally during the honing operation, the cylinder bore should be thoroughly cleaned and the piston selected for the individual cylinder checked for correct fit.
3. When finish honing a cylinder bore to fit a piston, the hone should be moved up and down at a sufficient speed to obtain very fine uniform surface finish marks, in a crosshatch pattern of approximately 45 to 65 degrees included angle. The finish marks should be clean but not sharp, free from imbedded particles and torn or folded metal.
4. Permanently mark the piston for the cylinder to which it has been fitted and proceed to hone cylinders and fit the remaining pistons.

   CAUTION: *Handle the pistons with care and do not attempt to force them through the cylinder until the cylinder has been honed to correct size as this type piston can be distorted through careless handling.*

5. Thoroughly clean the bores with hot water and detergent. Scrub well with a stiff bristle brush and rinse thoroughly with hot water. It is extremely essential that a good cleaning operation be performed. If any of the abrasive material is allowed to remain in the cylinder bores, it will rapidly wear the new rings and cylinder bores in addition to the bearings lubricated by the contaminated oil, the bores should be swabbed and then wiped with a clean dry cloth. Cylinder should not be cleaned with kerosene or gasoline. Clean the remainder of the cylinder block to remove the excess material spread during the honing operation.

OIL FILTER BYPASS VALVE

Inspection and Replacement

With the oil filter removed, check the spring and fibre valve for operation. Inspect for a cracked or broken valve. If replacement is necessary, the oil filter adapter and bypass valve assembly must be replaced as an assembly. Clean valve chamber in cylinder block thoroughly. Torque retaining screws to specifications.

Piston Selection

1. Check USED piston to cylinder bore clearance as follows:
   a. Measure the "Cylinder Bore Diameter" with a telescope gage (2-1/2" from top of cylinder bore).
   b. Measure the "Piston Diameter" (at skirt across center line of piston pin).
   c. Subtract piston diameter from cylinder bore diameter to determine "Piston to Bore Clearance".
   d. Locate piston to bore clearance on Piston Selection Chart and determine if piston to bore clearance is in the acceptable range.
2. If used piston is not acceptable, check Piston Size Chart and determine if a new piston can be selected to fit cylinder bore within the acceptable range.
3. If cylinder bore must be reconditioned, measure new piston diameter (across center line of piston pin) then hone cylinder bore to correct clearance (preferable range).
4. Mark the piston to identify the cylinder for which it was fitted.

CRANKSHAFT

The crankshaft can be removed while the engine is disassembled for overhaul, as previously outlined or without complete disassembly as outlined below.

Removal

1. With the engine removed from the boat and the transmission and clutch housing removed from the engine, mount engine in stand and clamp securely.
2. Remove the oil dip stick and oil dip stick tube, (if applicable) and drain oil from engine.
3. Remove the flywheel.
4. Remove the spark plugs.
5. Remove crankshaft pulley and torsional damper.
6. Remove oil pan and oil pump.
7. Remove crankcase front cover, and if so equipped, remove timing chain and camshaft sprocket.
8. Check the connecting rod caps for cylinder number identification. If necessary mark them.
9. Remove the connecting rod caps and push the pistons to top of bores.
10. Remove main bearing caps and lift crankshaft out of cylinder block.
11. Remove rear main bearing oil seal and main bearings from cylinder block and main bearing caps.

Cleaning and Inspection

1. Wash crankshaft in solvent and dry with compressed air.
2. Measure dimensions of main bearing journals and crankpins with a micrometer for out-of-round, taper or undersize. (See Specifications.)
3. Check crankshaft for run-out by supporting at the front and rear main bearings journals in "V" blocks and check at the front and rear intermediate journals with a dial indicator. (See Specifications.)
4. Replace or recondition the crankshaft if out of specifications.

SPROCKET OR GEAR REPLACEMENT (REFER TO FIG. 6A2-73)

- On "Small V8" engines, remove crankshaft sprocket using ToolJ-5825, install using Tool J-5590.
- On 454 V8 engines, remove crankshaft sprocket using ToolJ1619, install using Tool J-21058.

Installation

1. Install rear main bearing oil seal in cylinder block and rear main bearing cap grooves. Install with lip of seal toward front of engine. Where seal has two lips install lip with helix towards front of engine.
2. Lubricate lips of seal with engine oil. Keep oil off parting line surface.
3. Install main bearings in cylinder block and main bearing caps then lubricate bearing surface with engine oil.
4. Install crankshaft, being careful not to damage bearing surfaces.
5. Apply a thin coat of brush-on type oil sealing compound to block mating surface and corresponding surface of cap only (Fig. 6A2-74). Do not allow sealer on crankshaft or seal.
6. Install main bearing caps with arrows pointing toward front of engine.
7. Torque all except rear main bearing cap bolts to specifications. Torque rear main bearing cap bolts to 10-12 ft. lbs. then tap end of crankshaft, first rearward then forward with a lead hammer. This will line up rear main bearing and crank-

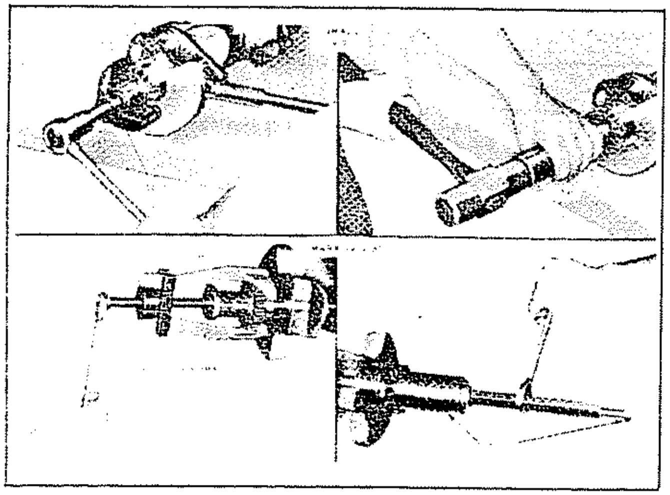


Fig. 6A2-73--Sprocket or Gear Replacement

shaft thrust surfaces. Retorque all main bearing cap bolts to specifications.

8. Measure crankshaft end play with a feeler gage. Force crankshaft forward and measure clearance between the front of the rear main bearing and the crankshaft thrust surface.

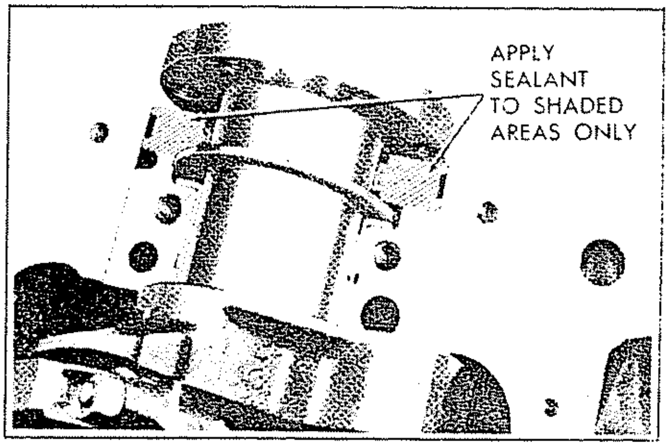


Fig. 6A2-74--Sealing Bearing Cap Block

9. Install flywheel and torque to specifications. A wood block placed between the crankshaft and cylinder block will prevent crankshaft from rotating.

   NOTE: Align dowel hole in flywheel with dowel hole in crankshaft.

SPECIFICATIONS

GENERAL DATA:

90° V6	TYPE	90° V-8 GASOLINE			
200 CUI 3.3	DISPLACEMENT LITRE (*)	305	350		454
L26	RPO	LG9	LS9		LF8
3.500	BORE	3.736	4.000		4.250
3.480	STROKE	3.480			4.000
8.2:1	COMPRESSION RATIO	8.5:1			
165432	FIRING ORDER	1-8-4-3-6-5-7-2			

CYLINDER BORE:

DIAMETER			3.7350-3.7385	3.9995-4.0025		4.2495-4.2525
OUT OF ROUND	PRODUCTION		.001 MAX			
OUT OF ROUND	SERVICE		.002 MAX			
TAPER	PRODUCTION	THRUST SIDE	.0005 MAX			
TAPER	PRODUCTION	RELIEF SIDE	.001 MAX			
TAPER	SERVICE		.001 MAX			

PISTON:

CLEARANCE	PRODUCTION	.0007-.0017	.0014-.0024
CLEARANCE	SERVICE	.0027 MAX.	.0035 MAX.

PISTON RING:

COMPRESSION	GROOVE CLEARANCE	PRODUCTION	TOP	.0012-.0032	.0017-.0032
COMPRESSION	GROOVE CLEARANCE	PRODUCTION	2ND	.0012-.0032	.0017-.0032
COMPRESSION	GROOVE CLEARANCE	SERVICE		HI LIMIT PRODUCTION + .001	
COMPRESSION	GAP	PRODUCTION	TOP	.010-.020	
COMPRESSION	GAP	PRODUCTION	2ND	.010-.025	.010-.020
COMPRESSION	GAP	SERVICE		HI LIMIT PRODUCTION + .010	
OIL	GROOVE CLEARANCE	PRODUCTION		.002-.007	.005-.0065
OIL	GROOVE CLEARANCE	SERVICE		HI LIMIT PRODUCTION + .001	
OIL	GAP	PRODUCTION		.015-.055	
OIL	GAP	SERVICE		HI LIMIT PRODUCTION + .010	

* VIN Designation

SPECIFICATIONS PECULIAR TO THE 454 4-BOLT ENGINE

Piston Clearance	Production	.0046-.0056
Piston Clearance	Service	.0061 Max
Camshaft Lobe Lift ± .002	Intake	.3000
Camshaft Lobe Lift ± .002	Exhaust	.3067

Specifications for the 3.3 Litre V6 are the same as the 305 & 350 CID engines except as listed.

PISTON PIN

		LG9	LS9	LF4	LF8
DIAMETER		.9270-.9273			.9895-.9898
CLEARANCE	PRODUCTION	.00025-.00035			
CLEARANCE	SERVICE	.001 MAX.			
FIT IN ROD		.0008-.0016 INTERFERENCE			

CRANKSHAFT

			LG9 / LS9	LF4	LF8
MAIN JOURNAL	DIAMETER		#1 2.4484-2.4493		#1 2.7485-2.7494
MAIN JOURNAL	DIAMETER		#2-3-4 2.4481-2.4490		#2-3-4 2.7481-2.7490
MAIN JOURNAL	DIAMETER		#5 2.4479-2.4488		#5 2.7478-2.7488
MAIN JOURNAL	TAPER	PRODUCTION	.0002 MAX.		
MAIN JOURNAL	TAPER	SERVICE	.001 MAX.		
MAIN JOURNAL	OUT OF ROUND	PRODUCTION	.0002 MAX.		
MAIN JOURNAL	OUT OF ROUND	SERVICE	.001 MAX		
MAIN BEARING CLEARANCE	PRODUCTION		#1 .0008-.0020		#1-2-3-4 .0013-.0025
MAIN BEARING CLEARANCE	PRODUCTION		#2-3-4 .0011-.0023		
MAIN BEARING CLEARANCE	PRODUCTION		#5 .0017-.0032		#5 .0024-.0040
MAIN BEARING CLEARANCE	SERVICE		#1 .001-.0015; #2-4 .001-.0025		#5 .0025-.0035
CRANKSHAFT END PLAY			.002-.006		.006-.010
CRANKPIN	DIAMETER		2.0988-2.0998		2.1985-2.1995
CRANKPIN	TAPER	PRODUCTION	.0005		
CRANKPIN	TAPER	SERVICE	.001 MAX.		
CRANKPIN	OUT OF ROUND	PRODUCTION	.0005		
CRANKPIN	OUT OF ROUND	SERVICE	.001 MAX		
ROD BEARING CLEARANCE	PRODUCTION		.0013-.0035		.0009-.0025
ROD BEARING CLEARANCE	SERVICE		.0030		
ROD SIDE CLEARANCE			.008-.014		.013-.023

CAMSHAFT

		LG9	LS9	LF4 / LF8
LOBE LIFT ± .002	INTAKE	.2484	.2600	.2343
LOBE LIFT ± .002	EXHAUST	.2667	.2733	.2343
JOURNAL DIAMETER		1.8682-1.8692		1.9482-1.9492
CAMSHAFT END PLAY		.004-.012		

VALVE SYSTEM

			200 V6 & 305 V8	350 V8		454
LIFTER			HYDRAULIC			
ROCKER ARM RATIO			1.50:1		1.70:1	
VALVE LASH	INTAKE		ONE TURN DOWN FROM ZERO LASH			
	EXHAUST					
FACE ANGLE (INT. & EXH.)			45°			
SEAT ANGLE (INT. & EXH.)			46°			
SEAT RUNOUT			002 MAX			
SEAT WIDTH	INTAKE		1/32-1/16			
	EXHAUST		1/16-3/32			
STEM CLEARANCE	PRODUCTION	INT.	0010-0027			
		EXH.	0010-0027		0012-0029	
	SERVICE		HI LIMIT - 001 INTAKE - 002 EXHAUST			
VALVE SPRING (OUTER)	FREE LENGTH		2.03			2.12
	PRESSURE LBS. @ IN.	CLOSED	76-84 @ 1.70 INT @ 1.61 EXH			74-86 @ 1.88
		OPEN	194-206 @ 1.25 INT @ 1.16 EXH			288-312 @ 1.38
	INSTALLED HEIGHT ± 1/32"		1 23/32 INT 1 19/32 EXH			1-7/8
DAMPER	FREE LENGTH		1.86			
	APPROX. # OF COILS		4			

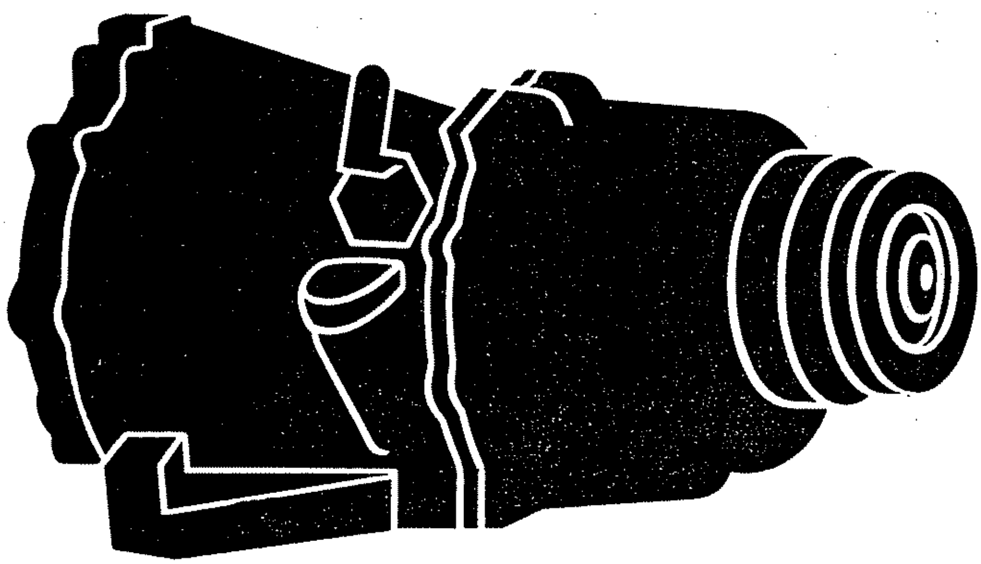
TORQUE SPECIFICATIONS

Crankcase Front Cover .... 80 lb. in.
Flywheel Housing Cover .... 80 lb. in.
Oil Filter Bypass Valve .... 80 lb. in.
Oil Pan (To Crankcase) (1/4-20) .... 80 lb. in.*
Oil Pan (To Front Cover) .... 55 lb. in.@
Oil Pump Cover .... 80 lb. in.
Rocker Arm Cover .... 45 lb. in.*
Rocker Arm Cover .... 50 lb. in.@
Camshaft Sprocket .... 20 lb. ft.
Oil Pan To Crankcase (5/16-18) .... 165 lb. in.*
Oil Pan To Crankcase (5/16-18) .... 135 lb. in.@
Clutch Pressure Plate .... 30 lb. ft.
Distributor Clamp .... 25 lb. ft.
Flywheel Housing .... 30 lb. ft.
Manifold (Exhaust) .... 20 lb. ft. [1]
Manifold (Inlet) .... 30 lb. ft.
Water Outlet .... 30 lb. ft.
Water Pump .... 30 lb. ft.
Connecting Rod Cap .... 45 lb. ft.*
Connecting Rod Cap .... 50 lb. ft.@
Cylinder Head .... 65 lb. ft.*
Cylinder Head .... 80 lb. ft.@
Main Bearing Cap .... 80 lb. ft.* [2]
Oil Pump .... 65 lb. ft.
Rocker Arm Stud .... 50 lb. ft.@
Flywheel .... 60 lb. ft.*
Flywheel .... 65 lb. ft.@
Torsional Damper .... 60 lb. ft.*
Main Bearing Cap .... 110 lb. ft.@
Temperature Sending Unit .... 20 lb. ft.
Torsional Damper .... 85 lb. ft.@
Oil Filter .... 25 lb. ft.
Oil Pan Drain Plug .... 20 lb. ft.
Spark Plug .... 17-27 lb. ft.
Spark Plug 200 V6 .... 20 lb. ft.

*Small block only
@ 454 only
1 Inside bolts on 350-V8 30 lb. ft.
2 Intermediate outer bolts are 70 lb. ft.

PCM
marine engines

Velvet Drive®
Marine Installation Manual



Warner Gear

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FOREWORD

This manual covers all Velvet Drive® transmissions. Data is given to assist you in selecting the proper transmission, cooler, damper drive and propeller shaft coupling. Proper installation is a requirement for a valid warranty. Instructions for making a proper installation are included. Better service and extended product life can be expected when the recommended components are used and properly installed.

THIS CHART HAS BEEN ADDED TO HELP IDENTIFY EARLY VELVET DRIVE ASSEMBLIES.

The following are identification markings for Warner Gear Division Marine Gears:

MODEL 70 I.D. NO.*	MODEL 71 I.D. NO.	MODEL 72 I.D. NO.	FORWARD RATIO	HAND OF ROTATION
0	1	2	Direct	Both
04	14	24	1.523 to 1	Both
05	15	25	2.100 to 1	Counterclockwise
05A	15A	25A	2.100 to 1	Clockwise
06	16	26	2.571 to 1	Both
07	17	27	2.909 to 1	Both

*These numbers are stamped on serial number plates preceding the serial numbers.

10-17 & 10-18 UNITS

The 1:1 ratio units in the 10-17 and 10-18 series are identical except for the nameplate to the 71C and 72C units which they repalce. The nameplate was changed to be consistent with reduction units of these models.

The forward and reversing portion of the reduction units of the 10-17 and 10-18 units is the same as the 71C and 72C units which they replaced. The reduction portion of the 10-17 and 10-18 units was changed to include a compression sleeve between the two tapered bearing components. Tightening the coupling nut causes the sleeve to be compressed, allowing the tapered bearing to be preloaded. A bearing retainer is not used and the rear oil seal is pressed into the reduction housing.

The reduction sun gear is pinned to the housing of 71C and 72C 1.5:1 units. The snap ring holds the sun gear to an adapter plate which is bolted to the reduction housing of 10-17 and 10-18 reduction units. An oil baffle is bolted to the reduction of 2.57:1 and 2.91:1 reduction units of the 10-17 and 10-18 series transmissions.

— IMPORTANT —

SERIES 10-17 AND 10-18 SERVICE INSTRUCTIONS

Practically all information which has been written for the 71C and 72C Velvet Drive transmissions applies to the 10-17 and 10-18 assemblies. Use the appropriate instructions given in the 71C and 72C service manuals when servicing the 10-17 and 10-18 transmissions. Use instructions given below for assembling the bearings and output shaft into the reduction housing.

Press two bearing cups into the reduction housing. Place rear bearing cone into the rear bearing cup. Press the oil seal into the reduction housing until rear face of oil seal is flush with rear face of bore in housing. Press the front bearing cone over output shaft and against face of shaft. Assemble the bearing sleeve over shaft and against cone. Lower the reduction housing over shaft components. Grease lips of oil seal and install the coupling and nut to the output shaft.

Locate reduction housing and attached parts on a suitable block placed under the carrier or other parts attached to the output shaft so that the reduction housing can be rotated as the coupling nut is being tightened. A tool should be used to hold the coupling while the output shaft nut is being tightened. A helper should rotate the reduction housing and the coupling nut should be tightened until an increase in effort required to turn the reduction housing is noted.

Lay the reduction housing on its side and use a torque wrench to turn the output shaft through the bearings to check the bearing drag caused by the bearings being preloaded. A maximum of 45 lb-ins (5.1 Nm) but perferably 15 to 30 lb-ins (1.7 to 3.4 Nm) torque should be required to rotate the output shaft through the oil seal and properly preloaded bearings. A new bearing spacer should always be used after the output shaft nut has been loosened after being properly preloaded. If the spacer must be reused, always go to a slightly higher preload than the sleeve had been torqued to previously.

IMPORTANT – SEE LATE BULLETINS ON THESE MODELS.

SELECTING A PROPER VELVET DRIVE

Optimum performance can only be obtained when all components are properly selected for the application. Applications having components which are excellent for a particular use may be completely unsuitable for another use. Basic considerations for component selection are discussed in this manual. Specific information is given for the various Velvet Drive models. Reference to various forms will be made to help you find information which is not included.

ENGINE ROTATION

Transmission selection will be simplified when the following method is used to describe engine rotation. This method may not agree with the engine manufacturers' for describing engine rotation.

Face the end of the engine on which the transmission is mounted and describe rotation as clockwise if the engine rotates clockwise. Describe the engine rotation as counterrotating if the engine rotates counterclockwise.

TRANSMISSION ROTATION

Describe transmission input and output shaft rotation as clockwise or counterrotating (counterclockwise) when standing behind the transmission coupling facing towards the input or engine end of the transmission.

All Velvet Drive units except the 2.10:1 In-Line and CR2 units may be used behind engines having either rotation; however, the pump must be indexed for the desired rotation. The reduction unit planetary carrier is different for opposite rotating 2.10:1 In-Line units and early failure will occur on these units if they are driven in the wrong direction.

The output shaft rotates in the same direction or in the opposite direction to the input shaft depending upon the transmission assembly; therefore, it is best to study the charts which show shaft rotation to determine the required model.

HYDRAULIC PUMP INDEXING

The transmission front adapter and pump housing are designed to permit the pump to be mounted in either of two positions. Each position permits oil to be pumped when pump gears are rotated in one direction only. The pump can only pump oil when any point on the gears is rotated past the inlet port first, then past the crescent shaped portion of the pump housing which separates the inlet from the outlet and then past the pump outlet.

The pump must be correctly indexed for each direction of rotation. An arrow with TOP L.H. and a second arrow with TOP R.H. can be found on early pump housings. The arrow which is located nearer the top of pump housing points in the direction the pump must rotate to pump oil. The letters L.H. and R.H. describe the required pump rotation when facing the pump and tells the same thing as the arrow points out. The letters L.H. and R.H. have been removed from current pump assemblies.

The wise mechanic will always check the pump setting prior to transmission installation to be sure that the arrow agrees with engine rotation.

Pump rotation is viewed from the opposite end of the transmission from which shaft and engine rotation is described. The arrow showing left hand rotation should be nearer the top of the units used behind clockwise rotating engines. The arrow showing right hand rotation should be nearer the top on units used behind counterclockwise rotating engines.

TO INDEX PUMP FOR OPPOSITE HAND ROTATION

CAUTION: This procedure is not applicable to CR2 units or the AS3, AS13, 10-17 and 10-18 models (2.10:1 In-Line reduction ratios) because special planetary gear mountings are used which are different for each rotation. These models must not be reindexed from the original factory settings.

1) Remove the four bolts which hold the pump to the transmission, (Fig. 1).

2) Loosen the pump housing. A rubber or plastic hammer may be used to tap the oil boss, but do not strike the bolt bosses.

3) Do not remove the pump from the shaft unless a seal protector is used to prevent the shaft splines from cutting the pump seal.

4) Care should be taken to see that the pump gasket does not stick to the pump housing during rotation, causing the gasket to be folded or torn.

5) Locate pump with the arrow indicating the proper direction of input shaft rotation nearer top of transmission.

6) Care must be taken to see that the gasket, seal and bolt bosses are kept in good condition to prevent leaks in these critical areas.

7) Torque the four bolts to 17-22 ft. lbs. (25.3-32.7 Kg/M.).

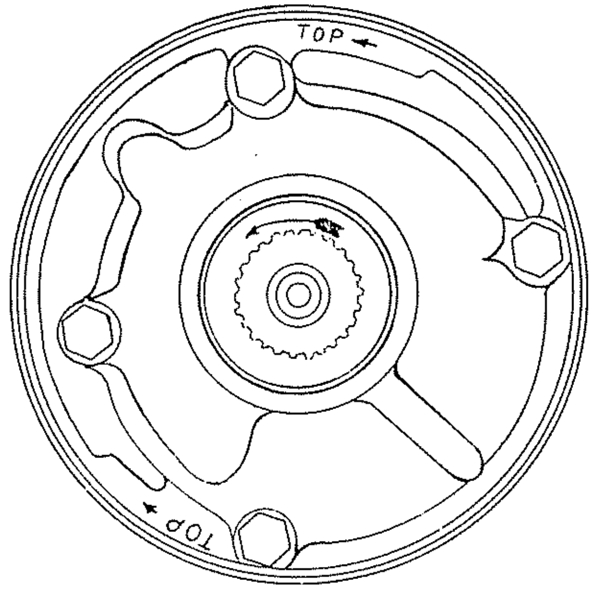


FIG. 1 VIEW FACING PUMP AND INPUT SHAFT

PROPELLER ROTATION

A right-hand propeller is a propeller which will thrust forward when turned clockwise when viewed from behind the boat looking forward.

A left-hand propeller is a propeller which will thrust forward when turned counterclockwise as viewed from behind the boat looking forward.

> **CAUTION:** Early gear failure will occur when the transmission must be operated in reverse to obtain forward when operated with a propeller having the wrong hand of rotation.

The required propeller is designated in the various charts as left hand (L.H.) or right hand (R.H.) for each transmission assembly.

TRANSMISSION RATIO SELECTION

Propeller shaft speed is determined by engine speed and transmission ratio. Every boat has a most desirable shaft speed, which has a direct relationship to boat speed. A small propeller must be used when shaft speeds are too high and this results in poor performance. A large propeller turning at high speed would overload the engine. Fast runabouts do best with direct drive units. Cruisers require reduction gears. The heavier and slower boats require correspondingly greater ratios of reduction. One hundred revolutions per minute of the propeller shaft for each mile per hour of boat speed is considered a very good rule of thumb for selecting the drive ratio.

EXAMPLE:

A boat which runs 20 MPH has an engine which runs 4000 RPM. MPH x 100 RPM propeller shaft=optimum shaft speed, or 20 x 100=2000 RPM would be optimum shaft speed.

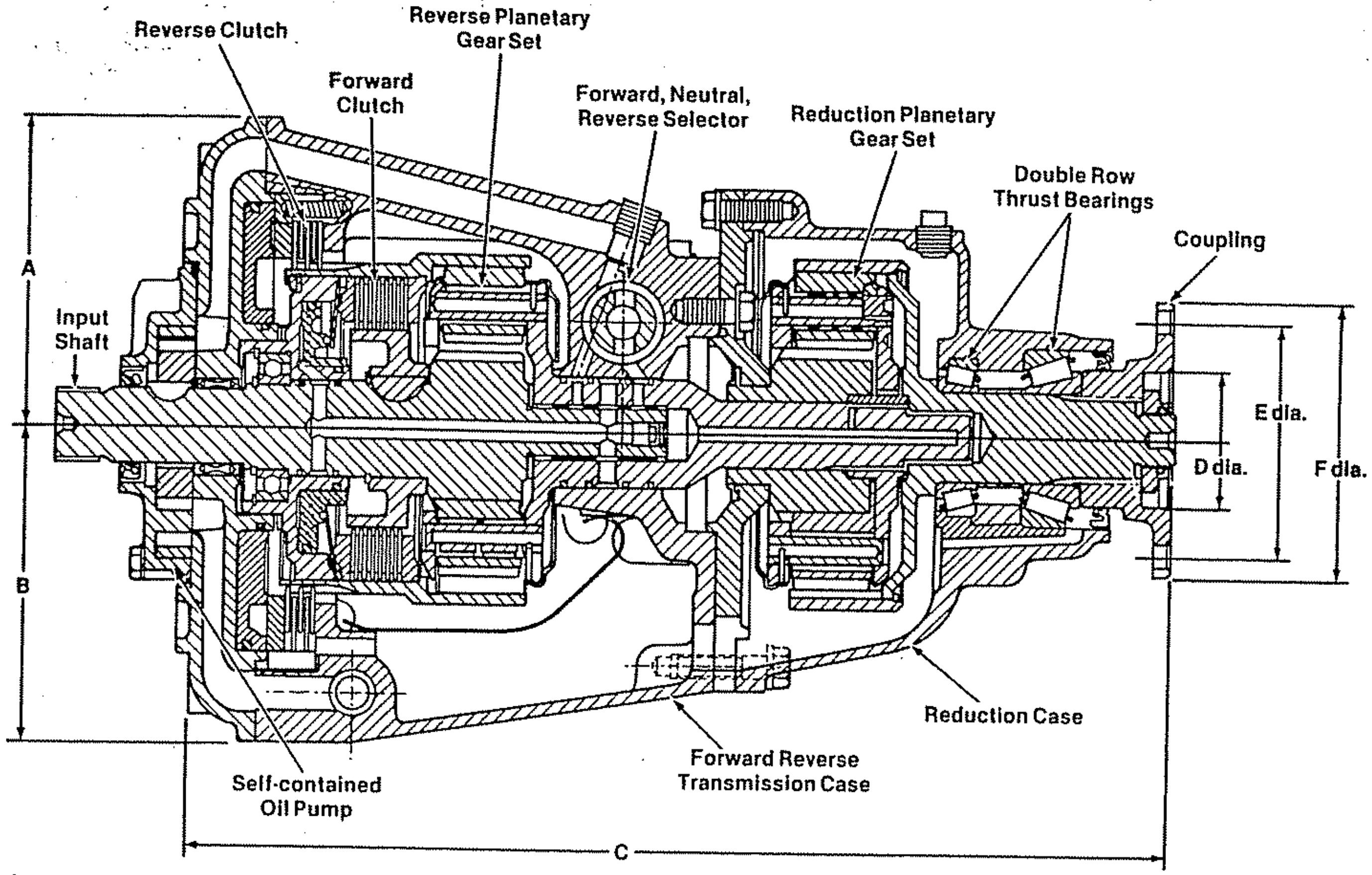
$$\frac{4000 = \text{Engine Speed}}{2000 = \text{Shaft Speed}} \text{ or } \frac{2}{1} \text{ Reduction Required.}$$

PROPELLER SELECTION

The propeller is selected to load the engine and still permit full power to be developed. The propeller must allow the engine to come up to rated speed. It is incorrect to use a propeller so large that the engine will be overloaded, because this will not only reduce the power delivered to the propeller shaft, but more importantly it will cause abnormally high loading within the engine. This can result in destructive pressures and temperatures which cause premature bearing and valve failure.

For ski towing, it is best to select a propeller which will permit the engine to maintain rated RPM when under load.

Figure 2 Installation drawing for In-Line transmissions (2.10:1.00 ratio illustrated)



General Performance Data

Model	Maximum SAE HP Input (1)		Available Ratios	Shaft Rotation	Approximate Dry Weight	
	Gasoline	Diesel			Direct Drive	Reduction
71C 10-17	255 @ 4200 rpm	145 @ 3200 rpm	1.00 1.52 1.91*	Outside same as Engine unless noted by asterisk (*)	95 lb. (43.1 kg.)	145 lb. (65.8 kg.)
72C 10-18	380 @ 4200 rpm	185 @ 2800 or 210 @ 3200	2.10 2.57 2.91 to 1.00		1.09 lb. (49.4 kg.)	153 lb. (69.4 kg.)
73C 10-06	560 @ 4200 rpm	400 @ 3200 rpm	1.00 1.50 2.00* 3.00 to 1.00	Output same as Engine unless noted by asterisk (*)	135 lb. (61.2 kg.)	185 lb. (83.9 kg.)

*Rotation is opposite engine.

Dimensions Inches and (millimeters)

Model	A	B	C(2)	D dia.	E dia.	F dia.
71C 10-17	5.63 (143.00)	5.69 (144.53)	16.89 (429.01)	2.50 (63.50)	4.25(3) (107.95)	5.00(3) (127.00)
72C 10-18	5.63 (143.00)	5.69 (144.53)	17.79 (451.86)	2.50 (63.50)	4.25 (107.95)	5.00 (127.00)
73C 10-06	5.94 (150.88)	6.88 (174.75)	19.45 (494.03)	3.00 (76.20)	4.75 (120.65)	5.75 (146.05)

Notes:

(1) The above transmission ratings are subject to change without notice and are intended only as a general guide for pleasure craft usage. For additional application information, consult a Warner Gear marine distributor.

(2) For "C" dimension—direct drive units:

71C 10-17	10.50 (266.70)
72C 10-18	11.44 (290.58)
73C 10-06	13.47 (342.14)

(3) Direct drive model 71 (only) uses 4" (101.60) coupling.

WARNING: System related noises or vibrations can occur at low engine speeds which can cause gear rattle and result in damage to the boat engine as well as the transmission. Warner Gear is not responsible for total system related torsionals of this type.

IDENTIFICATION OF VELVET DRIVE IN-LINE MODELS 70C, 71C, 72C & 73C

NEW TRANS. ASSEMBLY NUMBER	TRANS. ASSEMBLY NUMBER (8)	INPUT TO OUTPUT SPEED RATIO		ROTATION (1)			PUMP SETTING (2)	PROPELLER REQUIRED (3)	OIL CAPACITY (4)				APPROX. TRANS. WEIGHT	
				INPUT SHAFT	OUTPUT SHAFT				15° INCLINED		LEVEL			
		FORWARD	REVERSE		FORWARD	REVERSE			U.S. QTS.	LITERS	U.S. QTS.	LITERS	POUNDS	KGS.
10-04-000-022*	AS1-70C	1:1	1:1	CW	CW	CCW	LH	RH	1.3	1.23	1.8	1.70	92	41.7
10-04-000-023*	AS1-70CR	1:1	1:1	CCW	CCW	CW	RH	LH	1.3	1.23	1.8	1.70	92	41.7
10-04-000-026*	AS2-70C	1.52:1	1.52:1	CW	CW	CCW	LH	RH	2.7	2.56	2.5	2.37	142	64.4
10-04-000-027*	AS2-70CR	1.52:1	1.52:1	CCW	CCW	CW	RH	LH	2.7	2.56	2.5	2.37	142	64.4
10-04-000-028*	AS3-70C	2.10:1	2.10:1	CW	CW	CCW	LH	RH	2.7	2.56	2.5	2.37	142	64.4
10-04-000-029*	AS3-70CR	2.10:1	2.10:1	CCW	CCW	CW	RH	LH	2.7	2.56	2.5	2.37	142	64.4
10-04-000-030*	AS14-70C	2.57:1	2.57:1	CW	CW	CCW	LH	RH	2.7	2.56	2.5	2.37	142	64.4
10-04-000-031*	AS14-70CR	2.57:1	2.57:1	CCW	CCW	CW	RH	LH	2.7	2.56	2.5	2.37	142	64.4
10-04-000-032*	AS15-70C	2.91:1	2.91:1	CW	CW	CCW	LH	RH	2.7	2.56	2.5	2.37	142	64.4
10-04-000-033*	AS15-70CR	2.91:1	2.91:1	CCW	CCW	CW	RH	LH	2.7	2.56	2.5	2.37	142	64.4
10-04-000-034*	AS7-70C (5)	1.91:1	1.91:1	CW	CCW	CW	LH	LH	2.7	2.56	2.5	2.37	142	64.4
10-04-000-035*	AS7-70CR (5)	1.91:1	1.91:1	CCW	CW	CCW	RH	RH	2.7	2.56	2.5	2.37	142	64.4
10-04-000-024*	AS10-70C (7)	1:1	1:1	CW	CW	CCW	LH		1.7	1.61	2.1	1.99	95	43.1
10-04-000-025*	AS10-70CR (7)	1:1	1:1	CCW	CCW	CW	RH		1.7	1.61	2.1	1.99	95	43.1
10-17-000-001*	AS1-71C	1:1	1:1	CW	CW	CCW	LH	RH	1.3	1.23	1.8	1.70	95	43.1
10-17-000-002*	AS1-71CR	1:1	1:1	CCW	CCW	CW	RH	LH	1.3	1.23	1.8	1.70	95	43.1
10-17-000-003	AS1-71CB (6)	1:1	1:1	CW	CW	CCW	LH	RH	1.3	1.23	1.8	1.70	95	43.1
10-17-000-004	AS1-71CBR (6)	1:1	1:1	CCW	CCW	CW	RH	LH	1.3	1.23	1.8	1.70	95	43.1
10-17-000-005	AS2-71C	1.52:1	1.52:1	CW	CW	CCW	LH	RH	2.7	2.56	2.5	2.37	145	65.8
10-17-000-006	AS2-71CR	1.52:1	1.52:1	CCW	CCW	CW	RH	LH	2.7	2.56	2.5	2.37	145	65.8
10-17-000-009	AS3-71C	2.10:1	2.10:1	CW	CW	CCW	LH	RH	2.7	2.56	2.5	2.37	145	65.8
10-17-000-010	AS3-71CR	2.10:1	2.10:1	CCW	CCW	CW	RH	LH	2.7	2.56	2.5	2.37	145	65.8
10-17-000-011	AS14-71C	2.57:1	2.57:1	CW	CW	CCW	LH	RH	2.7	2.56	2.5	2.37	145	65.8
10-17-000-012	AS14-71CR	2.57:1	2.57:1	CCW	CCW	CW	RH	LH	2.7	2.56	2.5	2.37	145	65.8
10-17-000-013	AS15-71C	2.91:1	2.91:1	CW	CW	CCW	LH	RH	2.7	2.56	2.5	2.37	145	65.8
10-17-000-014	AS15-71CR	2.91:1	2.91:1	CCW	CCW	CW	RH	LH	2.7	2.56	2.5	2.37	145	65.8
10-17-000-007	AS7-71C	1.91:1	1.91:1	CW	CCW	CW	LH	LH	2.7	2.56	2.5	2.37	145	65.8
10-17-000-008	AS7-71CR	1.91:1	1.91:1	CCW	CW	CCW	RH	RH	2.7	2.56	2.5	2.37	145	65.8
10-17-000-015*	AS20-71C (7)	1:1	1:1	CW	CW	CCW	LH		1.7	1.61	2.1	1.99	98	44.5
10-17-000-016*	AS20-71CR (7)	1:1	1:1	CCW	CCW	CW	RH		1.7	1.61	2.1	1.99	98	44.5
10-18-000-001	AS11-72C	1:1	1.10:1	CW	CW	CCW	LH	RH	1.7	1.61	2.1	1.99	109	49.4
10-18-000-002	AS11-72CR	1:1	1.10:1	CCW	CCW	CW	RH	LH	1.7	1.61	2.1	1.99	109	49.4
10-18-000-003	AS12-72C	1.52:1	1.68:1	CW	CW	CCW	LH	RH	2.8	2.65	2.7	2.56	154	69.9
10-18-000-004	AS12-72CR	1.52:1	1.68:1	CCW	CCW	CW	RH	LH	2.8	2.65	2.7	2.56	154	69.9
10-18-000-007	AS13-72C	2.10:1	2.31:1	CW	CW	CCW	LH	RH	2.8	2.65	2.7	2.56	154	69.9
10-18-000-008	AS13-72CR	2.10:1	2.31:1	CCW	CCW	CW	RH	LH	2.8	2.65	2.7	2.56	154	69.9
10-18-000-009	AS14-72C	2.57:1	2.83:1	CW	CW	CCW	LH	RH	2.8	2.65	2.7	2.56	154	69.9
10-18-000-010	AS14-72CR	2.57:1	2.83:1	CCW	CCW	CW	RH	LH	2.8	2.65	2.7	2.56	154	69.9
10-18-000-011	AS15-72C	2.91:1	3.20:1	CW	CW	CCW	LH	RH	2.8	2.65	2.7	2.56	154	69.9
10-18-000-012	AS15-72CR	2.91:1	3.20:1	CCW	CCW	CW	RH	LH	2.8	2.65	2.7	2.56	154	69.9
10-18-000-005	AS17-72C (5)	1.91:1	2.10:1	CW	CCW	CW	LH	LH	2.8	2.65	2.7	2.56	154	69.9
10-18-000-006	AS17-72CR (5)	1.91:1	2.10:1	CCW	CW	CCW	RH	RH	2.8	2.65	2.7	2.56	154	69.9
10-18-000-013	AS20-72C (7)	1:1	1.10:1	CW	CW	CCW	LH		1.7	1.61	2.1	1.99	112	50.8
10-18-000-014	AS20-72CR (7)	1:1	1.10:1	CCW	CCW	CW	RH		1.7	1.61	2.1	1.99	112	50.8
	AS20-72CR (7)	1:1	1.10:1	CW	CW	CCW	LH		1.7	1.61	2.1	1.99	116	52.6
	AS30-72CR (7)	1:1	1.10:1	CCW	CCW	CW	RH		1.7	1.61	2.1	1.99	116	52.6
10-06-000-004	AS1-73C	1:1	88:1	CW	CW	CCW	LH	RH	1.5	1.42	1.6	1.51	135	61.2
10-06-000-005	AS1-73CR	1:1	88:1	CCW	CCW	CW	RH	LH	1.5	1.42	1.6	1.51	135	61.2
10-06-000-006	AS2-73C	1.5:1	1.32:1	CW	CW	CCW	LH	RH	2.2	2.08	2.0	1.89	185	83.9
10-06-000-007	AS2-73CR	1.5:1	1.32:1	CCW	CCW	CW	RH	LH	2.2	2.08	2.0	1.89	185	83.9
10-06-000-008	AS5-73C	3:1	2.64:1	CW	CW	CCW	LH	RH	2.2	2.08	2.0	1.89	185	83.9
10-06-000-009	AS5-73CR	3:1	2.64:1	CCW	CCW	CW	RH	LH	2.2	2.08	2.0	1.89	185	83.9
10-06-000-010	AS7-73C (5)	2:1	1.76:1	CW	CCW	CW	LH	LH	2.2	2.08	2.0	1.89	185	83.9
10-06-000-011	AS7-73CR (5)	2:1	1.76:1	CCW	CW	CCW	RH	RH	2.2	2.08	2.0	1.89	185	83.9

*Discontinued Models

(1) Input and output shaft rotation is described as clockwise (CW) or counter clockwise (CCW) when the observer is standing behind transmission coupling facing towards front or input shaft end of transmission.

(2) Pump rotation is described when the observer is standing in front of transmission facing the pump. The arrow located nearest the top of pump face must point in the direction pump will be driven by the input shaft. IT SHOULD BE REALIZED THAT INDEXING THE PUMP FOR OPPOSITE ROTATION DOES NOT CAUSE OUTPUT SHAFT ROTATION TO BE REVERSED, but does permit the transmission to be used behind an opposite rotating engine. All 10-06 units may have pump indexed for opposite rotation.

CAUTION: The pump indexing on all assemblies except 2.10:1 reduction units is the only difference between C and CR units. The planetary gears and cage assembly used in C units is different than the one used in CR units in the 2.10:1 reduction units; therefore, indexing the pump for opposite rotation is not permitted on these assemblies. No warranty claims will be allowed for failures caused by improper pump indexing on 2.10:1 reduction units.

(3) The propeller is described when the observer is standing behind the boat looking forward. A right hand (RH) prop will move the boat forward when rotated clockwise.

(4) Transmission oil capacity only is given. Additional oil will be required for filling oil cooler and cooler lines.

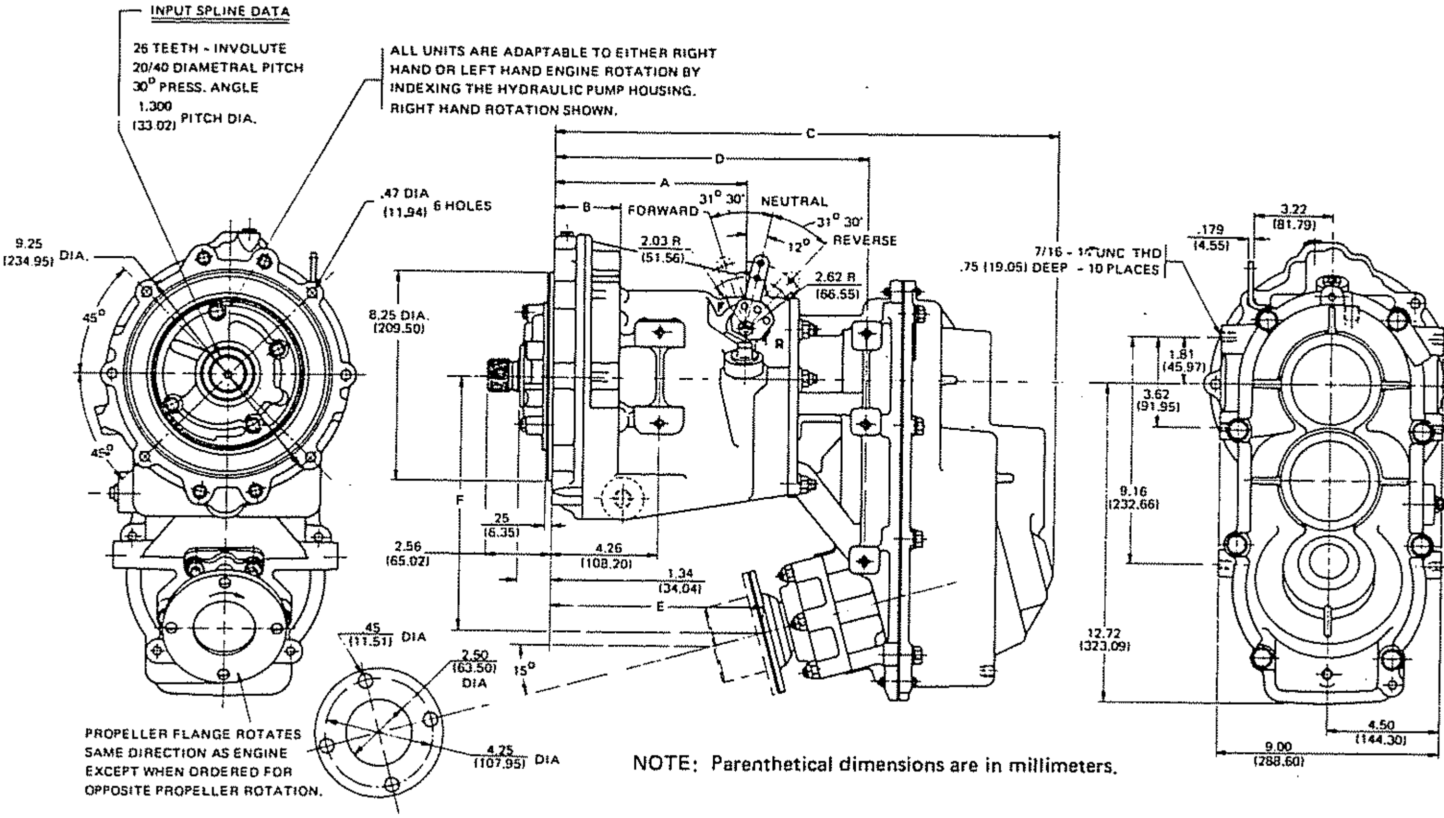
(5) All AS7 and AS17 reduction units are counter-rotating, i.e. the output shaft turns opposite to input shaft when the transmission is operated in forward.

(6) The AS1-71CB and AS1-71CBR units are for heavier reverse duty and diesel applications.

(7) Warner Gear supplies AS10-70C, AS10-70CR, AS20-71C, AS20-71CR, AS20-72C, AS20-72CR, AS30-70C and AS30-72C units for use with stern drives. V-Drives or other auxilary reduction gears. Contact the manufacturer of the supplementary gearing for details of the complete assembly.

(8) All Model 70C units have been discontinued.

FIG. 3 INSTALLATION DRAWING FOR V-DRIVE TRANSMISSIONS



NOTE: Parenthetical dimensions are in millimeters.

MODEL	A	B	C	D	E	F	REDUCTION
71C SERIES 10-04	6.83 (173.48)	2.38 (60.45)	19.15 (486.41)	11.65 (295.91)	7.64 (194.06)	10.19 (258.83)	.96:1, 1.21:1, 2.49:1, 3.14:1
						10.14 (257.56)	1.51:1, 1.99:1
72C SERIES 10-05	7.76 (197.10)	2.64 (67.06)	20.06 (509.52)	12.59 (319.79)	8.58 (217.93)	10.19 (258.83)	.96:1, 1.21:1 2.49:1, 3.14:1
						10.14 (257.56)	1.51:1, 1.99:1

GENERAL SPECIFICATIONS

MODEL	MAXIMUM SAE HP INPUT		AVAILABLE RATIOS	OUTPUT ROTATION	DRY WEIGHT
	GASOLINE	DIESEL			
10-04	255 @ 4200 rpm	145 @ 3200 rpm	0.96, 1.21, 1.51, 1.99, 2.49, 3.14 to 1.00	OPTIONAL	190 lb. (86.2 kg.)
10-05	380 @ 4200 rpm	185 @ 2800 rpm 210 @ 3200 rpm			203 lb. (92.1 kg.)

NOTE: All specifications and descriptive data are nominal and subject to change without notice. Specific installations should be referred to Warner Gear for application assistance.

V-DRIVE ASSEMBLIES

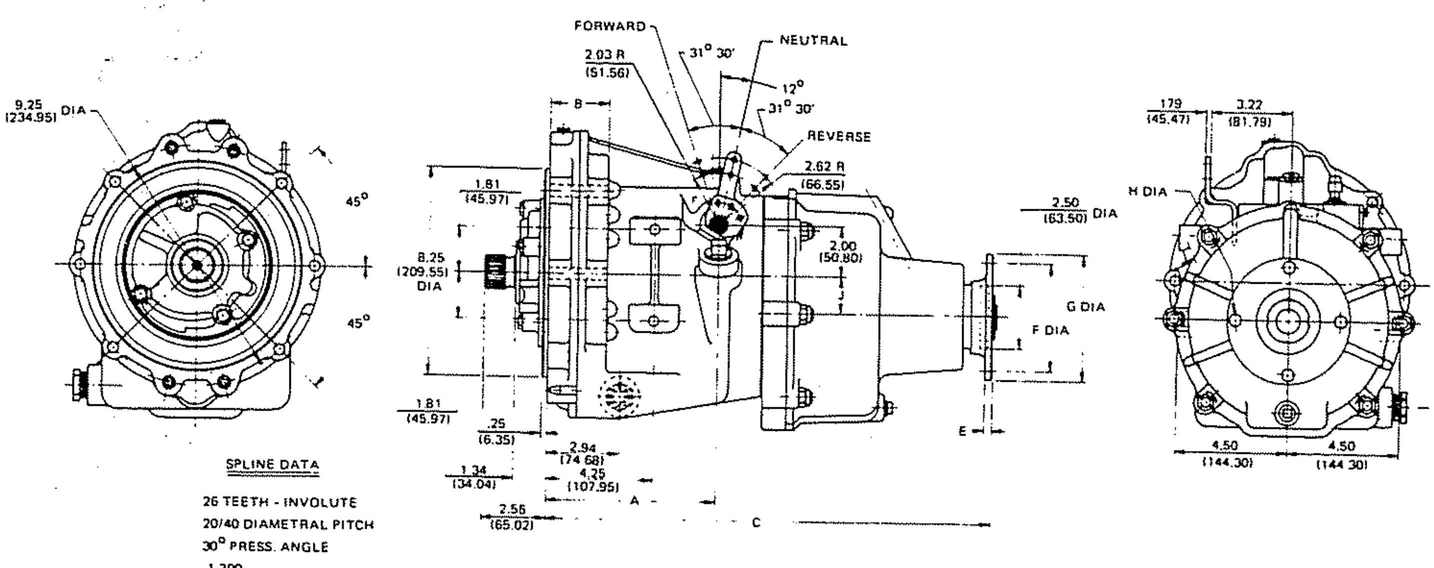
MODEL NUMBER & TYPE		ASSEMBLY NUMBER *	INPUT TO OUTPUT SHAFT RATIO FORWARD	INPUT TO OUTPUT SHAFT RATIO REVERSE	ROTATION INPUT SHAFT	ROTATION OUTPUT SHAFT FORWARD	ROTATION OUTPUT SHAFT REVERSE	PUMP SETTING	PROPELLER REQUIRED
10–04 / 13–08	GEAR DRIVE UNITS	10-04-000-002	1.99:1	1.99:1	C	C	CC	←	LH
		(13-08-410-002)			CC	CC	C	→	RH
		10-04-000-005	2.49:1	2.49:1	C	C	CC	←	LH
		(13-08-410-005)			CC	CC	C	→	RH
		10-04-000-007	3.14:1	3.14:1	C	C	CC	←	LH
		(13-08-410-007)			CC	CC	C	→	RH
		10-04-000-009	0.96:1	0.96:1	C	C	CC	←	LH
		(13-08-410-009)			CC	CC	C	→	RH
		10-04-000-011	1.51:1	1.51:1	C	C	CC	←	LH
		(13-08-410-011)			CC	CC	C	→	RH
		10-04-000-012	1.21:1	1.21:1	C	C	CC	←	LH
		(13-08-410-012)			CC	CC	C	→	RH
	CHAIN DRIVE UNITS	10-04-000-003	1.98:1	1.98:1	C	CC	C	←	RH
		(13-08-410-003)			CC	C	CC	→	LH
		10-04-000-004	2.50:1	2.50:1	C	CC	C	←	RH
		(13-08-410-004)			CC	C	CC	→	LH
		10-04-000-006	3.10:1	3.10:1	C	CC	C	←	RH
		(13-08-410-006)			CC	C	CC	→	LH
		10-04-000-008	0.97:1	0.97:1	C	CC	C	←	RH
		(13-08-410-008)			CC	C	CC	→	LH
		10-04-000-010	1.53:1	1.53:1	C	CC	C	←	RH
		(13-08-410-010)			CC	C	CC	→	LH
		10-04-000-013	1.21:1	1.21:1	C	CC	C	←	RH
		(13-08-410-013)			CC	C	CC	→	LH
10–05 / 13–08	GEAR DRIVE UNITS	10-05-000-002	1.99:1	2.19:1	C	C	CC	←	LH
		(13-08-410-002)			CC	CC	C	→	RH
		10-05-000-005	2.49:1	2.74:1	C	C	CC	←	LH
		(13-08-410-005)			CC	CC	C	→	RH
		10-05-000-007	3.14:1	3.45:1	C	C	CC	←	LH
		(13-08-410-007)			CC	CC	C	→	RH
		10-05-000-009	0.96:1	1.06:1	C	C	CC	←	LH
		(13-08-410-009)			CC	CC	C	→	RH
		10-05-000-011	1.51:1	1.67:1	C	C	CC	←	LH
		(13-08-410-011)			CC	CC	C	→	RH
		10-05-000-012	1.21:1	1.33:1	C	C	CC	←	LH
		(13-08-410-012)			CC	CC	C	→	RH
	CHAIN DRIVE UNITS	10-05-000-003	1.98:1	2.17:1	C	CC	C	←	RH
		(13-08-410-003)			CC	C	CC	→	LH
		10-05-000-004	2.50:1	2.75:1	C	CC	C	←	RH
		(13-08-410-004)			CC	C	CC	→	LH
		10-05-000-006	3.10:1	3.41:1	C	CC	C	←	RH
		(13-08-410-006)			CC	C	CC	→	LH
		10-05-000-008	0.97:1	1.07:1	C	CC	C	←	RH
		(13-08-410-008)			CC	C	CC	→	LH
		10-05-000-010	1.53:1	1.68:1	C	CC	C	←	RH
		(13-08-410-010)			CC	C	CC	→	LH
		10-05-000-013	1.21:1	1.33:1	C	CC	C	←	RH
		(13-08-410-013)			CC	C	CC	→	LH

C – CLOCKWISE

CC – COUNTER CLOCKWISE

* The (13-08-410) number below the number for the V-Drive assembly is the part number for the V-Drive portion only. 10-04-410-001 is the part number for the Front Box only (forward and reverse transmission) for the 10-04 units and 10-05-410-001 is for the 10-05 units.

FIG. 4 INSTALLATION DRAWING FOR DROP-CENTER TRANSMISSIONS



NOTE: Parenthetical dimensions are in millimeters.

MODEL	A	B	C	E	F DIA	G DIA	H DIA	REDUCTION	J OFFSET DIMS. OUTPUT ROTATION: ENGINE	OPPOSITE
71C SERIES										
10-13	6.82 (173.23)	2.39 (60.71)	18.42 (467.87)	.31 (7.87)	4.25 (107.95)	5.00 (127.00)	.45 (11.43)	1.58	1.23 (31.24)	1.06 (26.92)
								2.03	1.66 (42.16)	1.49 (37.85)
								2.47	1.95 (49.53)	1.77 (44.96)
								2.93	2.16 (54.86)	1.99 (50.55)
72C SERIES										
10-14	7.76 (197.10)	2.64 (67.06)	19.36 (491.74)	.31 (7.87)	4.25 (107.95)	5.00 (127.00)	.45 (11.43)	1.58	1.23 (31.24)	1.06 (26.92)
								2.03	1.66 (42.16)	1.49 (37.85)
								2.47	1.95 (49.53)	1.77 (44.96)
								2.93	2.16 (54.86)	1.99 (50.55)

GENERAL SPECIFICATIONS

MODEL	MAXIMUM SAE HP INPUT: GASOLINE	DIESEL	AVAILABLE RATIOS	OUTPUT ROTATION	DRY WEIGHT
10-13	255 @ 4200 rpm	130 @ 3200 rpm	1.58, 2.03, 2.47. 2.93 to 1.00	OPTIONAL	162 lb. (73.5 kg.)
10-14	380 @ 4200 rpm	185 @ 2800 rpm 210 @ 3200 rpm			175 lb. (79.4 kg.)

NOTE: The above transmission ratings are subject to change without notice and are intended only as a general guide. Specific applications should be referred to Warner Gear for engineering assistance.

NE=NON-AUTOMOTIVE ENGINE
E=AUTOMOTIVE ENGINE
O=AUTOMOTIVE OPPOSITE

CR2
(DROP CENTER ASSEMBLIES)

ASSEMBLY NUMBER	REDUCTION RATIO		SHAFT ROTATION (1)			(2) PUMP SETTING	(3) PROPELLER REQUIRED	NAME PLATE STAMPED
				OUTPUT				
	FORWARD	REVERSE	INPUT	FORWARD	REVERSE			
10-13-000-001	1.58:1.	1.58:1	(4) L.H.	ENGINE	OPPOSITE ENGINE	→	L.H.	E-1.6
10-13-000-002	1.58:1	1.58:1	L.H.	OPPOSITE ENGINE	ENGINE	→	R.H.	O-1.6
10-13-000-003	2.03:1	2.03:1	L.H.	ENGINE	OPPOSITE ENGINE	→	L.H.	E-2.0
10-13-000-004	2.03:1	2.03:1	L.H.	OPPOSITE ENGINE	ENGINE	→	R.H.	O-2.0
10-13-000-005	2.47:1	2.47:1	L.H.	ENGINE	OPPOSITE ENGINE	→	L.H.	E-2.5
10-13-000-006	2.47:1	2.47:1	L.H.	OPPOSITE ENGINE	ENGINE	→	R.H.	O-2.5
10-13-000-007	2.93:1	2.93:1	L.H.	ENGINE	OPPOSITE ENGINE	→	L.H.	E-3.0
10-13-000-008	2.93:1	2.93:1	L.H.	OPPOSITE ENGINE	ENGINE	→	R.H.	O-3.0
10-13-000-009	1.58:1	1.58:1	R.H.	ENGINE	OPPOSITE ENGINE	←	R.H.	NE-1.6
10-13-000-010	2.03:1	2.03:1	R.H.	ENGINE	OPPOSITE ENGINE	←	R.H.	NE-2.0
10-13-000-011	2.47:1	2.47:1	R.H.	ENGINE	OPPOSITE ENGINE	←	R.H.	NE-2.5
10-13-000-012	2.93:1	2.93:1	R.H.	ENGINE	OPPOSITE ENGINE	←	R.H.	NE-3.0
10-14-000-001	1.58:1	1.74:1	L.H.	ENGINE	OPPOSITE ENGINE	→	L.H.	E-1.6
10-14-000-002	1.58:1	1.74:1	L.H.	OPPOSITE ENGINE	ENGINE	→	R.H.	O-1.6
10-14-000-003	2.03:1	2.23:1	L.H.	ENGINE	OPPOSITE ENGINE	→	L.H.	E-2.0
10-14-000-004	2.03:1	2.23:1	L.H.	OPPOSITE ENGINE	ENGINE	→	R.H.	E-2.0
10-14-000-005	2.47:1	2.72:1	L.H.	ENGINE	OPPOSITE ENGINE	→	L.H.	E-2.5
10-14-000-006	2.47:1	2.72:1	L.H.	OPPOSITE ENGINE	ENGINE	→	R.H.	O-2.5
10-14-000-007	2.93:1	3.22:1	L.H.	ENGINE	OPPOSITE ENGINE	→	L.H.	E-3.0
10-14-000-008	2.93:1	3.22:1	L.H.	OPPOSITE ENGINE	ENGINE	→	R.H.	O-3.0
10-14-000-009	1.58:1	1.74:1	R.H.	ENGINE	OPPOSITE ENGINE	←	R.H.	NE-1.6
10-14-000-010	2.03:1	2.23:1	R.H.	ENGINE	OPPOSITE ENGINE	←	R.H.	NE-2.0
10-14-000-011	2.47:1	2.72:1	R.H.	ENGINE	OPPOSITE ENGINE	←	R.H.	NE-2.5
10-14-000-012	2.93:1	3.22:1	R.H.	ENGINE	OPPOSITE ENGINE	←	R.H.	NE-3.0

(1) VIEWED FROM BEHIND COUPLING FACING ENGINE
(2) VIEWED FROM IN FRONT OF TRANSMISSION INTO PUMP
(3) VIEWED FROM BEHIND BOAT
(4) L.H. – LEFT HAND OR COUNTERCLOCKWISE
R.H. – RIGHT HAND OR CLOCKWISE

CAUTION: Engine rotation must be the same as shown on the chart (input shaft rotation). Failure to comply can result in premature gear damage.

ADAPTER HOUSING

Adapter housings for mounting the transmission to the engine are normally manufactured by the engine manufacturer or marine engine converter. The rear face of the adapter and the adapter rear bore should have a total indicator reading of less than .005 of an inch when checked for run out. All Velvet Drive transmissions which are currently available may be mounted to the same sized bell housing.

Warner Gear does manufacture and have available the following adapters:

71C-1½ for flywheel end mounting to the Ford V-8 engines which have 239, 256, 272, 292, and 312 cubic inch displacement.

71C-1½B for flywheel end mounting to the Ford of England engines which have 220 and 330 cubic inch displacement diesel engines.

71C-1½C for flywheel end mounting to Mercury, Edsel, and Lincoln engines of 383, 410, and 430 cubic inch displacement, and Ford, Edsel, and Mercury engines of 332 and 352 cubic inch displacement.

TRANSMISSION INSTALLATION

INSTALLING TRANSMISSION TO ENGINE

The transmission may be installed to either the flywheel or timing gear end of the engine. A suitable damper assembly should be selected and installed to either the flywheel or to an adapter, which is attached to timing gear end of the crankshaft.

A transmission adapter should be purchased or manufactured to adapt the transmission to the engine. The adapter or spacers must be selected to cause the input shaft splines to make full engagement with the damper drive hub. Check for interference between the various parts as they are assembled.

Damper and transmission adapter alignment should be held to .005 inch total indicator reading for both bore and face readings.

Lubricate the input shaft and damper hub splines as the transmission is assembled to the engine.

Two studs should be screwed into center mounting bolt holes to insure transmission alignment and to support transmission weight to insure that damper will not be damaged as transmission is assembled to engine.

INSTALLATION ANGLE

The transmission and engine should be installed so that the maximum angle relative to horizontal does not exceed 15° when the boat is at rest, and should not exceed 20° when operating at the worst bow high condition. A higher angle of installation along with low oil level can permit pump cavitation when operating in rough water where pitching and rolling tends to throw the oil away from the pump inlet.

TRANSMISSION FLUID

Type F, Dexron® and other hydraulic fluids which meet the Detroit Diesel Allison Division of General Motors Corporation specifications for type C3 oils are recommended for use in all Velvet Drive marine gears.

Lubricating oils which are recommended for use in diesel engines and fall within Allison specifications for C3 oils may be used in all Velvet Drive marine gears if the engine RPM does not exceed 3000. SAE #30 is preferred. SAE #40 is acceptable if high operating temperatures are anticipated. Multi-visosity oils such as 10W-40 are not acceptable. The first choice is SAE-API service class "CD" oils. The second choice is SAE-API service class "CC" oils.

The equivalent DOD mil specs are:

CD	MIL-L-2104B
CC	MIL-L-45199

Detroit Diesel Allison Division of General Motors developed the C3 specifications for oils to be used in their hydraulic automatic and power shift transmissions used in heavy duty or severe service conditions. These oils are very well suited for use in all Velvet Drive marine gears.

Each oil company will provide information and specifications on their products which fall in the above specifications.

> NOTE: Be sure the cooler is properly installed and the transmission contains oil before cranking or starting the engine.

CHECKING OIL LEVEL

The oil level should be maintained at the full mark on the dipstick. Check oil level prior to starting the engine.

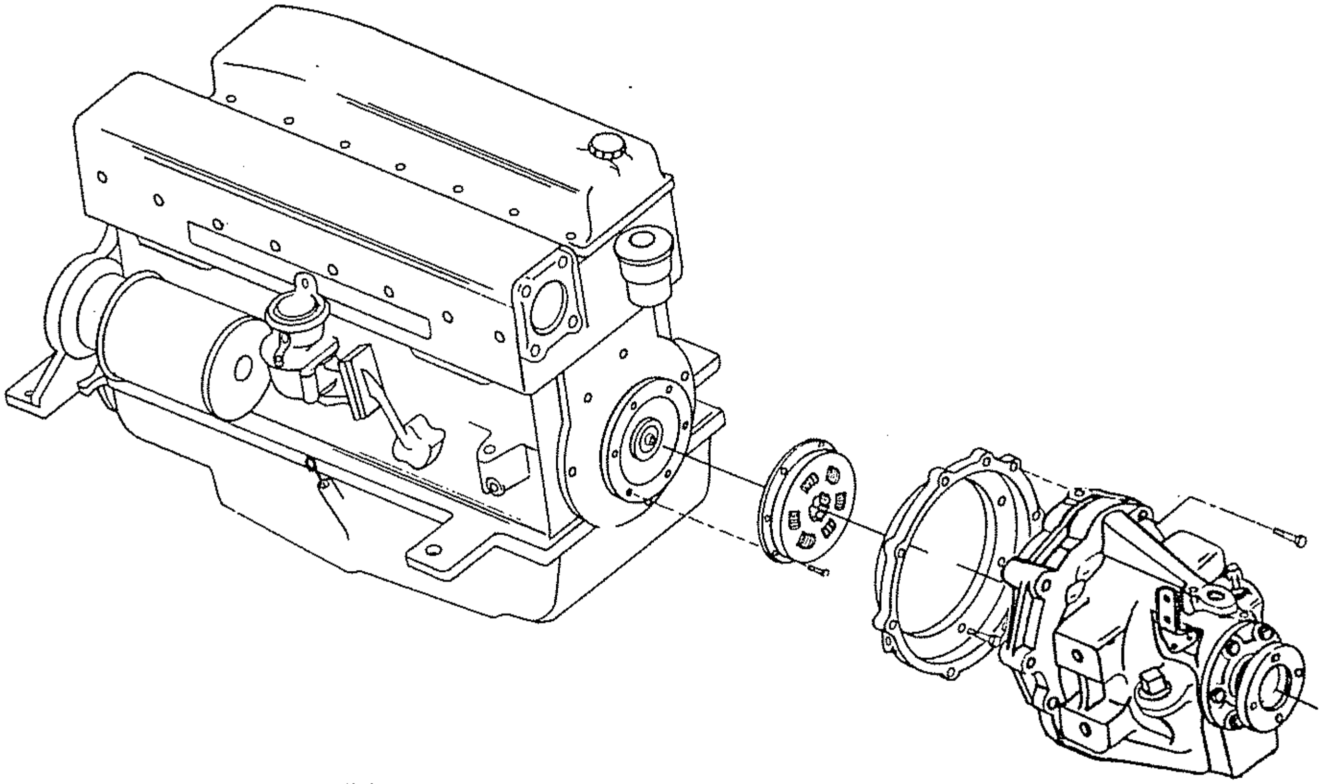


FIG. 6 TYPICAL TIMING GEAR END INSTALLATION

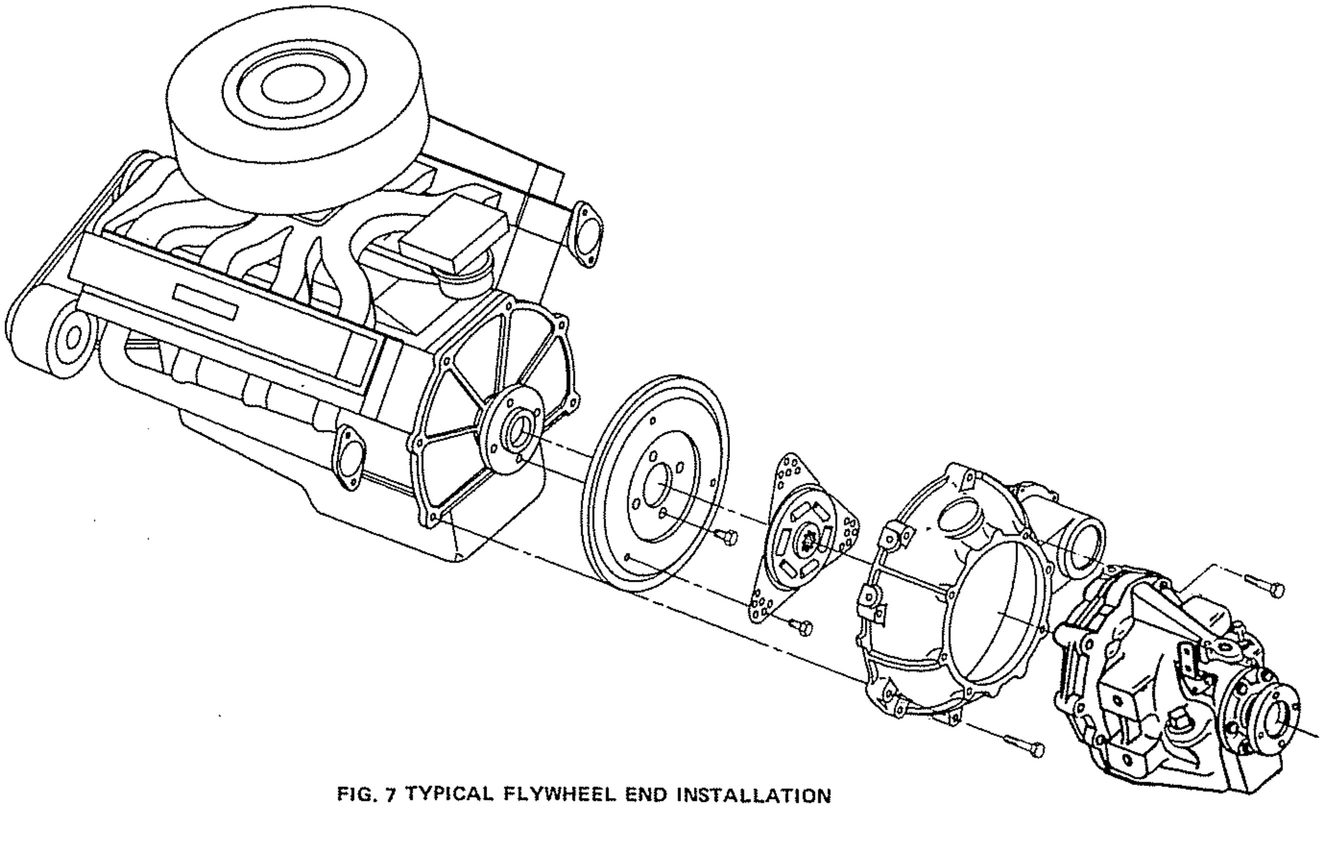


FIG. 7 TYPICAL FLYWHEEL END INSTALLATION

FILLING AND CHECKING THE HYDRAULIC SYSTEM

Check oil daily before starting engine. The Velvet Drive hydraulic circuit includes the transmission, oil cooler, cooler lines and any gauge lines connected into the circuit. The complete hydraulic circuit must be filled when filling the transmission and this requires purging the system of air before the oil level check can be made. The air will be purged from the system if the oil level is maintained above the pump suction opening while the engine is running at approximately 1500 RPM. The presence of air bubbles on the dipstick indicates that the system has not been purged of air.

New applications or a problem installation should be checked to insure that the oil does not drain back into the transmission from the cooler and cooler lines. Check the oil level for this drain back check only, immediately after the engine is shut off and again after the engine has been stopped for more than one hour (overnight is excellent). A noticeable increase in the oil level after this waiting period indicates that the oil is draining from cooler and cooler lines. The external plumbing should be changed to prevent any drain back.

TRANSMISSION OPERATION

STARTING ENGINE

Place transmission selector in neutral before starting engine. Shifts from any selector position to any other selector position may be made at any time and in any order if the engine speed is below 1000 RPM; however, it is recommended that all shifts be made at the lowest feasible engine speed.

NEUTRAL

Move the shift lever to the center position where the spring loaded ball enters the chamfered hole in the side of the shift lever and properly locates lever in neutral position. With shift lever so positioned, flow of oil to clutches is blocked at the control valve. The clutches are exhausted by a portion of the valve and complete interruption of power transmission is insured.

FORWARD

Move the shift lever to the extreme forward position where the spring loaded ball enters the chamfered hole in the side of the shift lever and properly locates lever in forward position.

REVERSE

Move transmission shift lever to the extreme rearward position where the spring loaded ball enters the chamfered hole in the side of the shift lever and properly locates it in the reverse position.

FREEWHEELING

Under sail with the propeller turning, or at trolling speeds with one of two engines shut down, the design of the Velvet Drive gear maintains adequate cooling and lubrication.

PRESSURE TESTS

For detailed checks of the hydraulic system, a pressure gauge should be installed in the hydraulic line. The transmission should be run until the oil temperature is 155°F to 165°F. (68°C-74°C). Pressure specifications are available in the repair manuals.

PROPELLER SHAFT COUPLINGS

COUPLING TO SHAFT ASSEMBLY

See form 1044 for specifications of couplings available from Warner Gear.

The propeller shaft coupling must be keyed to the propeller shaft. The key should be a close fit with keyway sides, but should not touch the top of the keyway in the coupling hub. The coupling should be a light press fit on the shaft, and may be warmed in hot oil to permit easier assembly.

> NOTE: Propeller shaft coupling distortion may occur when the propeller shaft is a few thousandths under the size required for the particular coupling, thus permitting the coupling to cock and distort as the set screws are tightened. A blank coupling should be machined to fit an undersize shaft. Distorted coupling may be refaced in a lathe.

Two optional methods for fastening the coupling to the propeller shaft are used. Type 1 couplings are pilot drilled through one side only, and the shaft and opposite side of the coupling must be drilled with the coupling in position on the propeller shaft. A 1/4 inch (6.35 mm) stainless steel spring pin must then be driven into the coupling and shaft to retain these parts. The spring pin should be selected so that it will be the same length as the coupling hub diameter and should be approximately flush with the coupling when assembled.

Type 2 couplings are drilled and tapped for set screws which are used to retain these parts. Some propeller shaft couplings are drilled and tapped for set screws, and are also pilot drilled for spring pin installation.

TRANSMISSION COUPLING TO PROPELLER SHAFT COUPLING ALIGNMENT

Vibration, gear noise, loss of RPM and premature oil seal and bearing failure can be caused by misalignment of the transmission coupling and propeller shaft coupling. The propeller shaft is usually fixed in the boat structure, and alignment is achieved by adjusting the engine mounts or by changing engine mount shims.

Preliminary alignment of the coupling faces should be carefully made prior to installing the engine and transmission hold-down bolts. A final alignment check should be made after the boat has been placed in the water. The fuel tanks should be filled and a normal load should be in position when making the final shaft alignment check.

It is common for a boat to change with age or various loads. An alignment check should be made at the beginning of each boating season.

Check coupling alignment with all bolts removed from the couplings. Hand hold couplings together with the snap fit engaged and check to determine the maximum clearance between couplings. Rotate the propeller shaft and then rotate the transmission coupling through at least one complete turn, stopping at 90° intervals and using a feeler gage (see figure 8) to check the air gap between the two flanges. Note any changes in the position where the air gap occurs. A bent shaft or coupling will cause the position of the air gap to move around the flanges as each shaft is rotated.

Alignment is satisfactory when shafts and couplings are on the same line of centers and the coupling faces are within .003 inch (0,076 mm) of parallel.

> CAUTION: Do not lift or pry against the transmission coupling to move the engine, as this can distort the coupling. Bent or distorted couplings can be refaced in a lathe.

USE OF FLEXIBLE COUPLINGS

Flexible couplings are used to reduce noise and for vibration dampening. Most boats are rigid enough to permit direct coupling of the propeller shaft coupling to transmission coupling, and this is recommended. Hulls which are not rigid enough to prevent undue twisting in heavy seas will permit shifting of engine and transmission with respect to propeller shaft. A suitable flexible coupling may be used when this condition exists.

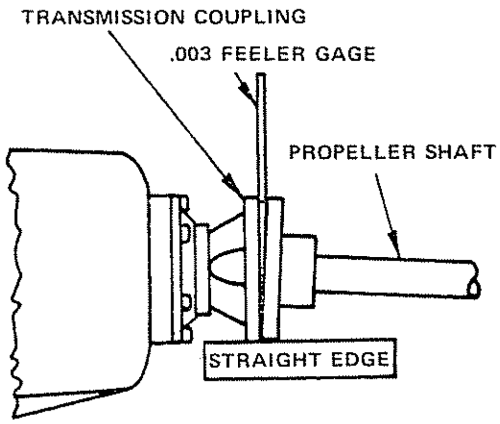


FIG. 8 CHECKING COUPLING ALIGNMENT

The alignment of the propeller shaft to the transmission output shaft should always be maintained even when flexible couplings are used.

Unbolt couplings to prevent bending of the shaft when boats are trailered or dry docked.

SHIFT LEVER

The oil flow to the hydraulic clutches is controlled by a barrel valve which is operated by the shift lever. To make the clutches function properly, the shift lever must be in the exact positions dictated by the detent ball and spring. Connect the push-pull cable to the shift lever so that proper travel and positioning will be obtained at the transmission when the control lever is shifted at the boat operator's station.

The warranty is jeopardised if the shift lever poppet spring and/or ball is permanently removed, or if the control lever is changed in any manner, or repositioned, or if the linkage between the remote control and the transmission shift does not have sufficient travel in both directions.

MOUNTING BRACKETS

Removing bolts in order to mount brackets, clamps, etc. can create leaks at gasketed joints.

Removing and reinstalling bolts over brackets can weaken the thread engagement. Proper bolt length and quality are required.

When brackets are bolted to the output shaft bearing retainer and seal mount, oil leaks tend to occur in this area.

Failure of the transmission due to loss of oil thru external causes is not covered by the warranty.

PAINTING

The cast iron transmission should be painted to prevent severe rusting. The color and painting procedure will be similar to that used on the engine.

Care must be taken to keep paint away from areas which have precision dimensions or mating parts. Masking tape or grease should be placed on these parts to prevent paint from sticking. Paint must be kept from the following areas:

1) The pilot diameter of the mounting face that mates with engine bell housing.

2) The input shaft spline which mates with the vibration damper hub.

3) The output shaft coupling flange which mates with the propeller shaft coupling half.

4) The shift lever detent ball and spring. An accumulation of paint here will prevent proper action of the detent.

5) The name plate should not be painted, otherwise the serial and model numbers may be impossible to read and this information should be available for ordering parts.

COOLERS

TRANSMISSION COOLING REQUIREMENTS

> WARNING: The transmission must never be operated without a cooler or by-pass tube connected into the cooler circuit.

The pressure regulator system depends upon cooler flow to exhaust a certain amount of oil, otherwise line pressure will become excessively high when a cooler is not connected in the cooler circuit. The transmission may be operated with a cooler bypass tube connected in the cooler circuit when an emergency exists and the transmission must be operated or when short tests are required; however, overheating is apt to occur.

Better efficiency and extended gear life will result when the transmission sump temperature is maintained between 140°F. and 190°F. or 60°C and 88°C. Transmission pressures are dependent upon cooler flow. It is important to select a cooler which has suitable flow characteristics as well as proper cooling capacity. Cooler back pressure affects line and cooler pressure. Low cooler pressure after an extended period of hard running indicates the need for a cooler which has more cooling capacity and possibly more back pressure. High cooler pressure after an extended period of hard running indicates the need for a cooler which has less back pressure.

COOLER LINES

Hydraulic hose with a minimum of 13/32 inch or 10.32mm inside diameter, standard pipe or flare fittings, should be used. Fittings should be large enough to avoid restricting the oil flow. Copper tubing should be avoided due to its tendency to loosen fittings and fatique crack when subjected to vibrations.

WARNER GEAR COOLERS

The coolers built and sold by Warner Gear have been discontinued. These coolers were of the single pass type and were approximately 2 inches (5.08 cm) in diameter. The 5, 9 & 12 in the chart refers to the length in inches of the main body of these coolers. This information should be helpful in determining the size of cooler to select for use with the Velvet Drive assemblies.

COOLER SIZE

The cooler size must be matched to the cooler circuit and the size and type of engine and transmission. The amount of cooling required depends upon the input power (which also governs transmission size) and the reduction ratios.

RECOMMENDATIONS FOR SIZING COOLERS

COOLER SIZE		TRANS. MODEL	TRANSMISSION RATIO
INCH	cm.		
5	127	70C	DIRECT DRIVE
5	127	71C	DIRECT DRIVE
9	228.6	70C	ALL REDUCTION RATIOS
9	228.6	71C	ALL REDUCTION RATIOS (EXCEPT 2.1:1)
9	228.6	72C	DIRECT DRIVE
9	228.6	10-04	ALL V-DRIVE
12	304.8	71C	2.1:1 RATIO
12	304.8	72C	ALL REDUCTION RATIOS
12	304.8	73C	ALL RATIOS
12	304.8	10-05	ALL V-DRIVE

The recommendations given above are based on typical marine engine installations which have a maximum water temperature at the cooler inlet of 110°F or 43°C and a minimum water flow of 10 U.S. gallons per minute or .63 liters/seconds. A larger sized cooler will be required when water entering the cooler has a temperature in excess of 110°F. or 43°C.

Coolers are available from many sources. Each cooler design has its own characteristics of cooling ability and oil flow resistance. **Since these characteristics affect transmission performance, the cooling system should be tested after installation to determine that temperature and pressures fall within recommended limits.**

WATER FLOW RATE

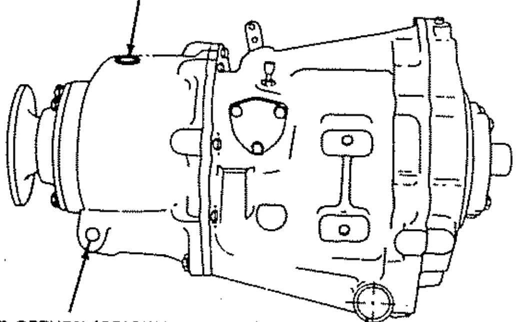
Water flow rates of from 10 to 20 U.S. G.P.M. or .63 to 1.26 liter/seconds are suitable for cooling any Velvet Drive transmission.

WATER TEMPERATURE TO COOLER

Raw water should be fed directly to cooler, otherwise the 110°F. (43°C) maximum water inlet temperature may be exceeded. Water temperature above 110°F. (43°C) is permissible only if larger sized coolers are used to maintain recommended transmission sump temperature.

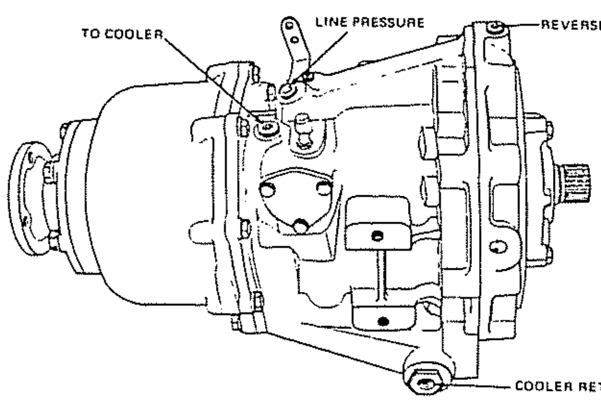
CONNECTING COOLER TO TRANSMISSION

WARNING: You must always determine the transmission to cooler and cooler return location for connecting lines to and from coolers for the particular transmission which is being installed. Several different circulation systems have been used. Failure to make the proper connections is sure to cause early transmission failure. Cooler return and to cooler locations may be found on the various installation drawings, which may be found in this manual, and also in the various service manuals. Be aware for future changes or differences which occur as new products are introduced.



70C, 71C, 72C, 10-17 & 10-18
IN-LINE REDUCTION TRANSMISSIONS

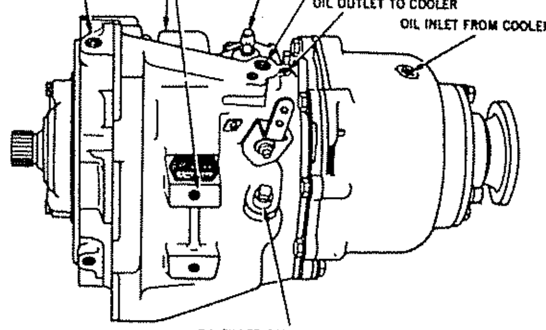
FIG. 9



ALL CURRENT 70C, 71C AND 72C REDUCTION UNITS EXCEPT 2.10:1.00 RATIOS

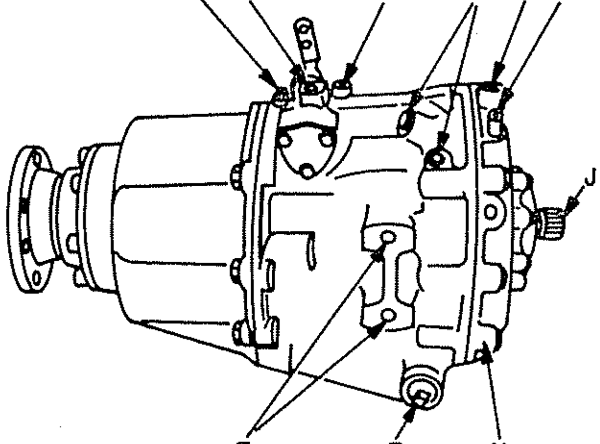
FIG. 10

NOTE: Transmissions are currently being shipped with plastic plugs installed in the to cooler and cooler return openings to identify their location.



DRAWING OF A CURRENT 2.10:1.00 REDUCTION UNIT

FIG. 11



RIGHT SIDE VIEW OF 73C REDUCTION TRANSMISSION

FIG. 12

LOCATION OF SEVERAL TRANSMISSION DETAILS ARE SHOWN BELOW:

- B. To cooler outlet
- C. Cooler return outlet
- D. Reverse clutch pressure tap
- E. Mounting bolt holes
- F. Drain plug
- I. Breather
- J. Input shaft
- N. Adapter
- O. Lube pressure tap
- P. Line pressure tap

COOLER OUT LOCATION

Cooler out is the oil leaving the transmission.

The cooler out location for all 70C, 71C and 72C series In-Line transmissions is located just behind the selector valve at the top rear of the forward and reverse transmission case.

The cooler out location for all 73C series transmissions is directly over the selector valve.

The cooler out location on V-Drive units is located just behind the selector valve at the top rear of the forward and reverse transmission case.

The cooler out location on the Drop-Center units is located just behind the selector valve at the top rear of the forward and reverse transmission case.

COOLER RETURN LOCATION

Cooler return is the oil returning to the transmission.

The cooler return location for all direct drive units of the 70C, 71C, 72C, 10-17 and 10-18 series transmissions is the drain plug opening in the transmission sump.

Early reduction units of the 70C, 71C, 72C, 10-17 and 10-18 series transmissions have the cooler oil returned to the lower side of the reduction housing, (figure 9). All units having the reduction housing drilled and tapped at the lower right side must have cooler oil returned to this location.

Reduction units of the 70C, 71C, 72C, 10-17 and 10-18 series, which do not have the reduction housing tapped in any location, must have the cooler oil returned to the sump fitting on the lower right side of the forward and reverse transmission case.

The 2.10:1 reduction transmissions of the 70C, 71C, 72C, 10-17 and 10-18 In-Line series are currently being drilled and tapped to return cooler oil to the top of the reduction housing, (figure 9). Any 2.10:1 reduction housing which is drilled and tapped for a ⅜-18 pipe fitting at this location must have cooler oil returned to this point.

All model 73C transmissions are currently manufactured to have cooler oil returned to either one of the two locations at the right top front end of the forward and reverse transmission case, (figure 12). The other cooler return opening should be plugged.

V-Drive units have cooler oil returned to an opening which is located at the lower rear of the V-Drive case.

Drop-Center reduction units have cooler oil returned to the sump fitting on the lower right side of the forward and reverse transmission case.

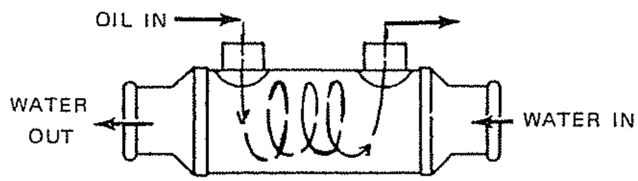
Better cooling efficiency will be obtained when oil and cooling water flow in opposite directions. A larger sized cooler may be required where oil and water flow in the same direction through the cooler.

MOUNTING COOLER

Air can be trapped above the oil in a cooler unless the cooler out fitting is located at the highest point on the cooler. Trapped air reduces cooling capacity, causes foaming, pump cavitation, loss of oil through the breather, and erratic oil level indication.

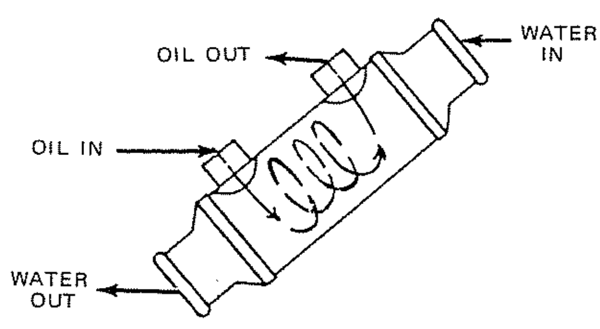
Horizontal mounting is preferred because it prevents oil from draining from the cooler. Drain back from a cooler which is mounted higher than the transmission sump will give a misleading high reading of the sump oil level; therefore, it is best to mount the cooler at sump level, i.e. at or below transmission centerline.

FIG. 13 COOLER MOUNTED HORIZONTALLY



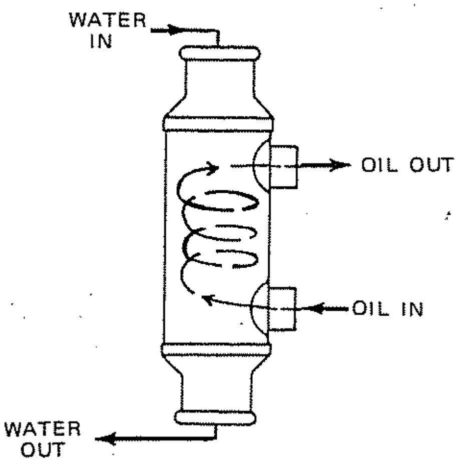
Oil coolers which are mounted on an angle should have cooler lines connected for oil to flow into the lower oil fitting and out of the higher oil fitting.

FIG. 14 COOLER MOUNTED ON AN ANGLE



Vertically mounted oil coolers should have the oil inlet located nearest the bottom of the cooler and the oil outlet located nearest the upper end of the cooler.

FIG. 15 COOLER MOUNTED VERTICALLY



TESTING COOLER CIRCUIT

The cooler size affects the oil temperature and lubrication pressures within the transmission; therefore, a test run should be made to insure that the transmission sump oil temperature falls between 140°F (60c) and 190°F (88c). The 190°F maximum sump temperature should not be exceeded when running at full throttle for an extended period of time. Overheating can cause transmission failure.

An accurate thermometer may be used to check the oil temperature by removing the dipstick and placing the thermometer directly in the sump oil. It is recommended that the engine be shut off while checking the temperature to prevent the possibility of catching the thermometer in the rotating gears. Continuous monitoring of sump temperatures is possible when a thermocouple is installed in the cooler out circuit near the transmission. The thermocouple should always be placed in the oil circuit so the oil passes over the sending unit.

Cooler pressures can be checked by connecting a pressure gage in the cooler out circuit near the transmission. When operating the engine at 2000 RPM, the normal cooler pressure at operating temperature should be approximately 40 p.s.i. or 2.81 kg/Cm2.

WATER DRAIN PLUG

Coolers are usually supplied with a drain plug which may be used to drain the water to prevent damage, which would occur in freezing weather. The plug should be located so that complete drainage of the cooler will occur when the drain plug is removed. Prior to ordering a cooler, consider the oil inlet location and drain plug location so that an assembly, which will satisfy all recommendations, may be ordered. Consider hose size and the angle of the hose connection so that the most direct cooler hook-up may be made.

COOLING PROBLEMS

Water passages inside of the cooler will sometimes become clogged, and this will reduce cooling capacity and cause overpressuring. Back flushing of the cooler will sometimes help to flush the foreign material from the cooler passages. The cooler and hose should be thoroughly flushed or replaced in the event a failure has occurred. Metallic particles from the failure tend to collect in the case of the cooler and gradually flow back into the lube system. Failure to prevent this by flushing or replacement may contaminate the oil and lead to transmission failure.

Water hoses may collapse and reduce or completely shut off all flow to the cooler. Collapsed hoses are usually caused by aging of the hoses or improper hose installation. Hose installation should be made with no sharp bends. Hoses should be routed so there is no possibility for engine shifting to cause hoses to pull loose or become pinched. A visual inspection of hoses while under way will sometimes allow detection of faulty hoses.

Reduction or complete loss of water flow can be caused by a faulty water pump. A rubber water pump impeller will sometimes fail and after such a failure the cooler passages may be restricted by the particles of rubber from the failed impeller. Water pump cavitation may be caused by improper or faulty plumbing or an air leak on the inlet side of the pump. The water pump may not prime itself or may lose its prime when inlet plumbing is not properly installed.

Cooler problems may be the result of improperly connecting the cooler to the transmission. Reports from the field indicate that the proper transmission plumbing locations have not always been used for connecting the cooler to the transmission. It is therefore suggested that a thorough study be made of the various cooler inlet and outlet locations for the various models as detailed at the introduction of this section on page 17.

SELECTIO

Each engine has its own
inertia. The application engineer
damper most suitable for the particular

DAMPER APPLICATION CHART
AND
DAMPER ASSEMBLIES WHICH ARE CURRENTLY AVAILABLE FROM WARNER GEAR

The following chart gives suggested maximum torques and engine displacements for for which these dampers are designed. Due to wide variations between individual torsional systems, all applications must be tested by the user to insure satisfactory operation.

SERIES	ASSEMBLY NUMBER	MAX. CU. IN. DSPL.	MAXIMUM FOOT POUNDS ENGINE TORQUE							
			GASOLINE				DIESEL			
			8 CYL.	6 CYL.	4 CYL.	1-3 CYL.	8 CYL.	6 CYL.	4 CYL.	1-3 CYL.
K1C (1)	AS12-K1C (7)	175	89	83	72	61	78	67	55	44
	AS1-K1C (7)	250	128	120	104	88	112	96	80	64
	AS4-K1C (7)	330	248	232	202	170	217	186	155	124
	AS5-K1C (8)	370	348	325	283	239	304	261	217	174
	AS7-K1C (8)	430	400	375	325	275	350	300.	250	200
	AS14-K1C (8)	430	400	375	325	275	350	300	250	200
K2C (2)	AS12-K2C(3)(7)	175	89	83	72	61	78	67	55	44
	AS1-K2C (3)(7)	250	128	120	104	88	112	96	80	64
	AS4-K2C (3)(7)	330	248	232	202	170	217	186	155	124
	AS8-K2C (4)(7)	330	248	232	202	170	217	186	155	124
	AS5-K2C(3)(8)	370	348	325	283	239	304	261	217	174
	AS7-K2C (3)(8)	430	400	375	325	275	350	300	250	200
	AS10-K2C(5)(8)	430	400	375	325	275	350	300	250	200
	AS3-K2 C (6)(7)	500	520	487	422	357	455	390	325	260
	10-04-650-001	500	520	487	423	357	455	390	325	260
	10-04-650-003		406	380	330	279	355	304	254	203
	10-23-650-003(9)		148	139	121	102	130	111	93	74
	10-23-650-002(9)		148	139	121	102	130	111	93	74

(1) K1C series dampers are usually installed to the timing gear end of the engine.

(2) K2C series dampers are usually installed to the flywheel end of the engine.

(3) Will fit most of the bolt circles for Borg & Beck and Long clutch cover plate locations.

(4) Will fit most of the bolt circles for Borg & Beck and Long clutch plate locations, which are under 12.25 inch diameter.

(5) Has a 10.625 inch bolt circle with six .31375 diameter bolt holes in a 11.36 inch diameter mounting plate.

(6) Fits some flywheels for larger Rockford, Long and Borg & Beck clutches for domestic engines.

(7) These assemblies have full capcity in both directions.

(8) These assemblies are for L.H. engines; however, may be used for R.H. engines when derated 30-40%.

(9) For use with series 1000 transmissions only.

DAMPER INSTALLATION

INSTALLATION DRAWINGS

Damper installation drawings are available from Warner Gear and may be referred to for hub spline data, mounting bolt hole locations and other data which may be required for making an installation. See form 1109.

SPLINE ENGAGEMENT

The engine builder must check the bell housing design and damper design to be sure that the transmission input shaft splines have full engagement into the damper hub splines. There should also be adequate clearance between the damper and transmission case. (The pump bolts have been overlooked and have caused interference in a few installations.) Rotate the engine slowly by hand after completing the installation to verify non-interference. The splines of the input shaft should be lubricated and fit freely into splines of damper hub.

DAMPER BOLTS

Body fit bolts must be used to attach the damper to the engine adapter or flywheel. Torsional reversals tend to "work" and loosen common bolts.

DAMPER HUB

Damper drives for timing gear end installations require a flanged hub to connect the crank shaft with the damper assembly.

EARLY DAMPER SPLINES

The early Velvet Drive transmission input shaft has 10 splines instead of the 26 splines which are currently being supplied. Early damper assemblies were supplied with ten splines to mate with the early transmission input shaft splines. These ten spline damper assemblies may still be purchased for servicing early installations; however, these assemblies may be discontinued as field requirements diminish.

DAMPER PROBLEMS

An unusually rough engine can cause the damper to rattle. This noise usually will go away as the engine speed is increased above 1000 to 1200 RPM. The ,,rattle.. is caused by the springs in the damper bottoming out or going solid.

A damper which is not correct for the particular engine will rattle even though the engine runs properly.

A noise will sometimes develop after a transmission overhaul. This noise is usually caused by a distorted damper. The damper may be distorted during transmission removal or assembly when the transmission input shaft splines are still engaged and the rear of the transmission is permitted to drop down, thus placing a bending load on the damper hub.

Transmission gears will sometimes rattle when a damper problem exists. Gear rattle is usually the result of an improper or a defective damper, and is not normally caused by faulty transmission parts.

A new neutral switch kit (part number 10-04-420-052) is now available and will replace the earlier kit number 71-1A4A.

Kit 10-04-420-052 contains hte following parts:

1	10-04-539-001	Switch and body assembly
1	10-00-640-004	Switch and "O" ring assembly
1	10-00-140-007	Switch
1	10-00-141-046	"O" Ring
1	10-16-039-001	Valve cover
1	10-16-009-001	Switch cam
3	179796	1/4-20 Hex head bolt
3	103319	1/4 Lockwasher
1	71-14	Valve cover
1	71-14	Valve cover gasket
1	OF1340	Instruction sheet

The new switch and valve cover have a 9/16-18 UNF-2A thread. An "O" ring is used to seal between valve cover and switch. This kit is supplied on all new Velvet Drive assemblies. The complete kit is required for servicing the earlier Kit 71-1A4A.

TRANSMISSION ALARM KIT A4867HN

This is the recommended method for monitoring transmission functions. The temperature will rise to indicate low oil level, low pressure or mechanical problems quicker than a pressure gauge will indicate a drop in line pressure.

TRANSMISSION ALARM KIT A4867HS

This kit is used in conjunction with the A4867HN kit. This kit provides extra components for making a dual station installation.

ROUTINE CHECKS AND MAINTENANCE

ANNUAL CHECKS

1) PROPELLER AND OUTPUT SHAFT ALIGNMENT

This check should also be made anytime the propeller strikes a heavy object and after any accident where the boat is stopped suddenly. Shaft alignment should also be checked after the boat has been lifted by a hoist or moved on a trailer.

2) SHIFT LEVER POSITIONING

The selector controls must position the shift lever exactly in F, N, and R selector positions with the ball poppet centered in the shift lever hole for each position.

3) BOLT TORQUE

Check all bolts for tightness.

4) COOLER CONNECTIONS

Check water lines, oil lines and connections for leakage. Make sure lines are securely fastened to prevent shifting.

5) CHANGING OIL

A seasonal oil change is recommended in pleasure boats. Work boats require more frequent changes. Change oil anytime the oil becomes contaminated, changes color, or becomes ranced smelling.

6) TRANSMISSION FLUID

Type F, Dexron® and other hydraulic fluids which meet the Detroit Diesel Allison Division of General Motors Corporation specifications for type C3 oils are recommended for use in all Velvet Drive marine gears.

Lubricating oils which are recommended for use in diesel engines and fall within Allison specifications for C3 oils may be used in all Velvet Drive marine gears if the engine RPM does not exceed 3000. SAE #30 is preferred. SAE #40 is acceptable if high operating temperatures are anticipated. Multi-visosity oils such as 10W-40 are not acceptable. The first choice is SAE-API service class "CD" oils. The second choice is SAE-API service class "CC" oils.

The equivalent DOD mil specs are:

CD MIL-L-2104B
CC MIL-L-45199

Detroit Diesel Allison Division of General Motors developed the C3 specifications for oils to be used in their hydraulic automatic and power shift transmissions used in heavy duty or severe service conditions. The oils are very well suited for use in all Velvet Drive marine gears.

Each oil company will provide information and specifications on their products which fall in the above specifications.

Automatic transmission fluid and engine oil may be mixed in an emergency, however it is not a good policy to mix the different fluids for normal use.

DAILY CHECKS

1) Check transmission oil level.

2) Check for any signs of oil leakage in the bell housing, at gasket sealing surfaces, or at the output shaft oil seal.

3) A quick visual check of the general condition of the equipment may cause faulty equipment to be detected.

4) Listen for any unusual noises and investigate to determine the cause of any such noises.

WINTER STORAGE

1) Drain water from the transmission oil cooler. This will prevent freezing in cooler climates, and prevent harmful deposits from collecting.

GENERAL CHECKS

1) Check coupling alignment each time a transmission is replaced in the boat.

2) Check shift linkage adjustment to insure that the transmission shift lever is positioned so that the spring loaded ball enters the chamfered hole in the side of the shift lever.

3) Connect an oil cooler into the cooler circuit before cranking or starting the engine. Various cooler circuits have been used and the correct cooler connections should be found from service literature prior to making the cooler installation.

4) Use a cooler of sufficient size to insure proper cooling.

5) Check engine rotation and transmission pump setting and the propeller rotation prior to assembling the transmission to engine.

6) Check oil pressure and temperature when transmission function indicates that a problem exists.

7) Use the recommended fluid for filling the transmission.

8) Fill the transmission prior to starting the engine.

9) Check oil level immediately after the engine has been shut off.

10) Use a clean container for handling transmission fluid.

11) Replace cooler line after a transmission failure, prior to installing a new or rebuilt transmission.

12) Check fluid level at operating temperature.

SUBJECT: MATCHING ENGINE, TRANSMISSION AND PROPELLER ROTATION

ENGINE ROTATION DESCRIBED

Modern marine engines are available with left-hand (L.H.) or right-hand (R.H.) turning crankshafts. An engine which rotates clockwise when viewed from the front or timing end would be described as having counter clockwise rotation when viewed from the rear or flywheel end of the engine. It is therefore important that a position be selected from which rotation is described so that confusion will not exist. A transmission may be mounted to either the flywheel or timing gear end of the engine, see figures 16 & 17. It is therefore necessary to describe engine rotation with respect to the transmission when selecting an engine and transmission combination.

Transmission selection will be simplified when the following method is used to describe engine rotation. This method may not agree with the method used by the engine manufacturer.

Face the end of the engine on which the transmission is mounted and describe rotation as right-hand if the engine rotates clockwise. Describe engine rotation as left-hand if the engine rotates counter clockwise.

TRANSMISSION SHAFT ROTATION DESCRIBED

Describe transmission shaft rotation when standing behind the transmission facing the engine on which the transmission is mounted. The output shaft may rotate in the same direction as the input shaft or in the direction opposite to input shaft, depending upon the model. Transmission input shaft rotation must always agree with engine rotation. Charts in the Velvet Drive installation manual should be used to help in selecting a suitable Velvet Drive, engine, and propeller combination.

PROPELLER ROTATION

A right-hand propeller will move the boat forward when turned clockwise as viewed from behind the boat, see figures 18 & 19.

A left-hand propeller will move the boat forward when turned counter clockwise as viewed from behind the boat.

Propeller hand of rotation must be the same as the transmission output shaft when operating in forward. It should be realized that when a V-Drive unit is used and shaft rotation is viewed from behind the V-Drive you would be facing to the rear of the boat. For this reason the charts showing V-Drive shaft and propeller rotation seem to disagree, however when both are described when standing behind the boat, the rotation does agree.

Propeller selection is very important since the transmission should only be operated in forward selector position to drive the boat forward. When the wrong hand propeller is selected, the transmission must be operated in reverse to drive the boat forward and early transmission failure should be expected.

HYDRAULIC PUMP INDEXING

The transmission front adapter and pump housing are designed to permit the pump to be mounted in either of two positions. Each position permits oil to be pumped when pump gears are rotated in one direction only. The pump can only pump oil when any point on the gears is rotated past the inlet first, then past the crescent shaped portion of the pump housing which separates the inlet from the outlet and then past the pump outlet.

The pump must be correctly indexed for each direction of rotation. An arrow with TOP L.H. and a second arrow with TOP R.H. can be found on early pump housings. The arrow which is located nearer the top of pump housing points in the direction the pump must rotate to pump oil. The letters L.H. and R.H. describe the required pump rotation when facing the pump and tells the same thing as the arrow points out. The letters L.H. and R.H. have been removed from current pump assemblies, (Fig. 20).

The wise mechanic will always check the pump setting prior to transmission installation to be sure that the arrow agrees with engine rotation.

Pump rotation is viewed from the opposite end of the transmission from which shaft and engine rotation is described. The arrow showing left hand rotation should be nearer the top of the units behind clockwise rotating engines. The arrow showing right hand rotation should be nearer the top on units behind counterclockwise rotating engines.

TO INDEX PUMP FOR OPPOSITE HAND ROTATION

CAUTION: This procedure is not applicable to CR2 units, or the AS3, AS13, 10-17 and 10-18 models which have 2.10:1 In-Line reduction ratios because special planetary gear mountings are used which are different for each rotation. These models must not be reindexed from the original factory settings.

1) Remove the four bolts which hold the pump to the transmission, (Fig. 16).

2) Loosen the pump housing. A rubber or plastic hammer may be used to tap the oil boss, but do not strike the bolt bosses.

3) Do not remove the pump from the shaft unless a seal protector is used to prevent the shaft splines from cutting the pump seal.

4) Care should be taken to see that the pump gasket does not stick to the pump housing during rotation, causing the gasket to be folded or torn.

5) Locate pump with the arrow indicating the proper direction of input shaft rotation nearer top of transmission.

6) Care must be taken to see that the gasket, seal and bolt bosses are kept in good condition to prevent leaks in these critical areas.

7) Torque the four bolts to 17-22 ft. lbs. (25.3-32.7 kg/m.).

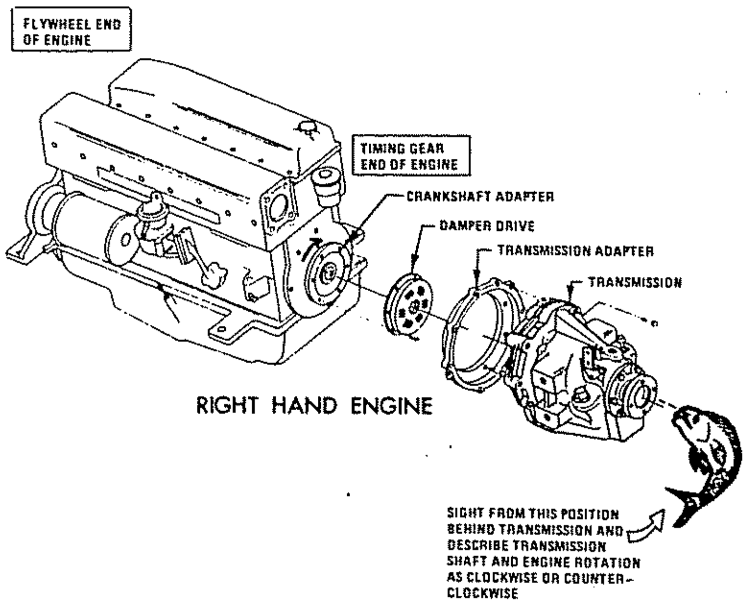


FIGURE 16 TYPICAL TIMING GEAR END INSTALLATION

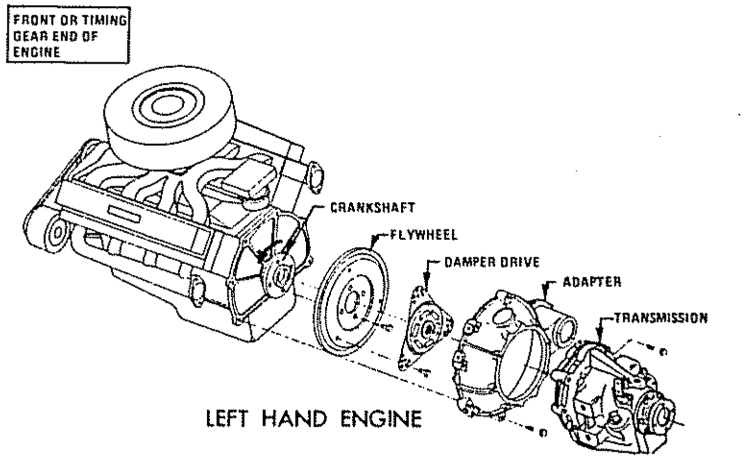


FIGURE 17 TYPICAL FLYWHEEL END INSTALLATION

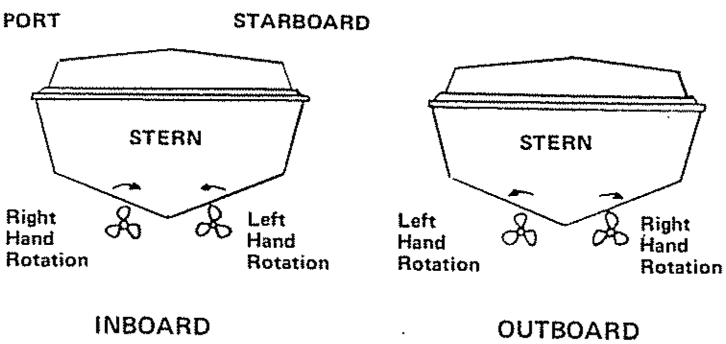


FIGURE 18 TWIN INSTALLATIONS – Showing inboard & outboard turning props. Outboard turning props are preferred.

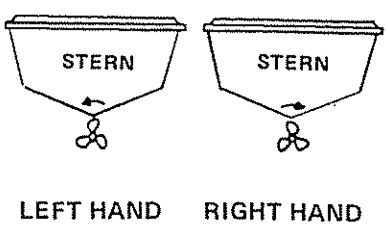


FIGURE 19 SINGLE PROP INSTALLATION – Showing right and left hand prop rotation. Right hand propellers are used more often than left hand propellers.

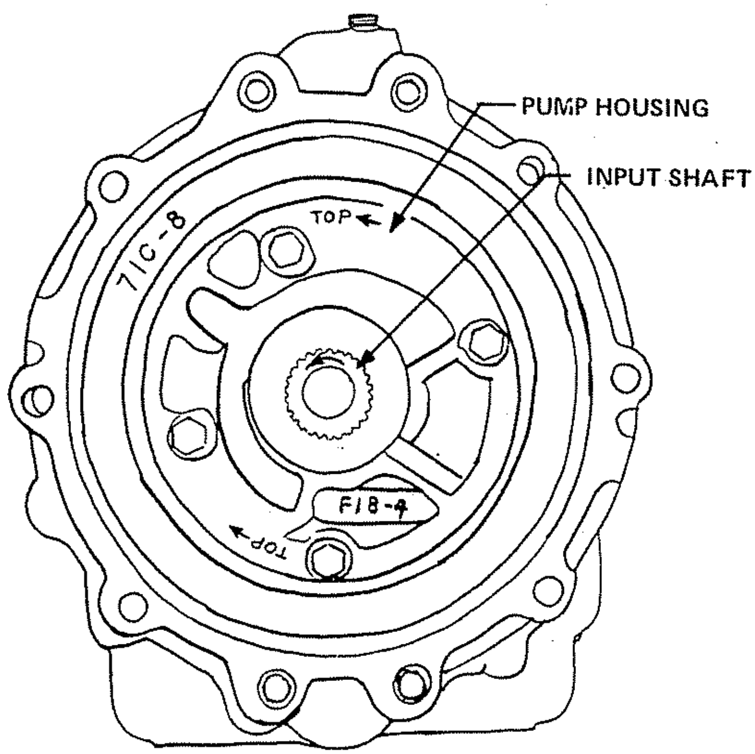


FIGURE 20 For a given direction of input shaft rotation, assemble oil pump with arrow at top pointing in the same direction. Looking into pump the arrow points to your left on above unit, however this unit would be described as having clockwise rotation when standing behind unit when describing shaft rotation.

PCM

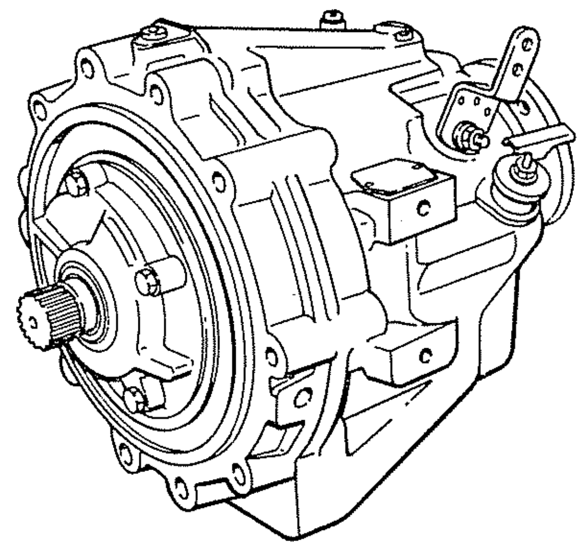
marine engines

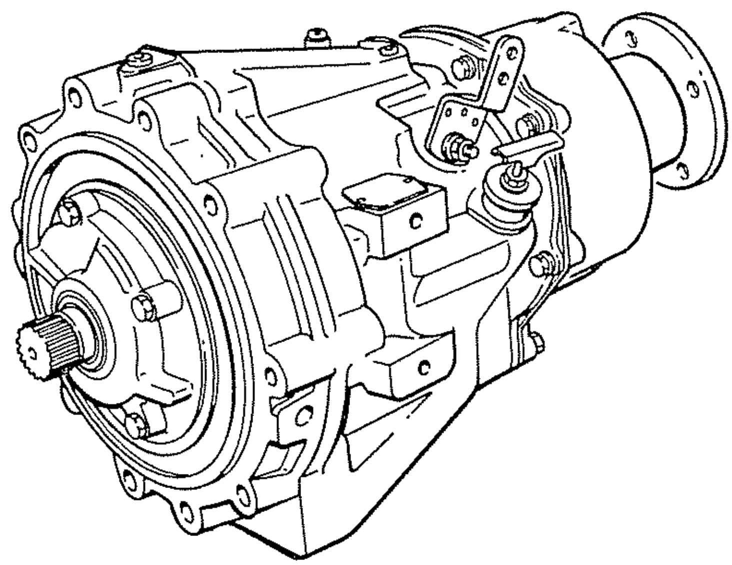
WARNER GEAR REPAIR & DIAGNOSTIC PROCEDURES

Original Rev-0 October 1, 1986

Price $15.00

71C - 72C Direct Drive and Reduction Ratios 1.5:1, 1.88:1, 1.91:1, 2.1:1, 2.57:1, 2.91:1





Borg-Warner Automotive, Inc.
Transmission Systems
Post Office Box 2688
Muncie Indiana 47302
Telephone 317 286-6100
Telex 27491

This manual reflects the transmission models as of April 1986. Later models may have differences. The following direct-drive and reduction models are covered in this manual:

Transmission Assembly Number	Previous Trans. Assembly Number	Transmission Ratio	
		Forward	Reverse
10-17-000-001	AS1-71C	1:1	1:1
10-17-000-002	AS1-71CR	1:1	1:1
10-17-000-003	AS1-71CB	1:1	1:1
10-17-000-004	AS1-71CBR	1:1	1:1
10-17-000-005	AS2-71C	1.52:1	1.52:1
10-17-000-006	AS2-71CR	1.52:1	1.52:1
10-17-000-007	AS7-71C	1.91:1	1.91:1
10-17-000-008	AS7-71CR	1.91:1	1.91:1
10-17-000-009	AS3-71C	2.10:1	2.10:1
10-17-000-010	AS3-71CR	2.10:1	2.10:1
10-17-000-011	AS14-71C	2.57:1	2.57:1
10-17-000-012	AS14-71CR	2.57:1	2.57:1
10-17-000-013	AS15-71C	2.91:1	2.91:1
10-17-000-014	AS15-71CR	2.91:1	2.91:1
10-17-000-015	AS20-71C	1:1	1:1
10-17-000-016	AS20-71CR	1:1	1:1
10-17-000-108	None	1.88:1	1.88:1
10-18-000-001	AS11-72C	1:1	1.10:1
10-18-000-002	AS11-72CR	1:1	1.10:1
10-18-000-003	AS12-72C	1.52:1	1.68:1
10-18-000-004	AS12-72CR	1.52:1	1.68:1
10-18-000-106	None	1.88:1	2.07:1
10-18-000-005	AS17-72C	1.91:1	2.10:1
10-18-000-006	AS17-72CR	1.91:1	2.10:1
10-18-000-007	AS13-72C	2.10:1	2.31:1
10-18-000-008	AS13-72CR	2.10:1	2.31:1
10-18-000-009	AS14-72C	2.57:1	2.83:1
10-18-000-010	AS14-72CR	2.57:1	2.83:1
10-18-000-011	AS15-72C	2.91:1	3.20:1
10-18-000-012	AS15-72CR	2.91:1	3.20:1
10-18-000-013	AS20-72C	1:1	1.10:1
10-18-000-014	AS20-72CR	1:1	1.10:1
10-18-000-015	None	1:1	1.10:1
10-18-000-106	None	1:1	1.10:1
10-18-000-017	None	1:1	1.10:1

The following international symbols are used in this service manual.

WARNING: THIS SYMBOL WARNS OF POSSIBLE PERSONAL INJURY.

CAUTION: This symbol warns of possible damage to transmission.

OEM: Original Equipment Manufacturer (Boat/Engine Manufacturer).

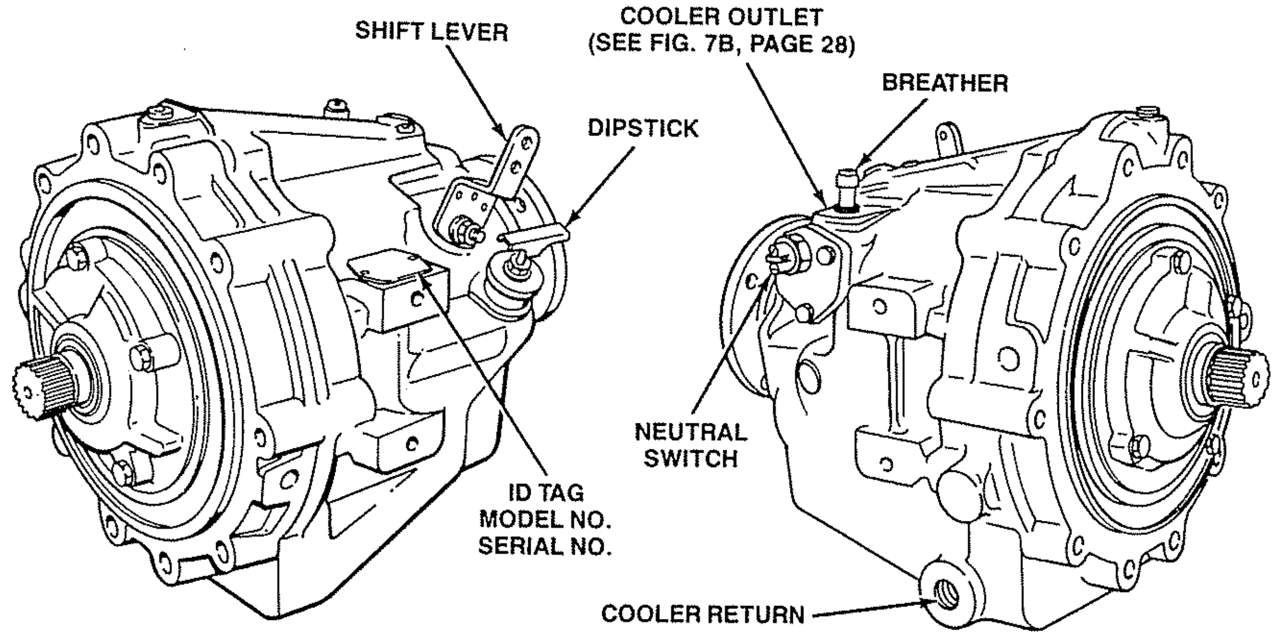


Figure 1. 71C and 72C Transmission Assembly

A. INTRODUCTION (See Figure 1).

The 71C and 72C transmissions consist of a planetary gear set and multiple disc clutches. The input and output shafts are in line.

Hydraulic Pressure is provided by a crescent type pump. The pump is driven at engine speed by the input shaft. Oil from the pump is sent to the control valve. The positions on the control valve are forward-neutral-reverse. An internal regulator valve controls system pressure. Oil discharged by the regulator valve is sent to the oil cooler.

B. THEORY OF OPERATION.

General. Forward is direct drive. A planetary gear set (1.1 to 1.0 ratio for 72C, and 1.0 to 1.0 ratio for 71C) is used to obtain reverse.

Table 1. Technical Specifications

DESCRIPTION	MODEL 71C	MODEL 72C
Speeds	One Forward One Reverse	One Forward One Reverse
Horsepower		
Gasoline (maximum)	310 HP @ 4200 RPM	475 HP @ 4200 RPM
Diesel (maximum)	182 HP @ 3200 RPM	274 HP @ 3200 RPM
Torque and Input Speed	See Ratings Charts (Form No. 1237)	See Ratings Charts (Form No. 1237)
Approximate Dry Weight		
Direct Drive	95 lb.	109 lb.
Reduction	145 lb.	153 lb.

The transmission oil pump is driven by the input shaft. It supplies oil pressure to operate the clutch packs, lubricate parts, and provide cooling.

A damper plate is bolted to the engine flywheel. The damper plate is splined to connect to the input shaft. The damper plate reduces torsional vibrations to the transmission from the engine. (See Figure 2).

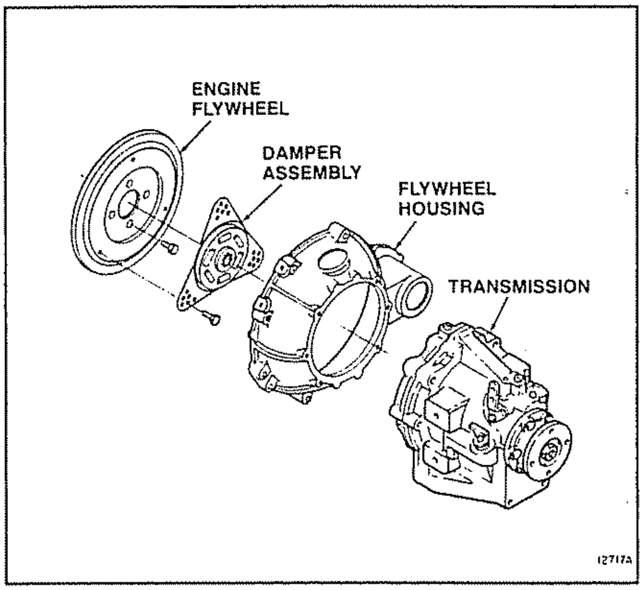


Figure 2. Typical Installation

Forward. The forward clutch is applied hydraulically when the shift lever is placed in the forward position. This connects the input shaft to the output shaft. The unit then transmits power at a 1 to 1 speed ratio in the same direction of rotation as the engine (See Figure 3).

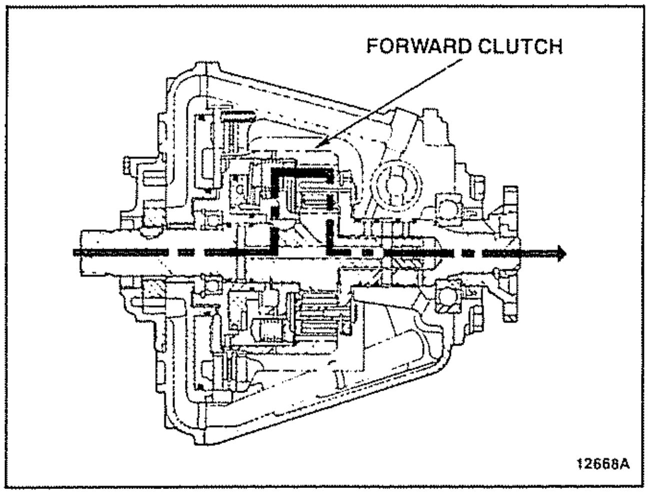


Figure 3. Forward Power Flow

Reverse. The reverse clutch is applied hydraulically when the shift lever is placed in the reverse position (See Figure 4). The applied clutch holds the ring gear. The input shaft and sun gear, driven by the engine, drive pinions, which drive the carrier output shaft. The output shaft turns opposite to engine rotation at a 1.1 to 1 speed reduction ratio for model 72C, and 1 to 1 speed ratio for model 71C.

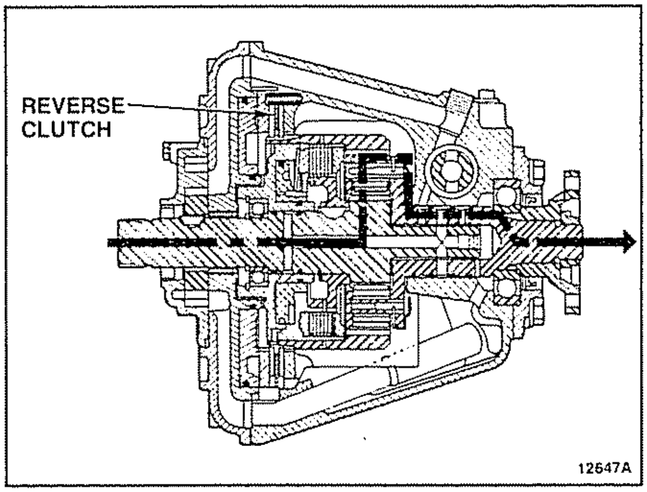


Figure 4. Reverse Power Flow

Hydraulic Circuit. Oil from the sump enters the pump suction passage and is directed to the pump (See Figure 5). The pump supplies oil under pressure through passages to the control and regulator valves.

Oil pressure on the end of the regulator valve moves the valve, compressing the spring. This movement allows oil to flow to the cooler.

Selector Valve. The selector valve shifts the transmission from neutral to forward or reverse. When selector valve is placed in the forward position, oil is directed to the forward clutch. When the selector valve is placed in reverse position, oil is fed to the reverse clutch. When one clutch is engaged the other is exhausted by a slot in the selector valve.

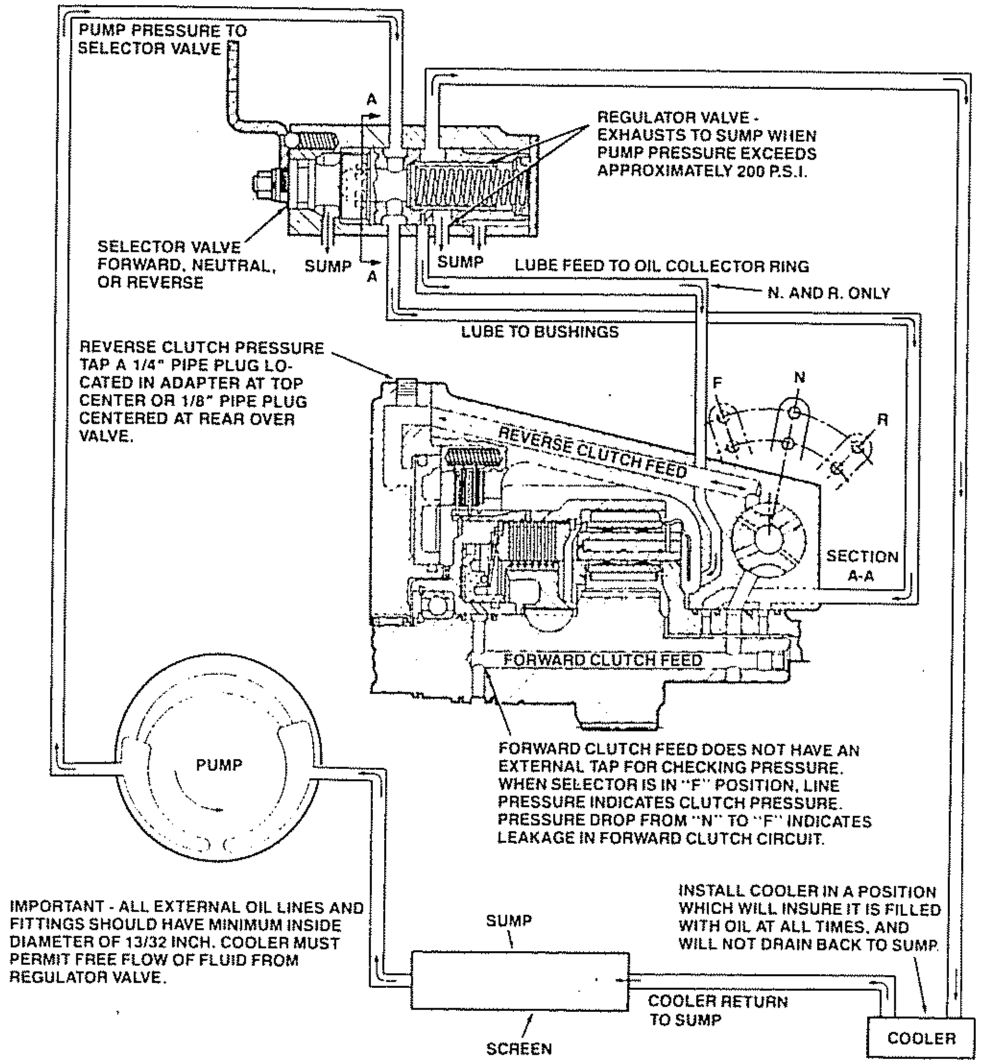


Figure 5. Hydraulic Circuit Schematic (Model 72C Direct-Drive Shown)

INSPECTION

A. GENERAL.

The transmission, cooler, cooler lines, and control linkage should be inspected at regular intervals. Regular inspections will ensure proper operation and help detect minor problems that can be corrected before they cause a transmission failure.

B. SCHEDULED INSPECTIONS (See Table 2).

The following recommended inspection intervals are based on normal operating conditions. Intervals should be adjusted for extremes of temperature or other adverse operating conditions.

Table 2. Scheduled Inspections

INSPECTION INTERVAL			
INSPECTION TASK	WEEKLY	PERIODIC 1 month or 100 hours, whichever comes first	SAFETY Annual or 1000 hours, whichever comes first
GENERAL			
⚠ **WARNING: FAILURE TO PERFORM THESE INSPECTIONS AT REQUIRED INTERVALS CAN RESULT IN INJURY TO PERSONNEL.**			
Inspect control linkage and shift lever for operation. There should be no sticking, binding, or looseness.		X	X
OIL COOLER AND LINES			
⚠ **CAUTION: Failure to perform these inspections at required intervals can result in transmission failure.**			
Inspect cooler for signs of leakage, damage, or loose mounting bolts.		X	X
Inspect all connection points for signs of leakage.		X	X

Table 2. Scheduled Inspections (Continued)

INSPECTION TASK	INSPECTION INTERVAL		
	WEEKLY	PERIODIC 1 month or 100 hours, whichever comes first	SAFETY Annual or 1000 hours, whichever comes first
TRANSMISSION			
Inspect for damage or signs of leakage around housing and/or bolts.		X	
CAUTION: If oil is discolored or has been overheated (above 190°F) it must be replaced.			
Remove dipstick. Check oil for signs of water or other contaminants. Check (smell) oil for signs of burnt oil (overheating). If found, replace fluid. See Maintenance.	X		
Inspect breather. Check for movement of cap. If no movement replace breather.		X	
Check mounting bolts for tightness. If loose, tighten to torque specified in OEM manual.			X

MAINTENANCE

A. GENERAL.

Maintenance to the transmission will normally consist of the following items.

- Checking oil level or changing oil. Regular scheduled oil changes are an important part of transmission maintenance.

WARNING: SHIFT LINKAGE MUST BE ADJUSTED FOR PROPER OPERATION OF TRANSMISSION.

NOTE: For details on each of these adjustments refer to the OEM manual.

- Checking pressure in each circuit (if a problem is detected).

CAUTION: Transmission mounting bolts should be checked and tightened to torque specified in OEM manual. Do not overtighten! Damage to the transmission can result.

B. LUBRICATION.

Due to the various installation angles and oil cooler set-ups, it may be necessary to adjust your oil level.

WARNING: DO NOT REMOVE DIPSTICK WITH ENGINE RUNNING. HOT OIL CAN CAUSE BURNS.

CAUTION: Clean around the area of the dipstick, before removing. Small particles of dirt can cause damage to internal components and cause valves to stick.

Check Oil Level.

The transmission should be at operating temperture (190° max.) to get an accurate oil level reading. Oil will expand when it is heated. Oil will drain back from the cooler. Expansion and drainback can significantly affect oil level.

Warm Oil Level Check.

When the transmission is at operating temperature, place selector lever in neutral. Shut off engine. Carefully remove transmission dipstick. Immediately insert clean dipstick and read oil level.

NOTE: Oil level must be checked immediately after engine shut-down to prevent an incorrect reading. Oil drains back into transmission from the cooler and cooler lines.

Add or remove oil if necessary. Repeat the above checking procedure as required until oil is at the dipstick mark.

Cold Oil Level Check.

For ease of checking the oil prior to engine start-up, a cold oil level mark can be made. To find the cold oil level mark, the oil level must first be set according to the warm oil level checking procedure. Then, let the boat sit overnight. Insert clean dipstick and read oil level.

Put a mark on the dipstick at the cold oil level reading.

You can use the new mark to check the oil level when cold. If oil level adjustment is needed, add oil to the new mark.

Type of Oil.

Dexron, Type F, or any hydraulic fluid which meets the C-3 oil specification is acceptable. Do not mix different brands. If engine doesn't exceed 3,000 R.P.M., a premium grade 30 weight engine oil is acceptable. SAE #40 and multi-viscosity oils are not recommended.

If the transmission oil temperature has exceeded 190° F or the alarm sounds, the oil must be changed in the transmission and cooler system.

Changing Oil.

Oil in transmission, cooler, and cooler lines should be changed after every 1,000 hours of operation or annually. Severe service conditions or high operating temperatures may require more frequent changes.

- Place selector lever in neutral. Run engine for five minutes at 1500 RPM. Shut down engine.

⚠ **CAUTION: Clean around the area of drain plug, before removing. Small particles of dirt can cause damage to internal components and cause valves to stick.**

- Drain oil from transmission, cooler, and cooler lines into a suitable container.

- Check oil for signs of metal or rubber particles.

⚠ **CAUTION: A few small metal particles are normal. However, if large metal chips or a large number of particles are found, this could be an early sign of transmission failure. The transmission should be disassembled and inspected for internal damage.**

NOTE: Particles of rubber can indicate cooler line wear. Each line should be inspected for cracks or fraying and should be replaced if damaged.

- Fill transmission with new oil.

NOTE: The amount of oil required will vary based on length of cooler lines. Use an amount equal to about three-fourths the quantity removed.

- Install dipstick. Run engine for two minutes to fill cooler and cooler lines with oil. Set oil level according to procedure at start of section B, Lubrication.

TROUBLESHOOTING

A. GENERAL.

Before troubleshooting the transmission, do the following.

- Check oil level and condition of oil. See Maintenance section for details.

- Check transmission, oil cooler and oil cooler lines for physical damage or leakage. Correct any problem.

- Check that engine, damper plate, or drive train alignment are not causing the problem.

Refer to OEM manual or Velvet-Drive Installation Manual (Form No. 1131) for drive train alignment requirements.

Perform all pressure checks at normal operating temperature. Refer to Specification section for details. Pressure gauges used should have a range of 0-200 or 0-300 psi. They must be accurate.

B. GUIDELINES.

When troubleshooting, shift into each selector position to determine when noise or problem occurs. Determine which parts are moving. This will help pinpoint the cause. Use the following information as a guide to common problems.

Damper Plate. Some transmission problems are damper plate related. Check and/or replace damper plate when the following problem occurs.

- Transmission "knocks" at idle or low RPM, then stops at 1,000 RPM or higher.

If the damper plate springs are too soft the sides of the windows will wear. If the springs are too hard the splines will wear. Consult engine OEM for correct damper plate recommended.

Clutches. Check and/or replace clutches if the following problem occurs.

- Excessive engine RPM (over the rated RPM). This can indicate a slipping clutch. The slipping clutch will usually squeal.

WARNING: DO NOT OPERATE TRANSMISSION IF THE FOLLOWING CONDITION IS SUSPECTED. FAILURE TO COMPLY CAN RESULT IN PERSONAL INJURY BECAUSE TRANSMISSION CAN NOT BE DISENGAGED.

The slipping clutch will normally overheat. This can result in warped plates. In severe overheating plates can weld together. This will cause a tie up condition in transmission when the other clutch is applied.

Table 3. Troubleshooting

PROBLEM	CAUSE	CORRECTION
LEAKS:		
1. At pump or output shaft seal.	Faulty seal.	Replace.
	Misalignment.	Correct.
	Rough shaft.	Replace.
2. Between seal and bore.	Rough housing bore.	Replace seal.
3. At gasket(s).	Loose bolts.	Torque bolts properly.
	Defective gaskets.	Replace gaskets.
	Face(s) not flat.	Replace defective parts.
4. Loss of oil with no trace of missing oil.	Oil leaking from cooler or cooler lines.	Replace cooler, or cooler lines that are defective.
5. Oil out of breather.	Oil has been overheated. (Lost anti-foam additive)	Replace oil.
	High or low oil level.	Correct oil level.
	Water in oil.	Change oil.
MALFUNCTION IN BOTH FORWARD AND REVERSE:		
1. Low oil pressure.	Regulator valve jammed.	Clean and polish.
	Internal leakage.	Replace defective sealing rings.
	Low oil level.	Add oil.
	Pump defective.	Replace pump.
2. No oil pressure.	Regulator valve jammed.	Clean and polish.
	Internal leakage.	Replace defective parts.
	Pump defective.	Replace pump.
	No oil.	Add oil.
	Pump incorrectly indexed.	Rotate pump to correct position.
3. High oil temperature.	Regulator valve jammed.	Clean and polish.
	Cooler line defective.	Replace cooler line.
	Oil cooler too small.	Install larger cooler.
	Restrictions in cooler lines or cooler.	Back flush to remove restrictions.

Table 3. Troubleshooting (Continued)

PROBLEM	CAUSE	CORRECTION
MALFUNCTION IN BOTH FORWARD AND REVERSE: (Cont.)		
3. High oil temperature.	Defective cooler.	Replace cooler.
	Defective temperature sensor.	Replace sensor.
4. No power, noise.	Broken gear teeth — gears not meshed.	Replace defective parts.
5. No line pressure.	Heavy weight oil (90 weight).	Remove and use proper weight oil.
	Pump Incorrectly indexed.	Rotate pump to correct position.
	Oil inlet shield or screen blocked.	Inspect and clean.
6. Noisy in Forward and Reverse.	Misalignment of damper plate with engine, or misalignment of output shaft components.	Align drive train components.
	Damaged gears.	Replace damaged gears.
MALFUNCTION IN FORWARD OR REVERSE:		
1. Clutch drags or does not release.	Warped clutch plate.	Replace defective parts.
	Mechanical failure.	Replace defective parts.
	Tight pack clearance.	Increase clearance to specification.
2. Clutch does not apply.	Low pressure.	See low oil pressure.
	Defective parts.	Replace defective parts.
3. Harsh engagement.	High pressure - valve sticking.	Clean and polish regulator valve.
	Engine idle too fast.	Adjust engine idle.
	Linkage binding or misadjusted.	Repair as required and adjust to OEM spec.
4. Soft engagement.	Low pressure.	See low oil pressure.
5. Won't move or sluggish.	Forward clutch seized.	Replace defective parts.
	Worn or broken sealing rings.	Replace defective parts.

Table 3. Troubleshooting (Continued)

PROBLEM	CAUSE	CORRECTION
MISCELLANEOUS PROBLEMS:		
1. Hydraulic noise or buzz.	Low oil level, or air in hydraulic circuit.	Check oil level and fill if low. Operate engine in neutral at 1200 RPM to remove air.
	Regulator valve sticking.	Clean and polish.
2. Gear noise in forward.	Broken, pitted, or cracked gear teeth.	Replace defective parts.
3. Gear noise in reverse.	Broken, pitted, or cracked gear teeth.	Replace defective parts.
MALFUNCTION IN NEUTRAL:		
1. Drives in forward direction.	Broken sealing rings or bushings.	Replace defective parts.
	Warped forward clutch plates or mechanical failure of clutch.	Replace defective parts.
	Exhaust blocked in control valve.	Clean control valve.
2. Drives in reverse direction.	Warped reverse clutch plates or mechanical failure of clutch.	Replace defective parts.
	Exhaust blocked in control valve.	Clean control valve.
3. Noisy in neutral only.	Low oil pressure. Pump gears worn.	Replace pump assembly.
	Oil level low.	Add oil.
4. Transmission overheating.	Oil level low. Cooler too small or restricted lines.	Add oil. All external oil lines should have minimum inside diameter of 13/32". Cooler must permit free flow of oil.
	Pump pressure low - worn or damaged pump.	Check pressures. If low, inspect pump. If worn or damaged, replace.
	Clutches slipping.	Check sealing rings. Replace if damaged.
	Internal leakage bypassing cooler.	Locate and fix leak.
	Temperature sensor defective.	Replace sensor.
	Incorrect type of oil.	Drain, flush and replace with correct type of oil.
	Regulator valve sticking.	Clean and polish.

OVERHAUL

A. GENERAL.

Before removal and disassembly, review the following procedures. Use the proper hand tools, slings, or hoists for the job.

WARNING: KEEP WORK AREA, TOOLS, AND TRANSMISSION CLEAN. WIPE UP ANY SPILLED TRANSMISSION FLUID TO PREVENT ACCIDENTS. AS REQUIRED, WEAR SAFETY GLASSES, SAFETY SHOES AND A HARD HAT TO PREVENT PERSONAL INJURY.

B. DISASSEMBLY.

NOTE: Read OEM Vehicle manual for specific removal instructions.

Before starting disassembly, review the exploded-view shown in Figure 8. The transmission can be disassembled following the index numbers shown in Figure 8.

Seals. Remove O-rings, sealing rings, and oil seals carefully to prevent damage if they must be reused. It is best to replace these items.

Bearings. Do not remove bearings unless replacement is required, or cleaning can not be done properly.

- Keep matched parts or sets together. Do not reverse or mix them.

C. CLEANING.

WARNING: CLEANING SOLVENTS CAN BE TOXIC, FLAMMABLE, AN IRRITANT TO THE SKIN, OR GIVE OFF HARMFUL FUMES. AVOID PROLONGED CONTACT, INHALATION OF VAPORS, OR SMOKING. FAILURE TO COMPLY CAN RESULT IN INJURY OR DEATH TO PERSONS.

- Rinse all metal parts in solvent to remove dirt, grease, and transmission fluid.
- Take special care to remove solvent from all parts.
- Air dry clutch plates.
- If O-rings are to be reused, air dry them.

D. INSPECTION.

Case. Inspect for cracks. Check sealing surfaces for nicks, scratches, or burrs that can cause leaks. Inspect output shaft bore for signs of wear on one side. This can indicate misalignment of prop shaft.

Gears. Inspect for unusual wear patterns, chipped, cracked, or broken teeth.

Bearings. Inspect for chips, cracks, galling, or missing bearings. Check for signs of overheating.

Threaded Parts. Inspect for stripped, damaged threads, or burrs.

Springs. Inspect for distortion, cracks, or other damage. Check springs against dimensions in Specification section.

E. REPAIR.

- Remove scratches, burrs, or minor surface defects with very fine emery cloth.
- Threaded holes can be retapped using the same size tap. Do not make the hole oversize.
- Repair or replace all damaged parts.

F. ASSEMBLY.

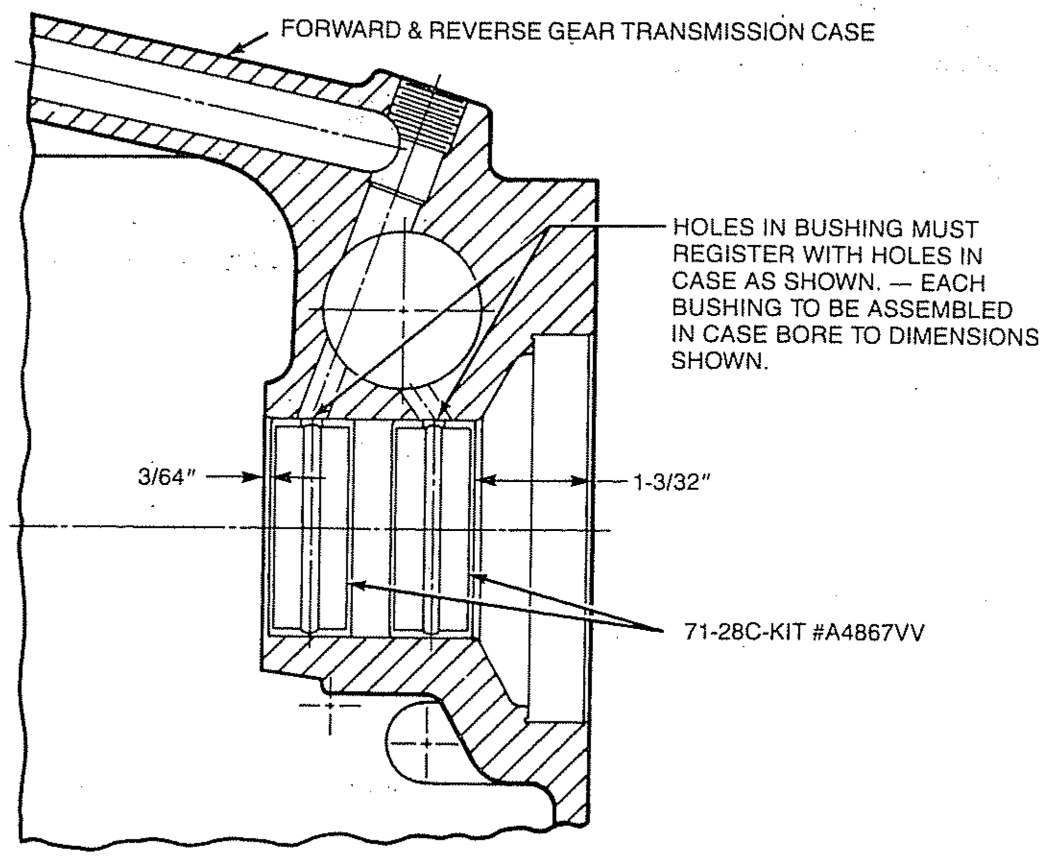
CAUTION: Threaded plugs, screws, bolts, and coupling nuts must be tigtened to the torques shown in Table 4 to prevent premature failure of transmission.

- A new coupling nut must be used at assembly.
- Prior to assembly, dip or coat internal parts with transmission fluid. Let excess fluid drain off.
- Use a light coat of vasoline to position or hold a gasket, O-ring, or small part for assembly. Apply to sealing rings before assembly.
- Inspect assemblies pressed together for proper fit and position.
- Check that each snap ring is fully engaged in groove.
- Threaded plugs, screws, and bolts should be tightened to the torques shown in Table 4.

NOTE: The following procedures are correct for most transmissions. Minor differences may be found on some models.

- Assemble the transmission using the following procedures. If a reduction unit is mounted to the transmission, refer to the correct section at the back of this manual for assembly procedures.

CAUTION: Transmissions manufactured prior to September 1978 used bushings instead of sealing rings. If bushings were in case they must be installed before assembly of transmission. See Figure 6 for details.



NOTE: THE 71-28C BUSHING IS THE PRE-SIZED BUSHING FOR FIELD SERVICE OF THE ORIGINAL 71-28B BUSHING INSTALLED AT FACTORY.

Figure 6. Bushing Installation

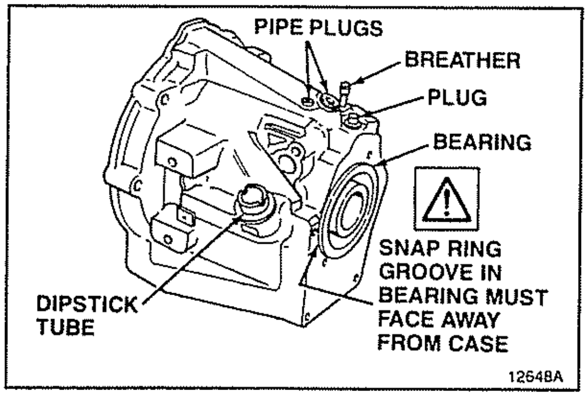
STEP 1. If removed, install the following parts in case (98). Tighten threaded parts to torque shown in Table 4.

Press bearing (7) into back of case (98).

Apply loctite #92, or equivalent, to threads of pipe plugs (96 and 97) and thread into top of case (98).

Apply loctite #592, or equivalent, to threads of dipstick tube (18) and thread into side of case (98).

NOTE: Plug (88) is a plastic shipping plug and should be installed hand-tight.

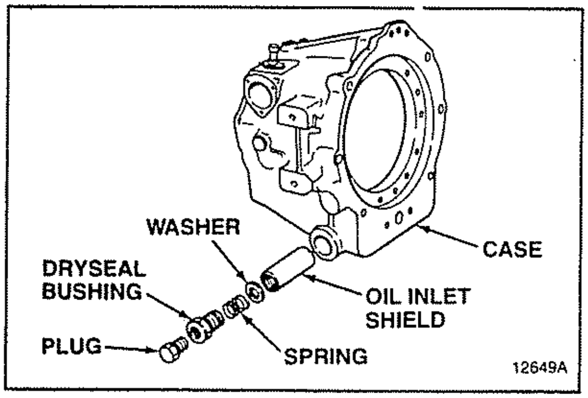


Case Assembly

STEP 2. Install shield (92) in case (98) with slot facing bottom of case (98). Install washer (91) and spring (90) inside shield (92).

Apply loctite #92, or equivalent, to threads of bushing (89). Thread bushing (89) into side of case (98) and tighten to torque shown in Table 4.

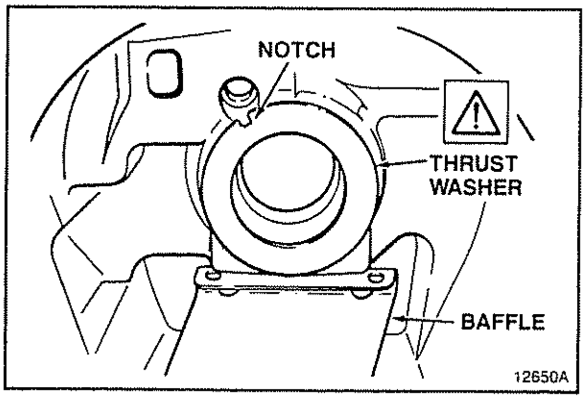
NOTE: Plug (88) is a plastic shipping plug and should be installed hand-tight.



Oil Shield Assembly

STEP 3. Install baffle (87) in case (98). Place thrustwasher (86) on face of bearing bore. Notch in thrustwasher (86) must align with notch in case (98).

CAUTION: Thrustwasher is used only on some models. (See Model Chart 71C and 72C Transmissions.)



Thrustwasher and Baffle Installation

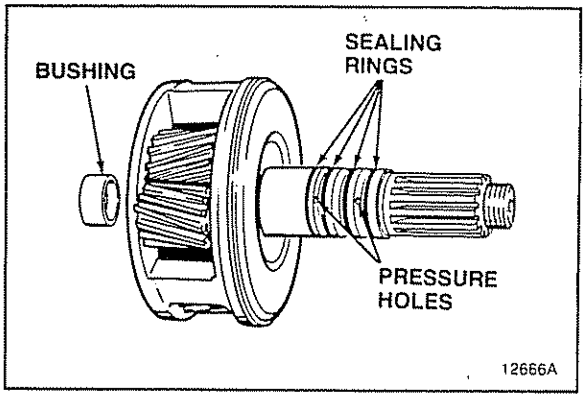
STEP 4. Lubricate sealing rings (83) and bushings (84) with vasoline.

If removed, press bushings (84) into pinion carrier (85).

CAUTION: Do not block pressure holes in pinion carrier (85) with bushings (84).

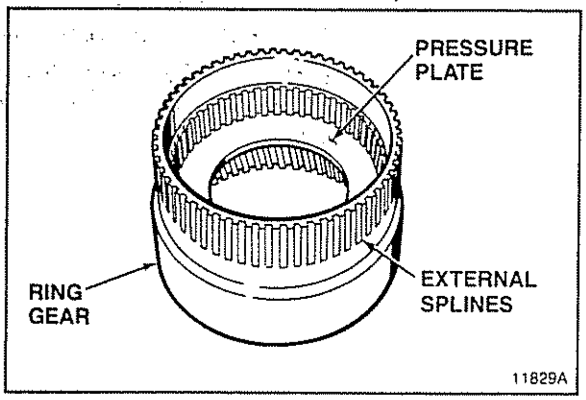
Install sealing rings (83) in grooves of pinion carrier (85). Compress each sealing ring (83) until it locks in place.

Install pinion carrier (85) in case (98).



Pinion Carrier Assembly

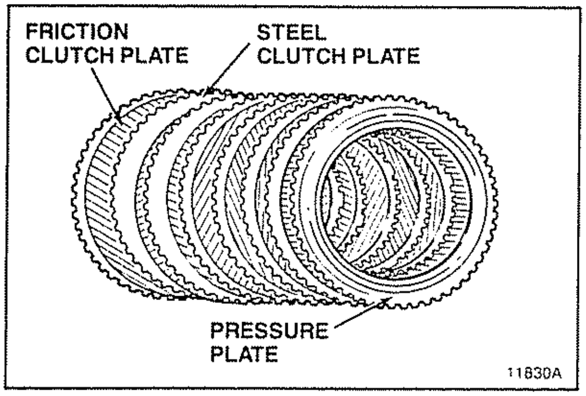
STEP 5. Install pressure plate (74) in ring gear (76).



Pressure Plate Assembly

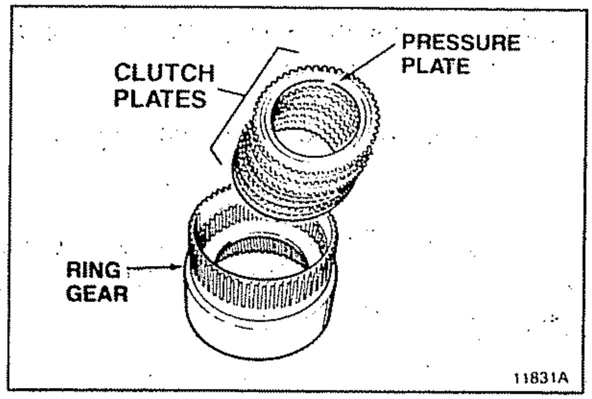
STEP 6. Starting with a friction clutch plate (73), alternately stack friction clutch plates (73) and steel clutch plates (72).

Place pressure plate (71) on top of clutch plates (72 and 73).



Forward Clutch Pack Arrangement

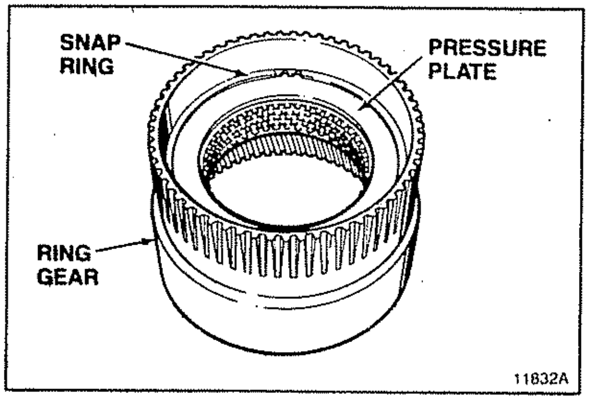
STEP 7. Install clutch plates (72 and 73) and pressure plate (71) in ring gear (76).



Forward Clutch Pack Assembly

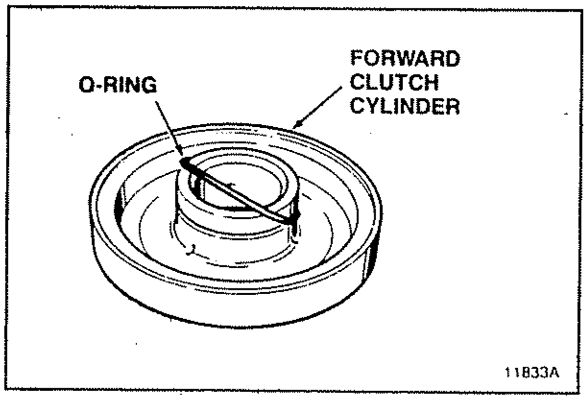
STEP 8. Install snap ring (70) in ring gear (76).

⚠ **CAUTION: Several different snap rings are used to assemble the clutch group. They have different thicknesses. Be sure the correct snap ring is used.**



Snap Ring Installation

STEP 9. Lubricate O-ring (66) lightly with vaseline and install in groove of forward clutch cylinder (64).



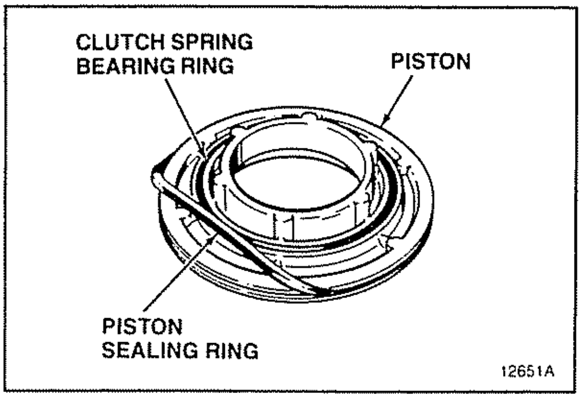
O-Ring Installation

STEP 10. Lubricate clutch spring bearing ring (68) and piston sealing ring (67) with vasoline.

Install clutch spring bearing ring (68) in groove on piston (65) face.

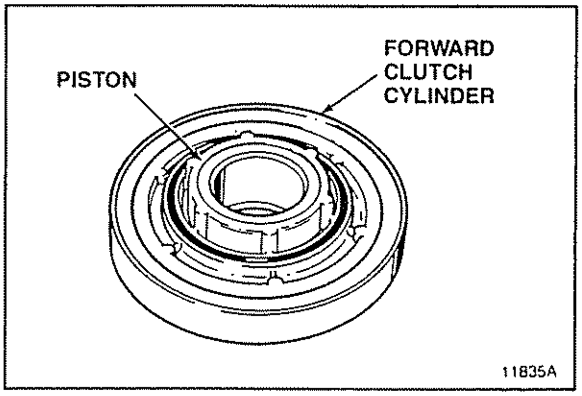
Install piston sealing ring (67) in outer groove of piston (65).

NOTE: Check that piston sealing ring (67) is not twisted, cut, or deformed. Replace if damaged.



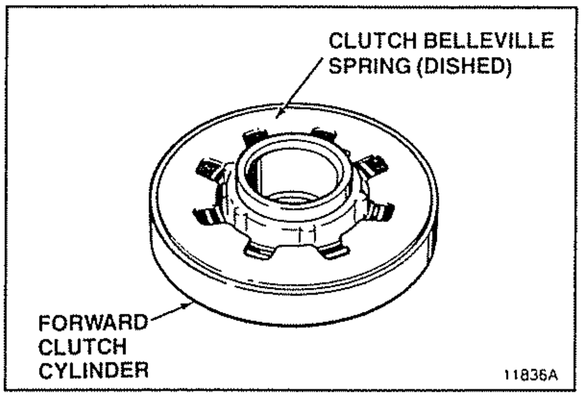
Clutch Rings Installation

STEP 11. Install piston (65) in forward clutch cylinder (64).



Piston Installation

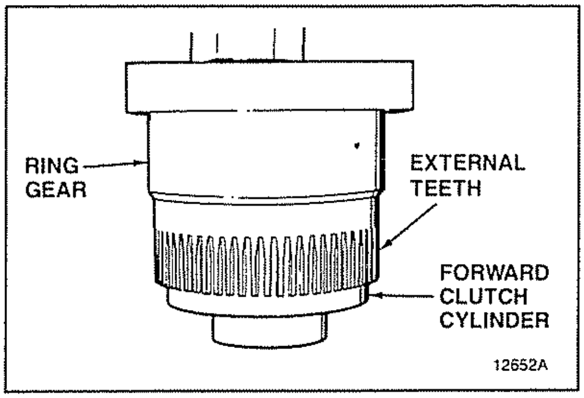
STEP 12. Place clutch belleville (dish) spring (69) inside rim of forward clutch cylinder (64). Spring is dished. The inside of the spring should be lower than the outside.



Clutch Spring Assembly

STEP 13. Install ring gear (76) over forward clutch cylinder (64), with piston (65) and spring (69) facing up. Press ring gear (76) down over forward clutch cylinder (64).

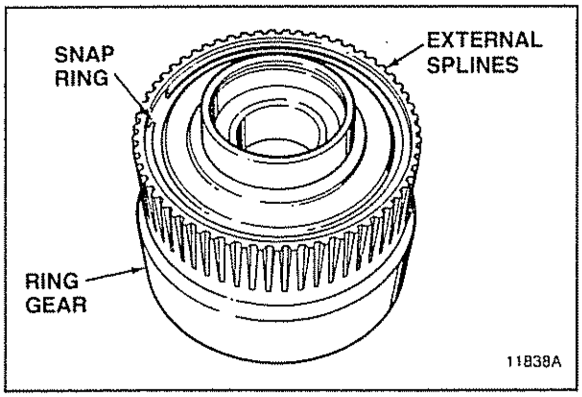
CAUTION: Check to see that clutch spring bearing ring (68) is still seated in the groove of clutch piston (65).



Forward Clutch Cylinder Installation

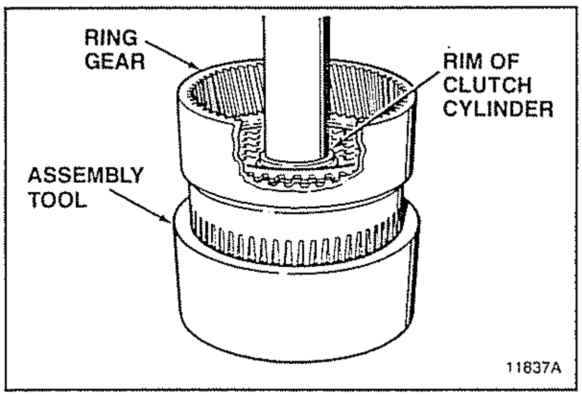
STEP 14. Remove clutch assembly from press. Install snap ring (60) in groove of ring gear (76).

CAUTION: Several different snap rings are used to assemble the clutch group. They have different thicknesses. Be sure the correct snap ring is used.



Snap Ring Installation

STEP 15. Place ring gear (76) in press with external splines facing down. Assembly tool should support the ring gear (76) only. The forward clutch cylinder (64) should not be touching the assembly tool. Press forward clutch cylinder (74) against snap ring (60). Remove clutch assembly from press.

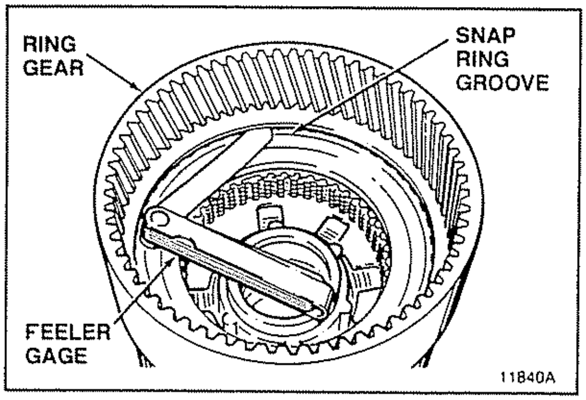


Compressing Clutch Pack

STEP 16. Push down, by hand, on clutch plates. Measure snap ring gap. Select proper thickness snap ring (75) or combination of snap rings (75) to set clutch pack clearance. Refer to chart below. More than one snap ring may be required.

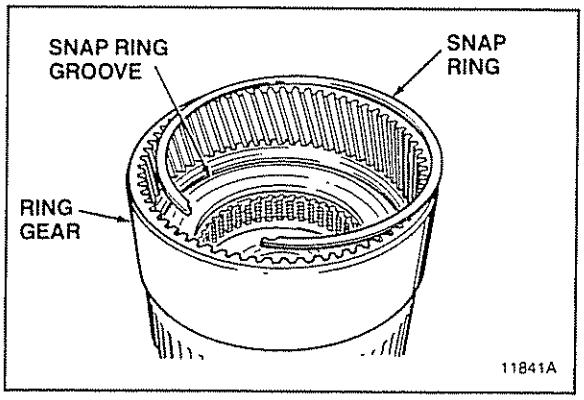
Clearance for bronze pack (71C)- 0.018"-0.053"
Clearance for bronze pack (72C)- 0.035"-0.055"
Clearance for paper pack (71C)- 0.018"-0.053"
Clearance for paper pack (72C)- 0.021"-0.046"

PART NUMBER	SNAP RING THICKNESS	
	in.	mm
4768	.050-.054	1.3-1.4
4768A	.074-.078	1.9-2.0
4768B	.096-.100	2.4-2.5
10-00-139-018	.062-.066	1.6-1.7
10-00-139-048	.033-.037	.84-.94
10-00-139-049	.050-.054	1.27-1.37



Snap Ring Selection

STEP 17. Install selected snap ring(s) (75) in groove of ring gear (76).



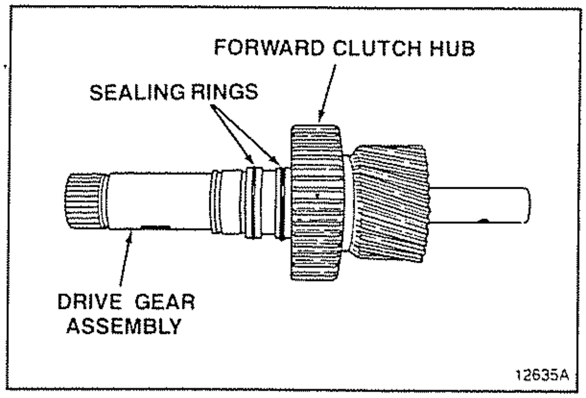
Snap Ring Assembly

STEP 18. If removed, install woodruff key (81) in drive gear assembly (82). Slide forward clutch hub (80) on drive gear assembly (82) and align with woodruff key (81). Press forward clutch hub (80) on drive gear assembly (82) and against shoulder.

Install snap ring (79) in groove of drive gear assembly (82).

Lubricate sealing rings (78) with vasoline and install in grooves of drive gear assembly (82).

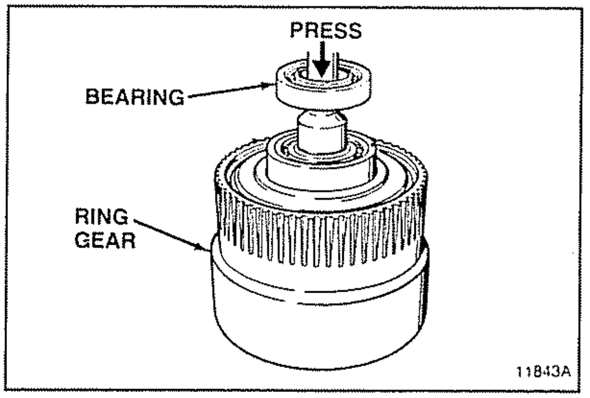
Compress each sealing ring (78) until it locks in place.



Sealing Ring Installation

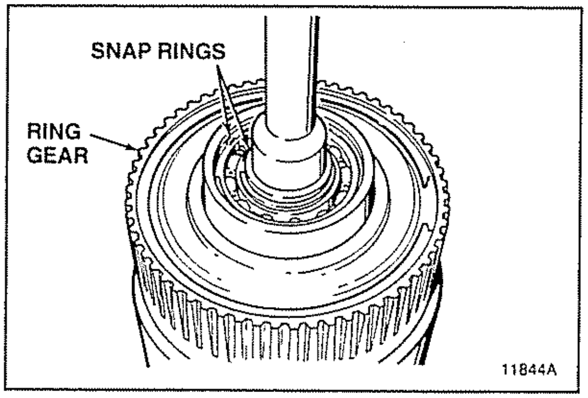
STEP 19. Install drive gear assembly (82) in clutch assembly. Slide bearing (63) down drive gear assembly (82).

Place complete assembly in press. Press bearing (63) into drive gear assembly (82) until seated against shoulder.



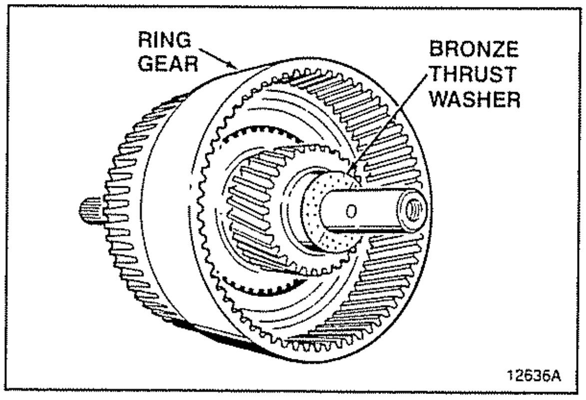
Bearing Installation

STEP 20. Install snap rings (61 and 62) in grooves of drive gear assembly (82) and forward clutch cylinder (64).



Snap Ring Installation

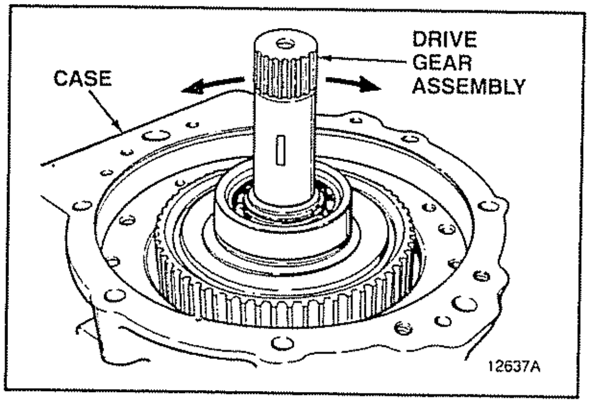
STEP 21. Apply vasoline to bronze thrustwasher (77). Install over end of shaft and against face of gear.



Thrustwasher Assembly

STEP 22. Install clutch and drive gear assembly (82) in case (98).

Rotate clutch and drive gear assembly (82) back and forth to engage ring gear teeth with pinion gear teeth.



Clutch and Drive Gear Installation

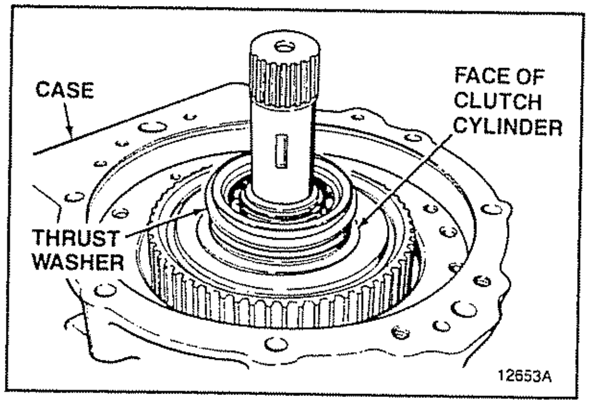
STEP 23. If original case and clutch cylinder are used, install thrustwasher (59) on face of clutch cylinder.

On model 10-18 transmissions select new thrustwasher (59) as follows:

Position case vertically as shown. Measure from face of case (98), without gasket (49), to face of clutch cylinder.

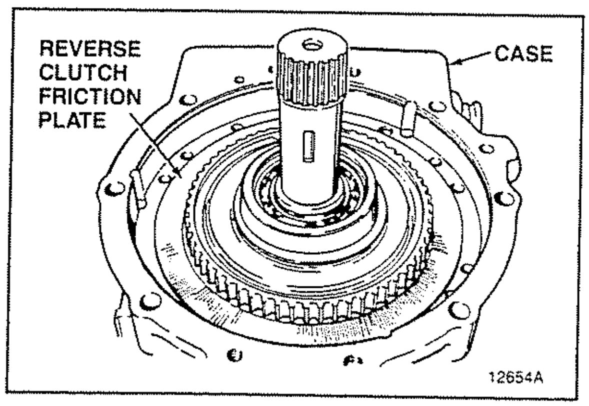
When dimension is 0.433 inch (11.0 mm) or less, use 71-15B thrustwasher.

When dimension is greater than 0.433 inch (11.0 mm), use 10-16-193-001 thrustwasher.



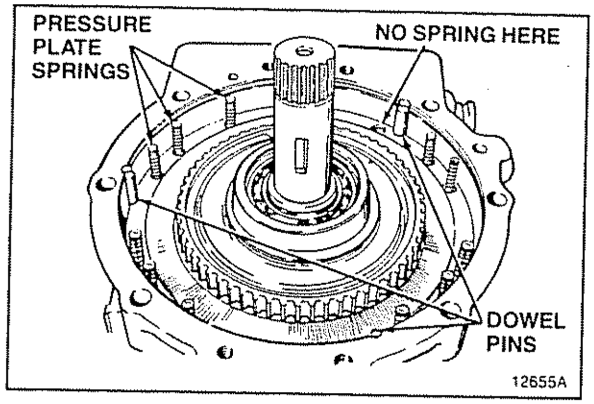
Thrustwasher Installation

STEP 24. Install one bronze reverse clutch friction plate (56) in case (98).



Friction Plate Installation

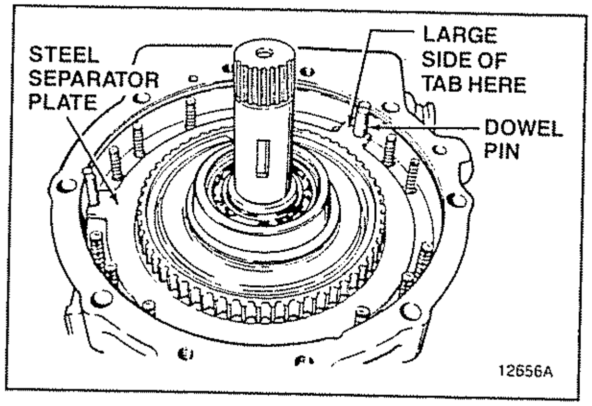
STEP 25. Install three dowel pins (58) and eleven pressure plate springs (57) in case (98).



Spring and Dowel Pin Installation

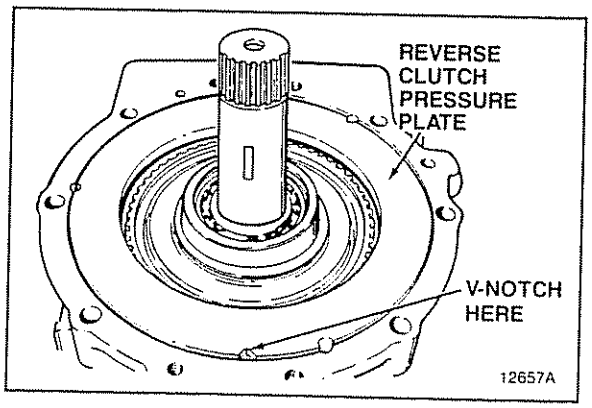
STEP 26. Install one steel separator plate (55) in case (98) with large part of tab to left of dowel pin (58).

Alternately stack remaining reverse clutch friction plates (56) and steel separator plates (55) in case (98).



Reverse Clutch Pack Installation

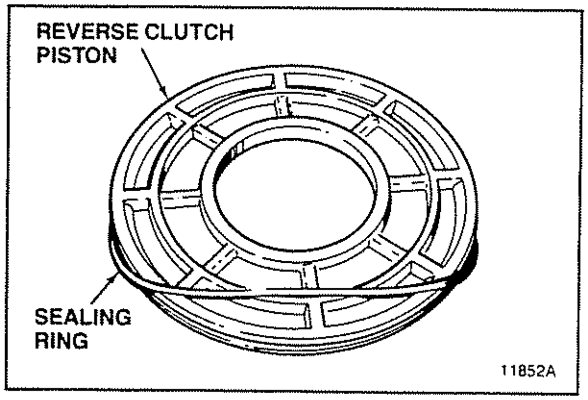
STEP 27. Install reverse clutch pressure plate (54) in case (98) with three half moons aligned with dowel pins (58). Be sure all springs are seated in their holes.



Pressure Plate Installation

STEP 28. Lubricate sealing ring (52) with vasoline and install in groove of reverse clutch piston (51).

NOTE: Be sure sealing ring (52) is not twisted, cut or distorted. Replace if damaged.



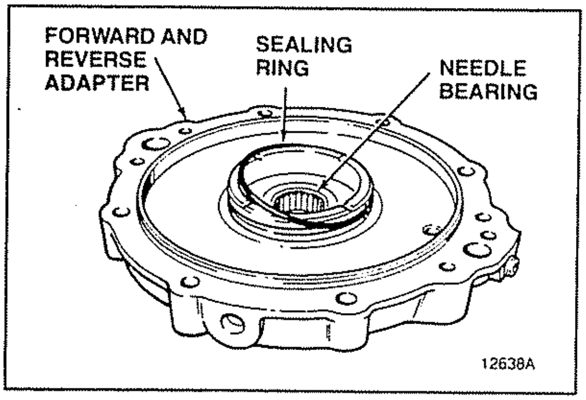
Sealing Ring Assembly

STEP 29. If removed, press needle bearing (48) into adapter (45). Needle bearing must be installed flush (even) with back face of adapter (45).

Lubricate O-ring (53) with vasoline and install in groove of adapter (45).

NOTE: Be sure O-ring (52) is not twisted, cut, or distorted. Replace if damaged.

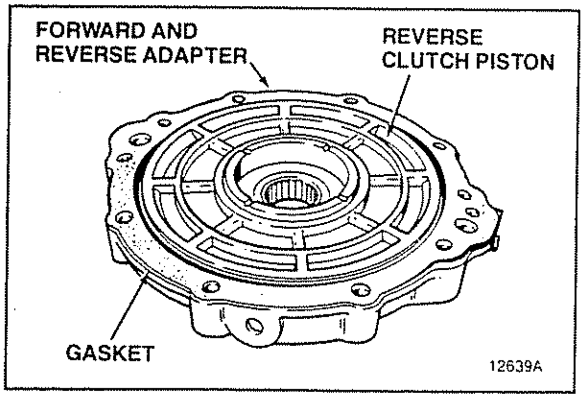
If removed, install dryseal plug (50) in adapter (45).



Sealing Ring Installation

STEP 30. Install reverse clutch piston (51) in adapter (45).

Lightly coat gasket (49) with vasoline and place on adapter (45).

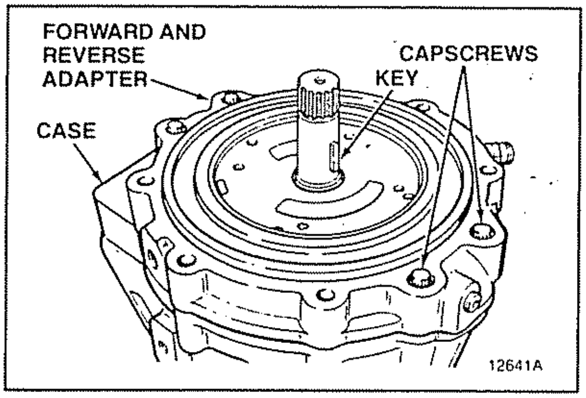


Reverse Clutch Piston Assembly

STEP 31. Install adapter (45) on case (98) and align bolt holes.

Thread four capscrews (46) into case (98). Tighten in a criss-cross pattern to final torque specified in Table 4.

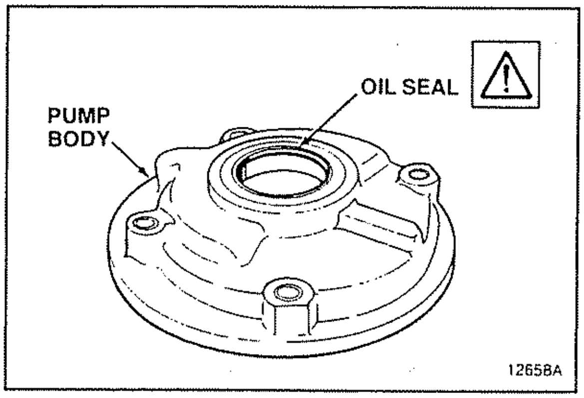
Lightly tap woodruff key (44) into place in drive gear (82) with a soft-faced mallet.



Adapter Installation

STEP 32. Press oil seal (42) into pump body.

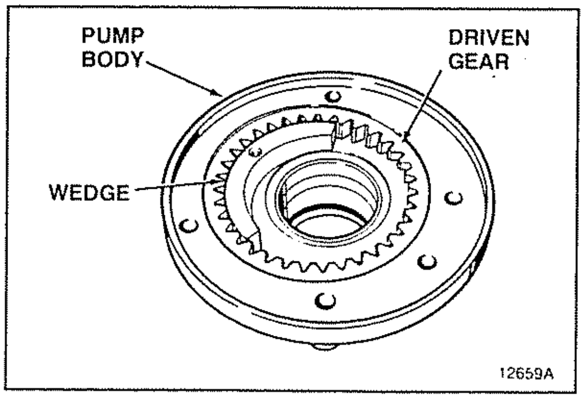
CAUTION: Oil seal must be installed dry. Lubricants can damage rubber coating.



Oil Seal Installation

STEP 33. Install driven gear in pump body.

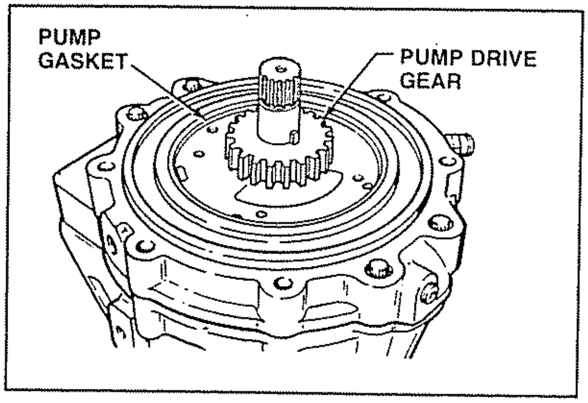
NOTE: Pump gear should be installed the same side down as removed.



Pump Driven Gear Assembly

STEP 34. Lubricate pump gasket (43) with vaseline and install in groove of adapter (47).

Install pump drive gear onto input shaft (82). Check that pump drive gear locates freely on woodruff key (44) and shaft (82).

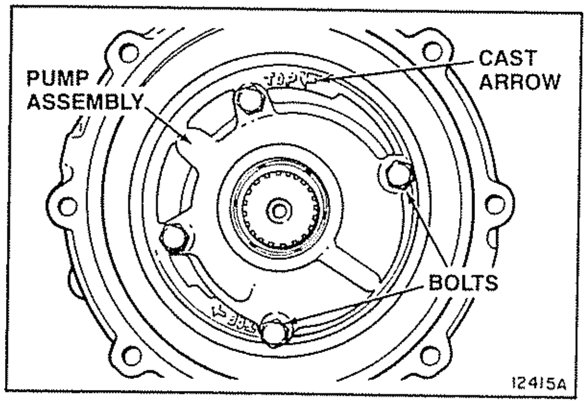


Pump Gasket Installation

STEP 35. Install pump assembly (40) on top of adapter (47) and align bolt holes.

⚠ **CAUTION: Position pump housing with cast arrow at top pointing in the same direction as engine rotation.**

Thread four bolts (41) into adapter (47). Tighten in a criss-cross pattern to final torque specified in Table 4.

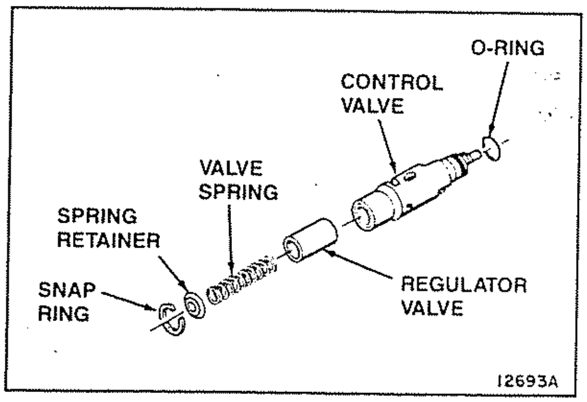


Pump Assembly Installation

STEP 36. Assemble control valve assembly (33). Refer to Figure 6.

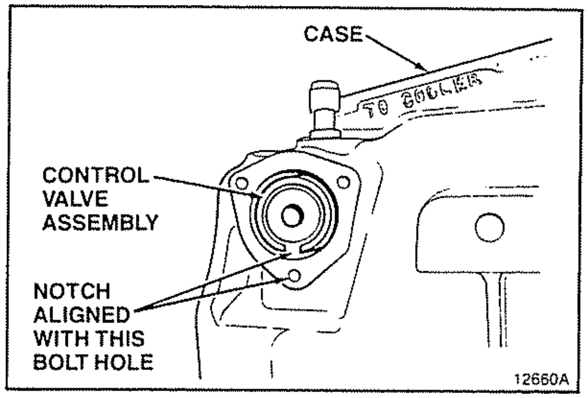
Lubricate O-ring (38) with vasoline and install on end of valve assembly (33).

NOTE: Gap in snap ring must be aligned with notch in control valve.



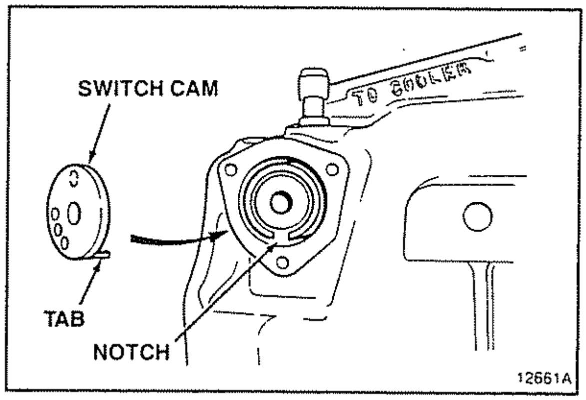
Valve Assembly

STEP 37. Lubricate control valve O.D. Slide control valve assembly (33) into side of case (98).



Valve Assembly Installation

STEP 38. Install switch cam (31) on end of valve assembly (33). Be sure tab on switch cam (31) sets in notch of valve assembly (33).



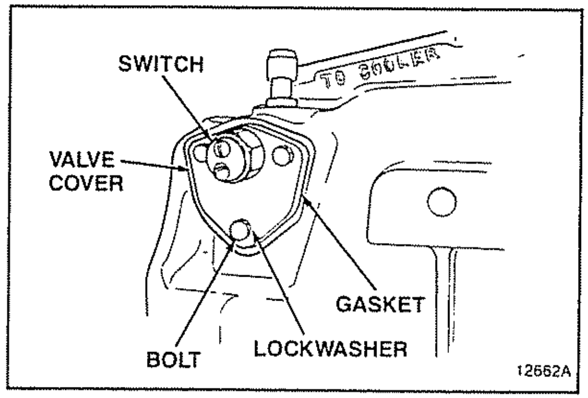
Switch Cam Installation

STEP 39. Install valve cover (28) as follows:

Position gasket (31) on case (98). Place valve cover (28) over gasket (32) and align bolt holes.

Thread three bolts (29) and lockwashers (30) into case (98). Tighten bolts in a criss-cross pattern to final torque specified in Table 4.

If removed, lubricate O-ring (27) with vasoline and install in groove of neutral switch (26). Thread neutral switch assembly (25) into valve cover (28) and tighten to torque specified in Table 4.



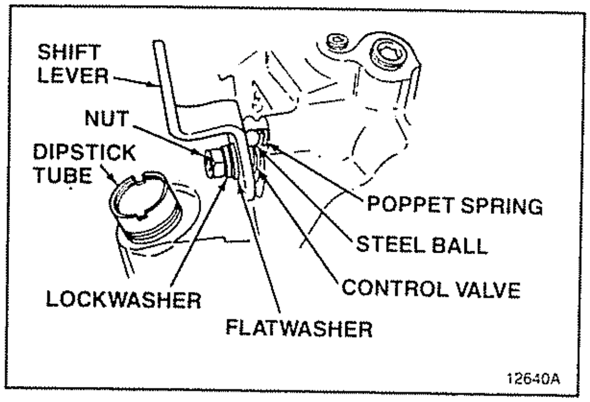
Valve Cover Installation

STEP 40. Install shift lever (19) as follows:

Lubricate poppet spring (24) and hole in case (98) with grease, shell alvania #2 or equivalent. Place poppet spring (24) and steel ball (23) in case (98).

Slide shift lever (19) over end of control valve assembly (33) and against steel ball (23). Rotate shift lever (19) to engage steel ball (23) in hole of shift lever (19).

Hold shift lever (19) against steel ball (23). Install washers (21 and 22) and thread nut (20) on control valve assembly (33). Tighten nut (20) to torque specified in Table 4.



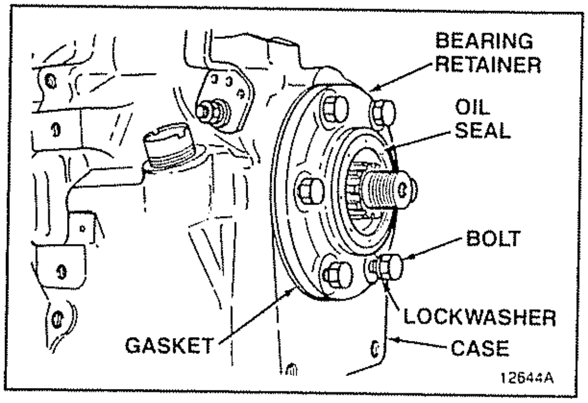
Shift Lever Assembly

STEP 41. Install bearing retainer (3) as follows:

If removed, press oil seal (6) into bearing retainer (3).

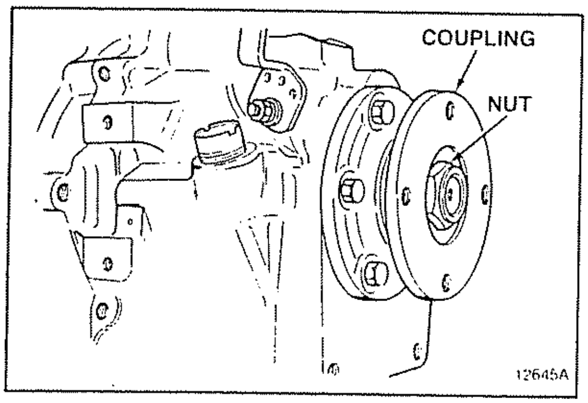
CAUTION: Oil Seal must be installed dry. Lubricants can damage rubber coating.

Install gasket (8) and bearing retainer (3) on back of case (98). Thread bolts (4) and lockwashers (5) into case (98). Tighten bolts (4), in a criss-cross pattern, to torque shown in Table 4.



Bearing Retainer

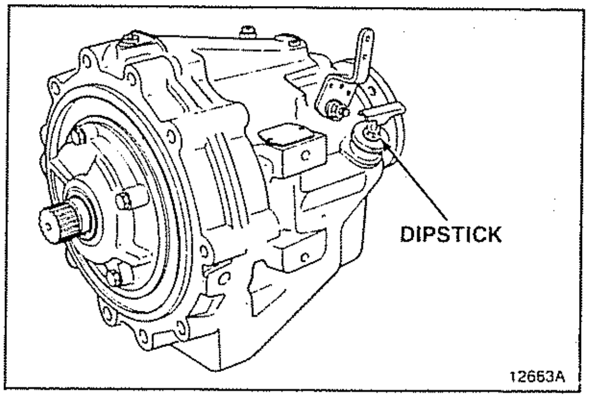
STEP 42. Slide coupling (2) on output shaft. Thread nut (1) on output shaft. Tighten nut (1) to torque shown in Table 4.



Coupling Installation

STEP 43. Install dipstick (17) in side of case (98). Turn handle until snug. Do not overtighten.

NOTE: For assembly of reduction units refer to the sections in the back of this manual.



Dipstick Installation

INSTALLATION

CAUTION: After a transmission failure the cooler and cooler lines must be flushed to remove contaminated hydraulic fluid and metal/rubber particles. Failure to comply can result in premature wear or failure of overhauled transmission.

- Align input shaft spline with damper plate.
- Assemble transmission to engine, and then install bolts. Do not use bolts to draw transmission against engine.

WARNING: CHECK THE SHIFT LEVER AT THE HELM TO SEE THAT FORWARD POSITION IS ALSO FORWARD POSITION AT THE TRANSMISSION SHIFT LEVER. (TRANSMISSION SHOULD NOT BE RUNNING IN REVERSE WHEN BOAT IS GOING FORWARD.)

- Adjust the shift cable so the holes in the shift lever are centered over the detent ball at each selector location. See Figure 7A.
- Read OEM manual for complete installation instructions. Installation literature is available from Borg-Warner Automotive-Transmission Systems. Request Form No. 1131.
- Connect oil line to oil to the cooler outlet. See Figure 7B.

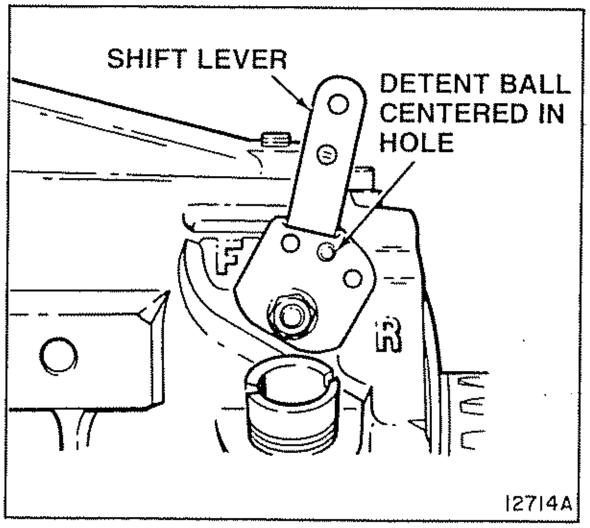


Figure 7A. Shift Cable Adjustment

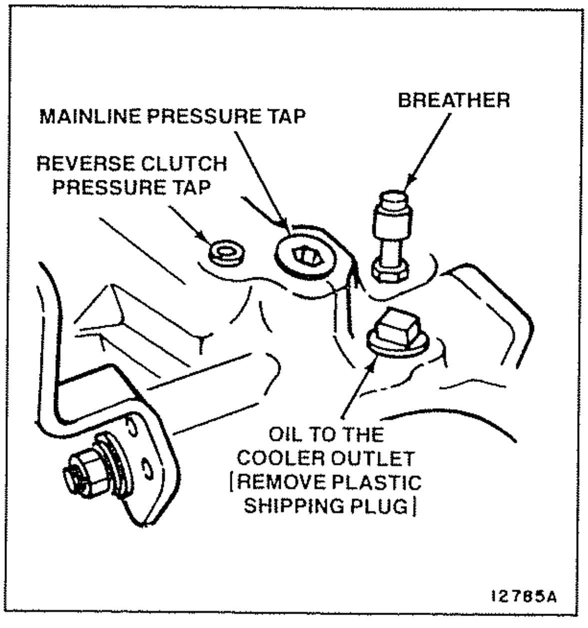


Figure 7B. Oil to Cooler Outlet

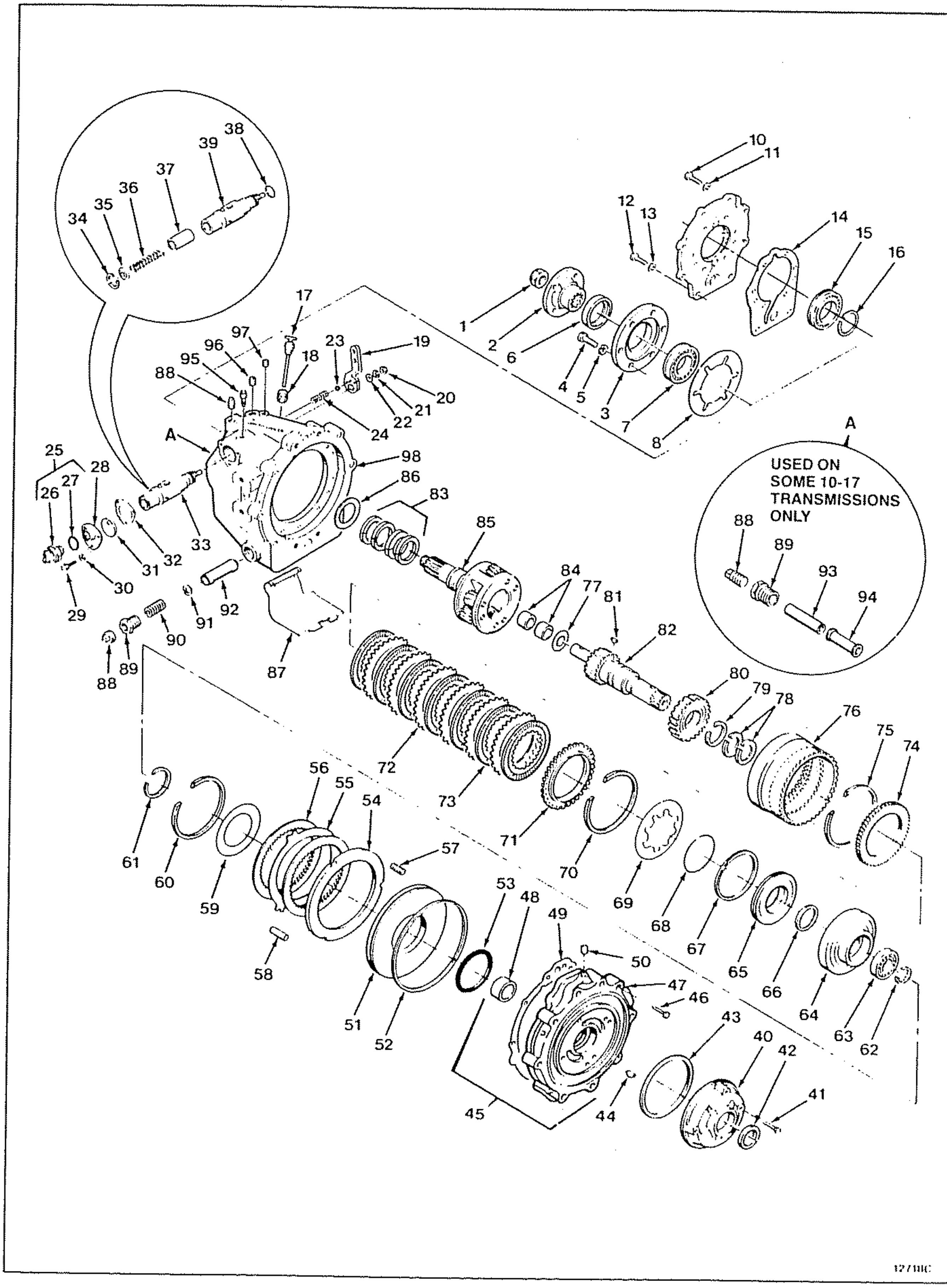


Figure 8. 71C and 72C Transmission Assembly - Current Production

INDEX NO.	PART NUMBER	DESCRIPTION	QTY
Fig. 8	10-17-000-*	TRANSMISSION ASSEMBLY (MODEL 71C)	
	10-18-000-*	TRANSMISSION ASSEMBLY (MODEL 72C)	
1	4775L	• OUTPUT SHAFT NUT	1
2	4547BA	• COUPLING (10-17 ONLY)	1
2A	4547AY	• COUPLING (10-18 ONLY)	1
3	71-7	• BEARING RETAINER (10-17 ONLY)	1
3A	72-7	• BEARING RETAINER (10-18 ONLY)	1
4	0000179859	• HEX HEAD BOLT (7/16-14 × 1-1/4) (10-17 ONLY)	6
4A	10-00-183-043	• HEX HEAD BOLT (7/16-14 × 1-1/4) (10-18 ONLY)	6
5	0000103322	• LOCKWASHER (7/16) (10-17 ONLY)	6
6	71C-110	• OIL SEAL	1
7	B111AG	• BEARING	1
7A	B308AGS	• BEARING	1
7B	B309AGS	• BEARING	1
8	71-147	• BEARING RETAINER GASKET (10-17 ONLY)	1
8A	72-147	• BEARING RETAINER GASKET (10-18 ONLY)	1
9	**	• ADAPTER	1
9A	**	• ADAPTER	1
9B	**	• ADAPTER	1
10	**	• LOCK BOLT (7/16-14 × 7/8)	6
11	**	• LOCKWASHER (7/16) (10-18 ONLY)	6
11A	**	• LOCKWASHER (7/16) (10-17 ONLY)	6
12	**	• HEX HEAD BOLT (7/16-14 × 1-3/4)	2
13	**	• LOCKWASHER (7/16)	2
14	**	• ADAPTER GASKET	1
15	**	• BEARING	1
16	**	• RETAINING RING	1
17	10-17-559-001	• DIPSTICK (ALL DIRECT DRIVES EXCEPT -015 AND -016)	1
17A	10-13-559-001	• DIPSTICK (FOR -015 AND -016)	1
18	10-04-034-002	• DIPSTICK TUBE	1
19	71-79B	• SHIFT LEVER	1
20	9418892	• HEX NUT (5/16-24)	1
21	0000108579	• LOCKWASHER (5/16)	1
22	0000103340	• FLATWASHER (5/16)	1
23	0000453632	• STEEL BALL (5/16)	1
24	71-42	• POPPET SPRING	1
25	10-00-640-004	• NEUTRAL SWITCH ASSEMBLY	1
26	NO NUMBER	• • NEUTRAL SWITCH (NSS)	1
27	10-00-141-046	• • O-RING	1
28	10-16-039-001	• • VALVE COVER	1
29	0000179796	• HEX HEAD BOLT (1/4-20 × 1/2)	3
30	0000103319	• LOCKWASHER (1/4)	3
31	10-16-039-001	• SWITCH CAM	1
32	71-14	• VALVE COVER GASKET	1
33	71-A244A	• CONTROL VALVE ASSEMBLY	1
34	4821	• • SNAP RING	1
35	71-246	• • SPRING RETAINER	1
36	71-242	• • VALVE SPRING	1
37	71-243	• • REGULATOR VALVE	1
38	4804H	• • O-RING	1

* REFER TO ASSEMBLY NUMBER ON ID TAG (See Figure 1)
** REFER TO REDUCTION SECTION IN BACK OF MANUAL.
NSS - NOT SERVICED SEPARATELY, BUY NEXT HIGHER ASSEMBLY

INDEX NO.	PART NUMBER	DESCRIPTION	QTY
39	71-244A	• • CONTROL VALVE	1
40	71C-A60	• PUMP ASSEMBLY	1
41	10-00-183-021	• HEX HEAD BOLT (5/16-18 × 1-3/8)	4
42	10-00-044-014	• • OIL SEAL	1
43	3-61	• PUMP GASKET	1
44	4873	• WOODRUFF KEY	1
45	71C-A8	• FORWARD AND REVERSE ADAPTER ASSEMBLY	1
46	4911	• CAPSCREW (3/8-16 × 1-1/4)	4
47	NO NUMBER	• • FORWARD AND REVERSE ADAPTER (NSS)	1
48	4840D	• • NEEDLE BEARING	1
49	71-144B	• GASKET	1
50	0000444858	• PIPE PLUG (1/4)	1
51	71-35	• REVERSE CLUTCH PISTON	1
52	4805A	• CLUTCH SEALING RING	1
53	4804G	• O-RING	1
54	71-71	• REVERSE CLUTCH PRESSURE PLATE	1
55	72-176	• STEEL CLUTCH PLATE	0-2
56	72-A66B	• FRICTION CLUTCH PLATE	1-3
57	71-97	• PRESSURE PLATE SPRING	11
58	71-87A	• DOWEL PIN (.312 DIA × .438 LONG)	3
58A	R6-177	• DOWEL PIN (.312 DIA × .621 LONG)	3
58B	4622E	• DOWEL PIN (.312 DIA × .875 LONG)	3
59	71-15B	• THRUSTWASHER	1
59A	10-16-193-001	• THRUSTWASHER	1
60	4822	• SNAP RING	1
61	R6A-7 1/2	• SNAP RING (10-17 ONLY)	1
61A	4766B	• SNAP RING (10-18 ONLY)	1
62	4734	• SNAP RING (10-17 ONLY)	1
62A	4559A	• SNAP RING (10-18 ONLY)	1
63	B107A	• BEARING (10-17 ONLY)	1
63A	B108A	• BEARING (10-18 ONLY)	1
64	71-70	• FORWARD CLUTCH CYLINDER (10-17 ONLY)	1
64A	72-70	• FORWARD CLUTCH CYLINDER (10-18 ONLY)	1
65	10-16-124-001	• FORWARD CLUTCH PISTON	1
65A	71-45	• FORWARD CLUTCH PISTON	1
66	5M-122	• O-RING	1
67	5L-36	• PISTON SEALING RING	1
68	5C-33	• CLUTCH SPRING BEARING RING	1
69	3-37	• CLUTCH BELLEVILLE SPRING	1
70	4755	• SNAP RING	1
71	5C-175A	• CLUTCH PRESSURE PLATE	1
72	3-176	• STEEL CLUTCH PLATE (10-17 ONLY)	4
72A	3-176	• STEEL CLUTCH PLATE (10-18 ONLY)	6
73	5C-A66A	• FRICTION CLUTCH PLATE (10-17 ONLY)	5
73A	5C-A66A	• FRICTION CLUTCH PLATE (10-18 ONLY)	7
74	5L-67	• CLUTCH PRESSURE PLATE	1
75	10-00-139-048	• SNAP RING (.033-.037 THICK) (10-17 ONLY)	1
75A	10-00-139-049	• SNAP RING (.050-.054 THICK) (10-17 ONLY)	1
75B	4768	• SNAP RING (.050-.054 THICK) (10-18 ONLY)	1-2
75C	4768A	• SNAP RING (.074-.078 THICK) (10-18 ONLY)	1
75D	4768B	• SNAP RING (.096-.100 THICK) (10-18 ONLY)	1
75E	10-00-139-018	• SNAP RING (.062-.066 THICK) (10-18 ONLY)	1

NSS - NOT SERVICED SEPARATELY, BUY NEXT HIGHER ASSEMBLY.

INDEX NO.	PART NUMBER	DESCRIPTION	QTY
76	71-6	• RING GEAR (10-17 ONLY)	1
76A	72-6	• RING GEAR (10-18 ONLY)	1
77	71-17	• THRUSTWASHER	1
78	4806J	• SEALING RING	2
79	4495	• SNAP RING	1
80	71-40	• FORWARD CLUTCH HUB (10-17 ONLY)	1
80A	10-16-179-001	• FORWARD CLUTCH HUB (10-18 ONLY)	1
81	0000218211	• WOODRUFF KEY (10-17 ONLY)	1
81A	0000124553	• WOODRUFF KEY (10-18 ONLY)	1
82	71C-3A16	• DRIVE GEAR ASSEMBLY (10-17 ONLY)	1
82A	72C-2A16	• DRIVE GEAR ASSEMBLY (10-18 ONLY)	1
83	4806B	• SEALING RING	4
84	A4877D (KIT)	• BUSHING	2
85	10-17-659-***	• PINION CARRIER ASSEMBLY (10-17 ONLY)	1
85A	10-18-659-***	• PINION CARRIER ASSEMBLY (10-18 ONLY)	1
86	71-159	• THRUSTWASHER	1
86A	10-17-193-001	• THRUSTWASHER	1
87	71-140	• OIL BAFFLE	1
87A	71B-140	• OIL BAFFLE	1
88	10-00-191-002	• PLUG (3/8-18)	2
89	4885B	• DRYSEAL BUSHING (3/4-14)	1
90	5L-222	• SPRING	1
91	35-143	• FLAT WASHER	1
92	72C-98	• OIL INLET SHIELD	1
93	71C-84	• OIL RETURN TUBE	1
94	71C-A98	• OIL STRAINER ASSEMBLY	1
95	A4740G	• BREATHER	1
96	0000444866	• PIPE PLUG (3/8-18)	1
97	0000444687	• PIPE PLUG (1/8-27)	1
98	10-17-565-***	• CASE (10-17 ONLY)	1
98A	10-18-565-***	• CASE (10-18 ONLY)	1

*** CHECK MODEL CHART TO DETERMINE CORRECT PART NUMBER

NOTE: The following kits are available for the Model 71C and 72C transmissions. Index numbers shown match the index numbers on the exploded-view, Figure 8.

INDEX NO.	PART NUMBER	DESCRIPTION	QTY
	A4867AB	FORWARD CLUTCH PACK KIT (10-18 ONLY)	
71	5C-175A	• CLUTCH PRESSURE PLATE	1
72A	3-176	• STEEL CLUTCH PLATE	6
73A	5C-A66A	• FRICTION CLUTCH PLATE	7
74	5L-67	• CLUTCH PRESSURE PLATE	1

INDEX NO.	PART NUMBER	DESCRIPTION	QTY
	A4867AE	FORWARD CLUTCH PACK KIT (10-17 ONLY)	
71	5C-175A	• CLUTCH PRESSURE PLATE	1
72	3-176	• STEEL CLUTCH PLATE	4
73	5C-A66A	• FRICTION CLUTCH PLATE	5
74	5L-67	• CLUTCH PRESSURE PLATE	1

INDEX NO.	PART NUMBER	DESCRIPTION	QTY
	A4867HA	OIL SEAL AND SEALING RING KIT	
6	71C-110	• OIL SEAL	1
38	4804H	• O-RING	1
42	10-00-044-014	• OIL SEAL	1
43	3-61	• PUMP GASKET	1
52	4805A	• CLUTCH SEALING RING	1
53	4804G	• O-RING	1
66	5M-122	• O-RING	1
67	5L-36	• CLUTCH SEALING RING	1
78	4806J	• SEALING RING	2
83	4806B	• SEALING RING	4
	10-00-044-017	• OIL SEAL (REDUCTION UNITS ONLY)	1
	10-17-410-002	• SERVICE GASKET KIT (FOR CONTENTS SEE NEXT KIT LIST)	1

INDEX NO.	PART NUMBER	DESCRIPTION	QTY
	10-17-410-002	SERVICE GASKET KIT	
8	71-147	• BEARING RETAINER GASKET (10-17 ONLY)	1
8A	72-147	• BEARING RETAINER GASKET (10-18 ONLY)	1
14	L4-146	• ADAPTER GASKET	1
32	71-14	• VALVE COVER GASKET	1
49	71-144B	• GASKET	1
	L4-145	• GASKET (REDUCTION UNITS ONLY)	1
	L4-147	• GASKET (REDUCTION UNITS ONLY)	1

INDEX NO.	PART NUMBER	DESCRIPTION	QTY
	10-04-420-052	NEUTRAL SWITCH KIT	
	10-04-539-001	• SWITCH AND BODY ASSEMBLY	1
25	10-00-640-004	• • NEUTRAL SWITCH ASSEMBLY	1
28	10-16-039-001	• • VALVE COVER	1
29	0000179796	• HEX HEAD BOLT (1/4-20 × 1/2)	3
30	0000103319	• LOCKWASHER (1/4)	3
31	10-16-099-001	• SWITCH CAM	1
32	71-14	• VALVE COVER GASKET	1
	1340	• INSTRUCTION SHEET	1

INDEX NO.	PART NUMBER	DESCRIPTION	QTY
	10-95-410-002	SNAP RING SERVICE KIT	
15	4766	• RETAINING RING	1
34	4821	• SNAP RING	1
60	4822	• SNAP RING	1
61	R6A-7½	• SNAP RING (10-17 ONLY)	1
61A	4766B	• SNAP RING (10-18 ONLY)	1
62	4734	• SNAP RING (10-17 ONLY)	2
62A	4559A	• SNAP RING (10-18 ONLY)	1
70	4755	• SNAP RING	1
75	10-00-139-048	• SNAP RING (.033-.037 THICK)(10-17 ONLY)	1
75A	10-00-139-049	• SNAP RING (.050-.054 THICK)(10-17 ONLY)	1
75B	4768	• SNAP RING (.050-.054 THICK)(10-18 ONLY)	2
75C	4768A	• SNAP RING (.074-.078 THICK)(10-18 ONLY)	1
75D	4768B	• SNAP RING (.096-.100 THICK)(10-18 ONLY)	1
75E	10-00-139-018	• SNAP RING (.062-.066 THICK)(10-18 ONLY)	1
79	4495	• SNAP RING	1
	4756D	• SNAP RING (REDUCTION UNITS ONLY)	1
	4756E	• SNAP RING (REDUCTION UNITS ONLY)	1
	4816	• SNAP RING (REDUCTION UNITS ONLY)	1
	4766A	• SNAP RING (REDUCTION UNITS ONLY)	1

TRANSMISSION MODEL NUMBER	CASE ASSEMBLY NEW STYLE W/O BUSHINGS	CASE ASSEMBLY OLD STYLE W/BUSHINGS	FORWARD PINION CARRIER ASSEMBLY NEW STYLE W/SEALING RINGS	FORWARD PINION CARRIER ASSEMBLY OLD STYLE W/O SEALING RINGS	REDUCTION PINION CARRIER ASSEMBLY	REDUCTION HOUSING	THRUSTWASHER (If used between forward pinion carrier assy and case)
10-17-000-001	10-17-065-004	71B-1A	10-17-659-012	71-1A2	NOT USED	NOT USED	NOT USED
10-17-000-002	10-17-065-004	71B-1A	10-17-659-012	71-1A2	NOT USED	NOT USED	NOT USED
10-17-000-003	10-17-065-006	71C-1	10-17-659-012	71-1A2	NOT USED	NOT USED	NOT USED
10-17-000-004	10-17-065-006	71C-1	10-17-659-012	71-1A2	NOT USED	NOT USED	NOT USED
10-17-000-005	10-17-565-002	71-A1K	10-17-659-020	71-1A2A	L4-A150	10-17-065-001	10-17-193-001
10-17-000-006	10-17-565-002	71-A1K	10-17-659-020	71-1A2A	L4-A150	10-17-065-001	10-17-193-001
10-17-000-007	10-17-565-002	71-A1K	10-17-659-018	71-1A2C	L9-A150	10-17-065-003	NOT USED
10-17-000-008	10-17-565-002	71-A1K	10-17-659-018	71-1A2C	L9-A150	10-17-065-003	NOT USED
10-17-000-009	10-17-565-002	71-A1K	10-17-659-016	10-17-659-004	10-17-659-006	10-17-065-002	10-17-193-001
10-17-000-010	10-17-565-002	71-A1K	10-17-659-016	10-17-659-004	10-17-659-010	10-17-065-002	10-17-193-001
10-17-000-011	10-17-565-002	71-A1K	10-17-659-018	71-1A2C	10-17-659-007	10-17-065-001	NOT USED
10-17-000-012	10-17-565-002	71-A1K	10-17-659-018	71-1A2C	10-17-659-007	10-17-065-001	NOT USED
10-17-000-013	10-17-565-002	71-A1K	10-17-659-018	71-1A2C	10-17-659-008	10-17-065-001	NOT USED
10-17-000-014	10-17-565-002	71-A1K	10-17-659-018	71-1A2C	10-17-659-008	10-17-065-001	NOT USED
10-17-000-015	10-17-565-002	71-A1K	10-17-659-020	71-1A2A	NOT USED	NOT USED	10-17-193-001
10-17-000-016	10-17-565-002	71-A1K	10-17-659-020	71-1A2A	NOT USED	NOT USED	10-17-193-001
10-17-000-108	10-17-565-002	71-A1K	10-17-659-018	71-1A2C	10-17-659-021	10-17-065-003	NOT USED
10-18-000-001	10-18-565-001	72-A1J	10-18-659-006	72-1A2	NOT USED	NOT USED	NOT USED
10-18-000-002	10-18-565-001	72-A1J	10-18-659-006	72-1A2	NOT USED	NOT USED	NOT USED
10-18-000-003	10-18-565-002	72-A1K	10-18-659-014	10-18-659-002	L4-A150	10-17-065-001	10-17-193-001
10-18-000-004	10-18-565-002	72-A1K	10-18-659-014	10-18-659-002	L4-A150	10-17-065-001	10-17-193-001
10-18-000-005	10-18-565-002	72-A1K	10-18-659-012	72-1A2C	L9-A150	10-17-065-003	NOT USED
10-18-000-006	10-18-565-002	72-A1K	10-18-659-012	72-1A2C	L9-A150	10-17-065-003	NOT USED
10-18-000-007	10-18-565-002	72-A1K	10-18-659-010	10-18-659-004	10-17-659-006	10-17-065-002	10-17-193-001
10-18-000-008	10-18-565-002	72-A1K	10-18-659-010	10-18-659-004	10-17-659-010	10-17-065-002	10-17-193-001
10-18-000-009	10-18-565-002	72-A1K	10-18-659-012	72-1A2C	10-17-659-007	10-17-065-001	NOT USED
10-18-000-010	10-18-565-002	72-A1K	10-18-659-012	72-1A2C	10-17-659-007	10-17-065-001	NOT USED
10-18-000-011	10-18-565-002	72-A1K	10-18-659-012	72-1A2C	10-17-659-008	10-17-065-001	NOT USED
10-18-000-012	10-18-565-002	72-A1K	10-18-659-012	72-1A2C	10-17-659-008	10-17-065-001	NOT USED
10-18-000-013	10-18-565-002	72-A1K	10-18-659-014	10-18-659-002	NOT USED	NOT USED	10-17-193-001
10-18-000-014	10-18-565-002	72-A1K	10-18-659-014	10-18-659-002	NOT USED	NOT USED	10-17-193-001
10-18-000-015	10-18-565-002	72-A1K	10-18-659-008	72-1A2A	NOT USED	NOT USED	10-17-193-001
10-18-000-016	10-18-565-002	72-A1K	10-18-659-008	72-1A2A	NOT USED	NOT USED	10-17-193-001
10-18-000-017	10-18-565-001	72-A1J	10-18-659-006	72-1A2	NOT USED	NOT USED	NOT USED
10-18-000-106	10-18-565-002	72-A1K	10-18-659-012	72-1A2C	10-17-659-021	10-17-065-003	NOT USED

Model Chart 71C and 72C Transmissions

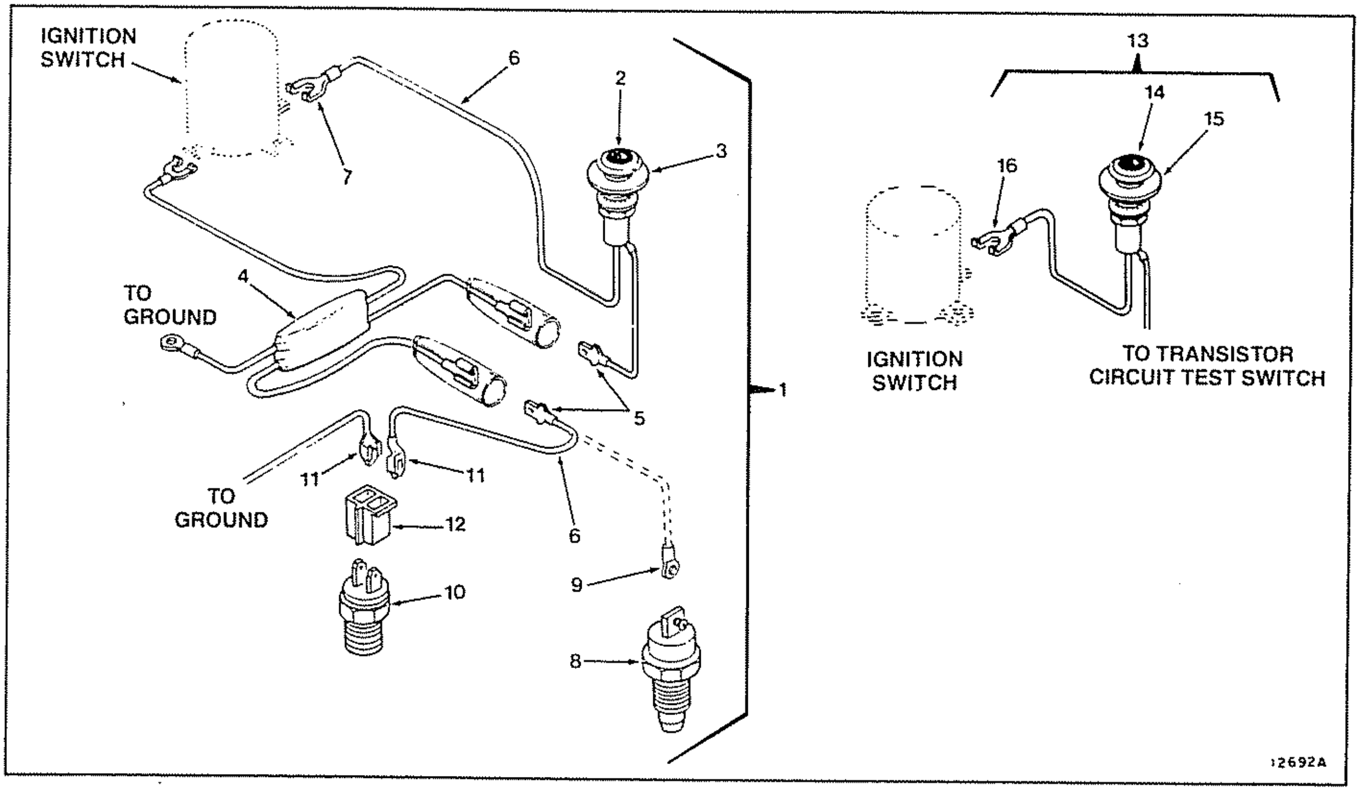


Figure 9. Optional Drive Gear Alarm Kits

INDEX NO.	PART NUMBER	DESCRIPTION	QTY
Fig. 9	NO NUMBER	OPTIONAL DRIVE GEAR ALARM KITS	
1	A4867HN	• DRIVE GEAR ALARM KIT	1
2	71C-309	• • PILOT LIGHT	1
3	71C-308	• • PLATE	1
4	71C-A312	• • TRANSISTOR CIRCUIT TEST SWITCH	1
5	4900E	• • 1/4" MALE TERMINAL	2
6	4927	• • INSTALLATION WIRE	1
7	4924	• • SPADE TERMINAL	1
8	71C-A102	• • TEMPERATURE SWITCH	1
9	4925	• • EYELET TERMINAL	1
10	10-00-140-004	• • TEMPERATURE SWITCH	1
11	10-00-140-005	• • FEMALE TERMINAL	2
12	10-00-140-006	• • FEMALE CONNECTOR	1
	71C-310	• • WIRING DIAGRAM	1
		• • INSTRUCTION SHEET	1
13	A4867HS*	• PILOT LIGHT KIT	1
14	71C-309	• • PILOT LIGHT	1
15	71C-308	• • PLATE	1
16	4924	• • SPADE TERMINAL	1
17	71C-310	• • WIRING DIAGRAM	1
		• • INSTRUCTION SHEET	1

* CAN BE PURCHASED TO ADD ANOTHER PILOT LIGHT TO THE DRIVE GEAR ALARM KIT. CAN NOT BE USED SEPARATELY.

SPECIFICATIONS

CAUTION: Threaded plugs, screws, bolts, and coupling nuts must be tightened to torque shown in this table to prevent premature failure of transmission or reduction unit.

Table 4. Bolt and Fastener Torques (Non-Lubricated)

PART NUMBER	DESCRIPTION	FT-LB	Nm
9418892	5/16-24 Shift Lever Nut	8-11	11-15
0000179796	1/4-20 x 1/2 Hex Head Bolt	8-11	11-15
4775L	Coupling Nut	160-260	217-353
0000179859	7/16-14 x 1-1/4 Hex Head Bolt	42-50	57-68
10-00-183-043	7/16-14 x 1-1/4 Hex Head Bolt (Self Locking)	42-50	57-68
10-00-183-073	7/16-14 x 7/8 Lock Bolt	42-50	57-68
0000179864	7/16-14 x 1-3/4 Hex Head Bolt	42-50	57-68
10-04-034-002	Dipstick Tube	10-40	14-55
10-00-183-021	5/16-18 x 1 Hex Head Bolt	17-22	23-30
4911	3/8-16 x 1-1/4 Capscrew	27-37	37-50
4885B	3/4-14 Dryseal Bushing	25-35	34-48
0000444866	3/8-18 Pipe Plug	17-27	23-37
0000444687	1/8-27 Pipe Plug	7-12	9-16
10-00-640-004	9/16-18 Switch Assembly	20-30	28-42
4853E	7/16-14 x 1-1/4 Lock Bolt	42-50	57-68
0000179840	3/8-18 x 1-1/8 Hex Head Bolt	27-37	37-50
4853B	5/16-18 x 3/4 Lock Bolt	17-22	23-30
4776BB	7/16-14 x 7/8 Lock Bolt	42-50	57-68
10-00-149-034	Coupling Nut	220-260	298-352

Table 5. Spring Dimensions

PART NUMBER	WHERE USED	APPROX. FREE LENGTH		APPROX. O.D.		DIAMETER OF WIRE		NO. OF ACTIVE COILS
		in.	mm	in.	mm	in.	mm	
71-242	Control Valve	2.66	67.6	0.78	19.8	0.14	3.6	12
71-42	Poppet	1.0	25.4	0.29	7.4	0.04	1.0	6
5L-222	Oil Inlet Shield	1.40	35.6	0.80	20.3	0.04	1.0	5
71-97	Pressure Plate	1.25	31.8	0.31	7.9	0.05	1.3	11

SPECIFICATIONS
(Continued)

Table 6. Test Pressures

PRESSURE TAP	ENGINE RPM	TYPICAL RANGE PSI	TYPICAL RANGE PSI	TYPICAL RANGE kPA	TYPICAL RANGE kPA
Neutral Line	600 2000 3500	115 NOT USED NOT USED	135 NOT USED NOT USED	793 NOT USED NOT USED	931 NOT USED NOT USED
Reverse Clutch	600 2000 3500	120 125 NOT USED	140 160 NOT USED	827 862 NOT USED	965 1103 NOT USED
Reverse Main Line	600 2000 3500	120 125 NOT USED	140 160 NOT USED	827 862 NOT USED	965 1103 NOT USED
Forward Main Line	600 2000 3500	115 125 135	140 160 180	793 862 793	965 1103 1241
		GPM	GPM	LPM	LPM
Reverse Cooler Flow	600 2000 3500	0 3.5 NOT USED	1.8 6.5 NOT USED	0 13.25 NOT USED	6.8 24.6 NOT USED
Forward Cooler Flow	600 2000 3500	0 3.5 6.0	1.8 8.0 10.5	0 13.25 22.7	1.8 30.3 39.7

NOTE: Pressures shown are typical at an oil temperature of 140 degrees F. Variations can occur due to plumbing, fittings, and cooler differences.

NOTE: Forward clutch feed does not have an external tap for checking pressure. When selector is in "F" position, line pressure indicates clutch pressure. Pressure drop from "N" to "F" indicates leakage in forward clutch circuit.

1.523:1 REDUCTION UNITS

A. DESCRIPTION

The 1.523:1 reduction unit is mounted on the back of a 71C or 72C transmission. The reduction unit output shaft rotates the same direction of the input shaft on the transmission. The output shaft rotates about one turn for every one and one half turns of the input shaft. Lubricating oil is supplied to the reduction unit through ports on the back of the transmission.

NOTE: For inspection, maintenance, and troubleshooting refer to the Table of Contents at the front of this manual.

B. OVERHAUL

The general overhaul information described on page 12 applies to these reduction units. Before starting disassembly, review the exploded-view shown in Figure 10. The reduction unit can be disassembled following the index numbers shown in Figure 10. The following procedures are correct for most reduction units. Minor differences may be found.

⚠ **CAUTION: Threaded plugs, screws, bolts, and coupling nut must be tightened to torque shown in Table 4 to prevent premature reduction unit failure.**

- A new coupling nut must be used at assembly.

- Do not disassemble the pinion carrier assembly unless damaged. The necessary tools must be available for proper assembly. Use the exploded view, Figure 10, for disassembly and assembly.

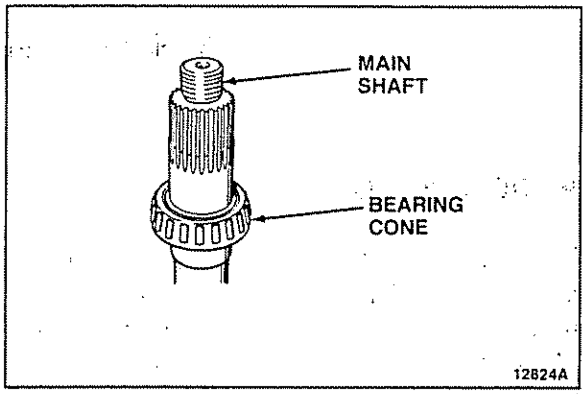
- The bearing cup and cone are a matched set. If one is damaged both must be replaced.

- A solid spacer is used to control rolling torque (end play). Rolling torque must be checked after assembly of the reduction unit, before assembly to the transmission.

NOTE: Early reduction units used a collapsible spacer. If this spacer must be replaced use the solid spacer.

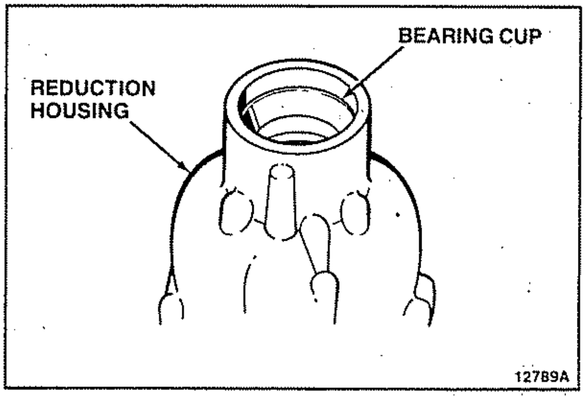
NOTE: Early reduction units used a bearing retainer on the output shaft end of reduction housing. To order correct parts refer to exploded-view, Figure 11.

STEP 1. If removed, press bearing cone (23) on main shaft (21).



Bearing Cone Assembly

STEP 2. If removed, press bearing cups (24 and 29) into reduction housing (30).

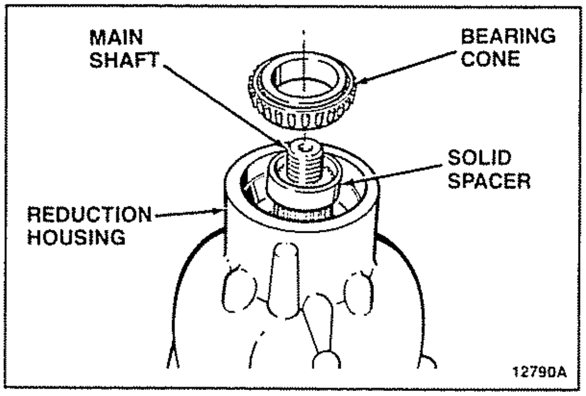


Bearing Cup Assembly

STEP 3. Install main shaft (21) in reduction housing (30).

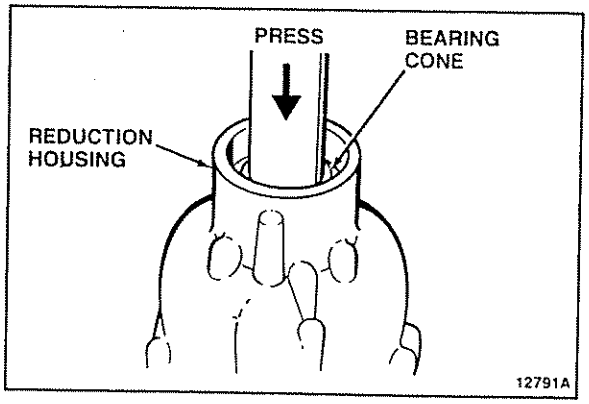
⚠ **CAUTION: If original spacer is not used the replacement spacer should be the same length. Using an incorrect size spacer can result in premature failure of reduction unit.**

Support main shaft (21). Install original spacer (25) and bearing cone (28) in reduction housing (30).



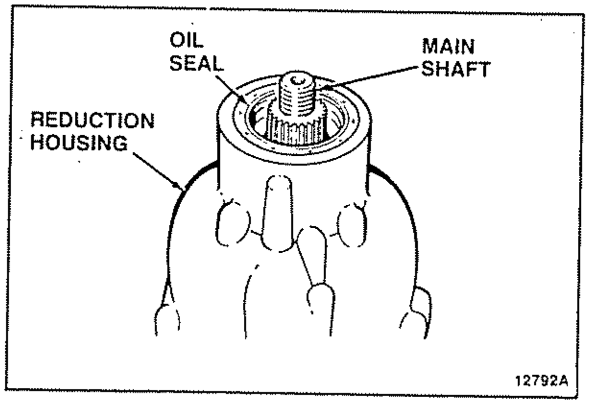
Spacer and Bearing Cone Assembly

STEP 4. Place reduction housing (30) in press with main shaft (21) supported. Press bearing cone (28) on main shaft (21). Remove reduction housing (30) from press.



Bearing Cone Assembly

STEP 5. Install oil seal (26) in reduction housing (30). Outer surface of oil seal (26) should be flush with face of reduction housing (30).



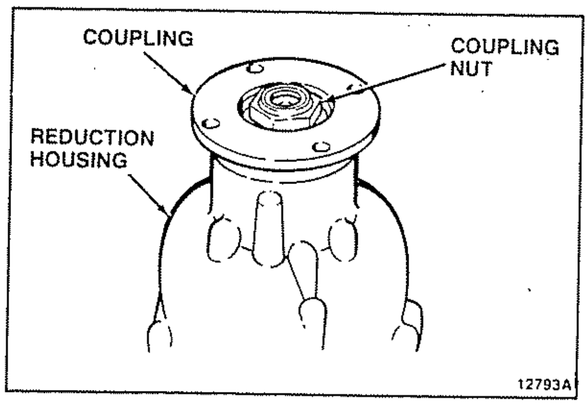
Oil Seal Assembly

STEP 6. Slide coupling (6) on main shaft (21). Thread nut (5) on main shaft (21). Tighten nut (5) to torque shown in Table 4.

Attach a torque wrench to nut (5). Turn torque wrench to check rolling torque of bearings (11 and 16). Rolling torque should be 5 to 30 in-lbs.

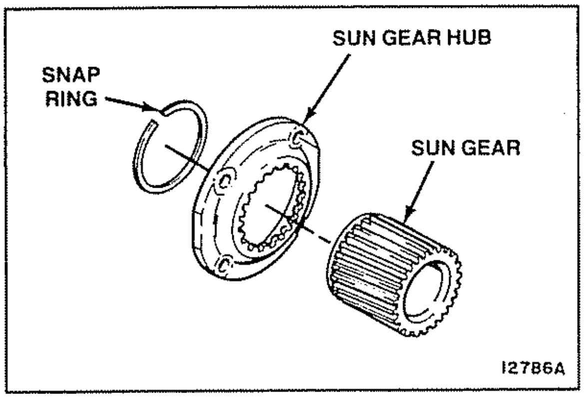
If rolling torque is over 30 in-lbs replace spacer (25) with a longer one. If rolling torque is under 5 in-lbs replace spacer (25) with a shorter one.

NOTE: Selection of the proper spacer (25) will result in 0 to 0.005 inch end play.



Coupling Assembly

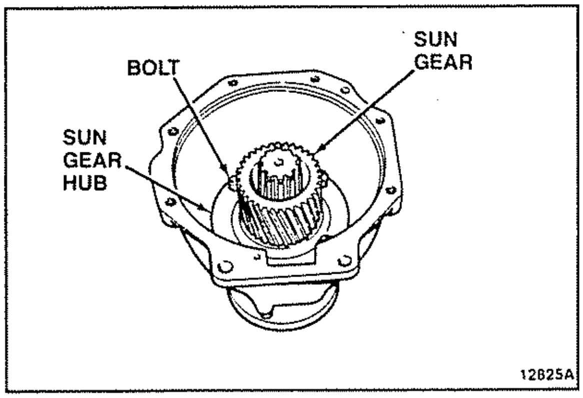
STEP 7. Slide sun gear (20) into sun gear hub (21). Turn sun gear hub (21) over. Install snap ring (19) in groove of sun gear (20).



Sun Gear Assembly

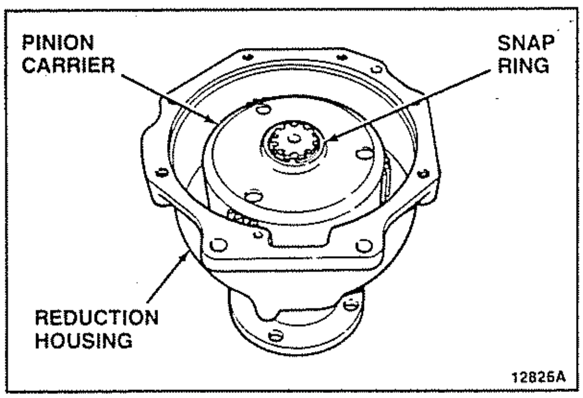
STEP 8. Install sun gear (20) and sun gear hub (21) in reduction housing (30).

Thread four bolts (17) into reduction housing. Tighten bolts (17) to torque shown in Table 4.



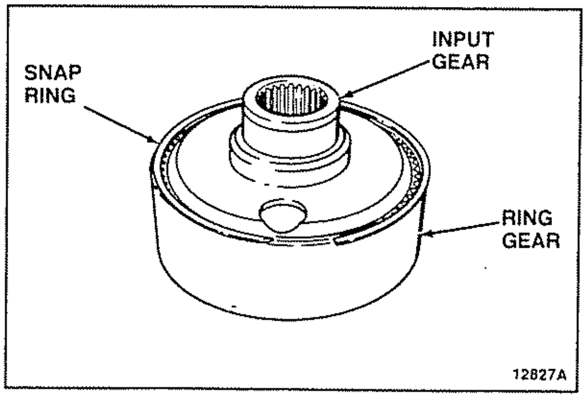
Sun Gear Installation

STEP 9. Install pinion carrier (8) in reduction housing (30). Install snap ring (7) in groove of main shaft (21).



Pinion Carrier Installation

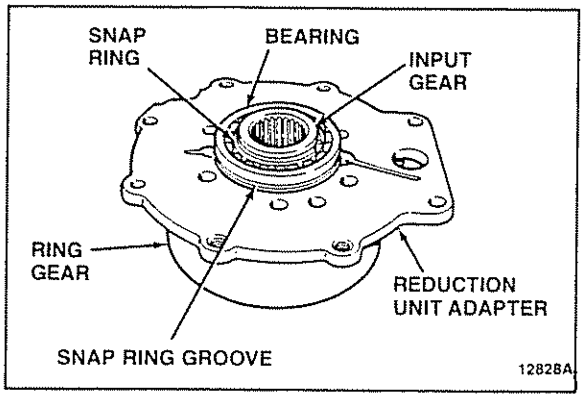
STEP 10. Install input gear (38) in ring gear (39). Install snap ring (37) in groove of ring gear (39).



Input Gear Assembly

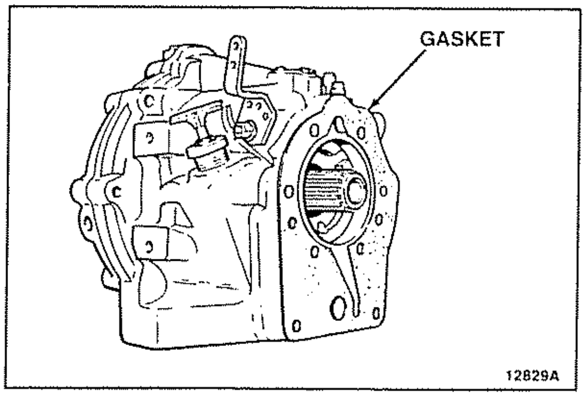
STEP 11. Install bearing (36) in reduction unit adapter (34). Snap ring groove in bearing (36) must be next to reduction unit adapter (34).

Press bearing (36) on input gear (38). Install snap ring (35) in groove of input gear (38).



Reduction Unit Adapter Assembly

STEP 12. Lubricate front adapter gasket (40) with vasoline and install on transmission.

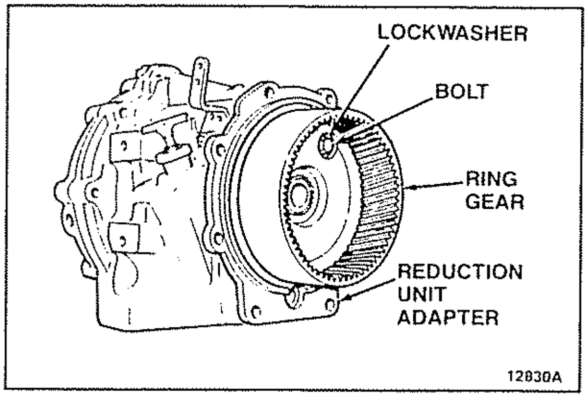


Front Adapter Gasket Installation

STEP 13. Install reduction unit adapter (34) on transmission.

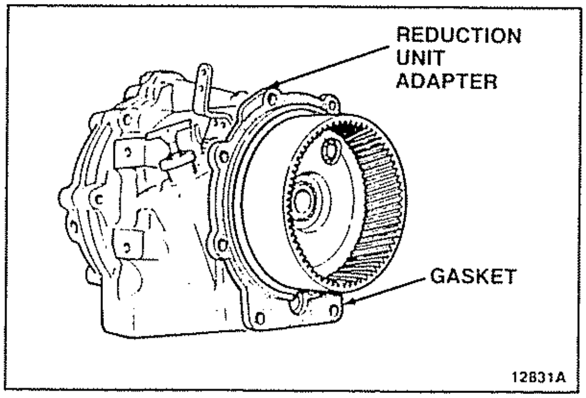
Thread six bolts (32) with lockwashers (33) into transmission. Tighten bolts (32) in a criss-cross pattern to torque shown in Table 4.

NOTE: To install bolts (32) turn ring gear (39). This will align two holes in input gear (38) with reduction unit adapter (34).



Reduction Unit Adapter Installation

STEP 14. Lubricate rear adapter gasket (31) with vasoline and install on reduction unit adapter (34).



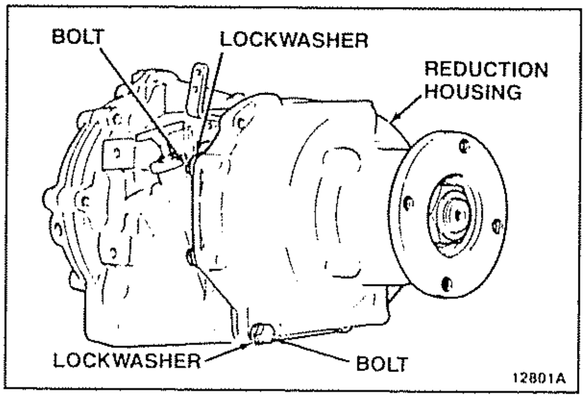
Rear Adapter Gasket Installation

STEP 15. Place reduction housing (30) on transmission. Turn coupling (6) to engage pinion gears (15) with ring gear (39).

Thread two bolts (1) with lockwashers (2) into transmission.

Thread six bolts (3) with lockwashers (4) into reduction housing (30).

Tighten bolts (1 and 3) in a criss-cross pattern to torque shown in Table 4.



Reduction Housing Installation

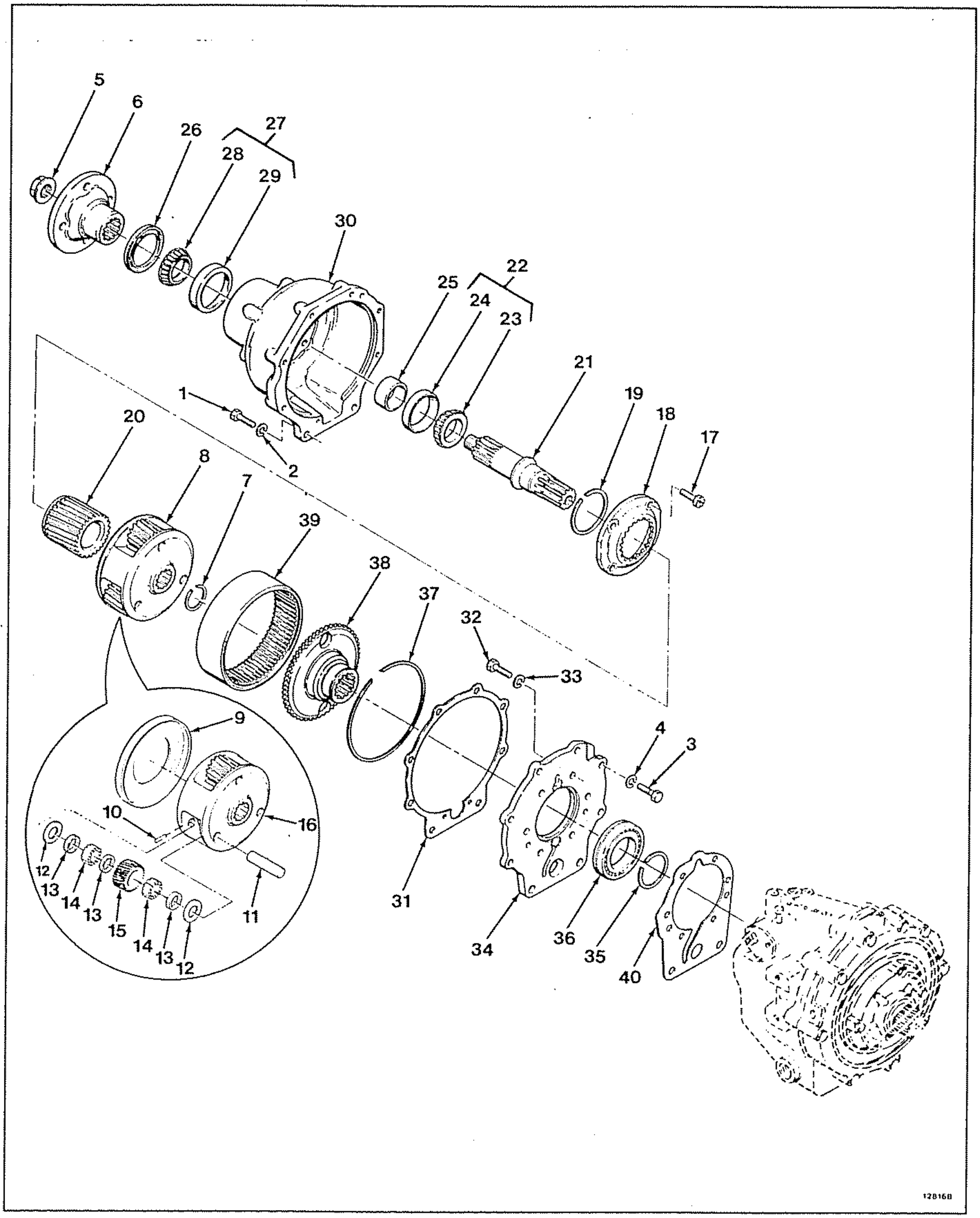


Figure 10. 1.523:1 Reduction Units - Current Production

INDEX NO.	PART NUMBER	DESCRIPTION	QTY
FIG. 10	NO NUMBER	REDUCTION UNIT ASSEMBLY (1.523:1)	
1	0000179864	• HEX HEAD BOLT (7/16-14 × 1-3/4)	2
2	0000103322	• LOCKWASHER (7/16)	2
3	0000179840	• HEX HEAD BOLT (3/8-18 × 1-1/8)	6
4	0000103321	• LOCKWASHER (3/8)	6
5	10-00-149-034	• COUPLING NUT	1
6	10-00-031-001	• COUPLING	1
7	4734	• SNAP RING	1
8	L4-A150	• PINION CARRIER ASSEMBLY	1
9	L4-135	• • OIL COLLECTOR RING	1
10	4717L	• • PINION SHAFT PIN	3
11	L5-39	• • PINION SHAFT	3
12	L3-43	• • PINION THRUSTWASHER	6
13	L3-41	• • PINION BEARING SPACER	9
14	4741A	• • ROLLER BEARING	144
15	L4-5	• • PINION GEAR	3
16	L4-150	• • PINION CAGE	1
17	4776BB	• LOCK BOLT (7/16-14 × 7/8)	4
18	10-17-179-001	• SUN GEAR HUB	1
19	10-00-139-013	• SNAP RING	1
20	10-17-165-001	• SUN GEAR	1
21	10-17-171-001	• MAIN SHAFT	1
22	NO NUMBER	• BEARING ASSEMBLY	1
23	10-00-133-010	• • BEARING CONE *	1
24	10-00-133-009	• • BEARING CUP *	1
25	10-17-053-002	• SOLID SPACER (.820-.821 INCH LONG)**	1
25A	10-17-053-003	• SOLID SPACER (.829-.830 INCH LONG)**	1
25B	10-17-053-004	• SOLID SPACER (.832-.833 INCH LONG)**	1
25C	10-17-053-005	• SOLID SPACER (.835-.836 INCH LONG)**	1
25D	10-17-053-006	• SOLID SPACER (.838-.839 INCH LONG)**	1
25E	10-17-053-007	• SOLID SPACER (.841-.842 INCH LONG)**	1
25F	10-17-053-008	• SOLID SPACER (.844-.845 INCH LONG)**	1
25G	10-17-053-009	• SOLID SPACER (.847-.848 INCH LONG)**	1
25H	10-17-053-010	• SOLID SPACER (.850-.851 INCH LONG)**	1
25I	10-17-053-011	• SOLID SPACER (.853-.854 INCH LONG)**	1
25J	10-17-053-012	• SOLID SPACER (.856-.857 INCH LONG)**	1
26	10-00-044-017	• OIL SEAL	1
27	NO NUMBER	• BEARING ASSEMBLY	1
28	10-00-133-002	• • BEARING CONE *	1
29	10-00-133-001	• • BEARING CUP *	1
30	10-17-065-001	• REDUCTION HOUSING	1
31	L4-146	• REAR ADAPTER GASKET	1
32	10-00-183-073	• LOCK BOLT (7/16-14 × 7/8)	6
33	0000103322	• LOCKWASHER (7/16)	6
34	L4-8B	• REDUCTION UNIT ADAPTER	1
35	4766	• SNAP RING	1
36	B111AG	• BEARING	1
37	4756D	• SNAP RING	1
38	L9-16	• INPUT GEAR	1
39	L3-6	• RING GEAR	1
40	L4-145	• FRONT ADAPTER GASKET	1

* REPLACE BOTH PARTS IF ONE IS DAMAGED.

** SELECT CORRECT SIZE SPACER AT ASSEMBLY. ONLY ONE REQUIRED.

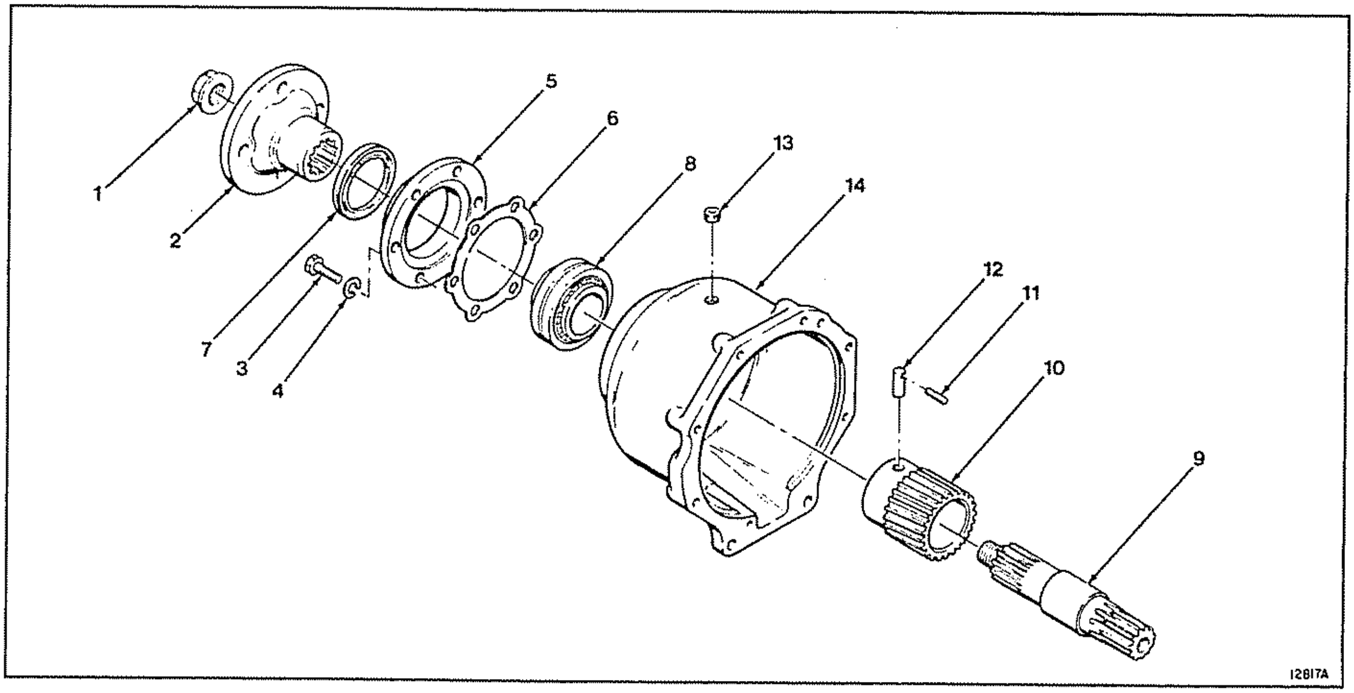


Figure 11. 1.523:1 Reduction Units - Early Production

INDEX NO.	PART NUMBER	DESCRIPTION	QTY
FIG. 11	NO NUMBER	REDUCTION UNIT	
1	4775L	• COUPLING NUT	1
2	4547AY	• COUPLING (72C ONLY)	1
2B	4547BA	• COUPLING (71C ONLY)	1
3	0000179860	• HEX HEAD BOLT (7/16-14 x 1-1/4)	6
4	0000103322	• LOCKWASHER (7/16)	6
5	L4-7	• BEARING RETAINER	1
6	L4-147	• BEARING RETAINER GASKET	1
7	71C-110	• OIL SEAL	1
8	4920A	• BEARING	1
9	L9-2	• MAIN SHAFT	1
10	L4-4	• SUN GEAR	1
11	4808	• SPRING PIN	1
12	L4-151	• PINION CAGE DRIVE PIN	1
13	103891	• EXPANSION PLUG	1
14	L4-1A	• REDUCTION HOUSING	1

NOTE: These early production parts are not interchangeable with current production parts in Figure 10. All other parts are the same.

1.88:1 AND 1.91:1 REDUCTION UNITS

A. DESCRIPTION

The 1.88:1 and 1.91:1 reduction units are mounted on the back of a 71C or 72C transmission. The reduction unit output shaft rotates the opposite direction of the input shaft on the transmission. The output shaft rotates about one turn for every two turns of the input shaft. Lubricating oil is supplied to the reduction unit through ports on the back of the transmission.

NOTE: For inspection, maintenance, and troubleshooting refer to the Table of Contents at the front of this manual.

B. OVERHAUL

The general overhaul information described on page 12 applies to these reduction units. Before starting disassembly, review the exploded-view shown in Figure 12. The reduction unit can be disassembled following the index numbers in Figure 12. The following procedures are correct for most reduction units. Minor differences may be found.

NOTE: Current Production 1.91:1 reduction units use a reduction unit adapter (39), lock plates (23), pinion carrier gasket (33), and o-ring (35) for noise reduction.

⚠ **CAUTION: Threaded plugs, screws, bolts, and coupling nut must be tightened to torque shown in Table 4 to prevent premature reduction unit failure.**

- A new coupling nut must be used at assembly.

- Do not disassemble the pinion carrier assembly unless damaged. The necessary tools must be available for proper assembly. Use exploded view, Figure 12, for disassembly and assembly.

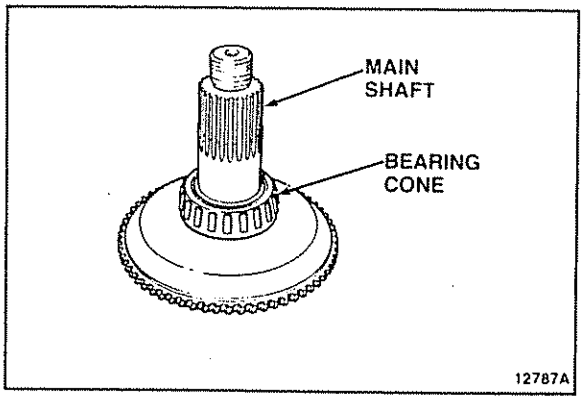
- The bearing cup and cone are a matched set. If one is damaged both must be replaced.

- A solid spacer is used to control rolling torque (end play). Rolling torque must be checked after assembly of the reduction unit, before assembly to the transmission.

NOTE: Early 1.91:1 reduction units used a collapsible spacer. If this spacer must be replaced use the solid spacer.

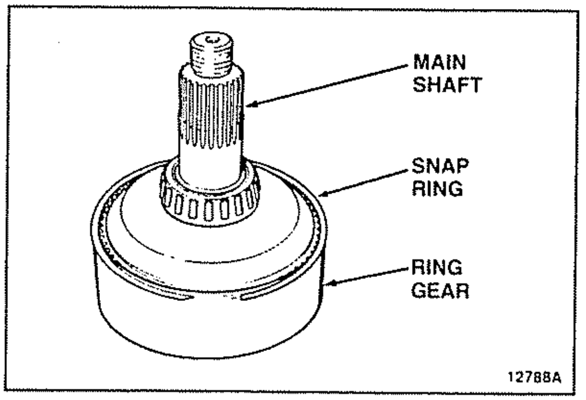
NOTE: Early 1.91:1 reduction units used a bearing retainer on the output shaft end of reduction housing. To order correct parts refer to exploded-view, Figure 13.

STEP 1. If removed, press bearing cone (11) on to main shaft (8).



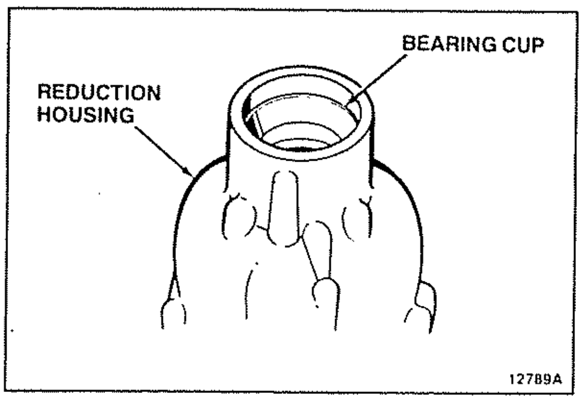
Bearing Cone Assembly

STEP 2. Install main shaft (8) in ring gear (9). Install snap ring (7) in groove of ring gear (9).



Main Shaft Assembly

STEP 3. If removed, press bearing cups (12 and 17) into reduction housing (18).

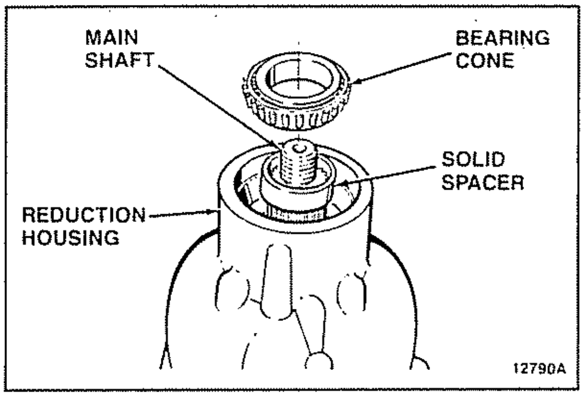


Bearing Cup Assembly

STEP 4. Install main shaft (8) and ring gear (9) in reduction housing (18).

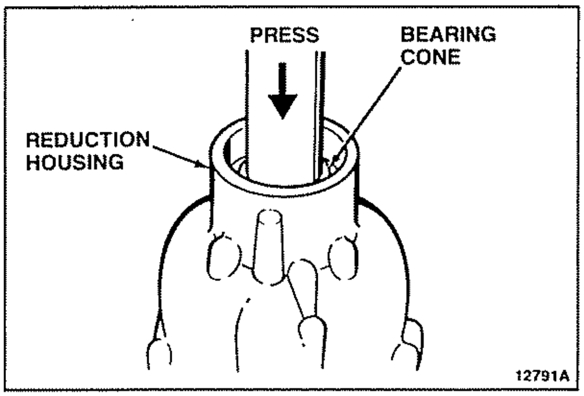
Support ring gear (9). Install original spacer (13) and bearing cone (16) in reduction housing (18).

> ⚠ **CAUTION: If original spacer is not used the replacement spacer should be the same length. Using an incorrect size spacer can result in premature failure of reduction unit.**



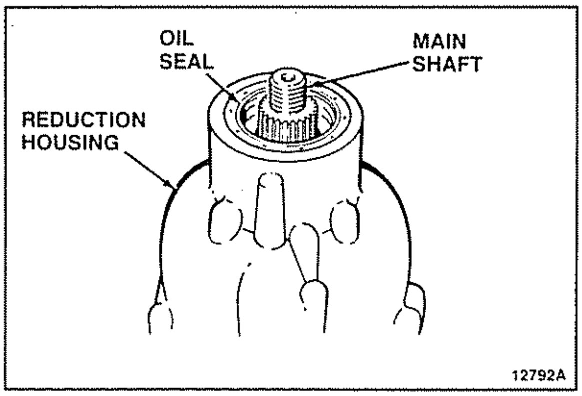
Spacer and Bearing Cone Assembly

STEP 5. Place reduction housing (18) in press with ring gear (9) supported. Press bearing cone (16) on main shaft (8). Remove reduction housing (18) from press.



Bearing Cone Assembly

STEP 6. Install oil seal (14) in reduction housing (18). Outer surface of oil seal (14) should be flush with reduction housing (18) face.



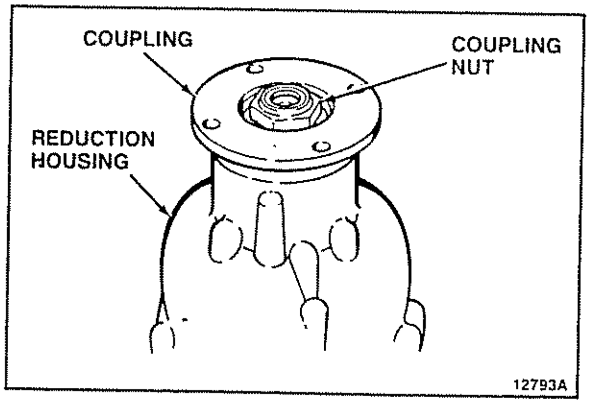
Oil Seal Assembly

STEP 7. Slide coupling (6) on main shaft (8). Thread nut (5) on main shaft (8). Tighten nut (5) to torque shown in Table 4.

Attach a torque wrench to nut (5). Turn torque wrench to check rolling torque of bearings (11 and 16). Rolling torque should be 5 to 30 in-lbs.

If rolling torque is over 30 in-lbs replace spacer (13) with a longer one. If rolling torque is under 5 in-lbs replace spacer (13) with a shorter one.

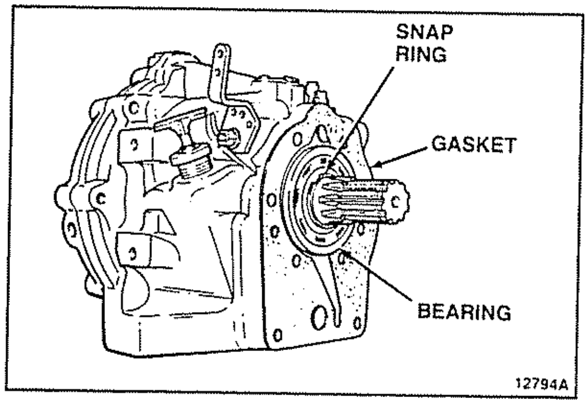
NOTE: Selection of the proper spacer (13) will result in 0 to 0.005 inch end play.



Coupling Assembly

STEP 8. If removed, install bearing (41) and snap ring (40) in transmission.

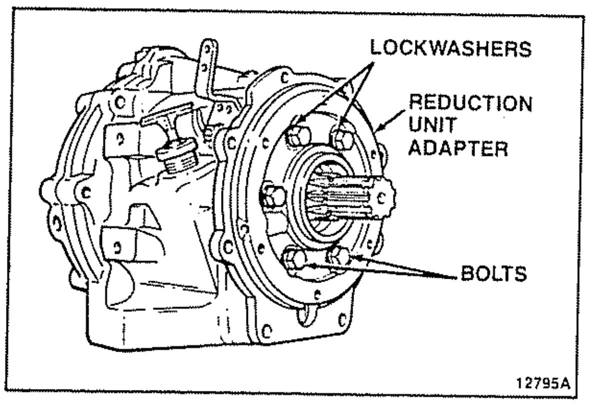
Lubricate front adapter gasket (42) with vasoline and install on transmission.



Front Adapter Gasket Installation

STEP 9. Install reduction unit adapter (39) on transmission.

Thread six bolts (37) with lockwashers (38) into transmission. Tighten bolts (37) in a criss-cross pattern to torque shown in Table 4.



Reduction Unit Adapter Installation

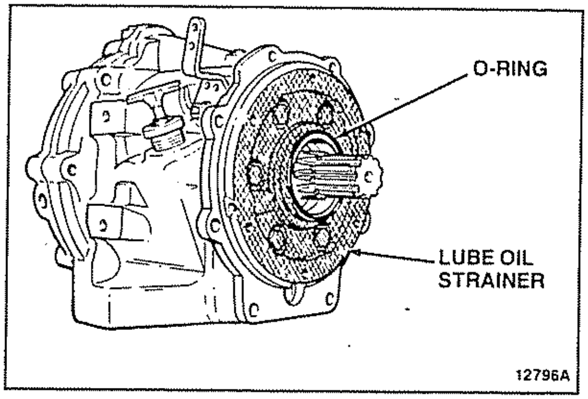
STEP 10. For the 1.91:1 reduction unit do the following:

⚠ **CAUTION: The o-ring can only be installed on a reduction unit adapter with the hub turned down. For complete details refer to Borg Warner Automotive Service Bulletin MB62.**

Lubricate o-ring (35) with vasoline and install on center hub of reduction unit adapter (39).

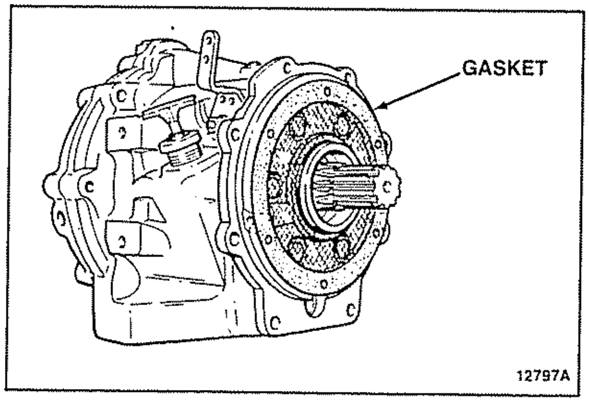
NOTE: Be sure o-ring (35) is not twisted, cut, or distorted. Replace if damaged.

Install lube oil strainer (34) on reduction unit adapter (39).



Lube Oil Strainer Installation

STEP 11. Place pinion carrier gasket (33) on lube oil strainer (34).



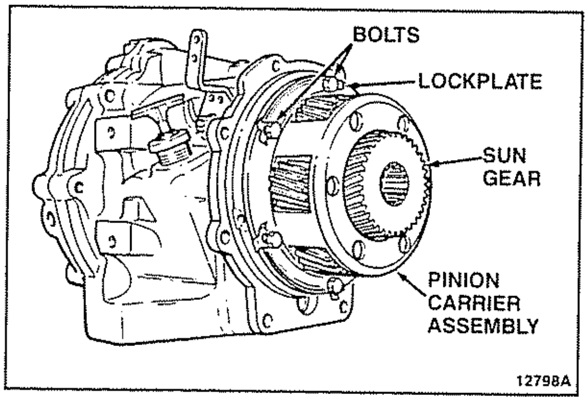
Pinion Carrier Gasket Installation.

STEP 12. Install pinion carrier (24) on pinion carrier gasket (33) and align bolt holes.

For 1.91:1 reduction units install three lockplates (23) and thread six bolts (21) into reduction unit adapter (39) until finger tight.

For 1.88:1 reduction units thread six bolts (21) with lockwashers (22) into reduction unit adapter (39) until finger tight.

Slide sun gear (25) partially into pinion carrier (24). Turn sun gear (25) by hand to be sure pinion carrier (24) is centered and pinion gears (31) turn freely.

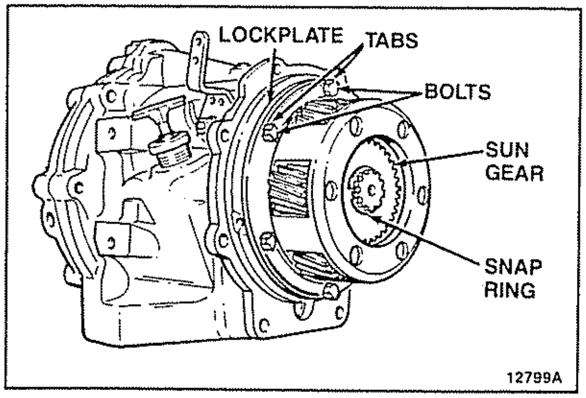


Pinion Carrier Installation

STEP 13. Tighten six bolts (21) in a criss-cross pattern to torque shown in Table 4.

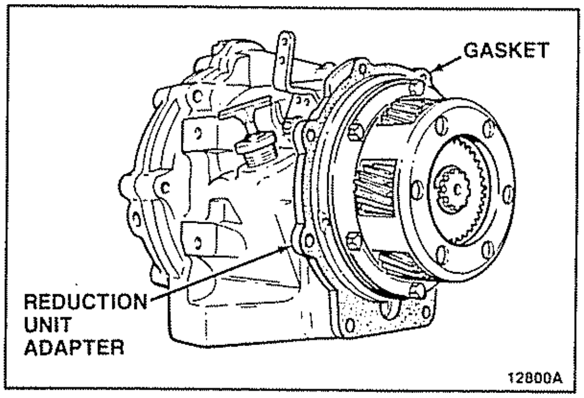
⚠ **CAUTION: For 1.91:1 reduction units bolts are torqued to 5 ft-lbs. Tabs on lockplates must be bent tightly against flats of bolts.**

Push sun gear (20) into pinion carrier (24). Install snap ring (19) in groove of transmission output shaft.



Sun Gear Installation

STEP 14. Lubricate rear adapter gasket (36) with vasoline and install on reduction unit adapter (39).



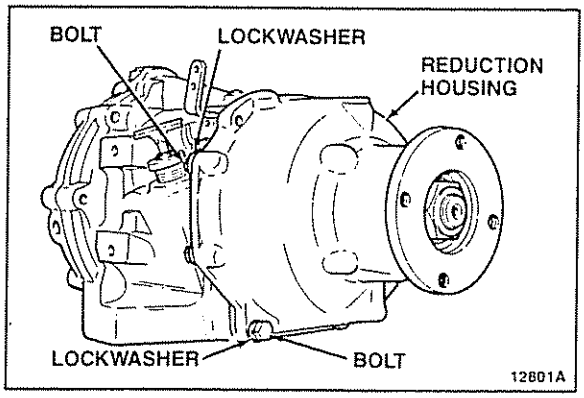
Rear Adapter Gasket Installation

STEP 15. Place reduction housing (18) on transmission. Turn coupling (6) to engage ring gear (9) with pinion gears (31).

Thread two bolts (1) with lockwashers (2) into transmission.

Thread six bolts (3) with lockwashers (4) into reduction housing (18).

Tighten bolts (1 and 3) in a criss-cross pattern to torque shown in Table 4.



Reduction Housing Installation

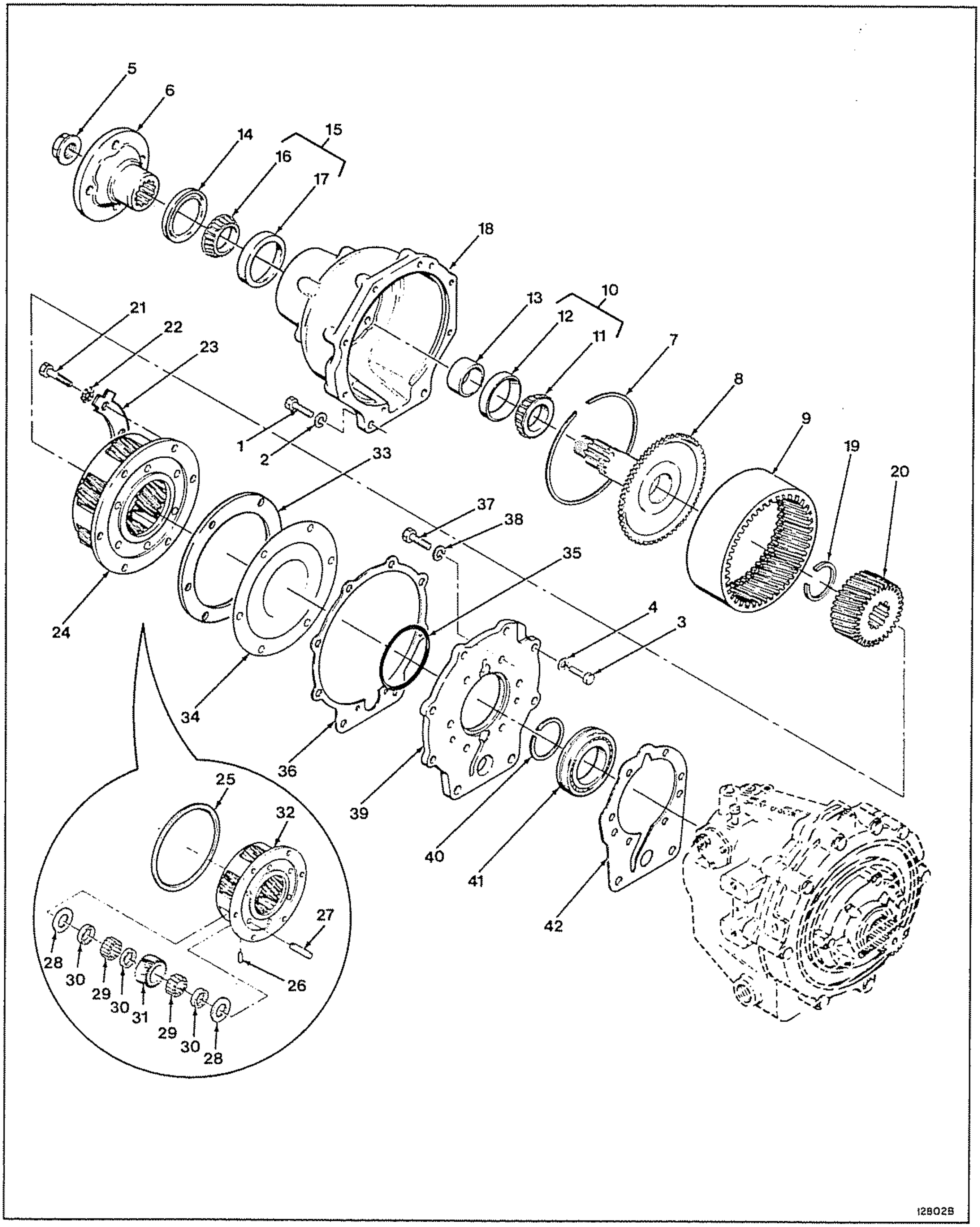


Figure 12. 1.88:1 and 1.91:1 Reduction Units - Current Production

INDEX NO.	PART NUMBER	DESCRIPTION	QTY
FIG. 12	NO NUMBER	REDUCTION UNIT ASSEMBLY (1.91:1)	
12A	NO NUMBER	REDUCTION UNIT ASSEMBLY (1.88:1)	
1	0000179864	• HEX HEAD BOLT (7/16-14. x 1-3/4)	2
2	0000103322	• LOCKWASHER (7/16)	2
3	0000179840	• HEX HEAD BOLT (3/8-18 x 1-1/8)	6
4	0000103321	• LOCKWASHER (3/8)	6
5	10-00-149-034	• COUPLING NUT	1
6	10-00-031-001	• COUPLING	1
7	4756D	• SNAP RING	1
8	10-17-171-002	• MAIN SHAFT (1.91:1 ONLY)	1
8A	10-17-171-004	• MAIN SHAFT (1.88:1 ONLY)	1
9	L3-6	• RING GEAR (1.91:1 ONLY)	1
9A	10-17-162-001	• RING GEAR (1.88:1 ONLY)	1
10	NO NUMBER	• BEARING ASSEMBLY	1
11	10-00-133-010	• • BEARING CONE *	1
12	10-00-133-009	• • BEARING CUP *	1
13	10-17-053-002	• SOLID SPACER (.820-.821 INCH LONG)**	1
13A	10-17-053-003	• SOLID SPACER (.829-.830 INCH LONG)**	1
13B	10-17-053-004	• SOLID SPACER (.832-.833 INCH LONG)**	1
13C	10-17-053-005	• SOLID SPACER (.835-.836 INCH LONG)**	1
13D	10-17-053-006	• SOLID SPACER (.838-.839 INCH LONG)**	1
13E	10-17-053-007	• SOLID SPACER (.841-.842 INCH LONG)**	1
13F	10-17-053-008	• SOLID SPACER (.844-.845 INCH LONG)**	1
13G	10-17-053-009	• SOLID SPACER (.847-.848 INCH LONG)**	1
13H	10-17-053-010	• SOLID SPACER (.850-.851 INCH LONG)**	1
13I	10-17-053-011	• SOLID SPACER (.853-.854 INCH LONG)**	1
13J	10-17-053-012	• SOLID SPACER (.856-.857 INCH LONG)**	1
14	10-00-044-017	• OIL SEAL	1
15	NO NUMBER	• BEARING ASSEMBLY	1
16	10-00-133-002	• • BEARING CONE *	1
17	10-00-133-001	• • BEARING CUP *	1
18	10-17-065-003	• REDUCTION HOUSING	1
19	4734	• SNAP RING	1
20	L7-104	• SUN GEAR (1.91:1 ONLY)	1
20A	10-17-165-004	• SUN GEAR (1.88:1 ONLY)	1
21	4853B	• LOCK BOLT (5/16-18 x 3/4)	6
22	0000114605	• LOCKWASHER (5/16) (1.88:1 ONLY)	6
23	10-00-014-002	• LOCK PLATE (1.91:1 ONLY)	3
24	L9-A150	• PINION CARRIER ASSEMBLY (1.91:1 ONLY)	1
24A	10-17-659-021	• PINION CARRIER ASSEMBLY (1.88:1 ONLY)	1
25	4827	• • RETAINING RING	1
26	4717L	• • PINION SHAFT PIN	6

* REPLACE BOTH PARTS IF ONE IS DAMAGED.

** SELECT CORRECT SIZE SPACER AT ASSEMBLY. ONLY ONE REQUIRED.

INDEX NO.	PART NUMBER	DESCRIPTION	QTY
27	L5-39	• • PINION SHAFT	6
28	L3-43	• • PINION THRUSTWASHER	12
29	4741A	• • ROLLER BEARING (1.91:1 ONLY)	288
29A	10-00-131-011	• • ROLLER BEARING (1.88:1 ONLY)	288
30	L3-41	• • PINION BEARING SPACER (1.91:1 ONLY)	6
30A	10-00-053-024	• • PINION BEARING SPACER (1.88:1 ONLY)	18
31	L4-5	• • PINION GEAR (1.91:1 ONLY)	6
31A	10-17-131-011	• • PINION GEAR (1.88:1 ONLY)	6
32	L9-150	• • PLANETARY CAGE (1.91:1 ONLY)	1
32A	10-17-159-011	• • PLANETARY CAGE (1.88:1 ONLY)	1
33	10-17-045-001	• PINION CARRIER GASKET (1.91:1 ONLY)	1
34	L9-99	• LUBE OIL STRAINER (1.91:1 ONLY)	1
35	10-00-141-149	• O-RING (1.91:1 ONLY)	1
36	L4-146	• REAR ADAPTER GASKET	1
37	10-00-183-073	• LOCK BOLT (7/16-14 × 7/8)	6
38	0000103322	• LOCKWASHER (7/16)	6
39	L9-8A	• REDUCTION UNIT ADAPTER ***	1
39A	10-17-172-001	• REDUCTION UNIT ADAPTER ****	1
40	4816	• SNAP RING	1
41	B308AGS	• BEARING	1
42	L4-145	• FRONT ADAPTER GASKET	1

* REPLACE BOTH PARTS IF ONE IS DAMAGED.

** SELECT CORRECT SIZE SPACER AT ASSEMBLY. ONLY ONE REQUIRED.

*** FOR USE WITH 1.91:1 NOISE REDUCTION PARTS. THESE INCLUDE LOCK PLATES (23), PINION CARRIER GASKET (33), AND O-RING (35).

**** FOR USE WITH 1.88:1 OR 1.91:1 WITHOUT NOISE REDUCTION PARTS

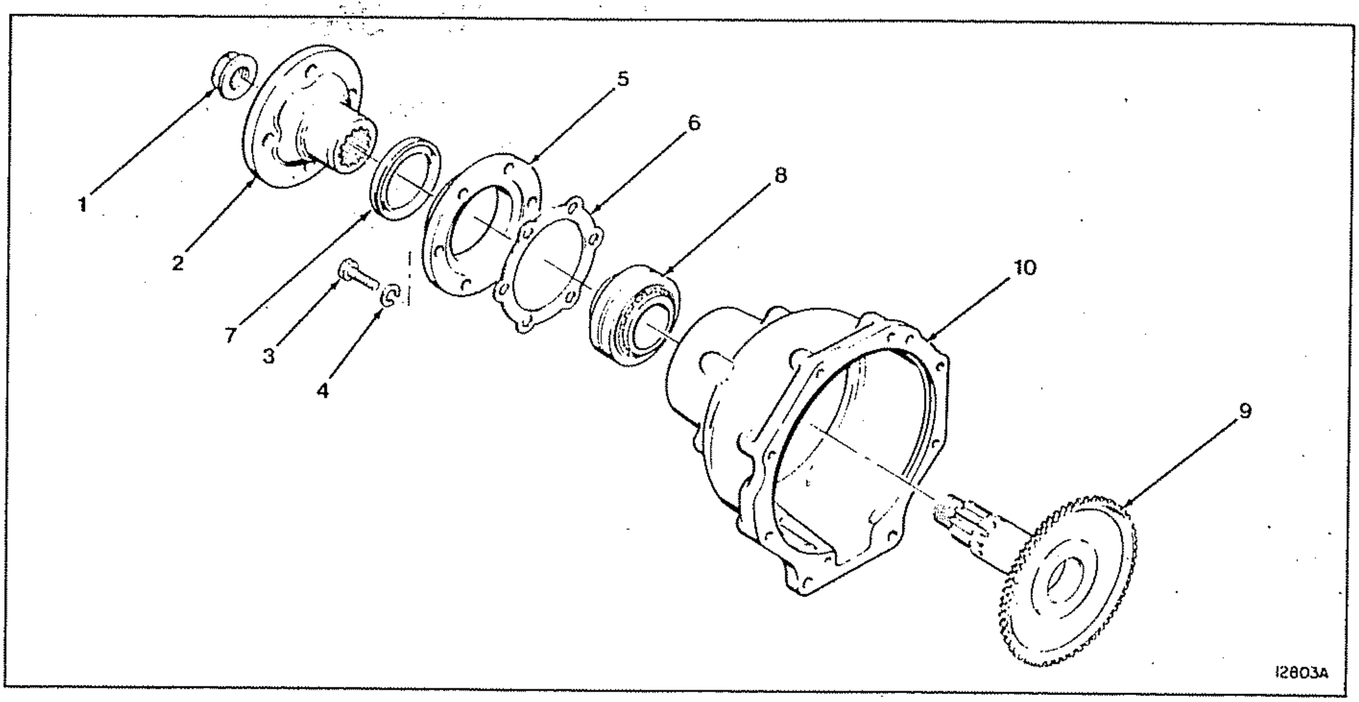


Figure 13. 1.91:1 Reduction Units - Early Production

INDEX NO.	PART NUMBER	DESCRIPTION	QTY
FIG. 13	NO NUMBER	REDUCTION UNIT (1.91:1 ONLY)	
1	4775L	• COUPLING NUT	1
2	4547AY	• COUPLING (72C ONLY)	1
2B	4547BA	• COUPLING (71C ONLY)	1
3	0000179860	• HEX HEAD BOLT (7/16-14 x 1-1/4)	6
4	0000103322	• LOCKWASHER (7/16)	6
5	L4-7	• BEARING RETAINER	1
6	L4-147	• BEARING RETAINER GASKET	1
7	71C-110	• OIL SEAL	1
8	4920A	• BEARING	1
9	L9-2	• MAIN SHAFT	1
10	L5-1A	• REDUCTION HOUSING	1

NOTE: These early production parts are not interchangeable with current production parts in Figure 12. All other parts are the same.

2.57:1 AND 2.91:1 REDUCTION UNITS

A. DESCRIPTION

The 2.57:1 and 2.91:1 reduction units are mounted on the back of a 71C or 72C transmission. The reduction unit output shaft rotates the same direction as the input shaft on the transmission. The output shaft rotates about one turn for every two and one half to three turns of the input shaft. Lubricating oil is supplied to the reduction unit through ports on the back of the transmission.

NOTE: For inspection, maintenance, and troubleshooting refer to the Table of Contents at the front of this manual.

B. OVERHAUL

The general overhaul information described on page 12 applies to these reduction units. Before starting disassembly, review the exploded-view shown in Figure 14. The reduction unit can be disassembled following the index numbers in Figure 14. The following procedures are correct for most reduction units. Minor differences may be found.

⚠ **CAUTION: Threaded plugs, screws, bolts, and coupling nut must be tightened to torque shown in Table 4 to prevent premature reduction unit failure.**

- A new coupling nut must be used at assembly.

- Do not disassemble the pinion cage and output shaft assembly unless damaged. The necessary tools must be available for proper assembly. Use exploded view, Figure 14, for disassembly and assembly.

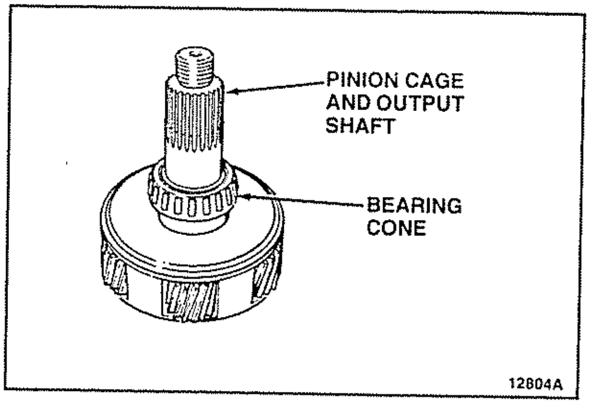
- The bearing cup and cone are a matched set. If one is damaged both must be replaced.

- A solid spacer is used to control rolling torque (end play). Rolling torque must be checked after assembly of the reduction unit, before assembly to the transmission.

NOTE: Early reduction units used a collapsible spacer. If this spacer must be replaced use the solid spacer.

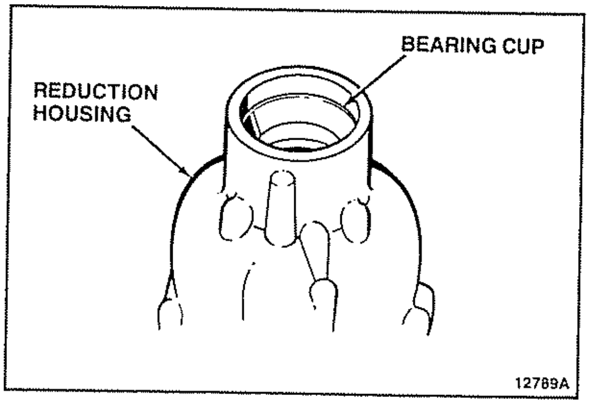
NOTE: Early reduction units used a bearing retainer on the output shaft end of the reduction housing. To order correct parts refer to exploded-view, Figure 15.

STEP 1. If removed, press bearing cone (17) on pinion cage and output shaft (7).



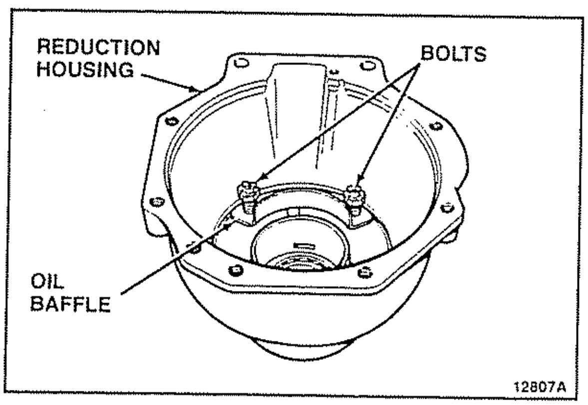
Bearing Cone Assembly

STEP 2. If removed, press bearing cups (18 and 23) into reduction housing (26).



Bearing Cup Assembly

STEP 3. Place oil baffle (25) in reduction housing (26). Thread two bolts (24) into reduction housing (26). Tighten bolts (24) to torque shown in Table 4.

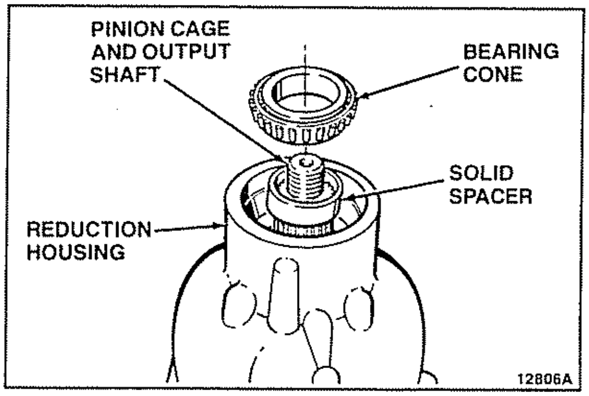


Oil Baffle Installation

STEP 4. Install pinion cage and output shaft (7) in reduction housing (26).

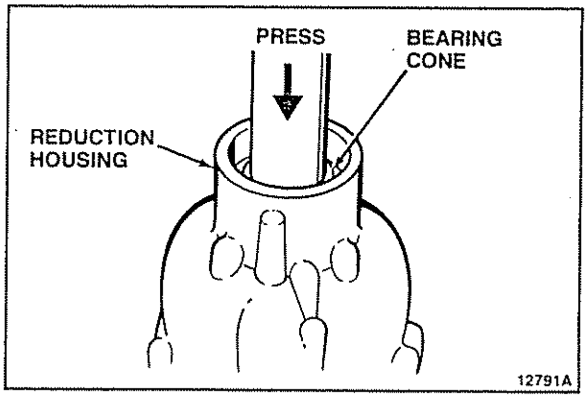
Support pinion cage and output shaft (7). Install original spacer (19) and bearing cone (22) in reduction housing (26).

CAUTION: If original spacer is not used the replacement spacer should be the same length. Using an incorrect size spacer can result in premature failure of reduction unit.



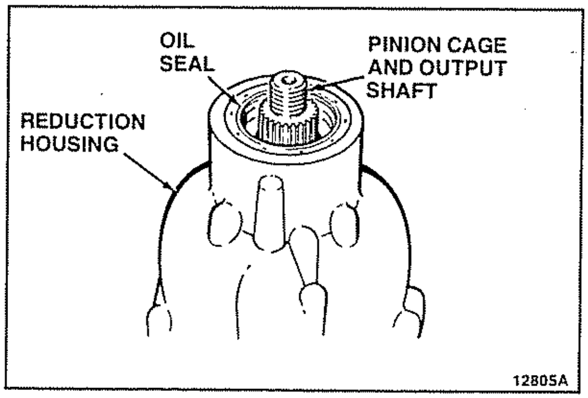
Spacer and Bearing Cone Assembly

STEP 5. Place reduction housing (26) in press with pinion cage and output shaft (7) supported. Press bearing cone (22) on pinion cage and output shaft (7). Remove reduction housing (26) from press.



Bearing Cone Assembly

STEP 6. Install oil seal (20) in reduction housing (26). Outer surface of oil seal (20) should be flush with face of reduction housing (26).



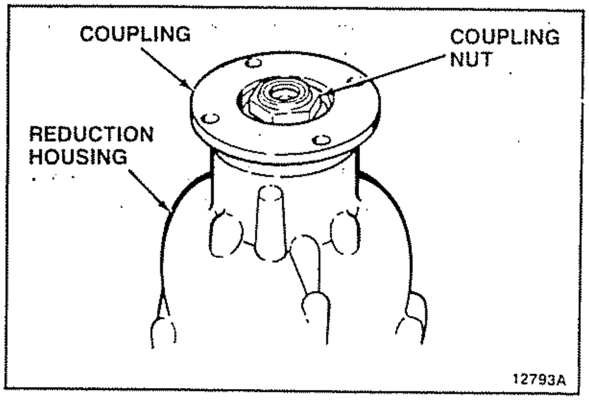
Oil Seal Assembly

STEP 7. Slide coupling (6) on pinion cage and output shaft (7). Thread nut (5) on pinion cage and output shaft (7). Tighten nut (5) to torque shown in Table 4.

Attach a torque wrench to nut (5). Turn torque wrench to check rolling torque of bearings (17 and 22). Rolling torque should be 5 to 30 in-lbs.

If rolling torque is over 30 in-lbs replace spacer (13) with a longer one. If rolling torque is under 5 in-lbs replace spacer (13) with a shorter one.

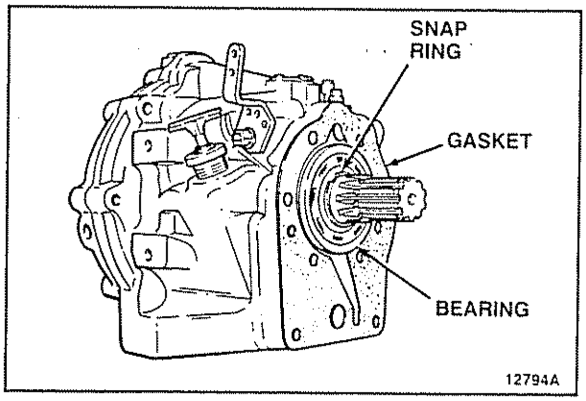
NOTE: Selection of the proper spacer (19) will result in 0 to 0.005 inch end play.



Coupling Assembly

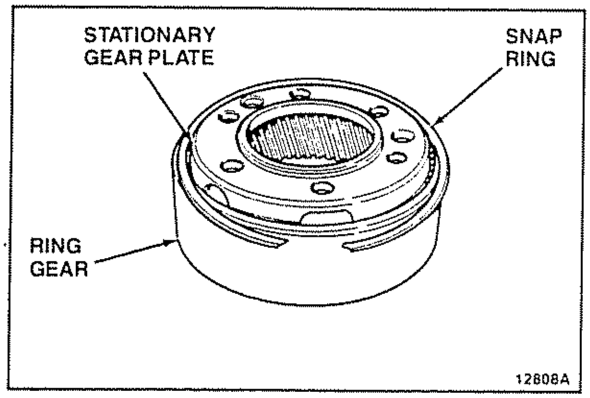
STEP 8. If removed, install bearing (37) and snap ring (36) in transmission.

Lubricate front adapter gasket (38) with vasoline and install on transmission.



Front Adapter Gasket Installation

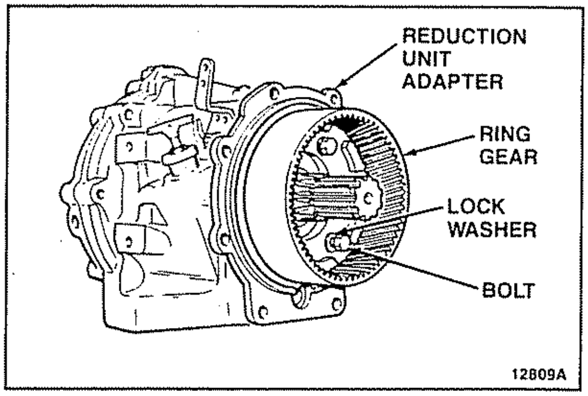
STEP 9. Install stationary gear plate (32) in ring gear (33). Install snap ring (31) in groove of ring gear (33).



Stationary Gear Plate Assembly

STEP 10. Install reduction unit adapter (35) and ring gear (33) on transmission.

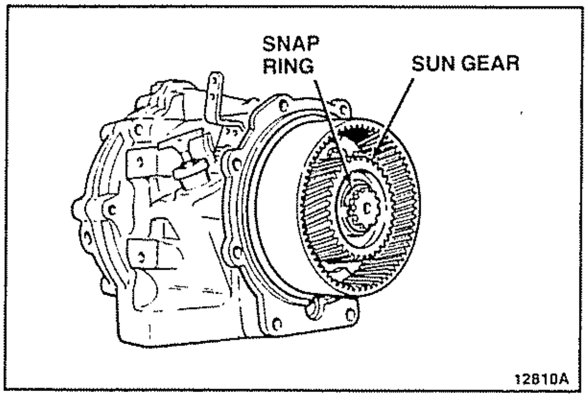
Thread six bolts (29) with lockwashers (30) into transmission. Tighten bolts (29) in a criss-cross pattern to torque shown in Table 4.



Reduction Unit Adapter Installation

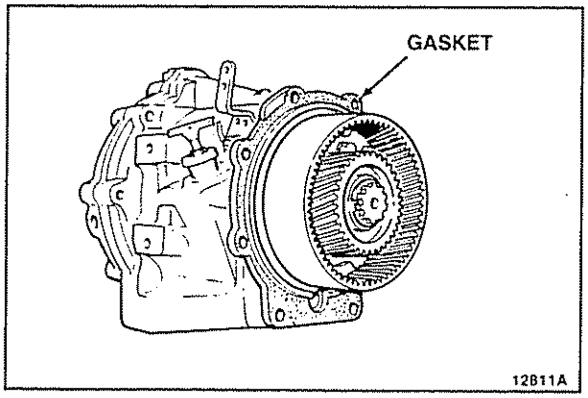
STEP 11. Slide sun gear (28) on transmission output shaft.

Install snap ring (27) in groove of output shaft.



Sun Gear Installation

STEP 12. Lubricate rear adapter gasket (34) with vasoline and install on reduction unit adapter (35).



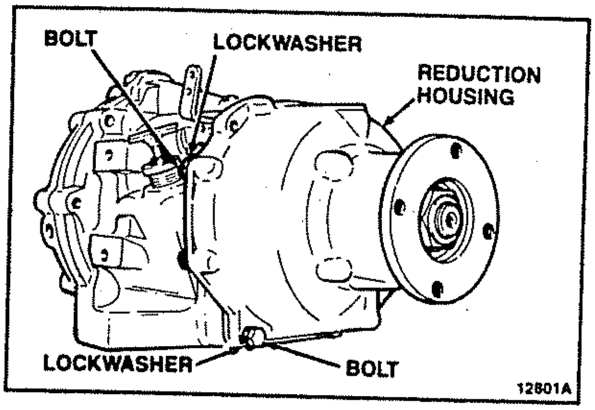
Rear Adapter Gasket Installation

STEP 13. Place reduction housing (26) on transmission. Turn coupling (6) to engage pinion gears (14) with ring gear (33).

Thread two bolts (1) with lockwashers (2) into transmission.

Thread six bolts (3) with lockwashers (4) into reduction housing (18).

Tighten bolts (1 and 3) in a criss-cross pattern to torque shown in Table 4.



Reduction Housing Installation

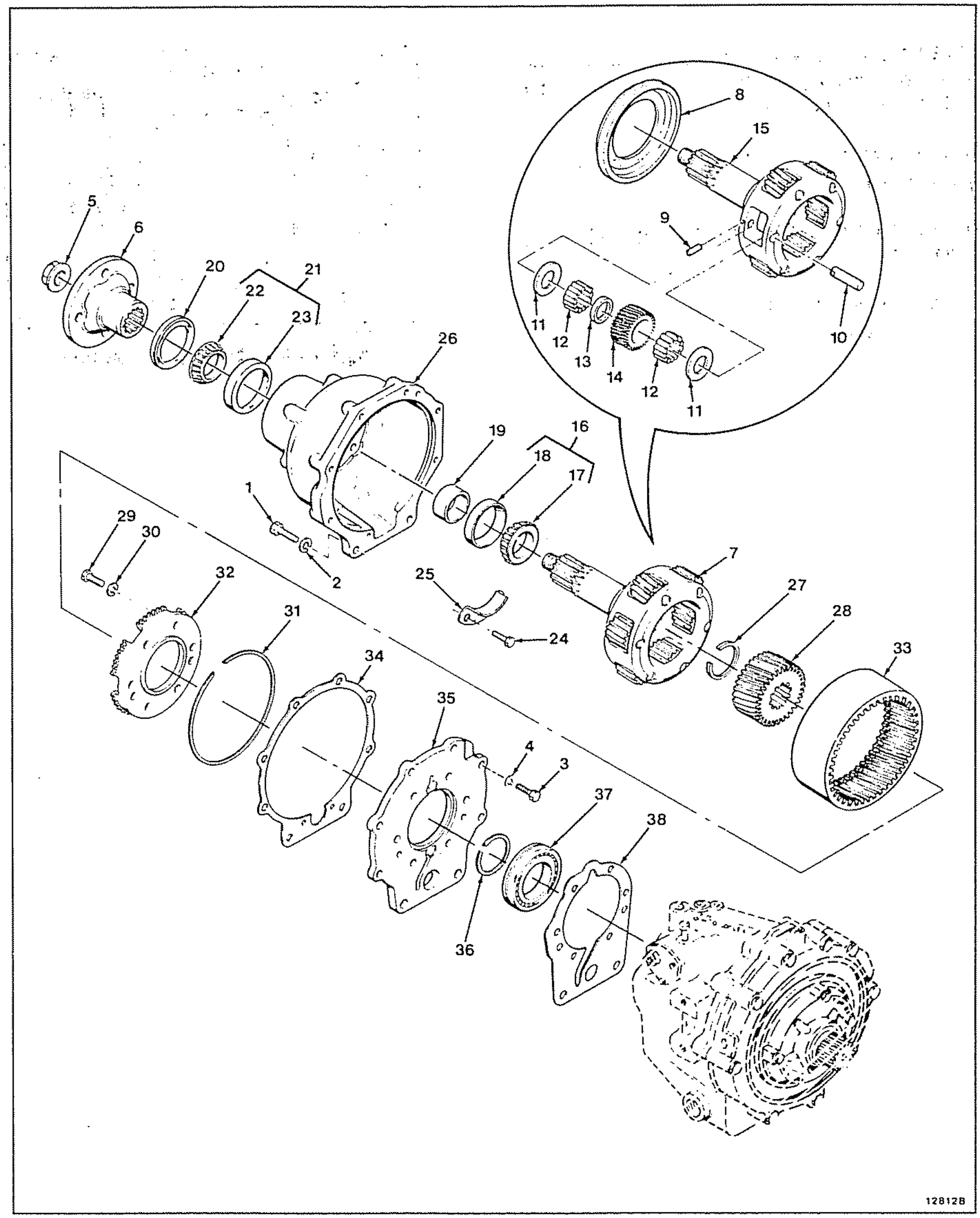


Figure 14. 2.57:1 and 2.91:1 Reduction Units - Current Production

INDEX NO.	PART NUMBER	DESCRIPTION	QTY
FIG. 14	NO NUMBER	REDUCTION UNIT ASSEMBLY (2.57:1)	
14A	NO NUMBER	REDUCTION UNIT ASSEMBLY(2.91:1)	
1	0000179864	• HEX HEAD BOLT (7/16-14 × 1-3/4)	2
2	0000103322	• LOCKWASHER (7/16)	2
3	0000179840	• HEX HEAD BOLT (3/8-18 × 1-1/8)	6
4	0000103321	• LOCKWASHER (3/8)	6
5	10-00-149-034	• COUPLING NUT	1
6	10-00-031-001	• COUPLING	1
7	10-17-659-007	• PINION CAGE AND OUTPUT SHAFT ASSEMBLY (2.57:1 ONLY)	1
7A	10-17-659-008	• PINION CAGE AND OUTPUT SHAFT ASSEMBLY (2.91:1 ONLY)	1
8	L6-135	• • OIL COLLECTOR RING (2.57:1 ONLY)	1
8A	L4-135	• • OIL COLLECTOR RING (2.91:1 ONLY)	1
9	R10B-40	• • PINION SHAFT PIN (2.57:1 ONLY)	6
9A	4717B	• • PINION SHAFT PIN (2.91:1 ONLY)	6
10	L5-39	• • PINION SHAFT	6
11	L6-43	• • THRUSTWASHER (2.57:1 ONLY)	12
11A	L3-43	• • THRUSTWASHER (2.91:1 ONLY)	12
12	4741A	• • ROLLER BEARING	288
13	L3-41	• • PINION BEARING SPACER	6
14	L6-5	• • PINION GEAR (2.57:1 ONLY)	6
14A	L4-5	• • PINION GEAR (2.91:1 ONLY)	6
15	10-17-159-003	• • PINION CAGE AND OUTPUT SHAFT (2.57:1 ONLY)	1
15A	10-17-159-004	• • PINION CAGE AND OUTPUT SHAFT (2.91:1 ONLY)	1
16	NO NUMBER	• BEARING ASSEMBLY	1
17	10-00-133-010	• • BEARING CONE *	1
18	10-00-133-009	• • BEARING CUP *	1
19	10-17-053-002	• SOLID SPACER (.820-.821 INCH LONG) **	1
19A	10-17-053-003	• SOLID SPACER (.829-.830 INCH LONG) **	1
19B	10-17-053-004	• SOLID SPACER (.832-.833 INCH LONG) **	1
19C	10-17-053-005	• SOLID SPACER (.835-.836 INCH LONG) **	1
19D	10-17-053-006	• SOLID SPACER (.838-.839 INCH LONG) **	1
19E	10-17-053-007	• SOLID SPACER (.841-.842 INCH LONG) **	1
19F	10-17-053-008	• SOLID SPACER (.844-.845 INCH LONG) **	1
19G	10-17-053-009	• SOLID SPACER (.847-.848 INCH LONG) **	1
19H	10-17-053-010	• SOLID SPACER (.850-.851 INCH LONG) **	1
19I	10-17-053-011	• SOLID SPACER (.853-.854 INCH LONG) **	1
19J	10-17-053-012	• SOLID SPACER (.856-.857 INCH LONG) **	1
20	10-00-044-017	• OIL SEAL	1
21	NO NUMBER	• BEARING ASSEMBLY	1

* REPLACE BOTH PARTS IF ONE IS DAMAGED.

** SELECT CORRECT SIZE SPACER AT ASSEMBLY. ONLY ONE REQUIRED.

INDEX NO.	PART NUMBER	DESCRIPTION	QTY
22	10-00-133-002	• • BEARING CONE *	1
23	10-00-133-001	• • BEARING CUP *	1
24	4776BB	• LOCK BOLT (7/16-14 x 7/8)	2
25	10-17-036-001	• OIL BAFFLE	1
26	10-17-065-001	• REDUCTION HOUSING	1
27	4734	• SNAP RING	1
28	L6-104	• SUN GEAR (2.57:1 ONLY)	1
28A	L7-104	• SUN GEAR (2.91:1 ONLY)	1
29	4853E	• LOCK BOLT (7/16-14 x 1-1/4)	6
30	0000115550	• LOCKWASHER (7/16)	6
31	4756E	• SNAP RING (2.57:1 ONLY)	1
31A	4756D	• SNAP RING (2.91:1 ONLY)	1
32	L6-31	• STATIONARY GEAR PLATE (2.57:1 ONLY)	1
32A	L7-31	• STATIONARY GEAR PLATE (2.91:1 ONLY)	1
33	L3-6	• RING GEAR (2.57:1 ONLY)	1
33A	L6-6	• RING GEAR (2.91:1 ONLY)	1
34	L4-146	• REAR ADAPTER GASKET	1
35	L7-8A	• REDUCTION UNIT ADAPTER	1
36	4816	• SNAP RING	1
37	B308AGS	• BEARING	1
38	L4-145	• FRONT ADAPTER GASKET	1

* REPLACE BOTH PARTS IF ONE IS DAMAGED.

** SELECT CORRECT SIZE SPACER AT ASSEMBLY. ONLY ONE REQUIRED.

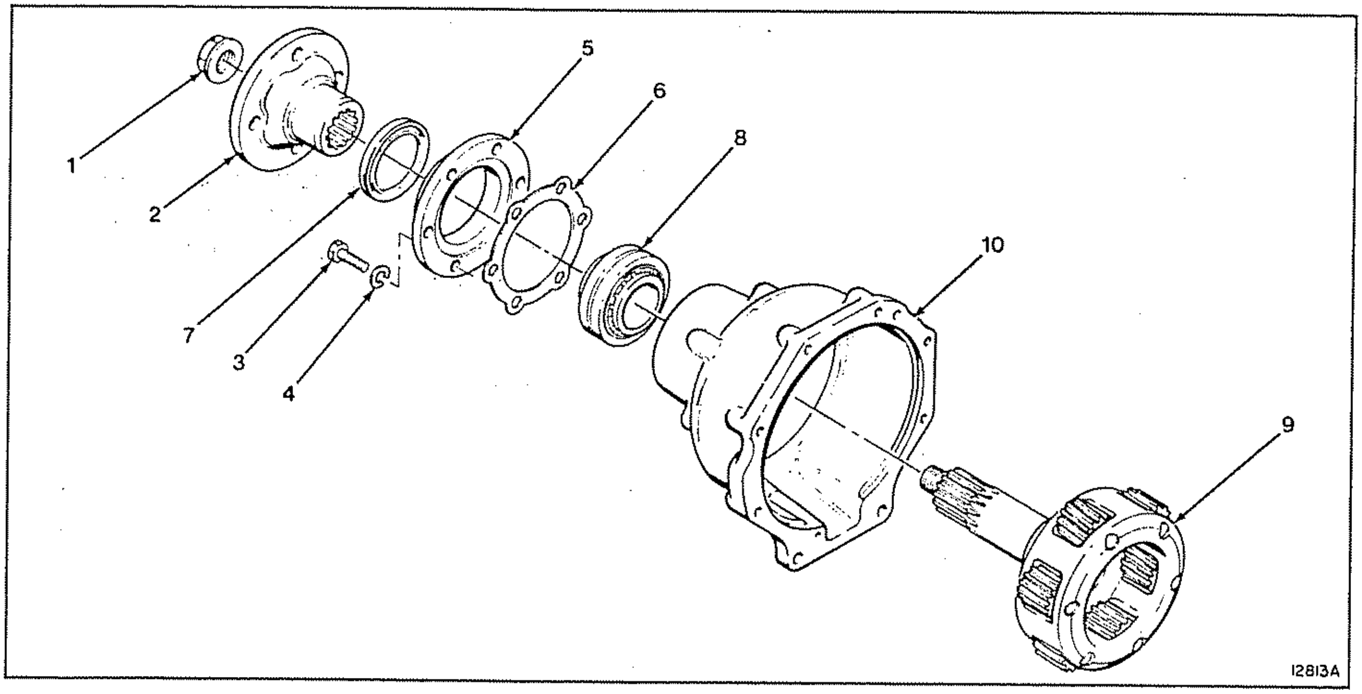


Figure 15. 2.57:1 AND 2.91:1 Reduction Units - Early Production

INDEX NO.	PART NUMBER	DESCRIPTION	QTY
FIG. 15	NO NUMBER	REDUCTION UNIT (2.57:1 ONLY)	
15A	NO NUMBER	REDUCTION UNIT (2.91:1 ONLY)	
1	10-00-149-002	• COUPLING NUT	1
2	4912	• COUPLING	1
3	0000179860	• HEX HEAD BOLT (7/16-14 × 1-1/4)	6
4	0000103322	• LOCKWASHER (7/16)	6
5	L4-7	• BEARING RETAINER	1
6	L4-147	• BEARING RETAINER GASKET	1
7	71C-110	• OIL SEAL	1
8	4920	• BEARING	1
9	L6-A3D	• PINION CAGE AND OUTPUT SHAFT ASSEMBLY (2.57:1 ONLY)	1
9A	L7-A3D	• PINION CAGE AND OUTPUT SHAFT ASSEMBLY (2.91:1 ONLY)	1
10	L7-1A	• REDUCTION HOUSING	1

NOTE: These early production parts are not interchangeable with current production parts in Figure 14. All other parts are the same.

2.10:1 REDUCTION UNIT

A. DESCRIPTION

The 2.10:1 reduction unit is mounted on the back of a 71C or 72C transmission. The reduction unit output shaft rotates the same direction as the input shaft on the transmission. The output shaft rotates about one turn for every two turns of the input shaft. Lubricating oil is supplied to the reduction unit through ports on the back of the transmission.

NOTE: For inspection, maintenance, and troubleshooting refer to the Table of Contents at the front of this manual.

B. OVERHAUL

The general overhaul information described on page 12 applies to these reduction units. Before starting disassembly, review the exploded-view shown in Figure 16. The reduction unit can be disassembled following the index numbers in Figure 16. The following procedures are correct for most reduction units. Minor differences may be found.

⚠ **CAUTION: Threaded plugs, screws, bolts, and coupling nut must be tightened to torque shown in Table 4 to prevent premature reduction unit failure.**

- A new coupling nut must be used at assembly.

- Do not disassemble the pinion carrier assembly unless damaged. The necessary tools must be available for proper assembly. Use the exploded view, Figure 16, for disassembly and assembly.

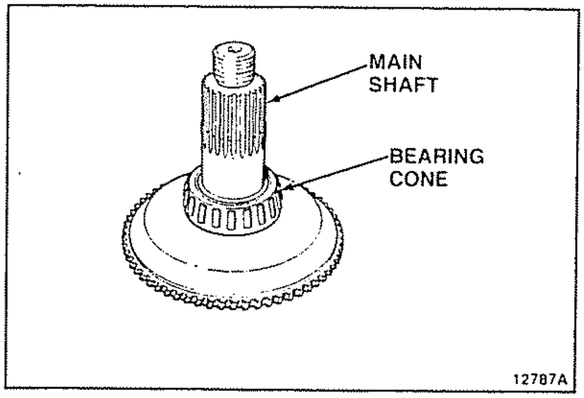
- The bearing cup and cone are a matched set. If one is damaged both must be replaced.

- A solid spacer is used to control rolling torque (end play). Rolling torque must be checked after assembly of the reduction unit, before assembly to the transmission.

NOTE: Early reduction units used a collapsible spacer. If this spacer must be replaced use the solid spacer.

NOTE: Early reduction units used a bearing retainer on the output shaft end of reduction housing. To order correct parts refer to exploded-view, Figure 17.

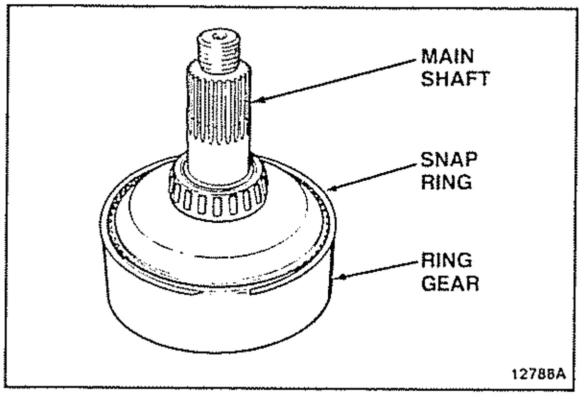
STEP 1. If removed, press bearing cone (12) on output shaft (8).



Bearing Cone Assembly

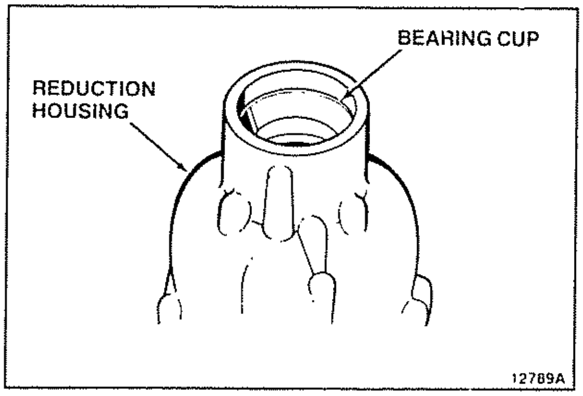
STEP 2. If removed, install bushing (9) in output shaft (8).

Install output shaft (8) in ring gear (9). Install snap ring (7) in groove of ring gear (10).



Output Shaft Assembly

STEP 3. If removed, press bearing cups (13 and 18) into reduction housing (20).

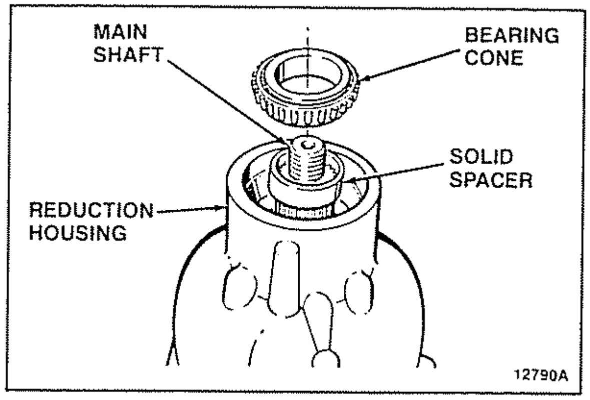


Bearing Cup Assembly

STEP 4. Install output shaft (8) and ring gear (10) in reduction housing (20).

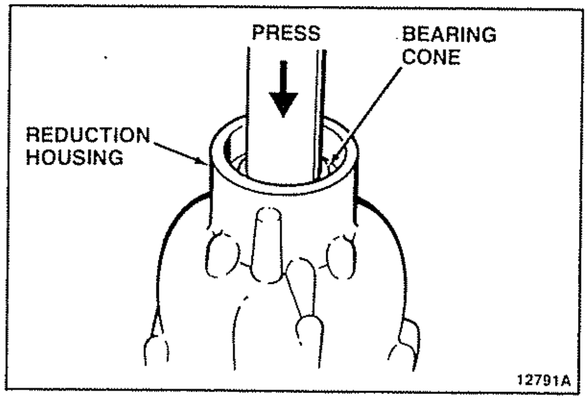
Turn reduction housing (20) over and install original spacer (14) and bearing cone (17) in reduction housing (20).

CAUTION: If original spacer is not used the replacement spacer should be the same length. Using an incorrect size spacer can result in premature failure of reduction unit.



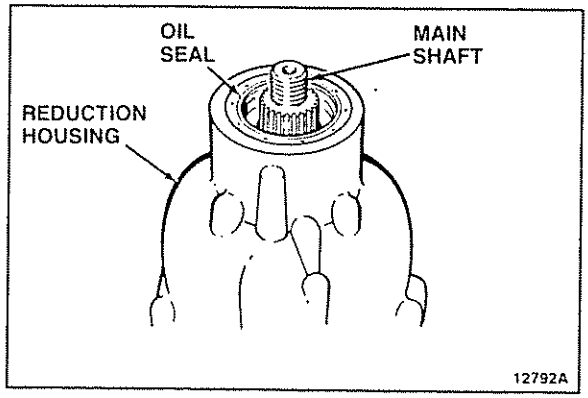
Spacer and Bearing Cone Assembly

STEP 5. Place reduction housing (20) in press with ring gear (10) supported. Press bearing cone (17) on output shaft (8). Remove reduction housing (20) from press.



Bearing Cone Assembly

STEP 6. Install oil seal (15) in reduction housing (20). Outer surface of oil seal (15) should be flush with reduction housing (20) face.



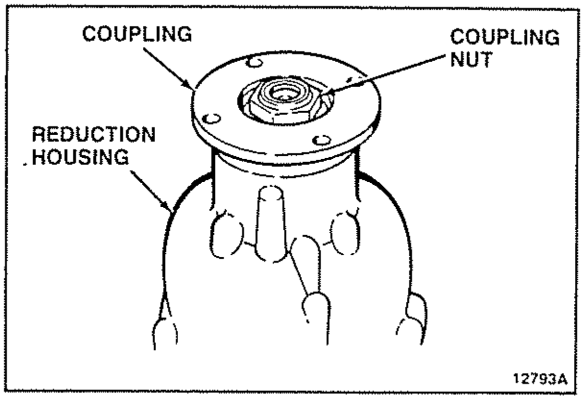
Oil Seal Assembly

STEP 7. Slide coupling (6) on output shaft (8). Thread nut (5) on output shaft (8). Tighten nut (5) to torque shown in Table 4.

Attach a torque wrench to nut (5). Turn torque wrench to check rolling torque of bearings (12 and 17). Rolling torque should be 5 to 30 in-lbs.

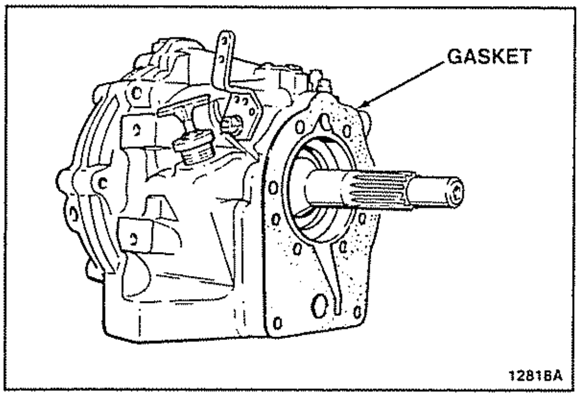
If rolling torque is over 30 in-lbs replace spacer (14) with a longer one. If rolling torque is under 5 in-lbs replace spacer (14) with a shorter one.

NOTE: Selection of the proper spacer (14) will result in 0 to 0.005 inch end play.



Coupling Assembly

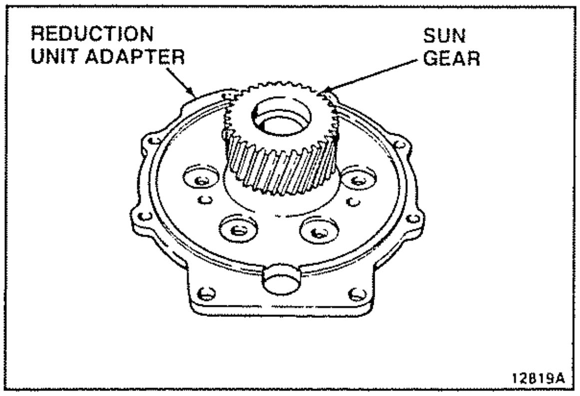
STEP 8. Lubricate front adapter gasket (43) with vasoline and install on transmission.



Front Adapter Gasket Installation

STEP 9. Slide sun gear (41) into reduction unit adapter (42).

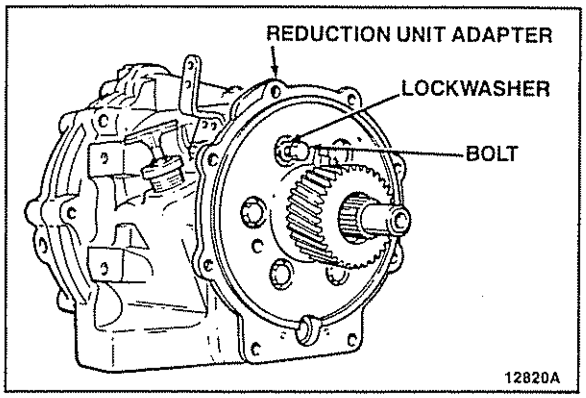
Turn reduction unit adapter (42) over. Install snap ring (40) in groove of sun gear (41).



Sun Gear Assembly

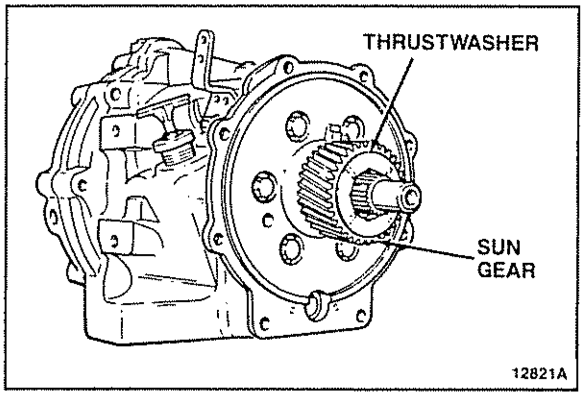
STEP 10. Install reduction unit adapter (42) on transmission.

Thread six bolts (38) with lockwashers (39) into transmission. Tighten bolts (38) in a criss-cross pattern to torque shown in Table 4.



Reduction Unit Adapter Installation

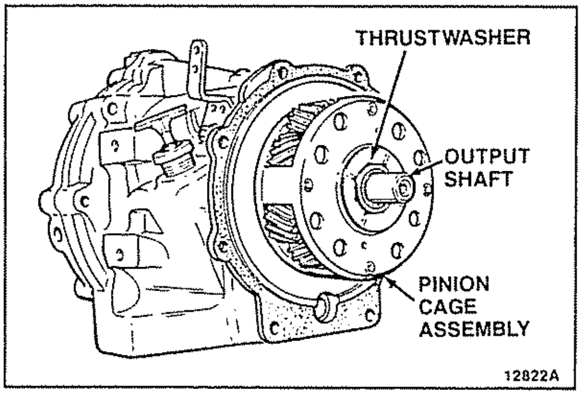
STEP 11. Lubricate one thrustwasher (21) with vasoline and install on sun gear (41).



Thrustwasher Installation

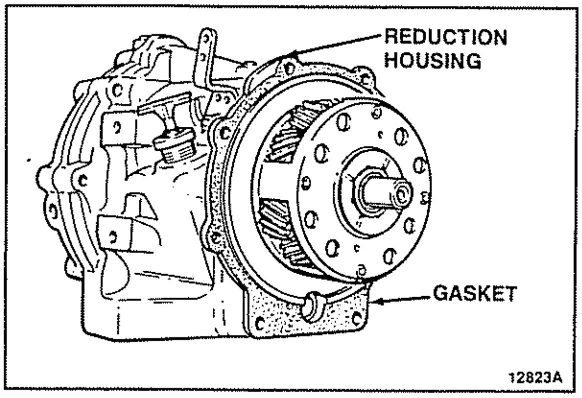
STEP 12. Slide pinion cage assembly (22) on transmission output shaft.

Lubricate thrustwasher (21) with vasoline and install on pinion cage assembly (22).



Pinion Cage Installation

STEP 13. Lubricate rear adapter gasket (37) with vasoline and install on reduction unit adapter (42).



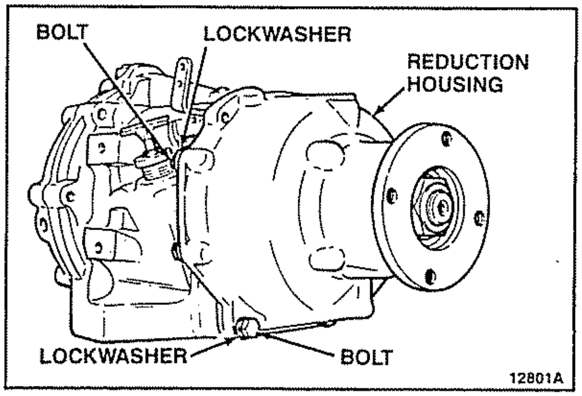
Rear Adapter Gasket Installation

STEP 14. Place reduction housing (20) on transmission. Turn coupling (6) to engage ring gear (10) with pinion gears (29 and 35).

Thread two bolts (1) with lockwashers (2) into transmission.

Thread six bolts (3) with lockwashers (4) into reduction housing (20).

Tighten bolts (1 and 3) in a criss-cross pattern to torque shown in Table 4.



Reduction Housing Installation

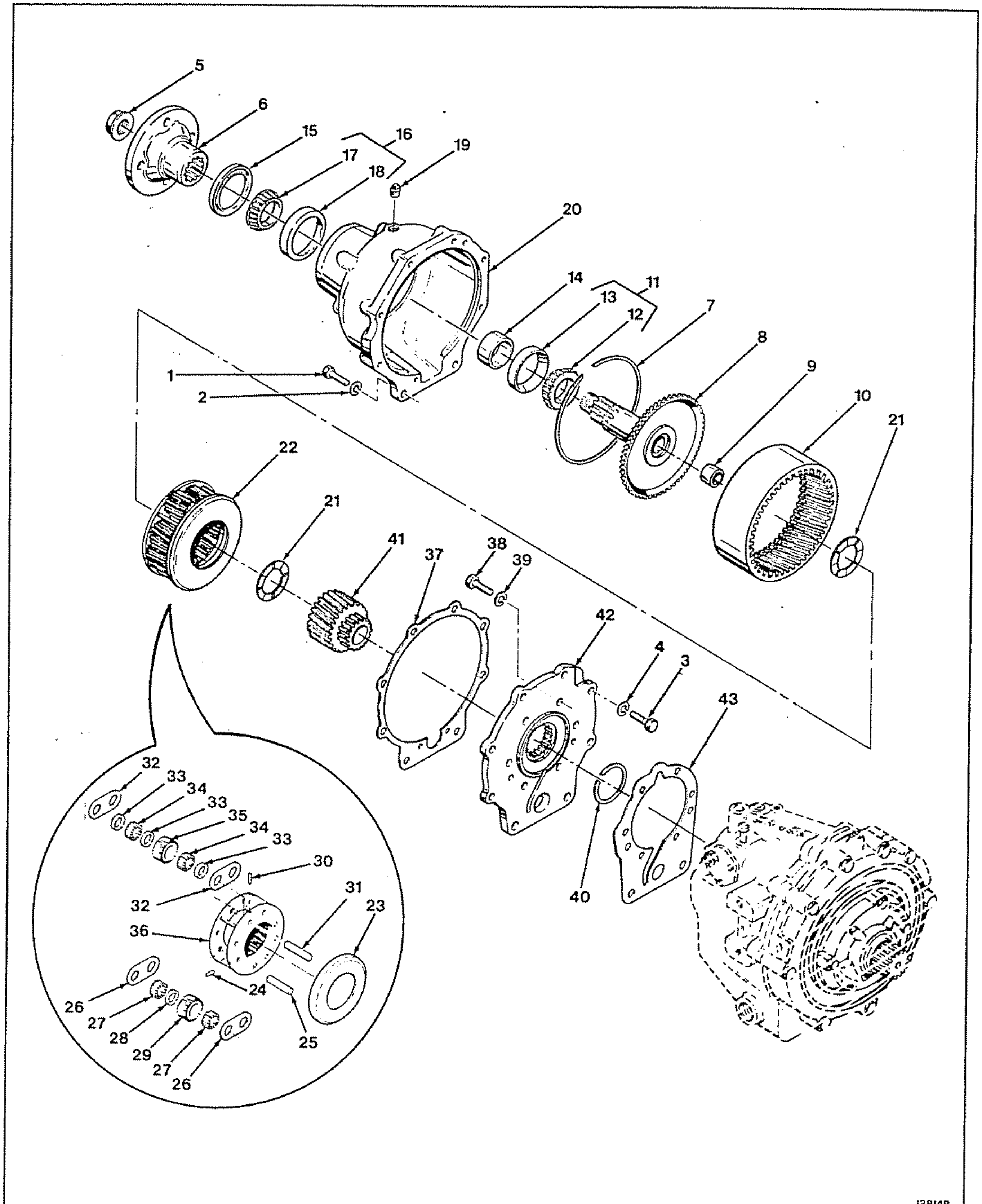


Figure 16. 2.10:1 Reduction Units - Current Production

INDEX NO.	PART NUMBER	DESCRIPTION	QTY
FIG. 16	NO NUMBER	REDUCTION UNIT ASSEMBLY(2.10:1)	
1	0000179864	• HEX HEAD BOLT (7/16-14 × 1-3/4)	2
2	0000103322	• LOCKWASHER (7/16)	2
3	0000179840	• HEX HEAD BOLT (3/8-18 × 1-1/8)	6
4	0000103321	• LOCKWASHER (3/8)	6
5	10-00-149-034	• COUPLING NUT	1
6	10-00-031-001	• COUPLING	1
7	4756D	• SNAP RING	1
8	10-17-671-001	• OUTPUT SHAFT AND BUSHING ASSEMBLY	1
9	A4867DD	• • BUSHING (KIT)	1
10	L3-6	• RING GEAR	1
11	NO NUMBER	• BEARING ASSEMBLY	1
12	10-00-133-010	• • BEARING CONE *	1
13	10-00-133-009	• • BEARING CUP *	1
14	10-17-053-002	• SOLID SPACER (.820-.821 INCH LONG) **	1
14A	10-17-053-003	• SOLID SPACER (.829-.830 INCH LONG) **	1
14B	10-17-053-004	• SOLID SPACER (.832-.833 INCH LONG) **	1
14C	10-17-053-005	• SOLID SPACER (.835-.836 INCH LONG) **	1
14D	10-17-053-006	• SOLID SPACER (.838-.839 INCH LONG) **	1
14E	10-17-053-007	• SOLID SPACER (.841-.842 INCH LONG) **	1
14F	10-17-053-008	• SOLID SPACER (.844-.845 INCH LONG) **	1
14G	10-17-053-009	• SOLID SPACER (.847-.848 INCH LONG) **	1
14H	10-17-053-010	• SOLID SPACER (.850-.851 INCH LONG) **	1
14I	10-17-053-011	• SOLID SPACER (.853-.854 INCH LONG) **	1
14J	10-17-053-012	• SOLID SPACER (.856-.857 INCH LONG) **	1
15	10-00-044-017	• OIL SEAL	1
16	NO NUMBER	• BEARING ASSEMBLY	1
17	10-00-133-002	• • BEARING CONE *	1
18	10-00-133-001	• • BEARING CUP *	1
19	10-00-191-002	• PLASTIC PLUG	1
20	10-17-065-002	• REDUCTION HOUSING	1
21	L3-24	• THRUSTWASHER	2
22	10-17-659-006	• PINION CAGE ASSEMBLY ***	1
22A	10-17-659-010	• PINION CAGE ASSEMBLY ****	1
23	L4-135	• • OIL COLLECTOR RING	1
24	4717L	• • PINION SHAFT PIN	4
25	L5-39A	• • PINION SHAFT	4
26	72-43	• • PINION THRUST PLATE	4
27	4741A	• • ROLLER BEARING	192
28	L3-41	• • PINION BEARING SPACER	4

* REPLACE BOTH PARTS IF ONE IS DAMAGED.

** SELECT CORRECT SIZE SPACER AT ASSEMBLY. ONLY ONE REQUIRED.

*** USED WITH TRANSMISSIONS 10-17-000-009 AND 10-18-000-007. HAS DRILL SPOTS ON PLANETARY CAGE FOR IDENTIFICATION.

**** USED WITH TRANSMISSIONS 10-17-000-010 AND 10-18-000-008.

INDEX NO.	PART NUMBER	DESCRIPTION	QTY
29	L3-105	• • RH PINION GEAR	4
30	R4-40	• • PINION SHAFT PIN	4
31	L5-39	• • PINION SHAFT	4
32	72-43	• • PINION THRUST PLATE	4
33	L3-41	• • PINION BEARING SPACER	12
34	4741A	• • ROLLER BEARING	192
35	L3-5	• • LH PINION GEAR	4
36	10-17-659-005	• • PLANETARY CAGE ASSEMBLY ***	1
36A	10-17-659-009	• • PLANETARY CAGE ASSEMBLY ****	1
37	L4-146	• REAR ADAPTER GASKET	1
38	10-00-183-073	• LOCK BOLT (7/16-14 x 7/8)	6
39	115550	• LOCKWASHER (7/16)	6
40	4766A	• SNAP RING	1
41	10-17-165-002	• SUN GEAR	1
42	L5-8A	• REDUCTION UNIT ADAPTER	1
43	L4-145	• FRONT ADAPTER GASKET	1

* REPLACE BOTH PARTS IF ONE IS DAMAGED.
** SELECT CORRECT SIZE SPACER AT ASSEMBLY. ONLY ONE REQUIRED.
*** USED WITH TRANSMISSIONS 10-17-000-009 AND 10-18-000-007. HAS DRILL SPOTS ON PLANETARY CAGE FOR IDENTIFICATION.
**** USED WITH TRANSMISSIONS 10-17-000-010 AND 10-18-000-008.

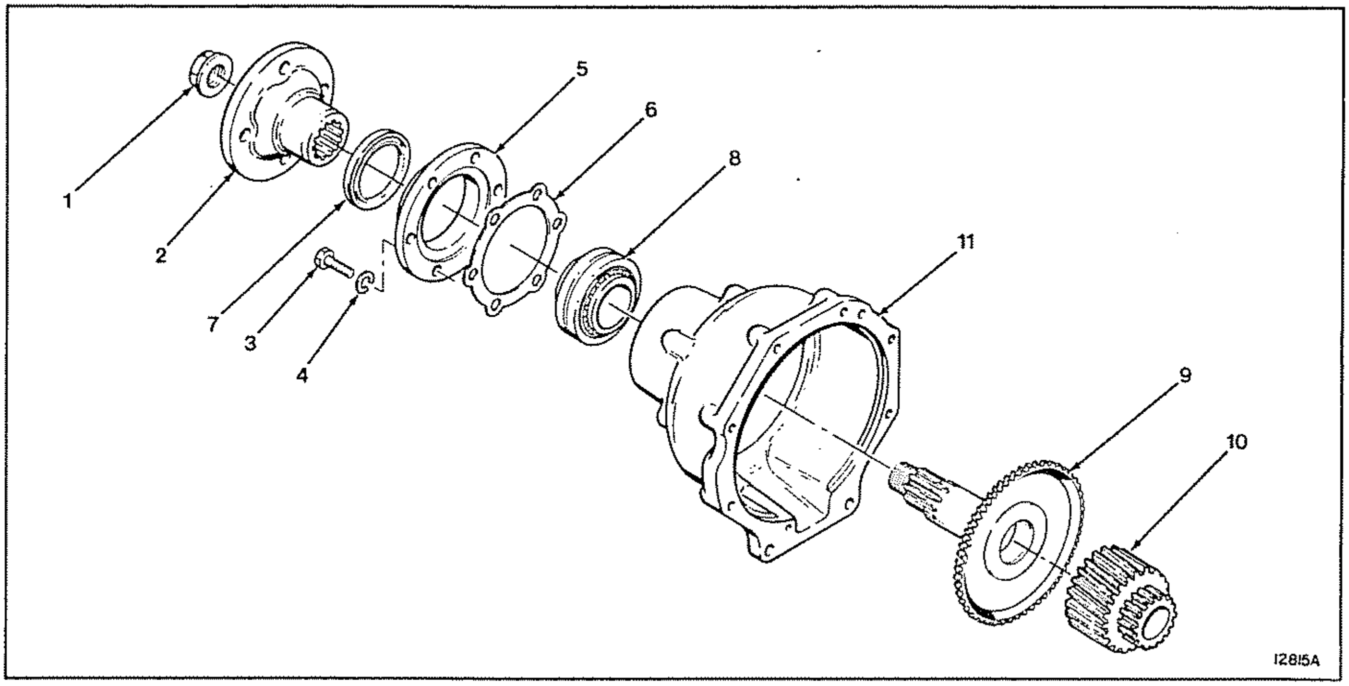


Figure 17. 2.10:1 Reduction Units - Early Production

INDEX NO.	PART NUMBER	DESCRIPTION	QTY
FIG. 17	NO NUMBER	REDUCTION UNIT (2.10:1)	
1	4775L	• COUPLING NUT	1
2	4547AY	• COUPLING (72C ONLY)	1
2B	4547BA	• COUPLING (71C ONLY)	1
3	0000179860	• HEX HEAD BOLT (7/16-14 x 1-1/4)	6
4	0000103322	• LOCKWASHER (7/16)	6
5	L4-7	• BEARING RETAINER	1
6	L4-147	• BEARING RETAINER GASKET	1
7	71C-110	• OIL SEAL	1
8	4920A	• BEARING	1
9	L5-A3	• OUTPUT SHAFT AND BUSHING ASSEMBLY	1
10	L5-4	• SUN GEAR	1
11	L5-1B	• REDUCTION HOUSING	1

NOTE: These early production parts are not interchangeable with current production parts in Figure 16. All other parts are the same.

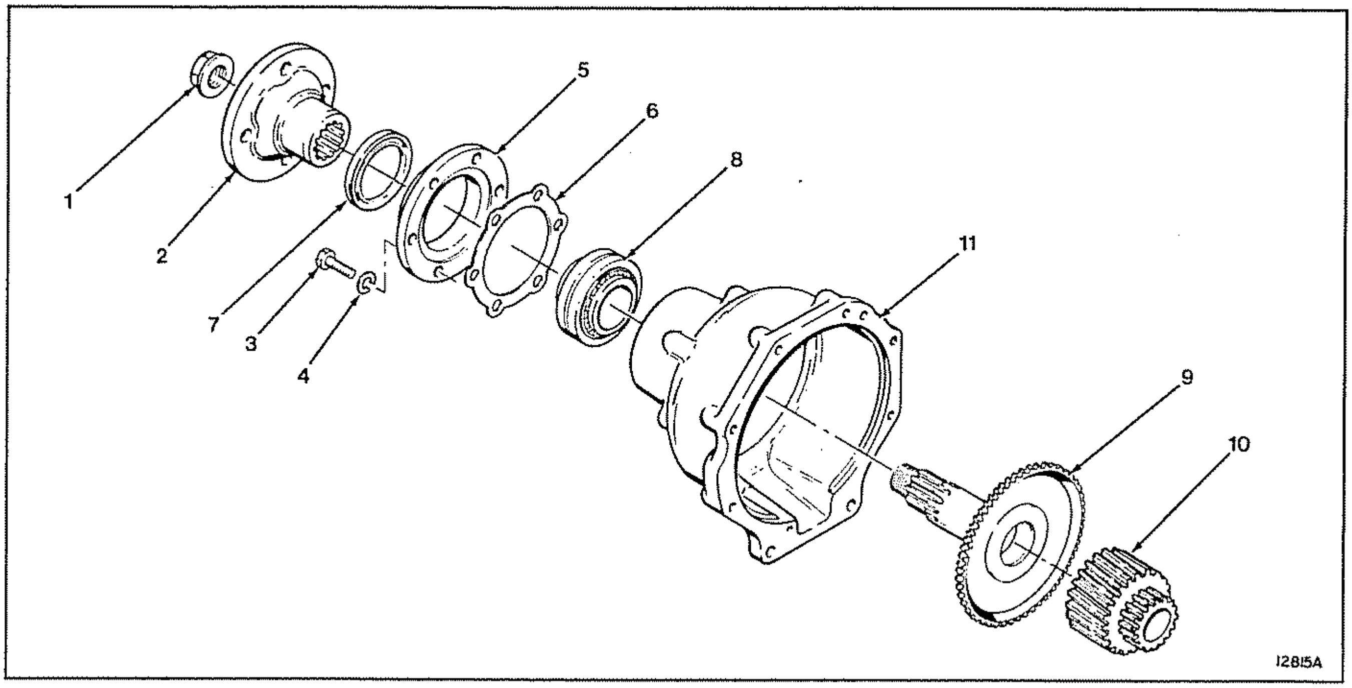


Figure 17. 2.10:1 Reduction Units - Early Production

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2	4547AY	• COUPLING (72C ONLY)	1
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5	L4-7	• BEARING RETAINER	1
6	L4-147	• BEARING RETAINER GASKET	1
7	71C-110	• OIL SEAL	1
8	4920A	• BEARING	1
9	L5-A3	• OUTPUT SHAFT AND BUSHING ASSEMBLY	1
10	L5-4	• SUN GEAR	1
11	L5-1B	• REDUCTION HOUSING	1

NOTE: These early production parts are not interchangeable with current production parts in Figure 16. All other parts are the same.

NOTES