INDEX

AND

BREAK DOWN OF SUBJECTS WITH ALLOTTED PERIODS
TRADE TRAINING ADVANCE
MTOF (MTM PART)

MID PHASE, MTM PART- I

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Syllabus : Automobile General Diesel and Petrol Technology

Course : Trade Training Advance, MTOF

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Aim : To study Personal Safety and First Aid in the Workshop

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WORKSHOP TECNOLOGY

Personal Safety and First Aid in the Workshop

1. a. **Introduction**. Certain compulsory rules are displayed in every workshop. These are concerned with workshop safety precautions and, based upon the Factories Act (revised 1961) they are designed to safeguard those employed in the workshop. These rules are concerned with the levels of cleanliness, ventilation, heating, lighting the use of electric and pneumatic power, fire protection, accident prevention, and first aid. In some jobs there are special risks for which additional local instructions are needed; in these instances a poster or notice is displayed near the danger to draw attention to the particular risk involved.

b. **General Workshop Precautions.**

(1) **Personal Safety.** Every reasonable safe ground is incorporated in the design of modern workshop equipment (such as guards and fences at danger points) but no safety device or set of rules can be fully effective against a person's incorrect behavior. A care less act, a moment of over-confidence, can be very costly in terms of working hours lost because of injury to personnel or damage to equipment. The lesson is simple: THINK before acting. However, in an emergency situation there is a little time for thought, and the right action must be instinctive. It is in such a situation that you must be able to act promptly and with confidence regardless of where you are in the workshop. Therefore, in the interests of your own safety, and also that of your workmates, make certain that you are thoroughly familiar with your surroundings and know what action to take. You must be able to readily locate, and use as required, all the items shown in (fig-1*) **any or all of these may be needed in an emergency.***

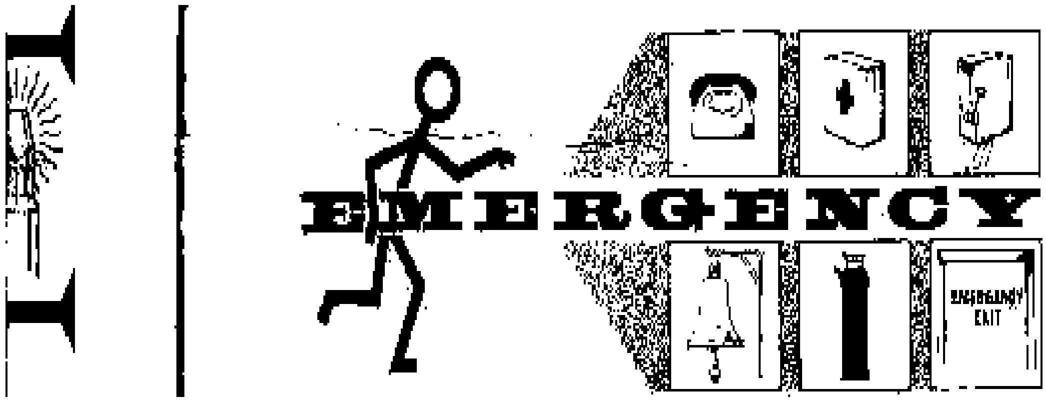

Fig-1 Personal Safety and First Aid

(2) **Workshop Tidiness.** All persons who work in, or have cause to enter, a workshop or servicing bay should be aware of the need for tidiness and the simple measures needed to avoid accidents. A tidy workshop is usually an efficient and safe place. The floor should be kept clean, free from patches of oil and grease on which people may slip, and not littered with equipment over which people may trip. Tools and materials not in use should be returned to the section store. Equipment should be tidily stacked, leaving adequate work space and gangways. The gangways should be clearly marked so as to provide a ready means of escape in case of emergency. If bulky equipment must protrude into the gangway, it must be clearly marked and must not prevent the gangway from being used as an escape way in emergency. General refuse, including oily rags and packaging materials, should not be allowed to accumulate and become a fire hazard. Metal bins are provided for collecting combustible waste; these should be emptied at the end of the working day and the rubbish burned in a safe place (normally under the supervision of the fire section). This regular disposal is important because, if oily waste is allowed to build up and become tightly packed in the bins, there is every danger of fire from spontaneous combustion. Contaminated fuels and lubricants are to be returned to the supply squadron for disposal; they are not to be poured down drains where they become a fire and explosive hazard or, later pollute local streams to become a menace to wild life.

(3) **Cleanliness.** Personal hygiene is always important. In a workshop it is essential, not only to health, but to the safe production of good work. Use the overalls provided; correctly fastened and laundered, they avoid contamination of your normal clothing and provide a reasonable protection against industrial dermatitis (an unpleasant skin infection caused by continual contact with fuels, oils, and solvents). Protect your hands by using the barrier creams provided. The barrier cream is used before starting work. On each occasion wash and dry your hands and then rub in the barrier cream.Each time you stop – yes, even at break time – clean off your hands with cleansing gel and then wash with soap and warm water. Always apply barrier cream

again before starting work. If you hands are likely to be exposed to solvents or similar cleaning material for long periods, suitable gloves or gauntlets should be worn. The surface of the work bench or engine stand is to be kept clean and tidy, and free from sharp edges or projections which could cause an injury. Nevertheless, use a brush when cleaning down and not your unprotected hands. As a further safety measure, the bolts securing the bench or stand should be checked periodically for tightness.

(4) **Using Hand Tools Safely.** Many hand tools such as files, screwdrivers, pliers, hammers and spanners are so common place that they are seldom considered to be dangerous. But they can be dangerous if misused, particularly if they are not properly maintained (fig- 2). In the workshop or store, hand tools should be arranged so that they are readily to hand and able to be easily checked for missing items. A shadow- board or similar device can help to safeguard tools and avoid time wasted in searching for mislaid items.

(a) **Files.** Never use a file without a sound, tight-fitting handle of the correct size for the file in use. To attempt to use a file without a handle may cause the tang to pierce the skin and injure the palm of the hand. File handles should have a metal ferrule which helps to secure the tang in the handle and reduces the risk of splitting the wood.

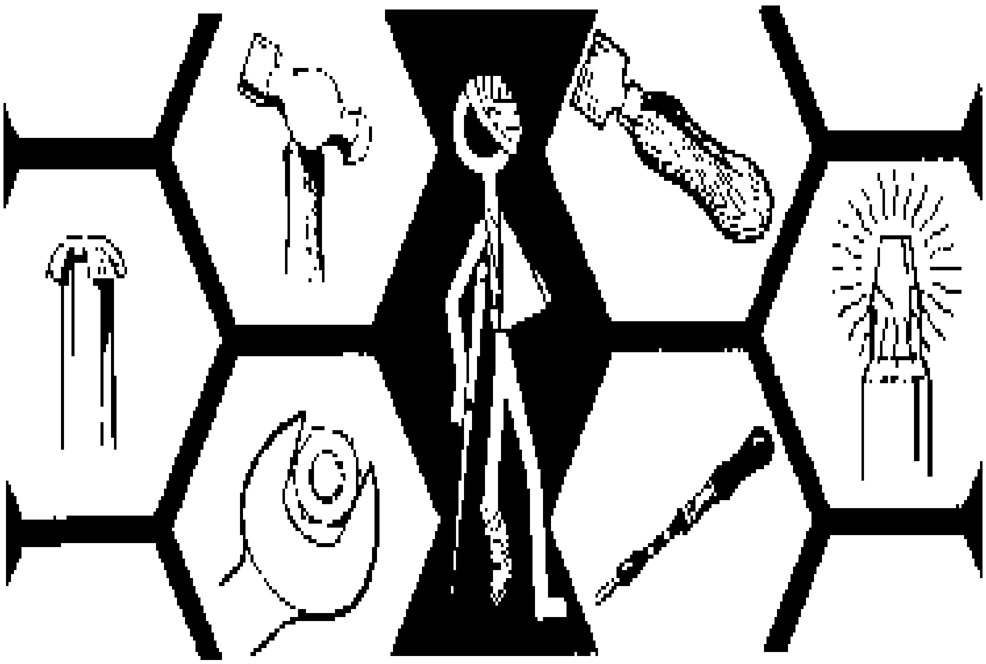

Fig-2 Dangerous tools

(b) **Hammers.** Before using a hammer always examine it to make sure that the shaft is sound and securely wedged in the hammer head.

Loose-fitting hammer heads are dangerous because they are liable to fly off, causing injury and damage.

(c) **Screwdrivers.** If a screwdriver slips when in use it can cause serious injury. Therefore, you are to select a screwdriver that is the right size and shape for the screw head; make sure that the tip of the blade is in good condition. The tip of the common screwdriver should be ground or filed square and kept thick enough to fit snugly into the screw slot; for electrical work, use a screwdriver with an insulated handle. No not carry screwdrivers or similar sharp-ended tools in your pocked, where a sharp movement or mend of the body may cause the blade to pierce the skin, possibly causing serious injury.

(d) **Punches.** Punches with cracked and mushroomed heads are a danger to users and passers-by. The head of the punch, or any tool that is repeatedly struck by a hammer, should be ground or filed as necessary to retain its original shape.

(e) **Spanners.** For every nut or bolt head there is a spanner of a shape and size that makes it a correct fit. This is the tight spanner, so be sure to use it. Ring and socket spanners are less likely to slip off the not and, for this reason, they are preferred to the open-ended spanner. The jaws of the adjustable spanner spread quite easily, and so it is normally only used as a last resort. When using any spanner, pull upon it rather than push. The spanner is controllable when pushing and sudden slackening of a nut may cause you to lose your balance and knock your hand upon adjacent hard sharp objects, with very painful results.

(f) **Pliers.** Care is needed to avoid pinching the skin when using pliers; when clipping wire hold the pliers so that the ends of the wire, when snipped off, are directed away from you towards the ground. Never use pliers upon nuts, bolts or screws.

(5) **Workshop Sense.** The following common-sense hints are of considerable value and should be introduced into your daily routine.

(a) Do not place tools or items of equipment in such a position that, if they are accidentally dislodged, they can fall upon you head.

(b) When using ladders or platforms make sure that they are in a serviceable condition and standing properly upon a firm base. The treads of the steps must be clean and free from grease.

(c) When working at a height, attach the tools in use to a length of light cord which is long enough to allow free movement but short enough to prevent the tool from falling upon those below you. Do not over-balance in snatching for a dropped tool; the cord will hold it for you.

(d) Wear goggles when chipping or when using a grindstone.

(e) Ensure that the grindstone rest is set to the correct clearance before using it. Do not use excessive pressure upon the stone and never use the sides of the grindstone.

(f) Never grind soft materials which will clog the grindstone.

(g) When using a drilling machine, make quite sure that the work is securely clamped.

(6) **Powered Tools.**

(a) **Using Powered Tools.** Extra care is needed when using power-operated tools and machines. These tools are designed to be powerful and, once started, can not be stopped immediately; even when the power is turned off, they need some seconds to run down. Never attempt to lubricate or clean the shafting of a powered tool while it is in motion.

(b) **Guards.** Before starting a powered machine, be sure you understand how to use it. In some workshops a notice may be displayed on each machine listing those personnel authorized to operate the machine. Before switching on, make sure that the appropriate guards and fences are secured in position, and be sure that no part of your body or clothing can come into contact with any moving parts. Although your overalls are correctly fastened, your tie should be removed or securely clipped so that it can not become entangled in the moving parts. This applies equally to fan belts and generator drives of motor engines.

(c) **Portable Powered Tools.** Before using an electrically-operated tool, such as a drill or a soldering iron, inspect the connecting cable to see that it is not damaged and, in particular, ensure that an earthed (3-pin) plug is properly fitted to its end (fig-. 3). If you are in any doubt, ask for an electrical tradesman to carry out electrical checks for you.

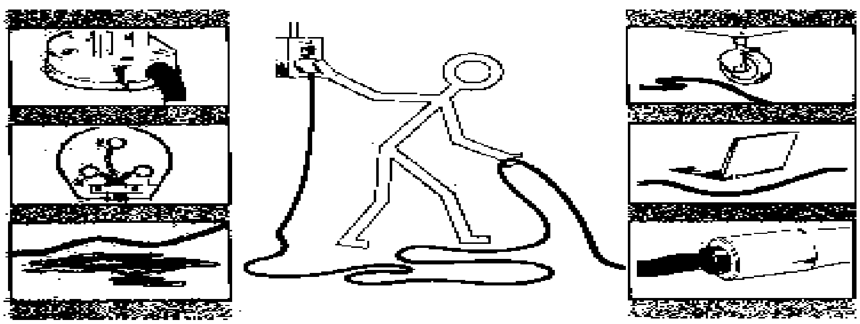

Fig-3 Using Electrical Tools

(7) **Electrical Power Supply.** Danger to life exists when the electrical power supply exceeds 30 volts ac or 50 volts dc. The following precautions will reduce the possibility of accidents arising from the use of such electrical supply:

(a) Switch 'OFF' before plugging into a mains supply socket and ensure that the voltage rating of the equipment matches the voltage of the supply.

(b) Dry floors or wooden platforms are to be used when electrical equipment is employed.

(c) Personnel using electrical equipment must be conversant with its operation.

(d) Mains switches must be clearly marked.

(e) When electrical tools are left unattended, switch off and remove the plug from the supply socket.

(f) When a lengthy run of cable is in use, allow slack to avoid strain upon both cable and connections. Route the cable so that it is not walked upon, run over, laying in oil or likely to be chafed by sharp edges. If the cable does come into contact with oil, clean the oil off at once and apply French chalk to the affected part.

(g) Electrically-operated tools should regularly tested, particular attention being paid to the flexible cable and its connections. Frayed leads and loose connections are not permitted.

(h) For electrical fires use only the correct extinguisher, this is one of the following:

BCF	(Green)
Dry Powder	(Blue)
CO_2	(Black).

On no account must domestic or foam extinguishers be used upon electrical fires.

(j) Before giving first aid to a person suffering from electroshock – switch off the current at the MAIS

(8) **Using Compressed Air**. Compressed air is often used to power portable hand tools and pressure lubricating equipment; if misused, it can be extremely dangerous. Air pressure line are to be handle with care and the outlet nozzles must never be pointed towards a person's body or towards any

position where an air jet will blast debris around. Apart from such obvious exposed danger spots as the eyes, ears and mouth, it must be realized that the blast from an air line nozzle can be penetrated clothing and cause serious injury if the air enters any part of the body. Therefore, ***do not play about with compressed air.***

(9) **Handling Equipment.**

(a) **Manhandling.** Despite the many mechanical aids that are available, we still use our hands for a great deal of every day lifting and caring. When it is necessary to manhandle equipment, do it correctly; it is easier that way. Most back injuries received when lifting heavy objects are caused by an incorrect lifting technique. When lifting, keep a straight back and let the leg muscles take most of the strain. If it is necessary to manhandle large heavy objects that can not be lifted by one man, the lift should be done by a group of persons under the supervision of one person. The supervisor is the only person who can give clear concise instruction for the lift. It is very important that all members of the group obey the instruction given by the supervisor (Fig-4).

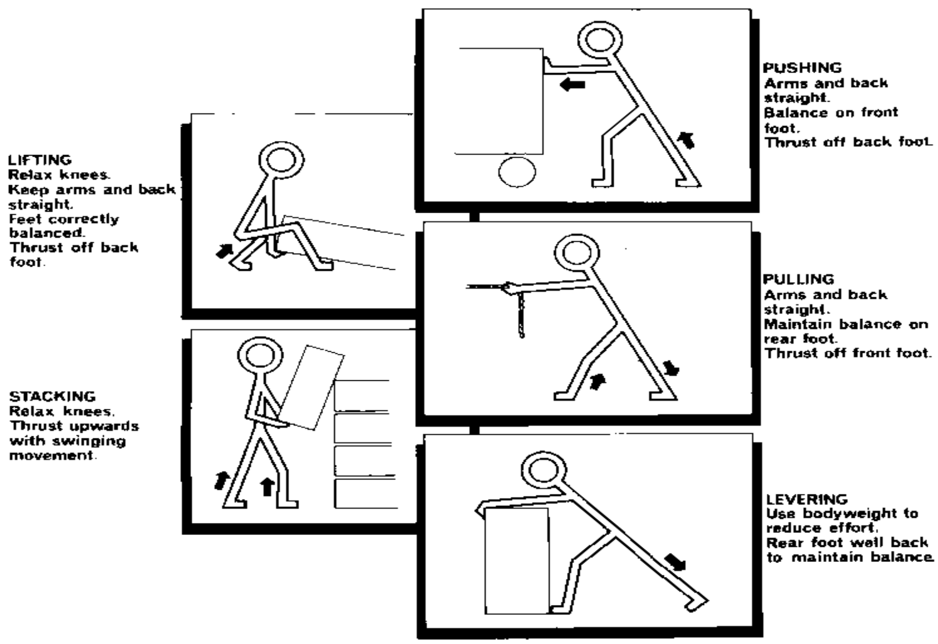

Fig-4 Correct Handling

(b) **Mechanical lifting.** There is a limit to the weight and bulk that can be lifted manually. When this limit id reached, heavier loads are lifted by cranes and slings; in the MT section the cranes are often of a portable type.

(c) **Using portable cranes**. When using portable cranes, observe these safety precautions

(I) Do not exceed the safe working load of the crane. It is marked on the crane for your benefit.

(II) Take a straight lift, otherwise the load will swing.

(III) Be sure that the crane is standing on a firm foundation and that the jacking feet are lowered.

(IV) Hen carrying a suspended load moves the crane by hand only and only then when the load is held by steady ropes.

(V) Do not stand or work under a suspended load and do not move a suspended load over other workers.

(VI) Do not carry out lifting operation unless supervised by an officer or NCO.

(d) **Using slings**. Never use a sling without first examining if for the fowling:

(I) It must carry a metal tag indicating the safe working load which must never be exceeded.

(III) It must be free from kinks, broking stands and raying; rings, links and hooks must be in a sound condition. Ropes slings must be free from cuts, frame and mildew, with all splices in good condition.

(IV) Protect slings where necessary by padding sharp corners of the equipment being lifting.

(V) Ensure that the load is safety held and properly balanced by taking the load and then inspecting before making the final load.

(e) **Using jacks**. Lust as there are sensible safety rules for cranes and slings, there are also rules to be observed when jacking up an MT vehicle:

(I) Ensure that the jack is suitable and that the load does not exceed the capacity of the jack.

(II) Check that the jack is clean, properly lubricated, and serviceable before attempting to use it.

(III) Place the jack on a firm safe place base; if it must be raised by packing, use good solid planks of wood. Never raise a jack by using bricks or any material which may collapse under load.

(IV) Before jacking a vehicle, chock the wheels fore and aft to prevent movement either backwards or forwards.

(V) Position the jacks so that no damage is caused when the load is applied.

(VI) Jack the vehicle to a height such that axles stands can be fitted and the load can then be transferred from the jack to the axle stand by carefully lowering the jack. If suitable stands are available, the vehicle can be supported upon baulks of timber; however, although not supporting the vehicle, the jack should not be removed. Personnel positioning axle stands or timber baulks must never move into a position where they could be trapped if the jack failed.

(VII) No person is permitted to remain in, or work upon a vehicle whilst it is being jacked up. All personnel must remain clears so that no one can be trapped if, for any reason, the vehicle falls off the jack.

(10) **Racks and benches**. Stores racks must be rigid to be safe. Loose bolts may result dangerous or even collapse; this could trap limbs and cause serious injury.

(11) **Engine- Driven Equipment**. When running the engine of ground equipment or MT vehicle in enclosed surroundings there must be sufficient ventilation to avoid the build-up of poisonous exhaust fumes. During periods of prolonged running it may be come necessary to stop the engine and allow the fumes to clear.

SAFETY IN THE AUTOMOBILE SERVICE SHOP

Safety is your Job

1. Yes, safety is your job. In the shop. You are "safe" when you protect your eyes, your fingers, your hands- all of yourself-from danger. And, just as important, when you look out for the safety of those around you. The rules of safety are listed and discussed in the next few pages. Follow the rules for your protection, and for the protection of your fellow workers.

Shop Layouts

2. The term "shop layout" means the locations of work benches, car lifts, machine tools, and so on. Shop layouts vary (Fig-1). so the first thing you should do in a shop is find out where everything is located. This includes the different machine tools and the workbenches, car lifts, and work areas. Many shops have painted lines on the floor to mark off work areas. These lines guide the workers away from danger zones where machines are being operated. The lines also remind workers to keep their tools and equipment inside work area lines. Many shops have warning signs posted around machinery. These signs are there to remind you about safety, and about how to use machines safely. Follow the posted instructions at all times. The most common cause of accidents in the shop is failure to follow instructions.

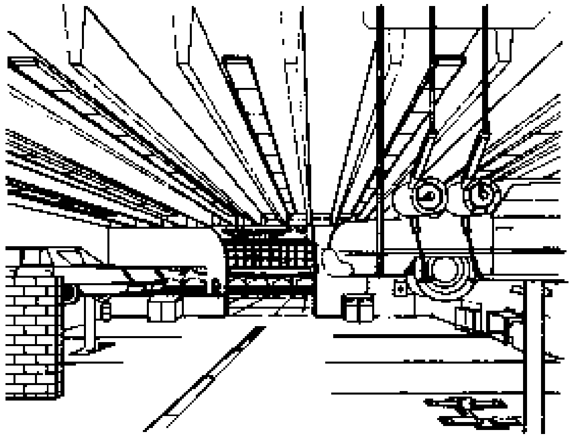

Fig -1, Typical shop layout.(Motor Vehicle Manufacturers Association)

What to do in Emergencies

3. If there is an accident and someone gets hurt, notify your supervisor at once. He will know what to do. He may try first aid himself, or phone to the M. I. Room for an ambulance. Be very careful in attempting first aid. You must know what you are doing. Trying first aid on an injured person can do more harm than good if it is done wrong. For example, a serious back injury could be made worse if the injured person is moved. On the other hand, quick mouth-to-mouth resuscitation may save the life of a person who has suffered an electric shock. Talk to your supervisor if you have any questions about this. And remember this about fires. The quicker you get at them, the easier it is to control them. But you have to use the right kind of fire extinguisher, and use correctly. Again, ask your supervisor if you have any questions.

Fire Prevention

4. Gasoline is used so much in the shop that people forget it is very dangerous if not handled properly. A spark or lighted match in a closed place filled with gasoline vapor can cause an explosion. Even the spark from a light switch can set off an explosion. So you must always be careful with gasoline. Here are some hints. Suppose there are gasoline vapors around, because someone spilled gasoline or a fuel line is leaking. Then you should keep the shop doors open or keep the ventilating system going. Wipe up the spilled gasoline at once, and put the rags outside to dry. Never smoke or light cigarette around gasoline. When you work on a leaky fuel line, carburetor, or fuel pump, catch the leaking gasoline in a container or with rags. Put the soaked rags outside to dry. Fix the leak as quickly as possible. And don't make sparks around the car, for instance by connecting a

trouble light to the battery. Store gasoline in approved safety container. Never store gasoline in a glass jug.

The jug could be broken and could cause a terrible explosion or fire. Oily rags can also be a source of fire. They can catch fire without a spark or flame. Oily rags and waste should be put into special closed metal containers where they can do no harm.

The Safety Rules

5. Some people say, "Accidents will happen" But safety experts do not agree. They say, "Accidents are caused: They are caused by careless actions, by inattention to the job at hand, by using damaged or incorrect tools. And sometimes accidents are caused by just plain stupidity!" To keep accidents from happening, follow these simple rules:

a. Work quietly and give the job your full attention.

b. Keep your tools and equipment under control.

c. Keep jack handles out of the way. Stand creepers against the wall when they are not in use.

d. Never indulge in horseplay or other foolish activities. You could cause someone to get seriously hurt.

e. Don't put sharp objects, such as screwdrivers, in your pocket. You could cut yourself or get stabbed. Or you could ruin the upholstery in a car.

f. Make sure your clothes are right for the fob. Dangling sleeves or ties can get caught in machinery and cause serious injuries. Do not wear sandals or open-toe shoes. Wear full leather shoes with nonskid rubber heels and soles. Steel-toe safety shoes are best for shop work.

g. If you spill oil, grease or any liquid on the floor. Clean it up so that no one will slip and fall.

h. Never use compressed air to blow dirt from your clothes. Never point a compressed air hose at another person. Flying particles could put out an eye.

j. Always wear goggles or a face shield when there are particles flying about. Always wear an eye protector when using a grinding wheel (Fig -2).

k. Watch out for sparks flying from a grinding wheel or welding equipment. The sparks can set your clothes on fire.

l. To protect your eyes, wear goggles when using chemicals, such as solvents. If you get a chemical in your eyes, wash them with water at once. Then report to the M.I. Room as soon as possible.

m. When using a car jack, make sure it is centered so that it won't slip. Never jack up a car while someone is working under it. People have been killed when the jack slipped and the car fell on them. Always use car stands or supports, properly placed, when going under a car (Fig. -3).

n. Always use the right tool for the job. The wrong tool could damage the part being worked on and could cause you to get hurt.

Fig -2, Keep your tools with in convenient reach, nearly arranged. Do not scatter them around.

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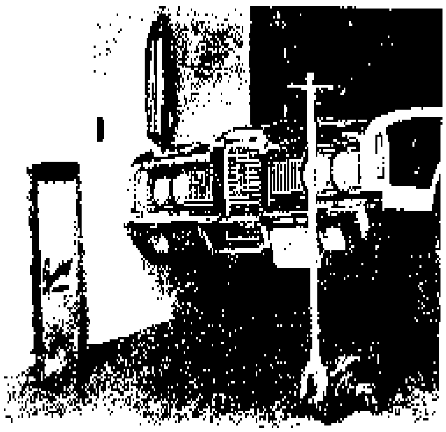
<tr><td>
Fig -3, Jack handle should be kept up. Creepers should be stood against the wall. Out of the way.</td><td>
Fig -4, Always wear goggles or a face mask when using a machine that can throw chips or sparks</td></tr>
<tr><td>
Fig -5, Car stand should be properly Placed before you go under a car.</td><td>Caution: Never run an engine in a closed garage that does not have a ventilating system. The exhaust gases contain carbon monoxide. Carbon monoxide is a colorless, odorless, tasteless, poisonous gas that can kill you. In a closed one-car garage, enough carbon monoxide to kill you can collect in only three minutes.</td></tr>
</table>

Taking care of your Tools

6. Tools should be clean and in good condition. Greasy and oily tools are hard to hold and use. Always wipe them off before trying to use them. Do not use a hardened hammer or punch on a hardened surface. Hardened steel is brittle, almost like glass, and may shatter from heavy blows. Slivers may fly out and become embedded in the hand or, worse, in the eye. Use a soft hammer or punch on hardened parts.

Using Power-Driven Equipment

7. A lot of power-driven equipment is used in the automobile shop. The instructions for using any equipment should be studied carefully before the equipment is operated. hands and clothes should be kept away from moving machinery. Keep hands out of the way when using any cutting device, such as a drum lathe. Do not attempt to feel the finish while the

machine is in operation. There may be slivers of metal that will cut your hands badly. When using grinding equipment, keep hands away from rotating parts. Do not try to feel the finish with the machine in operation. Sometimes you will work on a device with compressed springs, such as a clutch or valves. Use great care to prevent the springs from slipping and jumping loose. If this happens, the spring may take off at high speed and hurt someone. Never attempt to adjust or oil moving machinery unless the instructions tell you that this should be done.

Driving cars in the Shop

8. Cars have to be moved in the shop. They must be brought in for service, and may have to be moved from one work area to another. When the job is finished, they have to be moved out of the work area. You must be extremely careful when you drive a car in the shop. Make sure the way is clear. Make sure no one is under a nearby car. Someone might suddenly stick out an arm or a leg. Make sure there are no tools on the ground that you could run over. When you take a car out for a road test, fasten your seat belt, even though you are going only a short distance.

Caution: Always fasten your safety belt in a moving car, whether you are the driver or a passenger. Seat belts save lives; your seat belt could save yours. Buckle up for safety!

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(Aero Engg Trg Sqn)

Syllabus : Automobile General Diesel and Petrol Technology

Course : Trade Training Advance, MTOF

Subject : Engine Measurements and Performance

Aim : To study Engine Measurements and Performance

Ref : Automotive Mechanics by William H. Crouse Page, No 133-142 Chapter 16.

ENGINE MEASUREMENTS AND PERFORMANCE

MEASURING INSTRUMENTS

Introduction

1. The basis of the modern approach to economical servicing is accurate control of measurement. Complete replacement of a defective part is a common practice in the engineering world. Precision measurement is the cornerstone up on which this system of repair by replacement is built. Worn parts are not only inefficient and damaging. They often

constitute a hazard to read/ flying safety and a danger to life. By maintaining a high standard of dimensional accuracy servicing time and cost of repair is reduced.

OUTSIDE MICROMETER

2. a. **OUTSIDE METRIC MICROMETER**

(1) **Purpose :** The purpose of outside metric micrometer is to measure a length up to an accuracy of 1/100 of a millimeter (.01mm).

(2). **Principle :** It is based on screw thread principle.

(3). **Construction :** Same as English outside micrometer.

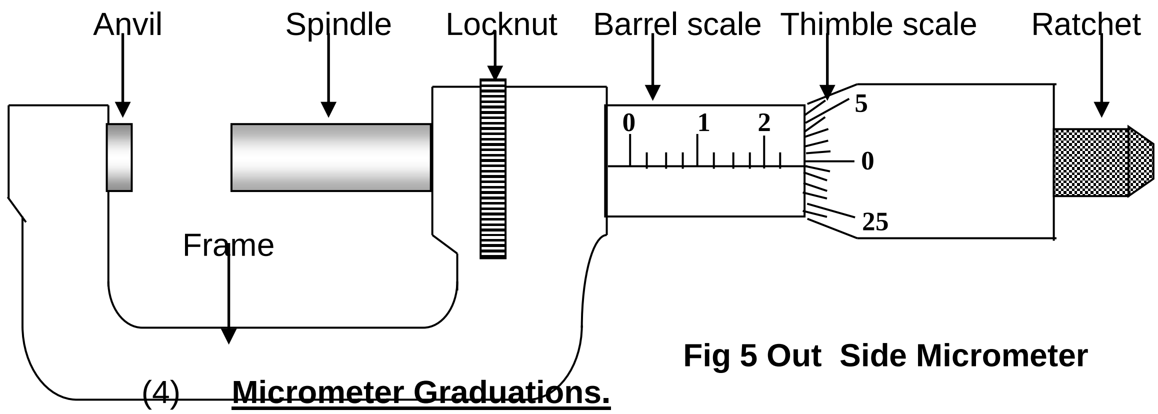

Fig 5 Out Side Micrometer

(4) **Micrometer Graduations.**

(a) **On the Barrel.** The barrel has a scale of 25mm length. the length is graduated into 25 divisions above the barrel datum line and are numbered every 5th graduation. So one division above the datum line of sleeve representing one millimeter. Again, same of 25mm length is graduated into 50 division below the barrel datum line. So, each smallest division below the barrel datum line, representing ½mm (0.5). Therefore, we can say barrel scale is graduated with two sets of line millimeter and half millimeters for easy reading (big division and small division respectively).

(b) **On the Thimble.** The bevel edge of the thimble is divided into 50 equal parts. The thread has a pitch of ½ (0.5mm) i.e. one complete of the thimble covers one smallest division on the barrel. The 50 divisions on the thimble has made it possible to rotate the spindle 1/50th of a turn, which will cause the gap between the measuring faces to open or close by 1/50th of 0.5mm i.e. 1/50 X ½mm 1/100mm= 0.01mm. Therefore the value of one thimble division is 0.01mm.

(5) **Range.** The range or measuring capacity of a single outside metric micrometer is 25mm.

(6) **Adjustment.** Same as English outside micrometer.

(7) **Reading :** To make a reading note the number of millimeters and half millimeters visible on the sleeve (barrel) and then add the hundredths of a millimeter ((.01mm) shown by the thimble scale division that coin-sides with the horizontal datum line on the sleeve. For example to take the measurement of 8.86mm dimensions, you will take the reading as follows:

(a) Highest graduation visible above the sleeve datum line is 8-(8X1mm) =9.00mm

(b) Lines (bottom) visible between the 8th figure (Top) and thimble edge is 1== 1X0.5mm) = 0.5mm

(c) Thus, 8.86mm dimensions are measured by the above mentioned way.

(8) **Handling precautions.** Same as English outside micrometer.

b. **English Outside Micrometer**

(1) **Purpose.** The purpose of English outside micrometer is to measure a length up to an accuracy of $\frac{1}{1000}$ (one thou) of an in ch (.100”) without Vernier scale and 5 $\frac{1}{10000}$ (Ten thou) of an inch with vernier scale. And even greater degree of accuracy is possible by a micrometer provided with a vernier scale.

(2) **Principle .** It is based on the principle of screw thread.

(3) **Construction.** It consists of the following parts:

(a) **Frame.** It is \`U\` shaped and make of cast iron. Its one end is attached with anvil and other end to the barrel.

(b) **Anvil.** Anvil is attached to the free end of the frame. It may be fixed or adjustable.

(c). **Barrel.** It is a hallow cylinder threaded internally to receive spindle and externally threaded for play adjustment nut. A scale is graduated on the barrel. A scale of one inch on the barrel is taken and divided into 40 divisions. Therefore the value of one smallest division is 1/40th of an inch.

(d) **Thimble.** It is attached to spindle to provide easy rotation. Its bevel edge is divided into 25 equal parts.

(e) **Spindle**. It is attached internally to thimble and moves inside the barrel. It provides a moveable surface moves inside the barrel. It provides a moveable surface for taking measurement.

(f) **Ratchet**. It is attached at the end of the thimble. It ensures even pressure on spindle while tightening.

(g) **Lock Ring**. This is to lock the micrometer after reading is taken.

(4) **Micrometer graduation**.

(a) **Barrel**. The barrel has a scale of one inch length. The length is divided into 10 (ten) equal parts and numbered as 1,2,3,4 etc. Each division is again subdivided into 4 (four) equal parts. Therefore, the value of each small division on the barrel is 1"/10 X 1"/4 = 1"/40 .025" (inch).

(b) **Thimble**. The bevel edge of the thimble is divided into 25 equal parts. One complete turn of the thimble covers one smallest division on the barrel. Therefore, the value of one division on the thimble is .25" ÷ 25= .001" (inch).

(5) **Vernier Scale Graduation**. Two similar scales but not completely alike are taken. Their difference is known as vernier scale. A distance of 9 division on the thimble is taken and divided into 10 (ten) equal parts on the barrel. From the micrometer graduation we have known that the value of one division on the thimble is .001" X 9 = .009". Therefore, the value of one vernier scale division (on the barrel) is 0.009" ÷ 10 =.009". So, vernier constant = one thimble division minus one vernier division = .0010"-.0001" (inch).

(6) **Range**. The range of English outside micrometer is one inch.

(7) **Size**. Different sizes of micrometer are supplied in service for workshop practices, such as 0-1", 1"-2", 2"-3", 3"-4" etc.

(8) **Adjustment** . If 0-1" English outside micrometer is out of accuracy i.e. zero of thimble does not coin-side with zero on barrel when fully closed, then adjust at the following point.

(a) Adjust on anvil by loosening the screw (if it is not fixed).

(b) By rotating the barrel (sleeve) with `C` spanner.

(c) Some micrometer can be adjusted by rotating thimble over the spindle.

(d). Adjust for back lash by unscrewing the thimble assembly and tightening nut over the split thread of the barrel end.

Note: *Larger sizes can be adjusted for accuracy by measuring machined gauge blocks and adjust exactly as per 0-1” micrometer.*

(9) **Reading:** To make a measurement note the number of divisions visible on the sleeve scale and then add the number of thimble divisions which have passed the datum line on the sleeve. If no division on the thimble coin-side with the sleeve datum, then the reading is taken to the nearest thimble division.

(a) Highest figure visible on the sleeve is 3=0.3”

(b) Lines visible between the number 3 and thimble edge is 2=.025”2=0.05”

(c) Lines on thimble which have passed sleeve datum line is 13=.025X2=0.05”

(d) The line on vernier scale which

(10) **Handling Precautions.** The following precautions should be observed while handling the micrometer:

(a) The contacting faces of the spindle and anvil must be cleaned.

(b) The micrometer must be held in one hand, leaving the other hand free to handle the job.

(c) Thimble should be turned by ratchet until free end of the spindle touches the job.

(d) Take the reading carefully and lock it after the reading is taken.

(e) Micrometer is a precision instrument. It should be used carefully.

(f) When not in use, put the micrometer in the box, by keeping it clean and applying oil lightly in order to prevent corrosion (when it is in storage).

Micrometer Care & Adjustment

3. a. Keep the anvil and spindle clean i.e. before use clean micrometer contacting face.

b. The micrometer must be hold in one and, leaving the other hand free to handle the job.

c. Turn the thimble by means of ratchet until free end of spindle touches the job operate the micrometer by the ratchet all the time.

d. Take the reading carefully and lock after the reading. Take more than one reading to ensure accurate measurement.

e. Check the new micrometer for accuracy before use (use test pieces).

f. Lightly oil the micrometer with clean oil when not in use.

g. Always keep the micrometer in the box provided when not in use.

English Inside Micrometer

4. a. **Purpose**: The English inside micrometer is used for measuring internal dimension up-to the accuracy of 0.001”

b. **Principle**: It is based on the principle of screw thread system.

c. **Construction**:

(1) **Body**: It has a provision for attaching a handle. There is a screw on the body for locking the extension rod. The length of the body is 1½” (inch) when zero mark of head (thimble) is aligned with the zero mark.

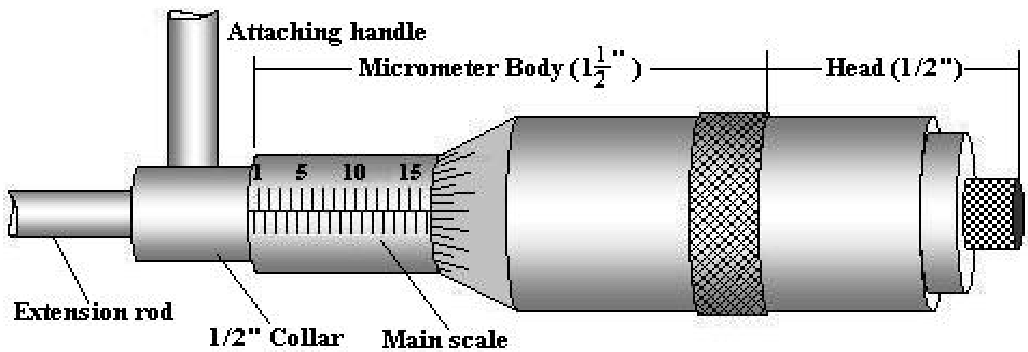

Fig-6 Inside Micrometer

(2) **Measuring Head**. The length of the head is ½”. It rotates and moves axially over the barrel. Its barrel edge is divided into 25 equal parts. The adjustment of the head is always ½”.

(3) **Collar**. The length of the collar is ½”. Some radial grooves are provided on the face of the collar. It can be used for measurement with the extension rod. The extension rods and the collar have the progressive range of measurement from 2” - 12”.

(4) **Extension rod.** A complete sets English internal micrometer has 9 detachable extension rods of various lengths. Appropriate size is written at the end of the rod. The extension rods and the collar have the progressive range of measurement from 2” - 12”.

(5) **Attaching Handle.** It provides better facility for gripping the micrometer during measurement. The end of the handle is screw threads. It is to be attached with the micrometer body while taking the measurement.

d. **Range.** The English inside micrometer has a range of measurement form 2”12” i.e. it can not measure a job is ½” (inch) and with collar and extension rods the range is 10” (inch)

e. **Graduations.** The length of scale on the barrel is 0.5” and it is divided into 5 main division which is numbered as 1, 2,3,4,5. Each division is again sub-divided into 4 smallest divisions. Therefore, the value of each smallest division on the barrel is (0.5÷ 5) X ¼ = $\frac{1}{40}$ = .025”. The bevel edge of the measuring head (thimble) is divided into 25 equal parts. One complete turn of the head covers one smallest on the barrel. Therefore, the value of one division on the measuring head is 0.0.25÷ 25 = 001” (inch).

f. **Reading.** To make a measurement note the number of divisions visible on the sleeve scale and the number of thimble divisions which have passed the sleeve datum line. Then find out the value and add with the value of micrometer body, collar and extension rod. For example to take the measurement of 5.362” (inch) internal dimension, you will take the reading as follows:

(1) The value of micrometer without collar (the length of the body).

(2) The value of collar is 0.5 inch

(3) The value of extension rod is 3.0 inch

(4) The highest figure visible on the sleeve is 3=0.1X3=.03 inch.

(5) The lines visible on sleeve between the highest figure 3 and measuring head (thimble) is 2=0.025X=0.050 inch.

(6) The lines on the measuring head which have passed sleeve datum line is 12=.001X12= $\frac{0.012}{5.362 inch}$

g. **Handling Precautions.**

(1) When assembling the micrometer the joining faces of the extension rod collar and micrometer body must be cleaned.

(2) The parts should be well pressed and fitted in screwing motion so that any oil or dirt is collected in the radial grooves.

(3) If the extension rods are stamped with a mating mark, usually in the form of a zero, then the mark must be aligned with a similar mark on the micrometer body when the rods are assembled in this position that perfect accuracy is guaranteed.

(4) Before being used, the overall length of the assembled micrometer should be checked with an external measuring instrument of known accuracy.

Dial Gauges

5. a. Dial test indicator

(1) Introduction. **Dial test indicator is a mechanical motion amplifying devices. It cannot be used alone for either measurement or gauging. It can only be used with the help of any of the various types of supports. The dial test indicator pointer will show any small movement imparted to its contact point by an object held against it. The irregularity in a surface can be easily detected with the ability of the contact point.**

(2). Purpose. **It is a mechanical device used to amplify the small motions. It is used for determining the degree of accuracy of a flat surface. It is also used for taking comparative measurement between components.**

(3) **.**Principle. **It works on the principle of a stopwatch.**

(4) Construction**. It consists of a case into which clock mechanism is used, a dial with graduations, a pointer a plunger guide and a plunger. The dial is adjustable and when adjusted by turning a knurled, can be locked with a locking screw. The contact point of dial test indicator may**

be one end of a pivoted lever linked to the indicating hand, or it may be screwed on a rod called the "Rack", which can move only length wise and moves the hand through a gear train. Many variations are possible, but all dial indicators have, in common, the ability to amplify the movement greatly, thereby enabling the inspector or workman to detect extremely small displacement of the contact point caused by irregularity in a surface, minute difference in size etc.

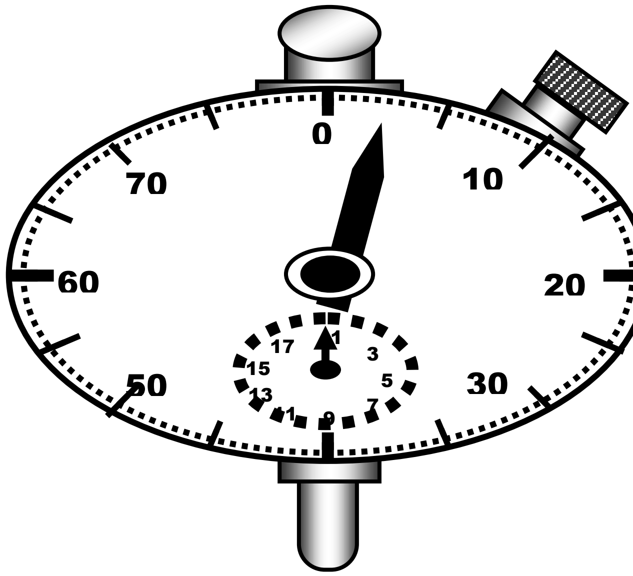

Fig-7 Dial test indicator

(5) Operation. **The ability of this indicator to amplify small linear movement of its contact point is made possible by an accurately built rack, pinion, and gear train. The rack spring tends to hold the scale pin and rack assembly downwards. From this position the rack can be displaced in its bearing only by upward movement of its contact point. The slide pin is allowed to move only vertically; hence the rack cannot**

be tuned without causing breakage. The fine tooth rack meshes with pinion mounted on larger gear. The gear assembly turns or jeweled bearings. The large rack gear, turning through the same angle as the pinion, imparts a larger movement to the smaller gear of the intermediate gear assembly and the larger gear imparts a still larger movement to the very small gear on the indicating hand shaft in front of the rack, so that the angular movement of the hand is quite larger in comparison with rack motion. A takes up gear assembly is used with the indicating hand shaft gear and winds up a hairspring anchored to hail fixed in construction point. The purpose of the take up gear assembly in conjunction with hairspring is to compensate backlash in the driving gear train. The dial is graduated and shows negative and positive reading.

(6) Uses**. The gauge is used along with a number of accessories and rigs for variety of operation. This instrument is used to check small variation in distance from a reference point or the relative movement of one component to the other. To obtain reading the gauge is to be installed on an accessory or rigs, which are of many types depending upon the use. When using the plunger of the gauge, it is to be depressed half way through and dial is to be adjusted and locked. The variation will be indicated by the pointer as the gauge will be moved about for checking. The low sports will be indicated by minus reading and high sports by plus reading. The accuracy of this gauge is 0.001".**

(7) Care and Handling. **While handling this gauge the following points are to be borne in mind:**

(a) Do not put any oil into click mechanism.

(b) Never drop it.

(c) No adjustment of this gauge is permitted.

(d) In case of doubt get it calibrated.

b. **Cylinder gauge.** This is a special form of dial gauge which is used for determining the amount of wear or machining error in cylindrical components. Unlike the test indicator, the cylinder gauge has two contacting plungers, one of which is spring- loaded and fitted to a 'T' shaped head which centralizes the gauge in the cylinder bore; the other contact is formed by one of a set of detachable extension rods.

Torque

1. Torque is twisting, or turning, effort. You apply torque to the top of a screw-tow jar when you loosen it (Fig-1). You apply torque to the steering wheel when you take a car around a turn. The engine applies torque to the wheels to make them rotate. Torque, however, must not be confused with power. Torque is turning effort which may or may not result in motion. Power is something else again. It is the rate at which work is being done, and this means that something must be moving. Torque is measured in pound-feet (or lb-ft, not to be confused with ft-lb of work).

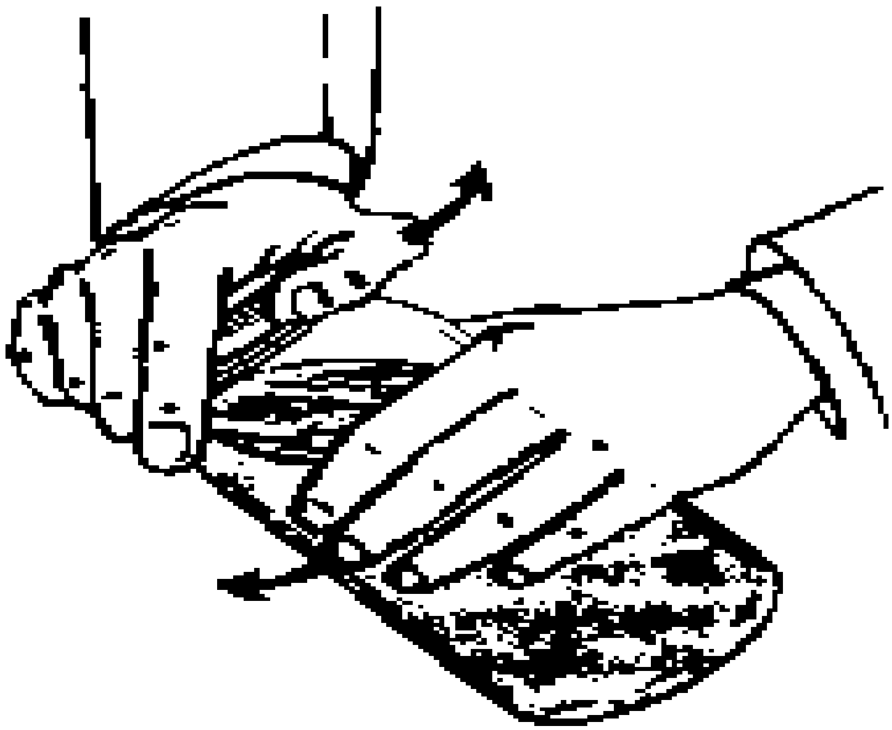

Fig -1, Torque Or Twisting Effort, Must Be Applied To Loosen And Remove The Top From A Screw-Top Jar.

For example, suppose you push on a crank with a 20-pound push, and the crank is 1½ feet long. You would be applying 30 pound-feet of torque to the crank (Fig-2). You would be applying this torque regardless of whether or not the crank was turning. The torque is there as long as you continue to apply the 20-pound push to the crank handle.

Fig -2, Torque Is Measured In Pound-Feet (Ib-Ft).It is Calculated By Multiplying the Push by the Crank Offset, Or the Distance of the Push from the Rotating Shaft

***NOTE**: In the metric system, torque is measured in kilogram-meters (kgm), and not pound-feet (lb-ft).*

Horsepower

2. A horsepower (hp) is the power of one horse, or a measure of the rate at which a horse can work. A 10-hp engine, for example, can do the work of 10 horses. A horsepower is 33,000 ft-lb per minute (fig-3).

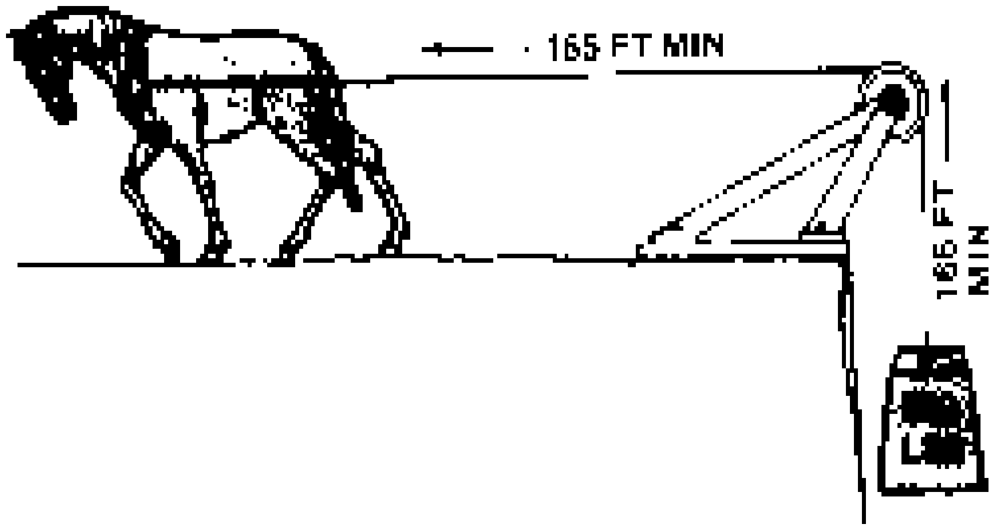

Fig 3, One Horse Can Do 33,000 Foot-Pounds Of Work A Minute.

In the illustration, the horse walks 165 feet in 1 minute, lifting the 200-pound weight. The amount of work involved is 33,000 ft-lb (165 feet X 200 pounds). The time is 1 minute. If the horse did this work in 2 minutes, then it would be only "half" working; it would be putting out only ½ hp.

One formula for horsepower is:

$$\mathbf{hp} = \frac{\text{ft-lb per minut}}{33{,}000} = \frac{L \times W}{33000, \times t}$$

Where hp = horsepower

L=length, in feet, through which W is exerted

W=force, in pounds, exerted through distance L

t = time, in minutes, required to move W through L

***NOTE**: In the metric system, power output from an engine is often measured in kilowatts (kW). That is, the power output is the amount of electricity the engine could produce if it were used to drive an electric generator. 1.34 hp is equal to 1 KW, and 1HP is equal to 0.746 KW. Thus, a 200-hp engine is equal to a 149-kW engine.*

Inertia

3. Inertia is a property of all material objects. It causes them to resist any change of speed or direction of travel. a motionless object tends to remain motionless. A moving object tends to keep moving at the same speed and in the same direction. Consider the automobile. When it is standing still its inertia must be overcome by applying power to make it move. to increase its speed, more power must be applied. To decrease its speed, the brakes must be applied. The brakes must overcome the cars inertia to slow it down. Also, when the car goes around a curve, its inertia tends to kept it moving in a straight line. The tires on the road must overcome this tendency, or else the inertia of the car will send it into a skid.

Friction

4. Friction is resistance to motion between two objects in contact with each other. If you put a book on a table and then pushed the book, you would find that i took a certain amount of push

If you put a second book on top of the book, you would find that you are to push harder to move the two books on the table top (fig. -5.thus, friction, or resistance to motion, increases with the load. The higher the load, the greater the friction. There are three kinds of friction: dry, greasy, and viscous. They are as follows:

a. **Dry friction.** This is the resistance to motion between two dry objects, for instance, a board being dragged across a floor.

b. **Greasy friction.** This is the friction between two objects thinly coated with oil or grease. In an automobile engine, greasy friction may occur in an engine on first starting. Most of the lubricating oil may have drained away from the bearing surfaces and from the cylinder walls and piston rings. When the engine is started, only the small amount of oil remaining on these surfaces protects them from undue wear. Of course, the lubricating system quickly supplies additional oil. But before this happens, greasy friction exists on the moving surfaces. The lubrication between the surfaces where greasy friction exists is not enough to prevent wear. This is why automotive engineers say that initial starting and warm-up of the engine is hardest on the engine and wears it the most.

c. **Viscous friction.** "Viscosity" is a term that refers to the tendency of liquids, such as oil, to resist flowing. A heavy oil is more viscous than a light oil and flows more slowly. (it has a higher viscosity, or higher resistance to flowing). Viscous friction is the friction, or resistance to motion, between layers of liquid. In an oiled engine bearing, layers of oil adhere to the bearing and shaft surfaces. Layers of oil clinging to the shaft are carried around by the rotating shaft. They wedge between the shaft and the bearing (Fig. 6).

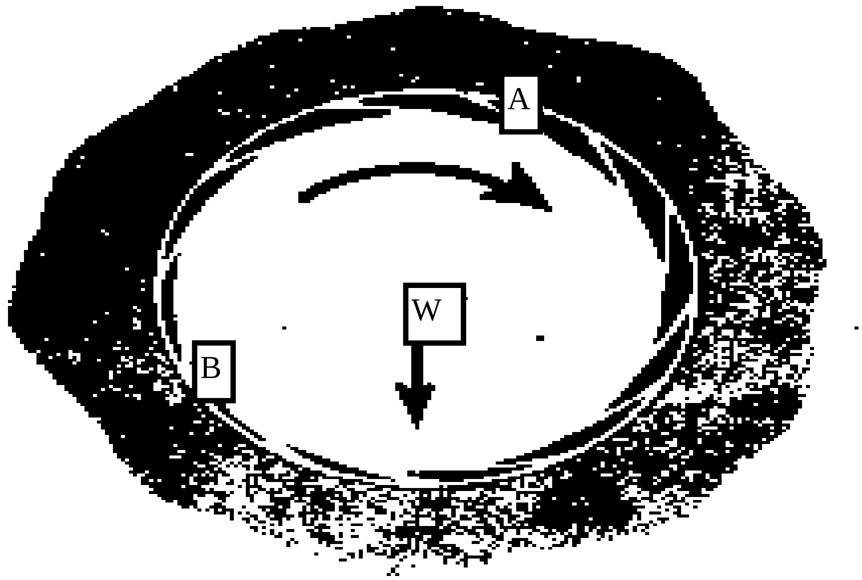

Fig -6 Shaft Rotation Causes Layers Of Clinging Oil To Be Dragged Around With It.

The wedging action lifts the shaft so that the oil supports the weight, or load. Now, since the shaft is supported (floats") on layers of oil there is no metal-to-metal contact. However, the layers of oil must move over each other. Some energy is needed to make them do so. The resistance to motion between these oil layers is viscous friction.

d. **Bushings and bearings.** In the engine, as in almost all machinery, the moving parts are lubricated with oil. The surfaces that move against each other are thus protected against dry friction. These surfaces are of special materials, specially prepared. The cylinder walls, for example, against which the pistons and piston rings slide, are of smooth gray iron or other metal with good wearing qualities. The cylinder walls in some small engines are chrome-plated to improve their resistance to wear. The piston rings are also made of material that gives long life. Shafts are supported by bushings or bearings. Three types of bearing surfaces found in engines are shown in (fig -7).

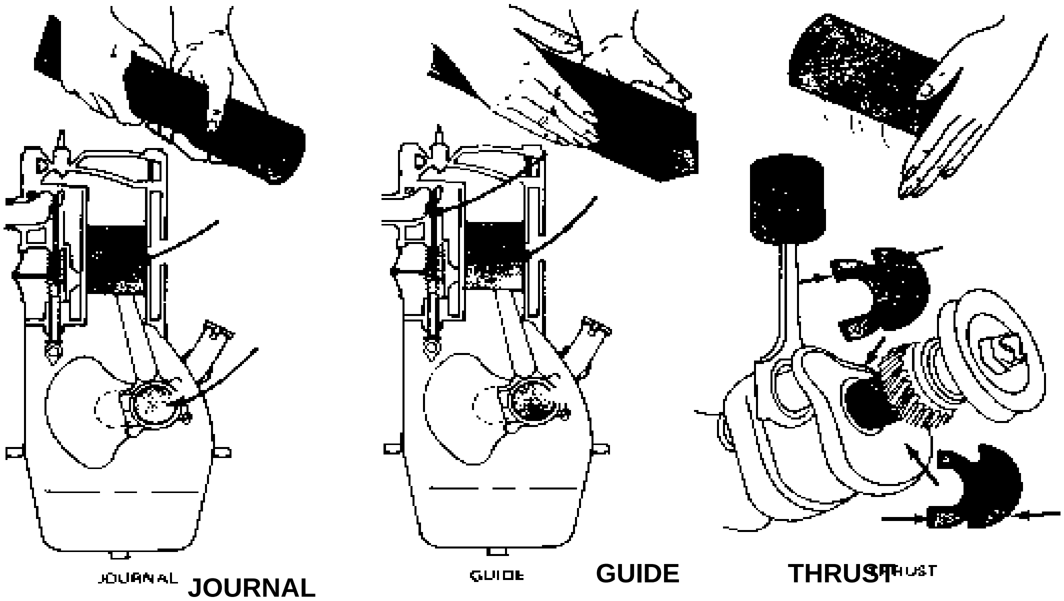

Fig -7 Three Types of Friction-Bearing Surfaces In an Automobile Engine

Bore and Stroke

5 The size of an engine cylinder is given by its bore an stroke. The bore is the diameter of the cylinder. The stroke is the distance the piston travels from BDC (bottom dead center) to TDC (top dead center). (See Fig. 8) The bore is always mentioned first. For example, in a 4-by 3½-inch cylinder, the diameter, or bore, is 4 inches, and the stroke is 3½ inches. These measurements are used to figure the piston displacement. Before about 1955, most engines where built with a long stroke and smaller bore, like, for instance, a 3 by 4 engine. More recently, engines have been designed with a shorter stroke and large bore. For example, one recent 350-hp Chevrolet engine has a 4-inch bore and a 3¼-inch stroke. Such engines are called "over square." A "square" engine has a bore and stoke of equal lengths. There are several reason for the swing to the over square engine. With the shorter piston stroke, there is less friction loss (Fig-9). and shorter piston-ring travel (which means less wear). Also, the shorter stroke reduces the loads on the engine bearings. In addition, the shorter stroke permits a reduction of engine height and, thus, a lower hood line.

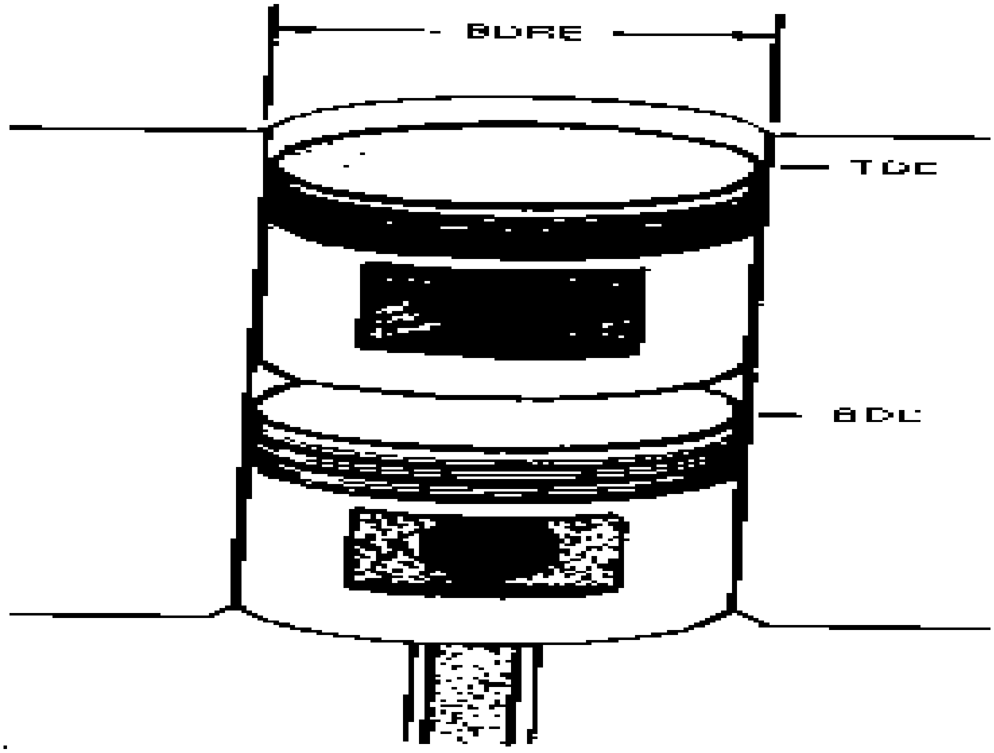

Fig-8 Bore and Stroke of an Engine Cylinder.

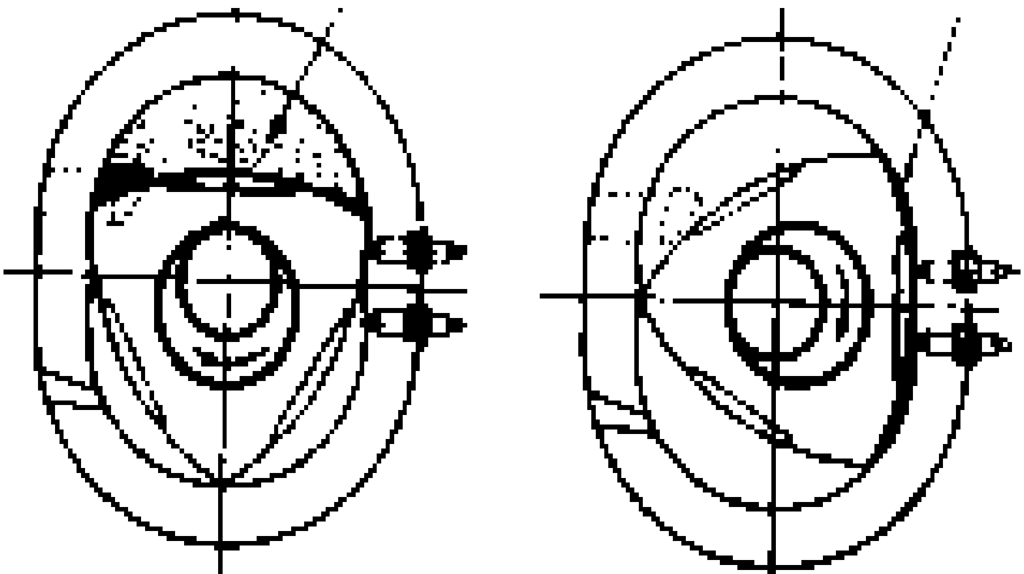

Fig -9 ingle Chamber Capacity of a Wankel Engine

NOTE: *In the metric system, bore and stroke are given in millimeters (mm). Thus, a 4-by 3.5-inch cylinder would be a 101.6-by 88.9-mm cylinder.*

Piston Displacement

6 Piston displacement is the volume that the piston displaces, or "sweeps out," as it moves from BDC to TDC. The piston displacement of a 4- by $3^{1/2}$ -inch cylinder, for example, is the volume of a cylinder 4 inches in diameter and 3½ inches long.

That is,

$$\frac{\eta \times D^2 \times L}{4} = \frac{3.1416 \times 4^2 \times 3\frac{1}{2}}{4}$$

$$= \frac{3.1416 \times 16 \times 3\frac{1}{2}}{4} = 43.98 \text{ in}^3$$

If the engine has eight cylinders, the total displacement is 43.98 times 8, or 351.84 cubic inches.

Note: *In the metric system, displacement is given in cubic centimeters (cc). Thus, a 200-cubic-inch displacement would be 3,280 cc in metric measurements. And, since, 1000 cc equals 1 liter (1) 3,280 cc is 3.281. In competitive racing, displacement limitations are set. Thus, at the Indianapolis 500-the "Indy 500" - the maximum allowable displacement for a recent race was set at 305.1 cubic inches for non-supercharged engines. In many races, the displacement is given in terms of liters. Thus, the indy-500 specification (305.1 cubic inches) is 5 liters. (1 liter is 61.02 cubic inches, so 305.1 divided by 61.02 is 5). The Wankel engine does not have pistons, so you cannot figure piston displacement on the Wankel. But you can figure the displacement the rotor produces as the volume in the combustion chamber goes from maximum to minimum (Fig-9). For example, suppose the volume is reduced 490 cc as it goes from maximum to minimum (Fig-9). This is the displacement in one of the three chambers of the rotor. Instead of using the term "piston displacement," this figure is called "single-chamber capacity."*

Compression Ratio

7. The compression ratio of an engine is a measure of how much the air-fuel mixture is compressed in an engine cylinder. It is calculated by dividing the air volume in one cylinder with the piston at BDC by the air volume with the piston at TDC (Fig. 10).

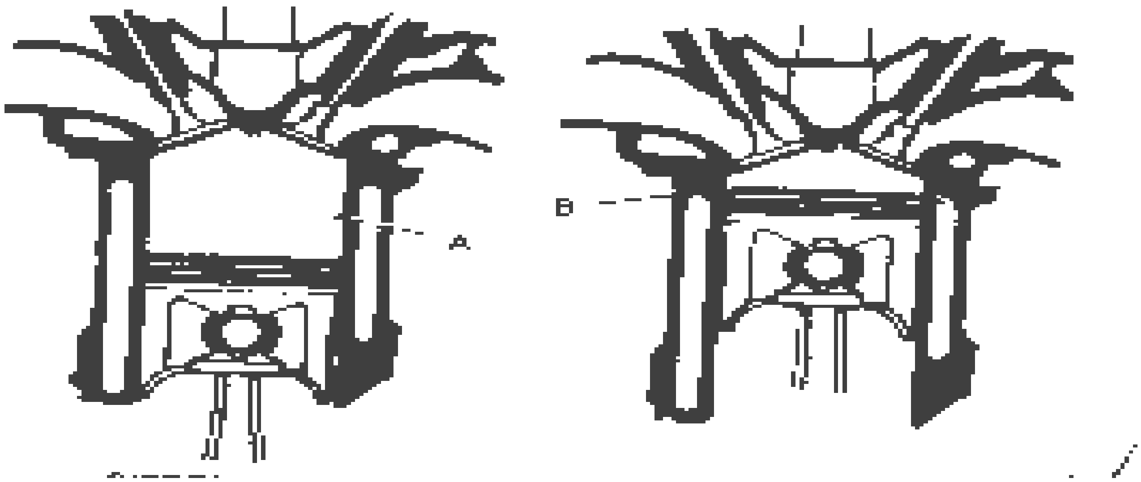

Fig -10, Compression ratio is the volume in a cylinder with the piston at BDC, divided by volume with the piston at TDC, or A divided by B.

NOTE *: The air volume with the piston at TDC is called the clearance volume. It is the clearance that remains above the piston at TDC.*

For example, the engine of one car has a cylinder volume of 42.35 cubic inches [694 cm^3] at BDC (A in Fig-12). It has a clearance volume of 4.45 cubic inches [73^3 cm] (B in Fig-10). The compression ratio, therefore, is 42, 35 divided by 4.45 [694÷73], or 9.5/1 (that is 9.5:1). In other words, during the compression stroke, the air-fuel mixture is compressed from a volume of 42.35 cubic inches [694cm^3], or to 1/9.5 of its original volume.

Increasing Compression Ratio

8. In recent years, the compression ratios of automotive engines have increased. This increase offers several advantages. The power and economy of an engine increase as the compression ratio goes up (within limits). This does not required an increase in engine size or weight. An engine with a higher compression ratio "squeezes" the air-fuel mixture harder (compresses it more). This causes the air-fuel mixture to produce more power on the power stroke. Here is the reason: A higher compression ratio means a higher pressure at the end of the compression stroke. This means higher combustion pressures during the power stroke; the piston is pushed harder. The burning gases also expand to a greater volume. It all adds up to this: There is more push on the piston for a larger part of the power stroke. More power is obtained from each power stroke. Increasing the compression ratio does, however, make special problems. As the compression ratio goes up, detonation, or "knocking," As the compression ratio goes up, detonation, or "knocking" becomes more of a problem.

Volumetric Efficiency

9. a. The amount of air-fuel mixture taken into the cylinder on the intake stroke is a measure of the engine’s volumetric efficiency. If the mixture were drawn into the cylinder very slowly, a full measure could get in. But the mixture must pass rapidly through narrow openings and bends in the carburetor and intake manifold. In addition, the mixture is heated (from engine heat); it therefore expands. The rapid movement and heating reduce the amount of mixture that can get into the cylinder. A full charge of air-fuel mixture cannot enter, because the time is too short and because the air becomes heated. Volumetric efficiency is the ratio of the amount of air-fuel mixture that actually enters the cylinder to the amount that could possibly enter. For example, a certain cylinder has an air volume (A in Fig-12) of 47 cubic inches (770 cm^3]. If the cylinder were allowed to completely "fill up," it would take in 0.034 ounce [0.964 g] of air. However, suppose that the engine is running at a high speed, so that only 0.027 ounce [0.765 g] of air can enter during each intake stroke. This means that the volumetric efficiency is only about 80 percent (0.027 is 80 percent of 0.034). Actually, 80, percent is a good volumetric efficiency for an engine running at fairly high speed. The volumetric efficiency of some engines may drop to as low as 50 percent at high speeds. This is another way of saying that the cylinders are only "half-filled" at high speeds.

b. This is one reason why engine speed and output cannot increase without limit. At higher speed, the engine has a harder time "breathing," or drawing in air. It is "starved" for air and cannot produce any further increase in power out put. To improve volumetric efficiency, intake valves can be made larger. In addition, the number of valves per cylinder can be increased. Also, valve lift can be increased. That, is the cam lobes on the cams can be made larger so the valve opens wider. However, when this is done, there is danger of the piston head striking the valve head. Unless the engine design takes this into account, serious engine damage could result. Volumetric efficiency can also be increased by making the intake-manifold passages wider, and as straight and short as possible. Also, the smoothness of the inside surfaces of the intake manifolds is important. Rough surfaces slow down the flow of air-fuel mixture. Another way to improve volumetric efficiency is to use carburetors with extra circuits, or air passages (called "barrels"), which open at high speed to improve engine breathing.

Brake Horsepower

10. a. The horsepower output of engines is measured in terms of brake horsepower (bhp). The name comes from the braking device that is used to hold engine speed down while horsepower is measured. When an engine is rated at 300 horsepower [223.8 kW], for example, it is really brake horsepower that is meant. This is the amount of power the engine can produce at a certain speed at wide - open throttle. The usual way to rate an engine is with a dynamometer Fig-11. This device has a mechanism (an electric generator or a water brake) which can put different load on the engine. Thus, the dynamometer can measure the amount of horsepower the engine can develop under various operating conditions. Some dynamometers are used to test engines that have been removed from cars. The dynamometer used in

the service shop checks the engine in the car. This type of unit is called a chassis dynamometer (Fig-11).

b. On these, the rear wheels of the car are placed on rollers.¸ the engine drives the wheels, and the wheels drive the rollers. The rollers can be loaded varying amounts so that engine output can be measured. The use of the chassis dynamometer is becoming more common in the automotive servicing field. It can give a very quick report on engine conditions (by measuring output at various speeds and loads). This type of dynamometer is also used to test and adjust automatic transmissions right in the shop; no road testing is necessary.

Indicated Horsepower

11. a. Indicated horsepower (ihp) is the power that the engine develops inside the combustion chambers during the combustion process. A special device is required to measure ihp. It measures the pressures in the engine cylinders (Fig-12).

b. The four small drawings show the four piston strokes, and the curve shows the pressures in the cylinder during these four strokes. These pressures are used to figure ihp. Of course, ihp is well above bhp because some of the power developed in the engine cylinders is used up to overcome friction.

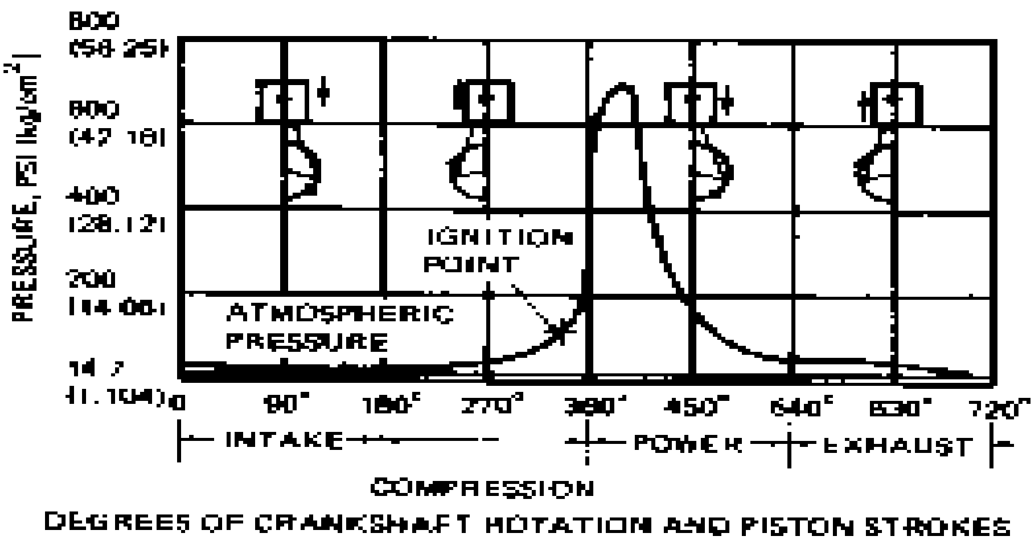

Fig -12, Pressures In an Engine Cylinder with During the Four Piston Stroke

Friction Horsepower

12. Friction horsepower (fhp) is the power required to overcome the friction of the moving parts in the engine. One of the major causes of friction loss (or fhp) is piston-ring friction. Under some conditions, the friction of the rings moving on the cylinder walls accounts for 75 percent of all friction losses in the engine. These points up one advantage of the short-stroke, over square engine. With a short stroke, the piston rings do not have as far to move,

and thus ring friction is lower. Figure 14 shows a curve of friction horsepower for one engine operating under certain specified conditions.

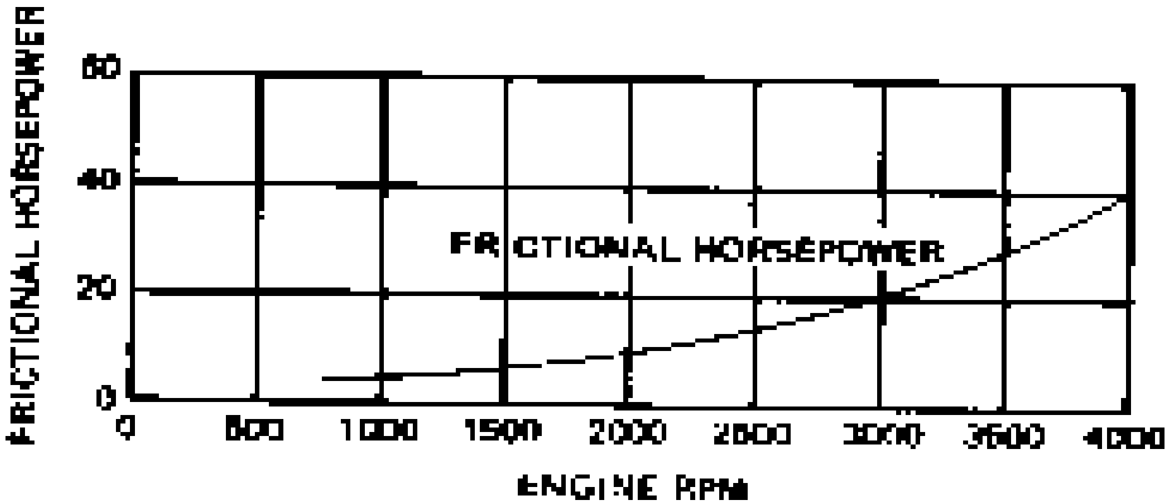

Fig -13, Friction Horse Power Curve, Showing the Relationship between FHP and Engine Speed.

<u>Relating BHP, IHP, and FHP</u>

13. Brake horsepower is the power delivered, IHP is the power developed in the engine, and FHP is the power lost due to friction. The relationship among the three is : BHP = IHP –FHP. That is, the horsepower delivered by the engine (BHP) is equal to the horsepower developed (IHP) minus the power lost due to friction (FHP).

<u>Brake horse power Versus Torque</u>

14. a. The torque that an engine can develop changes with engine speed during intermediate speeds, volumetric efficiency is high. There is sufficient time for the cylinders to become fairly well ‘filled up’. This means that with a fairly full charge of air fuel mixture, higher combustion pressures will develop. With higher combustion pressures, the engine torque is higher. But, at higher speed, volumetric efficiency drops off (there is not enough time for the cylinders to become filled up with air-fuel mixture).

b. Since there is less air-fuel mixture to burn, the combustion pressures lower. Fig-13-14 shows how the torque drops off as engine speed increases. The BHP curve of an engine is different from the torque curve. Fig-11-12 compares the BHP of the same engine for which the torque curve is shown it starts low at low speed and increases until a high engine speed is reached. Then, at still higher engine speeds, BHP drops off. The drop- off of BHP is due to reduced torque at higher speed and to increased FHP at the higher speed. Fig-11-13 compares the curves of torque, BHP and FHP for and engine.

Note: *That the cars in fig-11-12 are for one particular engine only. Different engines have different torque, BHP and FHP curves. Peaks may be at higher or lower speeds and the relationships may not be as shown in the curves in fig-11-12.*

Engine Efficiency

15. The term efficiency relates the effort exerted and the results obtained. For engines, efficiency is the relation between the power delivered and the power that could be obtained, if the engine operated without any power loss. Engine efficiency can be computed in two ways as, mechanical efficiency and as thermal efficiency.

a. **Mechanical efficiency:** This is the relationship between BHP and IHP. It is:

Mechanical efficiency = $\frac{BHP}{IHP}$

Example: *At A Certain Speed, The BHP ngine Is 116, And Its IHP Is 135. Mechanical Efficiency Is Thus BHP / IHP = 11635=0.86, Or 86 Percent. This Is, 86 Percent Of The Power Developed In The Cylinders Is Delivered By The Engine. The Remaining 14 Percent, Or 19 Hp [14.17 Kw], Is Consumed As FHP.*

b. **Thermal efficiency :** **"**Thermal means" of or related to heat. The thermal efficiency of an engine is the relation between the power output and the energy in the fuel burned to produce this output. Some of the heat produced by combustion is carried away by the engine cooling system. Some of it is lost in the exhaust gases, which are hot when they leave the cylinder. These are heat (thermal) losses that reduce the thermal efficiency of the engine. They do not add to the power output of the engine. The remainder of the heat is used by the engine to develop power. Because a great deal of heat is lost during engine operation, thermal efficiencies may be as low as 20 percent. They are seldom higher than 25 percent.

Overall Efficiency

16. The gasoline enters the engine with certain energy content, a certain ability to do work. At every step in the process, form the burning of the gasoline in the cylinders to the rotation of the car wheels, energy is lost.. Note that as little as 15 percent of the energy in the gasoline remains to actually propel the car. This energy is used to overcome rolling resistance, air resistance, and power-train resistance and to accelerate the car.

a. **Rolling resistance.** This results from irregularities in the road over which the wheels ride. It is also a result of the flexing of the tires as they turn under the car.

b. **Air resistance**. Air resistance is the resistance of the air to the passage of the car body through it. As car speed increases, also does the air resistance. At 90 mph (miles per hour) [144.8 km/h], tests show that as much as 75 percent of engine power is used up in overcoming air resistance. Streamlining the car body reduces power loss from air resistance.

c. **Power train resistance.** Some engine power is lost between the engine and drive wheels. One reason is because of friction between moving parts in the power train, which includes the clutch, transmissions and drive axle.

d. **Acceleration**. Power is required to increase car speed. The power applied to accelerate the car overcomes the inertia of the car. Energy in the form of speed is stored in the car.

BAF BASE ZAHURUL HAQUE (TRG WG)

(Aero Engg Trg Sqn)

Syllabus : Automobile General Diesel and Petrol Technology

Course : Trade Training Advance, MTOF

Subject : Reconditioning of Engine

Aim : To Study General of Reconditioning of Engine

Ref : AP-3126 Sec 4, Chap 1.

GENERAL

Introduction

1. The information contained in this section is intended to convey a broad outline of the work entailed when repairs become necessary or when a vehicle is overhauled. Detailed information for a particular vehicle is contained in the Air Publication for that type of vehicle. A tradesman should always consult the relevant Air Publication also contains the "Schedule of Fits and Clearances" to which reference must be made when checking or refitting any component parts.

Reconditioning

2. It is the responsibility of all Officers in charge of M.T. servicing to ensure that the fullest use is made of all available facilities to achieve the maximum utilization of each vehicle before it requires reconditioning or extensive repair. M.T. personnel must realize that efficient servicing is a very important factor concerning the life of a vehicle. A list of standard vehicles is attached as Appendix to A.P. 1464E, Vol. 2, Part 1, Leaflet 25, which states the minimum life which is to be contained from a vehicle before it is offered to Headquarters N o. 40 Group for reconditioning or extensive repair resulting from normal usage. The Senior Technical Staff Officer at Command Headquarters will decide when reconditioning of static or semi-static types of vehicle is necessary. The successful completion of an overhaul will depend upon the Following factors:

a. An accurate survey of the work to be done combined with (if possible) a road test of the vehicle.

b. A complete chain of inspection throughout the overhaul to ensure satisfactory and consistent workmanship.

c. Verification after test that the vehicle is fully road worthy and in every way capable of meeting service requirements.

d. Technical administration will be built around the above three principles. The work will be divided into well defined phases and, in some instances, into further sub-stages. This simplifies workshop layout and enables personnel to become more skilled, and consequently more efficient at their particular task than if they were to work on one vehicle from start to finish. Monotony can be avoided by a periodical change of task or phase.

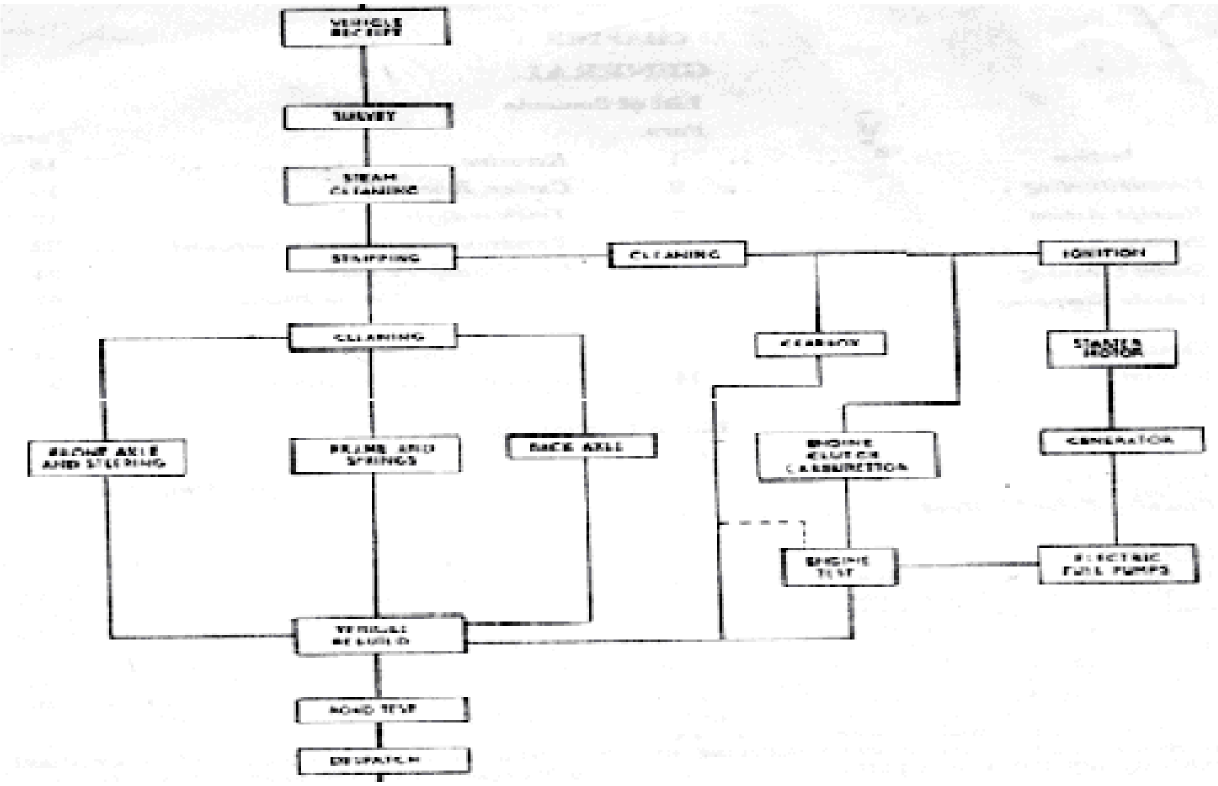

Fig-1
Overhaul Lay-out

e. Efficient documentation at each phase ensures high quality of both work and inspection, and reduces the inspection staff to a minimum. A typical set of documents is shown in the Appendices. The forms should be filed progressively and so provide a final record of the vehicle overhaul history for future reference. A Precis of the work done during the overhaul should be entered in the vehicle logbook, and a certificate of road worthiness attached thereto before despatch.

Receipt Action

3. On receipt, each vehicle must be checked according to the relevant Checking List and to the vehicle inventory (Form 748), all items found surplus or deficient being recorded in duplicate on pro-forma similar to Appendix 1. One copy should be kept in the overhaul history file and the other sent to the Equipment Section for correlation with the receipt voucher with a view to raising a Discrepancy Report where necessary. All loose items of equipment should be checked for serviceability and, after suitable identification, stored for safety.

Survey

4. The vehicle will be surveyed by a responsible officer or N.C.O. of the inspection staff, who may be aided by a member of the production staff, who may be aided by a member of the production staff. Forms 813 and 523 for the vehicle should be carefully checked before the survey is commenced. The final classification will be made with due regard to these two documents the survey itself and, if possible, a road test. he amount of stripping and rectification to be done will depend on the total deterioration of the vehicle, including such factors as mileage, previous replacements, conditions of operation, and certain defects as recorded in Form 523. The general condition of the vehicle should be such that a further lease of operational life of 29,000 miles or three years in a semi-static role may be expected from it after overhaul. All components not conforming to this requirement must receive the necessary attention during the overhaul. A pro-forma similar to Appendix 2 should be completed and have attached to it a pro-forma similar to Appendix 3 containing modification data. The vehicle can now be allocated to its position in the production schedule, and the Survey Sheet becomes a record of the work to be done during the overhaul. Parts which the survey has shown to be unserviceable are now put on demand so that they will be ready when the vehicle comes on the assembly line.

Steam Cleaning

5. When commitments are large enough, a thorough cleaning of the vehicle prior to stripping will be given with the aid of a stream cleaning plat. This plant uses a mixture of water and degreasing solution to provide a jet of steam at high pressure for removing dirt, oil, grease, and other contaminants. Details of the plat are given in Air Publication 4329A, Vol. 1 and Vol.6.

Vehicle Stripping

6. Reference should be made to the relevant Air Publication if personnel are not conversant with the particular type of vehicle being worked upon. Main components when removed should be sent to their respective overhaul bays. Electrical items will be sent to the Electrical Section, which may not necessarily be located in the M.T. overhaul shop. Main components should then be stripped to detail parts before cleaning. Complete identification may be maintained by the use of trolleys, racks, and suitable methods of marking, but at a Repair Depot where commitments are large it may be found that no attempt is made to identify parts (unless specifically stated in the Air Publication).

BAF BASE ZAHURUL HAQUE (TRG WG)

(Aero Engg Trg Sqn)

Syllabus : Automobile General Diesel and Petrol Technology

Course : Trade Training Advance, MTOF

Subject : Reconditioning of Engine

Aim : To Study Reconditioning of Engine Components
Ref : AP-3126 Sec 4, Chap 1.

RECONDITIONING OF ENGINE COMPONENTS

Introduction

1. When an engine is received in the Engine Overhaul Section it will must probably be complete with clutch assembly, carburetor, fuel pump and electrical equipment. All electrical equipment will be removed and dispatched to the Electrical Section. Where commitments are large, separate bays will also specialize in clutches and carburetors and mechanical fuel pumps.

Stripping

2. Engines will have to be stripped to detail parts for cleaning and degreasing prior to viewing. Components may be suitably marked for identification, but where commitments are large, identification may be dispensed with, except for the cylinder block, which will retain the original engine number. The stripping procedure is always detailed in the relevant Air Publication, and this should always be consulted if any doubt exists. The usual precautions must be observed to prevent damage to any parts. Cylinder head nuts must be gradually slackened, working in the reverse order to the tightening sequence. A diagram of the tightening sequence is included in the relevant Air Publication. On some engines jack nuts are provided to facilitate the breaking of the cylinder head joint. Consequently, no attempt must be made to slacken the jack nuts until the cylinder head is definitely ready for removal.

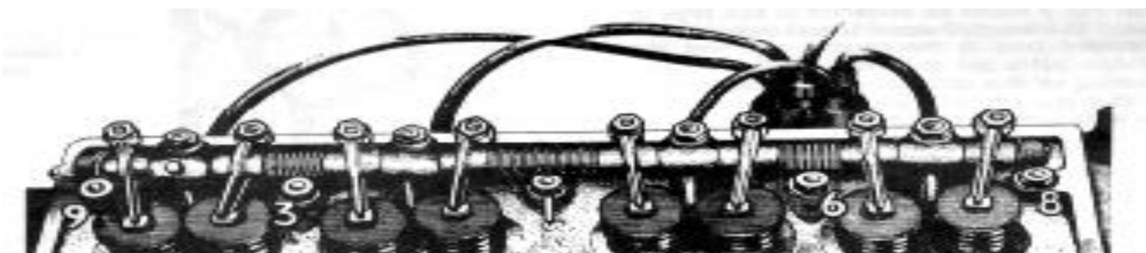

Fig – 2
Tightening Cylinder Head Nuts

Care when slackening cylinder head nuts applies especially to aluminum alloy heads; the head should be quite cold before any slackening of the nuts is attempted. Special device are sometimes provided to facilitate the lifting of a cylinder hear, but useful lifting tools can quite easily be made from the bodies of scrapped sparking plugs. If a head is difficult to remove, never attempt to lever it off. The joint may be broken and the head loosened by jarring the head with a wooden drift or hide faced hammer. Always break the joint and lift evenly.

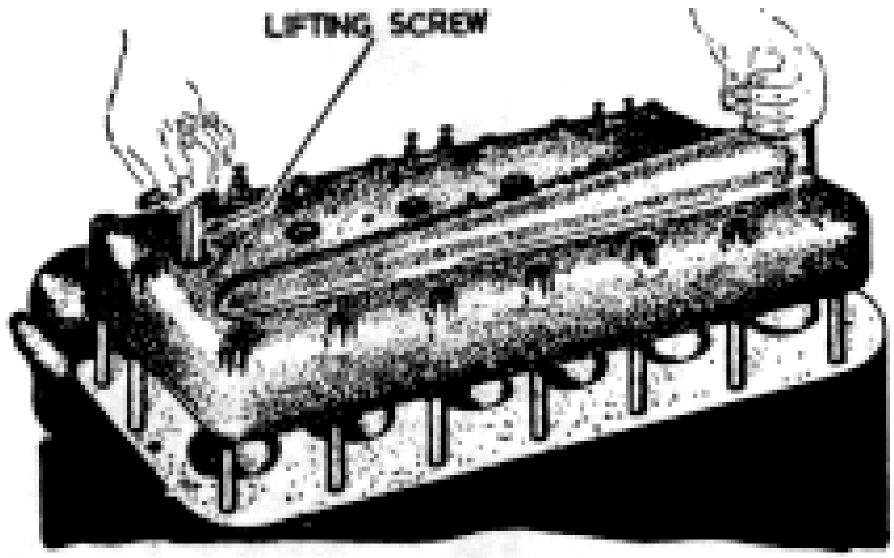

Fig- 3Breaking Cylinder Head Joint

The removal of the valves will necessitate the use of a valve spring compressing tool, the type of fool being dependent upon the type of engine. Fig-4 shows a valve spring compressing tool in used on an Austin cylinder head. An extractor is usually required for the removal of crankshaft main bearing caps, and Fig -5, shows an extractor of this type in use. The knurled screw is screwed into the threaded hole in the bearing cap, and the bridge piece is positioned with its legs bearing on the crankcase. Turning the nut with a spanner will cause the bearing cap to be withdrawn from the housing.

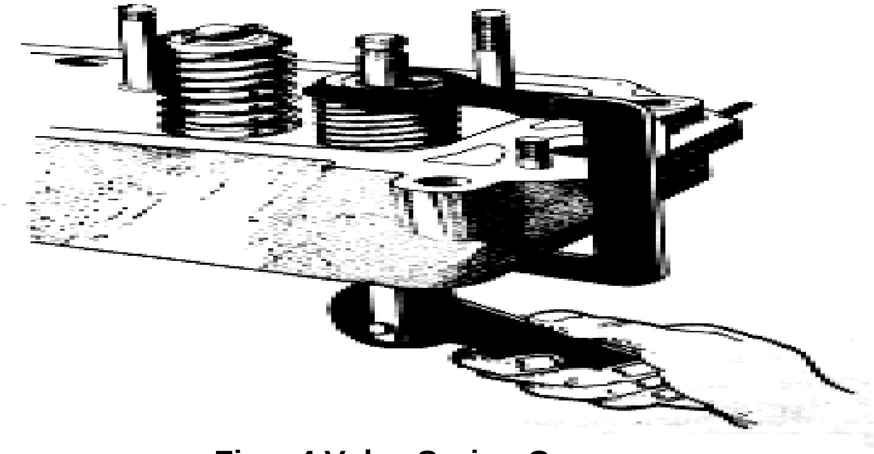

Fig – 4 Valve Spring Compressor

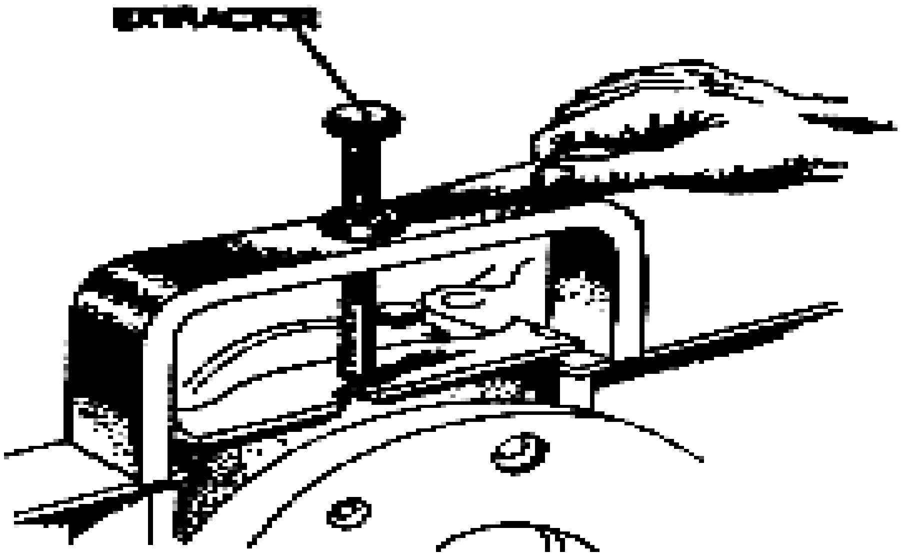

Fig -5 Withdrawing Main Bearing Cap

<u>Viewing and Reconditioning</u>

3. a. **<u>General.</u>** After the component parts have been cleaned by one of the approved processes, the parts will be viewed and will be passed for further service, rejected, or reconditioned. The following text is intended to give a broad outline of the procedure.

b. **<u>Valves.</u>** Examine the valve faces for pitting and ridging, the heads for burning and war page, and the cullet seating for wear. The stem should be measured by a micrometer for wear, taper and ovality. Valve stems should be checked for bow, and their heads for truth, using a rig as shown in Fig-6. Rotate the valve and note the reading on the dial, which, in the case of the stem, will be twice the actual error. If the valve stem is true, the head can then be tested in a similar manner.

c. **Valves Seats.** Inspect the valve seatings in the block or head for burning and pitting. If the seatings are inserts, inspect for cracks and check for looseness. If valve seats are damaged burnt or badly pitted, they will have to be refaced or rectified by the fitting of insets. Valve seats can be tested for concentricity by using a dial test indicator as shown in Fig-7.

d. **Valve Seat Inserts**. Inserts are fitted in a variety of ways, such as by pressing, “caulking”, screwing and shrinking. Consequently, the relevant Air Publication must always be consulted when inserts have to be fitted, because special equipment will invariably be required, and any machining will have to be done to the specified tolerances.

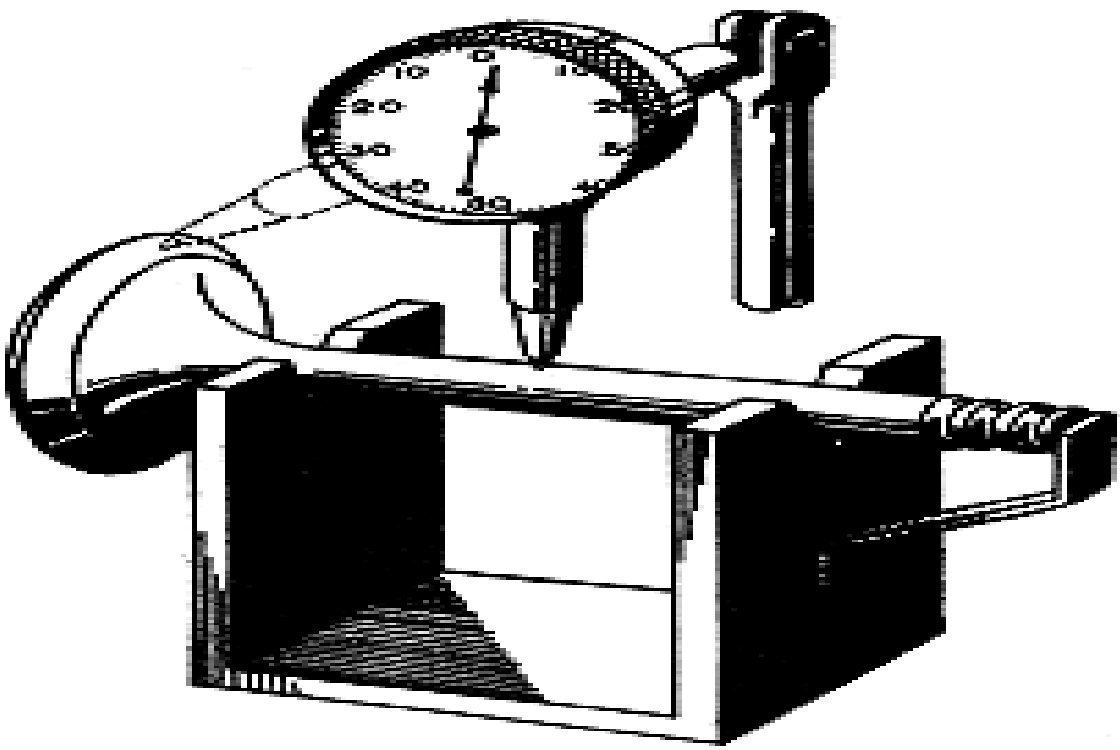

Fig – 6 Checking a Valve

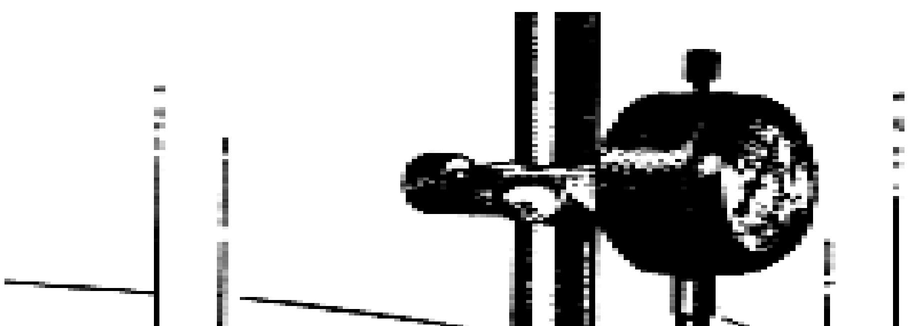

Fig – 7 Testing Concentricity of Seating

e. **Valve Guides.** It is essential that guides are checked and any necessary rectification is done before refacing the valve seatings. Examine the guides for scoring, picking up and corrosion, and check for looseness. Check the bore for size with a plug gauge; if gauges are not available, use a new valve stem to check for excessive wear. Guides may be removed and replaced by using a stepped drift but a simple extracting and inserting tool if not available, can quite easily be made up locally; this tool is shown being used in Fig -8. Ensure that a new guide is always fitted to the dimensions given in the relevant Air Publication.

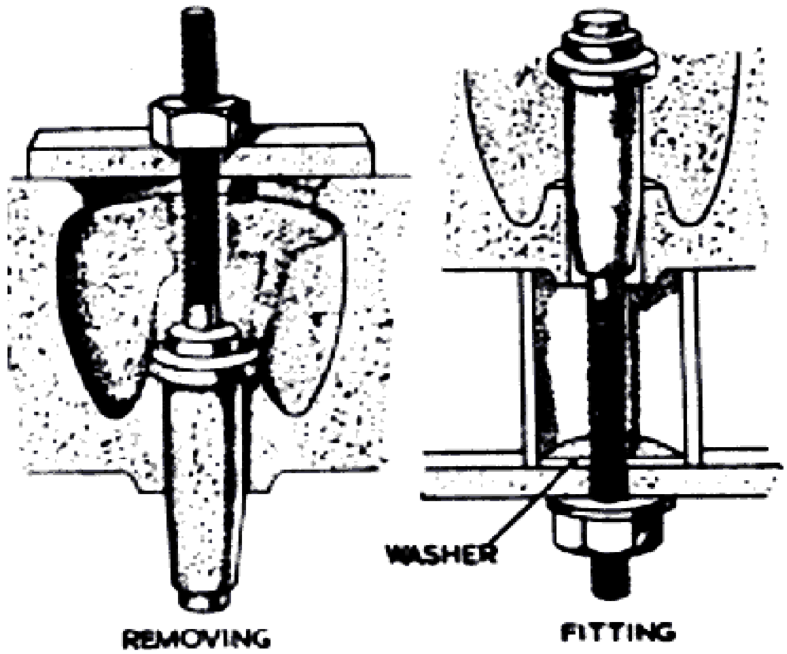

Fig -8 Valve Guide Tool

f. **<u>Valve Lapping.</u>** Lightly smear the valve face with grinding paste. The choice of rough or fine paste will be determined by the experience of the operator. If rough paste is required, the following operations will also have to be applied using fine paste after a satisfactory result has been attained with the rough paste. Place a light spring over the valve stem before inserting the valve in its guide. Press the valve on to its seat, and impart to it a slight backward and forward rotating motion by means of the appropriate tool. A suction type tool is shown i n use in Fig -9, but a screw drive will be required if the valve head is slotted, and a pronged tool if there are tow holes provided in the valve head. There is also a special kit available which is similar to a drill brace; the appropriate valve tool is secure in the chuck, the aforementioned motion being imparted when the handle of the tool is turned. Allow the spring to lift the valve off its seat occasionally; give the valve half a turn, depress it's again, and them continue the motion. Continue these operations until a well defined matt-grey ring on the face of the valve is obtained.

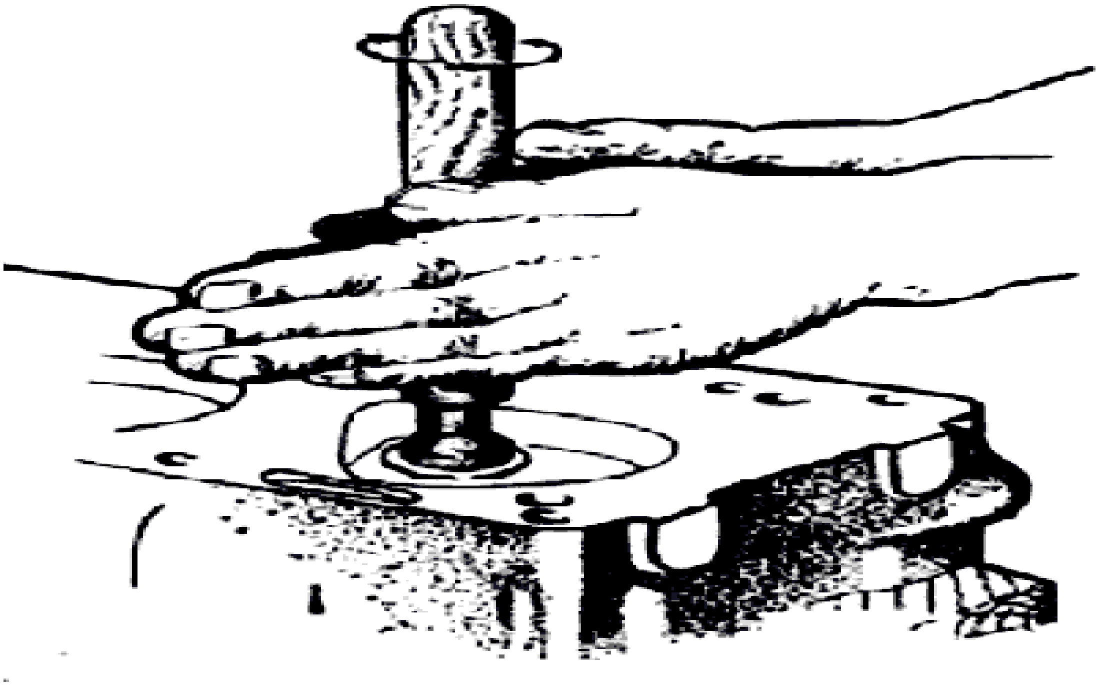

Fig -9 Suction Type Tool

One of the following checks can be made; to find out if the lapping in has produced a gas-

tight joint.

(1) Wipe the valve face and seat clean, and make a series of pencil lines across the valve face. Insert the valve in its guide, press down and give it several turns as for lapping in. Remove the valve and examine the pencil lines; if all the lines are cut through at the matt ring, the joint can be regarded as gas-tight.

(2(This check is very similar to (a), except that in this case the valve face is lightly smeared with engineers' marking instead of pencil marks. On examination, a complete circle of marking should appear on both valve face and seating, indicating a good seal.

(3) This check entails assembling the valve to its seat and fitting its springs and collects. Kerosene is then poured into the port and examination made for any leakage.

Note. It is important that all traces of the paste used for lapping in are removed. This can be done using kerosene and clean rag.

g. **Refacing Valves.** Valves must be refaced if it is unlikely that they would rapidly clean up with ordinary lapping in. If the seatings are in good condition, it is quite practicable to reface valves and lap them in on their seatings. It is usually better to replace a valve that needs extensive refacing,
because removal of metal will reduce the diameter of the head, and "pocketing" will result. The thickness of the head will also be reduced, and this is important as the thickness above the face edge should generally not be less than 1 in 32. Hand cutters have been used in the past for refacing valves, but and electric grinding machine (Fig -11) is now invariably used. The method of operation is given in the following paragraphs.

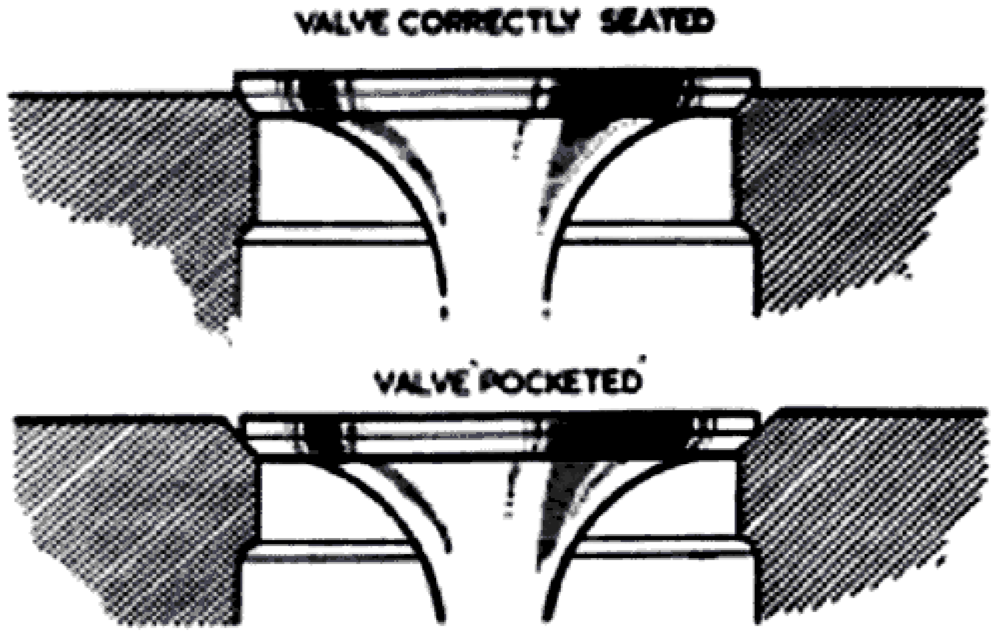

Fig-10

Valve Seating

Dress the grinding wheel by setting the work head to 45^0 and fitting the diamond dresser attachment (Fig -12). Switch on the grinding wheel motor, and move the centre of the wheel into the diamond. Take light cuts, and traverse the diamond slowly across the face of the grinding wheel until it becomes smooth and true. One wheel dressing is usually sufficient for a set of valves. Locate the work head at the exact angle corresponding to the angle of the valve face. Insert the valve in the collect so that the stem is gripped on the same portion that travels in the guide. The stem must pass through the back end of the collect order to prevent collect breakage; the collect should, therefore, grip the stem immediately below the upper limit of guide travel, which can usually be easily seen.

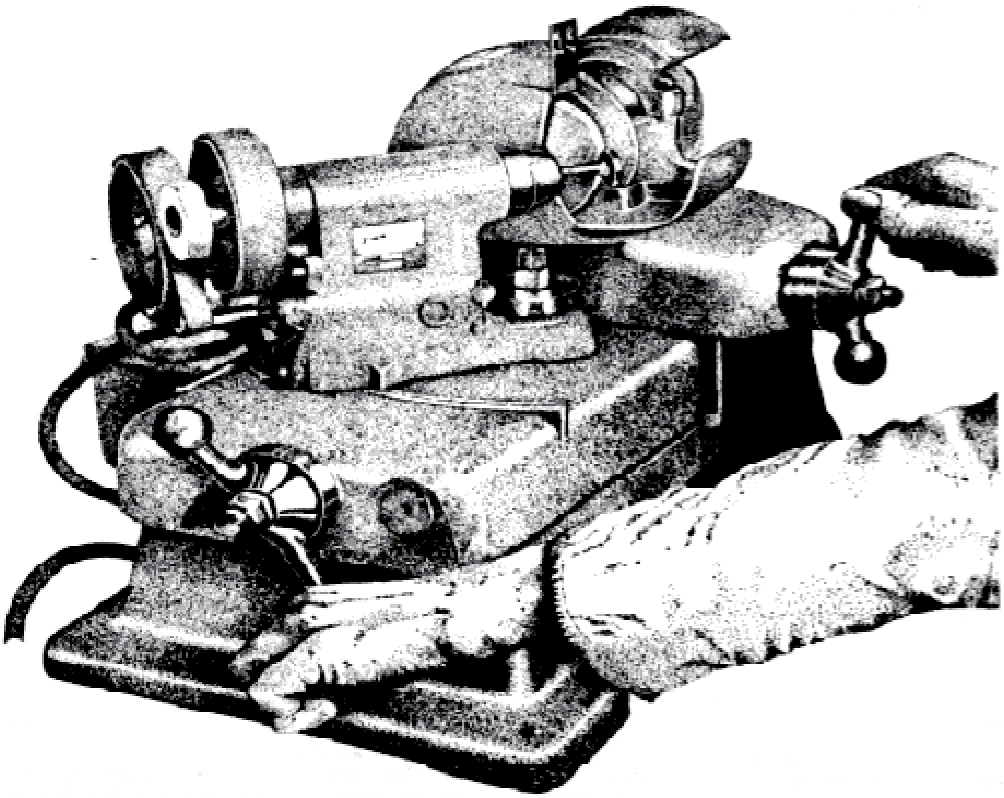

Fig -11 Electric Grinder

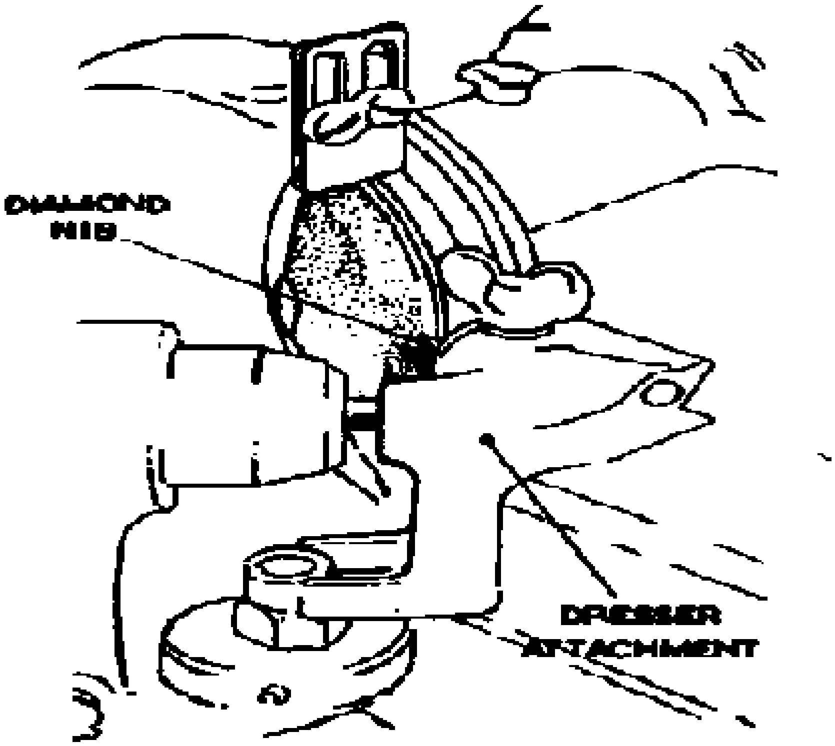

Fig-12 Dressing the Grinding Wheel.

Check the travel of the work table to see if the work head spindle or valve stem will foul the grinding wheel. Any fouling can be prevented by releasing the knurled set screw, moving the stop rod to the required position, and then re-tightening the screw (Fig -13). Switch on the work head and wheel head motors and bring the valve in front of the wheel. Feed the wheel slowly into the valve, taking a very light cut. Move the work head table back and forth with short strokes, suing the full face of the wheel but always keeping the valve on the wheel. The short strokes should be done slowly and evenly. To make inspection or when finished grinding back the wellhead table away from the valve, not the valve off the wheel. Be careful to remove only enough metal to remove pitting or riding, and giving a new true surface.

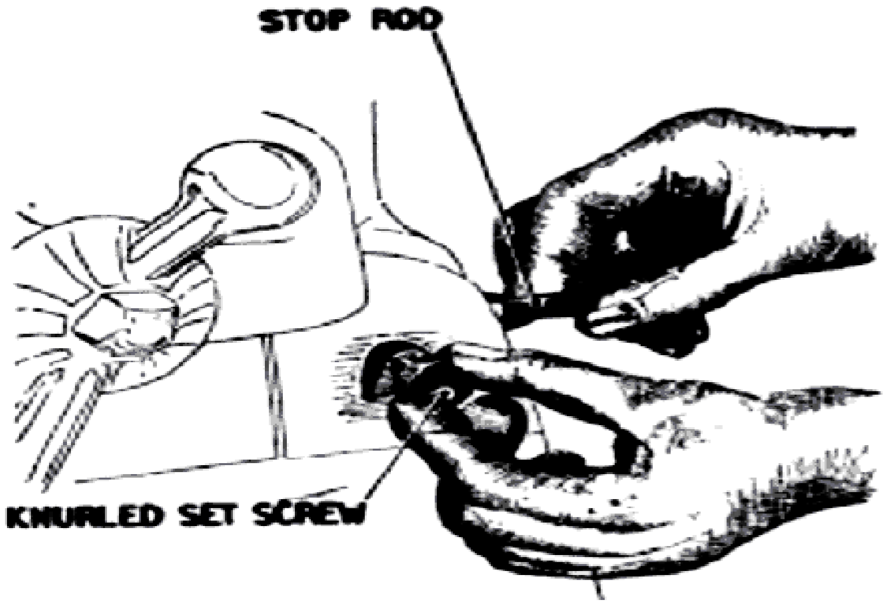

Fig -13 Work Table Travel Stop

If the thickness of the valve head is reduced below the limit, it may be possible to remove the thin edge by use of the grinding machine provided the diameter of the head is greater than that of the seat. Does not touch a newly ground valve face as this will cause rusting. Valves with have been refaced but are not required for immediate assembly, should be placed in a rack in order to prevent damage.

h. **<u>Coolant Fluid.</u>** This is a mixture of approximately fifty parts of water to one of coolant. For practical purposes it is sufficient to pour coolant into the reservoir until it just covers the bottom surface, and then add water until the total level is approximately ½in. from the top of the reservoir. The mixture should then be thoroughly stirred. Note. Never run the machine with water alone in the reservoir. The coolant must ALWAYS be present, not only to assist in obtaining a first class finish but to prevent the mechanical details of the pump, etc., from becoming rusty.

j. **<u>Refacing Valve Seats.</u>** This operation can be done by sing either hand cutters or electric grinding equipment; the latter method must be used if hardened steel inserts are fitted. It is again emphasized that any replacement of valve guides must be done before starting to reface the valve seats.

(1) **<u>Hand Cutters.</u>** A seating is refaced by mounting the correct angled cutter on a pilot fitted in the valve guide (Fig -14). Revolve the cutter smoothly in a clockwise direction until all damage has disappeared and a new face appears. No lubricant is required, but care should be taken to remove as little metal as possible.

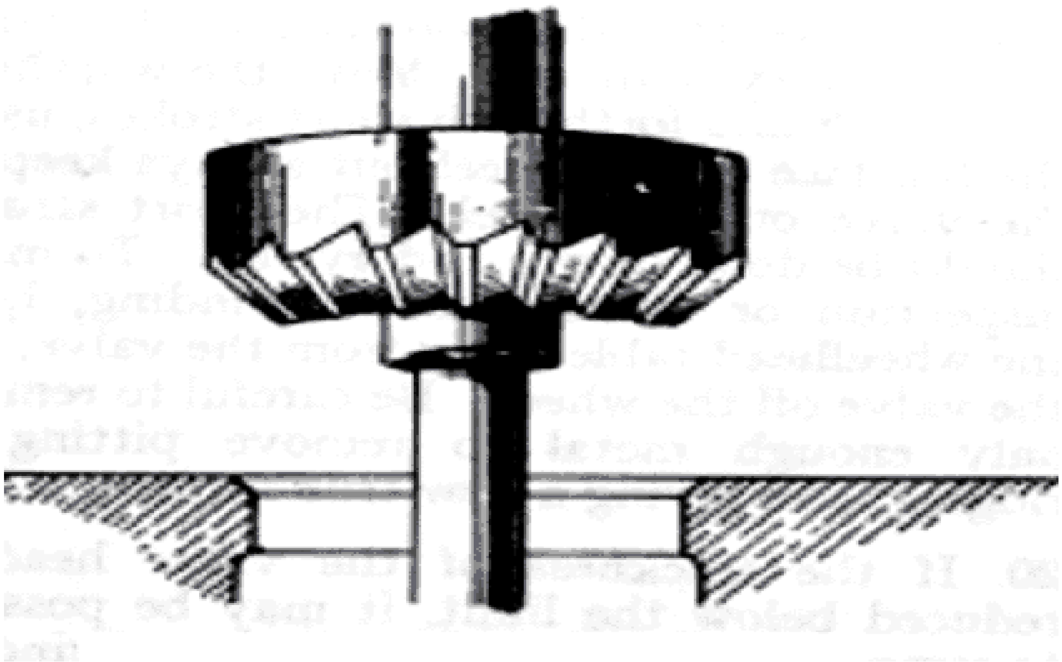

Fig.-14
Re-facing Cutter

The valve should then be inserted and checked for pocketing. If this condition exists, but it is considered that it can be rectified, sue the correct cutter for this operation as shown in Fig -15.

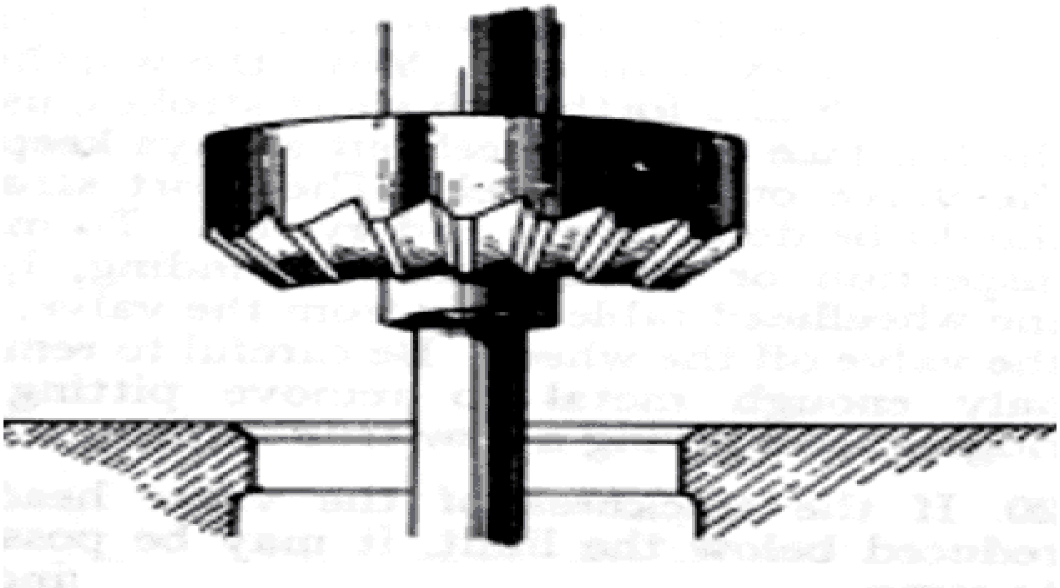

Fig -15 Rectifying Pocketing

Check the width of the valve seating and if it is too wide, rectify by using the correct cutter as shown in Fig -16. Ensure that all cuttings are removed. If the valve seating does not need refacing, the valve must then be lapped in to its seating, although very little attention in this way will be required.

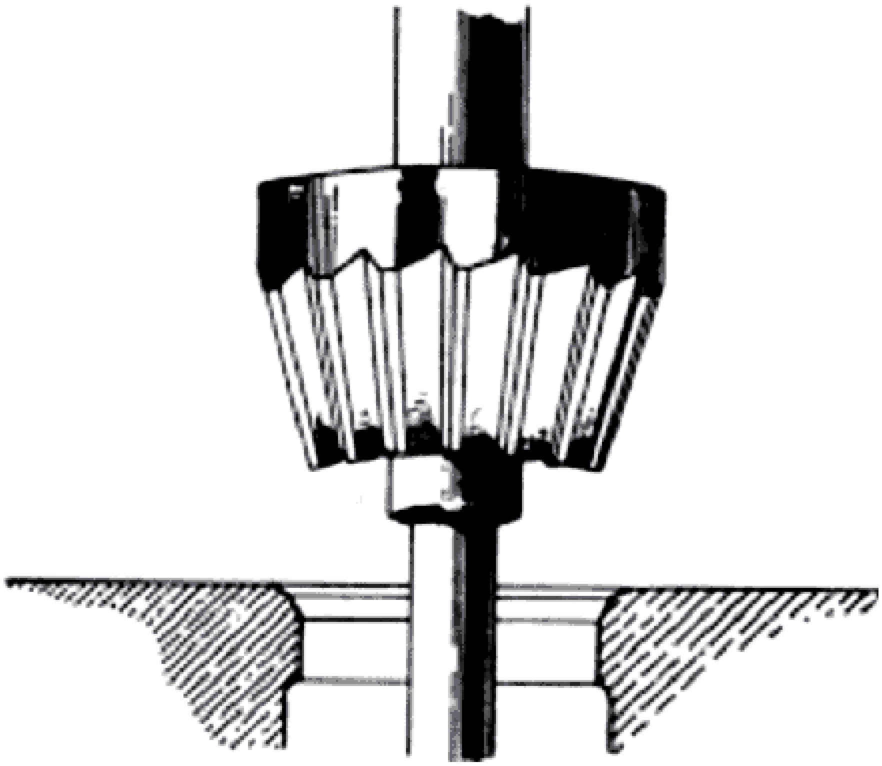

Fig-16 Reducing Width of Seating

(2) **Electric Grinding.** The first operation is to dress the valve seat stone. Select a stone of correct size and abrasive and fit it tightly on the sleeve. Set the dressing stand to the correct angle of the valve seating and ensure that the mandrel is quite clean. Put one or two drops of light oil in the stone sleeve bushing, place the stone and sleeve over the mandrel, and adjust until the diamond just touches the stone. Use the Fibro-Centric unit to drive the stone and sleeve, putting just enough pressure on the unit to overcome its vibrating action. With the stone revolving and taking a light cut, move the diamond slowly across the stone. Turn the adjusting screw two or three notches only, to take another cut. Repeat until the entire face of the stone is new and true. A stone should be dressed whenever it is mounted on a stone sleeve. Select the correct pilot, screw the split sleeve out as far as possible, inert the pilot as far as the upper taper will allow it to go, and turn the pilot clockwise until it is tightly locked in the guide. Wide the pilot shank with a clean oily rag, and put a slight film of oil on the shank. The stones are designed for dry grinding, and consequently they must be kept from contact with oil or similar matter. If necessary, a stone may be cleaned by dipping it in gasoline and spinning it on the dressing stand until dry. Insert the hexagon drive spindle into the stone sleeve socket, and during grinding partly support the weight of the drive unit so that the vibrating mechanism can operate freely. DO NOT PRESS ON THE DRIVE UNIT. Only a few seconds are required to recondition the average case iron block seat, and slightly longer for steel inserts. Steel seats may require grinding for several minutes, depending on their condition and when working on steel the stone should be lightly dressed after each seating. The finish left by the regular grinding stone is usually satisfactory for practical purposes, but a finer finish can be obtained by finishing with a fine abrasive stone, but only for a few seconds. The seat should then be checked for width, any rectification necessary being done with a 20^0 stone. It is quite unnecessary to lap in with abrasive compound when both valves and seats have been refaced by grinding.

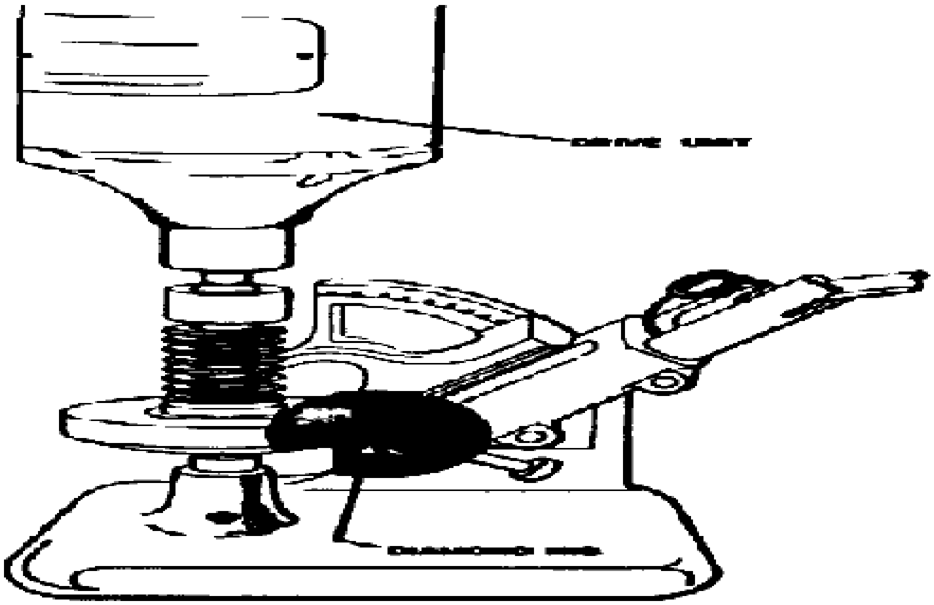

Fig-17 Stone Dressing

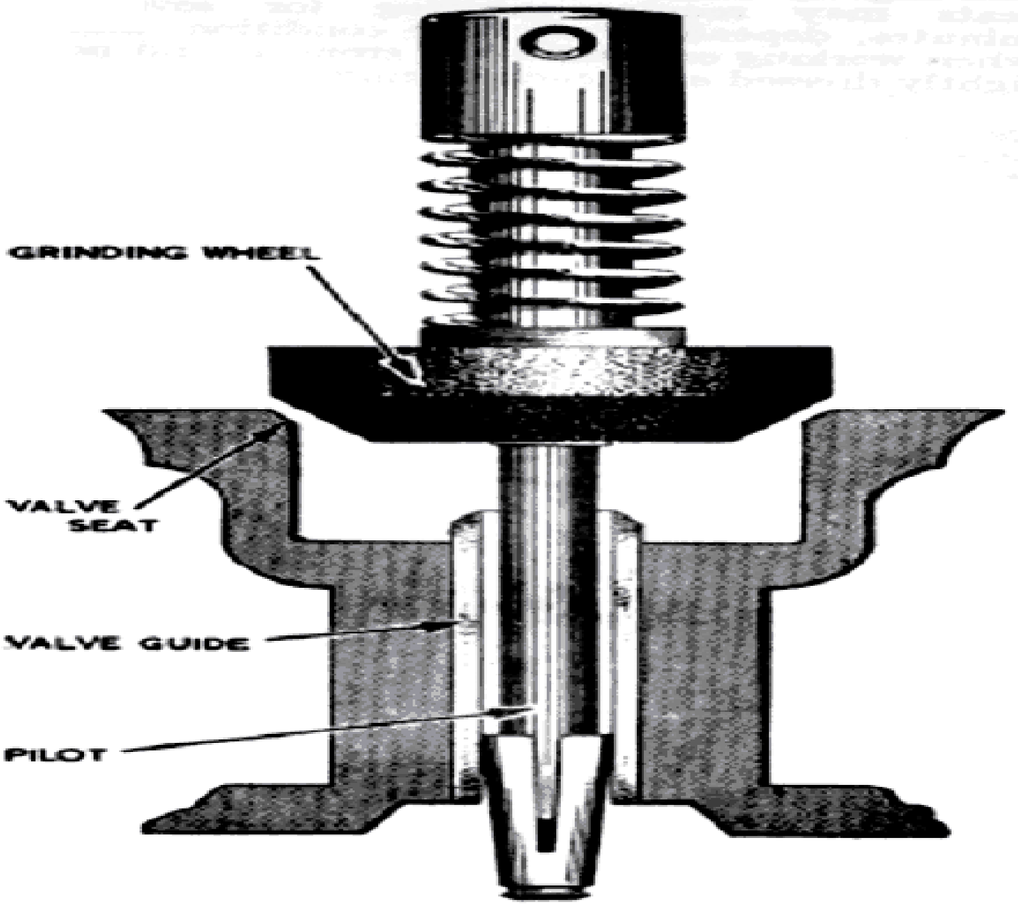

Fig -18 Stone Fitted On Pilot

j. **Valve Springs.** Valve springs should be examined for cracks and tested for strength. A valve spring testing machine should be used if available; otherwise a rig as shown in Fig -20 can be made up locally. A direct indication of a spring's strength is obtained by applying a specified weight and measuring the length of the spring. The correct loading weight and limits of length can be obtained from the relevant Air Publication. It may be found that some manufacturers check valve springs by simply measuring their free length and making comparison with the length of a new spring.

k. **Rockers and Push Rods.** If the engine is fitted with overhead valves, the rockers should be examined for wear on their operating pads and adjusting screws. Slightly worm operating pads can be rectified by stoning or grinding to profile, and worn adjusting screws will be renewed. Rocker bearing bushes will be dimensionally checked for wear and clearance with the shaft, and the results compared with the Schedule of Fits and Clearances. Ball and cup ends of push rods will be examined for wear, and all rods checked for straightness; slightly bent rods may be straightened. Ensure that all oil ways are clear, particularly any small delivery passage to the valve and push-rod ends of the rockers.

Fig – 19
Grinding Seat

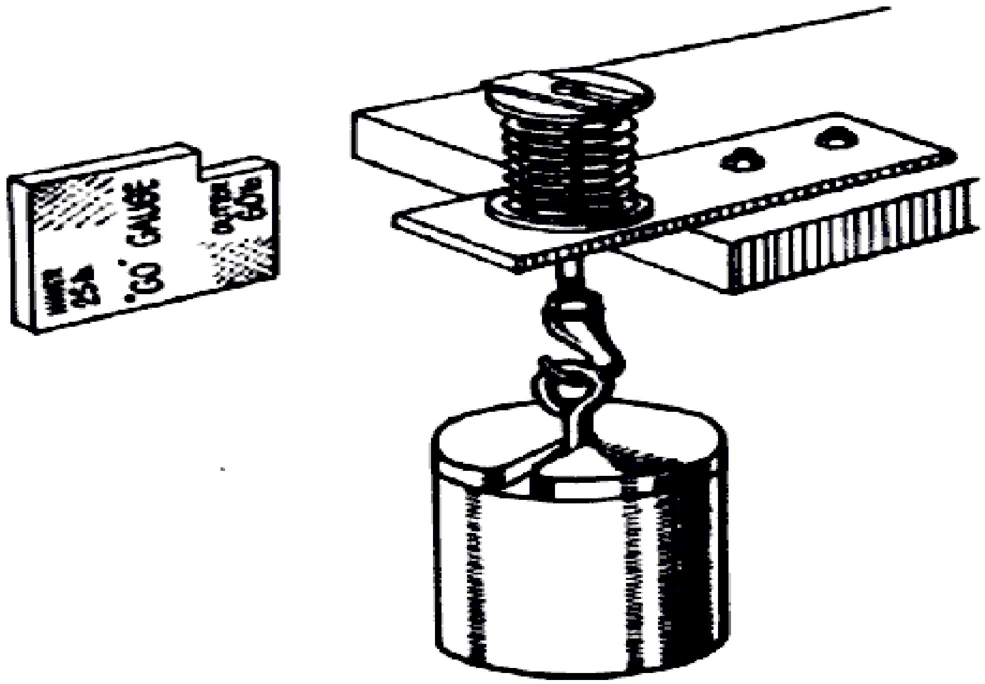

Fig – 20 Spring Test Rig

l. **<u>Cylinder Head.</u>** Examine the cylinder head for cracks, particularly between the valve seats. Examine all studs; insert valve seatings and sparking plug bushes (if fitted) for security and damage. It otherwise serviceable, the head should be suitably mounted on a surface table and checked for bowing. This can be done either by the use of a dial gauge or a straightedge, bearing in mind that if a straightedge is used, and it is resting on one end and the centre of the head, the other end will be twice the actual amount of bow over the whole length of the head. Distortion of the head will have to be rectified by grinding. The manifold should be checked on a surface plate using feeler gauges for distortion at the ports and the carburetor attachment flange.

m. **<u>Crankcase and Cylinder Block.</u>** These items should be examined for cracks, corroded or leaking core plugs (expansion or Welch plugs) and any damaged or loose studs. To remove a plug, drill a hole in the centre and lever out the plug with a suitable tool. When fitting a new plug, its edge is usually coated with jointing compound and the plug placed in position with the bulge on the outside. A blow with a small hammer direct, or with a blunt punch at the centre, will expand the plug sufficiently to make a watertight joint. If too heavy a blow is used, the plug will be useless, and will have to be replaced by another new one.

> 1) The upper and lower faces should be checked for bow by means of a straightedge. The block should also be mounted on a surface table the rear face and, where applicable, the front faces being checked for truth with a dial gauge.

2) The cylinder bores should be examined for pitting, scoring, overheating or damage, and if wet type cylinder sleeves are fitted, they should be examined externally for damage by corrosion. The bores should be checked for wear, taper and ovality with a cylinder gauge the clearance between a cylinder and piston can be obtained by subtracting the diameter of the piston from the diameter of the cylinder bore. The piston should be measured midway between gudgeon pin and bottom of skirt, but at right angles to the gudgeon pin. The cylinder diameter should be the biggest reading obtainable of the worm part of the cylinder bore.

3) In the past, worn bores of cylinder blocks have been bored oversize and oversize pistons and rings fitted in stages up to the maximum oversize allowed for pistons. In future, for engines not already fitted with liners, when the necessary fit between pistons and cylinders cannot be obtained by replacement standard size pistons and rings, the cylinder block is to be bored out and fitted with standard size liners, pistons and rings.

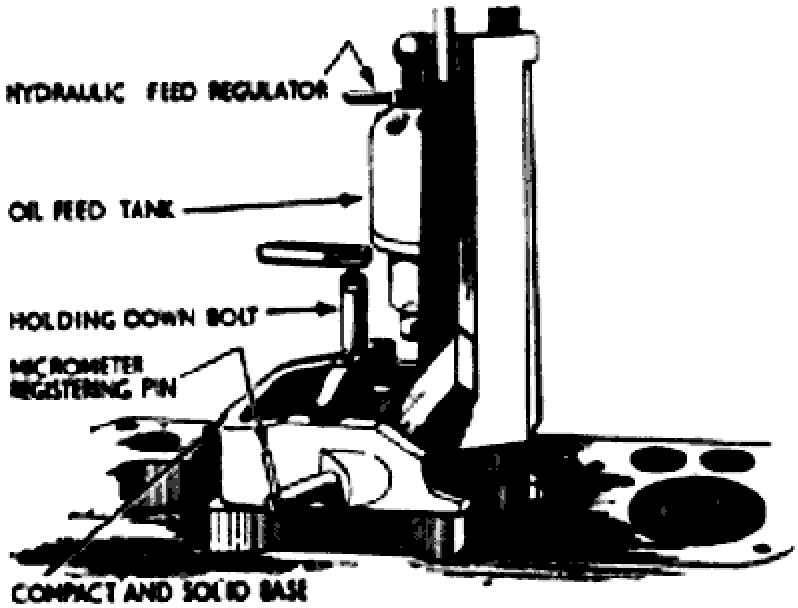

Fig -21 Cylinder Reburying

4) The most satisfactory way of truing up cylinder bores is to regrind them on a special internal cylinder grinding machine. This method ensures true parallelism of all the cylinder bores. Alternatively, reburying cylinders can be done by using a cylinder boring bar; this method is widely used in the motor industry and very often the cylinders are bored without removing the engine from the vehicle. As most portable boring bars are set up and clamped on the face of the cylinder block, all cylinder head studs must be removed, and the face must be checked to see that it is flat and at right angles to the axis of the cylinder bores. If the face is inclined, suitable adaptors have to be used to bring the boring bar into alignment with the bores. The bar is usually fitted with a quick centring device enabling the bar to be set centrally in the cylinder bore with the minimum of trouble.

A very important detail in operating the bar is the correct setting of the cutter; this is usually done with the aid of a micrometer. Various means are used to trap the metal dust whilst reburying and the block must be thoroughly cleaned after the operation.

5) Where a cylinder liner is already fitted, either as standard in manufacture or during a previous repair, the cylinder liner will be renewed as necessary. The renewal of wet liners or sleeves presents no difficulties, and on some engines using this type in order to counteract slight ovality, provision is made so that the sleeves can be rotated 90 degrees from the position in which they were originally fitted.

6) When cylinder bores are to be fitted with dray liners, the bores must first be enlarged to the correct diameter, this diameter being such as to give an interference fit between the liner and the bore. If the cylinder bores are already fitted with dry liners, these can be removed for renewal with the aid of a press, and the block bores then checked for correct size. When fitting new liners, it is usual smear the top of the bores with oil or other lubricant to facilitate entry of the liners, and then use a press with a dolly. Some manufacturers recommend that the liner is cooled and/or the cylinder block heated, to facilitate the pressing in operation. The top rim should be flush with the top face of the block, and it may be necessary to machine the rim if it protrudes. The size of the bores should then be checked, and if necessary, the bores should be honed to the limits given in the schedule of Fits and Clearance.

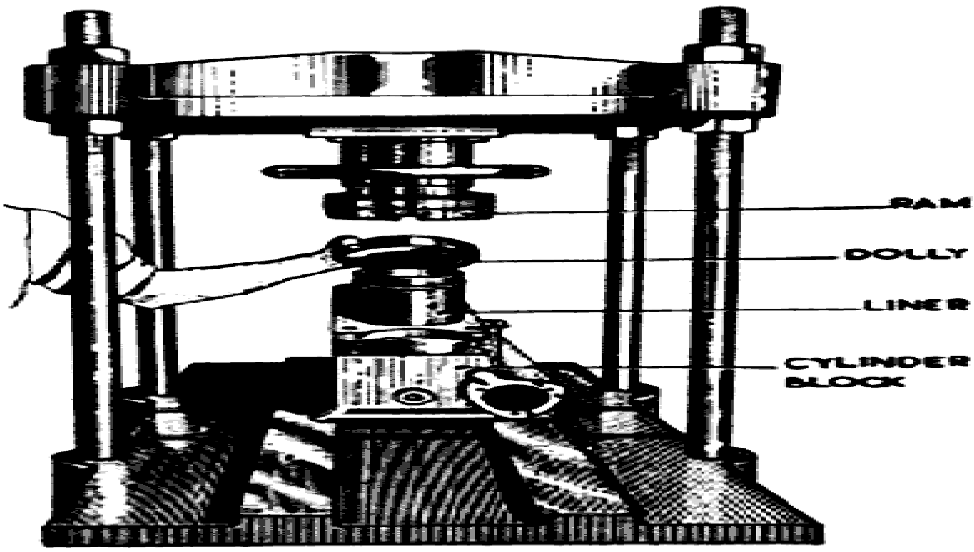

Fig -22 Pressing in Cylinder Liners

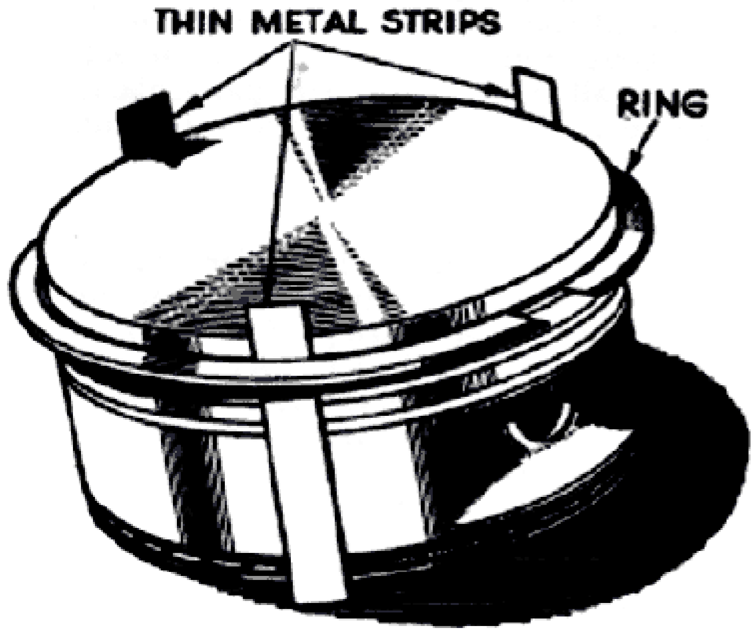

Fig -23 Fitting and Removing Piston Rings

n. **<u>Pistons, Rings and Gudgeon Pins.</u>** Examine pistons for scoring, cracks, picking up and signs of overheating or burning. Inspect the ring grooves for condition and check the circlip grooves are not burred. Slight scoring and picking up may be removed by stoning. Check for wear and ovality by measuring the diameter of; pistons with a vernier or micrometer, the measurements to be taken at the points stated in the Schedule of Fits and Clearances. Check the gudgeon pin and its bosses for wear and ovality, using a micrometer for the pin and plug gauge for the bosses. If the pin is fitted with aluminium end caps, examine these for condition and tightness. Another method is to place the piston in the cylinder and use long feeler gauges attached to a small spring balance, the clearance being checked using a 4 lb pull. Care must be taken when removing and fitting piston rings not to scratch the piston; Fig -23 illustrates how thin metal strips can be used to aid these operations. It is usual to fit new rings after removal of the used rings, but if the rings are to be used again they should be marked so that they can be refitted the same way up in the groove in which they were originally fitted. Piston rings showing scoring, blackened or discolored patches, either on the working surfaces or the sides, should be replaced by new ones. At a repair depot, piston rings are fitted by selective assembly, but used or new rings must be checked as follows.

(1) Place the ring in the cylinder, square it up with a piston and measure the gap with feelers. If the gap is to small it should be enlarged by filing one end only of the ring, care being taken to maintain a true mating joint, and this will be aided if a filing jig is used.

(2) Measure the side clearance of each ring in its groove, ensuring that the minimum clearance exists right round the groove. One method of checking with feelers is illustrated (Fig -24). If there is insufficient side clearance and other rings are not available, one side only of the ring should be rubbed down on fine emery on a surface plate; the rubbed down side should be fitted downwards on the piston. Excessive side clearance causes oil pumping, and consequent heavy oil consumption.

(3) With a ring in its groove, check that the ring does not stand proud of the lands at any point of its circumference.

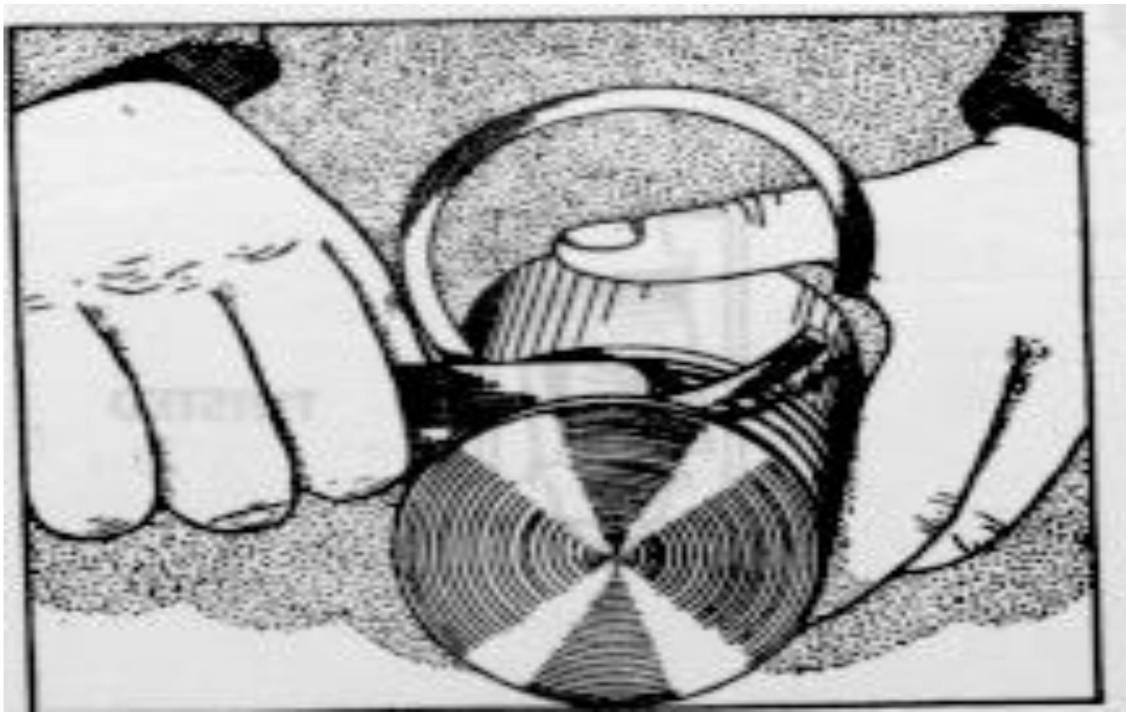

Fig -24, Checking side clearance

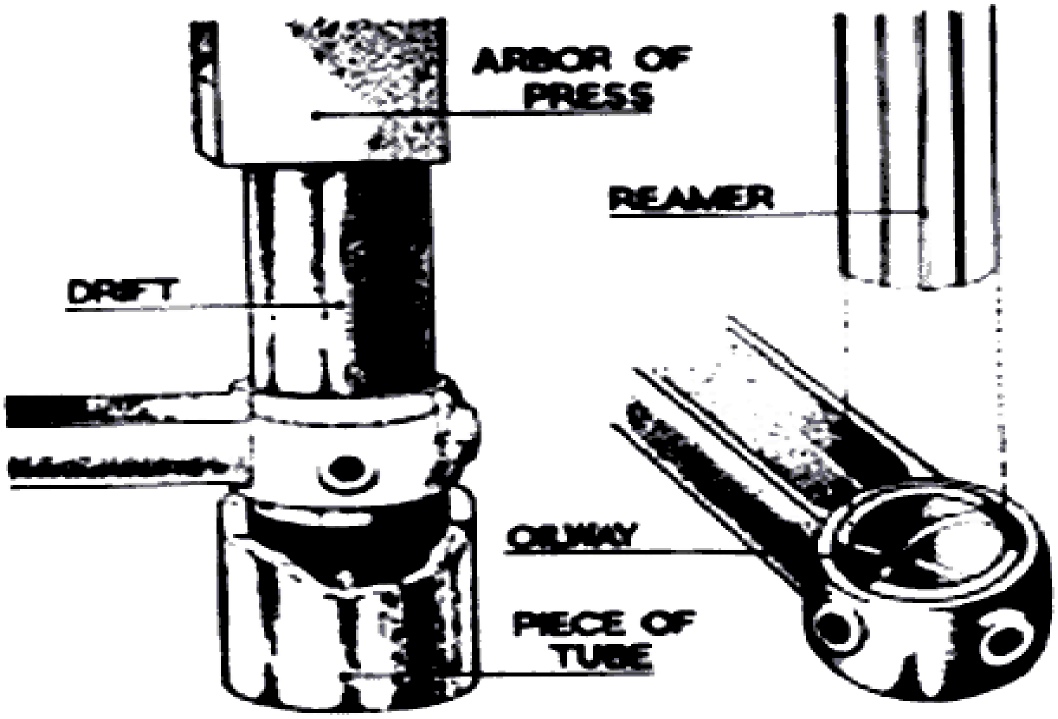

Fig -25 Renewal of Small end Bushes

p. **Connecting Rods.** The small ends of the connecting rods of some engines are bushed; these should be examined for scoring and picking up, and checked for wear and ovaliness either with a plug gauge or by measurement. The bushes can be removed either by driving them out with a stepped drift or by the use of a press. Care must be taken to ensure the correct alignment of any lubrication holes, and the bush should finally be reamed to size. Most modern big-end hearings are of the detachable precision made type, steel backed and white metal or lead bronze ; these should be examined for scoring and picking up, and checked for wear and oval ness either with a plug gauge or by measurement. The bushes can be removed either by driving them out with stepped drift of by the use of a press. Care must be taken to ensure the correct alignment of any lubrication holes, and the bush should finally be reamed to size. Most modern big-end bearings are of the detachable precision made type, steel backed and white metal or lead bronze lined, the object being to provide bearings which do not require a hand fitting operation. Examine the bearings for fretting, on the back faces, scoring on the bearing faces, and check the bore for wear, taper and ovality. If these precision checks are within the limits, the results must be compared with the results obtained regarding the crank pin diameter and the clearance between the components obtained. Wear must not be absorbed by filing the bearing caps. Rectification must be done by fitting a new set of bearings, or by regrinding the crankshaft and the use of undersize bearings. Bolts and nuts should be inspected for condition, unless it is definitely stated that new ones should be fitted.

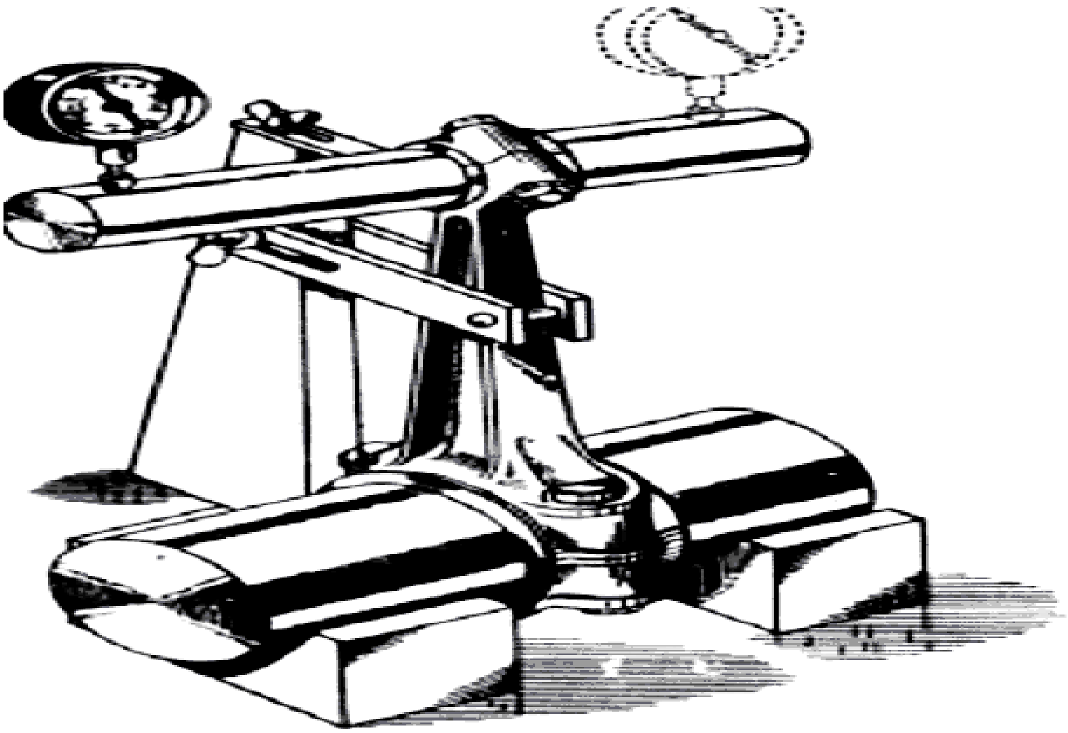

Fig -26 Testing For Parallelism

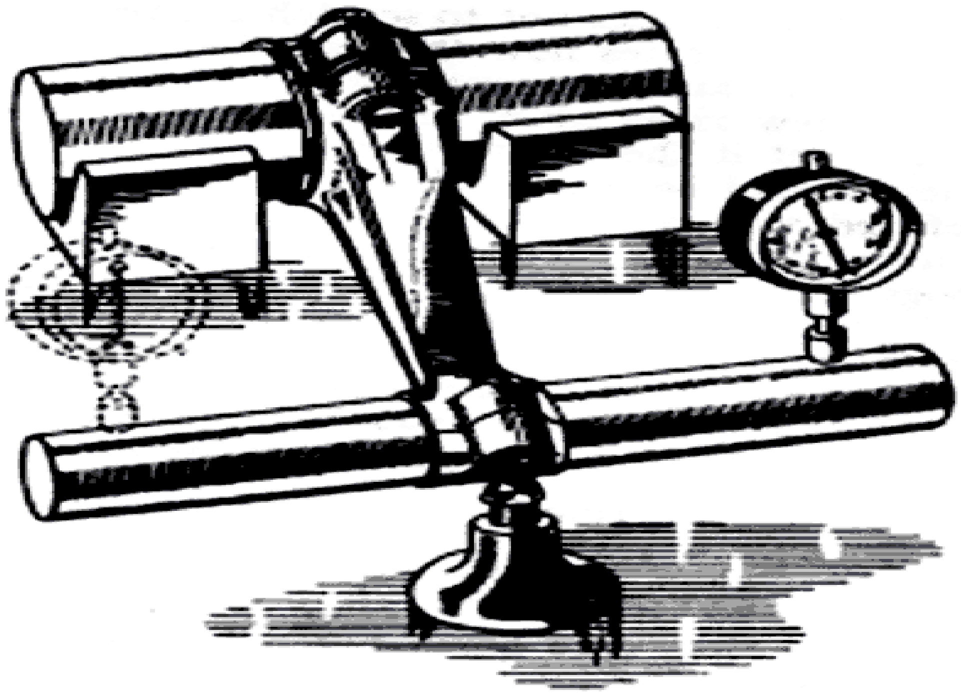

Fig – 27 Testing for Parallelism

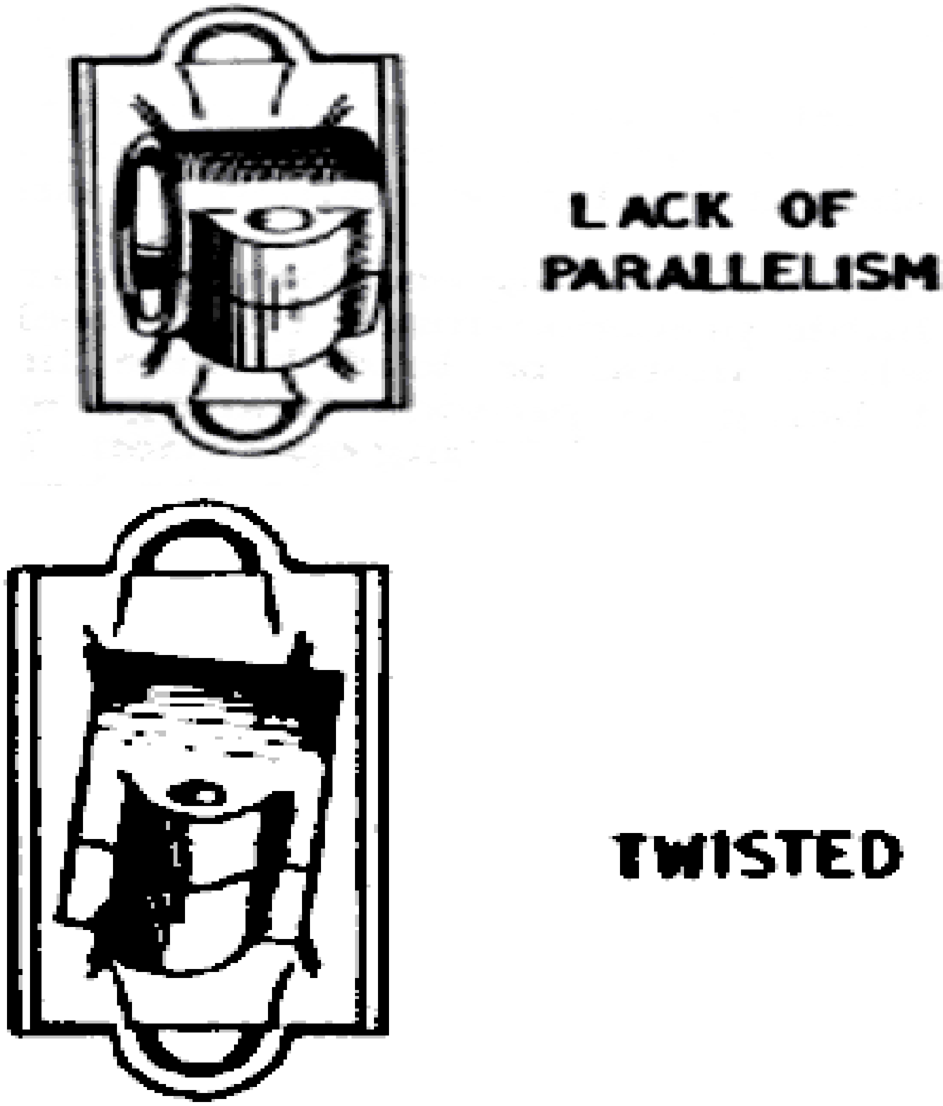

Fig - 28
Testing For Parallelism & Twist

Connecting rods should be checked for parallelism and twist between big and small ends. This should be done on an alignment jig or by using mandrels, “V” blocks, and a dial test indicator on a surface table, as shown in Fig -26,27 & 28. The rods should also be tested for bend in the plane of rotation by using a straightedge as shown in Fig.-29.

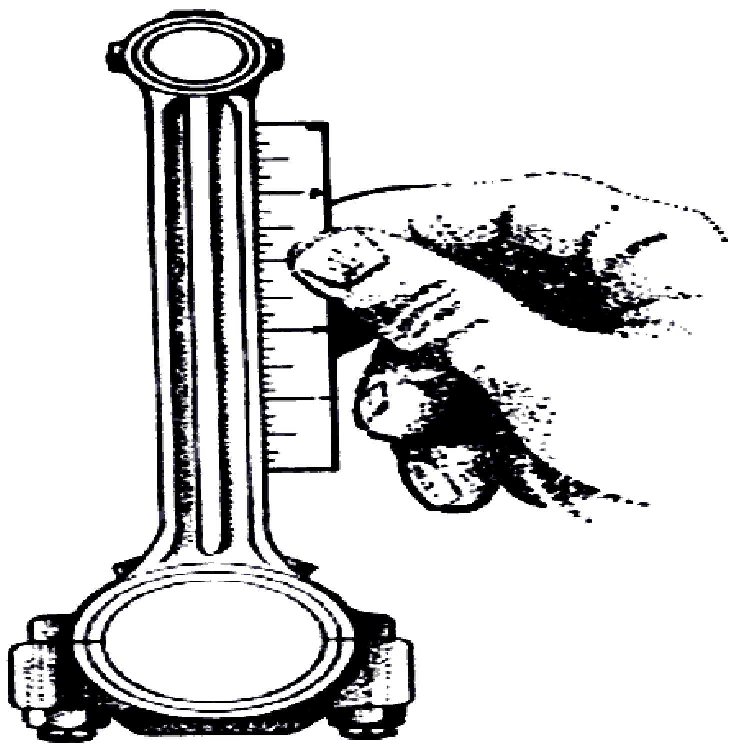

Fig -29 Testing For Bend.

Seriously bent or twisted connecting rods should always be rejected, but slight in accuracy's may be corrected by using a press or by means of a bending iron as shown in Fig.-30.

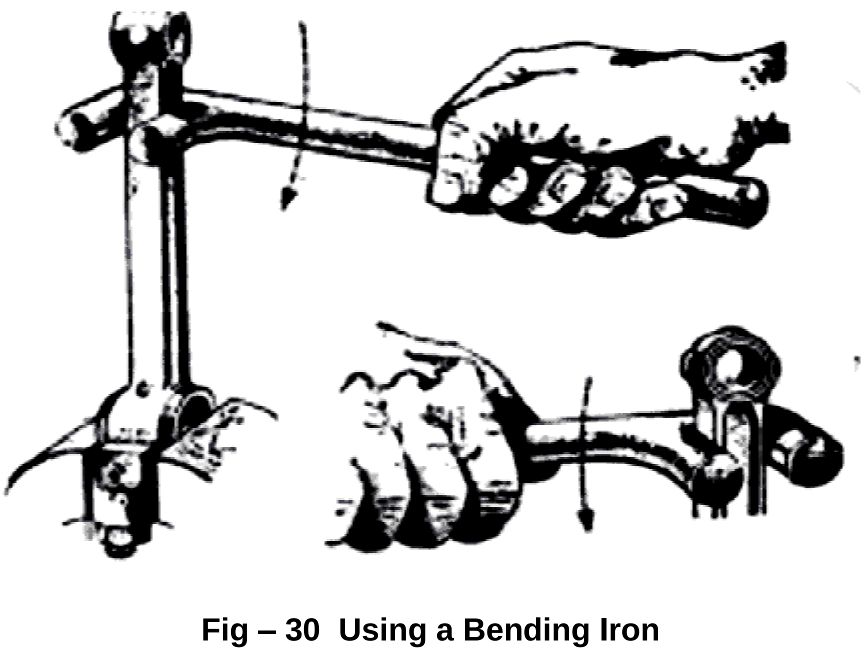

Fig – 30 Using a Bending Iron

q. **Crankshaft and Main Bearings.** When sealing caps are fitted to the journal and crank pin bores, the retaining bolts should be removed to enable the bores to be cleaned. The caps should be retained in their order of removal as the seating faces mate with their respective bore seats. The following information applies to precision type bearings. The bearings should be examined for signs of fretting on the back, denoting looseness in the housings, and the bearing faces for signs of wear or excessive scoring. Assuming that the bearings are in a satisfactory condition visually, temporarily assemble them to their respective housings and tighten down the nuts to normal running tightness. Check the bore of each bearing, the results obtained being required for comparison with the diameter of the journals as well as checking for size with the Schedule of Fits and Clearances.

Note : *Whenever bearing nuts are tightened, the operator should always use a torque loading spanner and tighten to the prescribed loading, or the particular spanner stated by the manufacturer.*

1) Journals and crank pins should be inspected for scoring, measured with a micrometer for wear, taper and ovality and the clearance found between the journals and main bearings. These results should be checked with the schedule of Fits and Clearances, in order to determine if any rectification is necessary. Under no circumstances should the bearing caps be filed to take up wear. Rectification may require the fitting of a new set of bearings if the journals are satisfactory or regrinding of the journals and the fitting of undersize bearings.

2) The crankshaft should be supported on “V” blocks on a surface table, and a dial test indicator used to check the shaft for bow. Care must be taken to ensure that wear is not mistaken for an indication of bow. If the bowing is not serious, a press may be used to straighten the shaft.

3) Although the majority of modern engines are fitted with bearings of the precision type, other types still exist using different methods of reconditioning. Where shims are provided between the two halves of the bearing, wear can be rectified by removal of the necessary number of shims until the correct fit is obtained. Alternatively, where no shims are provided, it may be permissible to take up excessive play by lightly filing, or rubbing down the faces of the bearing caps using a sheet of emery laid on a surface plate.

4) Some heavy vehicle engines use brass shell bearings lined with white metal, lead bronze or copper lead alloys. When the crankshaft has been reground and/or these bearings have been remetaled, the bearings will either be line bored with special equipment or they will be “scraped in”. In either case the brass shells will have to be first fitted into their housings, using marking and removing the high spots until as near as possible 100 percent contact is obtained. The edges of the shells should stand proud of their housings by about .001 in, so that the necessary “pinch” a obtained to ensure correct bedding down, and prevent the shells from working loose.

5) **Scraping in Main Bearings.** The main bearing journals are coated with marking, and the crankshaft is then laid in the top halves of the bearings, which are housed in the crankcase. The shaft is rotated several times and then removed, the high spots being scraped down before replacing the shaft and trying again; this procedure should be continued until the bearings show at least 75 percent contact. When three or more bearings are employed, the end ones should be done first, the remainder being replaced and scraped in one at a time. When all the top half bearings are marking satisfactorily, the caps should be done in a similar manner, starting with the centre one. During the scraping in it may be necessary to "let up" the cap to compensate for metal removed. When all main bearings are finished, oiled and tightened down, it should be possible to turn the shaft without too much effort.

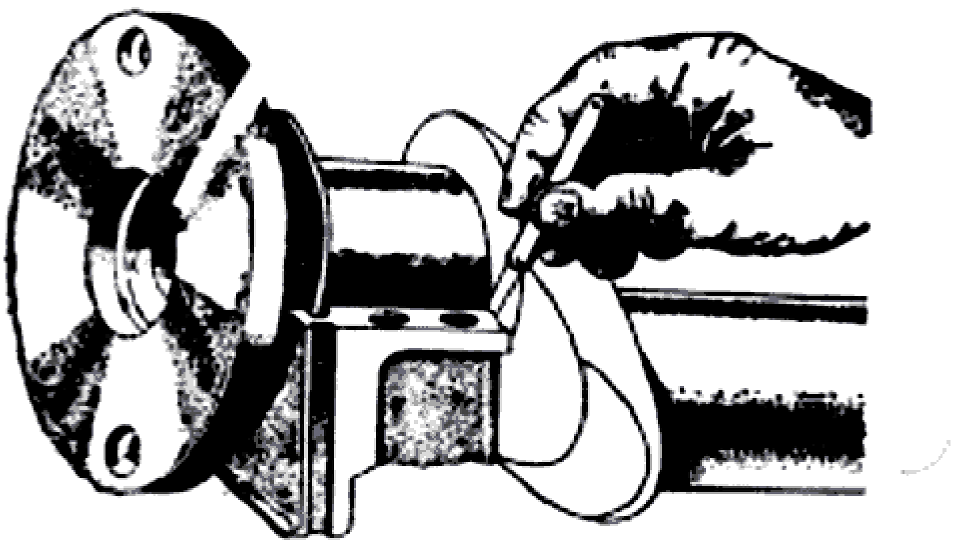

Fig – 31
Checked Crankshaft End Float

6) **End Float.** Crankshaft end float is sometimes controlled by one of the main bearings, but more frequently by special thrust washers. End float is checked with feelers as shown in Fig.-31. If end float is excessive it may be reduced by fitting new thrust washers by selective assembly, or by rubbing down washers which are slightly too thick on emery cloth on a surface plate.

7) **Spigot Bearing.** The spigot bearing must be examined for condition. Fig -34 shows the removal of a ball race using an extractor the new race would be replaced by means of a hardwood drift. When a grease retainer is fitted it is essential that this is replaced correctly.

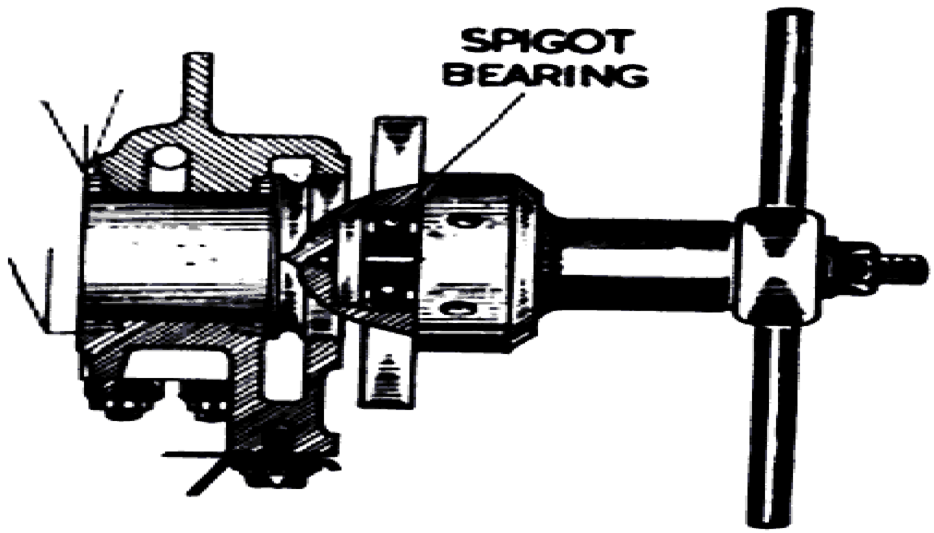

Fig -32
Removal of Spigot Bearing

q. **Flywheel.** Examine the rear face of the flywheel for scoring caused by the clutch plate. If necessary, any scoring can be rectified by skimming the scored face using a lathe. Examine the starter ring teeth for damage; if it is found necessary to replace the starter ring then the relevant Air Publication should be consulted.

(1) **Removing Ring.** One method of removing the starter ring is shown in Fig-35. The flywheel is placed in a suitable container of clean cold water, supported on three metal block placed under the starter ring. Arrange the flywheel so that it is submerged in the water, but with the starter ring about 18/8 in above the surface. Heat the ring evenly around its circumference by means of an oxy-acetylene torch, and the flywheel will drop out of the heated ring.

(2) **Fitting Ring.** This method of fitting a starter ring ensures that any heat treatment will not be affected. The fitting of the ring can be quite easily affected whilst cold. The immersion of the ring in boiling water or raising it to that temperature by other means will, however, assist the operation, but greater heating than this should be avoided. The flywheel should be placed on a solid base the starter ring being offered up squarely and tried for the most favorable position for its entry on the spigot. Four equally spaced "G" clamps should be fitted around the ring as shown in Fig-34.The starter ring should then be lightly tapped on to the spigot using a soft metal drift, taking care to keep the ring square and to follow its progress on to the spigot by tightening up the clamps. Having thoroughly started the ring on the spigot, the clamps can be removed and the ring driven fully home against its flange on the flywheel.

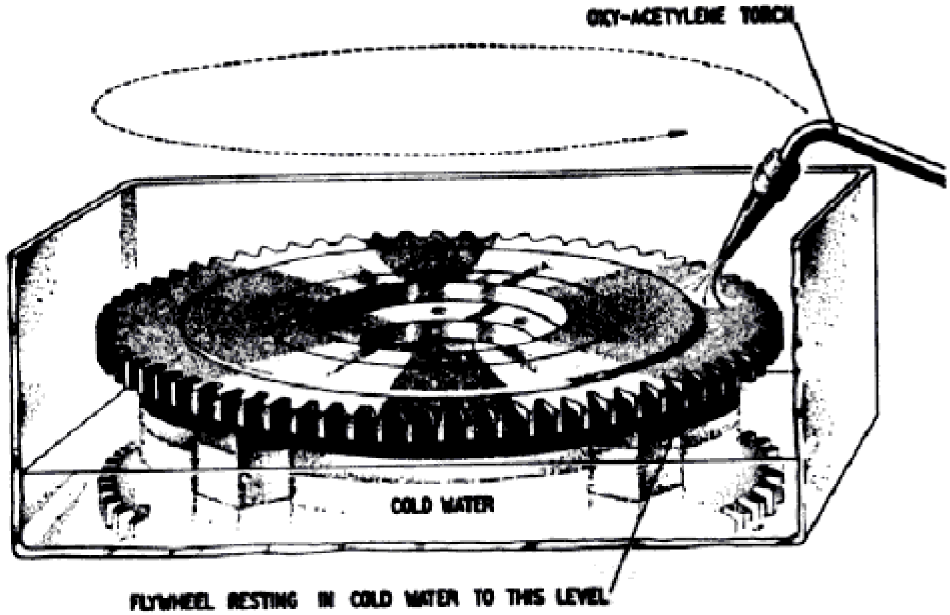

Fig – 33 Removing Starter Ring

r. **Camshaft and Bearings.** Examine the camshaft for scoring and wear on the cam lobes and bearing surfaces; slight scoring may be rectified by bearings for wear. The usual method of removing and replacing bearings is by gently tapping them with a suitable drift. It necessary, the bearings are reamed in line after fitting. Support the shaft on "V" blocks mounted on a surface table and uses a dial indicator to check the shaft for bow. Slight bowing can be rectified by using a press. Examine the teeth of any drive gears and, if necessary, rectify by careful stoning. Fit new keys where required. Check the end float of the shaft (Fig -35); this is frequently rectified by selective assembly or rubbing down of thrust washers.

s. **Timing Gear.** A timing chain should be inspected for condition and checked beside a new chain for stretch. For accurate comparisons of chain lengths it is essential that the new and the worn chain should be absolutely straight under tension. This can be achieved by hanging both chains from a common point and attaching similar weights to the free end of each chain. The teeth of the crankshaft and camshaft sprockets should be examined for wear and damage. If the teeth are booked, the sprockets will have to be rejected, but slight damage can be rectified by stoning. If the camshaft is gear driven, a backlash check of the gears in position will have to be made during the re-assembly of the engine.

- **Check Backlash.** Sometimes it is possible to measure backlash directly by inserting feelers between the mating teeth, but other methods must be used when the gear teeth are inaccessible. One method is shown in Fig-36. One of the gear wheels is locked ("gagged") by some suitable temporary locking device, such as a fibre plug, clamp or wooden wedge. A lever is fixed to the shaft of the mating wheel, its free end bearing on the plunger of a dial test indicator which is fixed to any convenient part of the gear casing.

When the second wheel is rocked backwards and forwards, the extent of the movement will be shown on the dial indicator. The extent of movement, corrected if necessary for the length of the lever, will be the amount of backlash. If the length of the lever is equal to the radius of the pitch circle of the wheel, the dial indicator reading will be the actual backlash, but if the length of the lever is twice the radius of the pitch circle, the reading must be divided by two, and similarly for other lengths.

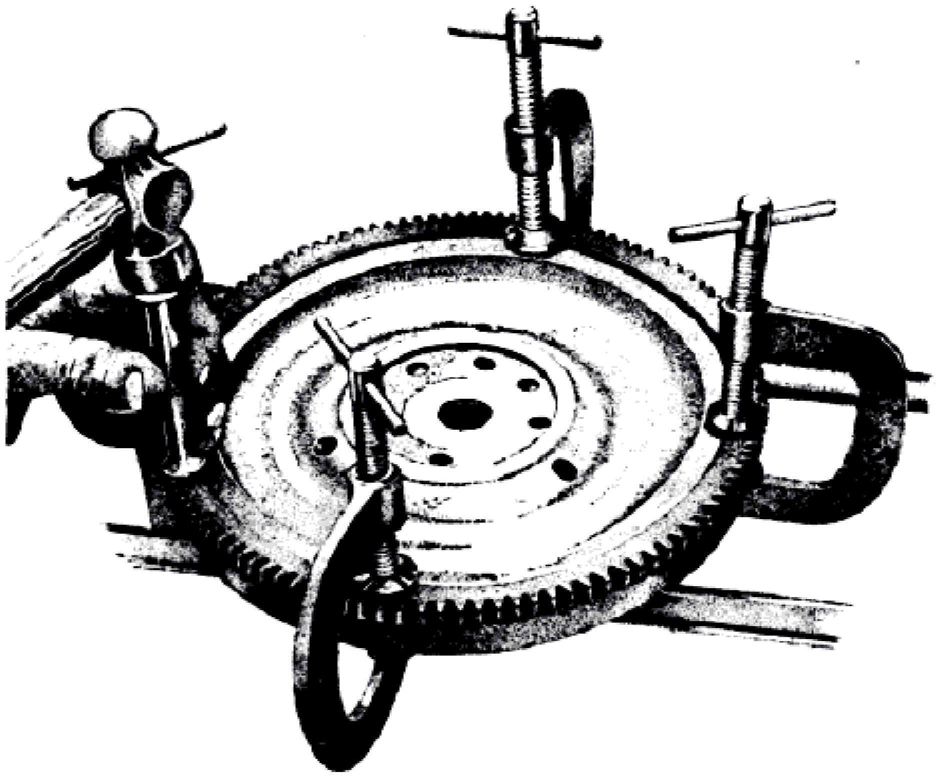

Fig – 34 Fitting Starter Ring

t. **Oil Pumps.** Oil pumps should be examined for wear which will affect delivery capacity, and such wear will vary according to the type of pump. Gears and the inside of pump bores should be examined for scores. Checks should be made of the fit of the gears in the pump body, backlash between the gears and end float. Fit and backlash can be checked with feelers and end float with a straightedge and feelers. If oil pump gears are to be renewed, they must only be replaced in pairs. End float is frequently rectified by rubbing down the end face of the pump body. Plungers of plunger type pumps should be a good working fit in the body of the pump. In vane type pumps, the vanes should be a good fit both in the pump body and the driving slots. Driving shaft bushes can be removed and refitted, by the use of a press preferably, but in some cases a stepped drift may be used. When new bushes have been pressed into position, they should finally be reamed in line. The teeth of spiral

drive gears may be cleaned up by filing off the end of the securing pin and tapping the pin out with a small pin punch. Relief valves and their seatings should be inspected for pitting and scoring, parts being renewed where necessary.
Relief valve springs should be inspected and checked, and if the valves are adjustable they should be set to "blow of" off" at the correct pressure.

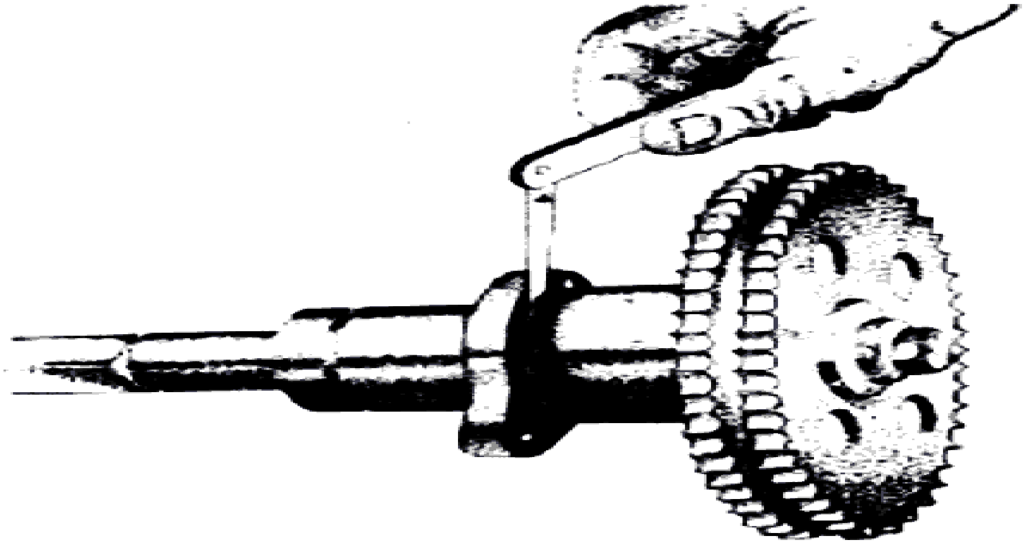

Fig – 35
Checking Camshaft End Float

u. **Water Pumps.** When dismantling water pumps it will frequently be found that an extractor is required for removal of the impeller (Fig -37). Do not try driving the spindle, and do not replace the impeller by any means other than a press, or damage is likely to result. Inspection of water pumps will vary according to design details, although main components are usually similar in all pumps. Examine the driving shaft for wear, corrosion and damage such as scoring or a bent shaft. The shaft should be ejected if defects cause the impeller vanes to foul the pump casing, or water to leak past the gland seal. Examine the pump casing for damage, corrosion and cracks. If a casing is cracked or its thickness greatly reduced by corrosion, the casing should be rejected. Ball bearings should be rejected. Ball bearings should be examined and checked. Bushes should be examine seals for scoring and checked for wear. Deep scores and excessive wear will entail the rejection of the seal. Examine the impeller for corrosion and damage. Slight corrosion may be removed with a smooth file, but the impeller must be rejected if corrosion is severe. The end float of the impeller should be checked and rectified as applicable. The carbon gland ring should be examined for cracks, scores and wear. This ring should have a smooth flat face, a small amount of wear being permissible, but if the ring is scored it should be renewed. Some pumps have the carbon ring secured in the pump casing, and, if necessary, the ring becomes easily removable. After the recess has been cleaned, the pump body should be heated and the new gland pushed into position.

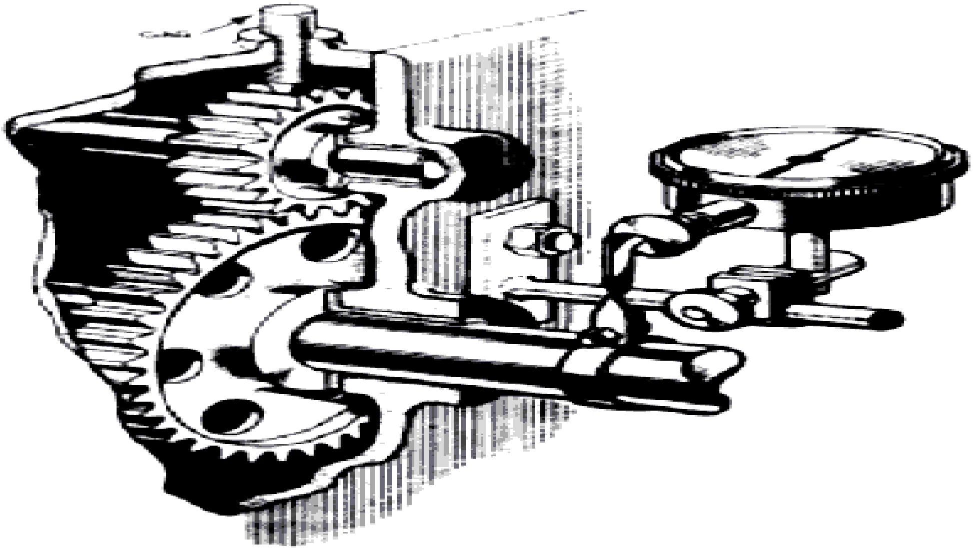

Fig – 36 Checking Backlash

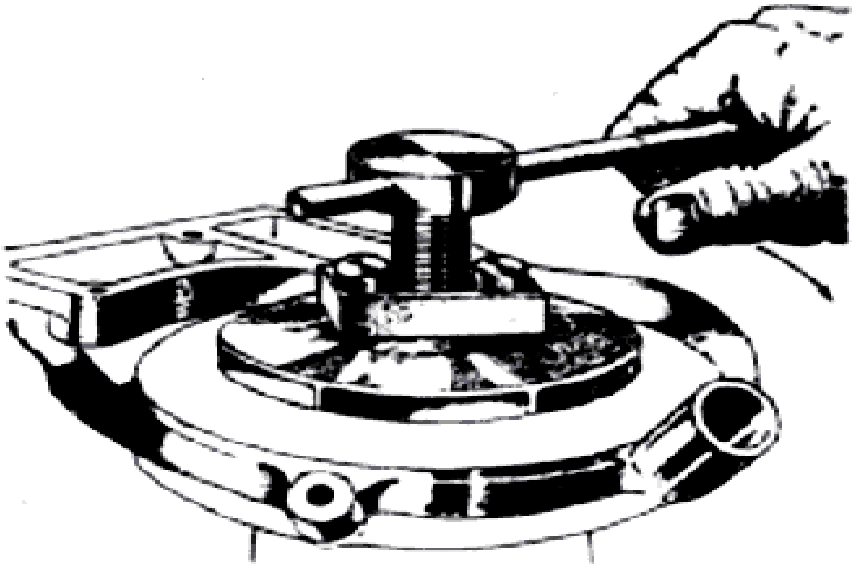

Fig – 37
Impeller Extraction

v. **Thermostats.** If a thermostat valve is found to be open when the component is removed from the engine, it can be assumed that the thermostat is defective and must be rejected. A thermostat can be tested by suspending it in a vessel containing water and a thermometer. Heat the water slowly and note the temperature at which the valve begins to open. The results should be checked with the relevant Air Publication, and, if outside the limits, the thermostat should be rejected. The bellows should be examined for solid deposits, removal of which may be effected by rubbing with a coarse cloth. On no account must the bellows be scraped with a tool, as they are fragile and easily punctured.

w. **Carburetors.** The components should be stripped and cleaned using trichloroethylene and wire brushes. Examination should be made for cracks and damage. Joint faces should be checked for flatness and any necessary rectification should be done by rubbing down on emery cloth on a surface plate. Fuel passages, jets and needle valve seats should be blown through using compressed air. Do not attempt grind-in a needle valve to its seating, if the damage to the seating is slight a new seating can be formed by gently tapping the needle on to its seating, at the same time rotating the needle. In bad cases the needle valve and seating must be rejected. Check any pistons, springs, pump leathers and ball valves for condition. Examine floats for condition and test for punctures by immersing the float in boiling water. Punctures will bed is closed by the emergency of bubbles. A punctured float should be rejected, because a repair by soldering will unbalance and overweight the float. Valve plates should be examined for excessive scoring on their seating faces, and also for the condition of location slots. Check the piston of a S.U. carburetor for sticking in the suction chamber. Any high spots on the interior of the chamber can be removed by careful use of half round scraper. When checking Carter carburetors (Rolls-Royce), the operator will need certain gauges which can be made up examined for damage to the gauze and cleaned by compressed air. All new gaskets will be fitted on reassembly of the carburetor.

x. **Fuel Pump.** The parts of mechanical fuel pumps should be cleaned in kerosene or trichloroethylene. Examine the domed cover for any defects that may prevent an air tight joint being made. Deformation of the cover will normally entail rejection, but if the end portion is slightly concave as the result of over-tightening the set screw, the cover should be carefully tapped back is its original shape, using a light hammer whilst the cover is inverted on a flat steel plate. The two halves of the pump body should be examined for cracks, and their diaphragm flanges tested on a surface plate. A crack or a badly warped flange will necessitate rejection of the faulty part. Any slight unevenness on the surface of the flange should be removed by careful use of a smooth file or by rubbing down. The pump mounting flange should also be checked and trued up if necessary in a similar manner to the diaphragm flanges. Valve discs should be rejected if they are warped or defaced, and likewise the valve spring if they are weak or deformed. Diaphragms should be rejected after the completion of a mileage of 30,000 if the pumps are employed on M.T. vehicles, and after 500 hours running time if employed on stationary engines. Diaphragms should also be rejected if the fabric shows any signs of cracking or tearing. Gaskets should rejected, and new ones fitted during assembly. The rocker arm and pivot pin should be examined for wear, and rejected if the rocker arm holes are worn oval or if the pivot pin is ridged. The push rod (if fitted) should be examined for wear and checked to see that it is not bent.

(1) **<u>Assembly.</u>** Besides the normal assembly precautions the following procedure should be strictly adhered to. When the upper half of the pump body is placed in the correct position relative to the lower half, the flange screws should be entered loosely in the threaded holes. The rocker arm should then be forced upward in order to pull the diaphragm into its correct working position. Holding the rocker arm in this position and evenly should be tightened gradually and evenly around the flange until all are fully tight.

(2) **<u>Testing.</u>** After a pump has been reconditioned it should be tested on a rig similar to that shown i n Fig -38. Where the bench rig is not available, a pump can be tested on an engine as described later of the following test procedure.

(a) **<u>Bench Test.</u>** The layout of the equipment required is shown in Fig- 40. The bottom tank should be almost filled with kerosene and the pump operated by hand. After sufficient kerosene has been pumped into the top tank to submerge the end of the delivery pipe, the pump should deliver kerosene free from air bubbles at each stroke. The presence of air bubbles indicates an air leak in the pipe line or at the pump cover gaskets which mist be rectified. The delivery valve should be closed and the pump again operated, when the pressure gauge should show a reading in accordance with the pressures given in below. A low reading would indicate faulty valves, and a high reading may be the result of an incorrectly fitted diaphragm or the fitting of a diaphragm return spring which is too strong.

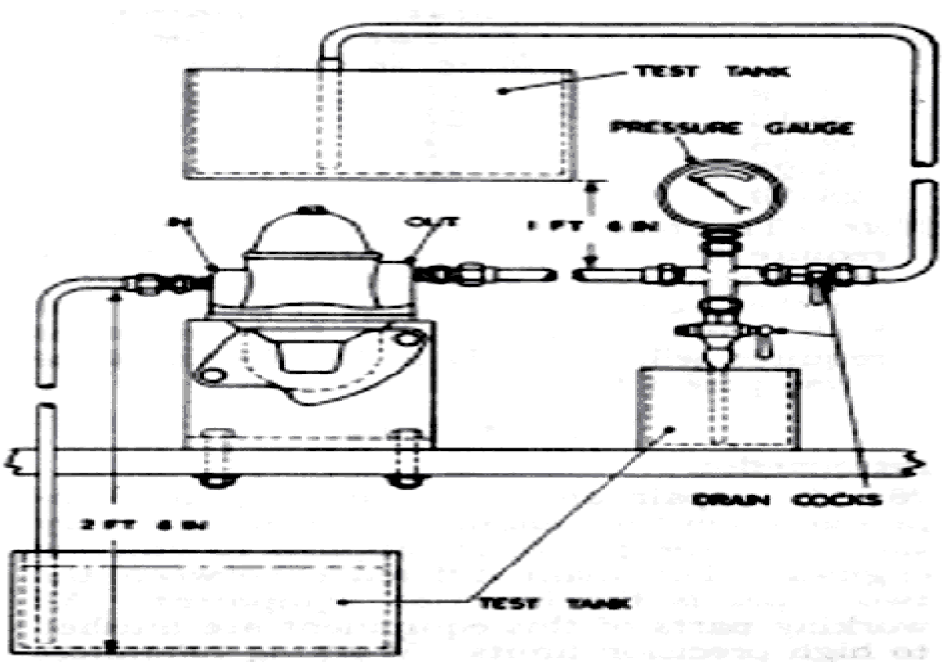

Fig – 38 Fuel Pump Test Rig

(b) **Engine Test.** The pump should be fitted to the engine and a test rig (similar to Fig -38) fitted in place of the normal pipe line. The carburetor should be fitted with a temporary gravity fed fuel supply. The engine should be started and allowed to run at idling speed, the pressure on the gauge being checked as in previous. The drain cock should then be turned on and the fuel should flow from the pipe end free from air bubbles. If a previous bench test had proved satisfactory, air leaks or obstructions on the suction side of the pump may be the cause of lack of pressure. The fuel pressure can be varied by the use of gaskets of different thickness, fitted between the pump mounting flange and the engine; a thicker gasket reduces pressure and a thinner one increases pressure. A guide as to the efficiency of the pump can be got by fitting a temporary gravity fed fuel supply, and arranging that the fuel delivery pipe feeds into a one pint vessel, fitted on the same level as the base of the float chamber. The time taken o pump one pint can then be compared with the time given in below.

❖ **<u>Fuel delivery pressures and times for A.C. fuel pump tests :</u>**

Horse Power R.A.C. rating	**Max pressure lb/sq in.**	**Delivery time 1 pint, secs**
7-9	1¾	90
9-12	2¼	90
12-16	2¾	60
16-25	3¼	60
25-30	3¾	45

Note: *The test pressure values given may require to be varied slightly in instances where the needle valve of the carburetor is either exceptionally light or heavy. For high speed engines the fuel pressures required will generally be less for the same horse power than that indicated.*

BAF BASE ZAHURUL HAQUE (TRG WG)
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Syllabus	**:**	**Automobile General Diesel and Petrol Technology**
Course	**:**	**Trade Training Advance, MTOF**
Subject	**:**	**Reconditioning of Engine**
Aim	**:**	**To Study Reconditioning of CI Engine**
Ref	**:**	**AP-3126 Sec 4, Chap 1.**

RECONDITIONING OF C.I. ENGINE

Introduction

1. The repair and reconditioning of compression ignition engines is generally very similar to the procedure applied to gasoline engines. The main difference between the two types is the injection equipment. All working parts of this equipment are finished to high precision limits. Working tolerances are not normally specified for mating parts, the serviceability of components being assessed by visual examination or by the results of calibration tests. Consequently, the necessity for SCRUPULOUS CLEANLINESS during the repair and testing of injection equipment cannot be over emphasized.

C.A.V. Fuel Feed Pump

2. After dismantling, wash all parts thoroughly in kerosene or fuel oil but do not use rag or such like material either for cleaning or drying the parts. Inspect all parts for scoring and corrosion. Defective valves or springs may be replaced by new ones, providing the seats are in good condition. A faulty plunger or spindle will necessitate rejection of the pump, as these components are mated to the body by selective assembly. If all parts are satisfactory, the pump should be reassembled, ensuring that the outlet valve plug, fuel priming device and plunger chamber cap are all securely tightened.

Testing C.A.V. Fuel Feed Pump

3. Provision is made on the Hartridge injection pump test bench to enable the feed pump to be tested during the general test of the injection pump. For the tests, the pump is connected up as shown in Fig - 39. The suction pipe from the supply tank is connected to the pump inlet connection and the delivery pipe from the pump outlet to the calibrating unit. Some pumps have two pipes leading to the inlet connection, and in this case, the nut and nipple connection should be blanked off.

a. **Priming Test.** The priming device should lift fuel a distance of 3 ft. within 20 strokes of the plunger. The outlet connection should be slackened off and the priming device operated. After approximately 20 strokes, fuel should appear at the outlet connection.

b. **Delivery Capacity Test.** With the injection pump running at 600 r.p.m., a feed pump should deliver 960 c.c. of fuel per minute. To carry out the test proceed as follows:

(1). Ensure that there is sufficient fuel in the supply tank.

(2) Open the drain cock of the calibrating unit, and also the air vent screw at the top of the unit.

(3) Start the test bench and adjust the speed to 600 r.p.m.

(4) Close the drain cock of the calibrating unit and at the same time set a stop watch in motion.

(5) After a period of 15 seconds switch off the test bench motor and check the amount of fuel delivered.

c. **Leakage Test.** This test is to prove the ability of the pump to deliver fuel against pressure and is applied as follows:

(1) Close the air vent screw at the top of the calibrating unit.

(2) Start up the test bench and when the calibrating unit gauge registers 2 atmospheres (29.4 lb. per sq. in.), switch off the test bench motor and observe the gauge.

(3) The rate of drop in pressure as shown by the gauge should not be more than 1lb per sq. in. in 5 seconds.

C.A.V. FUEL INJECTION PUMP

4. a. **Pre-dismantling Procedure**. All personnel responsible for this work should be able to interpret the type formula as given on the type plate attached to the pump or engraved on the unit. An unserviceable pump should be examined to assess whether the defect is the result of external controls having been incorrectly adjusted by inexperienced personnel. If this is the case, the pump should be examined to assess whether the defect is the result of external controls having been incorrectly adjusted by inexperienced personnel. If this is the case, the pump should be treated as newly assembled and subjected to the test bench routine.

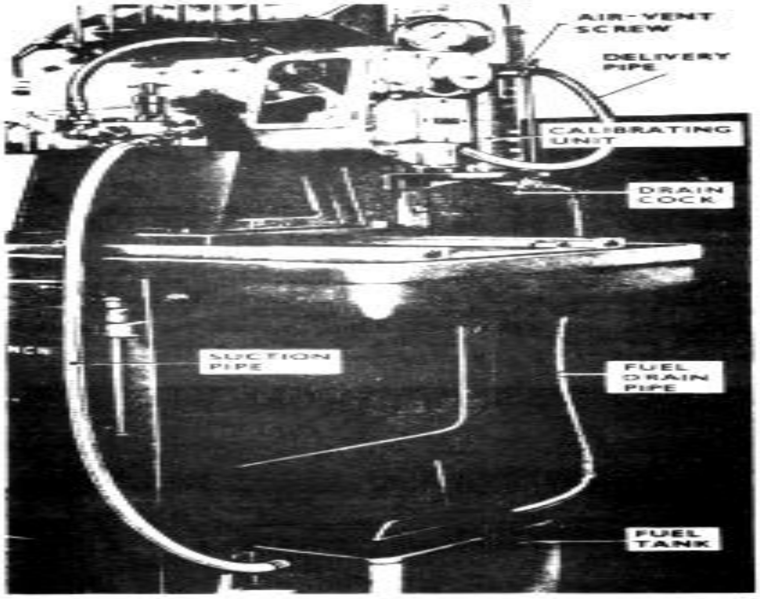


Fig – 39 Fuel Feed Pump on Test.

Before a pump in this condition is put on the test bench, it must be ensured that the camshaft can be turned in the normal manner. If it is suspected that the camshaft is bent although it is rota table, this should be checked by running the pump on the test bench with the end cover removed from the governor casing, and observing whether the governor runs eccentrically. Eccentricity is not a definite indication that the camshaft is bent, at the fault may be caused by incorrect mounting of the governor components on the fixing sleeve or of the fixing sleeve on the camshaft. Further checks should be made by running the pump after the governor components have been removed from the sleeve, and again after the sleeve has been removed from the shaft.

b. **<u>Dismantling,</u>** Before any pump is dismantled, all open fuel connecting points should be effective plugged or blanked and the pump thoroughly cleaned externally in kerosene. Dismantling operations will be facilitated if the pump is mounted on a vice as shown in (Fig-43) This also permits the camshaft to be effectively locked (Fig-40) whilst the governor assembly and driving coupling are being removed. The dismantling sequence as given in Air Publication 1464E should be strictly adhered to; some of the more important points being reproduced in the following paragraphs.

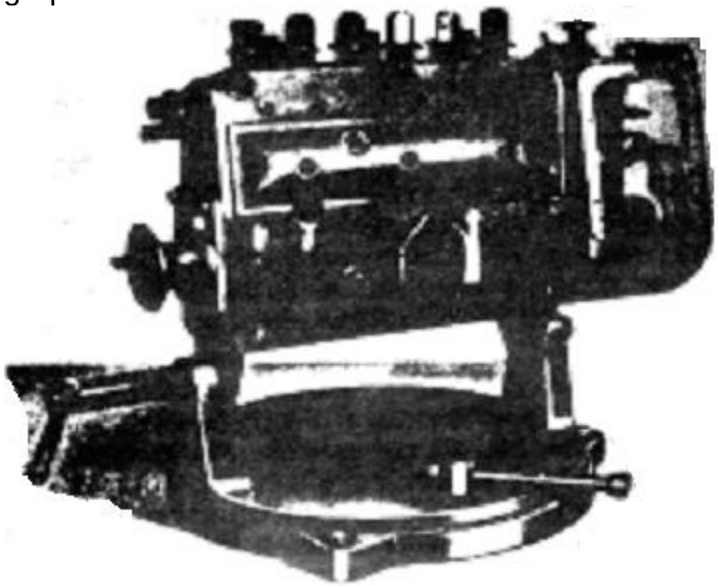


Fig - 40, Pump Mounted On Hartridge Vice

Before the camshaft can be removed, the pressure exerted by the plunger springs must be taken off the camshaft. This is done by turning the camshaft and as each lobe comes to T.D.C. a special holder is inserted under the head of the tappet adjusting screw (Fig-42). When the camshaft is removed, a note should be made of the total thickness of the adjusting shims, and also whether any gaskets are fitted between the bearing end plate and the pump housing.

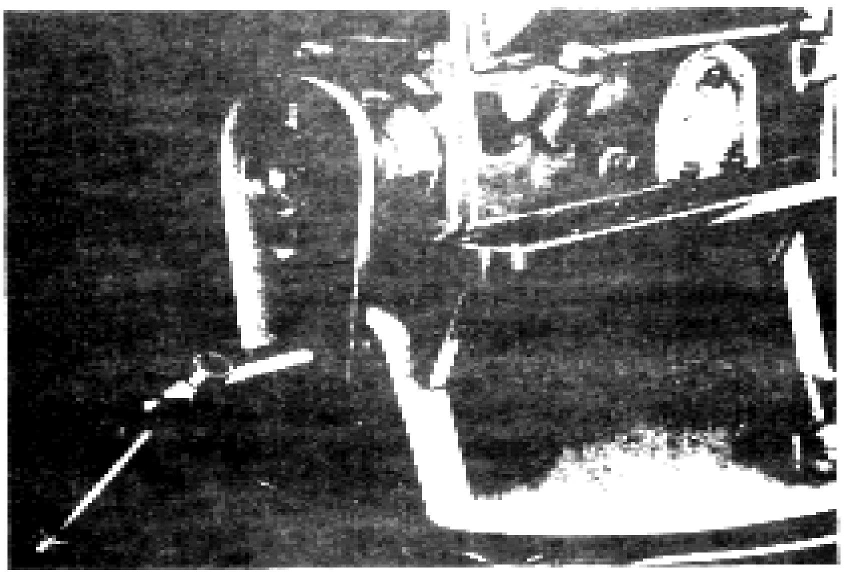
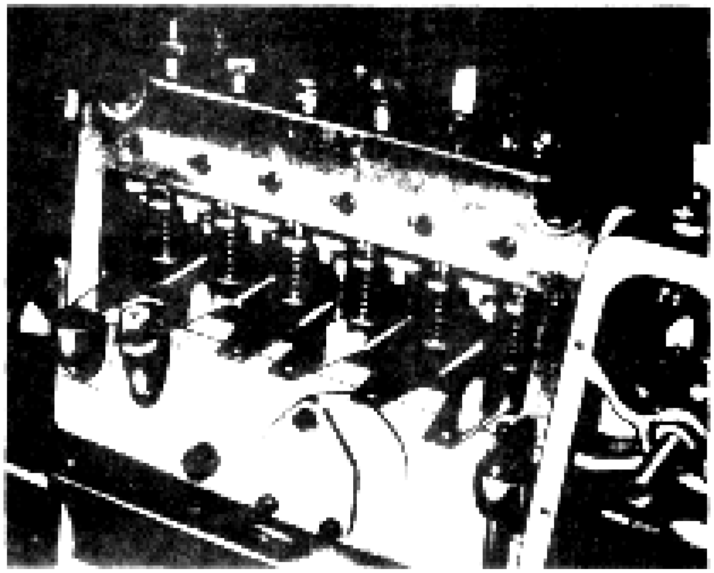


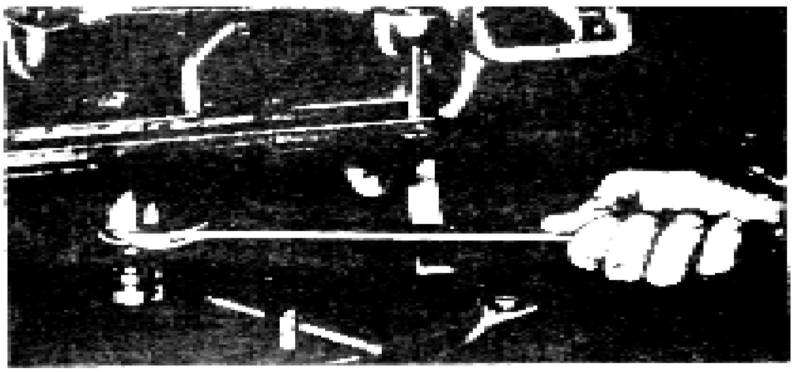
Fig -41, Camshaft Locking Plate in Position

The sealing plugs in the base of the pump housing must be removed before the tappets, springs, and plungers can be removed.



***F*ig -42, Tappet Holders in Position**

These sealing plugs are very tightly secured; they are removed by fitting a special tool into the slot of the sealing plug, adjusting the tool until its head is tight against the turntable of the vice, and then a spanner is used to turn the tool clockwise (Fig.-43). When the plungers are removed they must be placed apart so that on assembly each plunger can be mated with its original barrel.



***Fi*g -43, Removing a Base Plug**

Thoroughly clean all parts, using kerosene and a soft brush; the parts should then be placed in trays to drain. It is again emphasized that all mated parts (pump plungers and barrels, delivery valves and seats) must be kept together, as it during the cleaning operations that an interchange of parts is most likely to occur. No attempt must be made to degrease or clean in any way the diaphragm assemblies of pneumatic governors. The parts should be inspected according to the information in the following paragraphs.

(1) **Camshaft.** This component should be examined for wear and corrosion, particularly on the cam lobes. Worn lobes will cause erratic readings when the pump is calibrated and it will be found impossible to adjust the pump to give constant readings within the permissible limits. A camshaft with obviously worn lobes must be rejected. Surface corrosion is liable to affect the working aces of all cam lobes, especially which of the lift pump cam. Slight corrosion may be removed by light. The cone seating for the governor sleeve and the coupling end must be examined for picking up, which, if only slight, may be removed by stoning.

(2) **Tappets.** These should be examined for corrosion, especially on the working faces of the rollers. Each roller should be perfectly free on its pin, but without any appreciable wear, and without any signs of flats on the circumference. An eye-glass should be used to examine the rollers for cracks. The adjusting screw and nut should be examined for serviceability.

(3) **Pump Elements.** Each pump element should be inspected for scoring on any part of the working surfaces. The part of the plunger which operates in the vicinity of the two ports in the barrel should be carefully examined for signs of wear. Normal wear will be seen as minute scoring in these areas, especially on the helix side of the plunger. Fig.9-44 shows a magnified view of a worn plunger and it can be seen that the affected area extents from the top edge of the plunger to the helix edge, and to a width which is approximately the circular movement of the plunger between idling and maximum speeds. When it is not possible to assess accurately the serviceability of an element by visual examination, the final assessment must be made from the readings taken on the calibration test. Plunger springs should be inspected and judged by comparison with a new spring.

(4) **Delivery valve.** These components should be inspected for obvious defects, but no attempt should be made to recondition a valve or valve seat. Use an eye-glass to examine the anti dribble device for abrasions, and the contact face of the valve seat for radial abrasions which would indicate an interference leakage. The valve's efficiency can only be finally assessed from the test bench results. A valve spring should be tested by comparison with a new one.

(5) **Bearings.** These should be examined for wear and damage and tested for smooth running. Defective bearing inner and outer races can be removed (Fig-45) and new ones fitted with the aid of special tools. Oil seals should be examined and rejected if unserviceable or if they are at all doubtful.

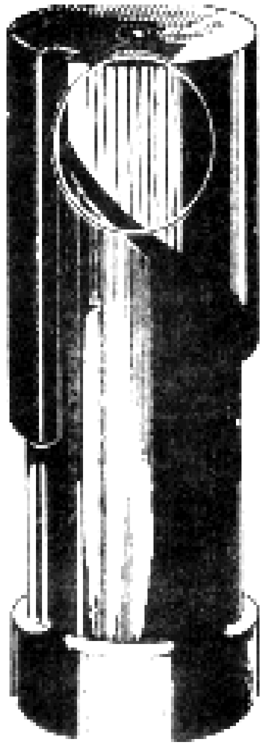


Fig-44, A Worn Plunger

(6) **Control Rod and Quadrants.** The teeth on the control rod and regulating quadrants should be carefully inspected for damage. The control rod should be tested for straightness and the bearing portions at each end examined for wear and damage. The quadrants should be examined for distortion, which is often caused by over tightening of the clamping screws can be easily turned and that the threads are not damaged. Examine the quadrant slots for damage.

(7) **Governor and Linkage.** The pivot pins used with these components should be inspected for general serviceability. The pins should fit quite freely in their working positions, but must not be slack. The diaphragms of pneumatic governors should every pliable and free from any signs of cracking; any defects in these respects will necessitate rejection.

(8) **Control Rod Bearings.** The control rod bearing bushes should be inspected for scoring and undue wear. Unserviceable bushes can be removed and new ones fitted with the aid of special tools, the bushes being finally reamed.

Fig - 45
Removing Bearing Inner Race.

c. **Assembly.** The assembly sequence is, in general, a reversal of the dismantling operations, plus the observance of several important points. Components must be rinsed in clean kerosene, allowed to drip, smeared with clean lubricating oil, and finally assembled entirely without the use of any kind of drying material. The camshaft should be fitted to the pump housing with the bearings, oil seals, adjusted if necessary by the shims to 0.005 in-0.007 in. The camshaft should then be removed and placed in a clean position ready for re-assembly after the elements and tappet assemblies have been fitted. After fitting the control rod, check that it is a good but perfectly free fit in its bearings and that it is positioned with the stop arrow pointing towards the governor housing. Ensure that each element barrel locking screw is fitted with a sealing washer, fit each barrel so that the end of the locking screw will enter the slot, and down. Fit a new sealing washer between the delivery valve seating and the valve holder. When fitting the regulating sleeves and quadrants, the control rod must first be clamped in its central position. The quadrants must be clamped in position on the sleeves with the timing marks coincident (Fig-46) and the upper spring plates fitted to the sleeves. The quadrant should be engaged with the control rod, with the clamping jaws centrally towards the operator. The control rod and quadrants should be tested for freedom of movement by turning the pump end of end several times and noting that the control rod falls freely under its own weight at each turn.

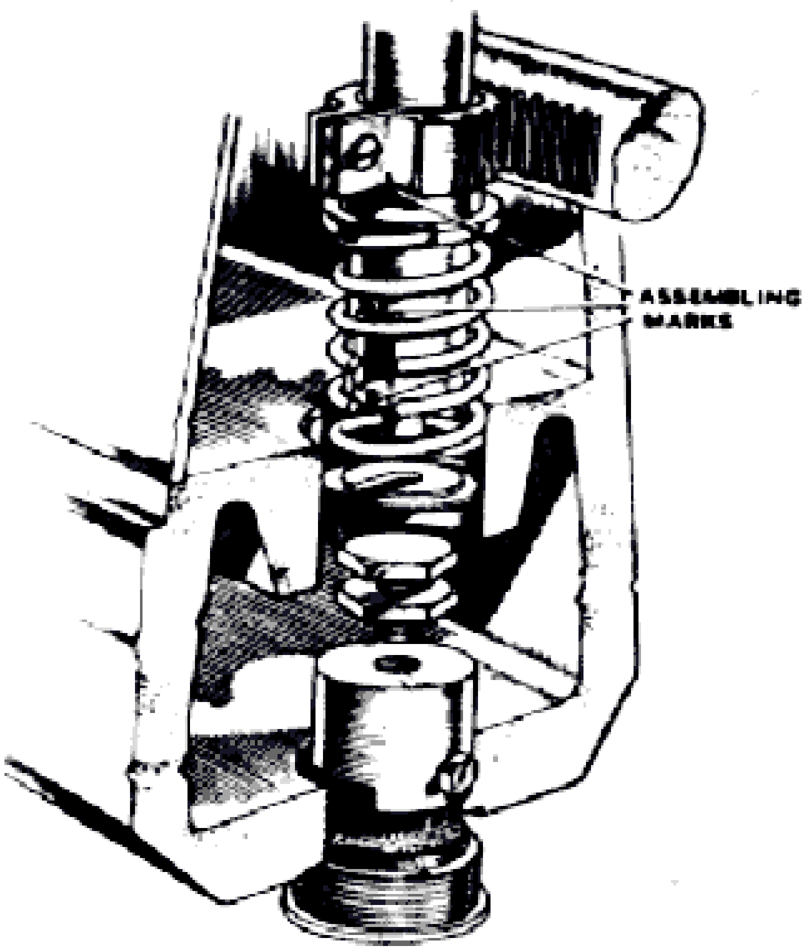


Fig – 46
Assembly Marks

When fitting the plungers, springs and tappets, the pump should be positioned on its side. Each spring must first be fitted to bear against the upper spring plate. The lower spring plate should then be fitted to the end of the plunger and the plunger end gripped in the special tool. With the marked lug of the plunger uppermost, the plunger should be carefully inserted in the barrel, the plunger lug engaged in the slot of the regulating sleeve, and the tool removed. The tappet assembly should be held in the special tool fitted in position and then pushed in against the spring pressure until a tappet holder can be inserted under the tappet head. 100. When a pneumatic governor is being assembled, the assembled, the diaphragm assembly must be fitted so that the small semi-circular tab on the diaphragm frame fits into the recess in the housing. In this position, and with the diaphragm assembly connected to the control rod, there must be no twist in the diaphragm itself. If there is twist, the diaphragm must be replaced by a new one.

<u>Principles of Phasing</u>

5. Phasing a fuel injection pump is the means adopted to ensure that fuel injection to the various cylinders occurs at equiangular intervals. Adjustment is by alternating the length of the tappet, thus rising or lowering the plunger in its barrel and so advancing or retarding the commencement of injection as required. Some pumps can be phased in the workshop whilst others have to be done on the engine, unless a slave camshaft is available. A hand operated test outfit or a Hartridge test bench is used for the phasing operations. The Hartridge bench is the more elaborate, but better method, because it enables the performance of the injection pump to be noted at any speed within its working range. The principle, when either type of equipment is used, is the same, but the methods of obtaining the results differ. The “spill” method for finding when injection starts is used for the hand operated outfit,

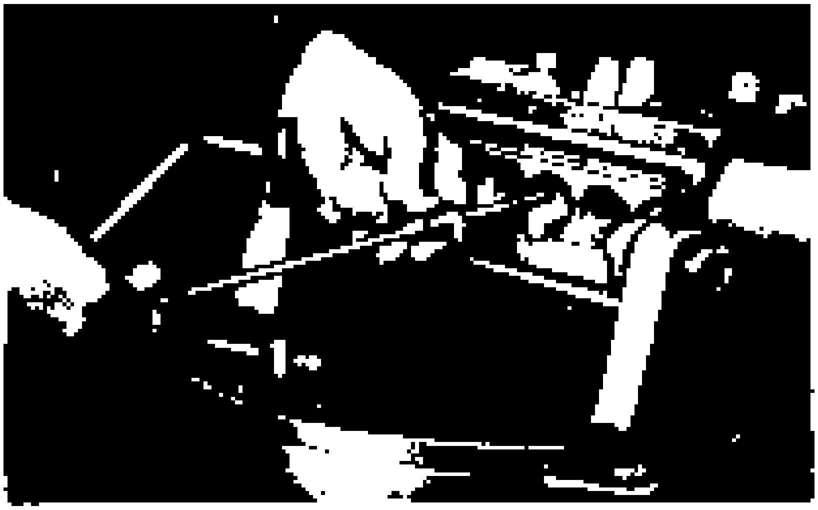


Fig - 47

Fitting a Plunger

Where as actual injection under working conditions can be observed on the Hartridge bench, although the spill method can be employed if required. The test procedure for a six cylinder unit with an injection sequence of 1,5,3,6,2,4, is given in below.

a. **Hand Operated Outfit.** Mount the pump on the bed of the test outfit, and fit the graduated wheel and handle to the pump coupling (Fig-50). Secure the extension rod and pointer to the inlet connection stud at the coupling end. Clamp the control rod in approximately its central position. Connect the fuel feed pipe to the pump inlet at the opposite end to the coupling, and ensure that the filter bowl is full of fuel when the tap is turned off. If the inspection cover plate is fitted, remove it. Vent the pump by loosening the air vent screw, turn on fuel, allow fuel to flow until there is no trace of air bubbles, and then tighten the air vent screw. Check that none of the element plungers touches the underside of its delivery valve seat when the camshaft is turned, as this would cause considerable damage. Turn the camshaft carefully, and as each plunger in turn comes to T.D.C., insert a screwdriver under the head of the tappet screw (Fig -51). Gently lever up the plunger assembly which should lift approximately 0.5 mm. (0.020 in.), any adjustment required need not be too accurate as a further adjustment will probably be needed whilst phasing. Phasing is normally started at No. 1 pump element, i.e. the element nearest the coupling; the exception to this is described later. Turn the camshaft to bring N o 1 plunger to T.D.C. As there is no gauge, and it is impossible to use feelers to check the clearance, the operator should proceed as follows. Slacken the lock nut and turn the adjusting screw until it is felt that the plunger is just touching the underside of the valve seat. The adjusting screw should then be turned back a half turn (three flats of the head), which, since the pitch of the thread is 1mm. Tighten the lock-nut. Remove N o. 1 delivery valve holder, valve spring and valve, and refit the holder only. Turn the camshaft in the normal direction of rotation until the plunger is at the bottom of its stroke, and then turn on the fuel. Fuel will flow through the pump suction chamber, through the open ports in the barrel and spill from the delivery valve holder. The other delivery valves are in position so there will not be any flow from these. Turn the camshaft slowly in the normal direction of rotation until the fuel flow is reduced to a trickle.

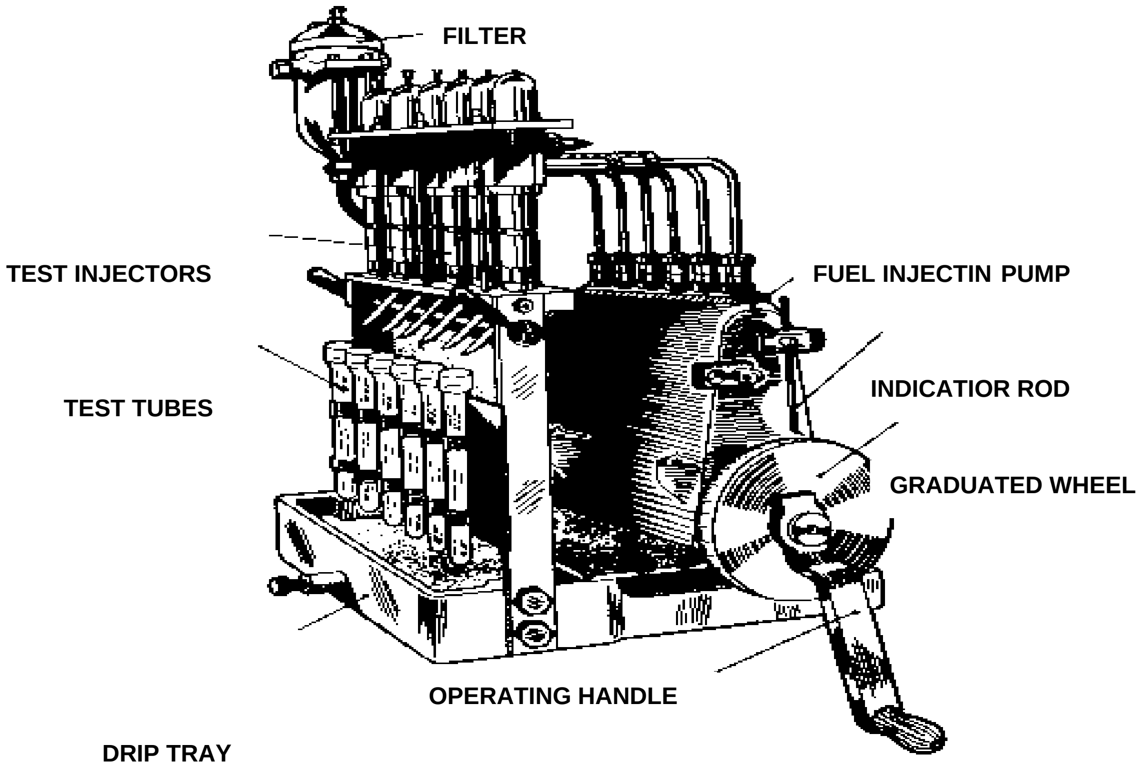


Fig-48, Hand Operated Outfit

Note - This operation must be done accurately as it has a distinct bearing on the adjustment of the other elements.

Continue to turn the camshaft by gently tapping it, and at each tap the fuel should be flicked from the delivery valve holder (Fig -49). Continue until there is no change in the surface of the fuel in the holder, which means that the barrel ports are closed and the theoretical point of “commencement of injection” has been reached. This point when the fuel flow finishes will be shown more definitely if a swan neck pipe is fitted to the delivery valve holder (Fig- 50). Take particular care that the plunger is raising at this point.

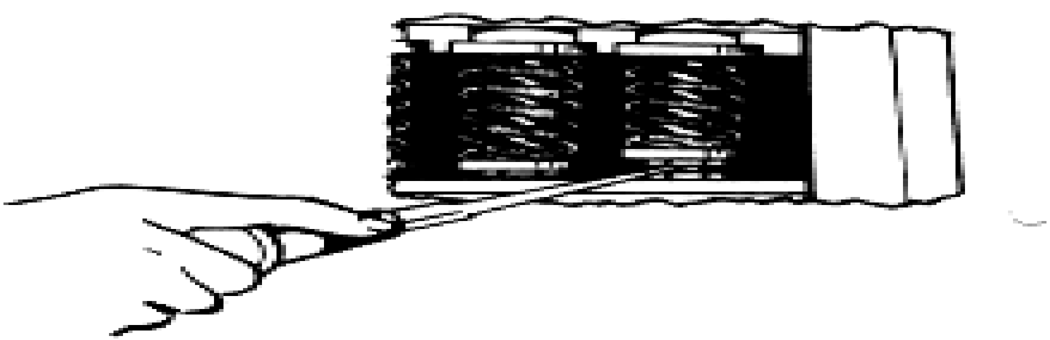


Fig-49 Testing plunger end Clearance

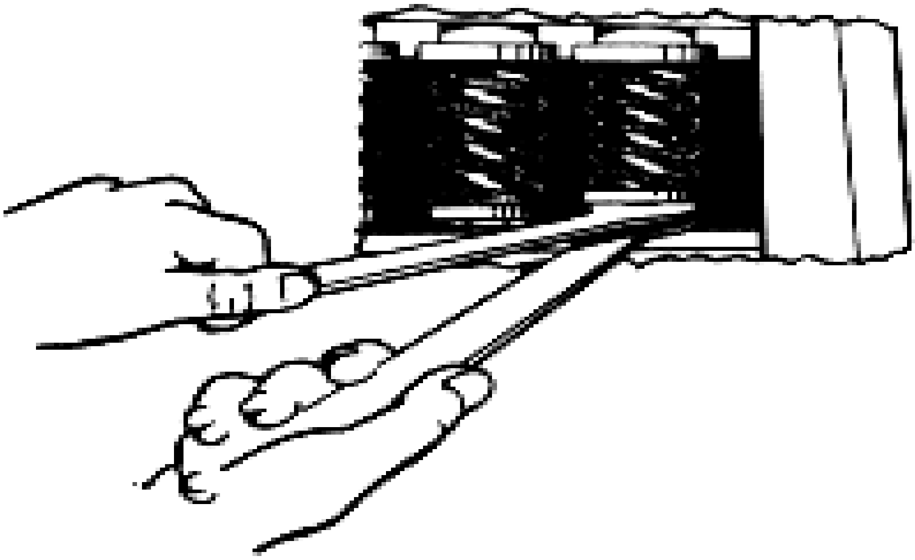


Fig – 50

Adjusting Tappet Screw

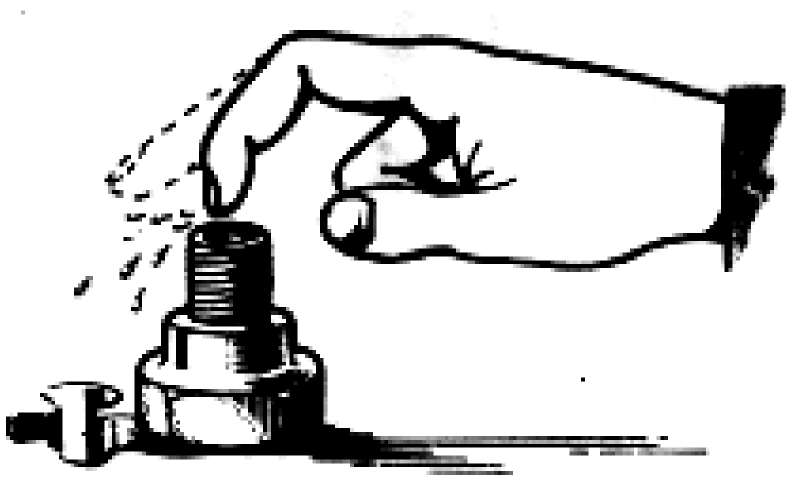


Fig – 51

Determining Spill Out-Off

Fig – 52 Swan Neck Pipe

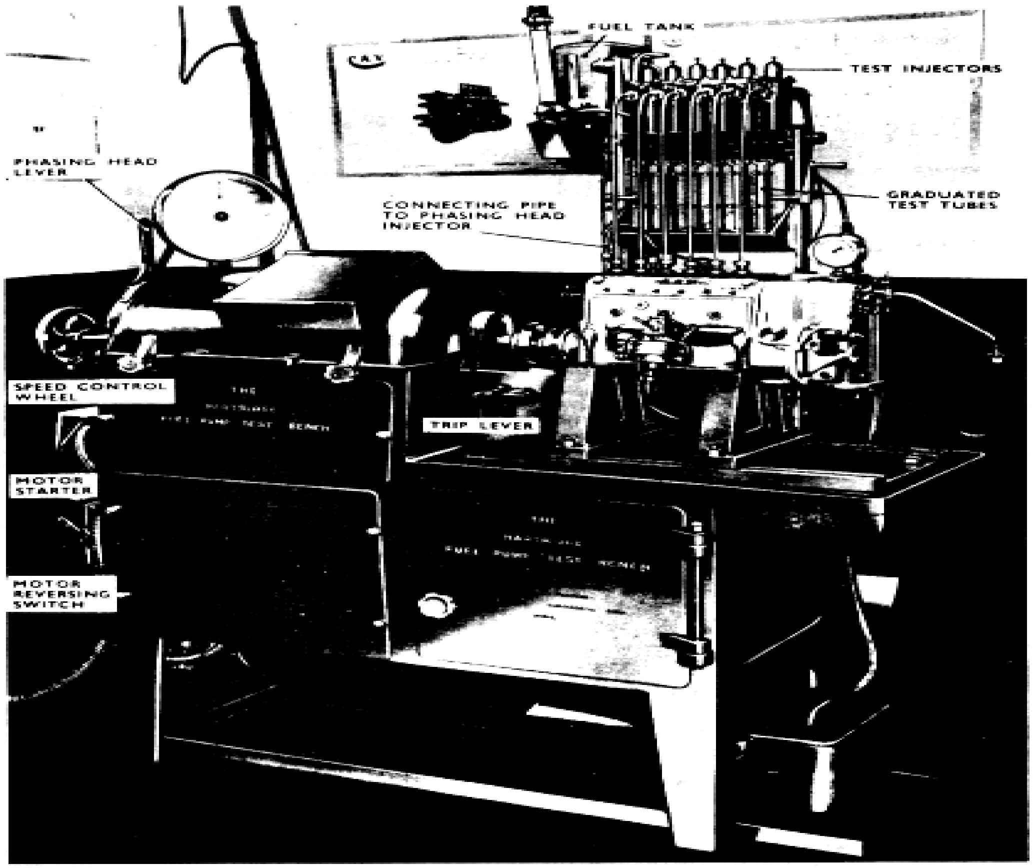


Fig – 53

Pump Mounted On Hartridge Test Bench

Slacken the handle securing nut and carefully set the wheel so that the pointer indicates 0^0. Check that the camshaft was not moved during the wheel adjustment. When satisfactory turn off the fuel, remove No. 1 delivery valve holder, wash this, the valve and its spring in clean fuel or kerosene and refit these parts. Each of the pump elements is now adjusted in turn to commence injection exactly 60^0 after the preceding element in the injection sequence. Remove No. 5 delivery valve holder, valve spring and valve, and refit the holder only. Turn on the fuel, and when it is flowing freely from the holder, turn the camshaft in the normal direction of rotation through nearly 60^0, and check the point when fuel flow ceases, as in previous discussion. The reading on the graduated wheel must be exactly 60^0. If there is an error of more than $½^0$, the tappet must be lowered when the reading is less than 60^0, and raised if the reading is more. Careful adjustment is necessary, 8/1 of a turn (one flat on head) of the adjusting screw will give 1^0 differences in the pointer reading. After locking the tappet, the point when fuel flow ceases should again be checked. When the phasing of No. 5 element is satisfactory, a check should be made as in previous discussion that the 0.5 mm. clearance exists. Should there be less than the minimum permissible clearance, the tappet must be adjusted to the minimum permissible clearance, i.e. 0.3 mm. (0-012 in), and the complete phasing of the pump recommenced. The sequence would now be 5,3,6,2,4,1, and if at a later stage any of the elements are found with less than the minimum permissible clearance, the element in question would be the starting point for complete re-phasing. Assuming the phasing of No. 5 element to have been satisfactory, the remaining elements should be tested in the same manner in injection sequence. A final test should be made of No. 1 element, or exceptionally, the element used as the starting point, checking that the pointer reads O^0. Any discrepancy here will indicate that the pointer wheel has moved, and the phasing will have to be checked again throughout.

b. **<u>Hartridge Test Bench.</u>** Injection pumps can be phased on a Hartridge bench by watching the actual injection from each pump element under working conditions, or by the spill method. In the following description the first method will be termed injection phasing and the second spill phasing. Before either method of phasing is commenced, check that there is clearance on all plungers. For either method the pump is mounted on the bench (Fig -53), and this procedure is described in the following paragraph. Mounting the Pump. Assuming the pump to be a six cylinder unit with an injection sequence of 1,5,3,6,2,4, and anticlockwise rotation, proceed as follows :

(1) Fit the appropriate pair of brackets to the bed of the test bench as shown in Fig - 53, this allows the left hand bracket to be as close as possible to the trip mechanism case.

(2) Fit clamping bolts to the pump and engage the bolt heads in the bracket channels.

(3) Turn the pump coupling in direction of rotation until No. 1 plunger is at commencement of injection, shown by the markings.

(4) Turn the test bed shaft until the knurled head locking pin is approximately at T.D.C.

(5) Slacken the Allen locking screws in each half of the test bench coupling and disengage the locking pin from the left hand half coupling.

(6) Turn the test bench shaft and until the lines marked “1” and “0” are in line (Fig-56). Re-engage the locking pin in the left-hand half coupling

(7) Slide the pump towards the test bench coupling until the delivery valve holders are approximately in line with the delivery pipes to the test injectors. Slight movement of the bench coupling on its shaft may be necessary to ensure correct engagement of the dogs (Fig-54), but ensure that the pump elements are kept approximately in line with the delivery pipes.

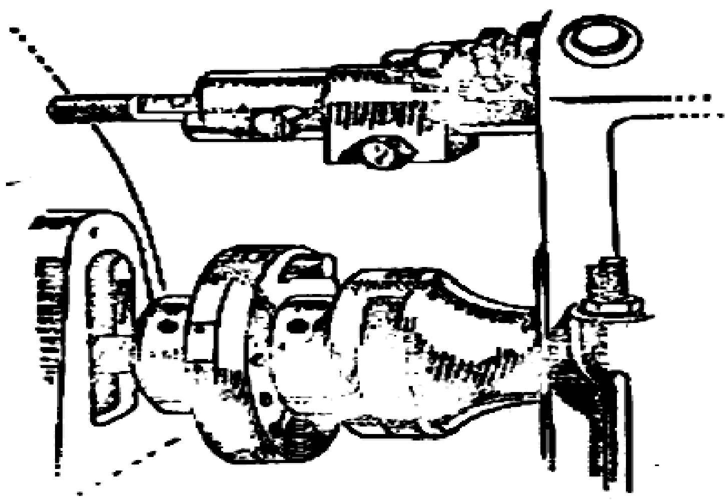


Fig-54 Coupling Correctly Engaged

(8) Ensure that the locking screw in each half coupling is securely tightened.

(9) Keep the pump in perfect alignment whilst securing it. Any incorrect alignment will be evident if the test bench driving shaft is turned by hand as the pump is being tightened.

(10) Connect the delivery pipes to their respective holders on the pump, and the feed pipe to the normal fuel inlet.

(11) **Fitting Control Rod Setting Device.** During the phasing operations it is necessary to control the setting of the rack in securely defined positions. This is done by fitting a rack setting device to the pump as described in Fig-55. The locating pin should then be removed and the graduated rod pulled out until it measures 12 mm, which is the recommended position for phasing.

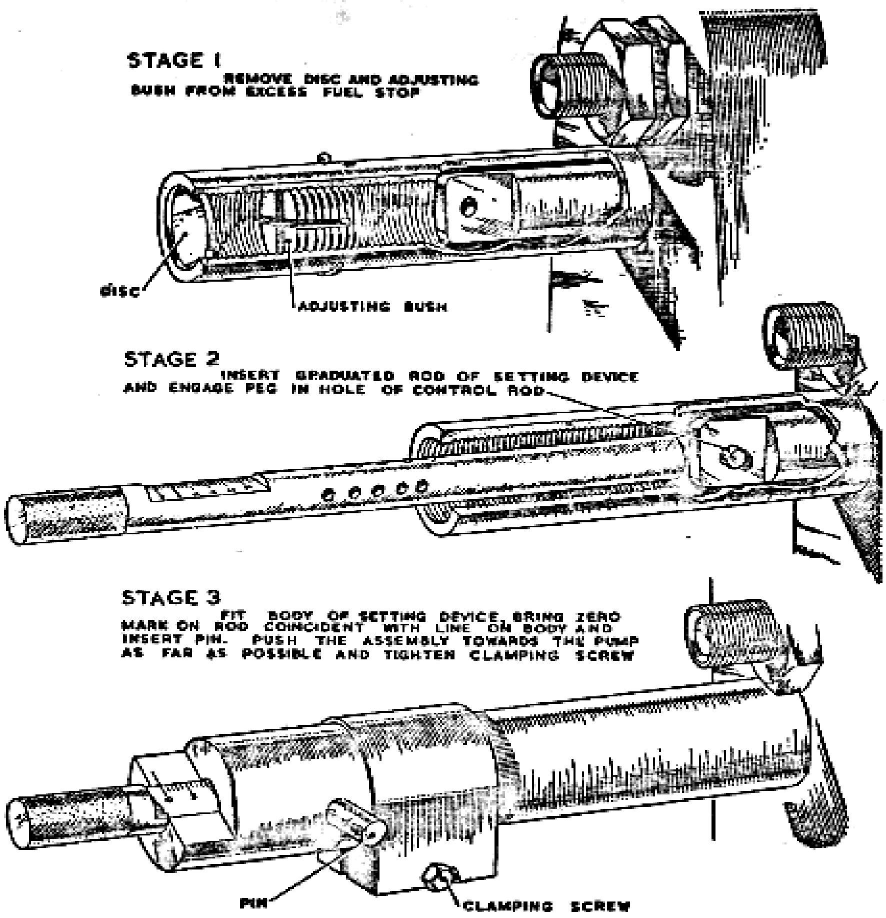


Fig - 55, Fitting Control Rod Setting Device

(12) **Injection Phasing.** Proceed with the phasing of the pump in the following sequence:-

(a) Disconnect No. 1 element delivery pipe at the holder, and in its place connect the delivery pipe leading to the phasing head injector.

(b) Adjust the T.D.C. clearance of No. 1 element plunger to 0.5mm.

(c) Switch on the phasing light, open the fuel tank cock, start the motor (in correct direction of rotation) and adjust the speed of the bench shaft as shown on the tachometer to approximately 500 r.p.m.

(d) Open the pump air vent cock until the fuel flows freely.

(e) Turn the phasing injector carrier towards the front of the bench until it is in approximately the position shown in Fig. 56.

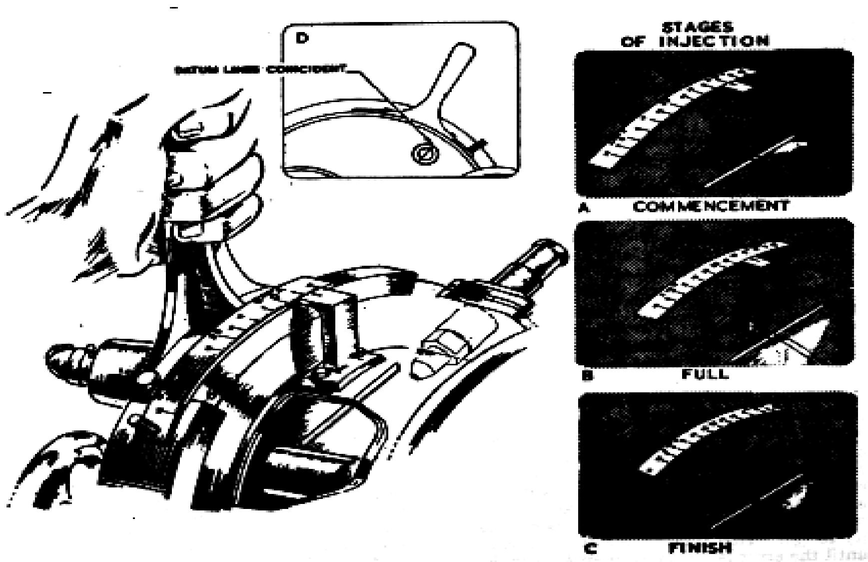


Fig-56 Using the Phasing Head

(f) Move the carrier slowly in the opposite direction (direction of pump rotation) until a full spray is observed through the viewing aperture (Fig -56, B).

(g) Move the carrier very slowly towards the front of the bench until the spray stops, and then slightly in the opposite direction tot he point where the spray just appears. This is the actual start of injection (Fig-56A).

(h) Adjust the scale attached to the injector carrier so that the zero mark against the arrow (direction of pump rotation) is in line with the line on the fixed bracket (Fig-56A).

Note - This setting must be accurate and only altered when the procedure described in Note 1 to this Para is necessary.

(j) Repeat operations (5) to (7) and check that the scale is correctly set. Stop the driving motor.

(k) Disconnect the phasing delivery pipe from No. 1 element and re-connect the normal delivery pipe. Disconnect the normal delivery pipe from No. 5 element and connect the phasing pipe in its place.

(l) Turn the bench driving pulley until the locking pin on the coupling is at T.D.C. (Fig-56).

(m) Slacken the Allen locking screw in the right hand half coupling and disengage the locking pin from the left hand half coupling.
(n) Turn the bench driving pulley in opposite direction to pump rotation (clockwise) until the first line marked “8” on the left hand half coupling comes into line with “8” on the right hand half. Re-engage the locking pin with the left hand half coupling and tighten the Allen screw.

(o) Start the motor, repeat operations (e) to (g) and check the reading on the injector carrier scale. If No. 5 is correctly phased at 60” after No 1, the reading will be exactly as for No. 1 (Fig-58, A). Note the error (Advanced or Retarded), adjust the tappet, and repeat operations (5) to (7). This procedure must continue until the error is not more than ½ ^{0} A or R.

(p) Stop the motor and refit the normal delivery pipe to No. 5 element.

(q) The remaining elements must be phased in injection sequence in the same manner as No. 5.

Note :

1) *After each adjustment of a tappet, check the plunger for minimum clearance (0.3 mm). If the clearance of any plunger is less than 0.3 mm, the complete phasing of the pump must be re-started from the element in question.*

2) *The foregoing procedure is applicable to other types of pumps except that due regard must be made for the direction of rotation of the pump, and also the different phasing angle according to the number of pump elements (normally the phase angle is $360^0 \div$ No of elements).*

3) *Pressure waves, always present in delivery pipes, may influence the start of injection and cause fluctuation in phase readings. A slight alteration of the pump speed will overcome this.*

(13) **Spill Phasing.** This similar to the method used on the hand operated outfit. The start of injection is found in the same manner, but the test bench coupling and phasing head are used instead of the graduated wheel

and pointer for finding the exact angular distance between injections. The pump is to be mounted on the test bench as described earlier but it is not necessary to connect the elements to the test delivery pipes. The procedure is as follows:

(a) Set No. 1 element to “start of injection”

(b) Rotate the phasing head injector carrier until the line on the inner dished wheel is in line with the lines on the carrier (Fig -56, D).

(c) Adjust the scale on the carrier so that the zero mark against the arrow (direction of pump rotation) is in line with the line on the fixed breaker (Fig-56A).

(d) Disengage the locking pin from the left hand half coupling, slacken the locking screw in the right hand half coupling, and turn the bench driving shaft in opposite direction to pump rotation (clockwise) until the first line marked “8” on the left hand half coupling comes into line with “6” on the right hand half. Re-engage the locking pin and tighten the right hand locking screw.

Note - The line on the dished wheel will have moved exactly 60” sway from the line on the carrier.

(e) Close the fuel feed cock.

(f) Reassemble No. 1 delivery valve and prepare No. 5 for the spill test.

(g) Open the fuels feed cock and turn the test bench shaft anti-clockwise to find “start of injection: No 5 element.

(h) If No. 5 is correctly phased, the line on the dished wheel should line up with the carrier lines. If it does not, move the carrier to line up the marks and the scale will then register the amount of error. No 5 tappet should then be adjusted until on repeat tests the error is not more than ½

(9) Test each element in injection sequence and finally re-check No. 1 element to ensure there has been no accidental movement of the phasing head scale. In turn, total phasing having to be re-started if any elements are found to have has clearance than the specified minimum of 0.3 mm.

Principles of Calibration

6. The full calibration of a pump ensures that the outputs from all elements are equal throughout the normal range of engine speed; it also ensures that the outputs conform, within reasonable limits, to those specified by the engine manufacturers. The hand-operated

outfit is not suitable for full calibration because its maximum speed is well below that at which the pump normally runs when the engine is idling. Any calibration on this outfit can be regarded only to be reasonably serviceable, and on which there have been no major replacements, or as will be explained later, to decide that the elements are unserviceable. If there have been major replacements, then it is essential that the pump is fully calibrated on a Hartridge test bench. For all calibration tests it is necessary for personnel to know the characteristics of the pump and to be in possession of the necessary data sheets. Calibration usually follows the phasing operations, and assuming that the pump has been mounted on the test equipment as previously described, the procedure for using both types of equipment is as follows.

a. **Using Hand Operated Outfit** Connect each of the test injectors to its respective delivery valve holder. Clamp the control rod in the central position, i.e. 12 mm. travels from the fully closed position. If the pump is fitted with a governor the operating lever must be secured. Turn the test injector delivery scopes away from the measuring glasses and ensure that the glasses are completely empty. Turn on the fuel supply, air vent the pump to expel any air from the delivery pipes and injectors. During the test run a speed of at least 120 r.p.m. must be steadily maintained. When this speed has been reached, the delivery scoops should be moved to divert the fuel supply to the measuring glasses, and turning the camshaft continued for a minimum of 100 revolutions. The amount of fuel in each measuring glass should be recorded, the figures compared and the relative efficiency of each element assessed. Suppose that the following figures are recorded:-

No. 1 element	..	9.8 cc.
No. 2 element	..	10.4 cc.
No. 3 element	..	10.1 cc.
No. 4 element	..	10.6 cc.
No. 5 element	..	9.4 cc.
No. 6 element		10.5 cc.

These figures show that No. 1,3, and 5 elements have deteriorated or are out of adjustment, and they should be adjusted to approximately the level of the rest.

(1) **Adjustment.** Unclamp the control rod and move it to the fully loosed position. Make a temporary datum mark on the quadrant and sleeve of each element requiring adjustment and slacken the clamping screws. Sleeves and quadrants fitted by the manufacturer are marked (Fig-44), but if these parts were fitted in a repair shop they may not be marked. To increase the fuel delivery from an element, the sleeve should be turned in the same direction as it turns when the control rod is moved to the open position. There is a hole in the sleeve for a Tommy bar by which the sleeve can be turned.

Note *- Only a very small movement is required for normal adjustment, and several test runs may be necessary to obtain the correct setting. Ensure that the quadrant is clamped after each adjustment.*

When all elements have been balanced, the test run should be repeated with a control rod setting of 6mm, opening and the readings recorded. If all elements are reasonably balanced, it can be assumed they are serviceable, but a big difference in outputs would indicate that the elements with the low outputs are worn and need renewing. This is a major replacement requiring full calibration tests on a Hartridge test bench.

Note:

1) *Table 1 shows minimum and maximum outputs for different sizes of plungers at 6.9, and 12 mm. control rod opening and should be used in conjunction with tests on the hand operated outfit when it is known that the camshaft speed can be evenly maintained at 120 r.p.m. and that the test delivery strokes can be accurately recorded to give the necessary 100.*

2) *After all tests have been completed and the required adjustments made, the pump should be tested with the control rod in the fully closed position to check that there is no delivery of fuel at this position.*

Table 1

Delivery quantities per 100 strokes "B" type pumps -20 mm, pitch helix

Camshaft speed in r.p.m.	Plunger diameter mm	Delivery in cubic centimeters					
		Control rod opening 6 mm		Control rod opening 9 mm		Control rod opening 12mm	
		Min	Max	Min	Max	Min	Max
120	10						
	9	2.6	3.4	8.4	9.6	14.0	15.6
	8	1.6	2.2	6.4	7.2	11.0	12.6
	7.5	1.6	2.2	5.2	6.0	9.0	9.8
	7	1.6	2.1	5.0	5.7	8.2	9.0
	6.5	1.4	2.0	4.1	4.8	7.2	7.8
	6	1.2	1.8	3.6	4.2	5.8	6.6
		0.8	1.4	2.8	3.2	4.7	5.3

b. **Using Hartridge Test Bench.** Full calibration of a pump is possible on this powered test bench because the pump can be run at a constant speed at any point in its working range, and because the number of deliveries to the test tubes is automatically controlled. Normally, it is sufficient to make test runs at 600 r.p.m. and 200 r.p.m. with control rod settings of 12mm and 9mm opening at both speeds, but if there is any doubt about the serviceability of an element, further runs with a 6mm, setting should be made. The principle involved is the same as for the hand operated outfit. The reading obtained should be recorded on a prepared record card.

Assuming that the pump has been installed on the bench, the delivery valve holders connected to the test injectors, and the system, pump and injectors have been air vented, proceed as follows:

(1) Set the control rod to 12 mm, opening, and adjust the bench speed to 600 r.p.m.

(2) Ensure that the test tubes are completely empty and then depress the automatic trip lever.

(3) When the automatic trip has operated to direct the fuel to the front set of glasses, release the lever.

(4) When the automatic trip has again operated to divert the fuel from the glasses, the amount of fuel in each glass should be recorded.

(5) From the readings it can be seen which elements need adjusting in order to balance the outputs. Any necessary adjustments should be done accordingly

Note - Ensure that the outputs at this control rod setting are within the limits of the specified maximum for the type of pump (Table 2). The permitted tolerance between element outputs is + 2½ per cent, of the mean average of the outputs which are within the specified tolerances for this particular control rod setting and r.p.m.

(6) When the elements have been satisfactorily balanced and the final figures recorded, the bench speed should be set to 200 r.p.m. a test run made, and the outputs recorded.

(7) Re-set the control rod to 9mm, opening, make test runs at 600 r.p.m. and 200 r.p.m. and record the outputs.

<u>Table 2</u>

Delivery quantities per 100 strokes "B" type pumps -20 mm, pitch helix

Camshaft speed in r.p.m.	Plunger diameter mm	Delivery in cubic centimeters					
		Control rod opening 6 mm		Control rod opening 9 mm		Control rod opening 12mm	
		Min	Max	Min	Max	Min	Max
	10	5.6	7.2	17.4	19.8	29.2	32.4
	9	3.6	4.6	13.2	14.8	23.0	25.2
	8	3.4	4.4	10.8	12.4	18.4	20.4
200	7.5	3.4	4.6	10.2	11.8	16.8	18.6

	7	3.4	4.6	9.0	10.4	14.6	16.4
	6.5	3.4	4.4	8.2	9.4	13.2	14.6
	6	2.2	2.8	6.4	7.2	10.6	11.8
	5	0.6	1.2	2. 8	3.8	6.0	7.0
	10	8.0	10.4	20.0	23.0	31.6	35.2
	9	5.6	7.2	15.2	17.4	25.0	27.6
600	8	4.4	5.6	12.0	13.8	19.6	21.8
	7.5	4.4	5.6	11.0	12.6	17.6	19.6
	7	4.0	5.2	9.8	11.4	15.6	17.6
	6.5	4.0	5.2	9.0	10.4	14.2	15.8
	6	2.4	3.2	6.6	7.8	10.8	12.2
	5	0.8	1.4	3.6	4.4	6.4	7.4

The serviceability of each element can be assessed from a comparison of the recorded figures. As an example, the readings from a test on a BPE pump are shown in Table 3. From these figures it will be seen, that although element No.3 gives the highest output at the 600 r.p.m. and 12 mm. control setting, it gives the lowest output on the rest of the rests. All the other elements are within the permissible limits; No. 3 element is therefore unserviceable.

Note *: If new elements are fitted the full calibration must be repeated, to permit the new elements to be balanced and to check their serviceability.*

(8). **Adjustment of Control Stops.** There are normally four control stops (Fig -56) which require being correctly set after a pump has been serviced. The maximum fuel stop, the auxiliary maximum fuel stop and the excess fuel stop can conveniently be set on a Hartridge test bench, but the minimum fuel or idling stop must be set after the pump has been installed on an engine.

The pump must be installed on the test bench and the delivery valve holders connected to the test injectors. The excess fuel stop must be fitted, care being taken not to enter the adjusting bush too far into the body. The blanking disc should not be fitted, and the maximum fuel stop adjusting screw should be set to an approximate working position.

Table 3

Calibration test figures “B” type pump-8 mm, dia plunger

Control rod setting	r.p.m.	Delivery in cubic centimeters					
		No 1 element	No 2 element	No 3 element	No 4 element	No 5 element	No 6 element

12 mm	600 200	21.4 20.2	21.0 19.8	22.0 19.0	21.2 20.2	21.6 20.2	21.2 19.8
9mm	600 200	13.4 12.0	13.0 11.8	12.4 10.8	13.0 11.6	13.6 12.2	13.2 11.4

(9) Maximum Fuel Stop. This stop is set to restrict the pump output to the engine manufacturer's specified permissible maximum. This maximum output should never be exceeded, and consequently the stop is sealed to deter unqualified personnel from making indiscriminate adjustment. The stop should be set in the following manner**:**

(a) Air-vent the test bench fuel system, pump and injectors, and ensure that the test glasses are completely empty.

(b) Start the test bench, set the speed to 600 r.p.m. and make a test run.

c) Check the output of each element against the engine manufacturer's specification and adjust the stop accordingly. If the output is less than that specified, the stop adjusting screw must be slackened an estimated amount, locked in position and another test run made. Repeat until the output is within the specified limits.

(d) When the result is satisfactory, check that the adjusting screw is locked and fit the cover and seal.

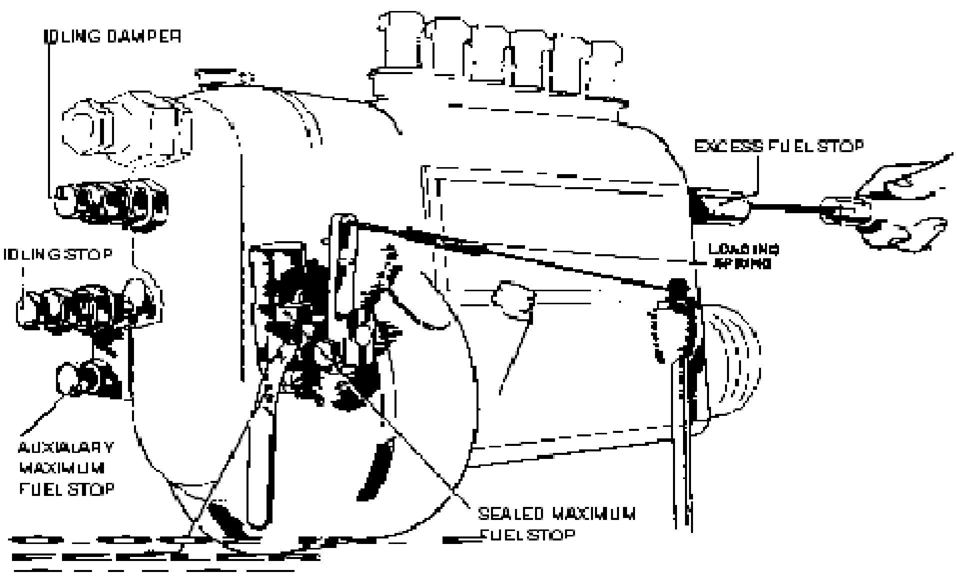


Fig -57, Control Stops

Note - The sealing cover of this top must only be removed by qualified personnel.

(10) **<u>Excess Fuel Shop.</u>** This stop is set to permit the pump to provide fuel in excess of that permitted by the maximum stop during engine starting operations. Set the stop as follows:

(a) Fit the loading spring between the governor lever and the pump holding down bolt (Fig. 57)

(b) Insert a 0.002 in, feeler between the lever and the maximum fuel stop and allow hanging (Fig.-57)

(c) The adjusting bush of the excess fuel stop should be screwed in slowly until it bears against the end of the control rod and the feeler gauge falls away. At this point, turn the adjusting bush back 1½ turns, insert the locking pin and fit the blanking disc.

Note - *The 1½ turns quoted is a general setting and the engine manufacturer's specification, which may be slightly different, should be used when available*

(11) **<u>Auxiliary Maximum Fuel Stop.</u>** This stop is set to permit the pump to provide the maximum fuel required on full load, which, for a serviced pump, is usually less than the permissible maximum controlled by the maximum fuel stop. Thus, if the efficiency of a pump tends to decline after a period of use, this state can be rectified by careful adjustment of the auxiliary maximum fuel stop up to the overriding maximum fuel stop.

(12) **<u>Idling Stop.</u>** The adjustment of this stop and also the auxiliary idling stop (when fitted) is done after the pump has been fitted to the engine and the engine is running.

(13) **<u>Testing and Adjusting the Governor.</u>** A flyweight governor can be conveniently tested on a Hartridge test bench, but the testing of a pneumatic governor requires the pump to be installed on its engine. When a flyweight governor requires adjustment, an equal adjustment must be made to both weights**.** Assuming the governor under test to be a BR/900 BF 60, which has a maximum control speed of 900 r.p.m. and a minimum of 200 r.p.m. The procedure is as follows :

(a) The control rod setting device must be fitted and the locking pin removed.

(b) Fit the loading spring between the governor lever and the pump holding down bolt (Fig - 58).

(c) Start up the test bench and set the speed to just below 900 r.p.m.

(d) Gradually increase the bench speed and observe the control rod. Record the r.p.m. shown on the tachometer when the control rod begins to dither. (This should be 900 r.p.m.

(e) Gradually increase the bench speed until the control rod is steady, indicating that the governor has completely "cut-in". The reading on the tachometer should now be 1,000 r.p.m, i.e. 100 r.p.m. above the dither point. If adjustment is required, the test bench must be stopped and one governor access plug removed; turn the pump camshaft until each governor adjusting nut is accessible in turn through the aperture. Insert the special tool to take the weight of the springs off the nut, and use the special key to adjust as required. To increase the "cutting-in" speed, the nut must be turned clockwise. When turning anti-clockwise to reduce the "cutting-in" speed, ensure that the nut is not turned past the point where its face is 0.5 mm, beyond the end of the bolt.

Note - *The adjusting nut is self locking at each half turn. Adjustment should therefore be a number of complete half turns (the same for each weight). One complete turn of each nut makes a combined difference of 25 r.p.m.*

This adjustment affects the loading on all three springs of each governor weight, there being no separate adjustment for the outer spring which controls the idling speed. When the governor has been satisfactorily adjusted at 900 r.p.m. a check test should be made at 200 r.p.m. Reduce the test bench speed to a little above 200 r.p.m. and then gradually reduce the speed whilst observing the control rod as before for the "cutting-in" point, which should be within reasonable limits of 200 r.p,m. A large discrepancy would indicate that the governor outer springs need to be renewed. 35. BEP/LB Governor. Very little adjustment of this governor can be done on the test bench, because only the maximum speed is governed by the flyweight assembly. The idling speed is governed by the pneumatic assembly which can be tested only when the pump is fitted to the engine. The diaphragm can be checked by moving the governor lever to the idling speed stop position and holding it there. Place a thumb over the vacuum pipe connection to seal the aperture and release the governor lever. If the diaphragm is serviceable, there should be no apparent movement of the lever, but a continuous movement of the lever towards the maximum speed position would indicate a faulty diaphragm. Normally, the loading of the flyweight springs is not adjustable and the only adjustment is to the control rod maximum stop, the procedure being as follows:

(1) The governor should be stationary and the control rod setting device fitted.

(2) The excess fuel plunger should be in its normal position.

(3) The maximum fuel stop should then be adjusted to bring the appropriate graduation (maker's figure) on the control rod in line with the datum line on the setting device. The stop screw should then be adjusted to give a clearance of I mm. between its end and the forked lever**.** The testing of Bep/Mz Governor. Must be done on the engine, but the diaphragm can be tested for serviceability. This is done by moving the control lever to the fully closed position, holding the thumb over the venturi inlet, and watching for movement of the quadrants when the control lever is released. Any appreciable movement will indicate that the diaphragm is leaking.

Storage and Transit Precautions

7. After all workshop attention to a pump has been completed; all open ports on the pump should be effectively and securely sealed to prevent the ingress of dirt and moisture during storage and transit periods. The requisite amount of the specified lubricating oil should be put into the pump governor housings.

Assembly

8. The assembly sequence is, in general, a reversal of the dismantling operations, plus the observance of several important points. Components must be
rinsed in clean kerosene, allowed to drip, smeared with clean lubricating oil, and finally assembled entirely without the use of any kind of drying material.

Recording

9. An example of the form used for recording the detailed assembly of an engine is shown at Appendix 4 to this section. It will be seen that the use of this form will ensure adequate inspection at each stage of the assembly procedure, and also form a record for future reference if required. Personnel employed at a repair depot will work to the master work sheet which contains details of all stages of the assembly.

Precautions

10. All normal precautions must be observed. Parts must be thoroughly clean and should be given a final visual examination for damage before fitting. All working parts should be smeared with clean lubricating oil. Observe assembly marks (Fig-58), and ensure that all parts are fitted in the correct way. Make certain that all locking devices are securely fitted; it is advisable to turn up slightly the tabs of any locking washers before fitting, as this will facilitate final locking. Take care not to over-tighten any nuts. When a torque loading is specified, or a special spanner or tool, always adhere to the instructions. Use new gaskets or seals, and only use jointing compound as and when instructed to do so.

a. The front and rear bearings on some engines are equipped with felt or cork packing washers, and care should always be taking to ensure that these are correctly fitted. Also at this stage, the end float of the crankshaft will probably be checked and rectified where necessary. If the thrust washers have one side faced with white metal, this side should always be fitted to face the crankshaft. On Rolls Royce B.80 engines new oil seals must be fitted to the side faces of the rear main bearing. These seals are of soft white pine; they should be carefully driven in and the surplus trimmed off flush with the housing face.

b. Piston ring gaps should be spaced at equal distances around the piston, and a piston ring clamp fitted to retain them in position. When fitting a piston and connecting rod, it is usual for the number on the crown of the piston to face the front end of the engine. The connecting rod nuts should be tightened progressively as specified in the relevant Air Publication. The crankshaft should be turned to check that binding does not occur and then the nuts must be split pinned.

c. After the camshaft has been fitted, it may be necessary on some engines to proceed with several checks. If the camshaft end float was not checked before assembly, a dial gauge should be suitably attached to a nearby stud on the crankcase face, and, with the camshaft pushed in towards the flywheel end, the gauge should be adjusted to contact the limit of its float and the reading on the gauge noted, the figure obtained being compared with the Schedule of Fits and Clearances.

Fig -58 Assembly Marks

d. In order to check the backlash between the camshaft and oil-pump gears, the oil pump will have to be temporarily fitted in position. The bottom cover of the pump and the idler gear should be removed, and a dial gauge mounted on the crankcase face so that the gauge makes contact with a tooth of the pump driven gear. By holding the camshaft steady and turning the drive shaft the amount of backlash will be shown on the dial. This figure should be shown on the dial. This figure should be compared with the Schedule of Fits and Clearances.

e. On engines having a gear-driven camshaft it will be necessary to check the backlash between these gears. To do this, the camshaft gear must be temporarily fitted and the backlash checked as described earlier. At this stage it is also usual practice to apply an oil pressure test to the crankshaft and its associated components. The test rig will most probably be of local design and manufacture, with provision for heating and supplying the oil at the temperature and pressure stated in the relevant Air Publication. The crankshaft should be turned, and inspection made to see that oil is reaching all bearing surfaces without excessive quantities escaping.

f. If the flywheel is not in place, it should now be fitted care being taken to ensure correct location. Tappets may now be fitted in their correct positions. Using a suitable valve spring compressing tool, assemble the valves, seating washers, oil seals (where fitted), springs and collects in their original locations. On side valve engines it will facilitate assembly to start with the valves at the front and rear ends and work inwards. If the engine is equipped with overhead valves or overhead inlet and side exhaust valves, the cylinder head will then be fitted.

g. A new cylinder head gasket should always be used, and although it is usual to smear both sides lightly with grease, the relevant Air Publication should be consulted. The reason for this is that some manufacturers, for example Rolls Royce on B-80 engines, recommend lightly smearing both faces of the gasket with jointing compound for approximately 1 in wide along the edge adjacent to the distributor mounting. On Standard “Vanguard” engine the upper face of the gasket should be smeared with grease and the lower face with jointing compound, the use of jointing compound being, in this case, to minimize the possibility of sleeve movement when the head is subsequently removed.

h. When tightening cylinder head nuts, similar precautions must be observed as for removal. Tighten the nuts progressively in the recommended torque or special spanner. The push rods for overhead valves should be fitted, care being taken, if they are marked, to fit them in their correct places. The rocker shaft assembly can then be fitted, and it will probably facilitate assembly if the tappet adjusting screws are screwed back beforehand. The nuts securing the rocker shaft pedestal brackets should be tightened progressively, working from the centre towards each end. The tappet clearances should then be set to the maker’s specification.

Note - *When working on a Standard “Vanguard” rocker assembly, always ensure the proper location of the outer valve spring caps on their respective valve spring caps on their respective valve stems, otherwise the push rods may be bent.*

Valve Timing

11. The method employed when timing the valves will depend on the particular engine being worked upon. Some engines have marked flywheels, other has their crankshaft and camshaft sprockets marked, and some-times it may be found that there are no markings. An example of each of these methods of timing is explained in the following paragraphs under their individual headings.

a. **Marked Flywheel (Rolls Royce B.80, Mk. ID). The procedure is as follows:**

(1) Adjust the tappet clearance of No. 1 cylinder inlet valve to .035 in.

(2) Temporarily fit the camshaft gear. Turn the crankshaft in the direction of rotation until a .005-in feeler is just nipped between the rocker and No. 1 inlet valve.

(3) Carefully remove the camshaft gear and turn the crankshaft until the 1.0 marks on the flywheel rim is in line with the centre line of the cylinders, or if the flywheel and clutch housing is fitted, in line with the pointer, which will be seen when the cover is removed from the top of the housing.

(4) Check that the feeler is still ripped between No. 1 cylinder inlet valve stem and the rocker.

(5) Assemble the thrust button and spring to the bore of the camshaft gear hub and carefully engage the gear with the crankshaft gear, bearing in mind that the teeth are helical and that a turning movement will occur during engagement. The gear should be positioned with the set screw holes in alignment so that the set screws can be entered without moving the gear. Temporarily secure the gear with at least two set screws.

(6) Turn the crankshaft back and then turn it forward until the .005 in feeler is again nipped between No 1 inlet valve and the rocker. Check that the flywheel 1.0. Marking is in alignment with the centre of the cylinder bores or with the timing pointer, as the case may be.

(7) A slight divergence from this position can usually be adjusted by carefully removing the camshaft gear and refitting it to align with a different set of holes.

(8) If the timing is satisfactory, remove the temporary set screws, fit the locking plate, and fit new lock washers and set screws. Tighten the set screws and bend over the tabs of the lock washers. Reset No 1 cylinder inlet valve tappet to its normal operating clearance.

b. **Marked Sprockets (Standard “Vanguard”). Using this method the procedure is as follows :**

(1). Set the engine with Nos. 1 and 4 pistons at T.D.C. the fan pulley and crankshaft sprocket keyways will be pointing vertically downwards Rest the camshaft sprocket on the camshaft spigot and line up the scribed lines.

(2) Turn the camshaft until the centre punch mark o n the camshaft end appears at the punch marked hole in the camshaft sprocket. The set screw holes should be exactly aligned with those of the camshaft.

(3) Fit the chain on to the crankshaft sprocket, remove the camshaft sprocket, taking care not to alter the camshaft position and fit it to the chain.

(4) Fit the camshaft sprocket to the camshaft so that the scribed lines on the two sprockets are in line and the driving side of the chain is tight.

(5) Fit the tab-washer and tighten the set screws, but do not bend up the tab-washer until after re-checking the position of the markings.

c. **Valve Overlap**. This method can be used when the timing marks have been omitted. The method is based on the assumption that the angles at which the inlet valves open and the exhaust valves close before and after T.D.C. are equal. he procedure is as follows :

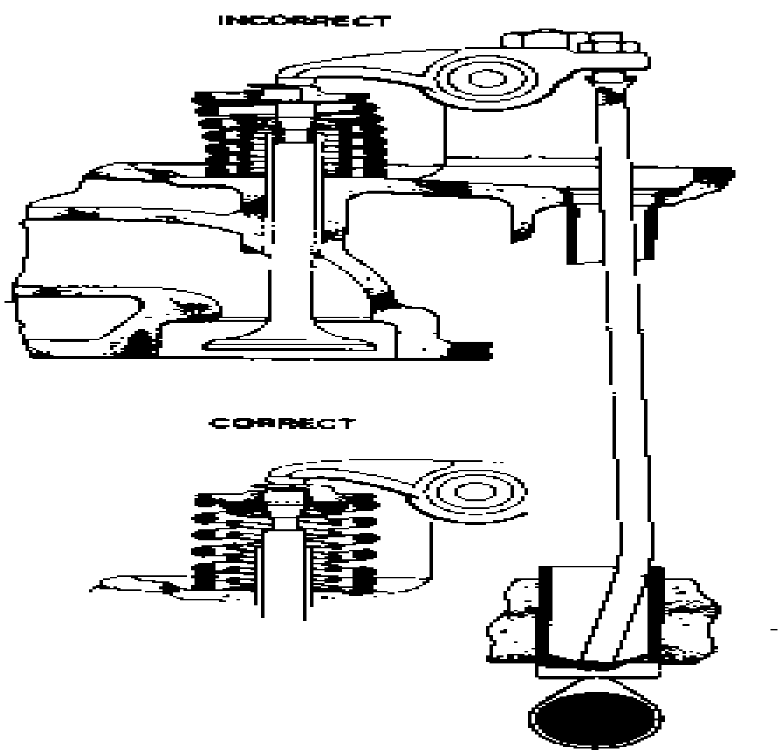


Fig – 59 Valve Gear Precaution

(1) Connect the crankshaft and camshaft provisionally.

(2) Set No 1 cylinder valve tappets to the figures specified by the manufacturer.

(3) Turn the engine in direction of rotation until both inlet and exhaust valves are slightly open, i.e. the inlet valve will be just starting to open and the exhaust valve just about to close.

(4) Disconnect the crankshaft from the camshaft and turn the crankshaft in the direction of rotation until No. 1 piston is at T.D.C.

(5) Re-connect crankshaft and camshaft, turn the engine and check the timing. If satisfactory, mark the sprockets in the manner advised in the relevant Air Publication.

Note - *On O.H.V. engines it is advisable to slacken fully all tappet adjusting screws, except those of No. 1 cylinder, before starting to time the valves. The tappets must be re-set to the recommended running clearance after the timing has checked.*

(1) After smearing the crankshaft aperture oil seal with approved grease (where appropriate), the timing case cover should be fitted.

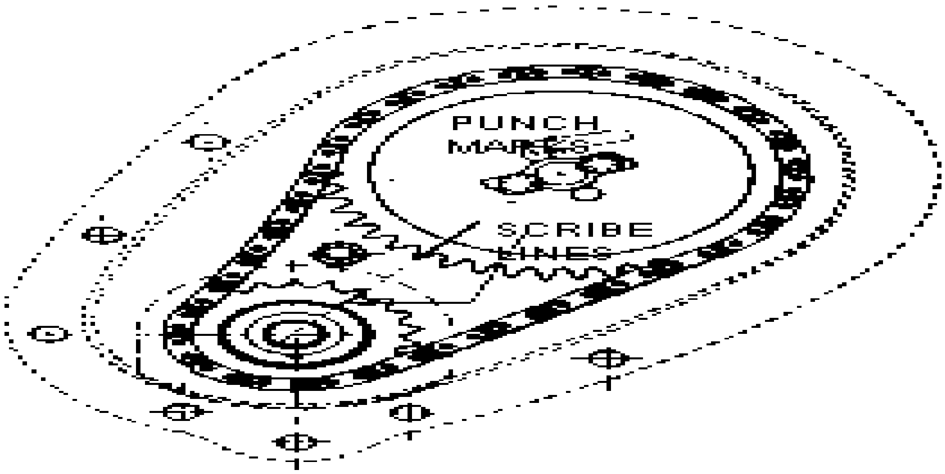


Fig-60 Valve Timing Marks

The retaining nuts being tightened progressively and evenly It may also be advisable at this stage to fit the cylinder head of a side valve engine. When fitting the oil pump, care must be taken to ensure that the oil pump driven gear is engaged with the camshaft drive gear in the correct or near correct position for ignition timing. The example shown in Fig- 61 is for the Standard “Vanguard”. The engine is set with No. 1 cylinder on T.D.C. compression stroke and the pump drive is correctly engaged as shown, the slot pointing rearwards directly towards the exhaust valve push rod sealing tube and the keyway in the helical gear will be in line with the oil dipstick. Check that all locking devices for the crankshaft, connecting rods and oil pump are secure, and that drain pipes where applicable are correctly fitted. Using a new gasket fit the sump, tightening all nuts progressively and evenly. Ensure that the drain plugs, with gaskets, are fitted and tightened.

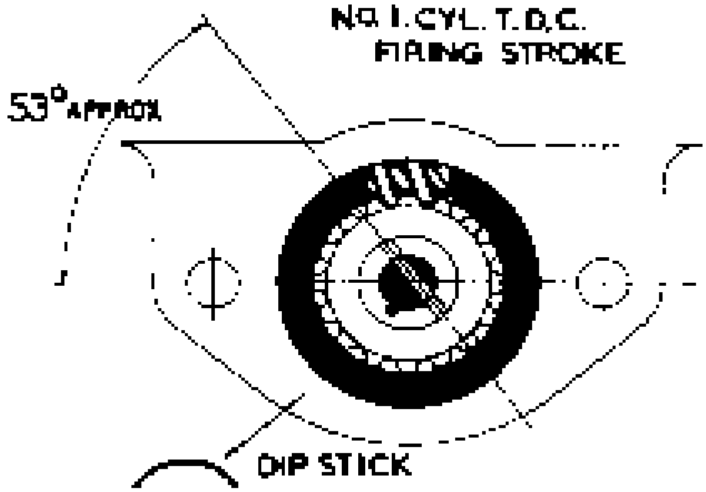


Fig-61 Meshing Oil Pump Gear.

Set No 1 piston at T.D.C. compression stroke. Check and adjust, if necessary, the gap of the distributor points. Fit the distributor, and turn the distributor body in the opposite direction to rotation till the points are just about to separate, with the rotor arm opposite No. 1 segment. Tighten the clamp bolt securely but not excessively. Fit the distributor cover. Using new washers, fit the sparking plugs and tighten them will the correct spanner. Connect up the leads, and if these are of the screened type, tighten the gland nuts securely, but not excessively. On some engines e.g. Rolls Royce B-80, it will be necessary to check the periphery and face of the gearbox mounting flange before the flywheel and clutch housing is completely fitted. With the lower cover removed secure the housing over the flywheel and clutch housing is completely fitted. With the lower cover removed secure the housing over the flywheel. Secure a dial gauge to the flywheel clutch friction face, position the gauge to contact the machined periphery or face of the gearbox mounting flange and slowly turn the flywheel. The limit of run-out in either direction must not be exceeded. If the engine is to be tested complete with clutch assembly, this should be fitted at this stage. Using new gaskets fit the manifolds and tightens the securing nuts evenly and progressively. Fit the water pump. Where appropriate, enter the fuel pump push -rod through the crankcase aperture and fit the fuel pump, ensuring that the correct gasket is used. Fit the carburetor and connect up any fuel pipes. Where applicable, fit the oil pressure relief valves, filter and pipes the system may be primed at the stage, or it may be left until the engine goes on to the test bench. Fit the coil and connect the H.T. lead to the distributor. Fit the rocker or valve chest cover and breather pipe. Fit the generator and any driving belts. Check that the engine is complete and ready for test. The engine is complete and ready for test. The engine will be tested on the test bench (this testing will be described in Section 6 of this publication.

CI Engine after Test

12. After test, the sump should be removed and the engine inspected internally. The engine should be thoroughly inspected externally and then inhibited. All apertures should be blanked off and the engine sprayed (heat resisting black). The engine now awaits allotment.

BAF BASE ZAHURUL HAQUE (TRG WG)

(Aero Engg Trg Sqn)

Syllabus	**:**	**Automobile General Diesel and Petrol Technology**
Course	**:**	**Trade Training Advance, MTOF**
Subject	**:**	**Engine Trouble Diagnosis and Engine Tune-up**
Aim	**:**	**To study Engine Trouble Diagnosis.**
Ref	**:**	**Automotive mechanic, by William H. Course Page-424 to 439.**

ENGINE TROUBLE DIAGNOSIS

Trouble-Diagnosis Chart

1. The chart that follows lists various engine complaints, their possible causes, and checks or corrections to be made. The information in this chart will shorten the time you need to correct a trouble. If you follow a logical procedure, you can usually find the cause of trouble quickly. On the other hand, haphazard guesswork wastes time and effort.

Complaint	Possible Cause	Check or Correction
1. Engine will not turn over.	a. Run-down battery	Recharge or replace; start engine with jumper battery and cables
	b. Starting circuit open	Find and eliminate the open; check for dirty or loose cables
	c. Starting motor drive jammed	Remove starting motor, and tree drive
	d. Starting motor jammed	Remove for teardown and correction
Continued	e. Engine jammed	Check engine to find trouble

Trouble-Diagnosis Chart : **Continued**

Complaint	Possible Cause	Check or Correction
Brought Forward	f. Transmission not in neutral, or neutral switch out of adjustment	Check and adjust if necessary
	g. Seat belt not fastened, or interlock faulty	Check interlock.
	h. Also causes listed under item 3 below, "Engine turns over at normal speed but does not start". Driver may have run battery down trying to start.	

Complaint	Possible Cause	Check or Correction

2. Engine turns over slowly but does not start.	a. Run-down battery	Recharge or replace start engine with jumper battery and cables
	b. Defective starting motor	Repair or replace
	c. Bad connections in starting circuit	Check for loose or dirty cables clean and tighten.
	d. Also causes listed under item 3 below, "Engine turns over at normal speed but does not start"; driver may have run battery down trying to start	

Complaint	Possible Cause	Check or Correction
3. Engine turns over at normal speed but does not start.	a. Ignition system defective	Try spark test check timing, ignition system
	b. Fuel pump defective or over choking	Prime engine check accelerator-pump discharge, fuel pump, fuel line, choke, carburettor
	c. Air leaks in intake manifold or carburettor	Tighten mounting replace gaskets as needed
	d. Defect in engine	Check compression or leakage valve action, timing
	e. Ignition by-pass resistor burned out	Replace
	f. Plugged fuel filter	Clean or replace
	g. Plugged or collapsed exhaust system	Replace collapsed parts
4. Engine lacks power, acceleration, or high-speed performance, hot only.	a. Engine overheats	Check cooling system (see item 10 below)
	b. Choke stuck partly open	Repair or replace
	c. Sticking manifold heat-	Free valve

	control valve	
	d. Vapour lock	Use different fuel, or shield fuel line

Complaint	Possible Cause	Check or Correction
5. Engine lacks power, acceleration, or high –speed performance, cold only	a. Automatic choke stuck open	Repair or replace
	b. Manifold heat-control valve stuck open	Free valve
	c. Cooling system thermostat stuck open	Repair or replace
	d. Engine valves stuck open	Free valves, service valve stems and guides as needed.
9. Engine lacks power acceleration, or high-speed performance, hot or cold.	a. Ignition defective	Check timing, distributor, wiring, condenser, coil, plugs
	b. Fuel system defective; secondary throttle valves not opening	Check carburettor, choke, filter, air cleaner, fuel pump
	c. Throttle valve not opening full	Adjust linkage
	d. Restricted exhaust	Check tail pipe, muffler; eliminate restrictio
	e. Loss of compression	Check compression or leakage
	f. Excessive carbon in engine	Remove carbon
	g. Defective valve action	Check with compression, leakage or vacuum tester.
	h. Excessive rolling resistance from low tires, dragging brakes, wheel misalignment, etc.	Correct the defect causing rolling resistance.
	I Heavy oil	Use lighter oil

	j. Wrong or bad fuel	Use good fuel of correct octane.
	k. Transmission not downshifting, or torque converter defective.	Check transmission

Complaint	**Possible Cause**	**Check or Correction**
10. Engine Overheats.	a. Lack of coolant	Add coolant; look for leak
	b. Ignition timing late	Adjust timing
	c. Loose or broken fan belt	Tighten or replace
	d. Thermostat stuck closed	Replace
	e. Clogged water jackets	Clean out
	f. Defective radiator hose	Replace
	g. Defective water pump	Repair or replace
	h. Insufficient engine oil	Add oil
	i. High-altitude, hot-climate operation	Drive more slowly; keep radiator filled
	j. Detective fan clutch	Replace
	k. Valve timing late, slack timing chain has allowed chain to jump a tooth	Retime adjust or replace
11. Rough idle	a. Carburetor idle adjustment incorrect	Readjust idle mixture and speed
	b. PCV valve stuck open	Replace
	c. Other causes, listed under item 9 above, “Engine lacks power”.	

Complaint	*Possible Cause*	**Check or Correction**

12. Engine stalls cold or as it warms up.	***a. Choke valve stuck closed, or will not close***	Open choke valve; free or repair automatic choke
	b. Fuel not getting to or through carburetor	Check fuel pump, lines, filter, float idle circuits
	c. Manifold heat-control valve stuck	Free valve
	d. Throttle solenoid improperly set	Adjust
	e. Engine idling speed set too low	Increase idling speed to specified value
	f. Malfunctioning PCV valve	Replace

Complaint	**Possible Cause**	**Check or Correction**
13. Engine stalls after idling or slow-speed driving.	a. Defective fuel pump	Repair or replace fuel pump
	b. Overheating	See item 10 above, "Engine overheats"
	c. High carburetor -float level	Adjust
	d. Idling adjustment incorrect	Adjust
	e. Malfunctioning PCV valve	Replace
	f. Throttle solenoid improperly set	Adjust
14. Engine stalls after high-speed driving.	a. Vapour lock	Use different fuel or shield fuel line
	Carburetor venting or idle compensator valve defective	Check and repair
	c. Engine overheats	See item 10 above, "Engine overheats"
	d. Malfunctioning PCV valve	Replace
	e. Improperly set throttle solenoid.	Adjust

Complaint	Possible Cause	Check or Correction
15. Excessive fuel consumption.	a. Jackrabbit starts	Drive more reasonably
	b. High speed	Drive more slowly
	c. Short-run operation	Make longer runs
	d. Excessive fuel-pump pressure or pump leakage	Reduce pressure repair pump
	e. Choke partly closed after warm-up	Open repair or replace automatic choke
	f. Clogged air cleaner	Clean
	g. High carburettor float level	Adjust
	h. Stuck or dirty float-needle level	Free and clean
	i. Worn carburettor jets	Replace
	j. Stuck metering rod or full-power piston	Free
	k. Idle too rich or too fast	Adjust
	l. Stuck accelerator-pump check valve	Free
	m. Carburettor leaks	Replace gaskets; tighten screws, etc.
Continue	n. Cylinder not firing	Check coil, condenser, timing, plugs, contact points, wiring

Complaint	Possible Cause	Check or Correction
15. Excessive fuel consumption.	o. Automatic transmission slipping or not up-shifting	Check transmission
	p. Loss of engine compression (worn engine)	Check compression or leakage.

Complaint	Possible Cause	Check or Correction
	q. Defective valve action (worn camshaft, chain slack, jumped tooth)	Check with compression, leakage, or vacuum tester.
	r. Excessive rolling resistance from low tires, dragging brakes, Wheel misalignment, etc.	Correct the defects causing the rolling resistance.
	s. Clutch slippage	Adjust or repair
16. **Engine is noisy**:		*Continue*
a. Regular clicking	Valve and tappet	Readjust valve clearance, or replace noisy hydraulic lifters.
b. Ping or chatter on load or accelerating	Detonation due to low-octane fuel, carbon, advanced Ignition timing, or causes listed under item 14 above, "Engine backfires"	Use higher-octane fuel; remove carbon; adjust ignition timing
c. Light knock or pound with engine floating	Worn connecting-rod bearings or crankpin, misaligned rod, lack of oil.	***Replace or adjust bearings service crankiness replace rod; correct lack of oil***

Complaint	Possible Cause	Check or Correction
16. **Engine is noisy**:		
d. Light metallic double knock, usually most audible	Worn or loose piston pin or lack of oil	Service pin and bushing; correct lack of oil

during idle.		
e. Chattering or rattling during accelerating	Worn rings, cylinder walls, low ring tension, broken rings.	Service walls; replace rings
f. Hollow, muffled, bell-like sound, engine cold.	***Piston slap due to worn pistons, walls, collapsed piston skirts, excessive clearance, lack of oil, misaligned connecting rods.***	Replace or resize pistons; service walls; replace rods; correct lack of oil.
g. Dull, heavy, metallic knock under load or acceleration especially when cold	Regular noise; worn main bearings; irregular; worn end-thrust bearing knock on clutch engagement or on hard acceleration	Replace or service bearings and crankshaft
h. Miscellaneous noises	Rattles, etc,from loosely mounted accessories ; alternator, horn ,oil pan, front bumper, water pump, etc	Tighten mounting
17. Excessive oil consumption.	a. External leaks	Correct seals; replace gaskets
	b. Burning oil in combustion chamber	Check valve-stem clearance, piston rings, cylinder walls, rod bearings
	c. High-speed driving	Drive more slowly

Complaint	**Possible Cause**	**Check or Correction**

Complaint	Possible Cause	Check or Correction
18. Engine backfires.	a. Ignition timing off	Adjust timing
	b. Spark plugs of wrong heat range	Install correct plugs
	c. Excessively rich or lean mixture	Repair or readjust fuel pump or carburettor
	d. Overheating of engine	See item 10 above, “Engine overheats”.
	e. Carbon in engine	Clean out
	f. Valves hot or sticking	Adjust, free; clean; replace if bad
	g. Cracked distributor cap	Replace cap
	h. Inoperative anti backfire valve	Replace
	i Cross firing plug wires	Replace
19. Too much HC and CO in exhaust.	a. Ignition miss	Check plugs, wiring, cap, coil, etc.
	b. Incorrect Ignition timing	Time ignition
	c. Carburetor troubles	Check choke, float level, idle - mixture adjustment screw, etc, as listed in item 20 below
	d. Faulty air injection	Check pump, hoses, manifold
	e. Defective TCS system	Check system
	f. Defective catalytic converters	Replace converters or catalyst

Complaint	Possible Cause	Check or Correction
20. Low oil pressure.	a. Worn engine bearings	Replace
	b. Engine overheating	See item 10 above
	c. Oil dilution or foaming	Replace oil

Complaint	Possible Cause	Check or Correction
	d. Lubricating system defects	Check oil lines, oil pump, relief valve
21. **<u>Smoky exhaust</u>**		
a. Blue smoke	Excessive oil consumption	See item 17
b. Black smoke	Excessively rich mixture	See item 15
c. White smoke	Steam in exhaust	Replace gasket; tighten cylinder-head bolts to eliminate coolant leakage into combustion chambers

<u>Engine Will Not Turn Over</u>

2. If the engine will not turn over when starting is attempted, turn on the headlights or dome light, and try to start. The lights will (1) stay bright, (2) dim considerably, (3) dim slightly, (4) go out, or (5) not burn at all. If the lights stay bright, there is an open circuit in the starting motor or starting-motor circuit. Also, the transmission may not be in neutral, or the neutral switch is out of adjustment. In addition, on late-model cars, the ignition-interlock safety belts may not be fastened properly, or the system may be defective. If the lights dim considerably, the battery may be run down. Or there may be mechanical trouble in the starting motor or engine. IF the battery tests okay, remove the starting motor for further checks. Try to turn the engine flywheel in the normal direction of rotation to see if the engine is jammed. If the lights dim only slightly, listen for cranking action (sound of an electric motor running). If it runs, the pinion is not engaging the flywheel (Bendix type), or the over-running clutch is slipping. If the solenoid clicks but the starting motor does not rotate, it could be a low battery but it is probably trouble in the starting motor. Remove it for service. If the lights go out as cranking is attempted, there may be bad connection in the main circuit, probably at a battery terminal. If the lights burn dimly or not at all when they are turned on, even before cranking is attempted, the battery is probably run down.

<u>Engine Turns Over Slowly But Does Not Start</u>

4. Causes of this condition could be a run-down battery, a defective starting motor, or mechanical trouble in the engine. Check the battery, starting motor, and circuit as outlined in respective para. If they are normal, the trouble probably is in the engine (defective bearings, rings, and so on that could produce high friction). Remember that, in cold weather, cranking speed is reduced by thickening of the engine oil and reduction of battery efficiency.

Engine Turns Over At Normal Cranking Speed But Does Not Start

5. This means the battery and starting motor are in normal condition. The cause of trouble is probably in the ignition or fuel system. The difficulty could be due to over knocking. Try cranking with the throttle wide open. If the engine does not start, disconnect the lead from one spark plug (or from the centre distributor-cap terminal). Hold the lead clip about 3/16 inch [4.76 mm] from the engine block. Crank the engine to see if a good spark occurs. If no spark occurs, check the ignition system. Is probably okay (the timing could be off, however).If the ignition system operates normally; the fuel system should be analyzed. First, prime the engine by operating the carburettor accelerator pump several times. Or remove the air cleaner, and squirt a small amount of gasoline into the carburettor air horn.

CAUTION: Gasoline is highly explosive. Keep back out of the way while priming the engine; the engine might backfire through the carburettor. Replace the air cleaner before cranking. If the engine now starts and runs for a few seconds, the fuel system is probably faulty. It is not delivering fuel to the engine. Temporarily disconnect the fuel inlet to the carburettor. Hold a container under the fuel line to catch fuel, and crank the engine to see whether fuel is delivered. If it is not, the fuel pump is defective or the fuel line is clogged. If fuel is delivered, the fuel filter is probably at fault, the automatic choke is not working correctly, or possibly there are air leaks into the intake manifold or carburetor. If the fuel and ignition systems seem okay on preliminary checks, check the mechanical condition of the engine with the compression and leakage tests 43-5. This applies to a cold engine. Failure to start with a hot engine may be due to a defective choke that fails to open properly as the engine warms up. This would cause flooding of the engine (delivery of too much gasoline). Open the throttle wide while cranking (this de-chokes the engine), or open the choke valve by hand.

Cylinder Compression and Leakage Testers

6. These testers are used to determine whether or not the cylinder can hold compression, or whether there is excessive leakage past the rings, valves, or head gasket. The compression tester has been a basic engine-testing instrument for many years. Recently, the cylinder-leakage tester has come into use. Some operators believe that it is more accurate in pinpointing defects in the cylinder the use of compression and leakage testers has been described in detail (compression tester and leakage tester.

Engine Runs but Misses

7. A missing engine is a rough engine. If one or more cylinders fail to fire, the engine is thrown out of balance. The result is roughness and loss of power. It is sometimes hard to track down a miss. The miss might occur at some speeds and not others. Also, a miss may skip around. The modern method of checking out a missing engine is to use an oscilloscope and a dynamometer. The oscilloscope is discussed. The dynamometer is discussed. If these testing instruments are not available, then the test can be made as follows. Use insulated pliers to remove each spark-plug wire in turn, to locate the missing cylinder. Removing the plug wire prevents the spark from reaching the plug, and the plug will not fire. If removing the wire changes the engine rhythm or speed, then the cylinder was delivering

power before you removed the wire. But if there is no change in engine speed or rhythm, then that cylinder was missing before you removed the wire.

a. Check a missing cylinder further by removing the spark-plug lead. Hold it close to the engine block while the engine is running. If no spark occurs, there is probably a high-tension leak due to a bad lead or a cracked or burned distributor cap. If a good spark occurs, install a new spark plug in the cylinder (or swap plugs between two cylinders). Then reconnect the lead, and see whether the cylinder still misses. If it does, the cause of the trouble is probably defective engine parts, such as valves or rings.

b. If the miss is hard to locate, perform a general tune-up. This will disclose, and maybe eliminate, various causes of missing. These could include defects in the ignition system or fuel system, loss of engine compression, sticky or damaged engine valves, overheated engine, sticky manifold heat control, clogged exhaust, and so on.

c. With most oscilloscopes, you can make a power balance test that will quickly pinpoint the missing cylinder. When the oscilloscope is connected to the running engine, you turn a knob and the cylinders are shorted out, one by one, in the firing order. The scope shows which cylinder is shorted out. If shorting a cylinder changes the engine rpm as registered on the tester. You know the cylinder was delivering power. But if no change in rpm takes place, them you know that cylinder was not delivering power.

Engine Vacuum Gauge

8. This is an important engine tester for tracking down troubles in an engine that runs but does not perform satisfactorily. It measures intake-manifold vacuum. The intake-manifold vacuum varies with different operating conditions, and with different engine defects. The manner in which the vacuum varies from normal indicates the type of engine trouble explains how to use the vacuum gauge.

Engine Lacks Power

9. This is general complaint that is often difficult to analyzer the best procedure is to do a tune up job this will disclose various engine conditions that could cause loss of power. It is helpful to know whether the engine lacks power only when cold, only when hot, or when cold and when hot. A chassis dynamometer or an oscilloscope can be used to help locate the trouble cause.

a. Engine lacks power and acceleration either hot or cold. The fuel system may not be enriching the mixture as the throttle is opened. This could be due to a faulty accelerator pump or a defective high-speed or full-power circuit in the carburettor. Also, the fuel system could be supplying an excessively lean or rich mixture. This could be due to a defective fuel pump clogged lines, clogged filter, worn carburettor jets or lines, air leaks at the carburettor or manifold joints, malfunctioning PCV valve, and so on. Carburettor and fuel system action can be checked with an exhaust gas analyzer. Another condition could cause lack of power with the engine hot or cold. This is an improper linkage adjustment that prevents full throttle opening. Also, the ignition system may be causing trouble, owing to incorrect timing, a "weak" coil, and reversed polarity wrong spark-plug heat range, and so on. The wrong fuel or oil for the engine could reduce performance. In the engine, numerous conditions could cause loss of power; engine deposits (carbon), lack of compression (faulty valves, rings, worn cylinder walls, pistons, and so on), and defective bearings. A clogged exhaust (bent or collapsed exhaust pipe or tail pipe or clogged muffler) could create back pressure that would cause poor engine performance. Also , any sort of excessive rolling resistance would absorb engine power and hold down engine acceleration and speed. This would include dragging brakes, under inflated tires, misaligned wheels, and excessive friction in the transmission or power train.

b. Engine lacks power only when hot. The engine may be overheating. Also, the automatic choke may not be opening normally as the engine warms up, the manifold heat-control valve may be stuck, or there may be a vapour lock in the fuel pump or line.

c. Engine lacks power when cold or reaches operating temperature too slowly. The automatic choke may be leaning out the mixture too soon (before the engine warms up). The manifold heat-control valve may not be close (So that insufficient heat reaches the intake manifold). Or, the cooling-system thermostat may be stuck open. In this case, water circulation goes on between the engine and radiator even with the engine cold and so warm -up is delayed. Occasionally, engine valves may stick when the engine is cold, but as the engine warms up, the valves become free and work normally.

Exhaust Gas Analyzer

10. At one time the major use of the exhaust analyzer was to adjust the carburettor. Today; its major job is to check the emission controls on the car. If the emission controls are not working properly, there will be excess HC and CO in the exhaust. The exhaust-gas analyzer measures the amount of HC and CO in the exhaust gases coming out the tail pipe. Use of the exhaust -gas analyzer is discussed.

Engine Overheats

11. Most engine overheating is caused by loss of coolant due to leaks in the cooling system. Other causes include a loose or broken fan belt, a defective water pump, clogged water jackets, a defective radiator hose, and a defective thermostat or fan clutch. Also, late ignition or valve timing, lack of engine oil, overloading the engine, or high-speed, high - altitude, or hot-climate operation can cause engine overheating. Also, freezing of the coolant could cause lack of coolant circulation so that local hot spots and boiling develop.

Rough Idle

12. If the engine idles roughly but runs normally above idle, chances are the idle speed and idle mixture are incorrectly adjusted. A rough idle could also be due to other causes, such as a loose vacuum hose or one that is disconnected from the intake manifold.

Engine Stalls.

13. If the engine starts and then stalls, note whether the stalling takes place before or after the engine warms up, after idling or slow -speed driving, or after high-speed or full-load driving. Special note should be made of the PCV valve. If this valve becomes clogged or sticks, it will cause poor idling and stalling.

a. Engine stalls before it warms up. This could be due to an improperly set fast or slow idle, or to improper adjustment of the idle fuel mixture needle in the carburettor. Also, it could be due to a low carburettor float setting or to insufficient fuel entering the carburettor. This condition could result from a thermostatic air cleaner not working, dirt or water in the fuel lines or filter, a defective fuel pump, or a plugged fuel-tank vent. Also, the carburettor could be icing. Certain ignition troubles could cause stalling after starting. But, as a rule, if the ignition troubles are bad enough to cause stalling, they would also prevent starting. However, burned contact points might permit starting but could fail to keep the engine going. One other condition might be an open primary resistance wire. When the engine is cranked, this wire is bypassed. Then, when the engine starts and cranking stops, this wire becomes part of the ignition primary circuit. If the wire were open, the engine would then stall.

b. Engine stalls as it warms up. This could result if the choke valve were stuck closed. The mixture becomes too rich for a hot engine, and the engine stalls. If the manifold heat-control valve sticks closed, the air-fuel mixture might become overheated and too lean, causing the engine to stall. If the hot-idle speed is too low, the engine may stall as it warms up because the idling speed drops too low. Also, stalling may be caused by overheating of the engine, which could cause vapour lock.

c. Engine stalls after idling or slow-speed driving. This could occur if the fuel pump has a cracked diaphragm, weak spring, or defective valve. The pump fails to deliver enough fuel for idling or slow-speed operation (although it could deliver enough for high-speed operation). If the carburettor float level is set too high or the idle adjustment is too rich, the engine may "load up" and stall. A lean idle adjustment may also cause stalling. The engine may overheat during sustained idling or slow-speed driving. With this condition, air movement through the radiator may not be sufficient to keep the engine cool. Overheating, in turn, could cause vapour lock and engine stalling, for causes of overheating.

d. Engine stalls after high-speed driving. This could occur if enough heat accumulates to cause a vapour lock. The remedy here would be to shield the fuel line and fuel pump or use a less volatile fuel. Failure of the venting or idle-compensator valve in the carburettor may also cause stalling after high-speed
Operation. Excessive overheating of the engine is also a primary cause of stalling.

Engine Backfires

14. Most backfiring is caused by a faulty antibackfire valve. It could also be due to late ignition timing, or ignition cross firing (caused by the spark jumping across the distributor cap or through the cable insulation). In addition, it could be due to spark plugs of the wrong heat range (which overheat and cause pre-ignition), excessively rich mixtures (caused by fuel-pump or carburettor troubles), overheating of the engine. Carbon in the engine, hot valves or intake valves that sticks or seat poorly. Carbon in the engine, if excessive, may retain enough heat to cause the air-fuel mixture to pre-ignite as it enters the cylinder, so that backfiring occurs. Carbon also in-creases the compression ratio and thus it is the tendency for knocking and pre-ignition. Hot plugs may cause pre-ignition cooler plugs should be installed. If intake valves hang open, combustion may be carried back into the carburettor. Valves which have been ground excessively sod that they have sharp edges, valves which seat poorly, or valves which are carboned so that they overheat often produce backfiring.

Engine Run-On Or Dieseling

15. Modern engines, with their emission controls, require a fairly high hot idle for best operation. This makes run-on, or dieseling, possible. If there are hot spots in the combustion chambers, the engine can continue to \run if the throttle is not completely closed. The hot spots take the place of the spark plugs. If the throttle is slightly open enough air-fuel mixture could get past it to keep the engine running. Ignition in the combustion chambers would be caused by the hot spots. Modern engines have an idle-stop solenoid to close the throttle completely when the ignition switch is turned off. If an engine runs on, or diesels, check the idle -stop solenoid (if present), to make sure it is releasing when the ignition is turned off. It could require adjustment to permit the throttle to close completely. Be sure the engine speed is not set too high. The trouble could also be due to advanced ignition timing. Correction of engine overheating is covered in 43-10. Correcting hot spots may require spark-plug service, or removing the cylinder head for cleaning, plus valve service.

Too Much HC And Co In Exhaust

16. If the exhaust-gas analyzer (42-7) discloses that there is too much HC and CO in the exhaust, correction must be made. Some states require exhaust-gas testing of all cars

during state inspection. Cars that emit too much HC and CO must be repaired before they can be passed. This restriction is designed to get the smoggers off the highways. Here are the possible causes. The corrections are obvious.

a. Missing due to ignition problems such as faulty plugs, high-tension wiring, distributor cap, ignition coil, condenser, or contact points. (If can also be caused by stuck or burned valves).

b. Incorrect ignition timing.
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c. Carburettor troubles such as the choke sticking closed, worn jets, high float level, and other conditions listed in 43-18.

d. Faulty air-injection system which does not inject enough air into the exhaust manifold to completely burn the HC and CO. This could be caused by a faulty air pump or a leaking hose or air manifold.

e. Defective transmission-controlled spark system which permits vacuum advance in all gear positions instead of high and reverse only.

f. Defective catalytic converters which must be replaced or service to restore the catalytic action.

Excessive Oil Consumption

17. Oil is lost from the engine in three ways :(1) by burning in the combustion chamber, (2) by leakage in liquid form, and (3) by passing out of the crankcase through the crankcase ventilating system in the form of mist or vapor. External leakage can often be detected by inspecting the seals around the oil pan, valve cover plate, and timing gear housing, or at oil line and filter connections. Burning of oil in the combustion chamber gives the exhaust gas a bluish tinge. Oil can enter the combustion chamber through the PCV system, through the clearance between intake-valve or exhaust-valve stems and valve guides, and past piston rings. If intake-valve -stem clearance is excessive, oil is "pulled" through this clearance, and into the combustion chamber, on each intake stroke. The appearance of the intake-valve stem often indicates that this is occurring. Some of the oil remains on the underside of the valve and stem to form carbon. The remedy is to install valve seals or a new valve guide and possible a new valve. Probably the most common cause of excessive oil consumption is passage of oil into the combustion chamber between the piston rings and the cylinder walls. This is often called "oil pumping." It is due to worn, tapered, or out-of-round cylinder walls or worn or carboned rings. In addition, when engine bearings are worn, excessive oil is thrown on the cylinder walls. The rings are not able to control all of it. Too much oil works up into the combustion chamber. *Continue*

High speed must also be considered if there is excessive oil consumption. High speed means high temperatures and thus thin oil. More oil, and thinner oil, is thrown on the cylinder walls at high speed. The piston rings, moving at high speed, cannot function so effectively. So more oil works up into the combustion chamber. In addition, the churning effect of the oil in the crankcase creates more oil vapor and mist at high speed. More oil is thus lost through the crankcase ventilating system. Tests show that an engine uses several times as much oil at 60 mph (miles per hour) as at 30 mph.

Low Oil Pressure

18. Low oil pressure is often a warning of worn oil-pump or engine bearings. The bearings can pass so much oil that the oil pump cannot maintain oil pressure. Also, the end bearings will probably be oil-starved and may fail. Other causes of low oil pressure are a weak relief-valve spring, a worn oil pump, a broken or cracked oil line, and a clogged oil line. Oil dilution, or foaming, sludge, insufficient oil, or oil made too thin by engine overheating will cause low oil pressure.

Excessive Fuel Consumption

19. This condition can be caused by almost anything in the car, from the driver to under inflated tires or a defective choke. A fuel-mileage tester can be used to accurately check fuel consumption The compression or leakage tester and the vacuum gauge will help determine whether the trouble is in the engine, fuel system, ignition system, or elsewhere. Also, the exhaust-gas analyzer, dynamometer, and fuel -flow meter are useful in analyzing the problem. If the trouble seems to be in the fuel system, consider the following:

a. A driver who pumps the accelerator when idling and insists on being the first to get away when the stoplight changes will use excessive amounts of fuel.

b. Operation with the choke partly closed after warm-up will use excessive amounts of fuel.

c. Short-run operation means the engine will be operating on warm-up most of the time. This means fuel consumption will be high. These three conditions are due to the type of operation. Changing operating conditions is the only cure. If the excessive fuel consumption is not due to any of these, then check the fuel pump for excessive pressure. High fuel-pump pressure will cause a high float-bowl level and a rich mixture. Special gauges check pump pressure.

d. If excessive fuel consumption is not due to high fuel-pump pressure or to operating conditions, the trouble is likely to be in the carburettor. It could be any of the following:

(1) If the car is equipped with an automatic choke, the choke may not be opening rapidly enough during warm-up or may not open fully.
This can be checked by removing the air cleaner and observing choke operation during warm-up.

(2). A clogged air cleaner that does not admit sufficient air will act somewhat like a partly closed choke valve. The cleaner element should be cleaned or replaced.

(3) If the float level is high in the float bowl, it will cause flooding and delivery of excessive fuel to the carburettor air horn. The needle valve may be stuck open or may not be seating fully. The float level should be checked and adjusted.

(4) if the idle is set too rich or the idle speed too high, excessive fuel consumption will result. These should be checked and adjusted as necessary

.

(5) Where the accelerator-pump circuit has a check valve, failure of the check valve to close properly may allow fuel to feed into the carburettor air horn. The carburettor will require disassembly.

(6) The metering rod may be stuck in the high-speed full-throttle position, or the economizer valve may be held open. These permit the high -speed full-power circuit to function supplying an excessively rich mixture. The carburettor will require disassembly for repair.

(7) Worn jets, permitting the discharge of too much fuel, require replacement during carburettor rebuilding.

(8) Faulty ignition can also cause excessive fuel consumption. The ignition system could cause engine miss and thus failure of the engine to use all the fuel. This sort of trouble also is found with loss of power, acceleration, or high-speed performance 43-8). Conditions in the ignition system that might add to the trouble include a "weak" coil or condenser, incorrect timing, faulty advance-mechanism action, dirty or worn plugs or contact points, or defective wiring.

(9) Inferior engine action can produce excessive fuel consumption. Examples are loss of engine compression from worn or stuck rings, worn or stuck valves, or a loose or burned cylinder-head gasket. Power is lost under these conditions, and more fuel must be burned to achieve the same speed.

(10) Excessive fuel consumption can also result from conditions that make it hard for the engine to move the car along the road. Such factors as low tires, dragging brakes, defective automatic transmission, and misalignment of wheels increase the rolling resistance of the car. The engine must use up more fuel to overcome this excessive rolling resistance.

Engine Noises

20. Some engine noises have little meaning. Other noises may indicate serious engine trouble that requires prompt attention to prevent major damage to the engine. Various

noises and their causes are described below, along with tests that may be necessary to confirm a diagnosis. A listening rod or stethoscope is of help in locating the source of a noise. The rod acts like the stethoscope. When one end is place at the ear and the other and at some pat of the engine, noises from that part of the engine are carried along the rod to the ear. A long screwdriver or one of the engine stethoscopes now available can be used. When using the listening rod to locate the souse of a noise, put the engine end at various places on the engine until the noise is loudest. You can also use a piece of garden hose (about 4 feet [1.2m] long) to place engine noise. Hold one end of the hose to your ear, and move the other end of the hose around the engine until the noise is loudest. In this way you can, for example, locate a broken and noisy ring in a particular cylinder, or a main -bearing knock.

CAUTION: *Keep away from the moving fan belt and fan when using the listening rod.*

Valve and tappet noise

a. This is a regular clicking noise that gets louder as engine speed increases. The cause is usually excessive valve clearance or a defective hydraulic valve lifter. A feeler gauge inserted between the valve stem and lifter or rocker arm reduces the clearance. If the noise also is reduced, then the cause is excessive clearance. The clearance should be re-adjusted. If inserting the feeler gauge does not reduce the noise, it is the result of such conditions in the valve mechanism as weak springs, worn lifter faces, lifters loose in the block, rough adjustment-screw face, or rough cams. Or else the noise is not from the valves at all.(See other conditions listed below).

b. **Detonation.** Spark knock or detonation is a pinging or chattering sound most noticeable during acceleration or when the car is climbing a hill. Some spark knock is normal. When it becomes excessive, it is due to conditions such as the sue of fuel of too low an octane rating for the engine, carbon deposits in the engine which increase compression ration, advance ignition timing, or the conditions.

c. **Connecting-rod noises.** Connecting-rod noises usually have a light knocking or pounding character. The sound is most noticeable when the engine is "floating" (not accelerating or decelerating). The sound becomes more noticeable as the accelerator is eased off with the car running at medium speed. To locate connecting-rod noise, short out spark plugs one at a time. The noise will be considerably reduced when the cylinder that is responsible is not delivering power. A worn bearing or crankpin, a misaligned connecting rod, inadequate oil, and excessive bearing clearances cause connecting-rod noise.

d. **Piston-pin noise.** Piston -pin noise is similar to valve and tappet noise, but it has a unique metallic double knock. It is usually most audible during idle with the spark advanced. However, on some engines, the noise becomes most audible at car speeds of around 30 mph. A check can be made by running the engine at idle with the spark advanced and then shorting out spark plugs. Piston-pin noise will be reduced somewhat when a plug in a noisy cylinder is shorted out. Causes of this noise are a worn or loose piston pin, a worn bushing, and lack of oil.

e. **<u>Piston-Ring noise.</u>** Piston-ring noise is also similar to valve and tappet noise. It is a clicking, snapping, or rattling noise. This noise, however, is most evident on acceleration. Low ring tension, broken rings, worn rings, or worn cylinder walls produce this noise. Since the noise can sometimes be confused with other engine noises, a test can be made as follows: Remove the spark plugs, and add an ounce or two of heavy engine oil to each cylinder. Crank the engine for several revolutions to work the oil down past the rings. Then replace the plugs, and start the engine. If the noise has been reduced, the rings are probably at fault.

f. **<u>Piston Slap.</u>** Piston slap is a muffled, hollow, bell-like sound. It is due to the rocking back and forth of the piston in the cylinder. If it occurs only when the engine is cold, it is not serious. When it occurs under all operating conditions, it should be checked further. It is caused by inadequate oil, worn cylinder walls, worn pistons, collapsed piston skirts, excessive piston clearances, or misaligned connecting rods.

g. **<u>Crankshaft Knocks.</u>** This noise is a heavy, dull metallic knock; it is most noticeable when the engine is under a heavy load or accelerating, particularly when cold. When the noise is regular, it probably results from worn main bearings. When the noise is irregular and sharp, it is probably due to a worn unusually bad, will cause the noise to be proceed each time the clutch is released and engaged, and when first accelerating.

h. **Miscellaneous Noises.** Other noises result from loosely mounted accessory parts, such as the alternator, starting motor, horn, water pump, manifolds, flywheel, crankshaft pulley, and oil pan. Other automotive components, such as the clutch, transmission and differential, may also develop noises.

Aim : To study Engine Tune-up

Ref : Automotive mechanic, by William H. Course Page-424 to 439.

ENGINE TUNE-UP

What Tune-Up is?

1. Engine tune-up means different things to different people. To some, it means a light once-over check of the engine that takes in only the more obvious trouble spots. To others, it means used of the proper test instruments to do a careful, complete analysis of all engine components. In addition, it means adjusting everything to specs" and repairing or replacing all worn parts. The latter is the proper meaning of engine tune-up; it is the procedure outlined in this chapter.

Tune-Up Procedure

2. An engine tune-up follows a more-or-less set procedure. Many mechanics use a printed form supplied by automotive or test-equipment manufacturers. By following the form and checking off the items listed, one by one, the mechanic is sure of not overlooking any part of the procedure. However, all tune-up forms are not the same. Different companies have different ideas about what should be done, and the order in which it should be done. In addition, the tune-up procedure depends on the equipment available. If the shop has an oscilloscope or a dynamometer, it is used as part of the tune-up procedure. If these test instruments are not available, then a tune-up is performed differently. The procedure that follows includes car-care inspection. It lists all essential checks and adjustments, in what authorities believe are the most logical sequence:

Tune-Up and Car Care

3. The tune-up procedure restores derivability, power, and performance that have been lost through wear, corrosion, and deterioration of engine parts. These changes take place gradually in many automotive parts during normal car operation. Because of federal laws limiting automotive emissions, the tune-up procedure must include checks of all emission controls. Here is the procedure;

   a. If the engine is cold, operate it for 15 to 20 minutes at 1,500 rpm (revolutions per minutes), or until it reaches operating temperature.

   b. Connect the oscilloscope, if available, and perform an electronic diagnosis. Check for any abnormal ignition-system conditions that appear on the pattern. Make a note of any abnormality and the cylinders in which it appears.

c. Remove all spark plugs. Fully open the throttle and choke valves. Disconnect the distributor primary lead from the coil so the engine will not start.

d. Check the compression of each cylinder. Record the readings. If one or more cylinders read low, squirt about a tablespoon of engine oil through the spark-plug hole. Recheck the compression, and record the new readings.

e. Clean, inspect, file, gap, and test the spark plugs. Discard worn or defective plugs. Gap all plugs, old and new. Install the plugs.

f. Inspect and clean the battery case, terminals, cables, and hold -down brackets. Test the battery. Add water, if necessary. If severe corrosion is present, clean the battery and cables with brushes and a solution of baking soda and water.

g. If the battery is low, or the customer complains that the battery keeps running down, check the charging system (alternator and regulator). If the battery is old it may have worn out. A new battery is then required.

h. Check the drive belts, and replace any in poor condition. If you have to replace one belt of a two-belt drive, replace both belts. Tighten belts to the correct tension, using a tension gauge.

j. Inspect the distributor rotor, cap, and primary and high-tension (spark plug) wires (Fig. -1).

k. Clean or replace and adjust distributor contact points by setting the point gap. Lubricate the distributor breaker cam if specifications call for this. On distributors with cam lubricators .specifications call for turning the cam lubricator 180^0 every 12,000 miles (19,311 Km) and replacing the cam lubricator every 24,000 miles (38,624 Km).

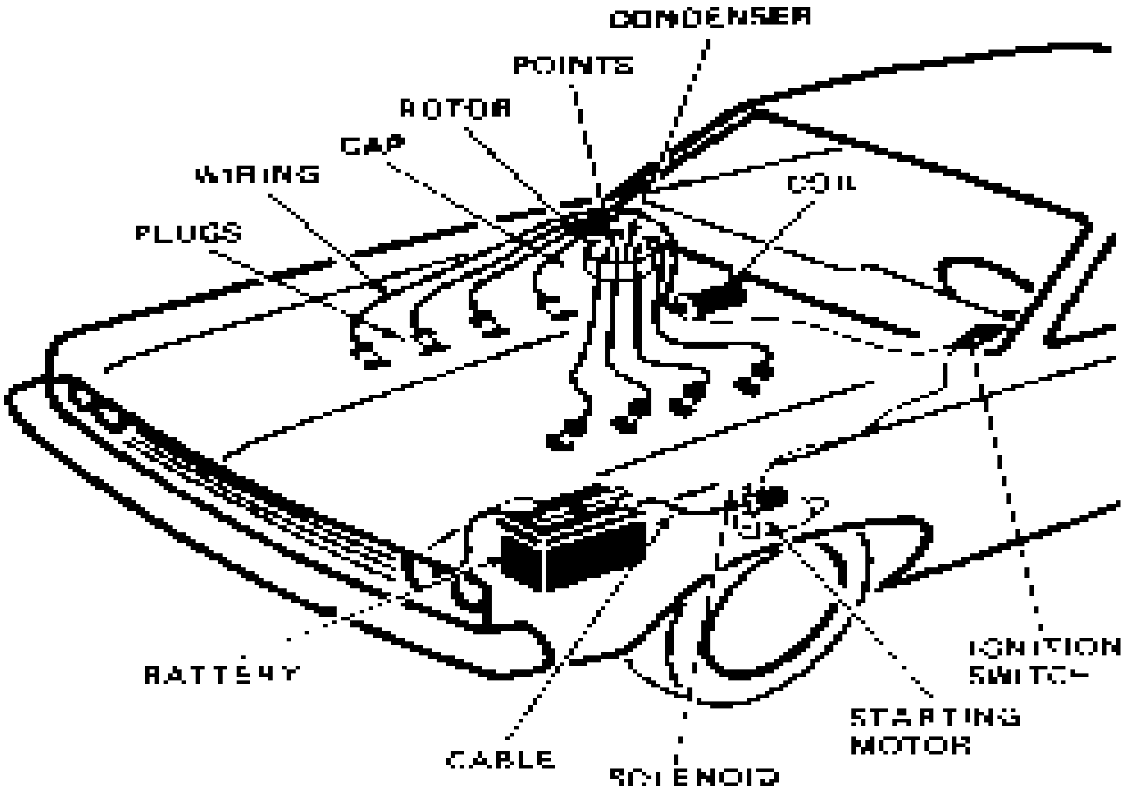


Fig-1

Simplified drawing of an engine ignition system

l. Use the oscilloscope to recheck the ignition system. Any abnormal conditions that appeared in step.2, above, should now have been eliminated.

m. Check the manifold heat-control valve. Lubricate, it with heat-valve lubricant. Free up or replace the valve, if necessary.

n. Check fuel-pump operation with a fuel -pump tester. Replace the fuel filter. Check the fuel-tank cap, fuel lines, and connections for leakage and damage.

p. Clean or replace the air-cleaner filter. If the engine is equipped with a thermostatically controlled air cleaner, check the operation of the control damper.

q. Check the operation of the choke and the fast-idle cam. Check the throttle valve for full opening and the throttle linkage for free movement.

r. Inspect all engine vacuum fittings, hoses, and connections. Replace any brittle or cracked hose.

s. Clean the engine oil-filler cap, if a filter type oil filler cap is used.

t. Check the cooling system (Fig. -2). Inspect all water hoses and connections, the radiator, water pump, and fan clutch, if used. Check the strength of the antifreeze, and record the reading. Pressure-check the system and the radiator cap. Replace any defective hose.

u. Check and replace the PCV valve, if necessary (see Fig. 3-4). Clean or replace the PCV filter, if required. Inspect the PCV hoses and connections. Replace any cracked or brittle hose.

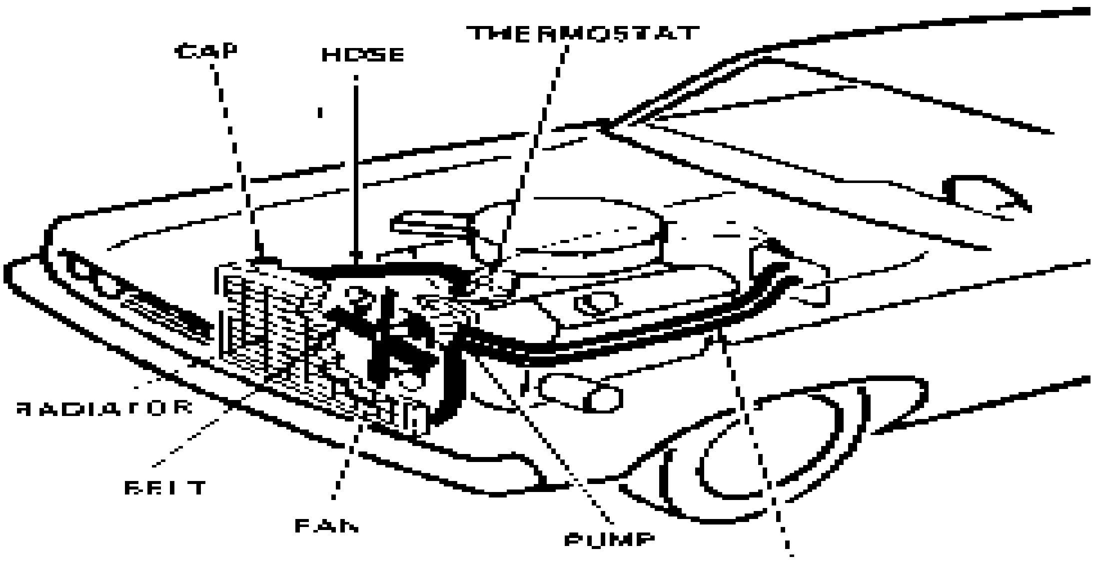


Fig -2 Engine Cooling System

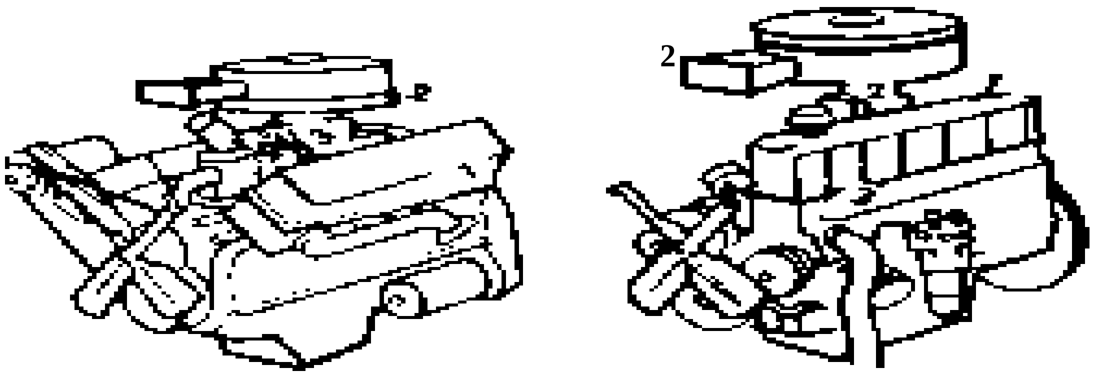


Fig -3 PCV-Valve Location

In a V-8 engine the pcv valve is located In :	***In a six-cylinder engine the pcv valve is located in :***
1. Rocker arm cover 2. Rear of engine 3. Carburettor base	1. Rocker arm cover 2. Base of carburettor 3. Hose

u. If the engine is equipped with an air-pump type of exhaust-emission control, replace the pump-inlet air filter, if used. Inspect the system hose s and connections. Replace any brittle or cracked hose.

v. If the vehicle is equipped with a fuel-vapor recovery system, replace the charcoal-canister filter.

w. Check the transmission-controlled vacuum spark-advance system, if vehicle is so equipped.

x. On engines equipped with an EGR system, inspect and clean the exhaust gas re-circulation valve. Inspect and clean the EGR discharge port.

y. Tighten the intake-manifold and exhaust-manifold boots to the proper tension in the proper sequence.

z. Adjust the engine valves, if necessary.

aa. Adjust the carburettor idle speed. Use an exhaust-gas analyzer, and adjust the idle mixture screw. Check the CO and HC in the exhaust gas.

ab. Road test the car on a dynamometer or on the road. Check for derivability, power, and idling. Any abnormal condition should be noted on the repair order before you return the car to the customer.

ac. Check the door jamb sticker to determine if an oil and oil-filter change is due. Also note the schedule for chassis lubrication. Recommend an oil change and a lube job if they are due (See fig. 4).Note that car manufacturers recommend changing the oil filter every time-or every other time-the oil is changed.

ad. Check the brakes for even braking and adequate braking power.

ae. Check the steering system for ease and smoothness of operation. Check for excessive play in the system. Record any abnormal conditions.

af. Check the tires for inflation and for abnormal wear. Abnormal wear can mean suspension trouble, and a front-alignment job should be recommended.

ag. Check the suspension system for looseness, excessive play, and wear.

ah. Check the front wheels and ball joints for excessive wear or loose bearings. Adjust the bearings if necessary.

aj. Check the headlights and horns to make sure they are in good working order. Check all other lights. Replace any burned-out lights. Check the headlight alignment, if possible.

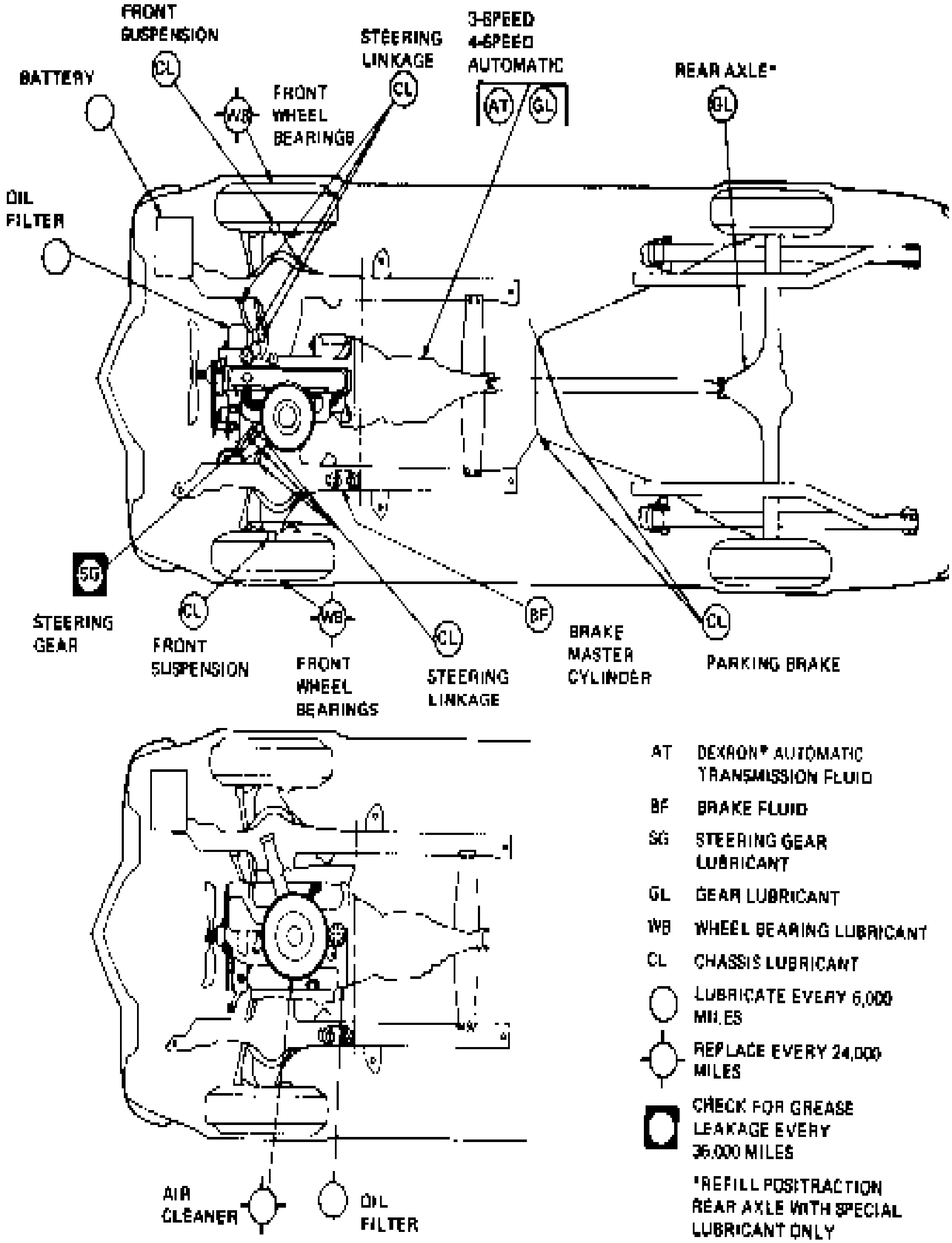


Fig 4 Lubrication recommendation for a late-late model Chevrolet.(Chevrolet Motor Division of General Motors Corporation)

Engine Analyzer

3. Fig -5, shows an engine analyzer which includes an oscilloscope and other instruments for making comprehensive tests of all engine components. Once the mechanic learns how to use this equipment, a complete engine analysis can be made in a very short time.

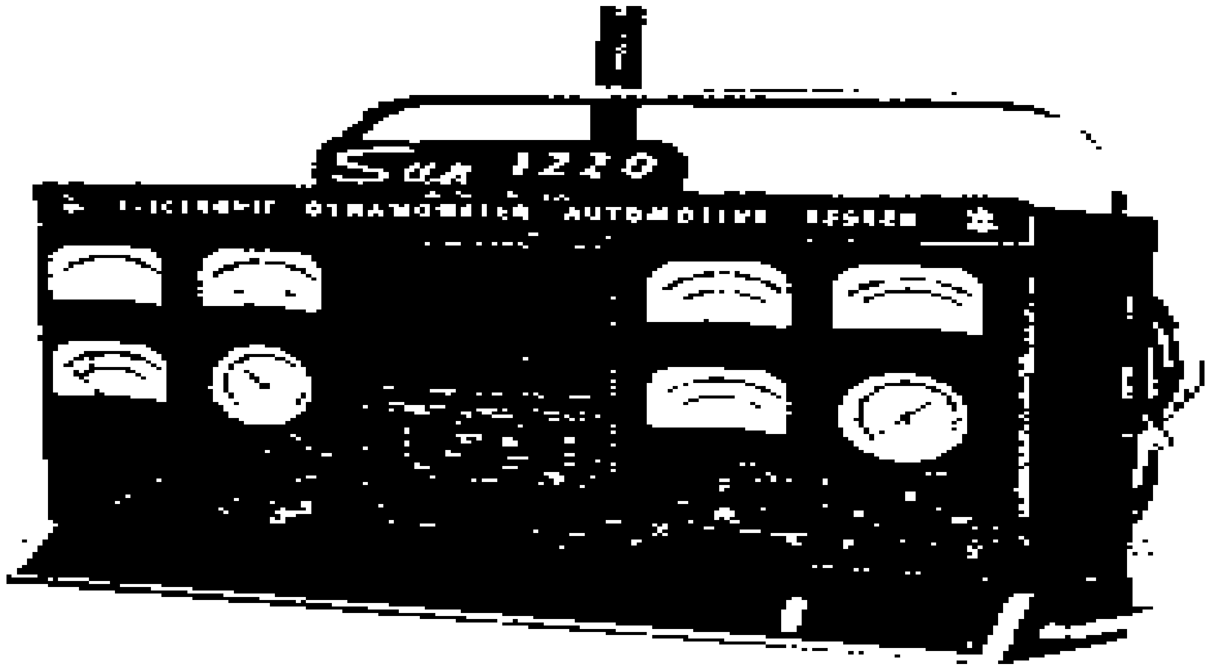


Fig -5
Electronic diagnosis engine tester, or engine analyzer.

In addition to these analysers, there are more complex testers. They run many of the tests almost automatically and then produce a printed record of the tests and their results. For example, fig 4-6 shows a system that uses a computer and an interpreter. The various connections to be made are shown in the illustration. Also shown in the remote channel selector, *w*hich can be used to select either a display device or a printer. Thus, the test result can be displayed on a screen or printed out as a permanent record. The operation of the tester shown in simple, once the connections are made. You simply select the proper computer -program card and insert it into the computer. The punched car has the specifications for the model car under test. The tester then makes the tests. An even simpler system has been developed. In this system, the vehicle has a connector that is already attached to the various car components. The tester has a plug that is connected to all the testing instruments. Thus, the automotive mechanic only has to plug the tester plug into the connector on the vehicle. This completes all connections between the engine components and the test instruments. The mechanic then can run all the tests in a minimum of time. One further refinement has been suggested. This is to put into the computer information of the costs of parts and repair operations. Then the computer could print out, along with the test information, the cost of fixing any troubles. That is, it would print out the costs of parts and labour. It has also been suggested that the computer could be programmed to schedule the work, depending on the manpower and space available in the shop.

(Aero Engg Trg Sqn)

Syllabus : Automobile General Diesel and Petrol Technology

Course : Trade Training Advance, MTOF

Subject : Automobile Test Equipments

Aim : To Study TI Crypton 312 Engine Analyzer

Ref : Operating Instructions for TI Crypton Engine Analyzer page no 1, 3, 5 & 7.

TI CRYPTON 312 ENGINE ANALYSER

Introduction

1. It's an electronic Engine Test Equipment. It is manufactured by ***TI Crypton LTD, Bridgwater, and Somerest, England. Model-312/FA. 10428, Volts-12-15 and Amps-4.*** This 312 Engine Analyzer is designed to operate from a D.C negative earth supply only.

Safety Precautions

2. a. This equipment is not weather proof and should not be used outside in rain or snow.

b. The internal circuits and components of the equipment should not be tampered with while the battery power supply (red and blue leads or plug-in diagnostic lead) is connected as high voltage circuitry is used.

c. When testing a vehicle, never allow HT sparks to short to the battery or engine dipstick as this can cause an explosion of hydrogen or fumes.

d. Most electronic fault diagnosis is performed with the engine running therefore operators should exercise due caution with regard to the fan and associated belts, shock from ignition components and burns from the exhaust and cooling systems. Care should be taken to keep the test leads clear of the fan.

e. Where the test area is confined, provision should be made to extract the exhaust gases.

Power supply

3. The 312 engine analyzer is designed to operate from a 12V DC negative earth supply only.

Warning: *The red and blue hooded power supply/test leads must never be connected to a 24Volts supply. Particular care should be taken when testing vehicles with 24Volts electrical system.*

On 24V systems, connect the earth test clip (Blue) to battery earth and the battery live test clip (red) to the 12V point on the battery.

General Information

4. a. Arrows on the meter dial, when illuminated, indicate which meter scale is in use.

b. The equipment is intended primarily for use on negative earth battery systems. Tests of engine speed, ignition timing and HT voltages may, however, be made on positive earth system, i.e. HT measurements only.
[
c. A holster on the right of the equipment is used to hold the timing light when not in use.

d. Most of the equipment functions can be calibrated by the operator using the five small potentiometers situated at the left lower corner of the front panel.

e. The equipment is suitable for use on vehicles fitted with magnetic or optical timing systems when used with the appropriate diagnostic test harness.

f. When the test leas are connected to an engine which is stationary with the ignition switched on, the Green lamp0 next to the distributor volt drop button (F) will light if the contact points are closed.

g. The red circular push button near the lower left corner of the instrument console is used only during calibration. It is not a vehicle test button.

Button Functions

5. The equipment functions are entirely controlled by 17 push buttons and one slide switch on the front panel. The slide switch is used during contact dwell tests to select angle or percentage. The push button will show one of two colours according to whether they are depressed or released. Symbols are used to indicate the functions of each button or group of buttons and these should be found simple to use with a minimum of experience. To further simplify the explanations in this manual, each button or group of buttons has been identified by a letter as shown in the illustration on next page.

1) Button A stops the engine.

2) Button B selects the tachometer or ohmmeter.

3) Button C sets the analyzer for 2 stroke or 4 stroke engines.

4) Buttons D to L select the engine test readings.

5) Button in group M selects the number of cylinders for the engine under test. When checking the dwell angle of 12 cylinder engines having one distributor e.g. Jaguar V12, depress the 6 cylinder button and half the reading shown on the digital display.

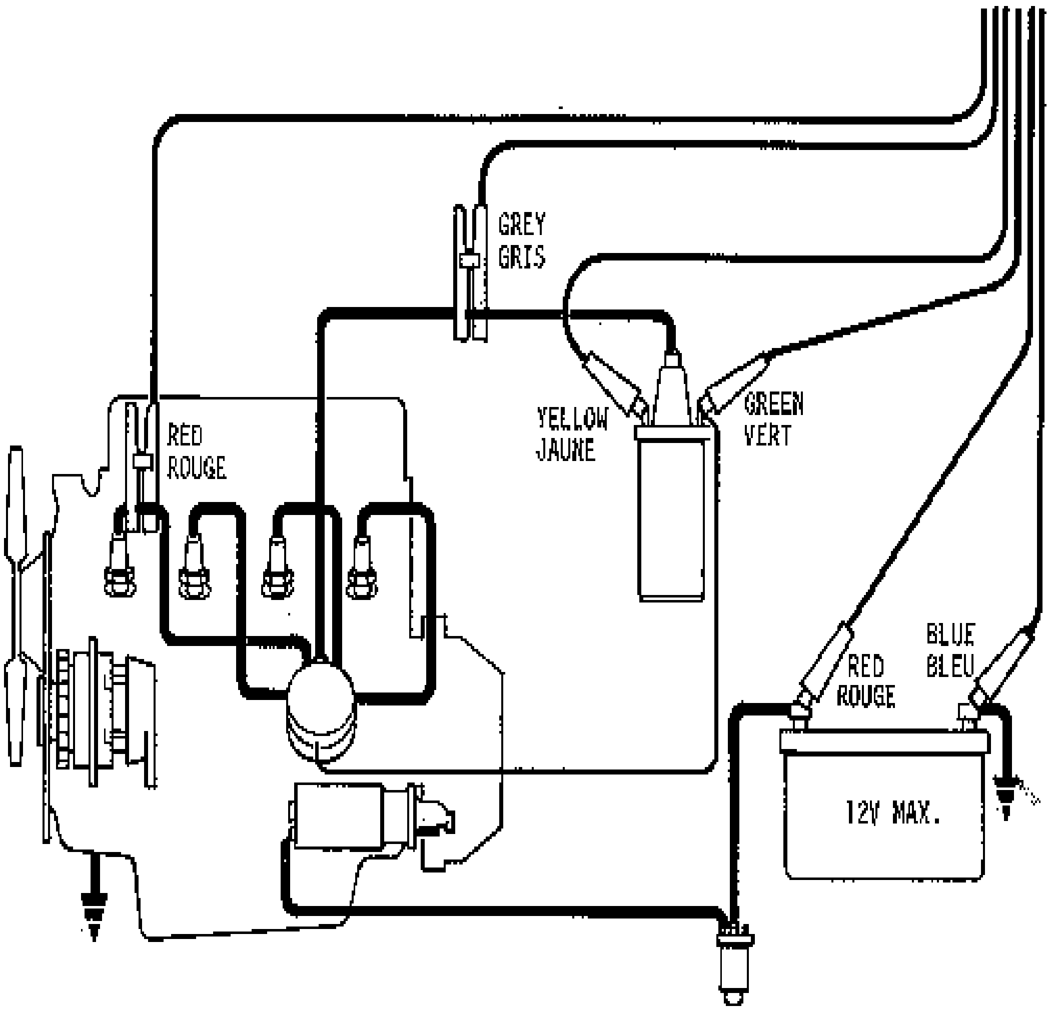


Fig -1, Jumper lead connections

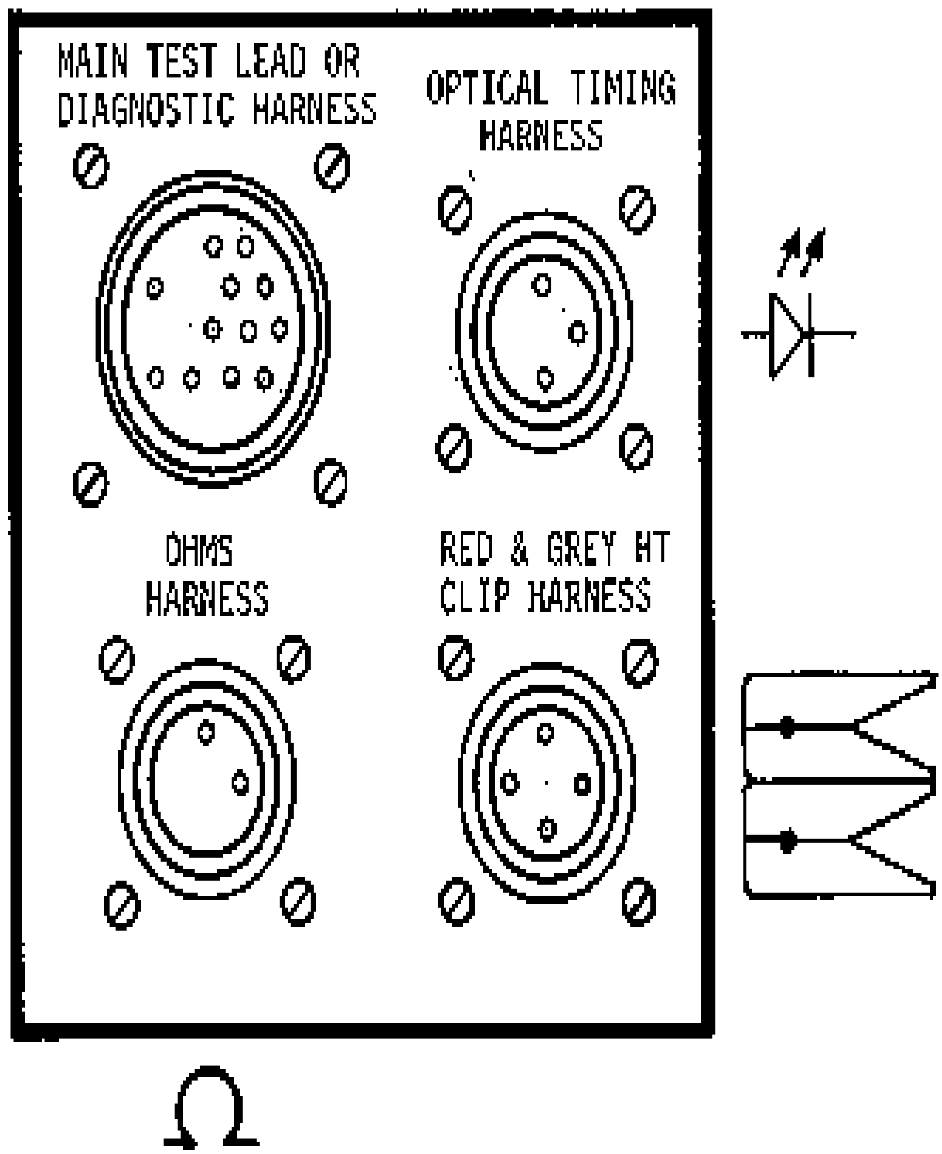


Fig -2, Jumper lead & clip connections

<u>Table of Button Functions</u>

6.

Button	Colour Out	Colour In	Functions
A	Green	Red	Push to stop engine. Push to release
B	Green	Red	Push to select ohms reading on meter release to select tachometer.
C	Green	Red	Push for 2 stroke or wankel engine release for 4 stroke engine.
D	White	Red	Push for read battery volts. Button d to k is interlocking.
E	White	Red	Push to read coil Sw (+) volts.
F	White	Red	Push to read distributor voltage drop with engine stopped or running.
G	White	Red	Push to read average dwell angle or dwell percentage. Slide switch below digital display selects % or angle.
H	White	Red	Push to operate timing light and read timing degrees on digital display.
J	White	Red	Push to read ignition timing on engines with facilities for magnetic or optical timing. Used in conjunction with plug-in diagnostic test harness
K	White	Red	Push to read average or individual ignition key values.
L	Green	Red	Pushes to read centre zero sensitive tachometer. Push to release
Group M	Black	Green	Push to select no. Of engine cylinders. These buttons are interlocking.

Jumper Lead Connection

7. The jumper lead, which incorporates a 7 amps fuse, is supplied to ensure that current is flowing in the primary ignition circuit regardless of the distributor condition when the engine is stationary. This in turn ensures reliable and reaccurate voltage readings of the primary circuit to be made. The fuse will blow if the jumper lead is accidentally connected to the SW (+) side of the ignition coil. This can be prevented by running the engine and connecting the voltmeter between earth and each LT terminal of the coil in turn. .The terminal giving the lowest reading is CB (-). Always connect the jumper lead to the terminal giving the lowest reading.

> ***Warning:*** *Beware of the danger from rotating components; shocks from the ignition HT leads; scales from the cooling system and burns from the exhaust pipes..*

Preliminary button selection

8. Before commencing each vehicle test certain buttons should be selected to suit the particular engine.

a. Release button B to select the tachometer.

b. Press or release button C according to whether the engine is a 2 stroke or a 4 stroke.

c. Push the button in group M corresponding with the number of engine cylinders. For 12 cylinder engines with one distributor, push the 6 cylinder button.

Note: *Button is used at any time during the test to stop the engine.*

Connecting to the vehicle

9. Using appropriate adopters where necessary connect the test leads as follows:

a. The red HT clip onto No. 1 spark plug lead (No. 6 on Rover 2300 & 2600).

b. The grey HT clip onto the coil HT lead for coil KV measurement or to any spark plug lead for individual KG measurement.

c. The red test lead to the battery live terminal. (For positive earth vehicles connect red lead to earth terminal).

d. The blue test lead to the battery earth terminal or a good engine earth if the battery is not available. (For positive earth vehicles connect blue lead to live terminal).

e. The yellow test lead to the coil SW (+) terminal.

f. The green test lead to the coil CB (-) terminal.

Important: *The red and blue leads also connect the equipment power supply and therefore must be connected to a 12V supply for the equipment to operate. Never connect these leads to a 24V supply. On 24v systems, connect the earth test clip (Blue) to battery earth and the battery live test clip (Red) to the 12V point on the battery.*

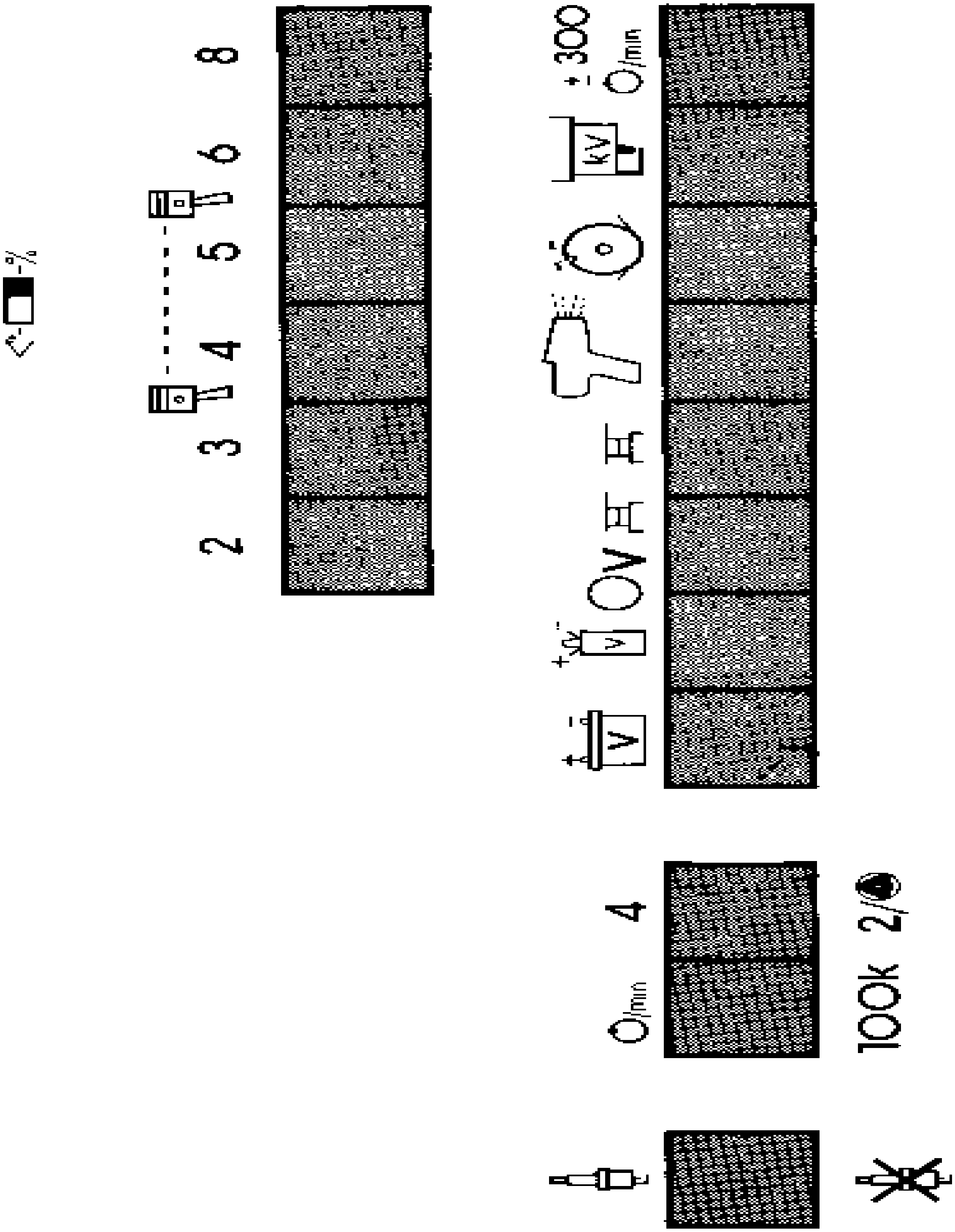


Fig -3, Button symbols

Test Sequence

10. By the TI CRYPTON ANALYSER we can test the followings:

a. Battery volts(Ignition coil)

b. Coil SW volts (ignition on)

c. Coil SW volts (starter cranking)

d. Distributor voltage drop(Static)

e. Distributor voltage drop(Dynamic)

f. Battery volts (Generator charging)

g. Dwell angle or percentage

h. Dwell adjustment

J. Well variation

k. Initial timing (stroboscopic method)

l. Initial timing (Sensor method)

m. Automatic advance (stroboscopic method)

n. Automatic advance (sensor method)

p. Coil polarity

q. Spark plug condition

r. Plug KV on acceleration

s. Coil KV

t. Carburetor adjustment

u. Cylinder balance

v. Ohm meter tests

BAF BASE ZAHURUL HAQUE (TRG WGING)

(Aero Engg Trg Sqn)

Syllabus	**:**	**Automobile General Diesel and Petrol Technology**
Course	**:**	**Trade Training Advance, MTOF**
Subject	**:**	**Test Equipments**
Aim	**:**	**To study TI Crypton Distributor Tester Model BC75)**
Ref	**:**	**Operating Instructions for TI Crypton Distributor Tester Model BC75**

TI CRYPTON DISTRIBUTE TESTER MODEL BD75

Safety precautions for distribute tester

1. a. The equipment should be marked. For use by authorized personnel only.

b. The equipment is not weather proof and should not be used outside in rain or snow.

c. Operators should not allow themselves to come into contact with water or other similar conductors when using the equipment.

d. The equipment should not be left switched on while unattended.

e. Position the test leads so that they cannot come into contact with the rotating parts.

f. Remove the distributor cap and rotor arm before running the distributor at high speed.

g. Do not wear lose items of clothing that may catch in the rotating components.

h. The internal circuits and components of the equipment should never be tampered with while the mains supply is switched on as lethal voltages are present.

k. The earth lead of the mains cable MUST ALWAYS be connected to a good earth point.

Specification

2. The BC 754 distributor Tester is designed to operate from a 200-250 volt 50 Hz single phase mains supply. The equipment leaves the factory connected for 240V. If your supply differs from this voltage, remove the machine from its case by unscrewing the 4 screws (two at the top rear and two beneath the front) Locate the mains terminal block, disconnected the wire from the 240V tapping and reconnect it to the terminal appropriate to the supply voltage. Do not switch on until the cover is replaced. Test of dwell angle (cam) angle, dwell overlap and variation, centrifugal and vacuum advance are possible at speeds up to 3500 rpm.

Installation

3. Install the equipment in a dry clean environment. The distributor tester, like any other mains operated equipment must not be used in a damp or wet condition.

Connecting to the Mains Supply

4. Connect a suitable plug to the mains lead as follows:

a. Brown lead to `L` ive
b. Blue lead to `N` eutral
c. Green/Yellow lead to `E` arth

Fuse the plug at 3 amps, this value should not exceeded.

Thermal Overload

5. A 3 amp automatic trip switch is situated on the front panel to protect the equipment in the event of an overload. If the switch trips out, reset by pushing the button in firmly. If trip operates frequently a Tran service engineer should be called.

Control Functions

6. The front panel contains the following controls, switches and distributor connecting points:

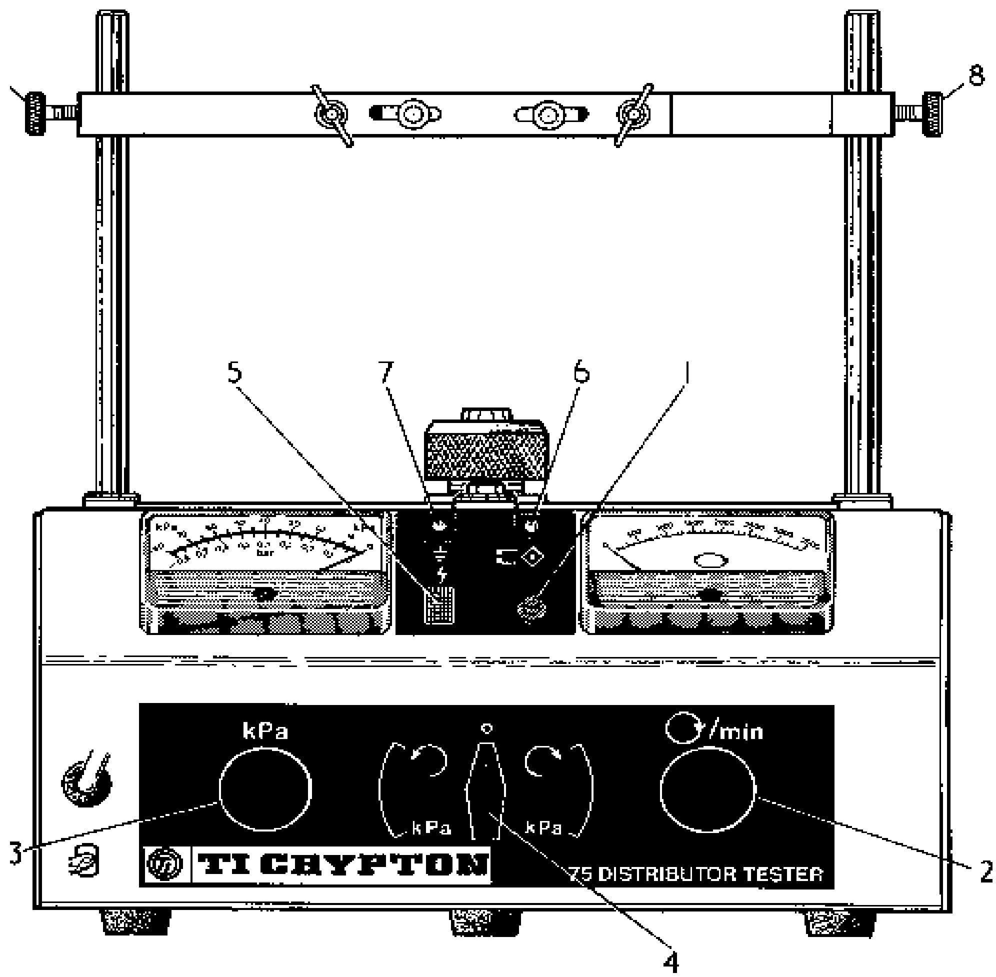
a. Motor speed control turns clockwise to increase distributor rpm.

b. Vacuum control turn clockwise to increase the amount of depression when testing vacuum advance units.

c. Mains ON/OFF, distributor direction of rotation and vacuum pump switch (Fig. -4).

d. An amber light glows when the mains switch is `ON`.

e. Contact Breaker (CB) and Earth distributor connections.



Fig, -4 Ti Crypton Distributor Tester Model BC75

Instrumentation

7. Two instruments are fitted in the front panel, an electronic tachometer scaled from O - 3500 on the Right relating to distributor speed and a vacuum gauge on the Left, scaled O to minus 80 Kpa and 0 to minus 0.8 bars.

Visual Inspection of the Distributor

8. It is recommended that the distributor is checked for loose connections, contact condition and shaft or bush wear. Any visible faults should be rectified before commencing the test.

Mounting the Distributor

9. a. Slacken the two knurled locking screws. Raise the mounting assembly well clear of the chuck. Lightly retighten the knurled locking screws.

b. Fit the appropriate distributor drive adopter to the main drive spindle using the chuck. When tightening the chuck place one hand on the black disc to prevent rotation.

c. Place the distributor locking shank in the mounting assembly clamp as shown in Fig -5, and securely tighten the wing nuts.

d. Connect the CB right hand socket) and Earth (left hand socket) leads from the front panel onto their appropriate distributor connections.

e. Connect the flexible vacuum pipe to the distributor vacuum unit inlet.

Note: *The earth lead has crocodile clip fixed to one end and the CB lead is fixed to a push on connector, this will fit directly onto the CB connection of many distributors. For distributors with other types of CB terminal a crocodile clip supplied with the equipment should be connected to the push on terminal.*

Principle of Operation

10. The disc situated in the top of the tester and mounted inside a degree ring is made to rotate at the desired speed by the control. Housed beneath the disc and close to its circumference is a small neon tube and above the tube is a thin slot cut in the disc. During distributor rotation the contact breaker points open and close. This function is employed to switch the neon off during the closed or dwell period and on during the open period. When the rotating disc is viewed by an operator, a glowing section of light is seen for the points open period of each ignition cycle. The dark sector represents the dwell period which can be measured against the degree ring and compared with the manufacturers dwell specification.

Dwell Angle

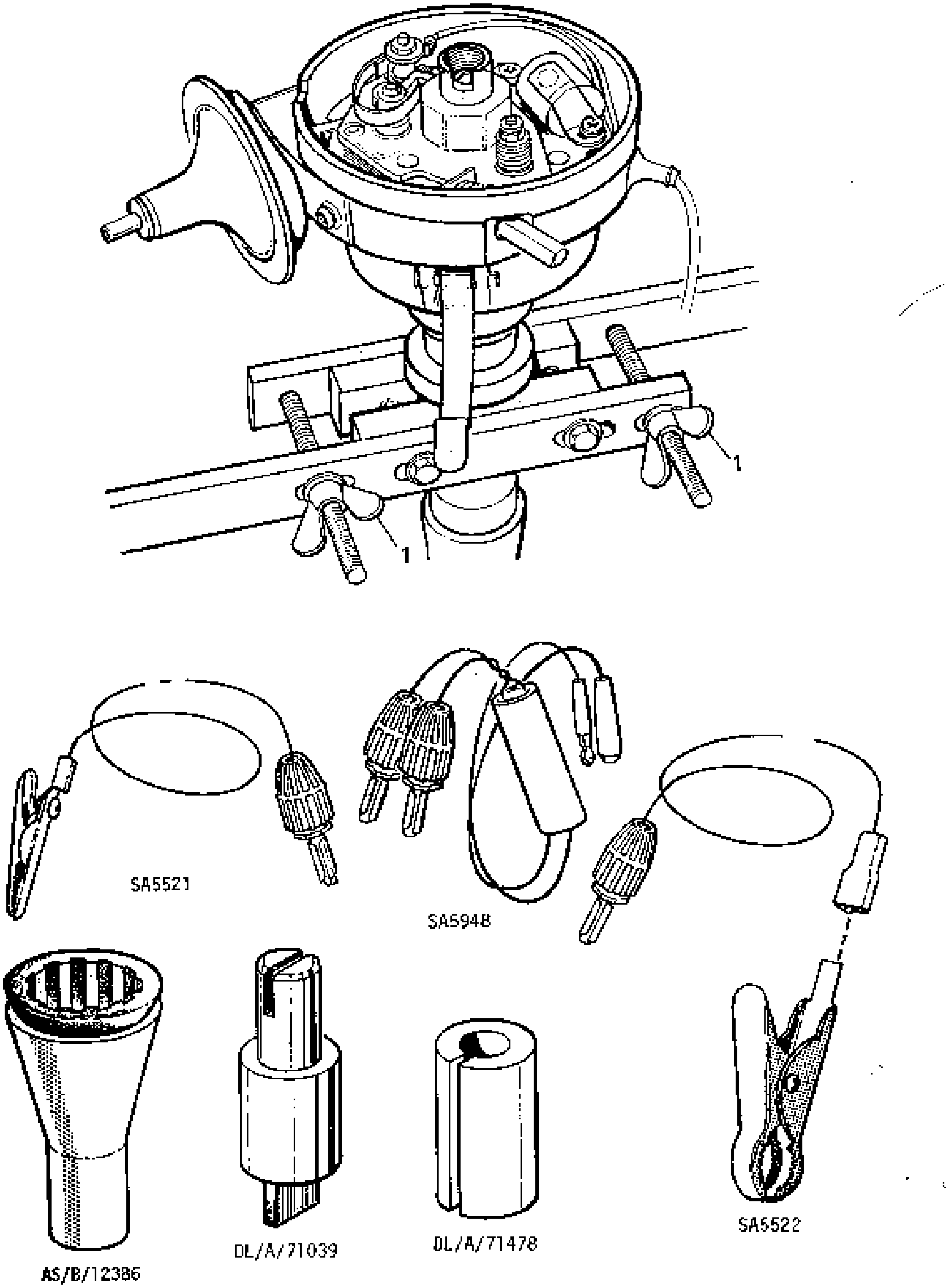
11. a. Move the Direction of Rotation switch to suit the distributor under test. The distributor should be tested with the cap and rotor removed.

b. Adjust the Motor Speed Control until the distributor is running at 500 r.p.m .

c. Move the degree ring using the peg provided until the zero line coincides with the commencement of one dwell sector. shows a 4 lobe distributor with dwell sectors of 60^0.

d. Measure the degrees indicated by the dark sector and compare this figure with the manufacture’s recommended dwell setting.

e. The correct dwell angle readings, continue running the distributor and with the contact locking screw slackened, adjust the contact position until the dark sector corresponds with the desired number of degrees.



Fig, -5 Distributor Fitted To the Tester

Dwell Overlap

12. a. Run the distributor at 500 r.p.m.

b. Measure carefully the dwell angle or ONE ignition cycle.

C. Check the number of degrees for each dwell period. The majority of distributors have a tolerance of 3^0 for dwell over lap but any doubt exists consult the manufacturer's recommended test specification.

Note: Dwell overlap is caused either by an oval distributor cam or bent drive shaft

Dwell Variation

13. a. Raise the distributor speed to 1500 r.p.m. Or manufacturer's stated speed.

b. Move the degree ring until the zero line coincides with the commencement of one dwell sector.

c. Compare the dwell angle with the angle shown when running the distributor at 500 r.p.m. Any change in dwell angle is a result of wear in the distributor shaft or bushes.

d. Switch the main selector to VAC and using the vacuum control fully operate the vacuum advance mechanism with the distributor running at 1500 r.p.m.

e. Move the degree ring until the zero line once again coincides with the beginning of one dwell sector.

f Compare the dwell angle with the previous reading. Any change is a result of wear in the vacuum advance plate. The combined dwell variation for both tests should not exceed 3^0.

Note: The life of the vacuum pump motor will be prolonged if the main selector is turned to VAC only during a vacuum test.

The Test Procedures

14. The test procedure is as follows:

a. Run the distributor at a speed below the commencement of centrifugal advance (in example quoted, 550, rpm).

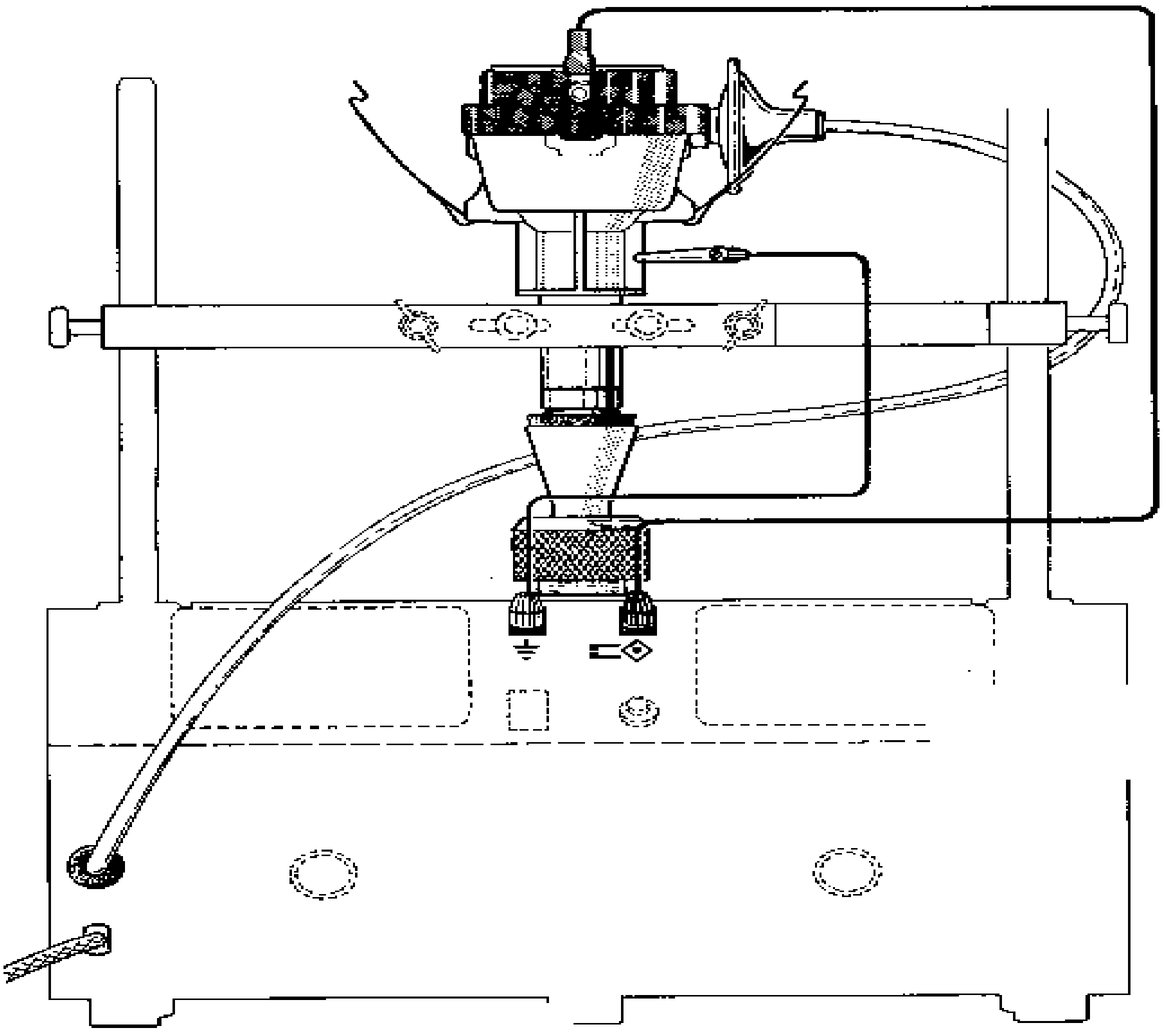
b. Ensure that the vacuum reads zero, (vacuum control fully anti-clockwise).

c. Move the degree ring until the zero line coincides with the commencement of one dwell sector.

d. Raise the distributor speed to the first intermediate advance figure given in the test data (700 rpm. In the example).

e. Note the number of degrees that the dwell sector has moved from the zero line on the degree ring and compare this with the date information (1 - 3^0 in the example).

f. Repeat step 5 for each intermediate advance speed, noting each degree reading until the maximum advance speed is reached. This should be determined prior to the test from the manufacturer's instructions.

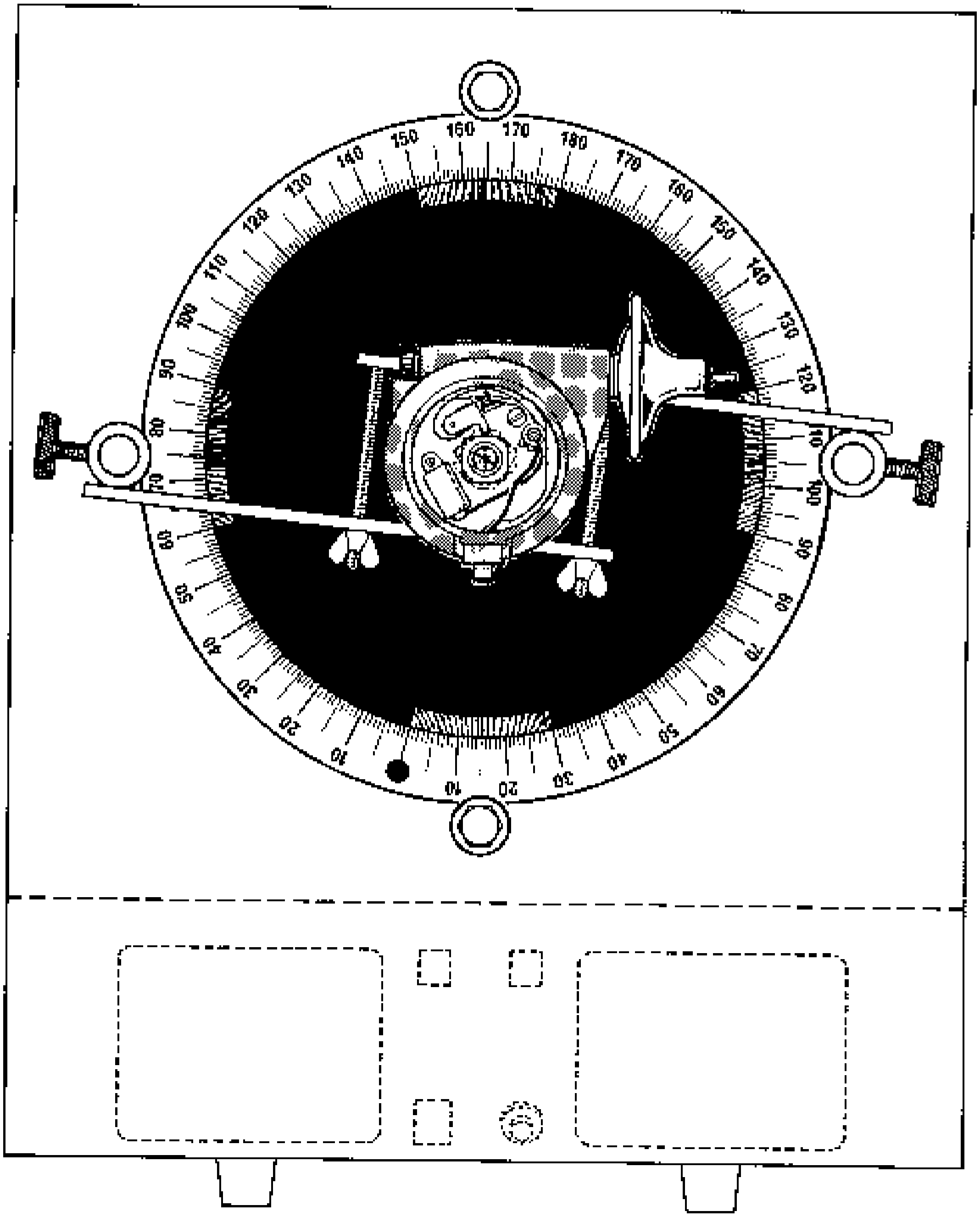


Fig, -6 Distributor Testing

***Important Note**: Some distributors MUST be checked on deceleration starting at the Maximum advance speed.*

Turn the vacuum control clockwise until the vacuum gauge indicates the Kpa/bar to start operating the until the vacuum then turn progressively until the unit moves through its full travel. Ensure that the unit operates between the stated values of depression. Ensure that the vacuum unit does not leak. A leak is indicated when the vacuum gauge fails to read 68kpa (0.68 bar) or more with the vacuum control turn fully clockwise. Compare the degrees of vacuum advance with the Kpa/bar applied to the unit and check the results against manufacturer's data.

Note: Some type of vacuum unit have a hole drilled in the diaphragm housing to produce a calculated air bleed. To test for leaks of this type of unit, the bleed hole should be temporarily blanked off.



Fig, -7 Distributor Rpm and Degrees Shown

BAF BASE ZAHURUL HAQUE (TRG WGING)
(Aero Engg Trg Sqn)

Syllabus : Automobile General Diesel and Petrol Technology

Course : Trade Training Advance, MTOF

Subject : Test Equipments

Aim : To study Wheel Alignment Gauge

Ref : Operating Instructions for wheel alignment equipment

OPERATING INSTRUCTIONS FOR WHEEL ALIGNMENT EQUIPMENT

Preliminary Procedure

1. a. Check and correct all tyre pressures to marker's recommendations.

   b. Check floor level at the four points where the car tyres will rest.

   c. Check vehicle for sagging springs, especially at the front end.

   d. Check all wheels for correct size of tyres and any excessive radial or lateral run out.

   e. Fit 121LA Gauge to wheel.

Castor and King Pin Inclination Measurement Checks (Turntables are required for these checks):

2. a. Position car with front wheels straight ahead

   b. Place 121T turntables and 121W Wooden Ramps centrally in front of wheels with turntable lock pins in position.

   c. Set Turntables to approximate zero.

   d. Roll vehicle on to Turntables, centralize, and apply foot brake to lock all wheels (use a pedal depressor such as Churchill No. 121Pd).

   e. Remove locking pins and set turntables scales to exact zero.

   f. Clamp 121LA Steering Gauge to wheel, as instructed in preliminary procedure paragraph (e).

g. Rear wheels must be raised to same height as front wheels, using the two rear wheel ramps. Alternatively the turntables may be sunk into the floor, thus rendering the ramps unnecessary.

Castor Check

3. a. Turn body of steering gauge so that it is at right angles to wheels.

   b. Turn front of wheel towards operator until scale on turntable reads 20^0.

   c. Centralize spirit level.

   d. Set castor KPI scale to zero and tighten screw.

   e. Turn front of wheel away from operator until scale on turntable reads 20^0.

   f. Centralize spirit level bubble and not reading on castor KPI scale.

   g. Correct reading for floor level is necessary.

Toe-Out on Turns Check: (Steering Gauge is not required for this check)

4. a. Check that wheels are set straight ahead on the turntables.

   b. Check that turntable scales are at zero.

   c. To obtain figure for right turns, turn left hand wheel until scale on turntable reads 20^0.

   d. Read angle on turntable sunder right wheel. The difference between the two readings is the Toe0out on turns angle for right turn.

Camber Check: (Turntables are not essential for this check)

5. a. Index body of steering gauge so that it is at right angles to wheel.

   b. Centralize spirit level bubble. Camber can then be directly read on the Camber scale (against index).

   c. Correct reading for floor level if necessary.

   d. For utmost precision when measuring camber angles the operator should check to see that 121LA steering Gauge is set square to the axis of rotation of the wheels as follows:

e. Jack up wheels, loosen thumb screw which secures the spirit level gauge, and slowly rotate wheel with the gauge indexed in the camber position, note the reading of the spirit level against the camber scale if the wheel is true the spirit level bubble will not move.

f. Lateral run out of the wheel is indicated by movement of the spirit level bubble. To compensate, stop the wheel at a position mid way between the two extreme readings, and note the approximate radial position of the wheels. Lower and remove jack. The same radial position should be resumed when taking camber reading.

Important. *Vehicle makers` instructions regarding preparation of a vehicle for steering angle measurements should always be followed. These may include loading instructions, bouncing front end of car to settle suspension etc.*

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(Aero Engg Trg Sqn)

Syllabus	**:**	**Automobile General Diesel and Petrol Technology**
Course	**:**	**Trade Training Advance, MTOF**
Subject	**:**	**Test Equipment**
Aim	**:**	**To study Spark Plug tester and cleaner**
Ref	**:**	**Operating Instructions for BOSCH spark plug tester and Cleaner**

BOSCH SPARK PLUG TESTER AND CLEANER

[
Application

1. You can carry out the following work using this spark plug tester and cleaner:

a. **Clean fouled spark plugs or remove oil and combustion deposits using the sand blast unit.**

b. Test insulators under pressures up to 14 bar and at high voltage

c. Evaluate the condition the electrodes on the basis of the voltage required for spark discharge.

d. A mirror to observe the ignition spark and the auxiliary spark gap during the high voltage test is installed in the tester.

e. Measure and adjust the electrode gap.(For this purpose you should use the gap gauge, 0 684 201 400, with an adjusting tool for resetting the ground electrodes). The individual working steps and tests must be carried out in this sequence at each spark plug. Tests of insulation and of the electrode gap can only be made with perfect accuracy if the operating air pressure at the tester is at least 12 bars.

Why test Spark Plugs

2. The answer to this question becomes clear if we consider what requirements are placed on a spark plug:

a. **High Insulation Property.** The function of the spark plug is to introduce the high voltage developed in the ignition system as a spark in the combustion chamber and thus to initiate combustion. With electronic ignition systems the ignition voltage can be as high as 40000V. This means that the spark plug must be very well insulated so that the ignition spark actually jumps across the gap between the electrodes and so that the high voltage is not dissipated along some creep age path.

b. **Low Voltage Required for Ignition :** In order to achieve adequate and reliable ignition under all engine operating conditions, the voltage required for ignition should be as low as possible (to produce a fatter ignition spark). Special material and the shape of the electrode are two essential factors which promote favorable spark discharge. Unfortunately, the spark plug electrodes gradually burn away during the course of time. The associate change in shape results, for the same spark gap, in increased voltage being required for spark discharge. By evaluating the voltage required for ignition using the spark plug cleaner and tester, Model EFKE 2K, conclusions can be drawn on the condition of the electrodes and thus on the condition of the spark plug itself.

c. **Correct Electrode Gap.** In order to ensure optimum combustion and proper operation of the ignition system at all engine speeds, it is very important that the electrode gap be kept exactly as specified for each engine (these electrode gaps are given in the BOSCH spark plug recommendation chart). An electrode gap that is too small can, for example, result in rough operation of the engine, while a gap that is too wide increases the ignition voltage required to produce a good spark.

What kinds of Tests Can be Made?

3. Using the Model EFKE 2K spark plug cleaner and tester, the insulating property of the spark plug can be tested. It must be remembered here however, that this test is made with a cold spark plug. The ignition voltage required by a spark plug when it is not installed in an engine can be evaluated, assuming that the electrode gap is correct, by comparing the pressure at which the fir5st sparks jump across the gap with specified reference values. For the purpose a Rota table disc with three colored segments is installed in the pressure gauge. The disc is set to the correct electrode gap based on the position of the needle on the pressure gauge when discharge starts at the spark plug, can be evaluated. The electrode gap can be checked and set with the electrode gap gauge supplied with the spark plug cleaner and tester. In addition to the tests mentioned here a visual examination must also be carried out in order to evaluate the behavior of the spark plug when hot. The various spark plug faces and their causes are given at the last of these topics for comparison purposes.

Test Unit

4. The test unit consists of a vibrator ignition coil, a transformer, a push button and power cord, a high voltage cable for attaching to the spark plug, an auxiliary spark gap, a pressure chamber with a pressure gauge for 0-16 bar, as well as inserts and plugs with a pressure release valve for spark plugs. On the front of the housing, under the threaded necks for the spark plugs, there is an opening behind which a mirror is mounted to observe the spark plug and the auxiliary spark gap during the high voltage test. A relatable colour sector disc is mounted in the front of the pressure gauge, and when this disc is set to the

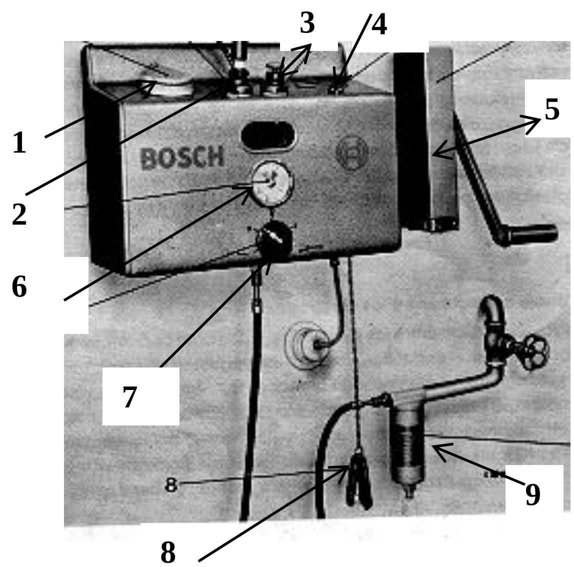
electrode gap measured on the spark plug being tested it shows the pressure at which this spark plug must be tested .

Operation of the Test Unit

5. The spark plug to be tested is first blown dry, and is then screwed into one of the two pressure chamber fittings, during the testing it is subjected to a pressure which can be adjusted by a valve. When the push button is pressed, the vibrator ignition coil produces ignition pulses in a rapid sequence which is fed simultaneously through the high voltage cable to the spark plug and to the auxiliary spark gap. At a low testing pressure the ignition sparks will jump across the gap between the electrodes on the spark plug. When the pressure is increased, however, the high voltage ignition current will choose the larger gap in free air and will jump across the auxiliary spark gap instead. The ignition voltage rise is therefore limited with increasing pressure.

Sand Blast Unit

6. In addition to the pressure chamber, there is also a cloth covered container for the blasting sand in the tester housing, into which a suction tube leads. The air and sand blast nozzle is attached to the other end of this tube. The sand blast unit is sealed externally by a replaceable rubber disc with an aperture for the spark plug being sand blasted. A Spring loaded swivel cover closes the aperture when the sand blast unit is not in use. If the sand blast unit is accidentally turned on without a spark plug in place, this cover provides good protection for the operator’s eyes. The container that holds the blasting sand is closed by a rubber plug on the bottom of the housing.



Key way to fig, 8-8

1 Filler opening for blasting sand

2. Pressure chamber

3. Pressure chamber
4. Push-button
5. Pressure booster
6. Pressure gauge
7. Selector knob
8 Electrode gap gauge

Fig -8, Test Unit

Selector Valve

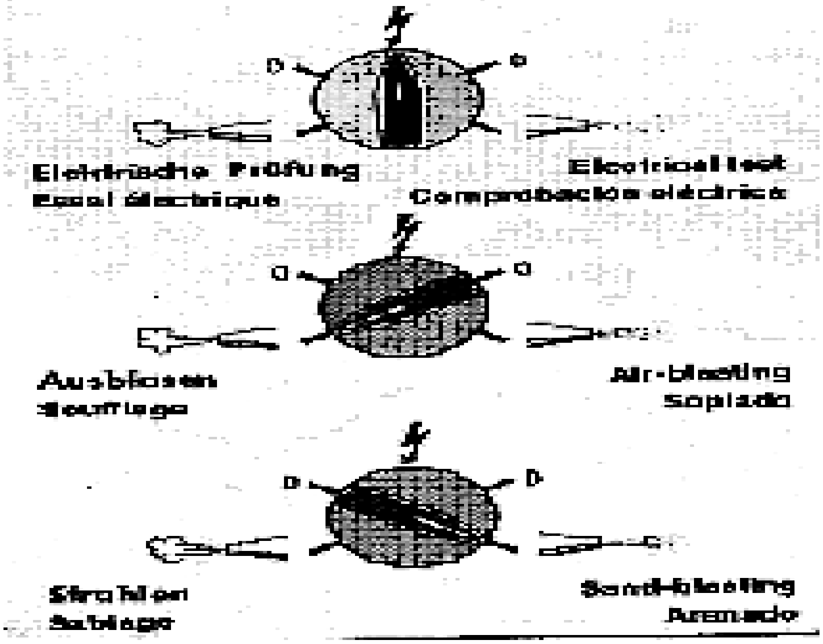
7. The compressed air for the various operating steps is controlled by a sector knob Through a selector valve. When the knob is turned it snaps into place at the various symbols and at `O`.

How Does One Test and Clean

8. a. **Introduction:** Assurance in the evaluation of the spark plugs to be tested gives you a good basis for sales discussions with your customers. This assurance is provided by your spark plug cleaner and tester if it is always in good condition and ready for operation.

b. **Important Pre-requisites for Proper Operation are.**

(1) **Clean Blasting at all Times.** If the tester is used frequently, it is advisable to replace the blasting sand every 1 or 2 weeks.



Fig, -9 Selector Valve

(2) **Sand Blast Nozzle in Perfect Condition.** The nozzle orifice diameter must not be more than 3mm because otherwise the blasting action will be degraded and the spark plugs will not be cleaned thoroughly.

(3) **Air blast Nozzle in Perfect Condition.** Replace badly worn air blast nozzles.

(4) **Dry Compressed Air and Dry Blasting Sand.** Use of a water separator is absolutely necessary. This water separator must also be emptied regularly.

(5) **Compressed Air Pressure at Least 4 Bars.** This pressure is required for good blast cleaning. If the supply pressure is higher than 8 bar, the throttle disc supplied with the accessories must be installed.

(6) **Seals in Perfect Condition.** The rubber seals in the inserts must be replaced when they have become pressed inward to a significant extent and no longer form a seal even when the spark plugs are screwed in very tightly. We recommend that in order to avoid damaging the rubber seal the spark plugs be tightened only by hand or with the single head engineer, wrench and then only slightly more until a condition of gas tightness is reached.

Visual Examination

9. Before making a test of a spark plug with the tester, we recommend that a visual examination be made suing the BOSCH illuminating magnifier. This magnifier has a magnifying power of 4 and illuminates the part of the spark plug so that you can easily recognize the characteristics features of the spark plug face. You can derive at least provisional conclusions concerning possible causes of spark plug malfunctions from the section entitled “spark plug faces at the back of this instruction

manual.

Fig -10 Visual Examination

Cleaning the Spark Plug

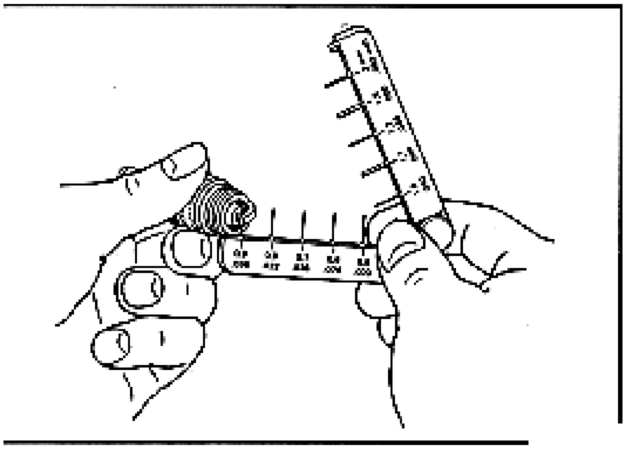
10. Spark plug cleaning procedure as follows:

a. **Preparations for Cleaning**. All spark plugs and particularly all special spark plugs, for example surface air gap spark plugs with or without a control electrode (WG.. MA,, WET..) surface air gap spark plugs with a control electrode, as well as spark plugs with a platinum or silver centre electrode (WB.. W. P. M. P X. P. U. P) can not be cleaned by blasting if, after an extended period of operation, they have deposit of non burnable materials material or show electrode erosion of more than 0.3mm. Such spark plugs must be regarded as being completely worn out. Stood or oil otherwise apparently still in good condition can be sand blasted. However they must first be thoroughly washed in a grease solvent gasoline or some other cleaning agent such as trichloroethylene). These spark plugs must then be permitted to dry with compressed air.

b. **Sand Blasting.** Rough dirt is removed from the scavenging area of the spark plug with the cleaning blade of the gauge. The spark plug must then be sand blasted to remove metals deposits from the insulator nose (danger of spark discharge). In order to sand blast the spark plug, insert it after they cover has been swung out of the way into the hole in the rubber seal ring. Set the selector knob to the ‘o’ position and sand blast the spark plug for 10 to 15 seconds, swinging and turning the plug as this is done. Then air blast the spark plug; to do this, set the selector knob to the position. This step is very important and must be carried out thoroughly. Before removing the spark plug, set the selector knob to the “O” position. If the insulator and the electrodes are still not clean, the sand and air blasting procedure can be repeated again. In the case of silver centre electrodes, blasting can cause pitting. For this reason, it is advisable to protect the centre electrode on this types of spark plugs by placing a piece of plastic tubing over it.

Adjusting the Electrode Gap

11. *Detailed instructions for each electrode gap specified are given in the BOSCH spark plug catalogue. In order to adjust the electrode gap, the gauge is used that is* ***supplied with the tester****.* The various measuring wires are designed to check the gap between the centre electrode and the ground electrode; the bending lever used for resetting the ground electrodes.



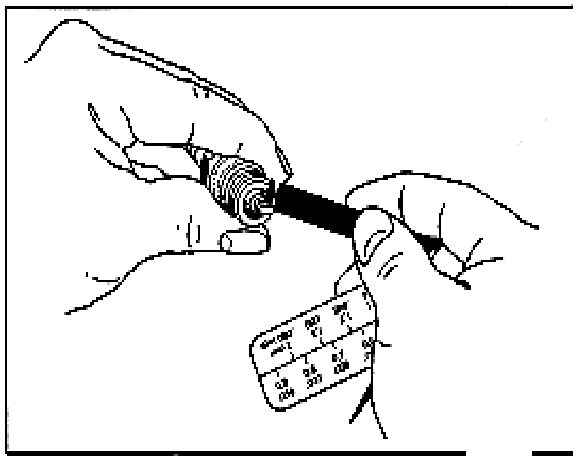


Fig -10 Central Electrode & Ground Electrode Gap Checking

***Fig -11, Bending lever used for Re-setting the Ground Electrodes*.**

<u>Changing the Spark Plugs Is Just as Important as On Oil Change</u>

12. Spark plugs, in common with every fast moving part, are subject to wear and tear, and they have a limited service life despite repeated cleaning and readjustment. Experience has shown that an engine benefits in terms or power and reduced operating costs if a new set of spark plugs is installed after about every 15,000 km of operation in two stroke engines, the spark plugs should be replaced after correspondingly shorter periods of operation.

<u>Spark Plug Faces</u>

13. The customer expects the specialist to be able to give him expert advice on his spark plug problems. The spark plug face can show quite clearly what is going on inside the combustion chamber. The following pages contain a series of illustrations with text of typical spark plug faces.

<u>Normal Condition</u>

14. Insulator nose grayish white or grayish-yellow brown. Engine is in order. Heat rating of the plug is correct.

.

<u>Stood Carbon Fouled</u>

15. Insulator nose, electrodes and spark plug shell covered with velvet like dill black soot deposits.

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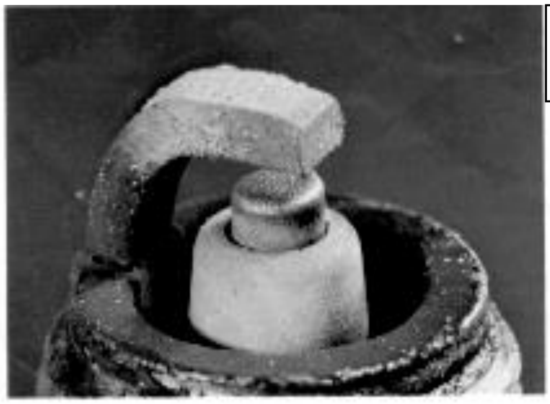

Fig -12, Spark plug face Scooted-Fig -13, Spark plug face Normal Condition

Carbon Fouled

a. **<u>Causes.</u>**

(1). Carburetor setting, mixture too rich

(2). Air filter element very dirty

(3). Automatic choke not in order

(4). Manual choke pulled too long

(5). Extreme stop and go city driving,

(6) Too many traffic light stops

(7) Spark plug heat rating possibly too high

b. **<u>Effect.</u>** Danger of shunts (cold shunt) particularly during cold start with fuel enrichment.

c. **<u>Remedies.</u>** Correct carburetor and automatic choke adjustments, clean air filter, accelerate engine slowly up to full load if this does not help, try using spark plugs with next lower heat rating.

❖ **<u>Please Note:</u>**

If engine runs too long at idle speed before spark plug removal, the spark plug face can also appear stood (especially) if the engine has not reached operating temperature.

Oil-Fouled

16. Insulator nose, electrodes and spark plug shell covered with wet, shiny oil carbon and soot deposits.

a. **Causes:**

(1) Too much oil in the combustion chamber

(2) In two stroke engine too much oil in mixture

(3) Badly worn cylinders, piston rings and valve guides

b. **Remedies**: Correct mixture ratio, overhaul engine, fit new spark plugs.

Heavy Lead Deposits

17. **Yellow glazed insulator deposits which can also be greenish in places:** In places, the insulator nose is glazed brownish yellow. The deposit is a solidly bonded with the insulator nose.

a. **Causes:** Fuel additives

b. **Effect.** The glaze indicates melting of deposits under heavy engine tress; the result is a shunt (warm shunt).

c. **Remedy,** Cleaning and sand blasting useless. The spark plug must be replaced.

Heavy Electrode Erosion

18. a. **Causes.** Natural wear and tear, recommended interval between spark plug changes not complied with.

b. **Effect.** Jerky behavior is due to misfiring (particularly during acceleration), since voltage required for ignition.

c. **Remedy.** Fit New spark plugs.

Centre Electrode Completely Melted Away, Insulator Nose Cracked

19. a. Cause. **Abnormal combustion processes, for example fuel knocking, precognition due to ignition being advanced too far. Expansion overheated centre electrode can result in the insulator cracking**

b. **<u>Effect.</u>** Misfiring, power loss, engine damage.

c. **<u>Remedy.</u>** Check engine particularly ignition system and mixture formation. Fit new spark plugs with the correct heat rating.

<u>Ash-from Oil and Fuel Additives</u>

20. Heavy ash deposits on the insulator nose, in the scavenging area and on the ground electrode. The structure of the ash is loss to cinder like.

a. **<u>Causes.</u>** Alloying constituents from oil and fuel leave an incombustible ash in the combustion chamber (piston head, valves, and cylinder head) and on the spark plug face.
b. **<u>Effect.</u>** Can lead it to pre-ignition with resultant of power loss and thus may caused engine damage.

c. **<u>Remedy.</u>** Repair engine. Fit new spark plugs.

BAF BASE ZAHURUL HAQUE (TRG WG)
(Aero Engg Trg Sqn)

Syllabus	**:**	**Automobile General Diesel and Petrol Technology**
Course	**:**	**Trade Training Advance, MTOF**
Subject	**:**	**Variable Valve Timing with Intelligence (VVTI)**
Aim	**:**	**To study Variable Valve Timing with Intelligence (VVTI)**
Ref	**:**	**Internet Wikipedia**

VARIABLE VALVE TIMING AND INTELLIGENCE (VVTI)

Definition:

1. VVT-I is a system that allows a hydraulically controlled cam sprocket to change position, which in turn alters an engine's valve timing. The engine's computer reads input from all of a vehicle's sensors in order to determine the valve timing that's required to meet current demands. The change can occur rapidly, which means it delivers optimum performance upon acceleration, but after cruising speed is reached it can change again to provide the best fuel economy. Dual VVT-I is used on vehicles equipped with separate intake and exhaust camshafts; setting for each can be altered independently by the computer.

Primary benefits of the system include:

a. Easier starting

b. Quicker, smoother acceleration

c. Better fuel economy

d. Lower emissions

VVTI engine in automobile, consumes less fuel than EFI engine:

2. a. EFI = Electronic Fuel Injection.
VVT = Variable Valve Timing.

b. It basically means that in addition to electronic control over fuel injection and spark timing, the engine also has control over the times the intake/exhaust valves open and close, which means the engine can automatically adjust itself so more power is available when you want it, but the rest of the time the engine can still be efficient.

How to drive a VVTI and other modern engine to save fuel:

3. Not all engines are designed the same. The more advanced the engine, the more power the engine can deliver while maintaining lower emission and lower fuel consumption. However some people did not understand what a modern car's engine can do. On this article, Toyota's VVT-i engine to represent modern engine, since VVT-i is the most commonly used valve timing technology. Most people just think that the word VVT-i is just a marketing gimmick, but by using VVT-i correctly, the driver could save up to 30% fuel compared to non VVT-i engine. However using VVT-i incorrectly could waste 30% of fuel compared to non VVT-i engine. So it is a double edged sword. By using VVT-i correctly, drivers of VVT-i engine can save some petrol.

a. When VVT-i engineis used correctly - a 2AZ-FE on ACV 36 Toyota Camry engine could deliver close to 14 km/L (32 MPG) that is the fuel consumption of 1.6 L non VVT-i engine.

b. Both Daihatsu Xenia and Suzuki Carry car has 1.0L engine, the Xenia is VVT-i enabled and driven swiftly at much higher speed compared to Suzuki Carry that is driven moderately.

c. Before continuing to drive car with VVT-i, it will need to give a short explanation on VVT-i. VVT-i is a sophisticated valve timing control mechanism developed by Toyota, other manufacturers has similar technologies such as Honda's VTEC, BMW's Vanos.

d. To Compare with conventional engine, VVT-i engine is capable to deliver more torque at lower RPM range and more horsepower at higher RPM while maintaining fuel efficiency and lower emission. However as other systems, VVT-i has disadvantages. Using VVT-i requires learning and experience so VVT-i will be able to minimize car's fuel consumption immediately.

e. First thing is need to study engine's characteristic. Usually VVT-i engine will change its timing between low engine speed and high engine speed at around 3000 RPM. The difference between low speed timing and high speed timing usually the car's acceleration goes faster at that RPM.

f. It is needed to check the lowest RPM to move car on straight and level road. Check it on each gear. Usually it will be near 2000 RPM. This is where VVT-i plays, it could deliver 90% of its torque from RPM as low as 2000.

g. It is needed to change driving habit. To drive quickly it will need to press the throttle quickly but then shift up just under the engine's timing change RPM. So, if engine's timing change RPM is at 3000, it will need to shift at 2950. Usually the engine and transmission is designed to work together so the RPM could drop to just above the lowest RPM to move the car comfortably (e.g. from 2950 to 1900).

h. This will preserve the car's swiftness and safe some fuel. Contrary to popular believe to press the throttle softly to higher RPM (3500 - 4000 RPM), Press the throttle quickly to low RPM. This comes from physics theory:

j. E=P*T or Energy = Power * Time or watt (horse power) * second

k. The higher the RPM the more horse power your engine deliver. The longer you stay at high RPM the more energy you waste.

l. The quicker pressure on the throttle the quicker it reaches desired RPM and this results in quicker it shift to the next gear. This will reduce the time required to reach the desired speed, so the 'T' variable will be small. Then by using lower RPM means lower average power output from the engine, therefore reducing the 'P' variable. With 'P' and 'T' small the 'E' will be small as well, while 'E' is the factor that directly related to fuel consumption.

m. Inefficiency of old carburetors engine tends to waste fuel when accelerating quickly, VVT-i with injection engine will only use the needed fuel, in milliliter precision.

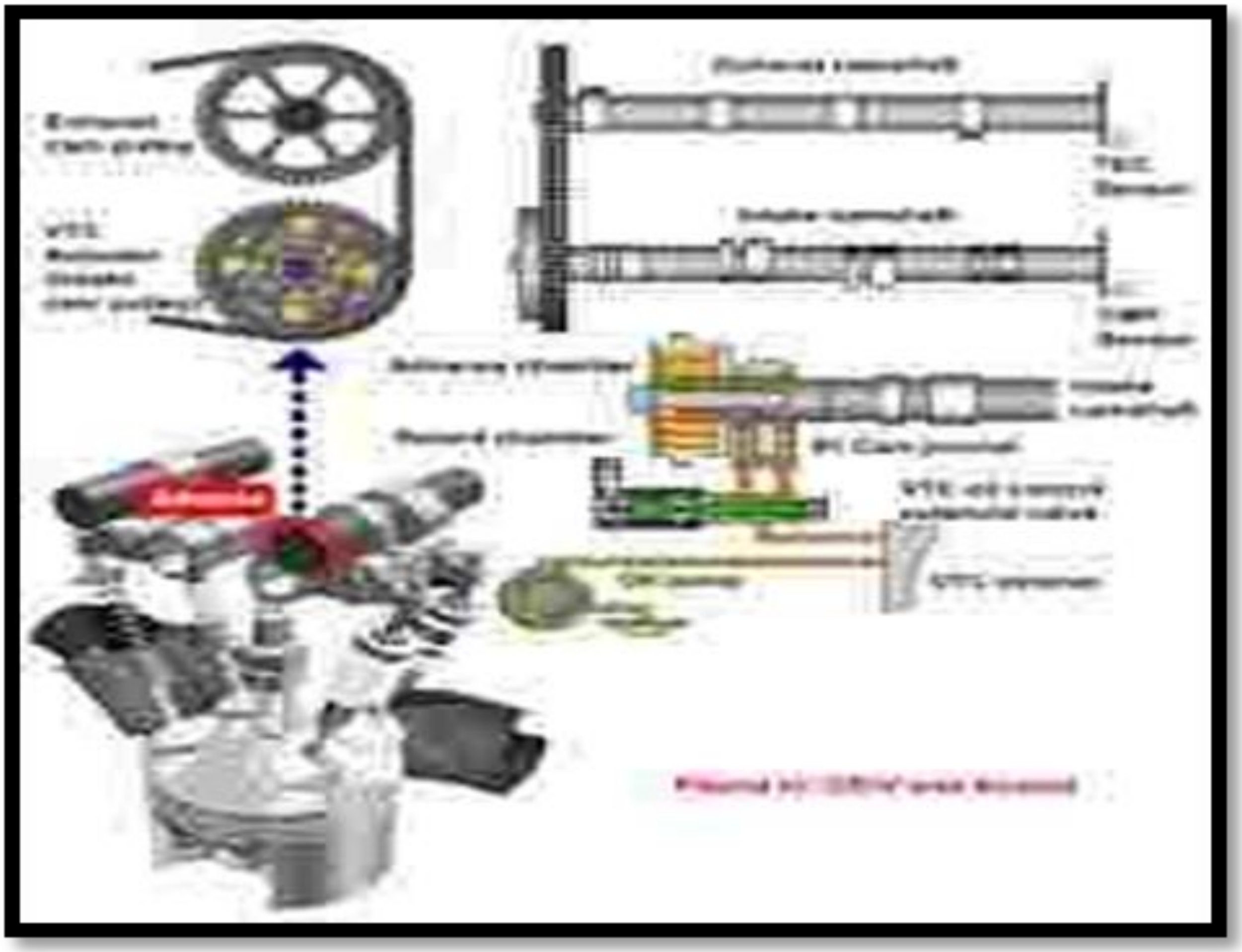

Fig-1: VVTI Engine components

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INDEX

AND

BREAK DOWN OF SUBJECTS WITH ALLOTTED PERIODS
TRADE TRAINING ADVANCE
MTOF (MTM PART)

MID PHASE, MTM PART- II

BAF BASE ZAHURUL HAQUE (TRG WG)
(Aero Engg Trg Sqn)

Syllabus	**:**	**Automobile General Diesel and Petrol Technology**
Course	**:**	**Trade Training Advance, MTOF**
Subject	**:**	**Electronic Ignition System**
Aim	**:**	**To Study Electronic Ignition system**
Ref	**:**	**Automotive mechanics by William H. Crouse**

ELCTRONIC IGNITION SYSTEM

Definition of Electronic Ignition System:

1. The electronic ignition system does not use contact points. Instead, it uses a magnetic pick-up device in the distributor and an electronic amplifying device with transistors. With the cap on, the distributor looks the same as the contact-point distributor. However, when the caps are removed, the difference between the two is apparent. There are various kinds of electronic ignition systems. We shall describe two of them: the Chrysler system and the General Motors system.

Chrysler Electronic Ignition System

2. An electronic ignition system has been used in all Chrysler Corporation cars made in the United States since 1973. In this system, the distributor has a metal rotor with a series of tips on it. This rotor, called the reluctor is shown in Fig.-1. The reluctor takes the place of the breaker cam in the contact-point distributor previously discussed. Notice that the reluctor in Fig. -1 has six tips, It is for a six-cylinder engine, so there is one for each cylinder. Notice also that the distributor has a permanent magnet and a pick-up coil. The principle of operation is simple. The reluctor provides a path for the magnetic lines of force from the magnet. Every time a tip of the reluctor passes the pick-up coil, it carries the magnetic field through the coil. This magnetic field produces a pulse of electric current in the coil. The current is very small, but is it enough to trigger the control unit into action. The control unit uses electronic devices-diodes and transistors-to control the flow of current to the ignition coil. When the pulse of current from the pickup coil arrives at the control unit, the control unit stops the flow of current to the ignition coil. This is the same job the contact points do in the other type of distributor. When the current stops flowing in the ignition coil, the magnetic field in the coil collapses. This causes the coil to produce a high-voltage surge. The high-voltage surge is led through the distributor rotor, cap, and wiring, to the spark plug that is ready to fire. The tip of the reluctor now rotates past the pick-up coil. The pulse of current from the pick-up coil ends. This allows the control unit to close the circuit from the battery to the ignition coil. Primary current flows again, and a magnetic field builds up once more in the

ignition coil. Then the next tip of the reluctor passes the pick-up coil, and the whole series of events is repeated. In this system there are no contact points to adjust or wear out. Everything is automatic. The only adjustment required is the ignition timing, which we shall discuss later.

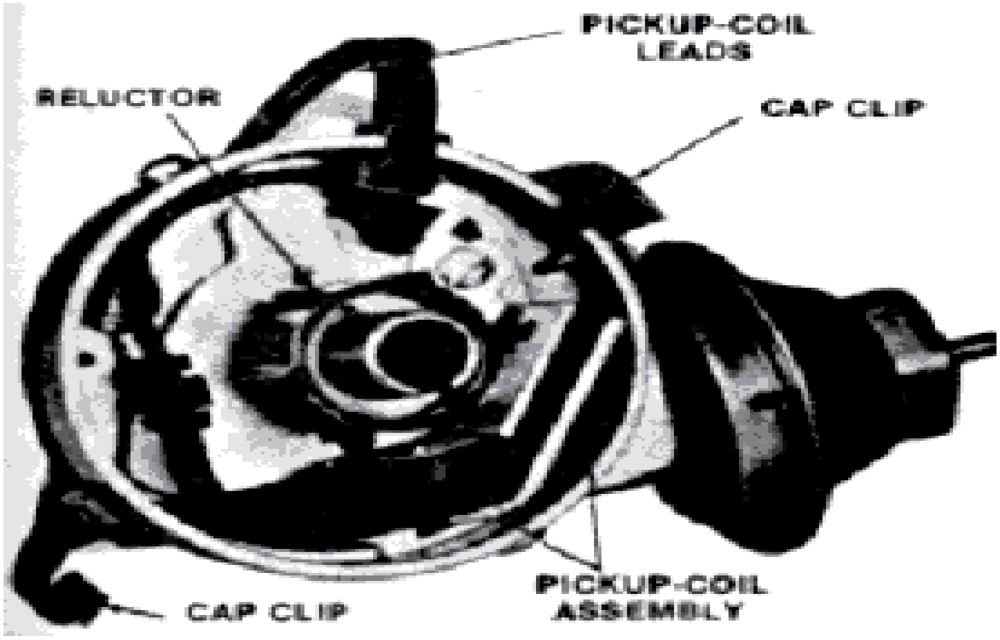


Fig-1: Top View of the Chrysler Electronic Ignition Distributor. The Cap And Rotor Have Been Removed To Show The Reluctor And The Pick-Up Coil.

Figure 2 shows the wiring for the Chrysler electronic ignition system. The dual ballast is a double-resistor unit that protects the system from overload. But it allows maximum current to flow during cranking. This assures a strong spark for good starting performance.

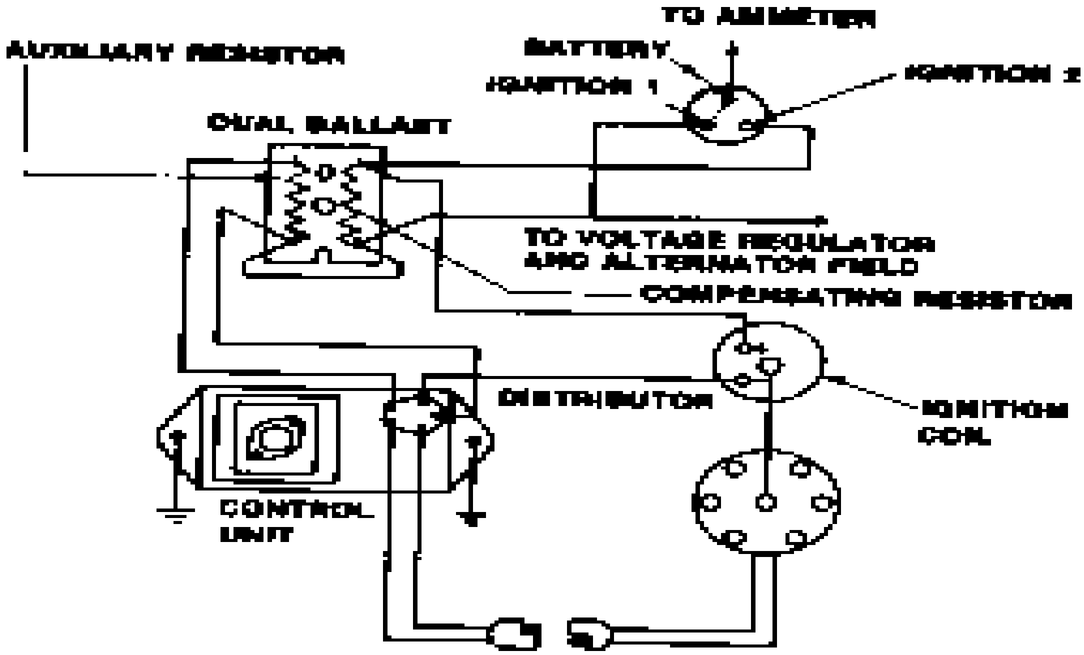


Fig-2: Schematic Wiring Diagram For The Chrysler Electronic Ignition System.(Chrysler Corporation)

<u>General Motors Electronic Ignition System</u>

3. General Motors calls the distributor used in their electronic ignition system a magnetic-pulse distributor Figure -3 shows the distributor. It looks much like the Chrysler unit, and it works in about the same way. They General Motors distributor has a pole piece in the form of a ring. The pole piece has a series of teeth, pointing inward. *Continue*

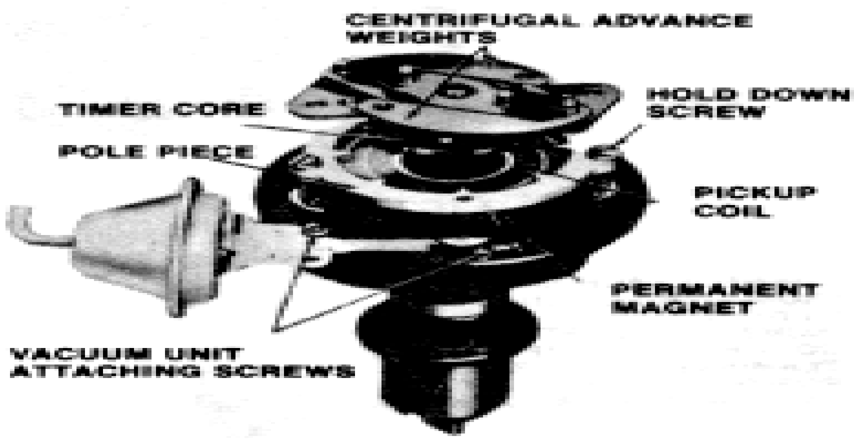


Fig-3: Magnetic Pick-Up Distributor With The Cap And Rotor Removed.(Delco - Remy Division Of General Motor Corporation)

There is one tooth for each cylinder in the engine. Under the pole piece is permanent magnet with a pick-un coil. The timer core, made of iron, is placed on top of the distributor shaft. It is placed exactly the same way as the cam in the contact-point distributor. The timer core also has one tooth for each cylinder in the engine. There is one tooth for each cylinder in the engine. Under the pole piece is permanent magnet with a pick-un coil. The timer core, made of iron, is placed on top of the distributor shaft. It is placed exactly the same way as the cam in the contact-point distributor. The timer core also has one tooth for each cylinder in the engine. When the engine is running, the teeth on the timer core align with the teeth on the pole piece. They align the same number of times per timer-core rotation as there are cylinders in the engine. Suppose we had an eight cylinder engine. Then there would be eight teeth on the pole piece and eight teeth on the timer core. The teeth would align eight times for every revolution of the timer core. Every time the teeth align, magnetic lines of force are carried through the pick-up coil. This produces a pulse of current that flows to the ignition-pulse amplifier (Fig. -4). There the pulse electronically opens the circuit ignition-coil primary. The magnetic field in the coil collapses, and a high-voltage surge is produced. This surge is carried by the high-tension leads, the distributor cap, and the rotor to the spark plug that is ready to fire.

Unit Distributor

4. In 1972, the Delco Remy Division of General Motors introduced an ignition distributor that has the ignition coil assembled into it. With this assembly, *Continue*

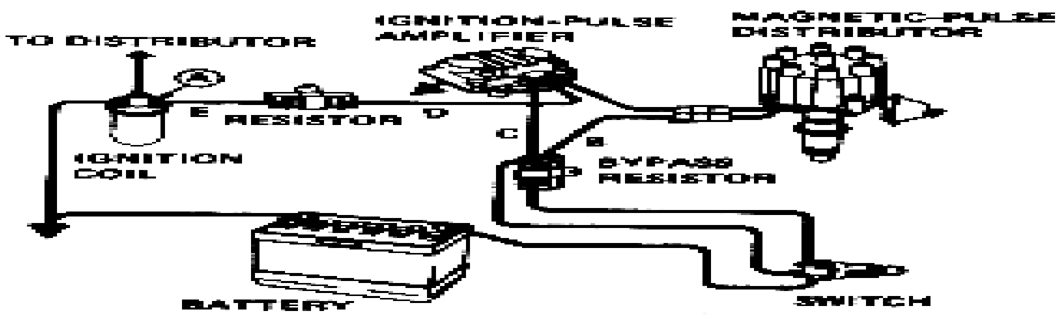


Fig-4: Wiring Diagram For An Ignition System Using A Magnetic-Pulse Distributor And A Transistor Control Unit To Amplify The Ignition Pulse.

The wiring is greatly simplified, as shown in Fig. -5. Note that there is one lead from the battery (which Delco-Remy calls an "energizer"). It goes through the ignition switch to the unit distributor. The only other leads are the high-tension cables going to the spark plugs.

Figure -6 shows the distributor assembled, and Fig. -6 shows the unit partly disassembled. The ignition coil looks different from the ignition coils on older cars. But it works the same way. All the connections between the coil and distributor are inside the unit distributor, so the wiring is much simpler. The distributor uses the magnetic-pulse principle. This is explained in 4 and illustrated in Fig -. 3 and -4. Figure, -6 shows what Delco-Remy calls the "High Energy Ignition System" unit distributor. It also has the ignition coil built in. This system produces a considerably higher secondary voltage.

Spark Plugs

5. The spark plug (Fig.-10) is a metal shell in which a porcelain insulator is fastened. An electrode extends through the center of the insulator. A second electrode is attached to one side of the shell. This electrode is bent in toward the center electrode. Threads on the metal shell allow it to be screwed into a tapped hole in the cylinder head. This grounds the electrode that is attached to the shell. The two electrodes are of special heavy wire. There is a gap of up to ignite the air-fuel mixture in the combustion chamber. The spark jumps from the center, or insulated, electrode to the grounded, or outer, electrode. Some spark plugs have a built-in resistor (Fig.-10) which is part of the center electrode. this resistor reduces radio and television interference from the ignition system. It also reduces electrode erosion caused by over-long sparking. We have been taking of the high-voltage surge from the ignition coil secondary as if it were a single powerful surge. Actually, the action is more complex than that. There may be a number of early surges before a full spark forms. At the end of the sparking cycle, the spark may die and re-form several times. All this takes place in only a few ten-thousandths of a second. The effect is that the ignition wiring acts like a radio transmitting antenna. The surges of high voltage send out static that causes radio and television interference. However, the resistors in the spark plugs tend to reduce the number of surges. They thus reduce the interference and the wear on the electrodes.

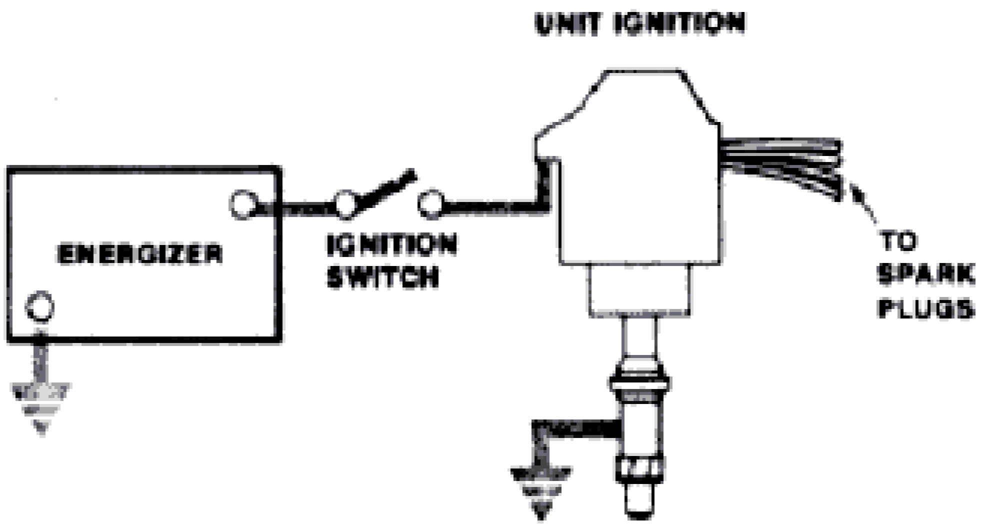


Fig- 5: Basic Wiring Diagram Of The Ignition System Using The Unit Distributor.(Delco Remy Division Of General Motor Corporation

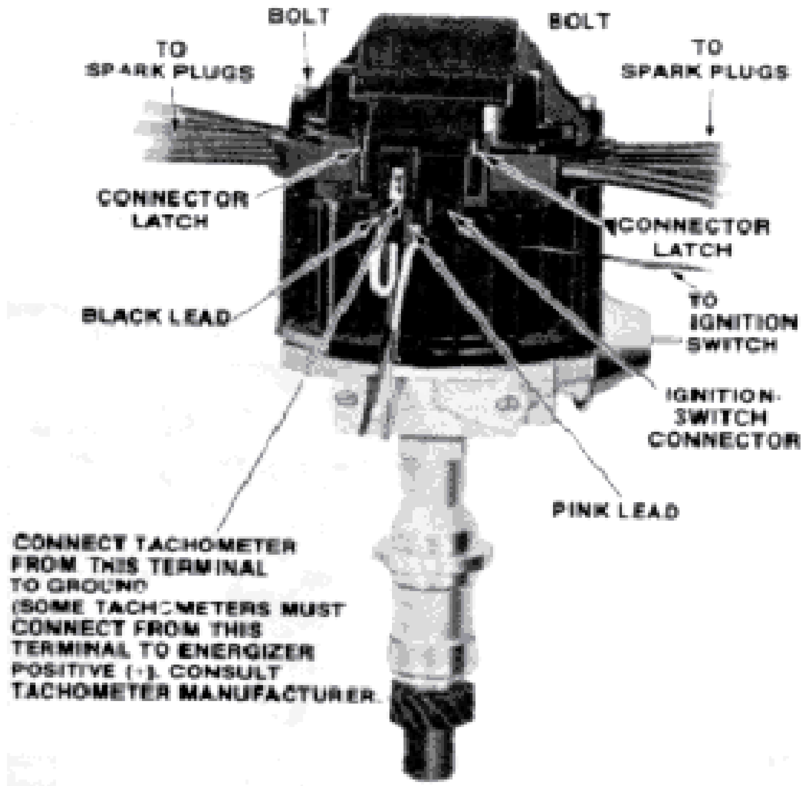


Fig-6: Basic Wiring Diagram Of The Ignition System Using The Distributor, And Diagram Of Unit Distributor, Which Includes The Ignition Coil.

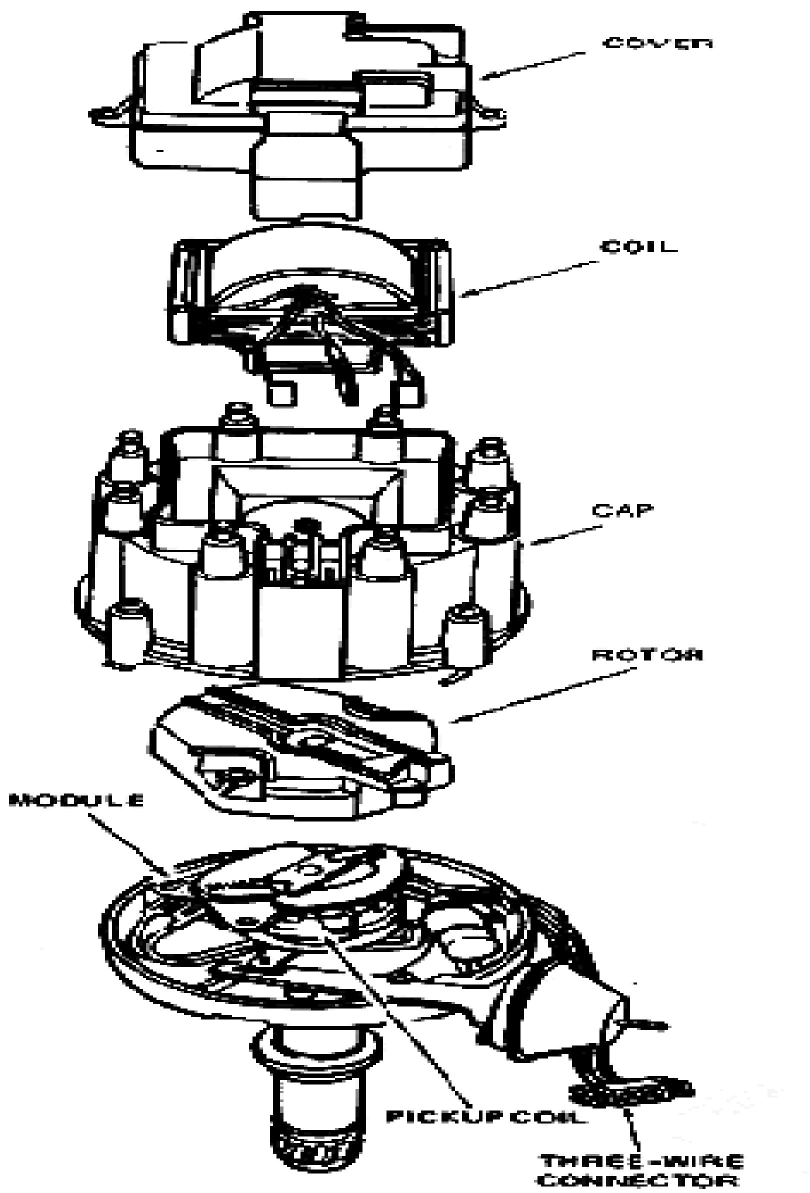


Fig-7: Unit Distributor, Partly Disassembled. (Delco-Remy Division of Genera Motors Corporation)

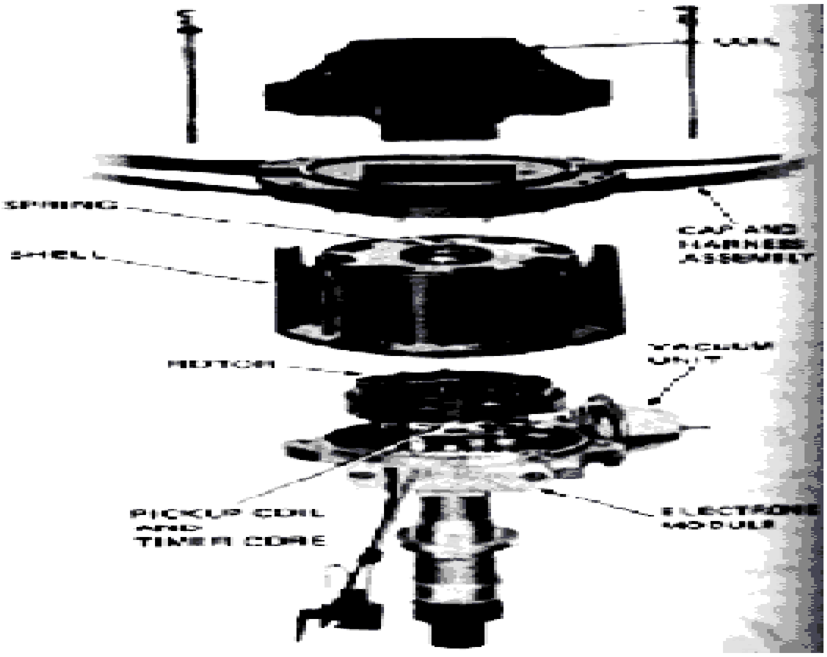


Fig-8: Distributor Of High-Energy Ignition System, Which Includes The Ignition Coil.

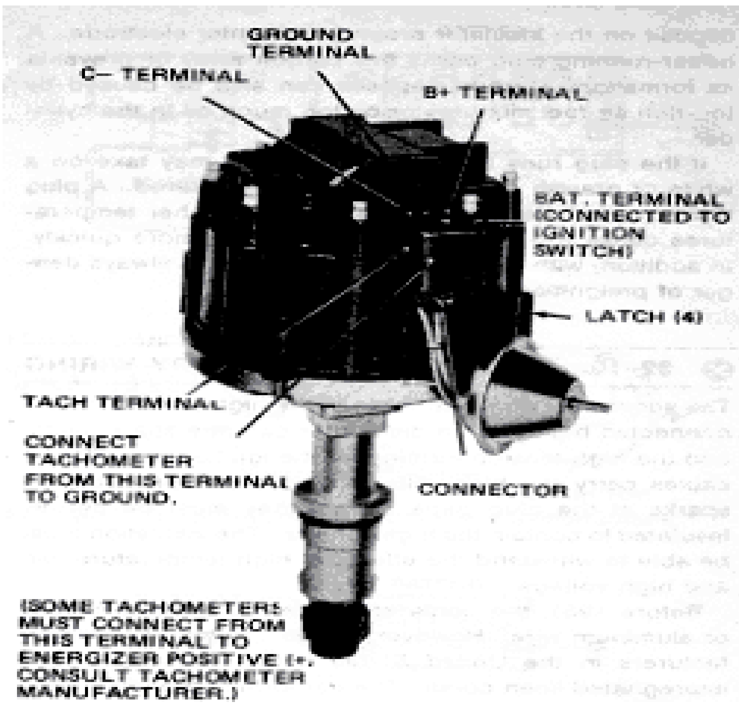


Fig-9: Partly Disassembled Distributor (Delco-Remy Division Of General Motors

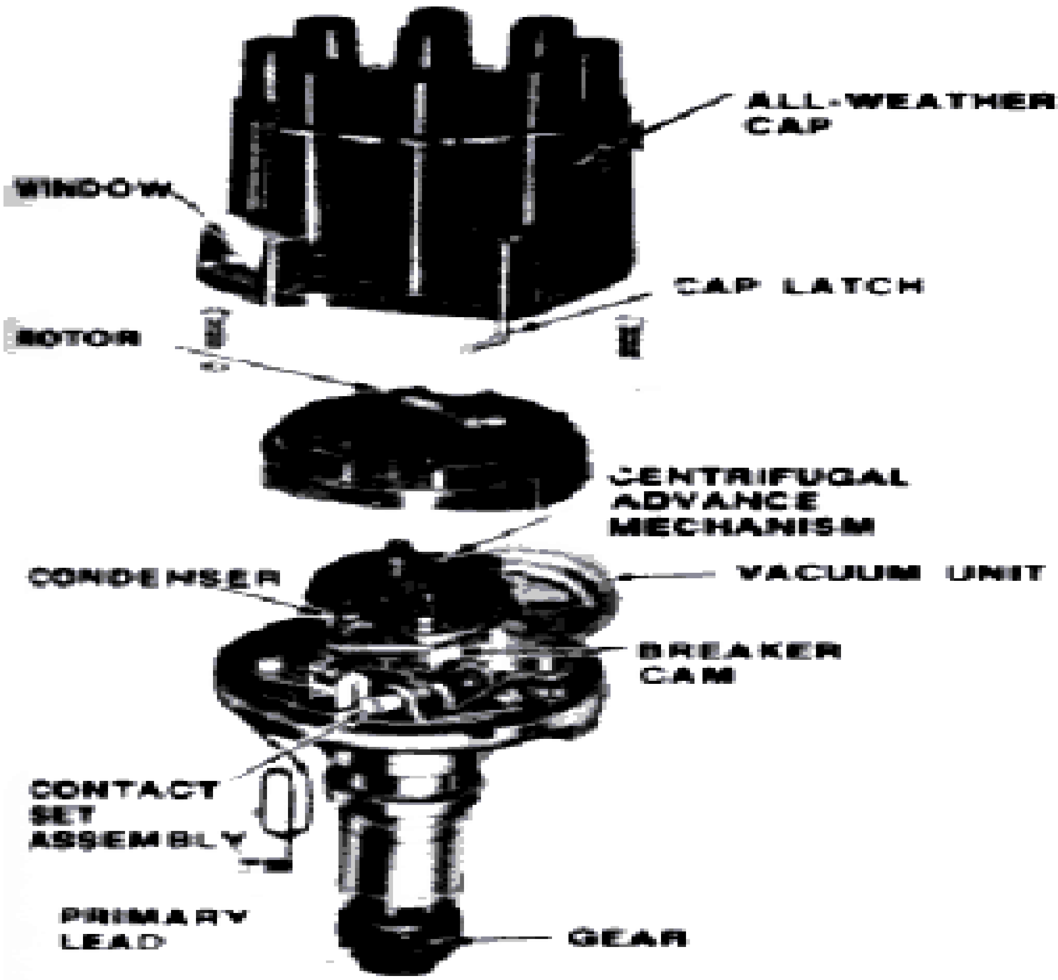


Fig-10: Cutaway View Of A Resistor-Type Spark Plug.(Ac Spark Plug Division Of General Motors Corporation)

Spark-Plug Heat Range

6. The heat range of a spark plug tells how hot the plug gets in operation (Fig.-11). The temperature that a plug reaches depends on how far the heat must travel. The heat path is from the center electrode to the cooler outer shell of the plug and then to the cylinder head. If the path is long, the plug will run hotter than if the path is short. When a plug runs too cold, sooty carbon will deposit on the insulator around the center electrode. A hotter-running plug burns this carbon away or prevents its formation. Carbon deposits can also be caused by too-rich air-fuel mixtures or by too much oil in the cylinder. *Continue*

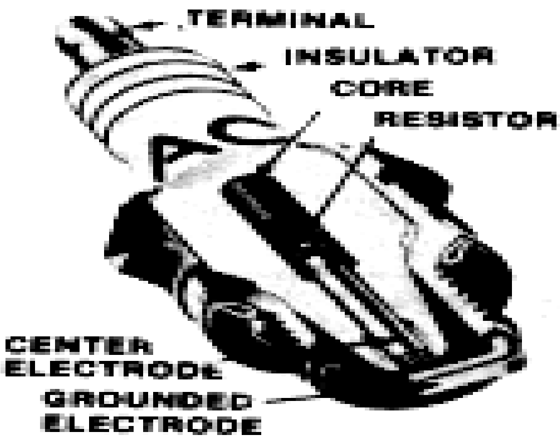


Fig -11: Heat Range Of Spark Plugs. The Longer The Heat Path (Indicated By Arrows), The Hotter The Plug Runs.

If the plug runs too hot, the insulator may take on a white or grayish cast and may appear blistered. A pug that runs hot wears more rapidly. The higher temperatures cause the electrodes to burn away more quickly. In addition, with a hot-running plug, there is always danger of pre-ignition.

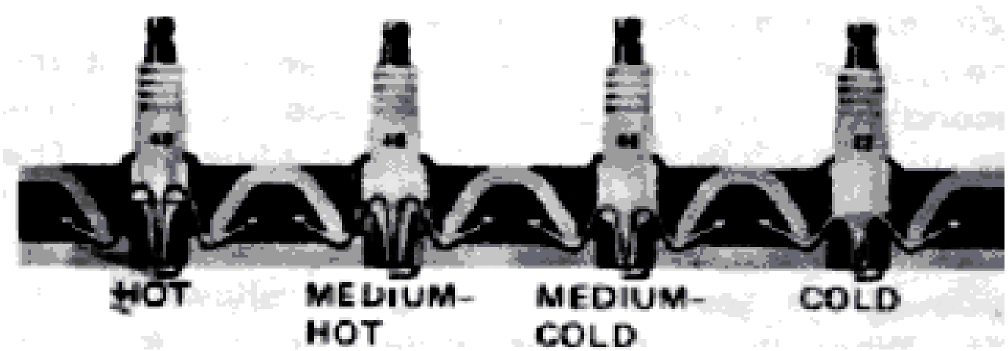


Fig -12: Heat Range Of Spark Plugs. The Longer The Heat Path (Indicated By Arrows), The Hotter The Plug Runs.

<u>Secondary Wiring</u>

7. The secondary wiring consists of the high-tension cables connected between the distributor cap, the spark plugs, and the high-tension terminal of the ignition coil. These cables carry the high-voltage surges that produce the sparks at the plug gaps. Thus, they must be heavily insulated to contain the high voltage. The insulation must be able to withstand the effects of high temperature, oil, and high voltage. Before 1961, the cores of the cables were of copper or aluminium wire. However, in 1961, automotive manufactures in the United States began to use carbon linen cores. The carbon-impregnated linen forms a

resistance path for the high-voltage surges. It produces the same effect as the resistors in the spark plugs mentioned above. These cables thus prevent the ignition system from interfering with radio and television. In 1963, manufacturers began using cables with graphite-saturated fiber-glass cores. These worked like the carbon-impregnated linen-core cables. However, it is claimed that they resist breakage when pulled off spark plugs. Also, they have fewer tendencies to char from high temperatures.

Ignition Coil

8. The ignition coil transforms, or steps up, the 6 or 12 volts of the battery to the high voltage required to make the current jump the spark -plug gap. The air-fuel mixture between the two electrodes presents a high resistance to the passage of current. The voltage (pressure) must be very high in order to push current (electrons) from the center to the outside electrode. The ignition coil has two circuits, a primary circuit and a secondary circuit (Fig.-13) the secondary circuit is made up of many thousands of turns of a fine wire. The primary circuit is made up of a few hundred turns of heavier wire. The wire is wrapped or wound around the outside of the secondary winding, as shown in Fig -12. When the distributor contact points close and current flows in the primary circuit, a magnetic field builds up. When the distributor contact points open and current stops flowing, the magnetic field collapses. The collapsing magnetic field induces high voltage in the secondary winding. This creates the high-voltage surge that is conducted thorough the distributor rotor and cap to a spark plug.

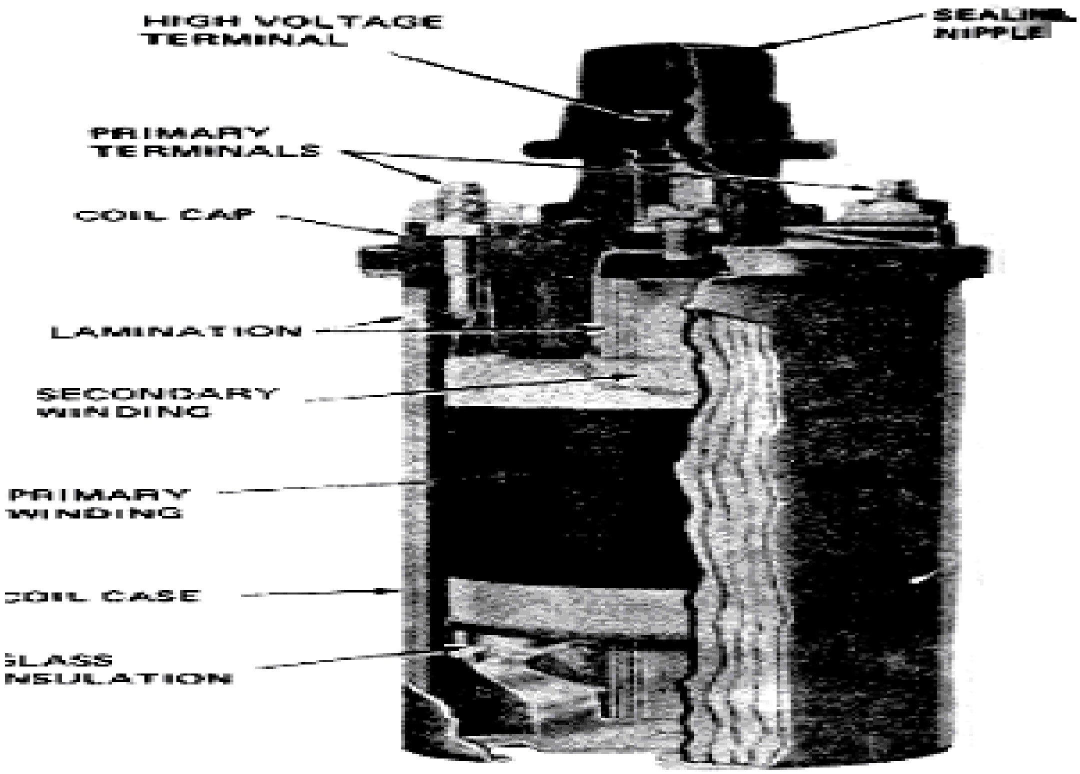


Fig -13: Ignition Coil. The Case Is Cutaway To Show How The Primary Winding Is Wound Around The Outside Of The Secondary Winding.

<u>Primary and Secondary Circuits</u>

9. In order to get a clearer picture of the two circuits in the ignition system, let us look at each one separately. Figure 15 shows the primary circuit. It consists of the battery, the contact points in the distributor, the primary winding in the ignition coil, the ignition switch, and the wiring. Figure -15 is the same illustration with the secondary circuit added. The secondary circuit includes the secondary winding in the ignition coil, the distributor cap and rotor, the spark plugs, and the connecting wires.

<u>Distributor-cap and Rotor Action</u>

10. As you can see from Figs.-17 and -18, the rotor sits on top of the cam in the distributor. Figure -19 shows several rotors. The purpose of the rotor is to connect the center terminal of the distributor cap to the outside terminals of the cap. The terminals are insulated from one another and are held in place in the cap. You can see three of them cut away in Fig. -20. The center terminal of the cap has a carbon button on its lower end. This button rests on one end of the rotor blade. A small spring holds the carbon button and rotor blade in continuous contact.

Continue

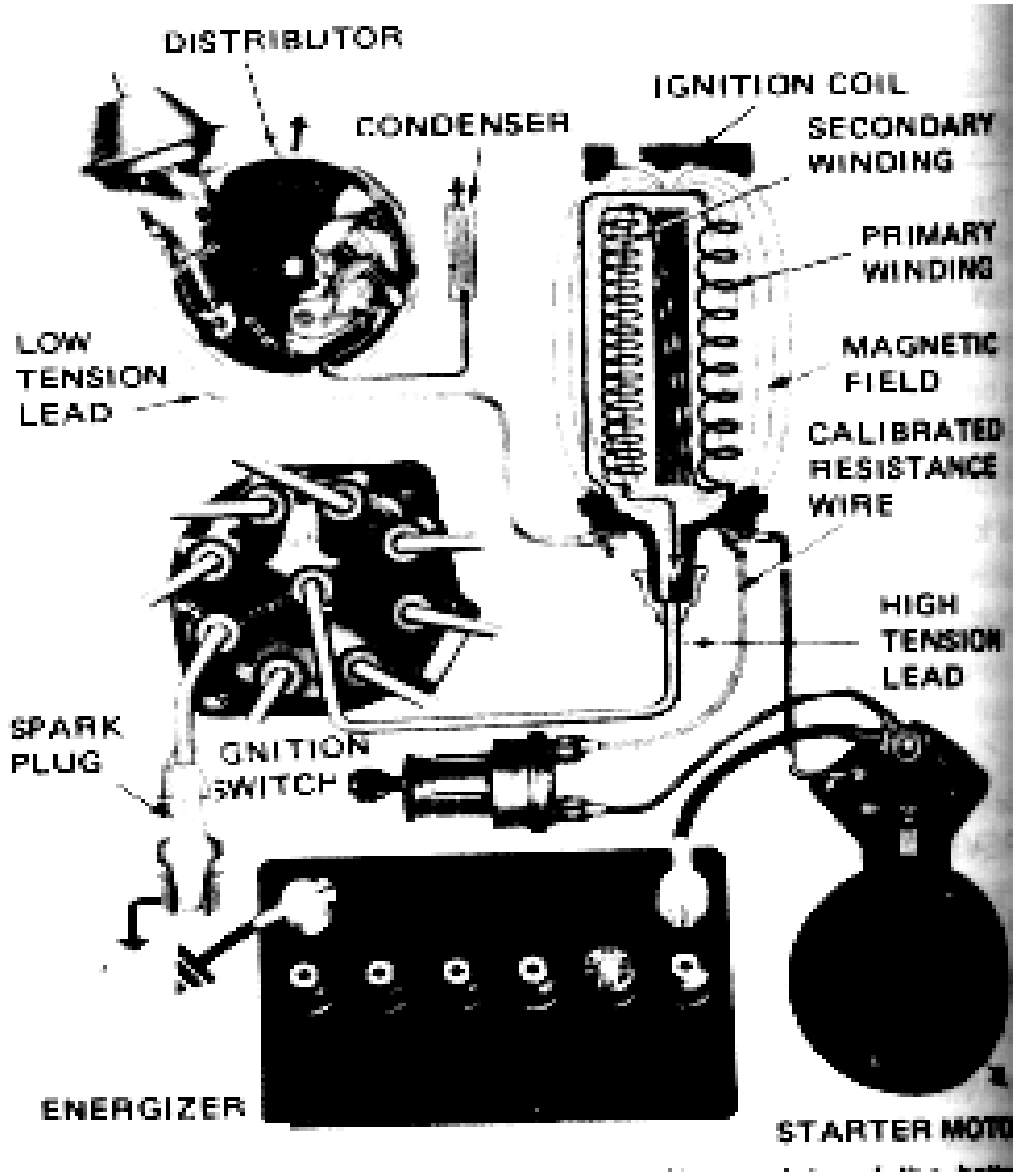


Fig -14, Typical Ignition System

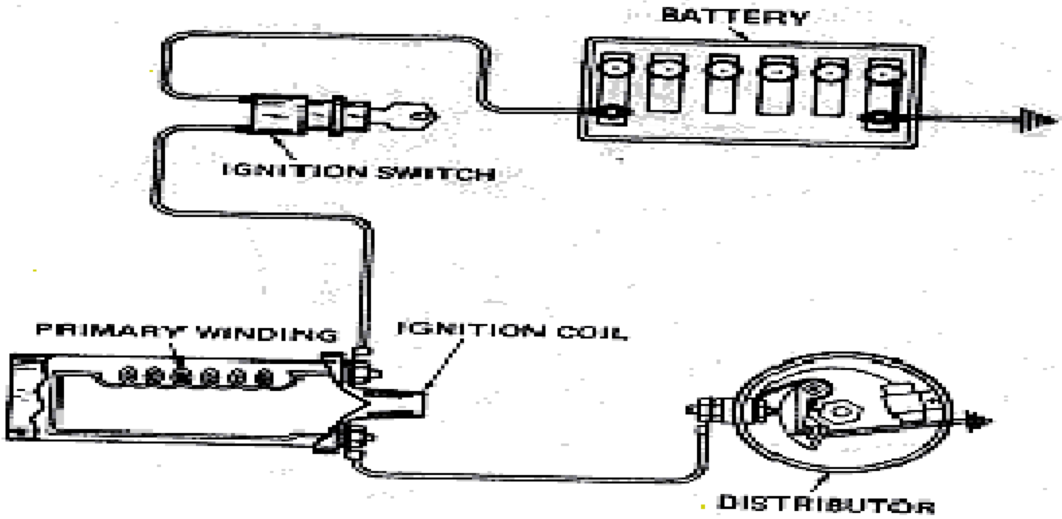


Fig-15: Simplified Primary Circuit Of The Ignition System.

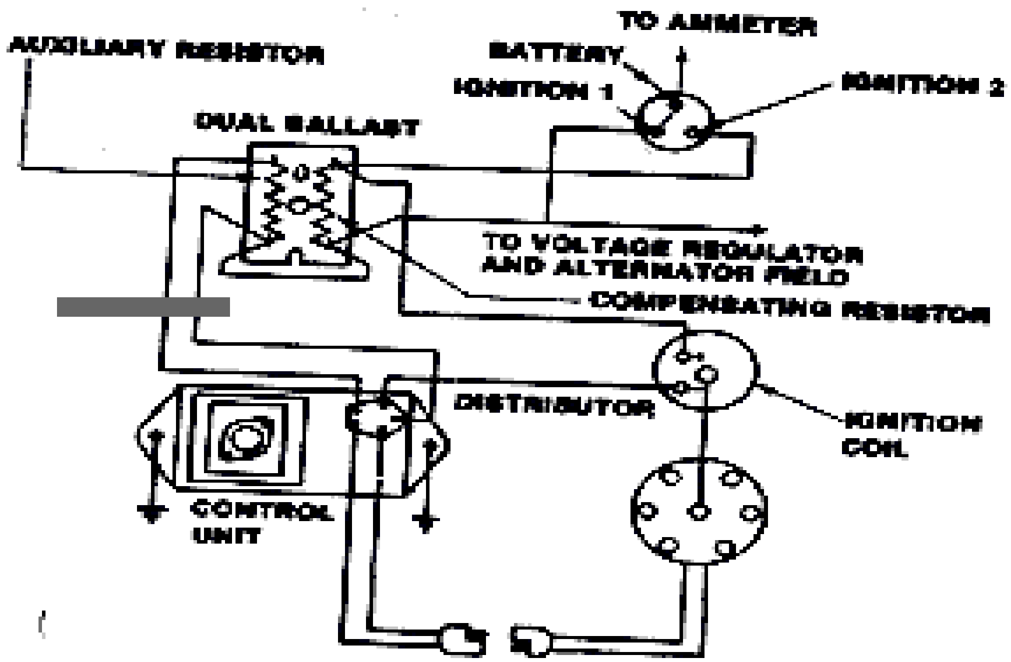


Fig-16: Secondary Circuits Added To The Primary Circuit Of The Ignition System. Only One Spark Plug Is Shown.

Therefore, the rotor blade is always connected to the secondary winding of the ignition coil. Whenever the coil secondary winding produces a high-voltage surge, the rotor blade turns. It then is pointing at the side terminal which is connected to the spark plug that is ready to fire (Fig. -16).

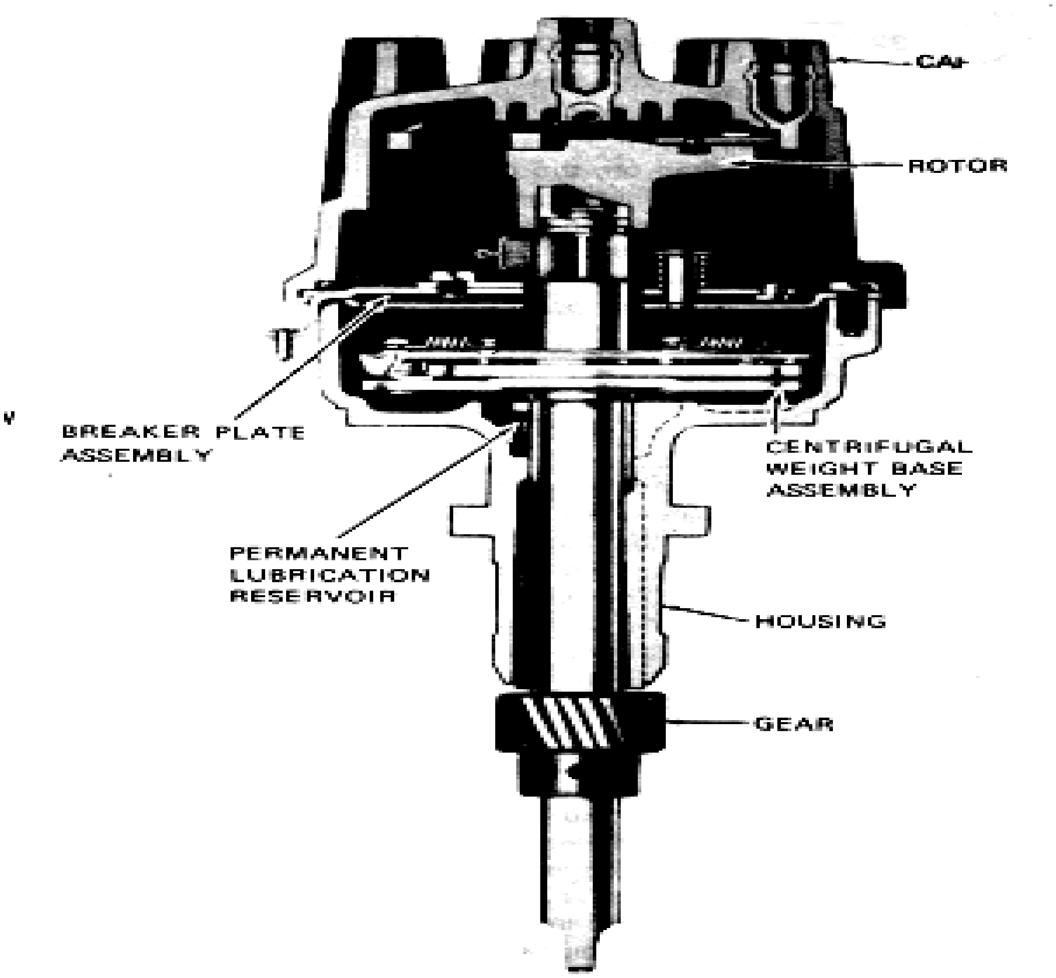


Fig-17: Sectional View of an Ignition Distributor

Let's review the actions: The contact points open. The magnetic field created current flowing in the coil primary winding collapses. This collapse produces a high-voltage surge in the coil secondary winding. The high-voltage surge is led from the center terminal of the ignition coil to the center terminal of the distributor cap. From there it goes through the rotor blade and to one side terminal. The side terminal is connected to the spark plug in the cylinder in which the compression stroke is ending. The spark produced at the spark plug by the high-voltage surge ignites the compressed air-fuel mixture. It burns, and the power stroke follows. Now, let us review in more detail how the magnetic field is produced, what happens when it collapses, and how the condenser enters into the action.

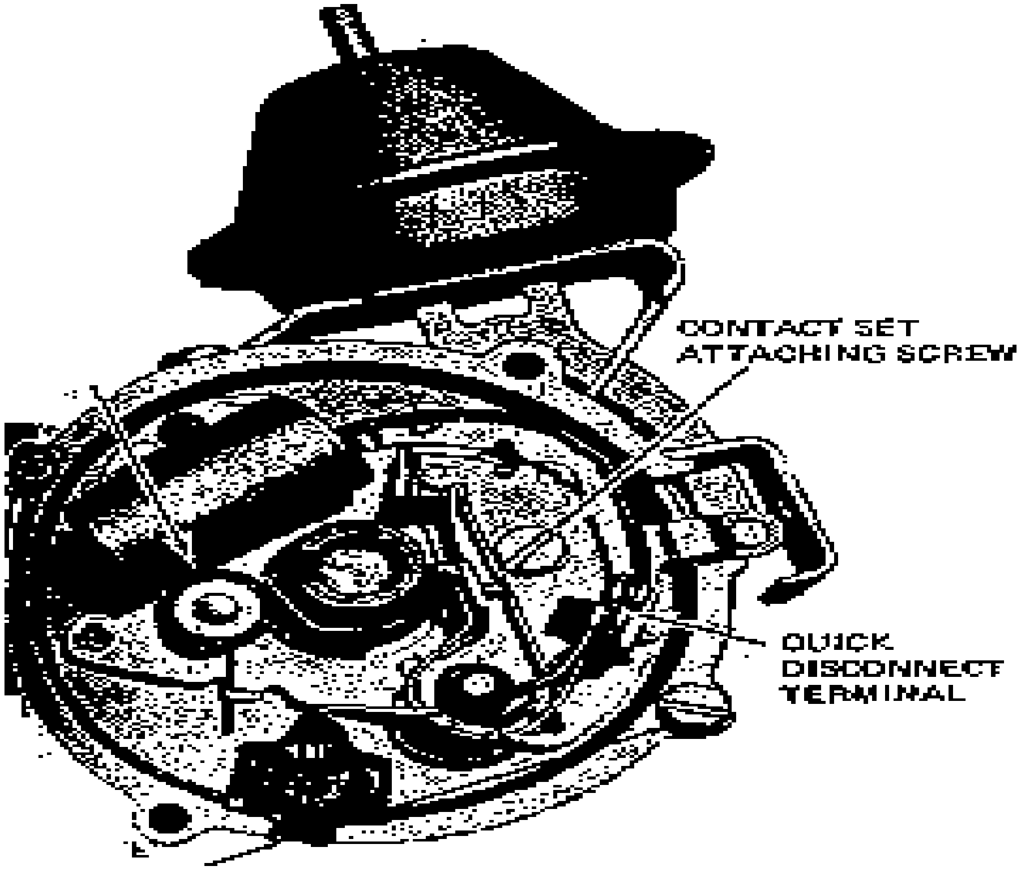


Fig-18: Top View of an Ignition Distributor

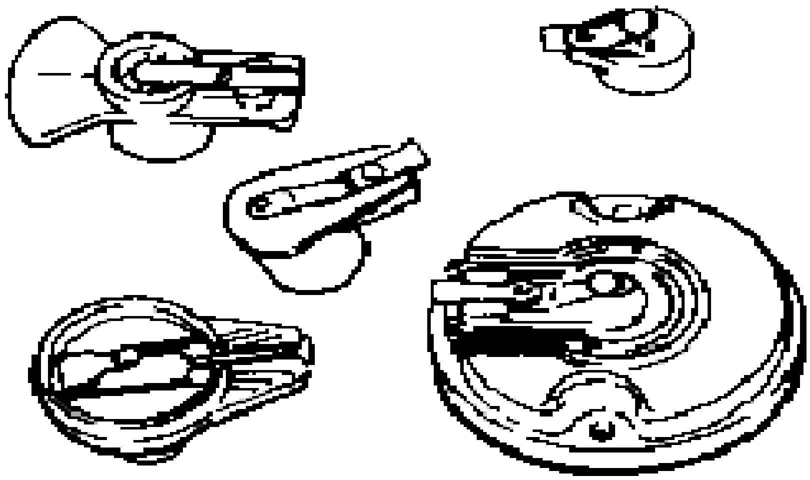


Fig-19: Types of Distributor Rotors. The One At The Lower Left Has Carbon Resistor. The One At Lower Right Is Attached To The Advance Mechanism By Screws.

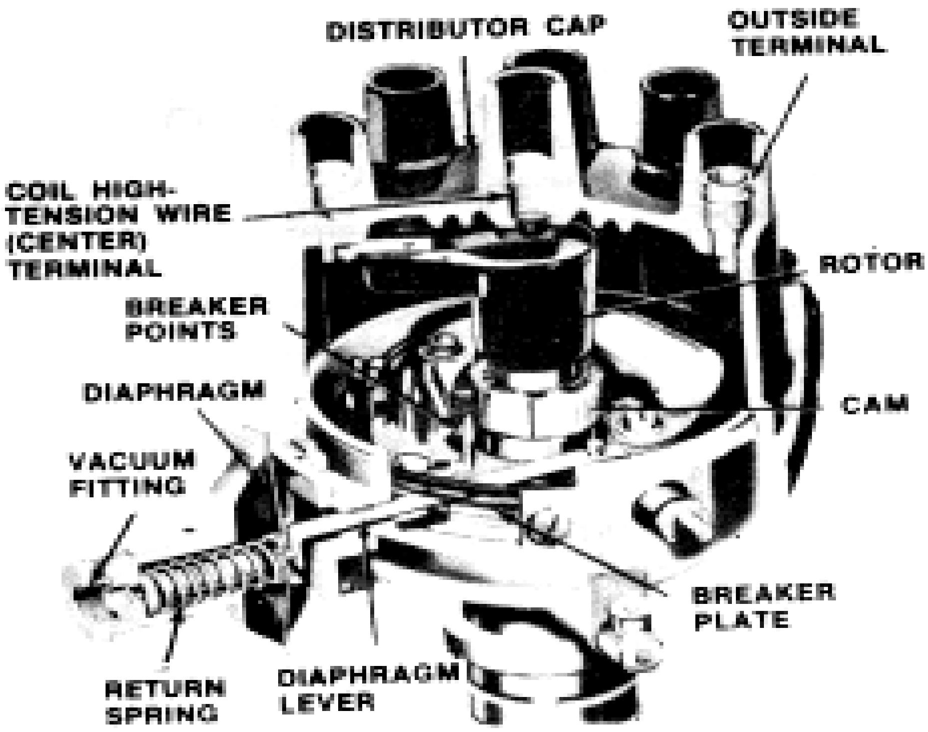


Fig-20: Cutaway View Of distributor, Showing How The Rotor Is Mounted On Top Of The Cam.. This Picture Also Shows The Construction Of The Vacuum Advance Mechanism.

Producing the Magnetic Field

11. Current flowing through a winding causes a magnetic field. The magnetic field does not, however, spring up instantly when the circuit is closed to the battery. It takes a small fraction of a second (called the buildup time) for this to occur. The reason for this lies in the fact that the winding has self-induction.

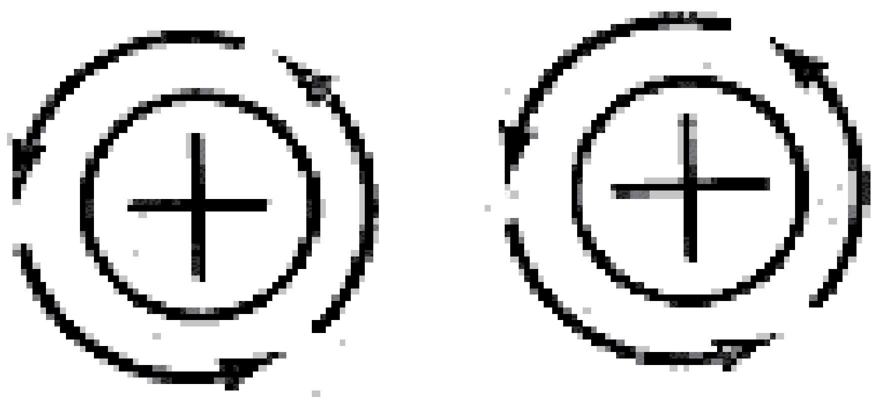


Fig-21: Magnetic Fields Surrounding Two Neighboring Turns Of Wire, In A Winding Through Which Current Is Passing.

This term expresses the effect of each turn of wire in the winding on nearby turns. Figure. 1-21 illustrates the magnetic fields surrounding two neighboring turns of wire in the winding. They are seen in end view, as current is flowing away from the reader, as indicated by the crosses. When the current first starts to flow, the encircling magnetic fields begin to move outward from the wires. This is somewhat like the ripples on a pool of water moving out from where a stone has been dropped. Figure -22 states the effect of this action on the right-hand wire. The increasing magnetic field cuts across the right-hand wire. It thus attempts to induce, in that wire, a flow of current in the opposite direction. This is indicated by the which means the current is flowing toward the reader. To understand how current can be induced in the wire, consider the alternator. The alternator rotates a magnetic field through the stator, which has stationary conductors. The movement of the magnetic field produces a flow of current in the conductors. In the ignition coil, there is movement of the current and movement of the magnetic filed. The moving magnetic field induces current in the stationary conductors. This is the effect illustrated in Fig.-.22 the turns of wire are stationary. But the expanding magnetic field from the left-hand conductor cuts across the right-hand conductor and induces current flow in the opposite direction. This is shown by the dot in the right-hand wire. Actually, the current cannot flow in this direction in the right-hand wire. The battery is already forcing current through the winding and every turn of wire in the opposite direction, as shown in fig.1-21. But there is a tendency for current to be induced in the reverse direction in every turn of wire. The result is that this tendency combats any increase in current flow through the winding. It takes a fraction of a second for the battery voltage to overcome this tendency and build up the magnetic field in the winding.

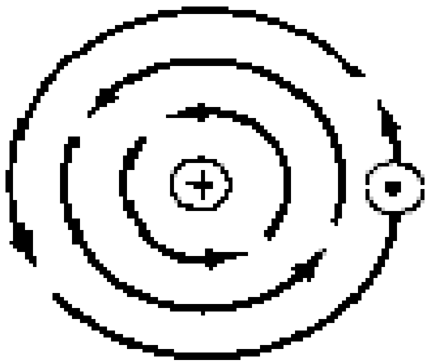


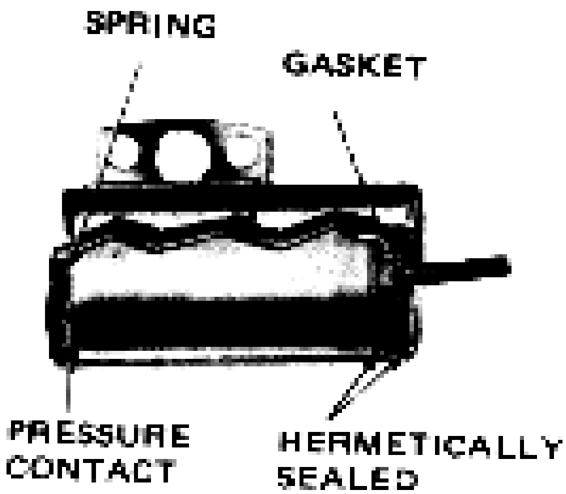
Fig-22: Effect on Neighboring Wire of An Increasing Magnetic Field From One Wire

<u>Effect on Primary Winding of Collapsing Magnetic Field</u>

12. When the distributor contact points open, the current stops flowing. The magnetic field from the primary winding begins to collapse. This means that the magnetic field surrounding each turn of wire begins to collapse back toward the wire. Thus, instead of the field moving to the right, as in fig.-22, the field moves to the left. This induces a flow of current in the right-hand wire in a direction opposite to that shown, that is, in the direction in which it flowed when the winding was connected to the battery. Such action, again, is self-induction.

Condenser Effect

13. As the distributor contact points open, the current from the battery through the primary winding of the coil is stopped. Instantly, the magnetic field begins to collapse. This collapse tends to reestablish the flow of current. If it were not for the condenser (also called a capacitor), the flow of current would be reestablished. This means a heavy electric arc would take place across the separating contact points. The points would burn, and the energy stored in the ignition coil as magnetism would be consumed by the area. The condenser prevents this, however. It provides a place for the current to flow as the points begin to move apart. The condenser (or capacitor) is made up of two thin metallic plates separated by an insulator. The plates are two long, narrow strips of lead or aluminum foil. They are insulated from each other by special condenser paper and wrapped to form a winding. The winding is then installed in a container. A condenser is shown in Fig. -23. The two plates provide a large surface area onto which the electrons (flow of current) can move at the instant the contact points separate. Remember, it is the massing of electrons in one place in a circuit that causes them to move and produce a current. The condenser provides a large surface area. Thus, many electrons can flow into it without producing an excessive massing of electrons in one spot.



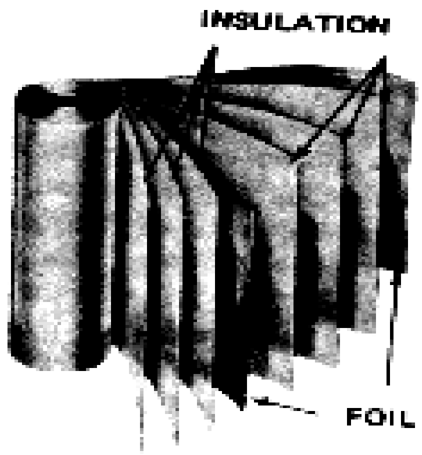


Fig-23: Condenser Assembled and With the Winding Partly Unwound

The number of electrons the condenser can accept is, however, limited. It quickly becomes charged. But, by this time, the contact points are sufficiently far apart to prevent an arc from forming between them. In effect, the condenser acts as a reservoir into which electrons flow at the instant the points begin to separate. By the time the reservoir is filled, the points are too far apart for the electrons to jump across them. The electrons or current must stop flowing in the primary circuit. *Continue*

It is a current flow that induces the magnetic field. Thus, the quick stoppage of the current causes the magnetic field to collapse rapidly. It is this rapid collapse that induces the high voltage in the secondary winding of the ignition coil.

Effect on Secondary Winding of Magnetic-Field Collapse

14. The rapid collapse of the magnetic field causes the magnetic lines of force to move rapidly across the thousands of turns of wire in the secondary winding. This means that each turn has a voltage induced in it. All turns are connected in series, so that the total voltage induced is the sum of the voltages in all the turn. Thus, the winding will supply a high voltage during the magnetic-field collapse. One end of the secondary winding is connected through ground (by way of the cylinder block and head) to the side electrode in the spark plug. The other end of the secondary winding is connected through the cap and the rotor of the distributor, and through the wiring to the center electrode in the spark plug. This high voltage, suddenly imposed on the spark plug, cause electrons (current) to jump across the gap, producing an electric spark. The spark is timed by the spark-advance mechanisms located in the distributor.

NOTE : *The ignition coil voltage output varies with different operating conditions. The coil produces only enough voltage to jump the spark-plug gap. The different plugs in an engine will have different voltage requirements because of differences in their gaps. Also, air-fuel mixture richness, and the amount of mixture compressed each compression stroke, will vary. These variations result from changes in throttle opening and engine speed. Thus, the coil voltage must change to meet these different conditions.*

Summary of Actions

15. Let us review briefly the action taking place in the ignition system. The piston in one of the engine cylinders starts up on the compression stroke. At the same time, one of the distributor breaker-cam lobes moves away from the contact-point breaker arm. The contact points close. Current flows through the primary winding of the ignition coil, and a magnetic field builds up. Then, the piston reaches the position in the cylinder at which ignition of the compressed air-fuel mixture should take place. At this instant the next cam lobe has moved around to where it strikes against the contact-point breaker arm, so that the contact points separate. The current stops flowing in the primary circuit and the magnetic field collapses. This induces high voltage in the secondary winding. the rotor on top of the breaker cam, in the meantime, has moved into position. It is now opposite the outside distributor-cap terminal connected to the cylinder spark plug. The spark plugs thus connected to the secondary winding of the ignition coil through the cap and rotor tat the instant that the high voltage is induced. A spark therefore occurs at the spark-plug gap.

Ignition-Coil Resistor

16. In many passenger cars with 12-volt systems, there is a resistance wire in the ignition-coil primary circuit. This wire is shorted out by the ignition switch when it is turned to START. Now¸ full battery voltage is imposed on the ignition coil for good performance during cranking. After the engine is started and the ignition switch is turned to ON, the resistance is in the ignition primary circuit. It thus protects the contact points from excessive current.

Spark-Advance Mechanisms

17. There are two general types of spark-advance mechanisms, centrifugal and vacuum. These mechanisms vary the spark timing for different engine-operating conditions.

Centrifugal Advance

18. When the engine is idling, the spark is timed to occur just before the piston reaches to dead center on the compression stroke. At higher speeds, it is necessary to deliver the spark to the combustion chamber somewhat earlier. This gives the mixture time to burn and deliver its power to the piston. To provide this advance, a centrifugal advance mechanism is used (Fig.-24). It consists of two weights that are thrown out against spring tension as engine speed increases. This movement is transmitted through a toggle arrangement to the breaker cam (or to the timer core of reluctor of magnetic-pick-up distributors). This causes the cam (or timer core or reluctor) to advance, or move ahead, with respect to the distributor drive shaft. On the contact-point distributor, this advance causes the cam to open and close the contact points earlier in the compression stroke at high speeds. On the magnetic-pick-up distributor, the timer core is advanced so that the pick-up coil advances the timing of its signals to the transistor control unit. Since the rotor, too, is advanced, it comes into position earlier in the cycle. The timing of the spark to the cylinder thus varies from no advance at low speed to full advance at high speed (when the weights have reached the outer limits of their travel). Maximum advance may be as much as 45 degrees of crankshaft rotation before the piston reaches top dead center. It varies with different makes of engines. The toggle arrangement and springs are designed to give the correct advance for maximum engine performance.

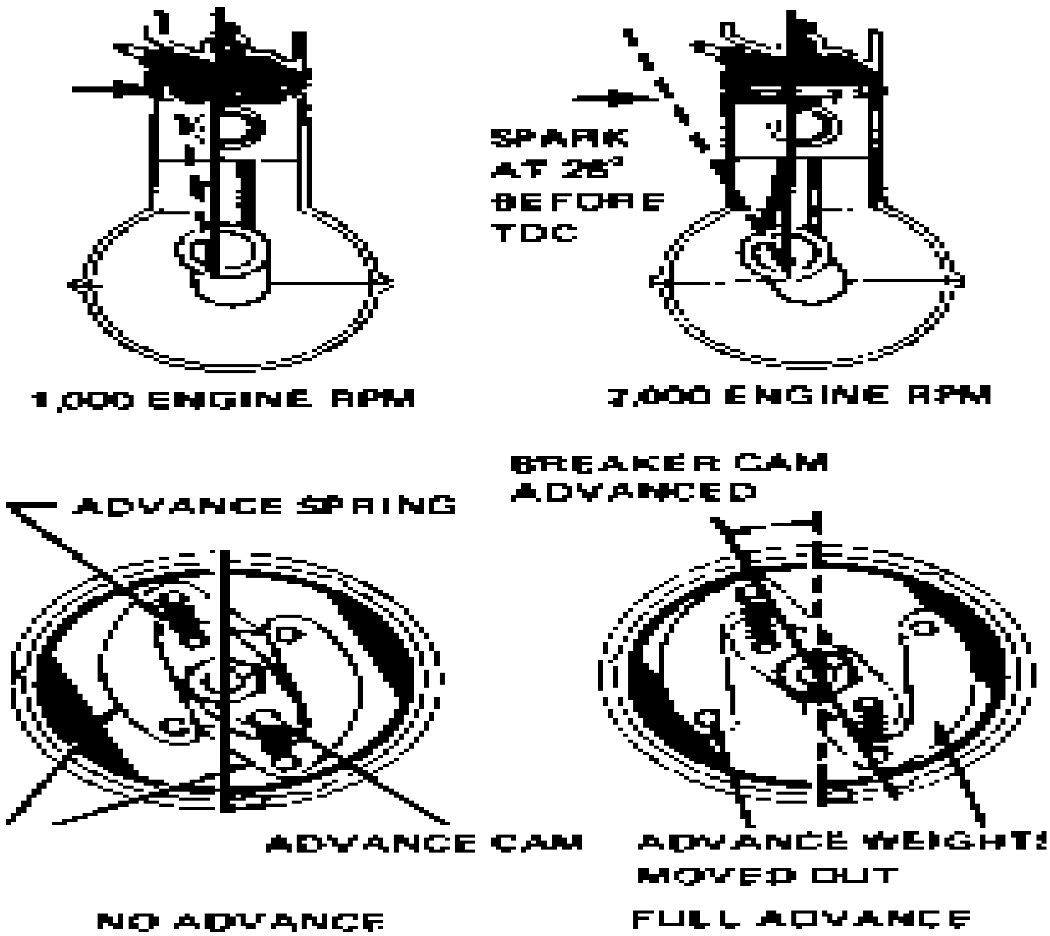


Fig-24: Centrifugal Advance Mechanism In No-Advance And Full-Advance Positions

<u>**Vacuum Advance**</u>

19. Under part throttle, a partial vacuum develops in the intake manifold. This means that less air and fuel will be admitted to the cylinder (volumetric efficiency is lowered). Thus, the mixture will be less highly compressed. The realize full power from it, the spark should be somewhat advanced. To obtain this spark advance, a vacuum advance mechanism is used. Figure -20 shows a type of vacuum advance mechanism used on contact-point distributors. It contains a spring-loaded, airtight diaphragm. The diaphragm is connected by a linkage, or lever, to the breaker plate.

The breaker plate is supported on a bearing so it can turn with respect to the distributor housing. It actually turns only a few degrees. The linkage to the spring-loaded diaphragm prevents any greater rotation than this.

Continue

The spring-loaded side of the diaphragm is connected through a vacuum line to an opening in the carburetor (Fig.-25) this opening is on the atmospheric side of the throttle valve when the throttle is in the idling position. There is no vacuum advance in this position.

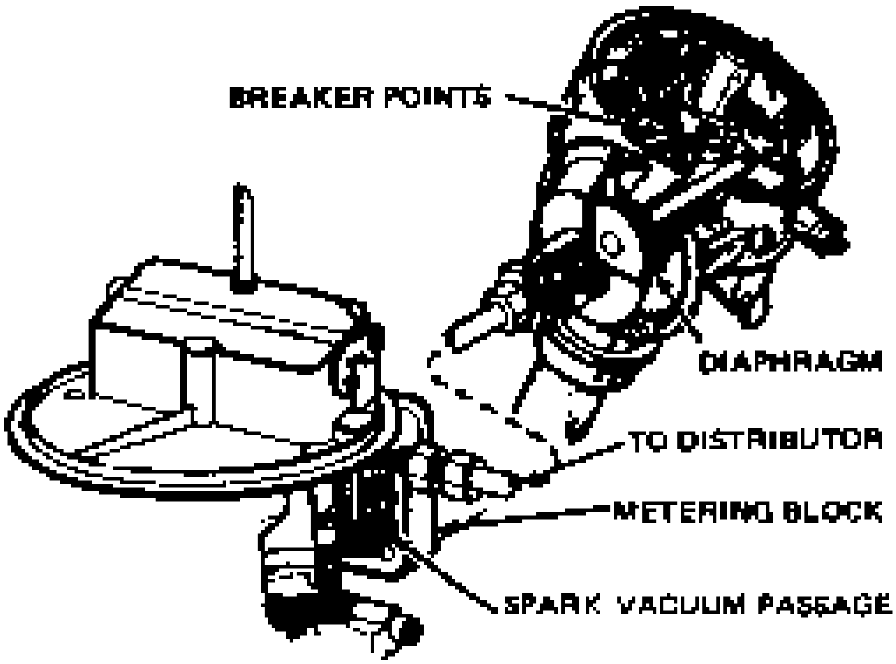


Fig -25, Connection Of The Vacuum Line Between The Carburetor And Vacuum Advance Mechanism On The Distributor (Ford Motor Company)

As soon as the throttle is opened, however, it moves past the opening of the vacuum passage. The intake-manifold vacuum can then draw air from the vacuum line and the airtight chamber in the vacuum advance mechanism. This causes the diaphragm to move against the spring. The linkage to the breaker plate then rotates the spring. The linkage to the breaker plate then rotates the breaker plate. This movement carries the contact points around. Thus, the cam, as it rotates, closes and opens the points earlier in the cycle. The spark then appears at the spark-plug gap earlier in the compression stroke. As the throttle is opened wider, there is less vacuum in the intake manifold and less vacuum advance. At wide-open throttle, there is no vacuum advance at all. The spark advance under this condition is provided entirely by the centrifugal advance mechanism. On the magnetic-pick-up distributor, the vacuum advance mechanism is attached to the magnetic-pick-up assembly (Fig.-3). This assembly is rotated to provide the vacuum advance.

Combination of Centrifugal and Vacuum Advances

20. At any particular engine speed, there will be some centrifugal advance due to engine speed. There may be an additional spark advance due to the operation of the vacuum

advance mechanism. Figure -26 illustrates this. At 40 mph (miles per hour) [64.37 km/h], the centrifugal advance mechanism provides 15 degrees of spark advance in this example. The vacuum mechanism will supply up to 15 degrees of additional advance under part-throttle conditions. However, if the operated at wide-open throttle, no vacuum advance will be obtained. The advance usually varies between the straight line (centrifugal advance) and the curved line (centrifugal advance plus total possible vacuum advance) as the throttle is closed and opened.

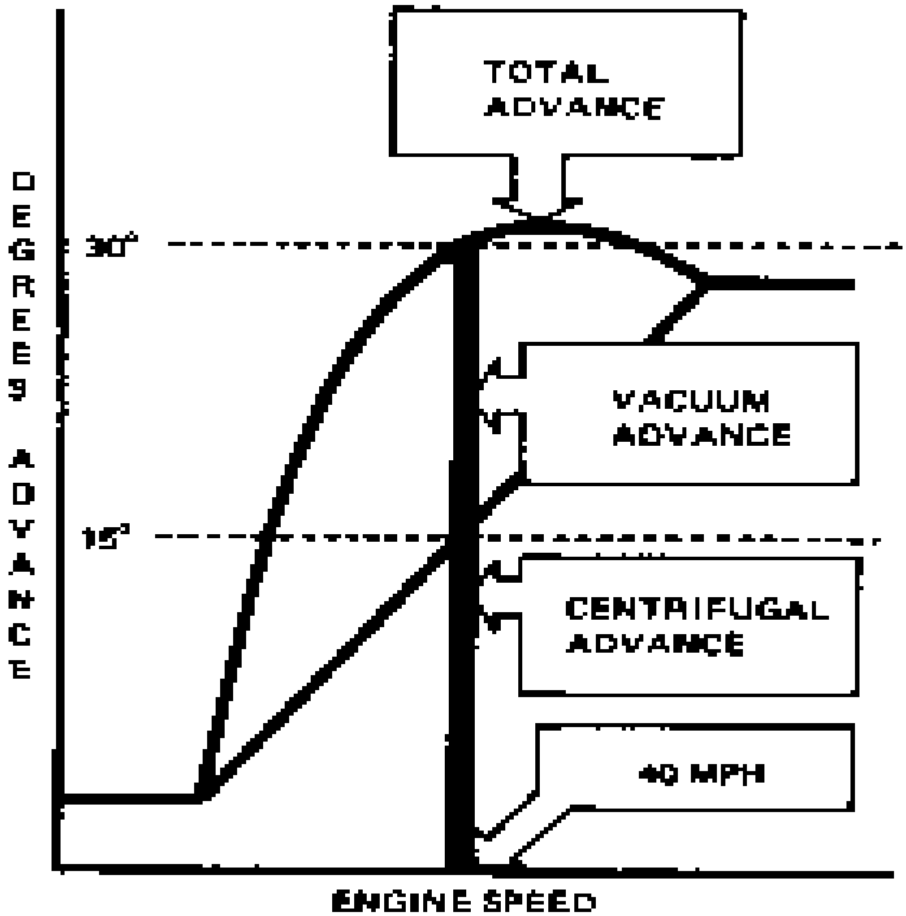


Fig-26: Centrifugal and Vacuum Advance Curves For One Particular Application

Full Vacuum Control

21. The distributor in Fig.-27 does not contain a centrifugal advance mechanism. Instead, it utilizes vacuum from the carburetor venture and intake manifold to produce the proper advance.

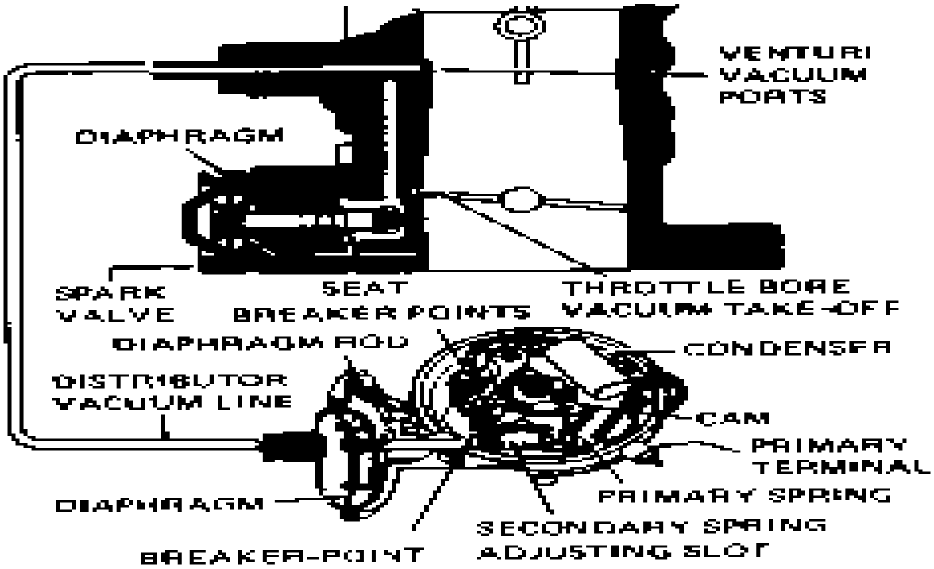


Fig-27: Vacuum-line connections between a carburetor and a distributor having full vacuum control (Ford Motor Company)

Full control by vacuum alone is possible because air speed through the carburetor air horn, and thus the vacuum in the venturi, is directly related to engine speed. Let us see how the system works. In the carburetor shown in Fig.-27, there are two vacuum openings in the air horn. One is at the venturi, and the other is just above the throttle when it is closed. The lower, or throttle, vacuum-takeoff opening may have two ports on some models, as in Fig. -27. These openings are connected by vacuum passages to each other. They are connected to the distributor vacuum advance mechanism by a vacuum line. Vacuum imposed on the diaphragm in the vacuum advance mechanism causes the breaker-plate assembly to rotate. This is very similar to the action of the vacuum advance devices discussed earlier. Rotation of the breaker-plate assembly causes an advance of the spark. As engine speed increases, the vacuum at the venturi in the carburetor increases. This is due to the increases of air speed through the venturi. This causes an increasing spark advance which is related to engine speed. At the same time, under part-throttle operating conditions, there will be a vacuum in the intake manifold. This acts at the throttle vacuum ports in the carburetor to produce a further vacuum advance. Thus, the vacuum conditions at the two points in the carburetor produce, in effect, a combined speed advance (as with a centrifugal device) and vacuum advance.

<u>Vacuum Advance Controls for Emission Reduction</u>

22. During some operating conditions, vacuum advance can increase the formation of nitrogen oxides during combustion. As we explained nitrogen oxides (NO_X) form during combustion at high temperatures. Thus, part-throttle operation in the lower gears can cause

an increase in NO in the exhaust gases. To prevent this, automobiles are equipped with control systems that prevent vacuum advance under some conditions. Car manufactures achieve vacuum advance control by different methods. Figure -28 shows one system. It allows vacuum advance only in high gear-with certain exceptions noted below. The system includes a transmissions witch, a solenoid vacuum switch, and a temperature override system. For normal operation in any gear but high, the transmission switch is closed.

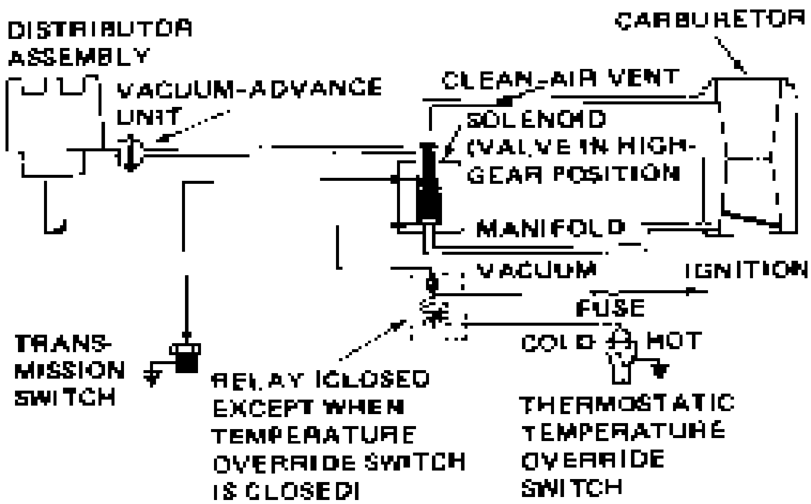


Fig-28: Sectional View Of The Transmission-Controlled Spark (TCS) System (Chevrolet Motor Division Of General Motors Corporation)

This connects the solenoid vacuum switch to the battery. The solenoid pulls in its plunger, closing off the vacuum connection to the lower part of the carburetor (that is, to manifold vacuum). At the same time, the solenoid opens a connection to the upper part of the carburetor through a clean-air vent. This releases any vacuum on the vacuum advance mechanism at the distributor. There is no vacuum advance. When the transmission goes into high gear, the transmission switch is opened. This allows the solenoid plunger to be pushed up by a spring. This shuts off the clean-air vent. It opens the line from the manifold vacuum vent to the vacuum advance unit. Now, normal vacuum advance can take place. The temperature override system provides full advance for better performance in all gears when the engine is cold. A thermostatic water-temperature switch is closed when the engine is cold. This connects the relay winding to the battery (through the ignition switch). The relay contact points open, thus opening the circuit to the solenoid. *Continue*

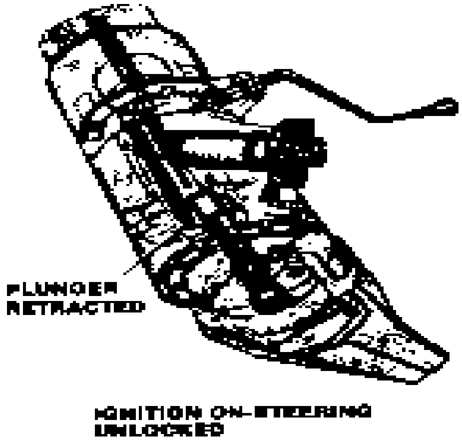


Fig-29: Combination Ignition Switch and Steering -Wheel Lock In Phanton Views, Showing The Two Positions Of The Lock (General Motors Corporation)

Now, regardless of the position of the transmission switch, the solenoid cannot operate. The vacuum advance unit remains connected to the manifold vacuum vent in the carburetor. Thus, the system provides normal vacuum advance. When the engine warms-up, then the thermostatic override switch opens. This opens the relay winding. The relay points close. The system now operates so that vacuum advance is obtained only in high gear, as explained above. The system also has a hot override position. This provides vacuum advance at all gear positions if the engine is overheating. The vacuum advance improves engine cooling.

Ignition Switch

23. In late-model cars, the ignition switch is mounted on the steering column, as shown in Fig. -29. This arrangement locks the steering shaft when the ignition switch is turned off and the ignition key is removed. A small gear on the end of the ignition switch rotates and releases a plunger. The plunger enters a notch in a disk on the steering shaft to lock the shaft. If a notch is not lined up with the plunger, the plunger rests on the disk. When the steering wheel, shaft, and disk are turned slightly, the plunger drops into a notch. When the ignition key is inserted and the ignition switch is turned on, the plunger is withdrawn from the disk to unlock the steering shaft. The ignition switch has an extra set of contacts that are used when switch is turned past ON to START. The contacts connect the starting motor solenoid to the battery so that the starting motor can operate. As soon as the engine is started and the switch is released, it returns to ON. The starting motor is then disconnected from the battery The alternator field circuit is connected to the battery through the ignition switch when it is turned to ON. When the ignition switch is turned to OFF, the alternator field circuit is disconnected.

Continue

This keeps the battery from running down through the field circuit. The ignition switch also operates a buzzer if the key is in the lock when the driver's car door is open. This reminds the driver to remove the key from the lock when the car is parked. It helps guard against theft of the car. Such accessories as the radio and the car heater are connected to the battery through the ignition switch. This arrangement prevents drivers from leaving these units running when they turn off the engine and leave the car. Such accessories as the radio and the car heater are connected to the battery through the ignition switch. This arrangement prevents drivers from leaving these units running when they turn off the engine and leave the car.

BAF BASE ZAHURUL HAQUE (TRG WG)
(Aero Engg Trg Sqn)

Syllabus : Automobile General Diesel and Petrol Technology

Course : Trade Training Advance, MTOF

Subject : Brake Service

Aim : To Study Brake Service

Ref. : Automotive Mechanics by William H. Crouse

BRAKE SERVICE

Brake Trouble Diagnosis

1. The charts and the sections that follow them give you a means of tracing brake troubles to their causes. After you know the complaint the charts provide you with the various possible causes. For each possible cause, the charts list the checks or corrections that you should make to eliminate the trouble. Following the trouble-diagnosis sections are sections on how to adjust and service automotive brakes. Brake trouble diagnosis is divided into three parts. The first chart with the explanatory sections following it covers drum brakes. The second chart, covering disk brakes, follows the third chart covers power brakes. However, some troubles can occur in any brake system, often from the same cause.

Drum-Brake Trouble Diagnosis Chart

2. A variety of braking problems bring the driver to the mechanic. Few drivers will know exactly what is causing a trouble. The chart that follows lists possible troubles in brake systems, their possible causes, and checks or corrections to be made. Following sections describe the troubles and causes or corrections in detail.

TROUBLE DIAGNOSIS CHART

Complaint	Possible Cause	Check or Correction
1. Brake pedal goes to floorboard	a. Linkage or shoes out of adjustment	Adjust
	b. Brake linings worn	Replace
	c. Lack of brake fluid	Add fluid; bleed system
	d. Air in system	Add fluid; bleed system
	e. Worn master cylinder	Repair

Complaint	Possible Cause	Check or Correction
2. One brake drags	a. Shoes out of adjustment	Adjust
	b. Clogged brake line	Clear or replace line
	c. Wheel cylinder defective	Repair or replace
	d. Weak or broken return spring	Replace
	e. Loose wheel bearing	Adjust bearing
3. All brake drags	a. Incorrect linkage adjustment	Adjust
	b. Trouble in master cylinder	Repair or replace
	c. Mineral oil in system	Replace damaged rubber Parts refill with recommended brake fluid
4. Car pulls to one side when braking	a. Brake linings soaked with oil	Replace linings and oil seals avoid over lubrication
	b. Brake linings soaked with brake fluid	Replace linings; repair or
	c. Brake shoes out of adjustment	Adjust
	d. Tires not uniformly inflated	Inflate correctly
	e. Brake line clogged	Clear or replace line
	f. Defective wheel cylinder	Repair or replace
	g. Brake backing plat loose	Tighten
	h. Mismatched linings	Use same linings ail around
5. Soft or spongy pedal	a. Air in System	Add brake fluid; bleed system
	b. Brake shoes out of adjustment	Adjust

Complaint	Possible Cause	Check or Correction
6. Poor braking action requiring excessive pedal force	a. Brake linings soaked with water	Will be all right when dried out
	b. Shoes out of adjustment'	Adjust
	c. Brake linings hot	Allow to cool
	d. Brake linings burned	Replace
	e. Brake drum glazed	Turn or grind drum
	f. Power-brake assembly not operating	Overhaul or replace
7. Brakes too sensitive or grab	a. Shoes out of adjustment	Adjust
	b. Wrong Innings	Insta1l correct linings
	c. Brake linings greasy	Replace; check oil seals; avoid over lubrication
	d. Drums scored	Turn or grind drums
	e. Backing plates loose	Tighten
	f. Power brake assembly malfunctioning	Overhaul or replace
	g. Brake 1Inings soaked with oil	Replace linings and oil seals; avoid over lubrication
	h. Brake linings soaked with brake fluid	Replace linings; repair or replace wheel cylinders
8. Noisy brakes	a. Linings worn	Replace
	b. Shoes warped	Replace
	c. Shoes rivets loose	Replace shoe or lining
	d. Drums worn or rough	Turn on grind drums
	e. Loose parts	Tighten
9. Air in system'	a. Defective master cylinder	Repair or replace
	b. Loose connections damaged tube	Tighten connections; replace tube
	c. Brake fluid lost	See tem 10 below

Complaint	Possible Cause	Check or Correction
10. Loss of brake fluid	a. Master cylinder leaks	Repair or replace
	b. Wheel cylinder leaks	Repair or replace
	c. Loose connections damaged tube	Tighten connections; replace tube
ll. Brakes do not self adjusted	a. Adjustment screw stuck	Free and clean up
	b. Adjustment lever does not engage star wheel	Repair: free up or replace adjuster
	c. Adjuster incorrectly installed	Install correctly
12. Warning light comes when braking	a. One section has failed	Check both sections for braking action repair defective section
	b. Pressure-differential valve defective	Replace

Brake Pedal Goes To Floor

3. When the brake pedal goes to the floor, there is no pedal wheels reserve. Full pedal travel does not produce adequate braking. One section might fail, but it would be rear for both of fail at the same time. It is possible that the driver has continued to operate the car with one section out. (Either the driver ignored the warning light, or the light or the pressure-differential valve has failed.) Causes of failure could be linkage or brake shoes out of adjustment, linings worn, air in the system, lack of brake fluid, or a defective master cylinder.

All Brakes Drag

4. When all brakes drag, the brake pedal may not have sufficient free travel. Then the pistons in the master cylinder do not fully retract. This would prevent the lip of the piston cup from clearing the compensating port, and hydraulic pressure would not be relieved as it should be. As a result, the wheel, cylinders would not allow the shoes to retract. A similar condition could result if engine oil was added to the system. Engine oil will cause the piston cups to swell. If they swelled enough, they would not clear the compensating ports even with the piston in the "fully retracted" position. A clogged compensating port would have the same result. Do not use a wire or drill to clear the port. This might produce a burr that would cut the piston cup. Instead, clear the port with alcohol and compressed air. Clogging of the reservoir vent might also cause dragging brakes by pressurizing the fluid in the reservoir. This would prevent release of pressure on the fluid in the lines. A clogged vent could also cause leakage of air into the system.

Car Pulls To One Side

5. If the car pulls to one side when the brakes are applied, more braking force is being applied to one side than to the other. This happens if some of the brake linings have become soaked in oil or brake fluid, if brake shoes are unevenly or improperly adjusted, if tires are not evenly inflated, or if defective wheel cylinders or clogged brake lines are preventing uniform braking action at all wheels. A loose brake backing plate or the use of two different types of brake lining will cause the car to pull to one side when the brakes are applied. Misaligned front wheels or a broken spring could also cause this problem. In a front-engine rear-wheel-drive car, linings will become soaked with oil if the lubricant level in the rear axle is too high. This may cause leakage past the oil seal (Fig. -1). At the front wheel, brake linings may get grease on them if the front-wheel bearings are over-lubricated or If the grease seal is defective or not properly installed. Wheel cylinders will leak brake fluid onto the brake linings if the cups are defective, if the cylinder bore is pitted, or if an actuating pin has been improperly installed. If the linings at a left wheel become soaked with brake fluid or oil, the car pulls to the left because the brakes are more effective on the left side. .However, the direction of pull may depend on the type of friction .material and the contaminant.

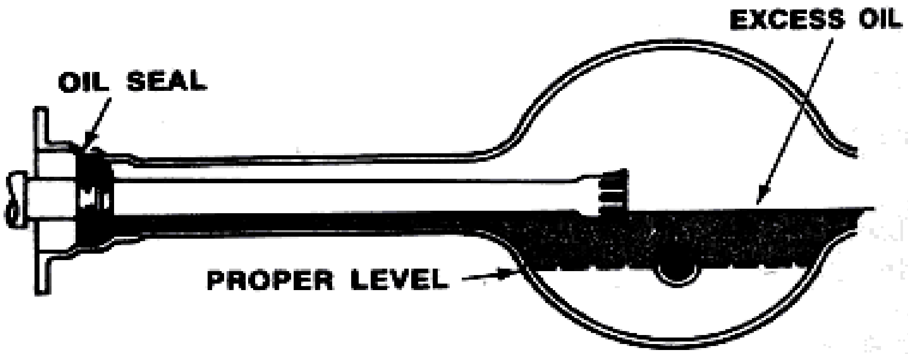


Fig-1
In a front engine rear wheel drive car

Soft or Spongy Pedal

6. If the pedal action is soft or spongy, there probably is air in the hydraulic system. Out-of-adjustment brake shoes could also cause this. Conditions that could allow air to enter the hydraulic system are described later on.

Poor Braking Action Requiring Excessive Pedal Force

7. A need for excessive pedal force could be caused by improper brake-shoe adjustment. The use of the wrong brake lining could cause the same trouble. Sometimes, brake linings that have become wet after a hard rain or after driving through water will not provide sufficient friction against the drums. However, normal braking action is usually restored after the brake linings have dried. Another possible cause of poor braking action is excessive temperature. After the brakes have been applied for long periods, as in coming down a long hill, they begin to overheat. This overheating reduces braking effectiveness so that the brakes "fade." Often, if brakes are allowed to cool, braking efficiency is restored. However, excessively long periods of braking at high temperature may char the brake linings so that they must be replaced. Further, this overheating may glaze the brake drum so that it becomes too smooth for effective braking action. Then the drum must be ground or turned to remove the glaze. Glazing can also take place even though the brakes are not overheated. Failure of the power-brake assembly will noticeably increase the force on the foot pedal required to produce braking.

Brakes Too Sensitive or Grab

8. If linings are greasy or soaked with oil or brake fluid, the brakes tend to grab with slight pedal force. Then the linings must be replaced. If the brake shoes are out. of-adjustment, if the wrong linings are used, or if drums are scored or rough (Fig -2); grabbing may result. A loose backing plate may cause the same condition. As the linings contact the drum, the backing plate shifts to give hard braking. A defective power-brake booster can also cause grabbing.

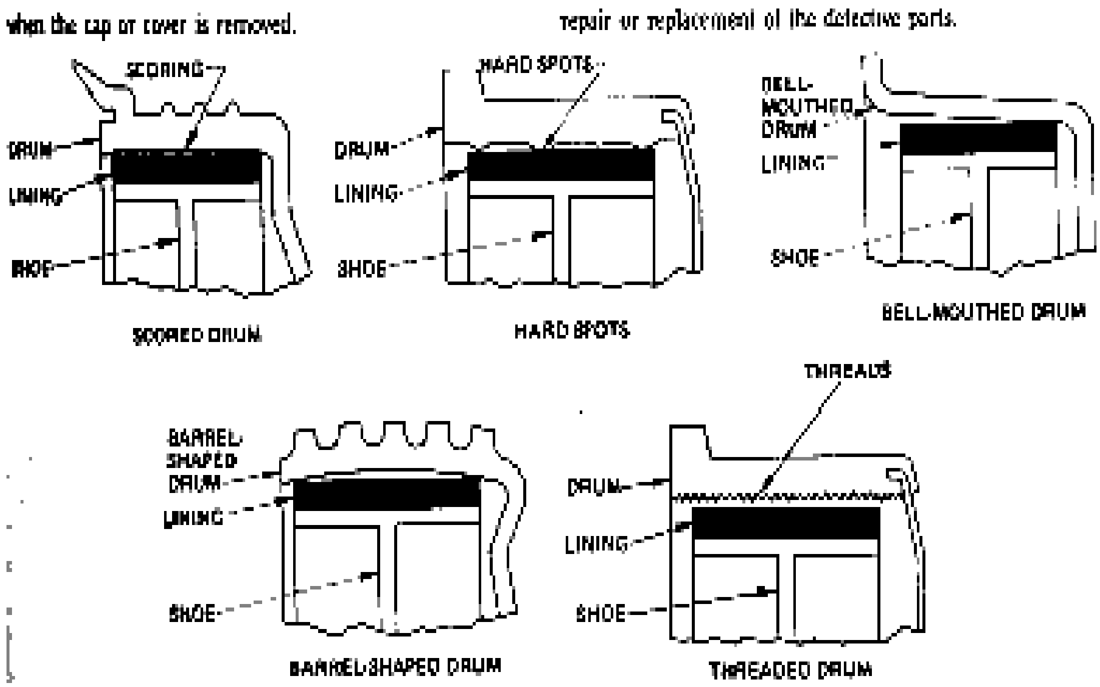


Fig – 2 various types of brake drum defect that require drum service

<u>Noisy Brakes</u>

9. Brakes become noisy if the brake linings wear so much that the rivets contact the brake drum, if the shoes become warped so that the contact with the drum is not uniform, if shoe rivets become loose so that they contact the drum, or if the drum becomes rough or worn (Fig -2). Any of these conditions may cause a squeak or squeal when the brakes are applied. Loose parts, such as the brake backing plate, also may rattle.

<u>Air In System</u>

10. If air gets into the hydraulic system, poor braking and a spongy pedal will result. Air can get into the system if the air vent in the master-cylinder cover or cap becomes plugged (Fig -3). This may tend to create a partial vacuum in the system on the return stroke of the piston. Air could then bypass the rear piston cup, as shown by the arrows in Fig -3, and enter the system. Always check the vent and clean it when the cap or cover is removed. Air can also get into the hydraulic system if the master- cylinder residual check valve is leaky and does not maintain a slight pressure in the system. A leak could allow air to seep in around the wheel-cylinder piston cups. Without residual line pressure in the system, there would be no pressure holding the cups tight against the cylinder walls.

Continue

Probably the most common cause of air in the brake system is insufficient brake fluid in the master cylinder. If the brake fluid drops below the compensating port, the hydraulic system will draw air in as the piston moves forward when braking. Air in the system must be removed by adding brake fluid and bleeding the system. These procedures are described later.

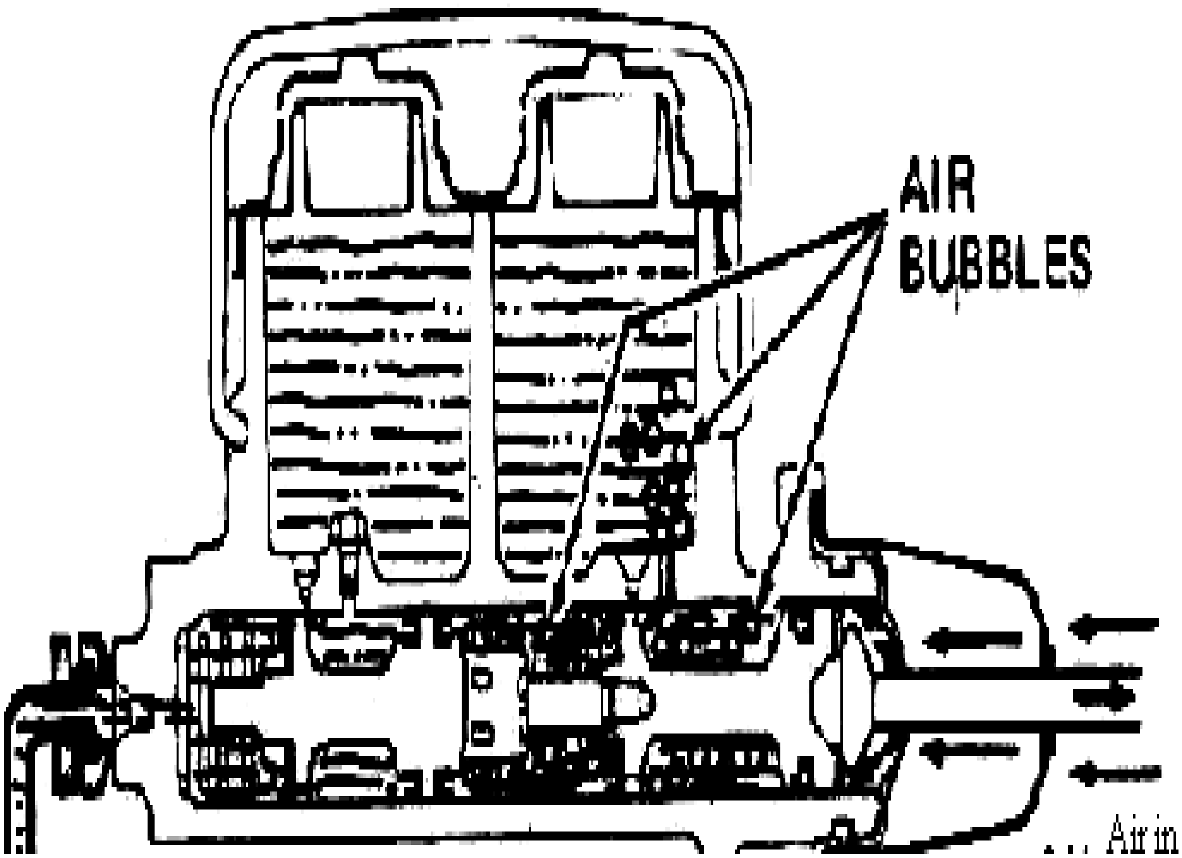
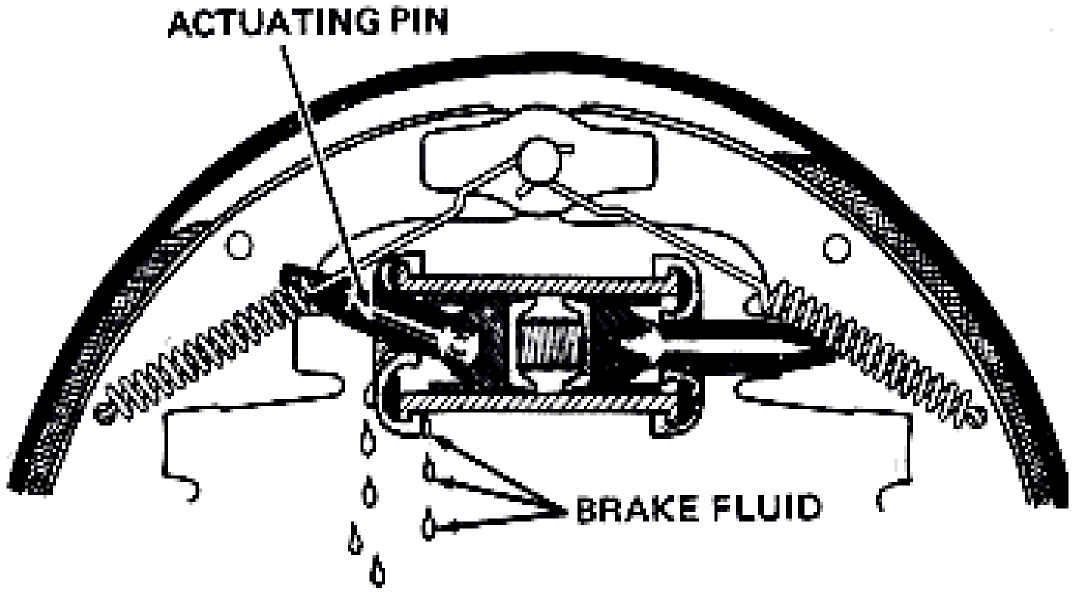


Fig-3
Air vent in the master cylinder cover becomes clogged

<u>Loss of Brake Fluid</u>

11. Bake fluid can be lost if the master cylinder leaks, if the wheel cylinder leaks, if the line connections are loose, or if the line is damaged. One possible cause of wheel-cylinder leakage is incorrect installation of the actuating pin (Fig - 4). If the pin is cocked, the side thrust on the piston may permit leakage past the piston. Leakage from other causes at the master cylinder or wheel cylinder requires removal and repair or replacement of the defective parts.



Fig–4

Incorrect installation of the pin in the wheel cylinder will cause a side thrust on the piston which permits brake fluid to leak out past the cup. The pm must align with the notch in the brake shoe.

<u>Brakes Do Not Self-Adjust</u>

12. Brakes do not self-adjust if the self-adjuster mechanism has been removed, the adjustment screw is stuck, the adjustment lever does not engage the star wheel, or the adjuster was incorrectly installed. Inspect the brake to find and correct the trouble.

<u>Warning Light Comes On When Braking</u>

13. If the warning light comes on when braking, it means there is low pressure in one section of the hydraulic system. One of the two braking sections has failed. Both sections should be checked so that the trouble can be found and eliminated. It is dangerous to drive with this condition. Even though the car slows, only half the wheels .are being braked.

<u>Disk Brake Trouble-diagnosis.</u>

14. The chart that follows lists disk-brake troubles, their possible causes, and checks or corrections to be made. Following sections describe the troubles and causes or corrections to be made.

a. **<u>TROUBLE-DIAGNOSIS CHARTT</u>**

Complaint	**Possible Cause**	**Check or Correction**
1. Excessive pedal travel	a. Excessive disk run out	Check run out; if excessive, install new disk
	b. Air leak, or insufficient fluid	Check system for leaks
	c. Improper brake fluid (low boiling point)	Drain and install correct fluid
	d. Warped or tapered shoe	Install new shoe
	e. Loose wheel-bearing adjustment	Readjust
	f. Damaged piston seal	Install new seal
	g. Power-brake malfunction	Check brake booster
2. Brake roughness or chatter (Pedal pulsation)	a. Excessive disk run out	Check run out; if excessive, install new disk
	b. Disk out. of parallel	Check run out; if excessive, install new disk
	c. Loose wheel bearings	Readjust
3. Excessive pedal force, grabbing, or braking	a. Power-brake malfunction	Check brake booster
	b. Brake fluid, oil, or grease on linings	Install new linings
	c. Lining worn	Install new shoes and linings
	d. Incorrect lining	Install correct lining
	e. Frozen or seized pistons	Disassemble caliper and free pistons; install new caliper and pistons, if necessary

Complaint	Possible Cause	Check or Correction
4.Noise Groan	Brake noise when slowly releasing brakes (Creep-groan). Not detrimental to function of disk brakes-no corrective action required.	This noise may be eliminated by slightly increasing or decreasing brake-pedal force.
5.Rattle	Brake noise or rattle at low speeds on rough Roads may be due to excessive clearance Between the shoe and the caliper	Iinstall new shoe and lining assemblies to correct.
6. Brakes heat up during driving and fail to release	a. Power-brake malfunction	Repair or replace brake booster
	b. Sticking pedal linkage	Free pedal linkage
	c. Driver riding brake pedal	Notify driver
	d. Frozen or seized piston	Disassemble caliper, clean cylinder bore, clean seal groove, and install new pistons, seals, and boots.
	e. Residual check valve in master cylinder	Remove valve from master cylinder.
	f. Incorrect linkage adjustment	Adjust linkage
7. Leaky caliper	a. Damaged or worn piston seal	Install new seal disassemble caliper, clean cylinder bore; if necessary
	b. Scores or corrosion on surface of piston or caliper bore	Install new pistons or replace caliper

Complaint	Possible Cause	Check or Correction

8. Brake pedal can be depressed without braking action	a. Piston pushed back in cylinder bores during servicing of caliper (and lining not properly positioned)	Reposition brake shoe and lining assemblies. Depress pedal a second time and if condition persists, look for the following causes:
	b. Leak in system or caliper	Check for leak, repair as required
	c. Damaged piston seal in one or more caliper	Disassemble caliper and replace piston calipers seals as required Bleed system
	d. Air in hydraulic system, or improper bleeding procedure	Close bleeder screw and bleed entire system
	e. Bleeder screw open	Tighten bleeder screw
	f. Leak past primary cup in master cylinder	Recondition master cylinder
9. Fluid level low in master cylinder	a. Leaks in system or caliper	Check for leak, repair as required
	b. Worn brake-shoe linings	Replace shoes
10. Warning light comes on when braking	a. One section has failed	Check both sections for braking action; repair defective system
	b. Pressure-differential valve defective.	Replace

b. **<u>Excessive Pedal Travel.</u>** Anything that requires excessive movement of the caliper pistons will require excessive pedal travel. For example, if the disk has excessive run out, it will force the pistons farther back in their bores when the brakes are released. Therefore, additional pedal travel is required when the brakes are applied. Warped or tapered shoes, a damaged piston seal, or loose wheel bearings could cause the same problem. In addition, air in the brake lines, insufficient fluid in the system, or incorrect fluid {which has a low boiling point) will cause a spongy pedal and excessive pedal travel. If the power brake is defective, it could also cause greater than normal pedal travel.

c. **<u>Brake-Pedal Pulsation.</u>** Brake-pedal pulsation is probably due to a disk with excessive run out or uneven thickness. The problem also may be caused by loose wheel bearings.

-

d. **Excessive Pedal Force, Grabbing, Or Uneven Braking**. If excessive pedal force is required to obtain normal braking action, the power brake may be defective. In addition\ if the linings are worn, hot, or water-soaked, they will not brake properly. Neither will a caliper that has a piston jammed: in it. All these conditions require an excessively hard push o~ the brake pedal to provide braking action.

e. **Car Pulls To One Side**. Pulling to one side is due to uneven braking action. It could be caused by incorrect front-wheel alignment, uneven tire inflation, or a broken or weak suspension spring. Such things as brake fluid on the linings, unmatched linings, warped brake shoes, jammed pistons, floating or sliding caliper seized, or restrictions in the brake lines could cause the car to pull to one side when braking.

NOISE: ***Th*****e chart covers various noises and their causes. Refer to it for details.**

f. **Brakes Fail To Release**. Brake-release failure could result from sticking pedal linkage, malfunctioning power brake, or pistons stuck in the calipers. It could also be due to the driver's riding the brake pedal or to failure of the master cylinder to release the pressure when the brakes are released.

g. **Leaky Caliper Cylinder.** A leaky caliper cylinder could be due to a damaged or worn piston seal. The leak would also be caused by roughness on the surface of the piston as a result of scores, scratches, or corrosion.

h. **rake Pedal Can Be Depressed Without Braking Action**. If the brake calipers have been serviced, the pistons may be pushed back so far in their bores that a single full movement of the brake pedal will not produce braking. After any service on disk brakes, the brake pedal should be pumped several times. Then the master-cylinder reservoir should be filled to the proper level before the car is moved. Pumping the pedal moves the pistons into position so that normal brake-pedal application causes braking. Other conditions can prevent braking action when the pedal is depressed. These include leaks or air in the hydraulic system. Leaks can occur at the piston seals, bleeder screws, or brake-Iine connections, or in the master cylinder. May have failed. This situation can occur, for example, if the warning-light bulb has burned out and the driver has been driving with one section defective. Then failure of the remaining section leaves the car with no braking action when the brake pedal is depressed.

j. **Fluid Level Low In Master Cylinder**. Brake-fluid level in the master cylinder should be¼ inch [6mm] the hydraulic system or caliper Worn disk brake shoe linings also an cause this problem. As the linings wear, the fluid level lowers in the master cylinder.

Power-Brake Trouble Diagnosis Chart

15. The chart below relates various power brake troubles to their possible causes and corrections. The charts and the sections that follow pertain to power-brake unit only. Generally, the Trouble-diagnosis charts, which cover hydraulic brakes, also apply to power brake system. There fore, the troubles listed in the charts, as well as the trouble Corrections described earlier in the chapter, also apply to power brakes.

Trouble Diagnosis Chart

Complaint	**Possible Cause**	**Check or correction**
1. Excessive brake-pedal force (vacuum booster)	a. Hose collapsed	Free or replace
	b. Vacuum fitting plugged	Replace
	c. Binding pedal linkage	Clear, replace
	d. Air inlet clogged	Free
	e. Faulty piston seal	Clear
	f. Stuck piston	Replace
	g. Faulty diaphragm	Clear, replace damaged parts
	h. Causes listed under item 6 in earlier chart	replace
2. Brakes grab	a. Reaction, or "brake-feel," mechanism damaged	Replace damaged parts Free"
	b. Air-vacuum valve sticking	
	c. Causes listed under item 7 in earlier chart.	Replace damaged parts
3. Pedal goes to floorboard	a. Hydraulic-plunger seal leaking	Replace
	b. Compensating valve not closing	Replace valve
	c. Causes listed under item in earlier chart	Replace damaged parts

Complaint	Possible Cause	Check or correction
4. Brakes fail to release	a. Pedal linkage binding	Free
	b. Faulty check-valve action	Free" replace damaged parts
	c. Compensator port plugged	Clean port
	d. Hydraulic-plunger seal sticking	Replace seal
	e. Piston sticking	Lubricate, replace damaged parts
	f. Broken return spring	Replace
	g. Causes listed under item 3 in earlier chart	Replace damaged parts
5. Loss of brake fluid	a. Worn or damage seal in hydraulic system	Replace
	b. lose the connections	Replace, fill, and bleed system
	c. Cause listed under 7 item in earlier chart	Tighten, replace seals

Brake Testers

16. There are two types of brake testers, the static and the dynamic. One type of static tester has four tread plates and registering columns (Fig - 5). To make the tests, the car is driven onto the tread plates at a specified speed and the brakes are applied hard. The stopping force at each wheel is registered on the four columns. If the readings are too low, or are unequal, brake service is needed. *Continue*

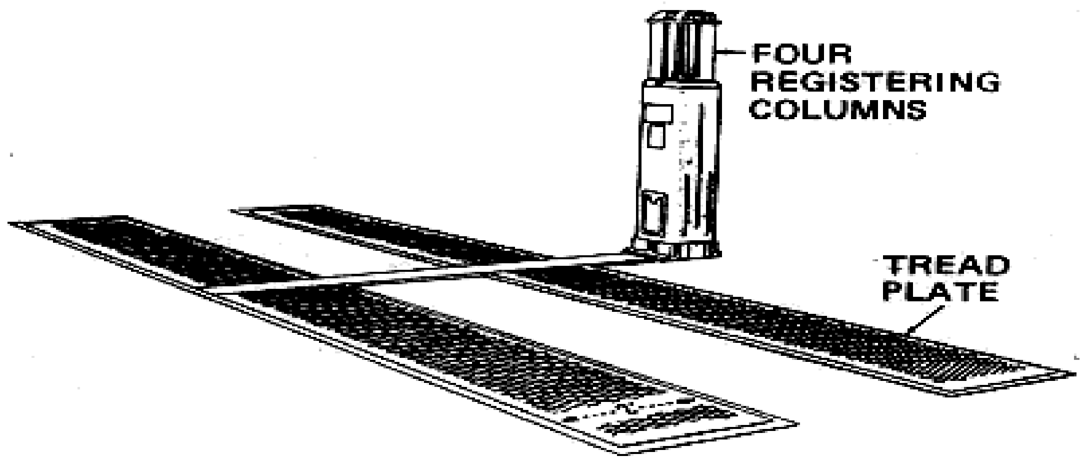


Fig – 5 Platform type brake tester

The dynamic brake tester has rollers in the floor. The two wheels for which the brakes are to be tested are placed on the rollers (Fig - 6). If these are the drive wheels, the wheels are spun at the specified speed by the vehicle engine. For non-driving wheels, the rollers and wheels are spun by an electric motor. Then the throttle is released or the electric motor is turned off and the brakes are applied. The braking force at each wheel registers on meters. This shows if the brakes perform normally or if they need service

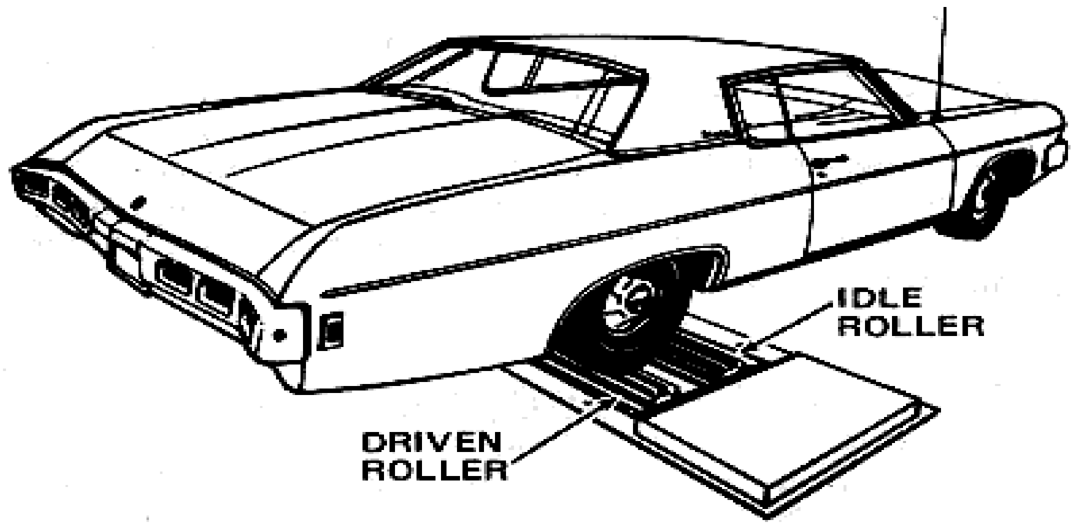


Fig – 6 Wheels on dynamic brake tester.

<u>Brake Service</u>

17. Any complaint of faulty braking action should be analyzed to determine the cause. Sometimes, all that is necessary in the earlier drum brakes is a brake-shoe adjustment to compensate for lining wear. On the later drum brakes with self- adjusters, the brakes automatically adjust to compensate for lining wear. However, the self-adjusters may fail. Other brake services include addition of brake fluid; bleeding the hydraulic system to remove air; repair or replacement of master cylinders, wheel cylinders, and calipers; replacement of brake linings; refinishing of brake drums or disks; and overhauling of power-brake units.

<u>Adjusting Drum Brakes</u>

18. Drum brakes without self adjusters require periodic adjustment of the brake shoes. This compensates for brake-Lining wear. Drum brakes are usually adjusted without removing the wheels and brake drums from the car. Self-adjusting brakes should require adjustment only after replacement of brake shoes, refinishing of the brake drums, or other service in which disassembly of the brakes was performed. This adjustment is called the manual adjustment, or preliminary adjustment. Adjustment procedures for drum brakes are given in the manufacturer's service manual.

Replacing Drum-Brake Shoes

19. When linings wear, the brake shoes must be replaced. To replace the shoes in a drum brake, the wheel and brake drum must be removed (Fig - 7) .Then shoes with new linings are installed. Few shops today reline brake shoes, although this was common practice years ago. Until a few years ago, most relined shoes were "arced." This meant the shoes were ground slightly to better fit the larger diameter of a used or refinished brake drum. However, grinding brake shoes is no longer universally recommended. This is because of the hazards resulting from the asbestos dust created during shoe grinding. See the CAUTION about asbestos dust at the beginning of this chapter.

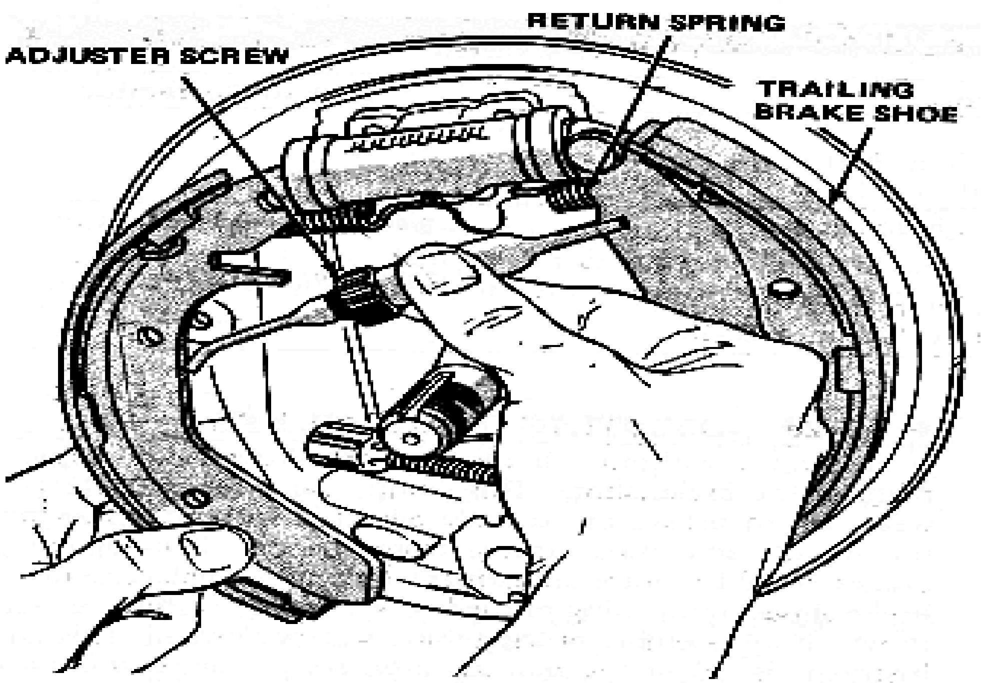


Fig – 7 Replacing brake shoes on a rear drum brake

Servicing Brake Disks and Drums

20. Brake disks require replacement only if they become deeply scored or are warped but of line. Light scores and grooving are normal and will not affect braking. Some manufactures recommend never grinding or re-facing a scored brake disk. Instead; installation of a new disk is recommended. Refer to the manufacturer's service manual for the proper procedure to follow and tools to use. Brake disks have a discard dimension (a number) cast into them. This dimension is the minimum thickness to which the disk can be refinished. If the disk must be refinished to a thinner diameter, discard it. *Continue*

The disk is too thin for safe use. On drum brakes, the drum should be inspected for distortion, cracks, scores, roughness, or excessive glaze or smoothness. Glaze lowers friction and braking efficiency. Drums that are distorted or cracked should be discarded, and new drums installed. Light score marks can be removed with fine emery cloth. All traces of emery must be removed after smoothing the drum. Deeper scores, roughness, and glaze can be removed by turning or grinding the drum. Many brake drums have their discard diameter cast into them. This dimension is the maximum allowable diameter. If it. is necessary to turn or grind the drum to a larger diameter, discard It. The drum would be too thin for safe brake; drums should not be refinished to larger than the original diameter by more than 0.060 inch [1.5 mm]. This leaves0.030 inch {0.76 mm] left for wear before the discard diameter is reached. The diameters of the left and right drums on the same axle~~ should be within 0.010 inch [0.25 mm] of each other. When the drum diameters on the same axle vary more than this. Replace both drums.

Wheel-cylinder service

21. Most wheel cylinders can be disassembled and rebuilt on the car. However, many manufacturers recommend that the wheel cylinder be removed from the backing plate and serviced on the bench. This makes it easier to properly and thoroughly clean, inspect, and reassemble the cylinder. To remove a wheel cylinder from the car, first remove the wheel and brake drum. Then disconnect the brake hose or tube from the wheel cylinder. Remove the wheel cylinder by taking out the attachment bolts or retainer (Fig-8). *Continue*

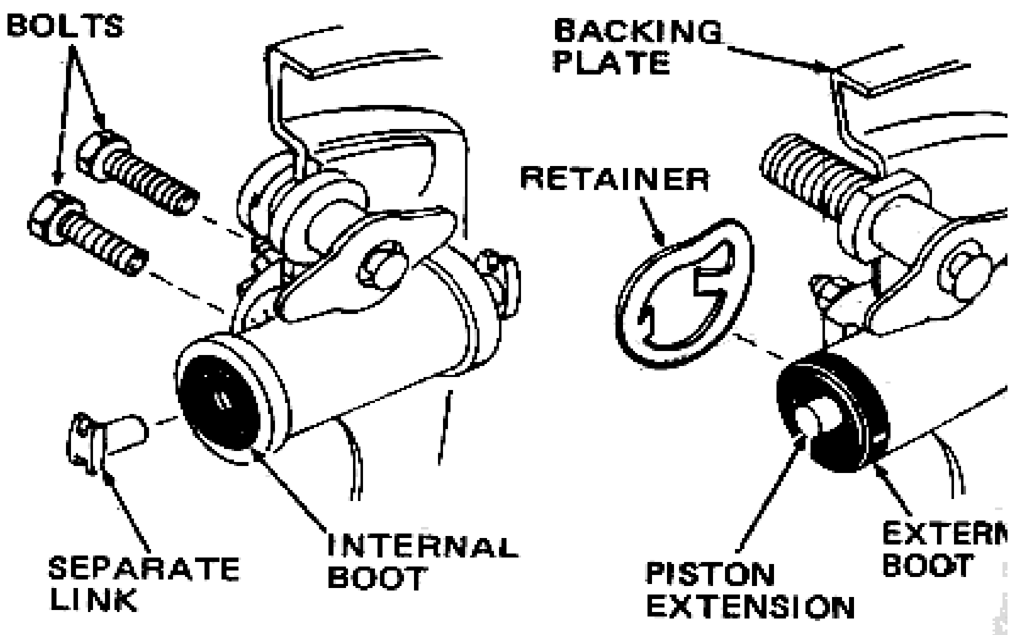


Fig-8 Two method of attaching the wheel cylinder to the backing plate.

Then tape the end of the hose or pipe shut to prevent any dirt from getting in. Disassemble the wheel cylinder by first pulling off the boots. Then push out the pistons, cups, and springs. Clean all wheel-cylinder parts in clean brake fluid. Dry the parts with compressed air. Then place the dried parts on clean lint-free shop towels or paper. Check that all passages in the wheel cylinder and bleeder screw are clear by blowing through them with compressed air. Inspect the cylinder bore for scoring and corrosion. Use crocus cloth to remove light corrosion and stains. Replace the wheel cylinder if crocus cloth does not remove the corrosion or if the bore is pitted or scored. Some manufacturers permit the use of a brake-cylinder hone (Fig-9) to remove scores and rust. However, the cylinder bore must not be honed more than 0.003 inch [0.08 mm] larger than its original diameter. If the scores do not clean out, replace the cylinder. The wheel cylinder also should be replaced if the clearance between the cylinder bore and the pistons is excessive. When reassembling the wheel cylinder, lubricate all parts with clean brake fluid. Then assemble the wheel cylinder, using all parts in the repair kit. Install the bleeder screw, and torque it to specifications.

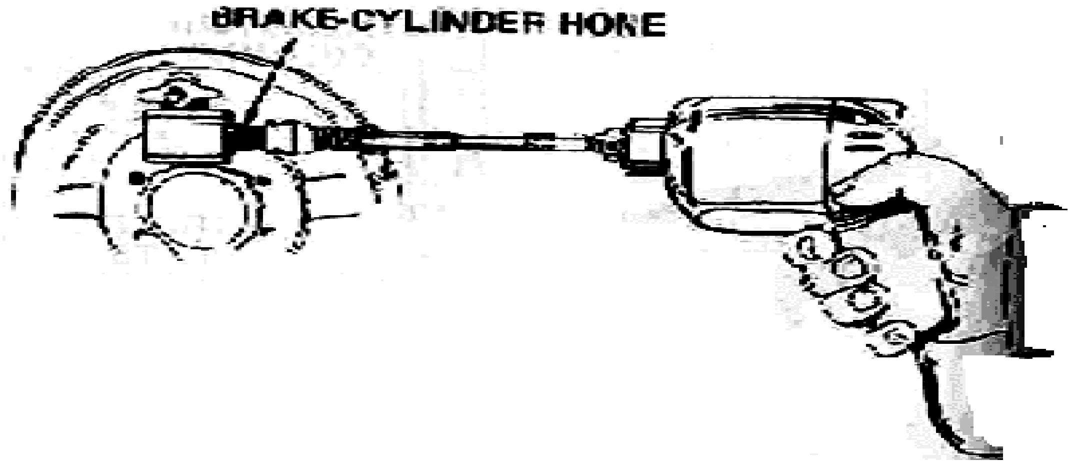


Fig-9 Honing the bore in a wheel cylinder

Careful: Never allow any grease or oil to contact the rubber parts or other internal parts, of the hydraulic system. Grease or oil will cause the rubber parts to swell, which may lead to break failure.

<u>Master Cylinder Service</u>

22. Master cylinders may require disassembly for replacement of internal parts. However, some technicians prefer to install a new or rebuilt master cylinder. The service procedures for master cylinders used with disk brakes and drum brakes are very similar. One difference is that with disk brakes a larger brake-fluid reservoir is required. Figure -10 is a disassemble bled master cylinder used with a braking system that has front-wheel disk brakes and rear-wheel drum brakes. Note that the fluid reservoir for the front-disk brakes is larger than the other .To service the master cylinder, clean the outside. Then remove the master cylinder from the car.

Continue

Remove the cover and seal, and pour out any remaining brake fluid. Mount the master cylinder in a vise. If the car has a manual brake sys- tem, slide the boot to the rear, remove the retainer clip, and then remove the retainer, pushrod, and boot. Use the push- rod to force the primary piston inward, and remove the snap ring from the groove in the piston bore. Then remove the primary-piston assembly. The repair kit contains a complete new primary-piston assembly. Remove the secondary-piston stop screw, if so equipped. Using the shop air hose, apply slight air pressure through the compensating port at the bottom of the reservoir. This will force out the secondary-piston assembly. Remove the piston seals from the secondary piston. The outlet-tube seats check valves, and springs must not be removed from some master cylinders. They are permanent parts of the master cylinder. However, these parts may be removed from other master cylinders. Follow the procedure in the manufacturer's service manuals. Most disk-brake hydraulic systems do not use check valves. Clean all parts in brake fluid or brake-cleaning solvent only. Blow dry with filtered compressed air. Blowout all pas- sages and ports to be sure they are clear. If the master cylinder is scored, corroded, pitted, cracked, porous, or otherwise damaged, replace it. Some manufacturers permit slight honing of the master-cylinder bore. But if the pits or scoring are deep, a new master cylinder must be installed. To assemble the n"1aster cylinder, dip all parts (except the body) into brake fluid. Insert the complete secondary-piston assembly, with return spring, into the master-cylinder bore. Install the secondary-piston stop screw, if so equipped. Put the primary-piston assembly into the bore. Depress the primary piston and install the snap ring in the bore groove. Install the pushrod, boot, and retainer on the pushrod, if so equipped. Install the push rod assembly into the primary piston. Make sure the retainer is properly seated and holding the pushrod securely.

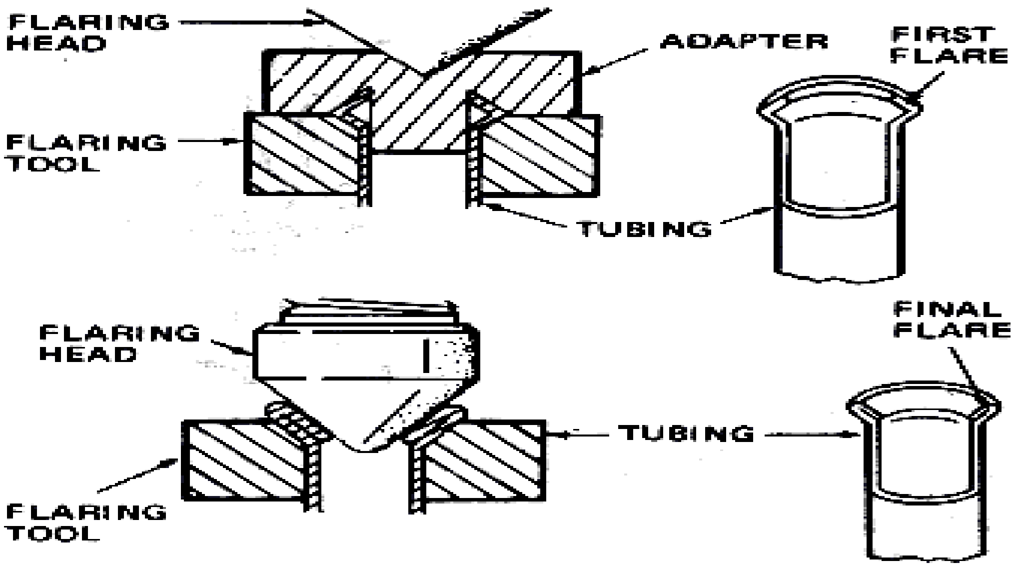


Figure – 10 Steps required to double flare hydraulic brake tubing

Careful: *Never add a stop screw to a master cylinder that does not have one. Even though It has a threaded hole for the screw It a stop screw is installed in a master cylinder of this type. The master cylinder may not function properly Position the inner end of the pushrod boot (if so equipped) in the re13ining groove in the master cylinder. Put the seal into the cover, and install it on the master cylinder, Secure the cover with the re13iner.*

Note: *The master cylinder should be bled before it is installed on the car. The procedure involves filling the master cylinder with brake fluid. Then the pistons are moved back and forth to get rid of any trapped air.*

<u>Disk Brake Service</u>

23. On fixed-caliper brakes, the brake shoes can be replaced without removing the caliper assembly. With the car on a lift or safety stands, remove the wheel. Then use two pairs of pliers and pull on the tabs to pull each shoe out. Before installing new shoes, push the pistons in with slip-joint pliers. How ever, before you do this, you should remove some fluid from the master cylinder. Otherwise, pushing the pistons in will force enough fluid back into the master cylinder so it will overflow. On the floating-caliper brake, remove both the wheel and 1 caliper to replace the brake shoes. First, remove two-thirds of r the fluid from the master-cylinder section for the disk brakes. e Discard the fluid. Raise the car and remove the wheel cover and wheel. Use a C clamp as shown in Fig. -11 and tighten d it to force the piston back into its cylinder. Remove the two mounting bolts and lift the caliper off. Support it with a wire hook so it does not hang from the brake hose. Remove the old shoes. Remove the sleeves and bushings from the four caliper ears. On reinstallation, first install new sleeves and bushings and the shoes. Put each shoe back on the same side of the caliper from which it was removed. Make sure the piston is pushed back into its cylinder. Position the caliper over the disk and install the mounting bolts. Clinch the upper ears of the out board shoe to hold It in place. The ears should be flat against the caliper. Add fresh brake fluid to the master cylinder. Pump the brake pedal several times to seat the linings against the disk and to get a firm pedal. Check and fill master cylinder as necessary. *Continue*

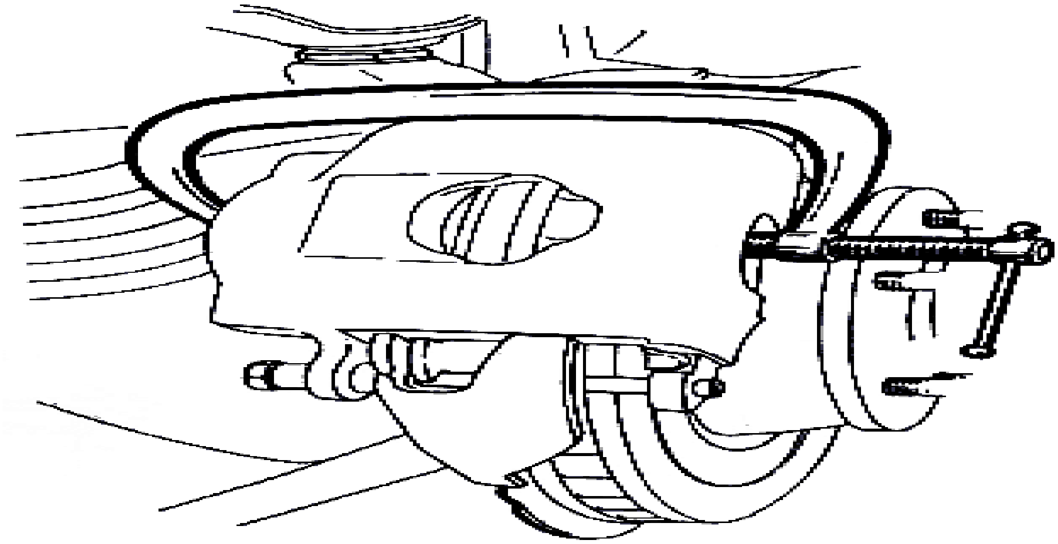


Fig – 11 Using a C clamp to force the piston into the call- per bore

Caution: *Do not attempt to move the car until you feel a firm brake pedal*.

If the caliper assembly must be removed from the car. Then compressed air or a special piston remover can be used to remove. The piston from the caliper. When installing a new seal on the piston, first dip the seal in clean brake fluid. Then install the piston in the bore, being careful not to unseat and twist the seal. Slight roughness or corrosion in the caliber bores can be cleaned out with a hone. If the bore diameter must be in creased more than 0.002 inch [0.05 mm], install a new caliper. If the piston is metal, and shows wear that has removed any of the chrome plating, install a new piston. After assembly and installation of the caliper, the front wheel bearings must be adjusted to specifications. Excessive play in the ',\'heel bearings may affect disk-brake action.

<u>Hydraulic Brake Tubing Repair</u>

24. Most hydraulic-brake tubing is made of double-walled, welded-steel tubing which is coated to resist rust. Only the tubing specified by the automotive; manufacturer should be used. When replacing a tube, use the old tube as a pattern to form a new tube. Do not kink the tubing or make sharp bends. Brake tubing must be cut off square with a special tube cutter. Do not use a jaw. Type cutter or a hacksaw to cut brake tubing. Either of these can distort the tubing and leave heavy burrs that would prevent normal flaring of the tube. After the tube has been cut off, a flaring tool must be used to double flare the end of the tube (fig-10).

<u>Flushing Hydraulic System</u>

25. The process of removing all of the old brake fluid from the hydraulic system is called flushing. Some car manufacturers recommend flushing the hydraulic system when new parts are installed in it. The system must be flushed if there is any indication of brake-fluid contamination. Signs of contaminated brake fluid include corroded metal parts and soft or swollen rubber parts. To flush the hydraulic system, install the pressure bleeder on the master cylinder (Fig -12). If the vehicle has a metering valve, it must be held in the open position. Place brake the bleeder wrench on the bleeder valve in the wheel caliper nearest the master cylinder. Install one end of a short the bleeder hose Place the other end in seal transparent container. Open the bleeder valve about 1½ turns, and let the fluid drain into the container. Close the bleeder valve when the fluid appears clean and clear. Then move on to the bleede1 valve next closest to the master cylinder. Repeat the procedure at each wheel. When flushing is completed, check that the master cylinder is filled. About 1 quart [0.946 L] of clean fresh brake fluid is needed to flush the hydraulic system If the hydraulic system is being flushed because of fluid contamination, replace all rubber parts in the brake system. This includes the rubber parts in the master cylinder, wheel cylinders and calipers, brake hoses, and combination valve. Then bleed the hydraulic system. Some manufacturers recommend the use of a special flushing fluid. This fluid is used instead of new brake fluid during the flushing operation. Flushing is continued until all the old brake fluid has been flushed out. Then the flushing fluid is purged by applying clean, dry air through the master cylinder to blow the fluid out. Do not use too much air pressure. After all flushing fluid is out; fill the master-cylinder reservoir with new brake fluid. Then bleed the system as explained below.

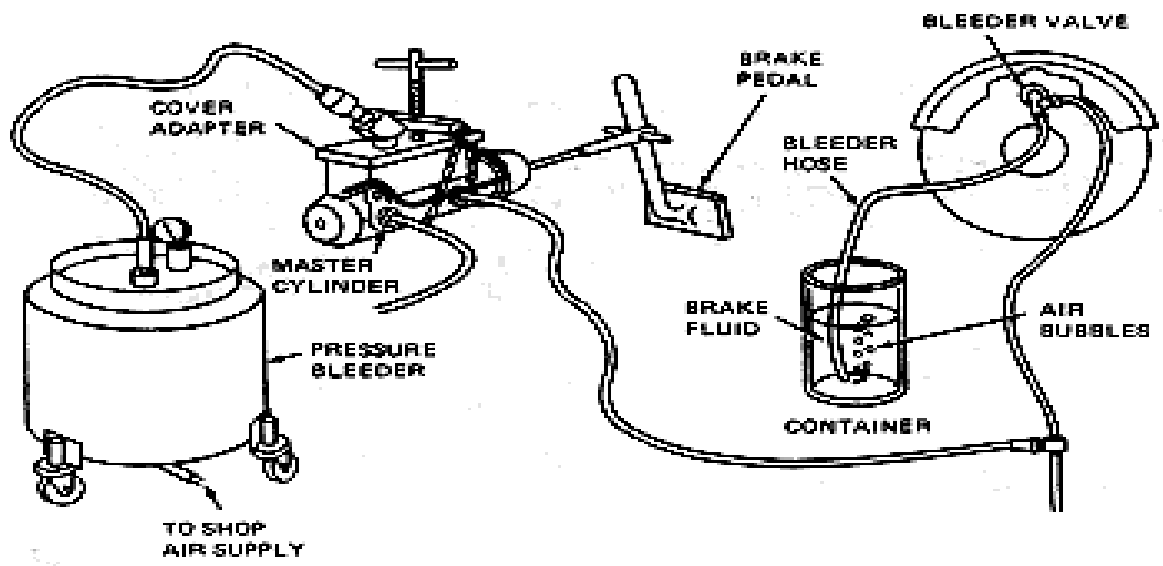


Fig -12

Bleeding a hydraulic system with a pressure bleeder

<u>Filling and Bleeding Hydraulic System</u>

26. After flushing the hydraulic system, or at any time Air may be in the hydraulic system, the hydraulic system must be filled and bled. For the brakes to operate properly, all air must be removed from the system. The process of getting rid of any air trapped in a hydraulic brake line or component is called bleeding. In the bleeding process, brake fluid is forced through the brake line or component that has air in it. To bleed the brakes, install the pressure bleeder on the master cylinder (Fig -12). If the car has a metering valve, it must be held in the open position. Place the brake cylinder or Install one bleeder wrench on the bleeder valve in the wheel cylinder or end of the bleeder hose on the bleeder valve. The lower end of caliper nearest the master cylinder. is immersed in a clear container partly filled with fresh brake fluid. This allows you to see any air bubbles that come out of the line. It also prevents any air from being pulled back into the line. This can happen if the pressure on the brake fluid is released before the bleeder valve is closed. If the master cylinder has a bleeder valve on it, bleed the master cylinder first. Open the bleeder valve about ¾ turn. Watch the flow of brake fluid from the end of the hose. As soon as the bubbles stop and brake fluid flows from the hose in a solid stream, close the bleeder valve. Repeat this step at each wheel. Then disconnect the pressure bleeder from the master cylinder. Check that the master cylinder is filled with brake fluid. Wipe up any spilled brake fluid. Install the master-cylinder cover seal and cover. Pump the brake pedal several] times. Be sure that a firm brake pedal is obtained before moving the vehicle.

Careful: *Clean away any dirt and grease from around the bleeder valve before opening it. This prevents any con1 lamination from entering the line it the pressure on the fluid is released before the bleeder valve is closed.*

<u>BAF BASE ZAHURUL HAQUE (TRG WG)</u>

(Aero Engg Trg Sqn)

<u>Syllabus : Automobile General Diesel and Petrol Technology</u>

Course : Trade training Advance, MTOF
Subject : Anti Lock Braking System
Aim : To study Anti Lock Braking System
Ref : Internet Wikipedia

<u>ANTI LOCK BRAKING SYSTEM</u>

Fig-1: ABS brakes on a BMW motorcycle

Anti-lock braking system (ABS):

1. Anti-lock braking system (ABS) is an automobile safety system that allows the wheels on a motor vehicle to maintain tractive contact with the road surface according to driver inputs while braking, preventing the wheels from locking up (ceasing rotation) and avoiding uncontrolled skidding. It is an automated system that uses the principles of threshold braking and cadence braking which were practiced by skillful drivers with previous generation braking systems. It does this at a much faster rate and with better control than a driver could manage. ABS generally offers improved vehicle control and decreases stopping distances on dry and slippery surfaces for many drivers; however, on loose surfaces like gravel or snow-covered pavement, ABS can significantly increase braking distance, although still improving vehicle control. Since initial widespread use in production cars, anti-lock braking systems have evolved considerably. Recent versions not only prevent wheel lock under braking, but also electronically control the front-to-rear brake bias. This function, depending on its specific capabilities and implementation, is known as electronic brake force distribution (EBD), traction control system, emergency brake assist, or electronic stability control (ESC).

Early systems:

2. ABS was first developed for aircraft use in 1929 by the French automobile and aircraft pioneer, Gabriel Vision, as threshold braking on airplanes is nearly impossible. These systems use a flywheel and valve attached to a hydraulic line that feeds the brake cylinders. The flywheel is attached to a drum that runs at the same speed as the wheel. In normal braking, the drum and flywheel should spin at the same speed. However, if a wheel were to slow down, then the drum would do the same, leaving the flywheel spinning at a faster rate. This causes the valve to open, allowing a small amount of brake fluid to bypass

the master cylinder into a local reservoir, lowering the pressure on the cylinder and releasing the brakes. The use of the drum and flywheel meant the valve only opened when the wheel was turning. In testing, a 30% improvement in braking performance was noted, because the pilots immediately applied full brakes instead of slowly increasing pressure in order to find the skid point. An additional benefit was the elimination of burned or burst tires. (This citation has no mention of Gabriel Vision, who was not involved in aviation at the time; neither are there patents to substantiate this claim). In 1958, a Royal Enfield Super Meteormotorcycle was used by the Road Research Laboratory to test the Maxaret anti-lock brake. The experiments demonstrated that anti-lock brakes can be of great value to motorcycles, for which skidding is involved in a high proportion of accidents. Stopping distances were reduced in most of the tests compared with locked wheel braking, particularly on slippery surfaces, in which the improvement could be as much as 30 percent.

Modern systems:

3. (a) Chrysler, together with the **Bendix Corporation**, introduced a computerized, three-channel, four-sensor all-wheel ABS called "Sure Brake" for its 1971 Imperial. It was available for several years thereafter, functioned as intended, and proved reliable. In 1970, Ford added an antilock braking system called "Sure-track" to the rear wheels of Lincoln Continentals as an option; it became standard in 1971. In 1971, General Motors introduced the "Trackmaster" rear-wheel only ABS as an option on their rear-wheel drive Cadillac models and the Oldsmobile Toronado In the same year, Nissan offered an EAL (Electro Anti-lock System) as an option on the Nissan President, which became Japan's first electronic ABS. In 1972, four wheel drive Triumph 2500 Estates were fitted with Mullard electronic systems as standard. Such cars were very rare however and very few survive today. In 1985 the Ford Scorpio was introduced to European market with a Bosch electronic system throughout the range as standard.

(b) For this the model was awarded the coveted European Car of the Year Award in 1986, with very favourable praise from motoring journalists. After this success Ford began research into Anti-Lock systems for the rest of their range, which encouraged other manufacturers to follow suit. In 1988, BMW introduced the first motorcycle with an electronic-hydraulic ABS: the BMW K100. Honda followed suit in 1992 with the launch of its first motorcycle ABS on the ST1100 Pan European. In 2007, Suzuki launched its GSF1200SA (Bandit) with an ABS. In 2005, Harley-Davidson began offering ABS as an option for police bikes.

Operation:

4. The anti-lock brake controller is also known as the CAB (Controller Anti-lock Brake).Typically ABS includes a central electronic control unit (ECU), four wheel speed sensors, and at least two hydraulic valves within the brake hydraulics. The ECU constantly monitors the rotational speed of each wheel; if it detects a wheel rotating significantly slower than the others, a condition indicative of impending wheel lock, it actuates the valves to reduce hydraulic pressure to the brake at the affected wheel, thus reducing the braking

force on that wheel; the wheel then turns faster. Conversely, if the ECU detects a wheel turning significantly faster than the others, brake hydraulic pressure to the wheel is increased so the braking force is reapplied, slowing down the wheel. This process is repeated continuously and can be detected by the driver via brake pedal pulsation. Some anti-lock systems can apply or release braking pressure 15 times per second. Because of this, the wheels of cars equipped with ABS are practically impossible to lock even during panic braking in extreme conditions. The ECU is programmed to disregard differences in wheel rotative speed below a critical threshold, because when the car is turning, the two wheels towards the center of the curve turn slower than the outer two. For this same reason, a differential is used in virtually all road going vehicles. If a fault develops in any part of the ABS, a warning light will usually be illuminated on the vehicle instrument panel, and the ABS will be disabled until the fault is rectified. Modern ABS applies individual brake pressure to all four wheels through a control system of hub-mounted sensors and a dedicated micro-controller. ABS is offered or comes standard on most road vehicles produced today and is the foundation for electronic stability control systems, which are rapidly increasing in popularity due to the vast reduction in price of vehicle electronics over the years. Modern electronic stability control systems are an evolution of the ABS concept. Here, a minimum of two additional sensors are added to help the system work: these are a steering wheel angle sensor, and a gyroscopic sensor. The theory of operation is simple: when the gyroscopic sensor detects that the direction taken by the car does not coincide with what the steering wheel sensor reports, the ESC software will brake the necessary individual wheel(s) (up to three with the most sophisticated systems), so that the vehicle goes the way the driver intends. The steering wheel sensor also helps in the operation of Cornering Brake Control (CBC), since this will tell the ABS that wheels on the inside of the curve should brake more than wheels on the outside, and by how much. ABS equipment may also be used to implement a traction control system (TCS) on acceleration of the vehicle. If, when accelerating, the tire loses traction, the ABS controller can detect the situation and take suitable action so that traction is regained. More sophisticated versions of this can also control throttle levels and brakes simultaneously. Upon the introduction of the Subaru Legacy in 1989, Subaru networked the four channel anti-lock brake function with the all wheel drive system so that if the car detected any wheel beginning to lock up, the variable assists the all wheel drive system installed on vehicles with the automatic transmission would engage to ensure all wheels were actively gripping while the anti-lock system was attempting to stop the car.

Components

5. There are four main components of ABS: speed sensors, valves, a pump, and a controller.

a) **Speed sensors:** The anti-lock braking system needs some way of knowing when a wheel is about to lock up. The speed sensors, which are located at each wheel, or in some cases in the differential, provide this information.

b) **Valves:** There is a valve in the brake line of each brake controlled by the ABS. On some systems, the valve has three positions:

(1) In position one, the valve is open; pressure from the master cylinder is passed right through to the brake.

(2) In position two, the valve blocks the line, isolating that brake the driver push the brake pedal harder.

(3) In position three, the valve releases some of the pressure from the brake.

c) **Pump:** When the ABS system operates the brake lines lose pressure. The pump re-pressurizes the system.

d) **Controller:** The controller is an ECU type unit in the car which receives information from each individual wheel speed sensor, in turn if a wheel loses traction the signal is sent to the controller, the controller will then limit the brake force (EBD) and activate the ABS modulator which actuates the braking valves on and off.

6. Use: There are many different variations and control algorithms for use in ABS. One of the simpler systems works as follows:

a. The controller monitors the speed sensors at all times. It is looking for decelerations in the wheel that are out of the ordinary. Right before wheel locks up, it will experience a rapid deceleration. If left unchecked, the wheel would stop much more quickly than any car could. It might take a car five seconds to stop from 60 mph (96.6 km/h) under ideal conditions, but a wheel that locks up could stop spinning in less than a second.

b. The ABS controller knows that such a rapid deceleration is impossible, so it reduces the pressure to that brake until it sees an acceleration, then it increases the pressure until it sees the deceleration again. It can do this very quickly, before the tire can actually significantly change speed. The result is that the tire slows down at the same rate as the car, with the brakes keeping the tires very near the point at which they will start to lock up. This gives the system maximum braking power.

c. When the ABS is in operation the driver will feel a pulsing in the brake pedal; this comes from the rapid opening and closing of the valves. This pulsing also tells the driver that the ABS has been triggered. Some ABS systems can cycle up to 16 times per second.

Brake types

7. Anti-lock braking systems use different schemes depending on the type of brakes in use. They can be differentiated by the number of channels: that is, how many valves that are individually controlled and the number of speed sensors. Four-channel, four-sensor ABS; This is the best scheme. There is a speed sensor on all four wheels and a separate valve for all four wheels. With this setup, the controller monitors each wheel individually to make sure it is achieving maximum braking force.

a. **Three-channel, four-sensor ABS:** There is a speed sensor on all four wheels and a separate valve for each of the front wheels, but only one valve for both of the rear wheels. Older vehicles with four-wheel ABS usually use this type.

b. **Three-channel, three-sensor ABS:** This scheme, commonly found on pickup trucks with four-wheel ABS, has a speed sensor and a valve for each of the front wheels, with one valve and one sensor for both rear wheels. The speed sensor for the rear wheels is located in the rear axle. This system provides individual control of the front wheels, so they can both achieve maximum braking force. The rear wheels, however, are monitored together; they both have to start to lock up before the ABS will activate on the rear. With this system, it is possible that one of the rear wheels will lock during a stop, reducing brake effectiveness. This system is easy to identify, as there are no individual speed sensors for the rear wheels.

C. **One-channel, one-sensor ABS:**

(1) This system is commonly found on pickup trucks with rear-wheel ABS. It has one valve, which controls both rear wheels, and one speed sensor, located in the rear axle. This system operates the same as the rear end of a three-channel system. The rear wheels are monitored together and they both have to start to lock up before the ABS kicks in. In this system it is also possible that one of the rear wheels will lock, reducing brake effectiveness. This system is also easy to identify, as there are no individual speed sensors for any of the wheels. The ABS is a four-wheel system that prevents wheel lock-up by automatically modulating the brake pressure during an emergency stop. By preventing the wheels from locking, it enables the driver to maintain steering control and to stop in the shortest possible distance under most conditions. During normal braking, the ABS and non-ABS brake pedal feel will be the same. During ABS operation, a pulsation can be felt in the brake pedal, accompanied by a fall and then rise in brake pedal height and a clicking sound. Vehicles with ABS are equipped with a pedal-actuated, dual-brake system. The basic hydraulic braking system consists of the following:

a) ABS hydraulic control valves and electronic control unit

b) Brake master cylinder

c) Necessary brake tubes and hoses

(2) The anti-lock brake system consists of the following components:

a) Hydraulic Control Unit (HCU).
b) Anti-lock brake control module.
c) Front anti-lock brake sensors / rear anti-lock brake sensors.

Anti-lock Brake Systems (ABS) operate as follows:

8. a. When the brakes are applied, fluid is forced from the brake master cylinder outlet ports to the HCU inlet ports. This pressure is transmitted through four normally open solenoid valves contained inside the HCU, then through the outlet ports of the HCU to each wheel.

b. The primary (rear) circuit of the brake master cylinder feeds the front brakes.

c. The secondary (front) circuit of the brake master cylinder feeds the rear brakes.

d. If the anti-lock brake control module senses a wheel is about to lock, that circuit. This prevents any more fluid from entering that circuit

e. The anti-lock brake control module then looks at the anti-lock brake sensor signal from the affected wheel again.

f. If that wheel is still decelerating, it opens the solenoid valve for that circuit.

g. Once the affected wheel comes back up to speed, the anti-lock brake control module returns the solenoid valves to their normal condition allowing fluid flow to the affected brake.

h. The anti-lock brake control module monitors the electromechanical components of the system.

j. Malfunction of the anti-lock brake system will cause the anti-lock brake control module to shut off or inhibit the system. However, normal power-assisted braking remains.

k. Loss of hydraulic fluid in the brake master cylinder will disable the anti-lock system. [li[The 4-wheel anti-lock brake system is self-monitoring. When the ignition switch is turned to the RUN position, the anti-lock brake control module will perform a preliminary self-check on the anti-lock electrical system indicated by a three second illumination of the yellow ABS wanting indicator.

l. During vehicle operation, including normal and anti-lock braking, the anti-lock brake control module monitors all electrical anti-lock functions and some hydraulic operations.

m. Each time the vehicle is driven, as soon as vehicle speed reaches approximately 20 km/h (12 mph), the anti-lock brake control module turns on the pump motor for approximately one-half second. At this time, a mechanical noise may be heard. This is a normal function of the self-check by the anti-lock brake control module.

n. When the vehicle speed goes below 20 km/h (12 mph), the ABS turns off.

p. Most malfunctions of the anti-lock brake system and traction control system, if equipped, will cause the yellow ABS warning indicator to be illuminated.

Fig-: ABS brakes on a Front Wheel

How to Test Brake Line Fittings

9. The base brake system in all modern cars is very similar to the hydraulic brake system introduced in the 1920 Duesenberg. Brake testing is simple and straightforward -- only a few hand tools are necessary.

How to Change Brake Pads

10 Changing the brake pads on your car or truck sounds like a difficult task -- but when you find out how simple it is, you'll wonder why you haven't been doing it yourself all along.

(Aero Engg Trg Sqn)

Syllabus : Automobile General Diesel and Petrol Technology

Course : Trade Training Advance, MTOF

Subject : Steering and Suspension Service

Aim : To Study Steering and Suspension Service

Ref. : Automotive Mechanics by William H. Crouse

STEERING AND SUSPENSION SERVICE

Steering and Suspension Trouble- Diagnosis Chart

1. A variety of steering and suspension problems bring the driver to the mechanic. The skilled technician should be able to diagnosis the cause of problem by inspection and road testing. Sometimes, an apparent steering problem is actually in the suspension system.

Steering and Suspension Trouble-Diagnosis Chart

Complaint	Possible Cause	Check or Correction
a. Excessive play in the steering system	(1) Looseness in steering gear	Readjust, replace worn parts
	(2) Looseness in linkage	Readjust, replace worn parts
	(3) Worn ball joints or steering-knuckle parts	Replace worn parts
	(4) Loose wheel bearing	Readjust
b. Hard Steering	(1) Power steering inoperative	Refer to manufacturer's service manual
	(2) Low or uneven tire pressure	Inflate to correct pressure
	(3) Friction in steering gear	Lubricate, readjust, replace worn parts
	(4) Friction in linkage	Lubricate, readjust, replace worn parts

Complaint	**Possible Cause**	**Check or Correction**
Continue	(5) Friction in ball joints	Lubricate, replace worn parts
Complaint	**Possible Cause**	**Check or Correction**
	(6) Incorrect alignment (caster, camber, toe, SAI)	Check alignment and readjust as necessary
	(7) Frame misaligned	Straighten
	(8) Front spring sagging	Replace or adjust
c. Car wander	(1) Low or uneven tire pressure	Inflate to correct pressure
	(2) Linkage binding	Readjust, lubricate, replace worn parts
	(3) Steering gear binding	Readjust, lubricate, replace worn parts
	(4) Incorrect front alignment (caster, camber, toe, SAI)	Check alignment and readjust as necessary
	(5) Looseness in linkage	Readjust, replace worn parts
	6) Looseness in steering gear	Readjust, replace worn parts
	(7) Looseness in ball joints	Replace worn parts
	(8) Loose rear springs	Tighten
	(9) Unequal load in car	Readjust load
	(10) Stabilizer bar ineffective	Tighten attachment, replace if damaged
d. Car pulls to one side when braking	(1) Brakes grab	Readjust, replace brake lining
	(2) Uneven tire inflation	Inflate to correct pressure
	(3) Incorrect or uneven caster	Readjust

Complaint	**Possible Cause**	**Check or Correction**
e. Car pulls to one side during normal driving	(1) Uneven tire pressure	Inflate to correct pressure
	(2) Uneven caster or camber	Check alignment, adjust as necessary
	(3) Tight wheel bearing	Readjust, replace parts if damaged
	(4) Uneven springs (sagging, broken, loose attachment)	Tighten, replace defective parts
	(5) Wheels not tracking	Check tracking, straighten frame, tighten loose parts, replace defective parts
	(6) Uneven torsion- bar adjustment	Adjust
	(7) Brakes dragging	Repair
f. Front- wheel shimmy at low speed	(1) Uneven or low tire pressure	Inflate to correct pressure
	(2) Loose linkage	Readjust, replace worn parts
	(3) Loose ball joint	Replace worn parts
	(4) Looseness in steering gear	Readjust, replace worn parts
	(5) Front springs too flexible	Replace, tighten attachment
	(6) Incorrect or unequal camber	Readjust
	(7) Irregular tire tread	Replace worn tires, match treads
	(8) Dynamic imbalance	Balance wheels

Complaint	**Possible Cause**	**Check or Correction**
g. Front- wheel tramp (high speed shimmy)	(1) Wheels out of balance	Rebalance
	(2) Too much wheel run out	Balance, remount tire straighten or replace wheel
	(3) Defective shock absorber	Repair or replace
h. Steering kickback	(1) Tire pressure low or uneven	Inflate to correct pressure
	(2) Springs sagging	Replace, adjust torsion bars
	(3) Shock absorbers defective	Repair or replace
	(4) Looseness in linkage	Readjust, replace worn parts
	(5) Looseness in steering gears	Readjust, replace worn parts
j. Tires squeal on turns	(1) Excessive speed	Take curves at slower Speed
	(2) Low or uneven tire pressure	Inflate to correct pressure
	(3) Front alignment incorrect	Check and adjust
	(4) Worn tires	Replace

Complaint	**Possible Cause**	**Check or Correction**
k. Improper tire wear	(1) Wear and tread side from under inflation	Inflate to correct pressure
	(2) Wear and tread center from over inflation	Inflate to correct pressure
	(3) Wear and one tread side from excessive camber	Adjust camber
	(4) Featheredge wear from excessive toe-in or toe-out	Correct toe-in or toe-out in turns
	(5) Concerning wear from excessive speeds on turns	Take turn at slower speeds
	(6) Uneven or spotty wear from mechanical causes	Adjust brakes, align wheels, balance wheels, and adjust linkages.
	(7) Rapid wear from sped	Drive more slowly for longer tire life
l. Hard or rough ride	(1) Excessive tire pressure	Reduce to correct pressure
	(2) Defective shock absorbers	Repair or replace
	(3) Excessive friction in spring suspension	Lubricate, realign parts
m. Sway on turns	(1) Loose stabilizer bar	Tighten
	(2) Weak or sagging springs	Repair or replace

Complaint	**Possible Cause**	**Check or Correction**
	(3) Caster incorrect	Adjust
	(4) Defective shock absorbers	Replace

Complaint	**Possible Cause**	**Check or Correction**
n. Spring breakage	(1) Over loading	Avoid over loading
	(2) Loose center pr U bolts	Keeps bolt tight
	(3) Defective shock absorber	Repair or replace
	(4) Tight spring shackle	Loosen or replace
p. Sagging spring	(1) Broken leaf	Replace
	(2) Spring weak	Replace
	(3) Coil spring short	Install shim
	(4) Defective shock absorber	Repair or replace
q. Noises	Could come from any loose, worn, or unduplicated part in the suspension or s tearing system	Replace

Excessive Play in Steering System

2. Excessive looseness in the steering system means that there will be excessive free play of the steering wheel without corresponding movement of the front wheels. A small amount of free play makes steering easier. But when the play, or lash, becomes excessive, it may make steering harder. Many drivers complain about it. Excessive free play in the steering sys- tem reduces the ability of the driver to accurately steer and control the vehicle. Excessive play may be due to wear or improper adjustment of the steering gear, worn parts or improper adjustments in the steering linkage, worn ball joints or steering-knuckle parts, or loose wheel bearings. In most cars with power steering, the steering-wheel rim should move 2 inches [51 mm] or less before the front wheels begin to move. On cars with manual steering, the maximum allowable free play is 3 inches [76 mm]. Figure -1 shows this measurement. *Continue*

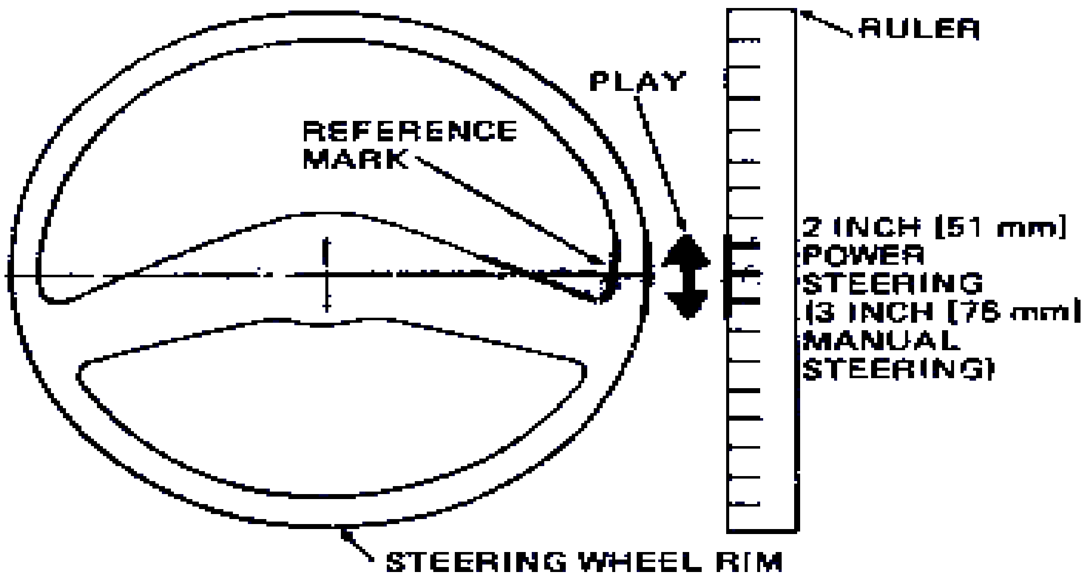


Fig-1 checking for play in the steering wheel

To check the amount of play in the steering system on vehicles with power steering, check the condition and tension of the drive belt for the power-steering pump. Then check the fluid level in the pump reservoir. Start the engine. Next, with the front wheels in the straight-ahead position, turn the steering wheel until the front wheels begin to move. Align a reference mark on the steering wheel with a mark on a ruler or scale (Fig.-1). Now slowly turn the steering wheel in the opposite direction until the front wheels start to move again. The distance that the steering-wheel reference mark has moved along the ruler is the amount of free play in the steering system. If the steering-wheel rim moves too much before the front wheels begin to move, there is excessive play.

a. **Steering-Linkage Check.** Steering linkage, including tie rods, can be checked for looseness. Raise the front of the car until the bottoms of the tires are lightly off the floor. Then grasp both front tires and push out on both at the same time

(Fig -2). Next pull in on both tires at the same time. Excessive movement means worn linkage parts. Excessive movement in the steering linkage can cause wheel shimmy, vehicle wander, uneven braking, steering- control problems, and excessive tire wear. On vehicles with 16 inch [406 mm] diameter (or smaller) wheels, the maximum movement should be 1/4 inch [6.35 mm] or less. Other steering and suspension check points for each car are shown in the manufacturer's service manual.

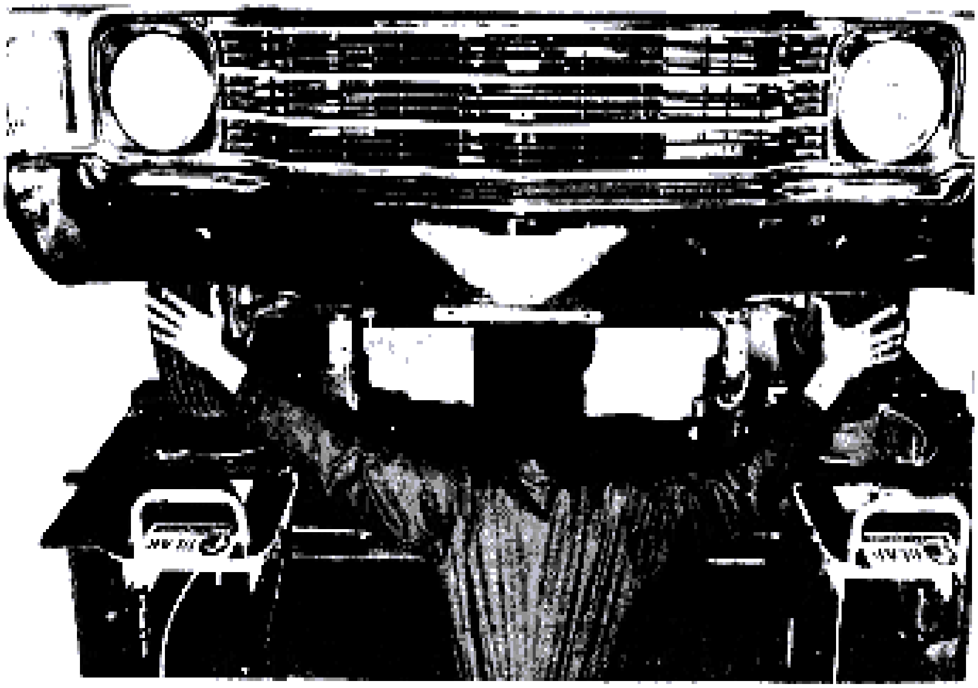


Fig – 2 checking looseness in steering linkage and the rod.

Note: The movement is excessive and the wheel bearings have not been adjusted. They may be loose. This will give a false reading by allowing excessive movement. To eliminate the effect of the wheel bearings, apply the brakes during the check. An assistant can do this, or you can use a portable brake depressor.

b. **Inspecting Front-Wheel Bearings.** Loose wheel bearings can cause poor steering control, car wander, uneven front-brake action, and rapid tire wear. To check the front- wheel bearings, raise the car on a lift or use floor jacks, properly placed. The lift points differ according to the type of front end. If the spring is between the frame and the lower control arm, the car should be lifted at the frame cross member. Use this same lift point for torsion-bar suspension systems that have the torsion bar attached to the lower control arm. If the spring is above the upper control arm, lift the vehicle at the lower control arm, close to the ball joint. Use this same lift point if the torsion bar is attached to the upper control arm. In either case, the weight of the wheel should take up any play in the ball joints. Now grasp the tire at the top and bottom (Fig-3), and rock. it In and out. Any movement is usually the result of loose front-wheel bearings. Look at the brake drum or disk and the backing plate or shield as you rock the wheel. If you see movement between the drum or disk and the plate or shield, the looseness is in the wheel bearing. Another check is to have an assistant apply the brakes as you try rocking the wheel. If this eliminates the free play, the wheel bearings are loose. In some inspection programs, the vehicle should be rejected if the wheel can be rocked more than⅛ inch [3.2 mm], measured at the outer circumference of the tire. This amount of wheel wobble can make the vehicle unstable and hard to steer. The wheel bearings should be adjusted.

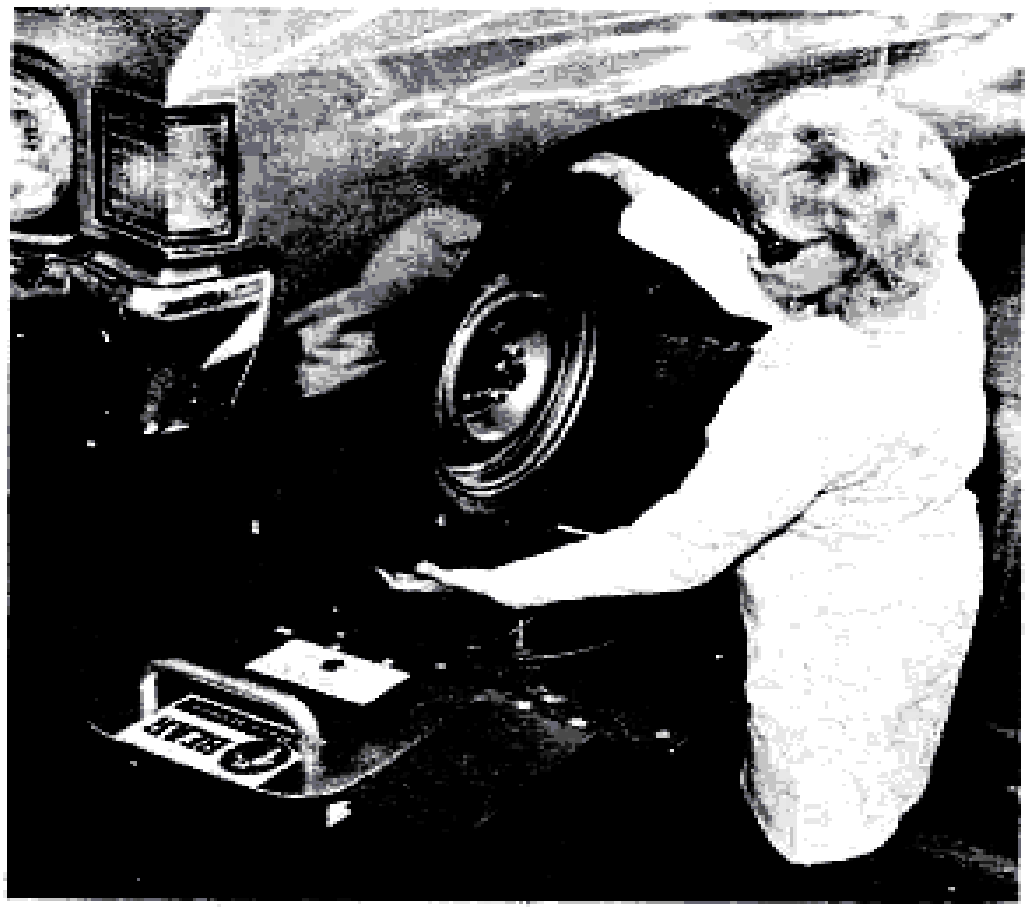


Fig – 3 checking for wear in the Ball joints and Wheel bearing,

c. **<u>Inspecting Ball Joints.</u>** Ball joints can be checked for wear while the wheel is supported as shown in Figs-4 and 5. Axial play or tolerance is also called vertical movement. It is checked by moving the wheel straight up and down. Radial play or tolerance also is called horizontal movement. It is checked by rocking the wheel in and out at the top and bottom. Figure - 3 shows this check. The actual amount of play in a ball joint is measured with a dial indicator. In Fig. 50-6, the dial indicator is clamped to the lower control arm. The plunger tip rests against the steering-knuckle leg. With a pry bar, try to raise and lower the steering knuckle. As you do this, the play in the ball joint i will show on the dial indicator. On the front-wheel-drive car:

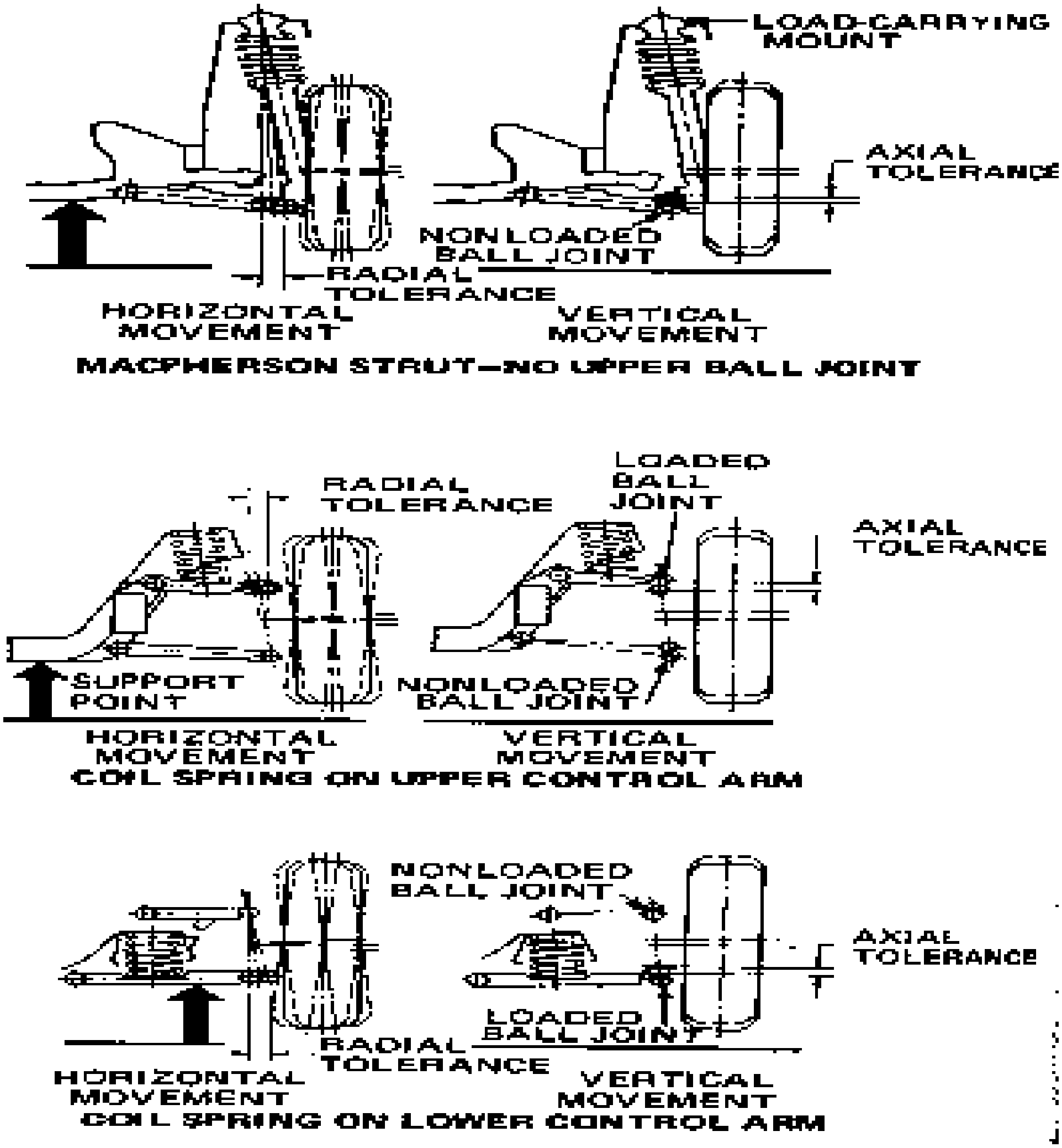
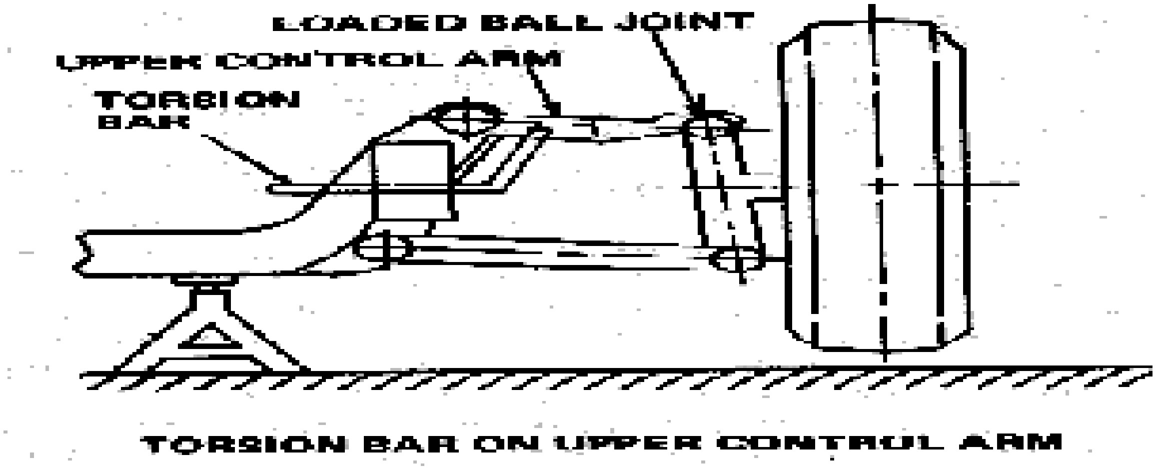


Fig-4 Support points for checking ball joints front-suspension systems using coil springs

Shown in Fig-6, vertical movement of the ball joint must not exceed 0.050 inch [1.2 mm]. The axial (up-and-down) play in a typical ball joint should not exceed V16 inch [1.6 mm]. The ball joints on vehicles manufactured prior to 1973 must be inspected with the ball joints unloaded. This means that the weight of the car must be removed from them. Be- ginning with some 1973 vehicles, manufacturers used wear-indicating ball joints. It is much easier to check this type of ball joint for wear. A quick visual check is all that is necessary .The check is made with the ball joints loaded, or carrying the weight of the car. *Continue*



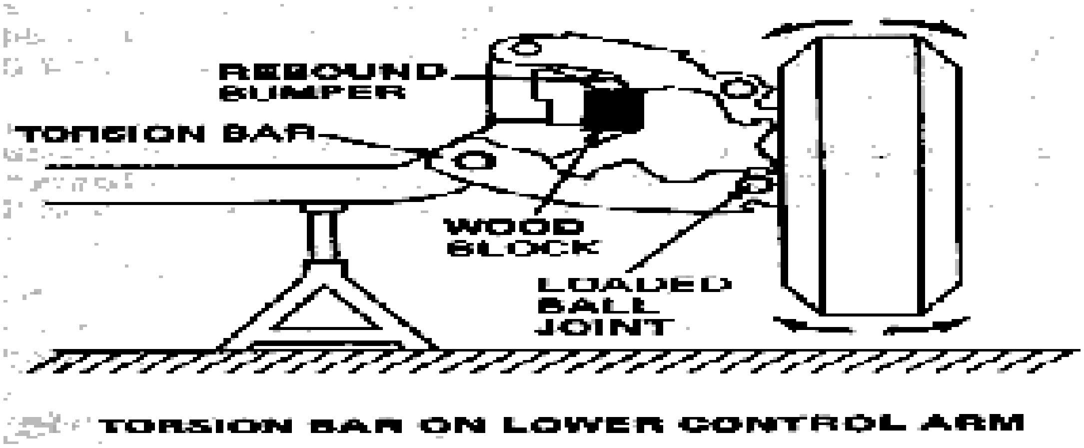


Fig-5 Support points for checking ball joints front-suspension systems using torsion bar.

Figures 4 and 5 identify the loaded and nonleaded ball joints for various suspension systems. The load is carried by the upper strut mount or by the ball joint for the control, arm on which the spring acts. For example, when the spring is mounted on the upper control arm, the upper ball joint carries the load. When the spring is mounted on the lower control arm, the lower ball joint carries the load. Most wear occurs in the load-carrying ball joints. Nonleaded ball joints usually wear relatively little.

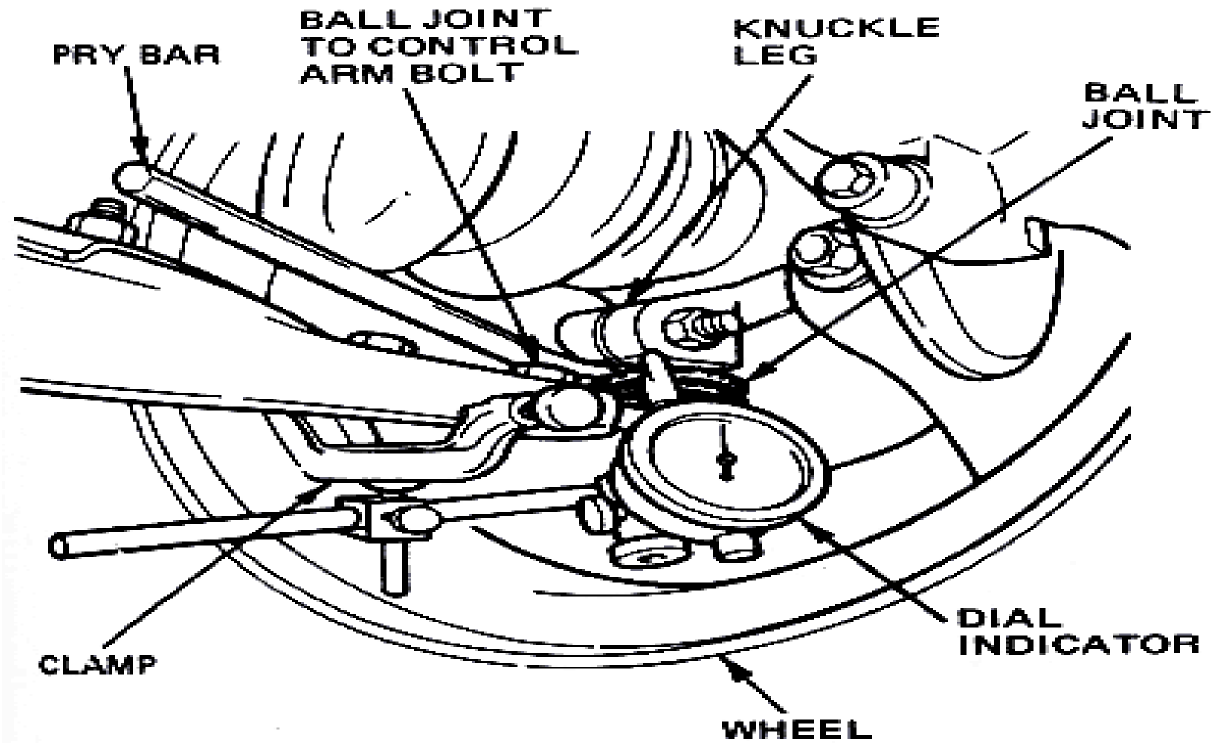


Fig-6 a Dial indicator can bused to measure the amount of play of ball joint

Figure -7 shows the use of a pry bar to check the ball joints. Pry under the front tire to see how much vertical movement the ball joints allow. Use only enough force to overcome the weight of the wheel assembly. If you use too much force, the ball joint may give you a false reading. You want to measure the movement of the wheel and ball joint as the joint is moved up to the LOAD position. Note the movement as indicated on the dial indicator. Next, grasp the tire at top and bottom (Fig -3), and try to wobble it. This is the test described earlier for inspecting front-wheel bearings. However, now we are assuming that the wheel bearings have been checked and either adjusted or found to be properly tightened. Therefore, we are now checking the horizontal movement of the ball joints. However, some manufacturers do not accept horizontal movement as an indicator of ball-joint wear .The actual specifications for the allowable wear limits of the ball joints are listed in the manufacturer's service manual. Refer to the specifications for the car you are checking. *Continue*

Figure – 7 Pry upward on the tire with a bar to check for loose ball joints

Note: *Some ball joints are preloaded with rubber or springs under compression. They should have very little movement In a vertical direction. These ball joins are marked as **preloaded** tables*.

Any ball joint should be replaced if there is excessive play in it on certain vehicles with the spring on the lower control arm, some manufacturers specify replacement of the lower ball joint whenever the upper ball joint is replaced. When checking ball joints on 1955 through 1970 Chevrolet cars the lower ball joint should be replaced if the radial play exceeds0.250 inch [6.35 mm]. Today this tolerance is less on most ball joints the lower ball joint should also be replaced if axial play between the lower controls arm and the spindle exceeds the tolerance specified in the manufacturer's service manual this specification may vary from 0 to 0.150 inch 3.81 mm]. When the spring is on the upper control arm, the specifications for some cars do not allow any play in the lower ball Joint. The lower ball joint should be replaced if it has any noticeable looseness. The upper ball joint should be replaced if the radial play exceeds 0.250 inch [6.35 mm]. The upper ball joint should also be replaced if the axial play between the upper control arm and the spindle exceeds the tolerance specified by the vehicle manufacturer. This specification may vary from 0 to 0.095 inch [2.41 mm] or more. For example, Ford specifies that no check for vertical movement, or axial play, is necessary when the spring is on the upper control arm. They recommend only that the radial play should be checked, using a dial indicator.

d. Inspecting Wear Indicating Ball Joints. Many cars have ball joints with wear indicators. The wear of this joint can be checked by visual inspection alone (Fig - 8). The amount of wear is indicated by the recession of the grease-fitting nipple into the ball joint socket. On a new ball joint, the nipple protrudes from the socket, 0.050 inch [1.27 mm]. As the ball joint wears the nipple recedes into the socket. When the wear has caused the nipple to recede 0.050 inch [1.27 mm] or more, the nipple will be level with or below the socket. Then replace the ball joint. To check a wear-indicating ball joint, the vehicle should be supported on its wheels so that the ball joints are loaded. You may find it convenient to raise the car on a drive-on type of lift so that you can get to the ball joints easily. Wipe the grease fitting to remove all dirt and grease. Then note the position of the grease-fitting nipple and compare with Fig. 50-8. Use a steel scale to check the position of the nipple. However, the wear can also be checked with a screw driver or even your fingernail. If the scale, screwdriver, or your fingernail passes over the nipple because it has recessed into the socket, then the ball joint is worn and should b replaced, Any ball joint that has cut, torn, or damaged seals should also be replaced.

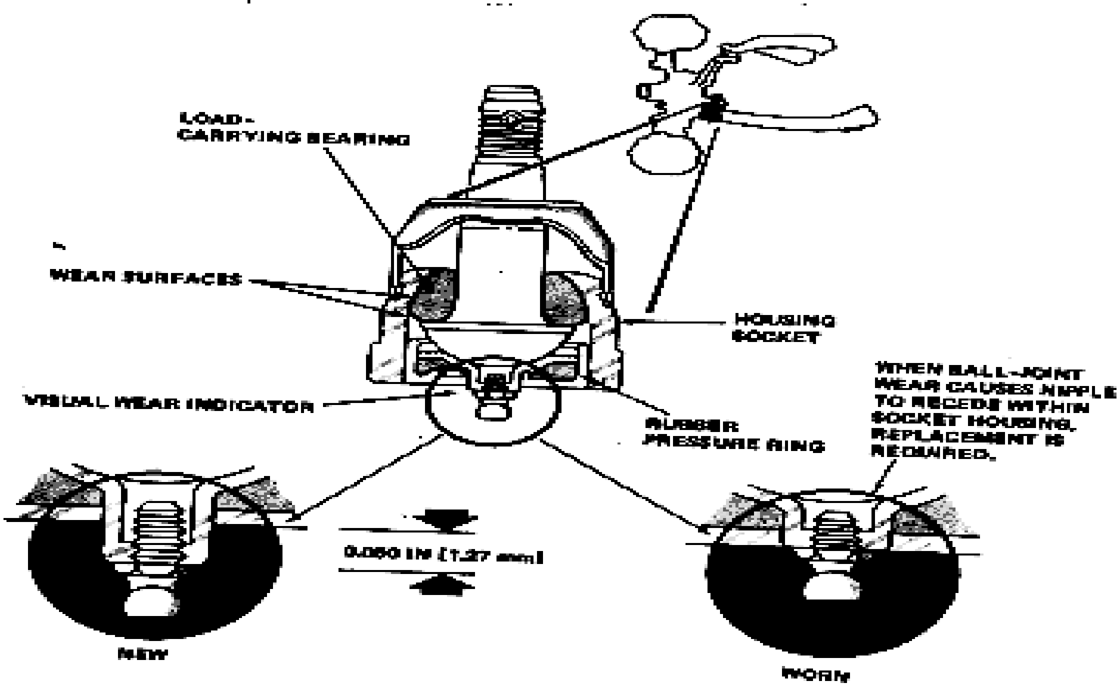


Fig - 8 how wear-indicating ball joints show that ball-1oint replacement is necessary. In a Worn ba1ljoipt, the grease-fitting nipple recedes into the socket, as shown to the right.

e. **Steering-Gear Check.** A quick check for looseness in the steering gear can be made by watching the pitman an while an assistant turns the steering wheel one way and then the other, with the front wheels on the floor. If, after reversal of steering-wheel rotation, excessive movement of the steering wheel is required to move the pitman arm, then the steering gear is worn or in need of adjustment Steering-gear service is covered in the manufacture's service manual.

Hard Steering

3. If hard steering occurs, it is probably due to excessively tight adjustments in the steering gear or linkages. Hard steering can also be caused by low or uneven tire pressure; abnormal friction in the steering gear, in the linkage, or at the ball joints; or improper wheel or frame alignment. If the car has power steering, its failure causes the steering system to revert to straight mechanical operation. A much greater steering force is then required from the driver. When this happens, the power-steering gear and the pump should be checked as outlined in the manufacturer's service manual. The steering system may be checked for excessive friction by raising the front end of the car, turning the steering wheel, and checking the steering-system components to locate the source of excessive friction. Disconnect the linkage of the pitman arm. If this eliminates the frictional drag that makes the steering wheel hard to turn, then the friction is either in the Linkage itself or at the steering knuckles. If the friction is not-eliminated when the linkage is disconnected at the pitman arm, the steering gear is probably at fault. If hard steering does not seem to be due to excessive friction in the steering system, the cause is probably incorrect front-wheel alignment, a misaligned frame, or sagging springs. Excessive caster, especially, causes hard steering. Wheel alignment is described later in the chapter.

Car Wander

4. Wander is the tendency of a car to veer away from a straight path without driver control. Frequent steering-wheel movements are necessary to prevent the car from weaving from one side of the road to the other. An example is when the driver must continually move the steering wheel back and forth to keep the car on the right side of the road or in the proper lane of traffic. A variety of conditions can cause car wander. Low or un- even tire pressure, binding or excessive play in the linkage or steering gear, or improper front-wheel alignment will cause car wander. Any condition that causes tightness in the steering system will keep the wheels from automatically seeking the straight-ahead position. The driver has to correct the wheels constantly. This condition would probably cause hard steering, which is described in the previous section. Loose- ness or excessive play in the steering system might also cause car wander. These conditions tend to allow the wheels to waver slightly from their normal running position. Several improper wheel-alignment angles may cause car wander. Excessively negative caster or uneven caster on the front wheels will tend to cause the wheels to swing away from the straight-ahead direction so that the driver must steer continually. An incorrect camber angle will do the same thing. Excessive toe-in may also cause the same condition.

Car Pulls To One Side during Normal driving

5. Sometimes a car pulls to one side so that force must constantly be applied to the steering wheel to maintain straight ahead travel. The cause could be uneven tire pressure, uneven caster or camber, a tight wheel bearing, uneven springs, uneven torsion bar adjustment,

or wheels not tracking. A lack of tracking means that the rear wheels are not following a path that is parallel to the path of the front wheels. Figure-9 shows this problem.
Anything that makes one wheel drag or toe-in or toe-out more than the other causes the car pulls to that side. The methods used to check tracking and front-wheel alignment are described later.

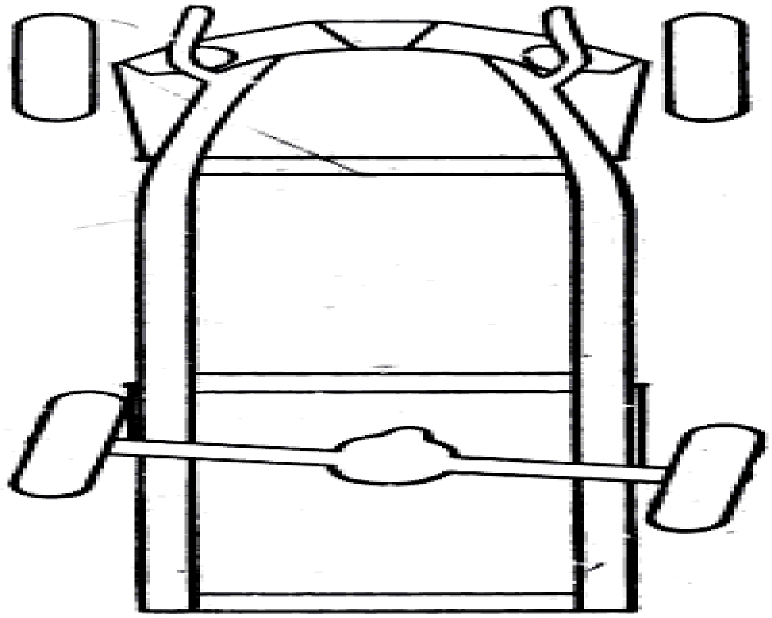


Fig – 9 If the frame Is bent or the rear axle Is swung back on one side. The car will not track properly.

Car Pulls To One Side When Braking

6. The most likely cause of pulling to one side when braking is grabbing brakes. This happens when the brake Lining on the shoes or pads becomes soaked with oil or brake fluid, when brake shoes are unevenly or improperly adjusted, or when a stuck wheel cylinder or caliper piston causes the shoes at one wheel to apply less braking force than the shoes at the wheel on the other side of the axle. The conditions listed in (Car wander) that cause car wander could also cause the car to pull to one side when braking. A pulling condition, from whatever cause, tends to become more noticeable as the car is braked to a stop.

Low-speed front-wheel Shimmy

7. Front-wheel shimmy and front-wheel tramp are sometimes confused. Low-speed shimmy is the rapid oscillation of the wheel on the steering-knuckle support. The wheel tries to turn in and out alternately. This action causes the front end of the car to shake from side to side. Front-wheel tramp, or high-speed shimmy, is the tendency for the wheel-and-tire

assembly to hop up and down and try to leave the pavement. Even when the tire does not leave the pavement, tramp can be observed as a rapid flexing-unflexing action of that part of the tire in contact with the pavement. The bottom of the tire first' appears deflated as the wheel moves down. *Continue*

Then appears inflated as the wheel moves up and low-speed shimmy can result from low or uneven tire pressure, excessive lateral run out, looseness in linkage, excessively soft springs, incorrect or unequal wheel camber, dynamic imbalance of the wheels, or tire-tread irregularities.

Front-wheel Tramp

8. Front-wheel tramp is often called high-speed shimmy. This condition causes the front wheels to move up and down alternately. One of the most common causes of front-wheel tramp is unbalanced wheels, or wheels that have too much radial run out. An unbalanced wheel is heavy in one spot, like the wheel in Fig-10. As it rotates, the heavy spot acts as an unbalanced rotating force. This tends to make the wheel hop up and down. A similar action occurs if the wheel has too much radial run out. This is the amount that the wheel rotates out-of- round, instead of making a true circle as it turns. Defective shock absorbers, which fail to control spring oscillations, also cause wheel tramp. Any of the causes described in the previous section on front-wheel shimmy may also cause wheel tramp. Servicing of the wheel and tire is described in earlier Chap.

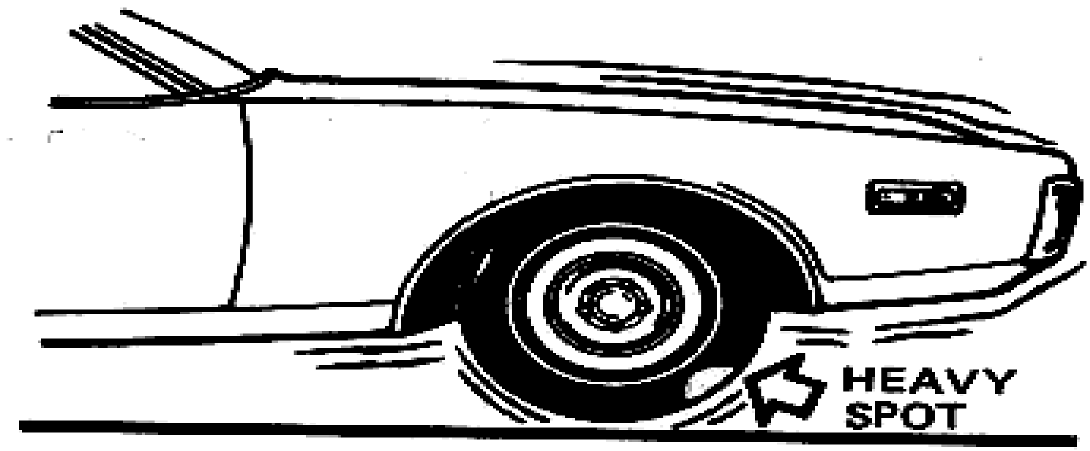


Fig -10 Front-wheel tramps can be caused by an out-of- balance wheel and tire
Steering kickback

Steering shock, or kickback

9. Steering shock, or kickback, consists of sharp and rapid movements of the steering wheel that occur when the front wheels encounter obstructions in the road. Normally, some kickback to the steering wheel will always occur. When it becomes excessive, an investigation should be made. This condition could be the result of incorrect or uneven tire

inflation, sagging springs, defective shock absorbers, or looseness in the linkage or steering gear. Any of these defects could permit road shock to carry excessively to the steering wheel.

Tires Squeal on Turns

10. If the tires skid or squeal on turns; the cause may be excessive speed on the turns. If this is not the cause, it is probably low or uneven tire pressure, worn tires, or misalignment of the front wheels. Improper camber and toe settings may tend to cause tire squeal.

Hard or Rough Ride

11. A hard or rough ride could be due to excessive tire pressure, improperly operating shock absorbers, or excessive friction in the spring suspension. The spring suspension can be checked for excessive friction in leaf-spring suspension systems. With a yardstick, measure from the floor to the lower edges of the car body, front and back. Then lift the front end of the car as 'high as possible by hand, and very slowly let it down. Carefully measure again and write down the distance. Push down on the car bumper at the front end, and again slowly release the car. Re-measure the distance from the floor to the body. Note the difference in measurements. Repeat this action several times to obtain accurate measurements. The difference is caused by the friction in the suspension system is called friction lag. After determining friction lag at the front end, check it at the rear of the car. Excessive friction lag is corrected by lubricating the springs, shackles, and bushings (on types where lubrication is specified) and by loosening the shock-absorber mounts, shackle bolts, and U bolts. Then retighten the U bolts, shackle bolts, and shock-absorber mounts, in that order. This procedure permits realignment of parts that might have become misaligned and caused excessive friction. A quick check of shock-absorber action on cars giving a 'd or uneven ride may be made by bouncing each corner of , car in turn. Shock-absorber bounce testing is described in earlier chap.
Sway on Turns

Sway on Turns

12. Sway of the car body on turns or on rough roads may be due to a loose stabilizer bar or sway bar. Stabilizer-bar attachments to the frame, axle housing, or suspension arms should checked. Weak or sagging springs could also cause excessive sway. If the shock absorbers are ineffective, they may permit excessive spring movement. This could cause strong body pitching and sway, particularly on rough roads. If the caster is excessively positive, it will cause the car to rollout, or lean out, on turns. Front-wheel alignment should be corrected.

Spring Breakage

13. Breakage of leaf springs can result from excessive overloading; loose U bolts that cause breakage near the center bolt, a loose center bolt that causes breakage at the center-bolt holes, an improperly operating shock absorber that causes breakage of the master leaf,

or a tight spring shackle that causes breakage of the master leaf near or at the spring eye. Determining the point at which breakage has occurred usually indicates the cause.

Sagging springs

14. For wheel alignment to be correct, the car must have the specified front-suspension height. Sagging springs allow the front-suspension height to drop. Springs will sag if they become weak, for example, from frequent overloading. When a coil-spring front-suspension system is overhauled, failure to return the shim to the coil-spring seat will make the spring seem shorter and give a sagging effect. Not all coil springs require or use shims. On many cars, shimming under a spring is not recommended. If a torsion- bar suspension system sags, the torsion bars can be adjusted to restore normal car height. Defective shock absorbers may restrict spring action. This makes the springs appear to sag more than normal. To check for sag of the coil spring, position the car on a smooth, level surface, bounce the front end several times, raise the front end, and allow it to settle. Then take the measurements shown in Fig -14. The differences should be as noted in the specifications for the car being checked. Next, take the measurements on the other side. The difference between the two sides should be no greater than 1/2 inch [12.7 mm]. To make a correction, the coil springs must be replaced. On a car with torsion bars, a similar check may indicate that the torsion bars should be adjusted.

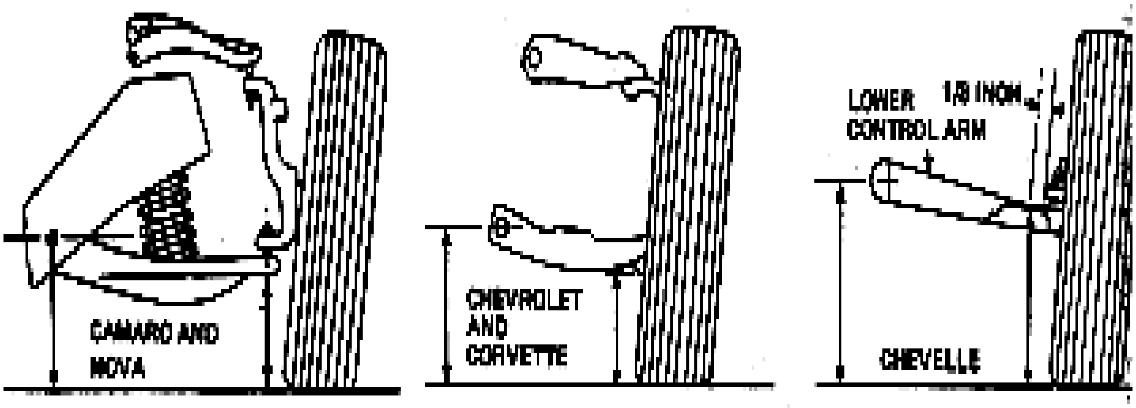


Fig-11 Measurements to check for front-spring sag on various cars

Noises

15. The noises produced by defects in springs or shock absorbers will usually be either rattles or squeaks. Rattling noises can be produced by looseness of leaf-spring U bolts, metal spring covers, rebound clips, spring shackles, or shock-absorber mounts. These noises can usually be located by a careful examination of the various parts in the suspension system. Spring squeaks can result from a lack of lubrication in the spring shackles, at spring bushings, or in a leaf spring itself. Squeaks in the shock absorber can result from tight or dry bushings. Rattles in the steering linkage may develop if link- age parts become loose. Sometimes squeaks during turns can develop because of a lack of lubrication in the joints or bearings of the steering linkage. This condition also produces hard

steering. Some of the connections between steering-Linkage parts are made with ball sockets that can be lubricated. Others are permanently lubricated on original assembly. If these develop squeaks or excessive friction, they must be replaced.

Service Steering Linkages and Suspension

16. If any defects are found, causes must be determined and correction made before attempting to align the wheels. Servicing steering and suspension includes removal, replacement, and adjustment of tie rods; removing and replacement of other linkage parts, such as the steering idler and upper and lower control arms; removal and replacement of springs; and removal and reinstallation of wheel hubs and drums or disks. In addition, the steering gear may require adjustment, or removal for service. All of these services, if needed, must be performed before aligning the wheels. It does no good to do an alignment if the wheel bearings or other part is defective, worn out, or in need of adjustment. If service to any of the above components is required, refer to the manufacturer.

Wheel Alignment

17. There are many types of wheel aligners. Some are mechanical types that attach to the wheel spindles (Fig -12). Some have light beams that display the measurements on a screen in front of t he car (Fig -13) others are electronic that indicate the measurements on meters, displays or printouts. When doing a front wheel alignment, you check and adjust (if needed) caster, camber, and toe. You also measure SAI and turning radius. These are not adjustable if they are out of specifications, it means parts are bent or damaged and must be replaced. However, before you make the alignment checks, the following pre-alignment inspection must first be made.

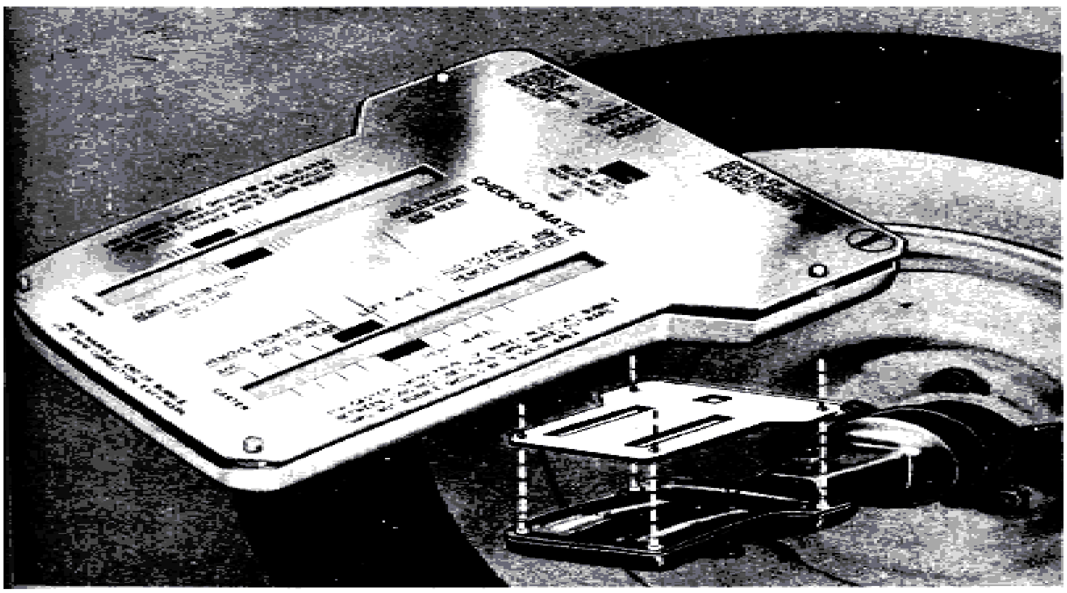


Fig-12 A mechanical caster camber gauge attach to the front wheel spindle.

<u>Wheel Alignment Checked</u>

18. a. Check correct tyre pressure

b. Check and adjust wheel bearing

c. Check and adjust wheel run –out

d. Check ball joints and, if they are too loose, replace them

e. Check steering linkages, and make any corrections necessary

f. Check wheel balance, and correct it if necessary

g. Check rear leaf springs for cracks, broken leaves, and loose U bolts. Make any corrections if necessary

h. Check front-suspension height

j. Check shock absorbers, and replace them if they are defective

k. Check wheel tracking. This means checking where the rear wheels follow the front wheels or is off the track. If the wheels are off the track, it usually means a bent frame. The frame must be straightened before you can do a wheel alignment.

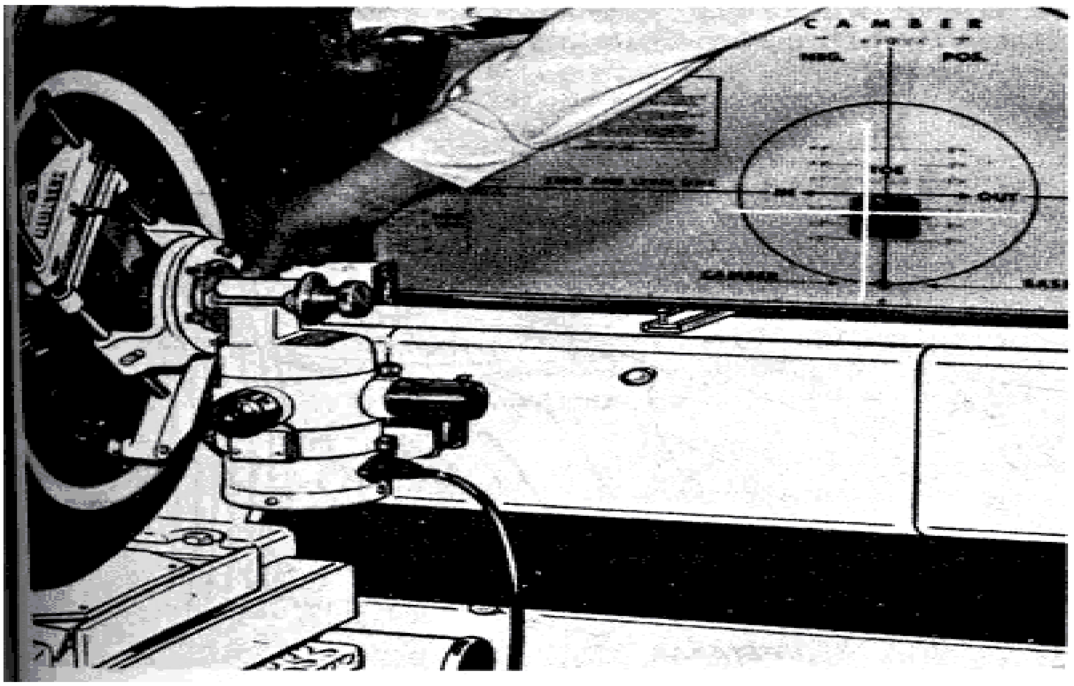


Fig – 13 adjusting the wheel gauge to make a wheel alignment check.

<u>Wheel Balance</u>

19. The wheel may be checked for balance on or off the car. This is done by either of two methods: static or dynamic. In static balancing, the wheel is taken off the car and put on a "bubble" balance or detect any imbalance (Fig -14). A wheel that is out of balance is heavier in one section. This will cause the bubble in the center of the balancer to move off center. To balance the wheel, weights are added to the wheel rim until the bubble returns to center.

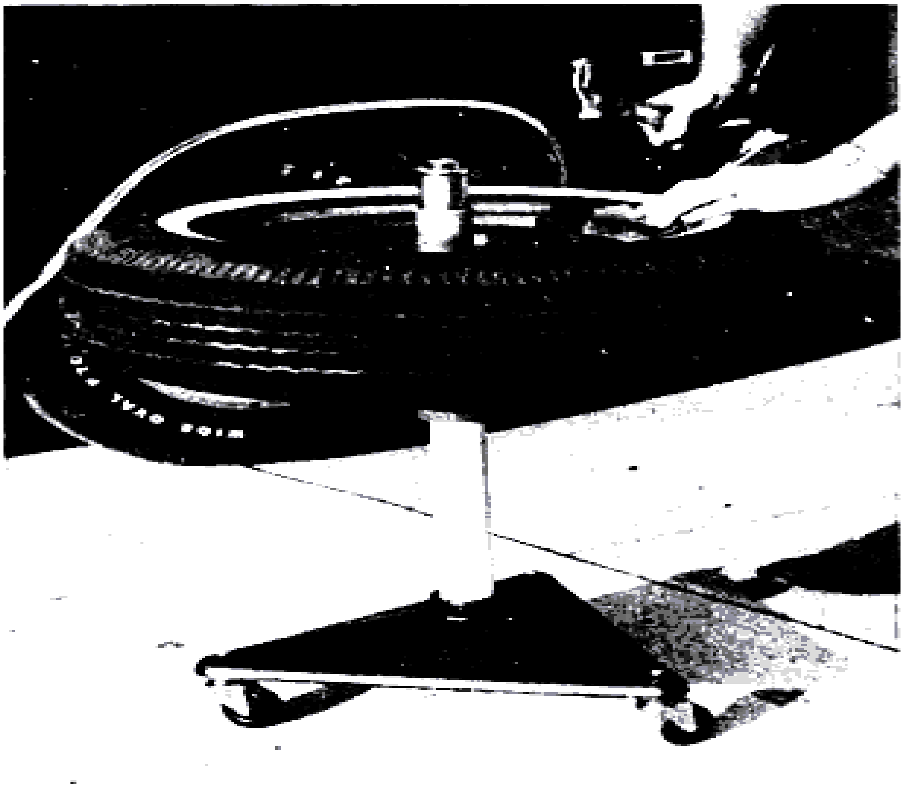


Fig – 14 Bubble or static type of wheel balancer

To dynamic- balance (or ""spin-balance") a wheel, the wheel is spun either on or off the car. Fig -15 shows an electronic wheel balancer being used to balance a wheel on a car. Lack of balance shows up as a tendency for the wheel to move off center or out of line as it spins. If the wheel is out-of balance, one or more weights are installed on the wheel rim. In the shop, you will learn how to balance wheels.

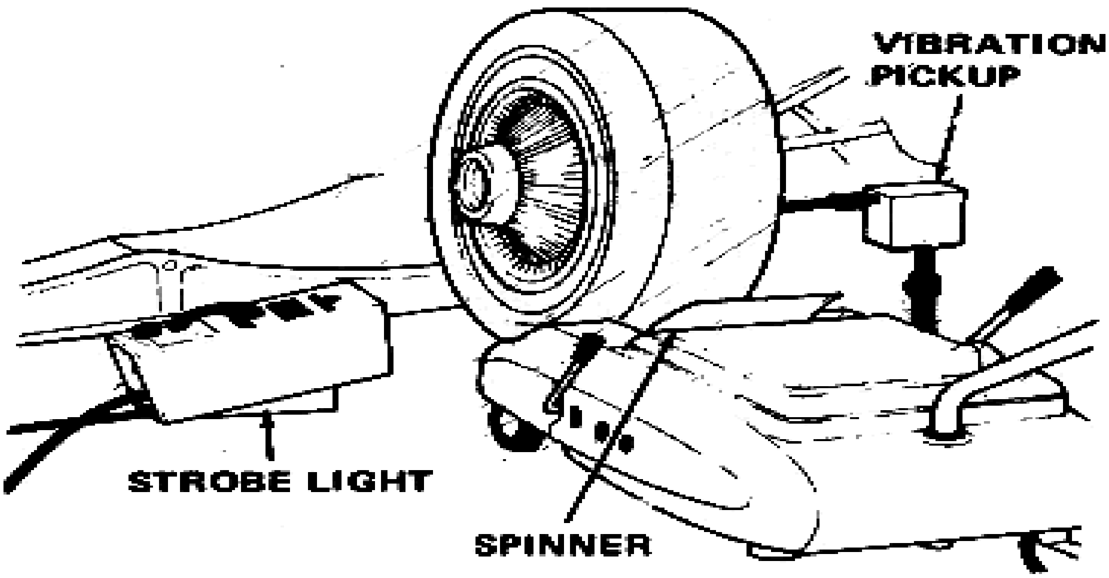


Fig -15 An electronic type dynamic wheel balancer

<u>Adjusting Camber and Caster</u>

20. Several different ways to adjust camber and caster have been used. Some of the methods include removing and installing shims, turning a cam, shifting the inner control-arm shaft, and changing the length of the strut rod.

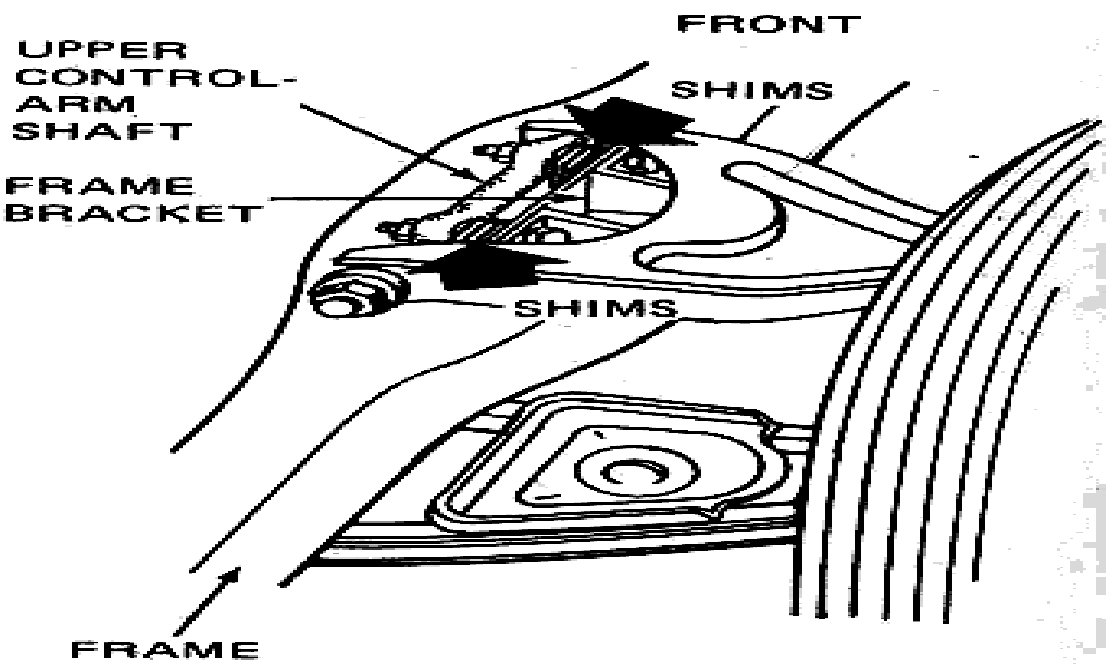


Figure -16 Location of caster and camber adjusting shims

a. **Adjustment by Installing or Removing Shims**. The shims are located at the upper control-arm shafts. They are placed either inside or out side the frame bracket. Figure - 16 shows the location of the shims in many general motors cars. The shims are inside the frame bracket. Figure -17 shows the location of the shims in many ford cars. The shims are outside the frame bracket. When the shims are inside the frame bracket, adding shims moves the upper control arm inward. This reduces positive camber. When the shims and shaft are outside the frame bracket, adding shims moves the upper control arm outward. This increases positive camber. If shims are added at one attachment bolt and removed the other, the outer end of the upper control arm shafts one way or the other. This increases or decreases caster.

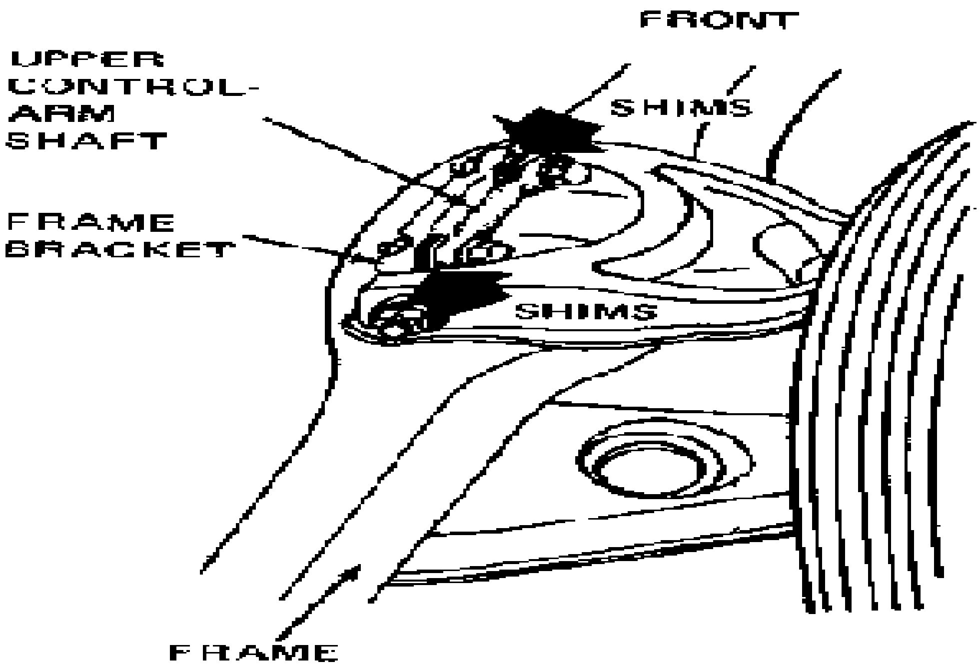


Figure -17 Location of caster and camber adjusting shims

b. **Adjustment by Turning a Cam.** There have been several variations of this method.Figure-18 shows the arrangement used on some Chrysler- built cars. The two bushings at the inner end of the upper control arm attached to the frame brackets by two attachment bolts and cam assemblies. When the cam bolts are turned, the camber and caster are changed. If both are turned the same amount and in the same direction, the camber is changed. If only one can bolt is turned, or if the two are turned in opposite directions, the caster is changed.

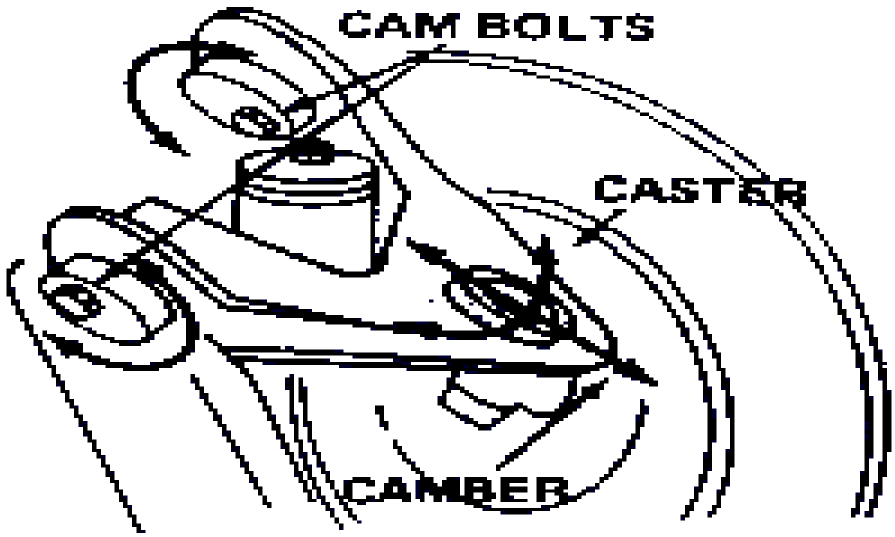


Figure -18 Turning the cam bolts

c. **<u>Adjustment by Shifting Inner Shaft.</u>** This system uses slots in the frame at the two points where the inner shaft is attached. When the attaching bolts are loosened, the inner shaft can be shifted in or out to change camber. Only one end is shifted to change caster.

d. **<u>Adjustment by Changing Length of Strut Rod.</u>** This type of adjustment is shown in fig -19.

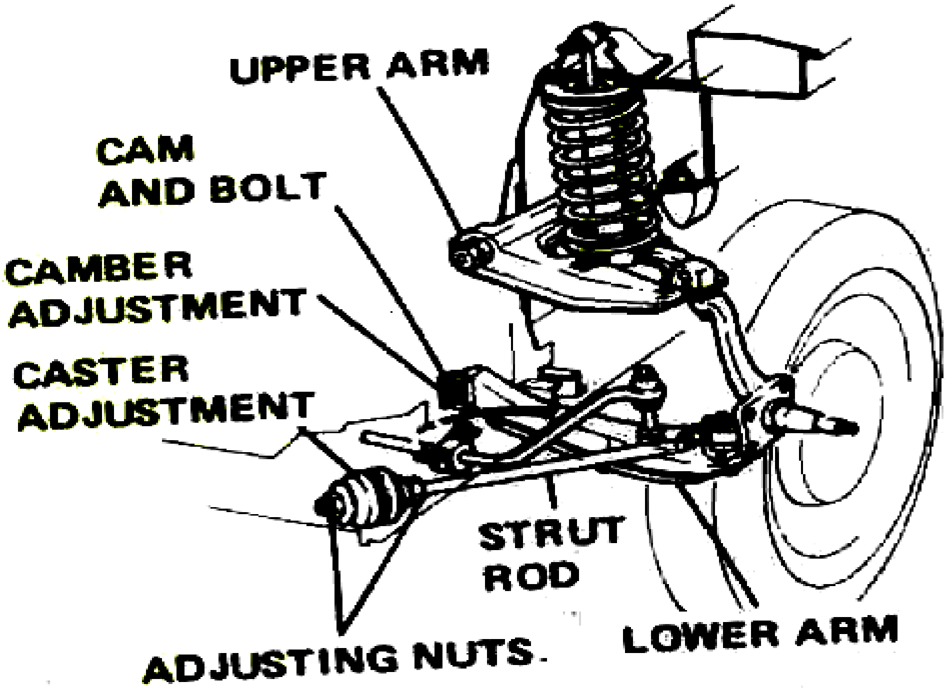


Fig -19 (50-25) Adjusting caster by Changing Length of Strut Rod

Adjusting toe

21. After correcting caster and camber, toe is adjusted. Place the front wheels in the straight-ahead position. Then check the positions of the spokes in the steering wheel. If they are not centered, they can be properly positioned when toe is set. Toe is adjusted by turning the adjuster sleeves in the linkage. If the adjuster sleeves are turned to lengthen the tie rods, the toe-in is increased.

Rear-wheel Alignment

22. On cars on front-wheel drive and cars with independent rear suspension. Such as the Chevrolet Corvette, the rear-wheel alignment can be checked. One method is to back the car onto the gauges used to align the front-wheels. Camber will read in the normal manner. But toe-in will read as toe-out, and toe-out will read as toe-in. Caster is usually set as zero originally and needs no adjustment. Check that the strut rods are straight. If they are bent, replace them.

a. **Camber Adjustment**. This is adjusted by turning the eccentric cam and bolt (Fig-20). Loosen the cam-bolt nut and turn the assembly to adjust the camber. Then tighten the cam-bolt nut.

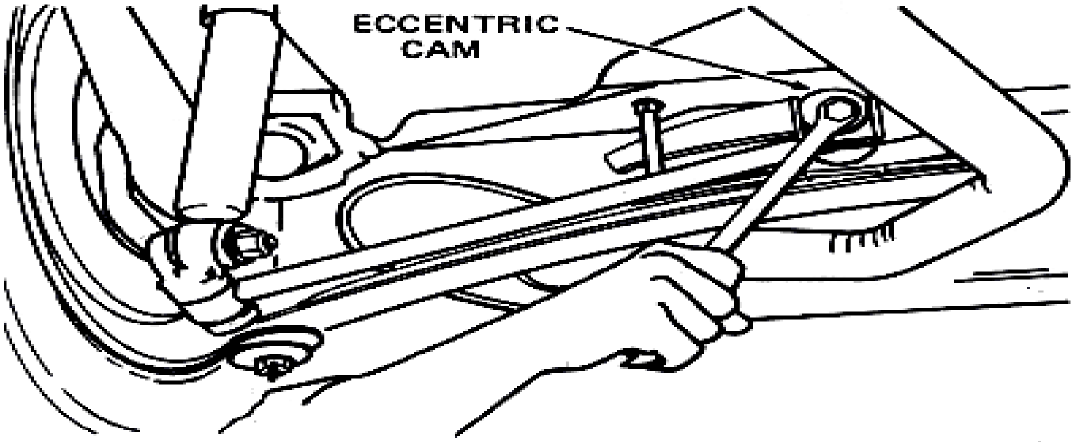


Fig- 20 Adjusting rear wheel camber

b. **Toe-in Adjustment**. Adjust toe-in by inserting shims inside the frame side member on both sides of the torque-control-arm pivot bushing.

Servicing the Steering Gear

23. Manual steering gear has two basic adjustments. One adjustment is on the worm gear and steering-shaft-end play. The other adjustment is the backlash or free play is between the worm and sector. Other adjustments are required on power-steering gears. Refer to the manufacturer's service manual for the procedures.

BAF BASE ZAHURUL HAQUE (TRG WG)
(Aero Engg Trg Sqn)

Syllabus : Automobile General Diesel and Petrol Technology
Course : Trade Training Advance, MTOF
Subject : Power Steering System
Aim : To study Power Steering System
Ref : Internet Wikipedia

POWER STEERING SYSTEM

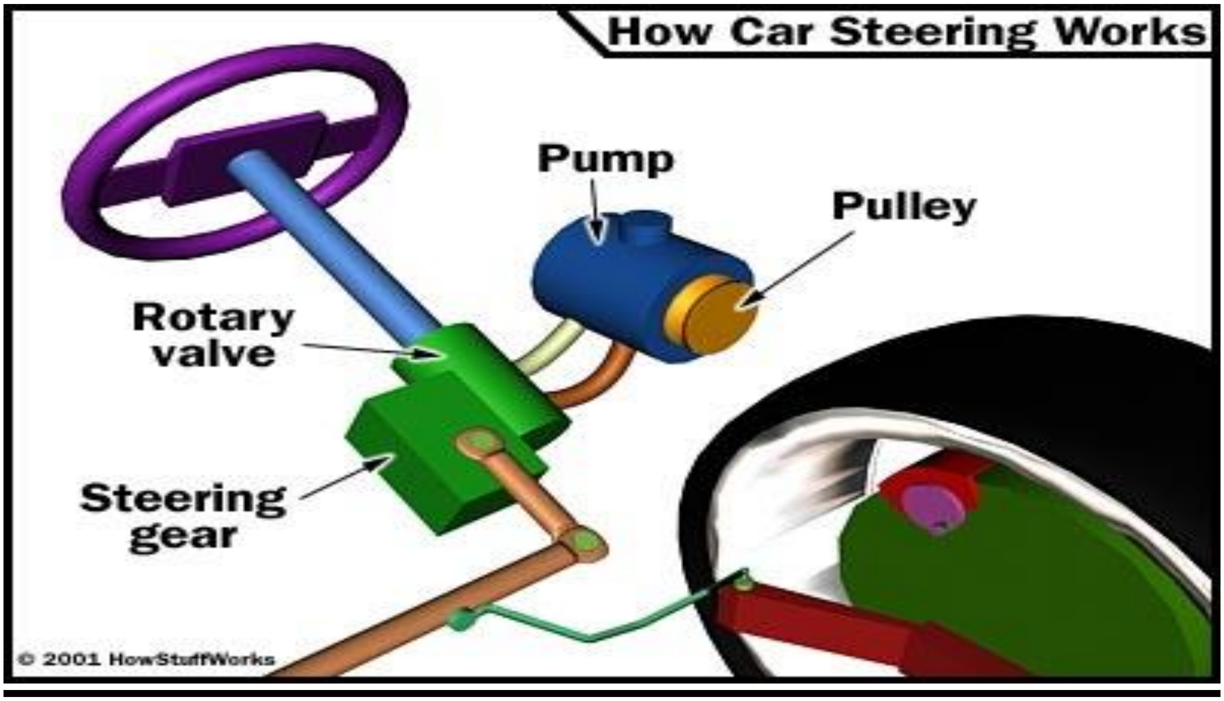


Fig: Power Steering system components

History

1. Power steering systems are probably the most used servo system by the common man, even though most users never give it a second thought. The first power steering unit was invented by Francis W. Davis in the mid 1920's [19], but was not introduced in passenger cars until 1951. A figure of the system can be seen in Figure. This system was of the type: ball and nut, and is still in use in vehicles with higher steering forces, typically larger trucks.
The predominant system used Figure 2.1 Figure from one of the first patents by Francis W. Davis [20]. today is of the type: rack and pinion, which was introduced in the late 1960's in medium performance sports cars. There are several different power assisted steering, PAS, solutions for passenger cars on the market today. The most common is the rack and pinion solution with a constant flow controlled pump, Hydraulic Power Assisted Steering – HPAS system. More recently an Electric Power Assisted Steering, EPAS system, was introduced in smaller cars.

Latin: servio -ire (with dat.), [to be a slave, to serve, help, gratify]. 13 Hydraulic Power Steering System Design in Road Vehicles 2.2 Working Principle of Hydraulic Power Assisted Steering Systems The main task of a power steering system in passenger cars is

to decrease the steering effort of the driver in certain situations such as low speed maneuvering and parking. Power steering has become a necessary component in modern cars of all sizes due to high axel weight, larger tire cross-sections and front wheel drive. In most medium and larger cars, the reduction of steering effort is accomplished by using a hydraulic system, which produces an additional torque to the torque applied by the driver. The basic principle of a hydraulic power steering system is an ordinary hydro mechanical servo parallel to a pure mechanical connection. A hydro mechanical servo is a system that copies an operator applied movement, normally with the possibility to cope with higher forces or torque. In a normal configuration of a
follower servo, the force fed back to the driver is minimal.

Definition of power steering

2. Power steering (similar to power brakes or windows) is a road vehicle steering system which relies only partly on your muscles - the hard part is done by a hydraulic or electric (power) mechanism which senses your movement and actually steers in the desired direction. It is a rather sophisticated system found in most modern cars, even the small ones. If it fails, you still have control as the power part is piggy-backed on the mechanical one (which is unlikely to fail), but you need your muscle power - you're on your own even for the hard part. Don't panic, slow down and steer to safety, but don't proceed - have the car repaired first. A simple way of avoiding this is checking the fluid level (in the case of hydraulic system) once every couple of months or more frequently if you suspect anything. Modern power steering systems are quite reliable; doing periodic maintenance as per Manufacturer's specs helps keep them in good shape. There are a couple of key components in power steering in addition to the rack-and-pinion or recirculating-ball mechanism.

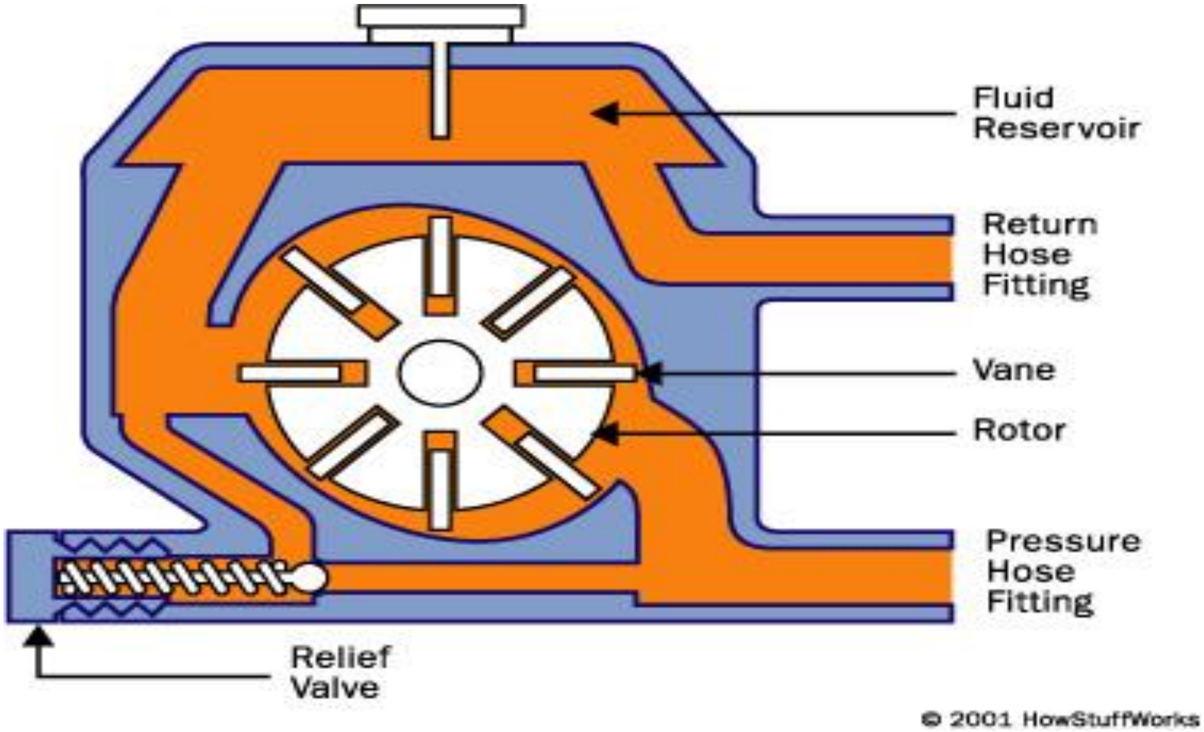


Fig: Steering Pump and elements

Pump

3. The hydraulic power for the steering is provided by a rotary-vane pump (see diagram below). This pump is driven by the car's engine via a belt and pulley. It contains a set of retractable vanes that spin inside an oval chamber. As the vanes spin, they pull hydraulic fluid from the return line at low pressure and force it into the outlet at high pressure. The amount of flow provided by the pump depends on the car's engine speed. The pump must be designed to provide adequate flow when the engine is idling. As a result, the pump moves much more fluid than necessary when the engine is running at faster speeds. The pump contains a pressure-relief valve to make sure that the pressure does not get too high, especially at high engine speeds when so much fluid is being pumped.

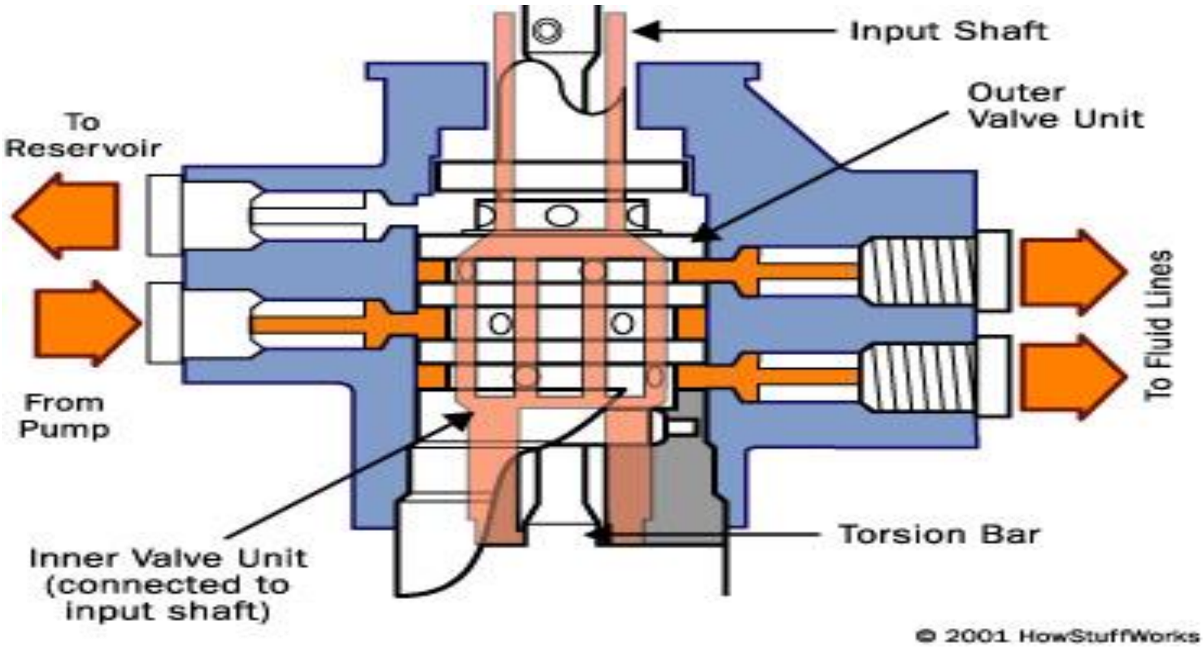


Fig: Steering Pump

Rotary Valve

4. A power-steering system should assist the driver only when he is exerting force on the steering wheel (such as when starting a turn). When the driver is not exerting force (such as when driving in a straight line), the system shouldn't provide any assist. The device that senses the force on the steering wheel is called the rotary valve. The key to the rotary valve is a torsion bar. The torsion bar is a thin rod of metal that twists when torque is applied to it. The top of the bar is connected to the steering wheel, and the bottom of the bar is connected to the pinion or worm gear (which turns the_wheels), so the amount of torque in the torsion bar is equal to the amount of torque the driver is using to turn the wheels. The more torque the driver uses to turn the wheels, the more the bar twists. The input from the steering shaft forms the inner part of a spool-valve assembly. It also connects to the top end of the torsion bar. The bottom of the torsion bar connects to the outer part of the spool valve. The torsion bar also turns the output of the steering gear, connecting to either the

pinion gear or the worm gear depending on which type of steering the car has. Animation showing what happens inside the rotary valve when you first start to turn the steering wheel.

As the bar twists, it rotates the inside of the spool valve relative to the outside. Since the inner part of the spool valve is also connected to the steering shaft (and therefore to the steering wheel), the amount of rotation between the inner and outer parts of the spool valve depends on how much torque the driver applies to the steering wheel. When the steering wheel is not being turned, both hydraulic lines provide the same amount of pressure to the steering gear. But if the spool valve is turned one way or the other, ports open up to provide high-pressure fluid to the appropriate line. It turns out that this type of power-steering system is pretty inefficient. Let's take a look at some advances we'll see in coming years that will help improve efficiency. The input from the steering shaft forms the inner part of a spool-valve assembly. It also connects to the top end of the torsion bar. The bottom of the torsion bar connects to the outer part of the spool valve. The torsion bar also turns the output of the steering gear, connecting to either the pinion gear or the worm gear depending on which type of steering the car has animation showing what happens inside the rotary valve when you first start to turn the steering wheel. As the bar twists, it rotates the inside of the spool valve relative to the outside. Since the inner part of the spool valve is also connected to the steering shaft (and therefore to the steering wheel), the amount of rotation between the inner and outer parts of the spool valve depends on how much torque the driver applies to the steering wheel. When the steering wheel is not being turned, both hydraulic lines provide the same amount of pressure to the steering gear. But if the spool valve is turned one way or the other, ports open up to provide high-pressure fluid to the appropriate line. It turns out that this type of power-steering system is pretty inefficient. Let's take a look at some advances we'll see in coming years that will help improve efficiency.

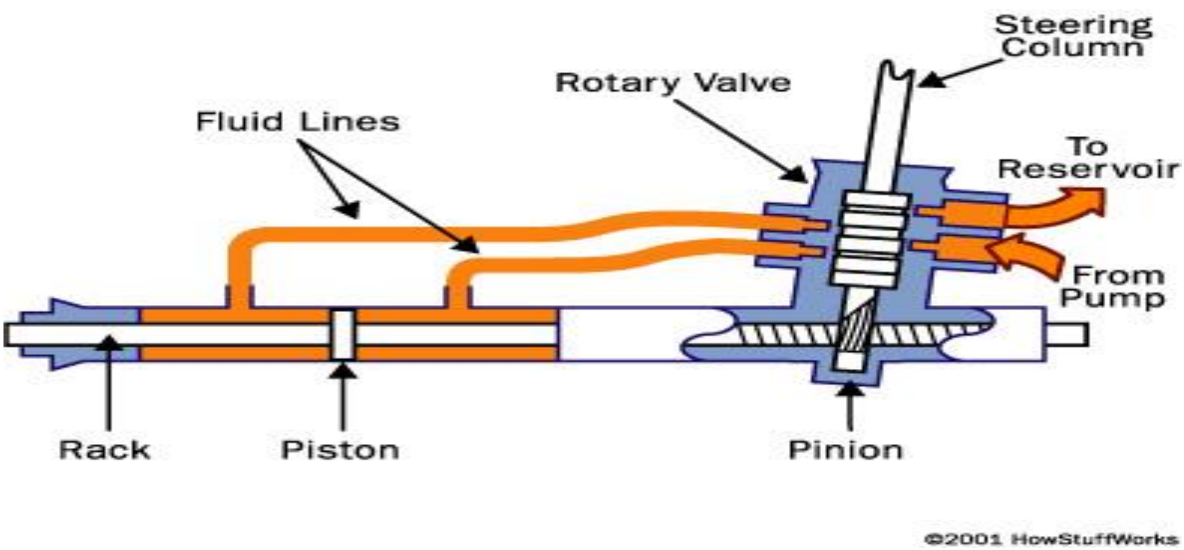


Fig: Power Steering Operation.

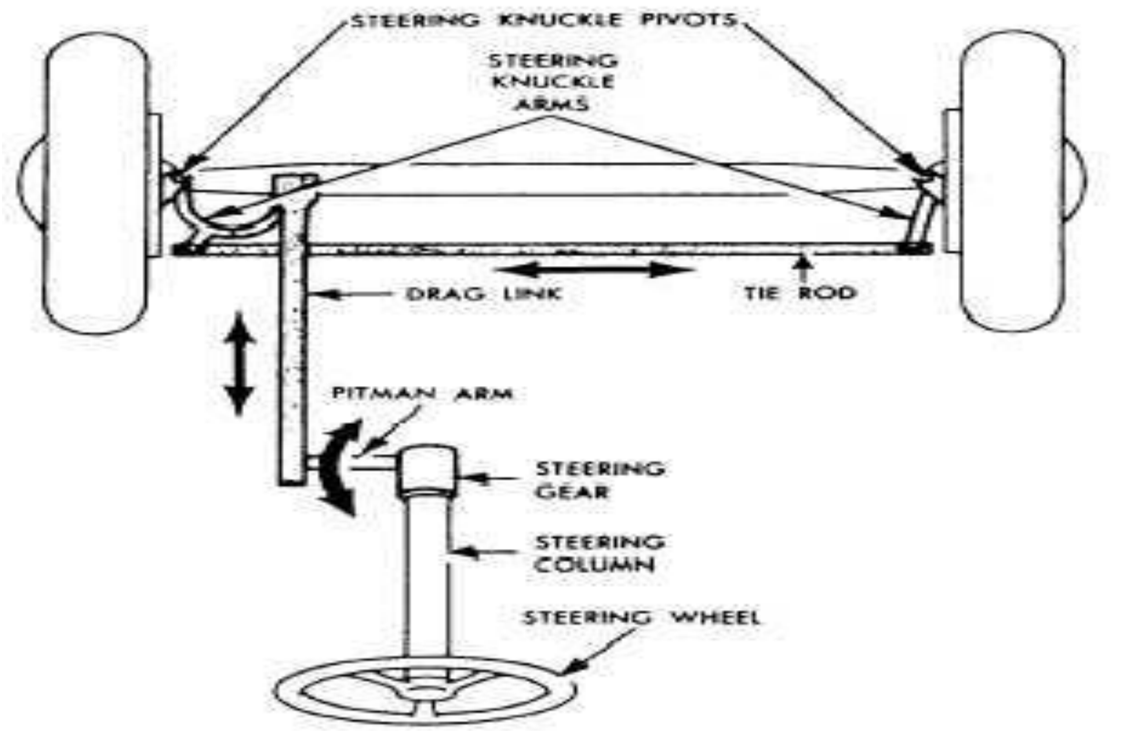


Fig: Manual Steering Components.

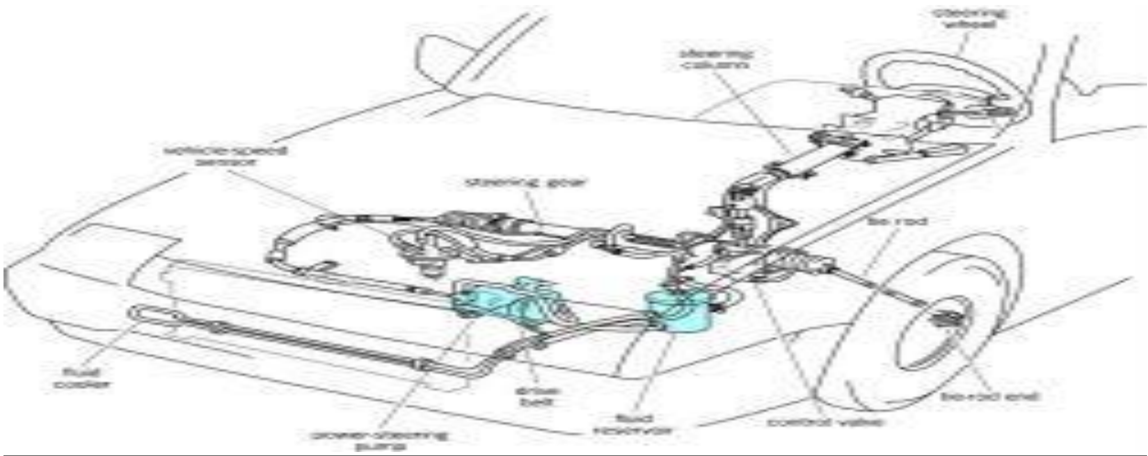


Fig: Power Steering Layout.

Power Steering Failure Warning Signs

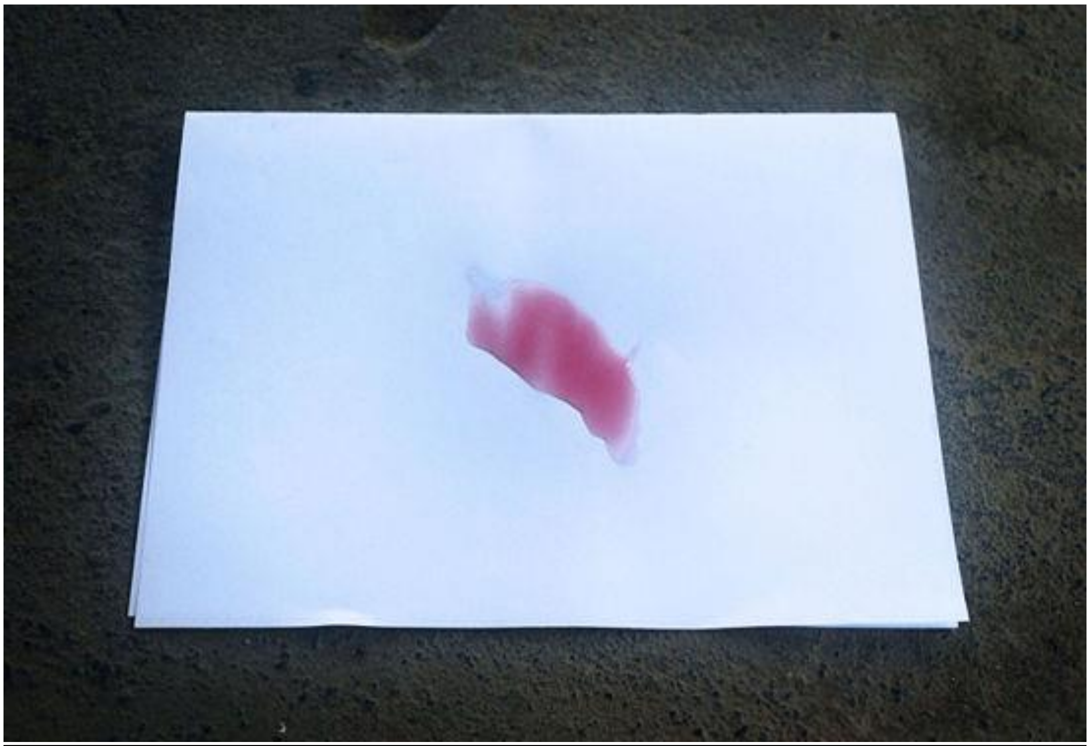
5. Listen for noises when you turn the steering wheel: If you hear a whining, moaning or shrieking sound, your power steering system pump could be seriously low on fluid.

Wheel Turns.

a. Normally, you should be able to turn the steering wheel with little effort whenever you want to steer the car into a curve or around a corner. If you find it a major effort to turn the steering wheel to turn the car, your power steering system is going out.

Check for power steering fluid leaks.

b. If you notice a stain on the ground under your car when it sits for a long period of time, fluid may be leaking from your car. If the stain appears amber, pink or red in color, it may be power steering fluid.



If you have trouble figuring out what color the stain is, place a sheet of white butcher paper under your car when you leave it parked for several hours. The color will be easier to see against a white background.

Handling Sudden Steering Failure

c. **Warn other drivers**. If your power steering fails while you're moving at high speed, your first instinct will be to panic. Instead, turn on your flashers and honk your horn to let other drivers know you're having sudden car problems. This will cause them to get out of your way.

Move toward the side of the road.

d. Do this as carefully as you can; without power, it will be much harder to steer the car.

Bring the car to a gradual stop, slowing the car gradually.

e. Slamming the brakes may throw the car into a skid that would be difficult to steer out of with power steering and almost impossible to steer out of without it.

If you car's power steering goes out as a result of the engine stalling, your brakes will feel stiffer if you have power brakes, forcing you to hit the pedal harder and depress it lower than normal. You may also have to downshift to a lower gear or use the friction of a guard rail, gravel shoulder or cement divider to slow the car enough for the brakes to do the rest.

Restart the engine if it stalled.

f. Turn the steering wheel in either direction to see how well it turns. If it turns as freely as usual, pull back onto the roadway and continue driving as normal. If it doesn't, either drive slowly to the nearest mechanic or call for a tow truck.

BAF BASE ZAHURUL HAQUE (TRT WG)
(Aero Engg Trg Sqn)

Syllabus	**:**	**Automobile General Diesel and Petrol Technology**
Course	**:**	**Trade Training Advance, MTOF**
Subject	**:**	**Maintenance and Management**
Aim	**:**	**To study MT Organisation**
Ref	**:**	**AFO No. 77-17**

M T ORGANISATION

General

1. The operational efficiency of the BAF is largely dependent upon its mechanical transport. The proper functioning and efficient operation of mechanical transport therefore, is of the highest importance to the service.

M.T. Squadron

2. The MT Squadron at station comprises of repair and inspection flight and inspection flight and MT Operations flight. An officer of the MT Engg Branch is established at all major BAF stations as officer in-charge MT Squadron. Where a warrant officer MTO trade is established, he is to take charge of the MT section MT. Operations flight as MT officer. On a station/unit where a warrant officer MTD is not established the officer commanding is to detail an officer is station/unit routine orders to take charge of the MT Section. The person so detailed MT Officer Commanding. There separate MT is established for different lodger units on a station, the lodger unit commander is to co-operate fully with the parent station and ensure that general Service type vehicles, held at the strength of the unit are made

available if required for the administrative services of the station as whole. It is to be clearly understood that all MT held with lodger unit is also under the complete control of station commander.

BAF BASE ZAHURUL HAQUE (TRT WG)
(Aero Engg Trg Sqn)

Syllabus	**:**	**Automobile General Diesel and Petrol Technology**
Subject	**:**	**Trade Training Advance, MTOF**
Course	**:**	**Maintenance and Management**
Aim	**:**	**To study Responsibilities of NCOIC MTR&I Section**
Ref	**:**	**AP. 3159 Section 9, Chapter 1.**

RESPONSIBILITIES OF NCOIC MTR&I SECTION

General

1. ASNCO MT fitter is detailed as NCOIC MTR&I section. He is the senior most member of NCO`s and airmen of the section. He is responsible to his officer in-charge. His appointment is published in RO.s/B.R.s.

Duties

2. **He is responsible for**:

a. Efficient functioning of his section

b. Second line servicing of MT vehicles (which includes repairs, minor and major servicing of MT vehicles).

c. Inspection of vehicles on acceptance or allotment.

d. Accident damage assessment.

e. OJT of his men

f. Vehicle recovery

g. Servicing and recording of ground equipment on charge.

h. Bicycle servicing

j. Proper recording of all MT repair and inspection on F.656, 813, 4115 etc.

k. Up keep of section lock-up

l. Discipline and welfare of section personnel.

BAF BASE ZAHURUL HAQUE (TRT WG)

(Aero Engg Trg Sqn)

Syllabus	**:**	**Automobile General Diesel and Petrol Technology**
Subject	**:**	**Trade Training Advance, MTOF**
Course	**:**	**Maintenance and Management**
Aim	**:**	**To study responsibilities of MT fitters**
Ref	**:**	**Station / Unit Standing Orders**

RESPONSIBILITIES OF MT FITTERS

1. **The individual responsibilities of MT fitters are as follows:**

a. To perform all routine servicing operations on standard type of vehicles.

b. To remove and install major components, e.g. engines, gear box and axles.

c. To carry out major servicing of MT vehicles including carburettors and ignition system.

d. To diagnose and rectify minor defects and to test the vehicles after affecting necessary repair.

BAF BASE ZAHURUL HAQUE (TRT WG)

(Aero Engg Trg Sqn)

Syllabus	**:**	**Automobile General Diesel and Petrol Technology**
Subject	**:**	**Trade Training Advance, MTOF**
Course	**:**	**Maintenance and Management**
Aim	**:**	**To study service system of BAF MT vehicles**
Ref	**:**	**AFO No. 77-29**

SERVICING SYSTEM OF BAF MT VEHICLES

Purpose

1. In order to improve the first and second line servicing to permit the extension of periods between overhaul of MT vehicles, the following system of MT servicing has been introduced.

Servicing

2. a. A standard servicing schedule common to all types of prime mover is to be employed and routine servicing is to be done one mileage/calendar basis. A similar schedule, on a calendar basis, is provided for all types of trailers. Specific information on the servicing requirement of particular makes of vehicles is to be obtained from the vehicles hand book/maintenance manual.

b. A sequence of daily tasks is to be carried out by MT. Drivers to make them familiar with the construction of their vehicles an to stimulate pride in appearance and efficiency of the vehicle and to accumulate pride in appearance and efficiency of the vehicles. To ensure adequate supervision of the daily task, a monthly check is to be done by an experience MTO.

c. Condition of vehicle report is to be filled in by the driver on return from the first run of the day of F-656. This provides a brief daily test report and is intended to claimant the development a accumulation of minor faults.

d. Servicing poster No. 32 is to be completed and displayed in a prominent position in the MT. Section; this proved data such as types of lubricant etc. needed for normal day to day servicing. The required information for this regard is to be obtaining from applicable IOs. Drivers bend or maintenance manual.

Servicing Cycle

3. **The servicing cycles are as follows:**

a. Daily servicing.

b. Intermediate servicing (1.000 miles) or monthly, which ever occurs earlier.

c. Minor servicing (3000 miles) or three monthly, which ever occurs earlier.

d. Major servicing (12,000 miles) or annual, which ever occurs earlier.

Specified Servicing Period

4. a. Specified periods are not laid down for such operations as de-carbonising and valve grinding; the need for them is to be determined as result of running experience and the functional test which form part of the minor and major servicing.

b. Daily servicing is to be done in the MT section by the drivers. The programme of NCOC monthly check is to be detailed by the officer-in-charge of the MT. Section who is responsible that these mechanical transport repairing inspections sections by then drivers supervised by a competent MT Fitter. Minor and major servicing is to be done in the mechanical transport repairing and inspection section. Officer or NCO in-charge of technical transport repairing and inspection section will be responsible for the quality of servicing and repair work done in this section. Where necessary the driver is to accompany his vehicle and assistant fitters/mechanics during defect rectification or routine servicing.

c. After (amended vide AHO/35019/1/GD/Eng). Servicing/repairs or whenever a major assembly is replaced, the vehicle is to be read tested by warrant officer/NCO in-charge mechanical transport repairing and inspection section. The fuel consumed in workshops during servicing repairs of road test should not exceed quantities authorised for various types of vehicles vide AFI. 52/51, as amended by AFI. 109/55.

d. When it is necessary to convert stationary engine running time to vehicle mileage, one hours running is to be regarded as the equivalent of ten miles.

e. The various documents to be used in servicing MT are 813, F.4115, F.656 and Form 1083. Those which are issued as posters are for all display in mechanical transport repairing and inspection and MT sections.

f. All major defects rectify action minor and major inspections and replacement of new component entries are to be recorded in the repair log of F. 813 and singed by warrant officer/NCOIC mechanical transport repairing and inspection sections.

g. Station/Unit MT repairing and inspection sections are equipped and manned to undertake first and second line servicing and repairs by replacement of an engine, the station/unit holding the vehicle on charge is to approach air Headquarters (Dte. of Engineering giving details of defects and mileage done by the original engine for prior approval.

Servicing Publication of M.T. Vehicle

5. a. A.P. 1464E, Vol, I & II RAF. Engineering MT

b A.P. 3260 PAF Manual of MT servicing

c. Relevant T.O. Hand Book or maintenance manual.

Modification

6. The condiment of any unauthorised modification to BAF MT vehicles is prohibited. Non-standard items of equipment or fittings are not to be introduced without the air Headquarters approval. Modifications issued by Air Headquarters are to be incorporating at as per instructions given on Model leaflets and recorded on f.813. Any proposed modifications are to be submitted to Air Headquarters modifications are to be submitted to Air Headquarters for approval and authority.

BAF BASE ZAHURUL HAQUE (TRT WG)

(Aero Engg Trg Sqn)

Syllabus	**:**	**Automobile General Diesel and Petrol Technology**
Subject	**:**	**Trade Training Advance, MTOF**
Course	**:**	**Maintenance and Management**
Aim	**:**	**To study Forms, 4115, 656, 813 and 1083**
Ref	**:**	**AP. 3159 Section 9 & A.P. 3260**

FORMS, 4115, 656, 813 AND 1083

Routine Servicing Work Sheet F- 4115

1. This form is used for 3000/12 miles servicing. These are to be serially numbered and are retained for record purpose for a period of one year.

Instructions of Use for NCOIC Servicing

2. The part I of this sheet is filled by NCOIC in that he is to write down the particulars of a vehicle to be serviced, the type of servicing and names of the tradesman detailed to carry out the servicing. He is carrying out the functional test of the vehicle in accordance with part

II of the work sheet. On completion of the test he is to complete column 3, 4 & 5 of part II. A tick mark in column 3 is to indicate a compete functional servicing. A cross mark in column 4 is to indicate the adjustment is required and cross in column 5 indicated as item referred is U/S, and is to be repaired or replaced, He is to allocate items to the tradesman according to their trades and knowledge. If during the servicing defect is found which will necessitate repair, in this case he is to enter the particulars of the defect and of the subsequent repair action (2 Para 5 on the reverse side of the sheet). On completion of the repair the NCOIC is to ensure that the tradesman detailed to carry out the repair, who need not necessarily be the man detailed to carry out the servicing sings in part `5` of the work sheet having carried out the repair and also initials in column `6` of part III to indicate that the servicing of particular item has been completed. On completion, the NCOIC servicing is to be check:

a. That the each item in Para 2, 3, 4 of the work sheet has been indicated by the tradesman to indicate that he has serviced.

b. Check that all defects recorded in part V have been rectified.

c. Complete part VI of the work sheet and transfer all applicable details to the MT Servicing F. 656 of vehicle concerned.

d. Make appropriate entries in vehicles log book f.813.

Mechanical Transport Servicing - F.656

3. A.M.T. Servicing form is raised monthly for each MT vehicle and each trailer on charge of an MT Section. The form is retained in the section office and is readily accessible to driver. When A vehicle is detailed for detached duty a copy of the current f.656 is given to the driver. The driver will keep the Form on the vehicle throughout the duration of the detachment, or until the end of the current month which ever is the shorter period, or the form is then returned to the Sec. Office. If the detachment does in fact extend from one month to another a replacement F. 656 is forwarded to the driver before the end of the current month. The driver must ensure that the speedometer reading as shown on the F.656 for the last day of the expired month is correctly transferred to the top left hand corner of the current f.656. The front of the form indicates daily servicing task and the dates on which each task is to be done. The tasks

are in accordance with poster No. 33. The back of the form is a Record of Repairs servicing modifications, special technical instructions, etc. for use of the MTR & SU personnel, and a daily servicing certificate for the vehicle and if appropriate the specialist equipment.

Mechanical Transport Vehicle Log Books F-813

4. The revised mechanical transport vehicle log book is designed to last the life of a vehicle. It is opened by the MT storage unit responsible for the acceptance of a new vehicle into the BAF from the manufacturers or contractors. It is transferred with the vehicle and remains with it throughout its service life. The MT storage unit is responsible for the initial inspection and test of the vehicle and the specialist equipment and for completing the entries in section 1, 2 & 7 of the log book. Thereafter the relevant details of monthly mileages and fuel consumption, reconditioning, replacements of major components, routine servicing, minor replacement and repairs, modifications and special technical instructions are entered in the log book. When a vehicle is struck off charge, written off charge, or handed over for disposal, the BAF F.813 is closed by the completion of section 13, and is sent by the holding unit to the disposal authority.

BAF Form 1083 Job Card

5. All the repair or servicing is to be recorded on F.1083 and signed by the fitter & NCOIC Workshop.

BAF BASE ZAHURUL HAQUE

(Aero Engg Trg Sqn)

Syllabus : Automobile General Diesel and Petrol Technology
Subject : Trade Training Advance, MTOF
Course : Maintenance and Management
Aim : To study maintenance of storage vehicles and storage Procedure.
Ref : AP 3260

MAINTENANCE OF STORAGE VEHICLES AND STORAGE PROCEDURE

General

1. The maintenance of storage vehicle and the procedure of storing are to be adopted through out the Air Force. In no way it is to be regarded as relieving personnel from their responsibility for taking any action to ensure the safety and reliability of the vehicle on their charge. Generally, storage procedure will become necessary for any vehicle for equipment there on which is out of use for period of more than one month.

Acceptance of Vehicles for Storage

2. Before preparation for storage all vehicles are to be thoroughly washed and cleaned. After washing the vehicle is to be inspected by the AIS or other competent authority, who is to take any repair or rectification necessary before the vehicle is placed in the storage. When the vehicle has been passed as in a serviceable condition it is to be prepared for storage as detailed in appropriate appendix. It is essential that the vehicle is thoroughly dry before storage preparation servicing carried out.

Composition of Schedules

3. Storage preparation schedules are lists of operation which are to be carried out by the appropriate tradesman before the vehicle is placed into covered storage or open storage as applicable.

Instructions for Use

4. **Tradesman.** Before the vehicle is placed in either cover or open storage, the tradesman is to refer to the appropriate schedule and perform the operations listed there in. They are to report dry defects to the NCOIC storage preparation, and on completion of the servicing are to sing in the appropriate column of F.656 or F.565fA as applicable.

NCOIC Storage Preparation

5. Should any defects be reported the NCOIC storage preparation is to arrange for necessary remedial action to be taken. The NCO is to ensure that details of the defect and of subsequent repair are entered in the repair record of F.6567A applicable.

Preparation of Covered Storage

6. **To be performed by the Tradesmen Detailed.** The operation of covered storage is to be carried out as per appendix “A” to chap-18, Sec-3 AP 3260A.

Preparation for Open Storage

7. **To be carried out by the Tradesmen Detailed.** The preparation for open storage is to be carried out as per appendix “P” to chap-18, Sec-3 of AP 3260A.

Intermediate storage servicing

8. Intermediate storage servicing mainly concerns anti-deterioration checks on the vehicles in storage. This servicing is to be performed by the tradesman detailed and should normally be done monthly for vehicles in open storage and every three monthly for vehicles in covered storage. In special circumstances the periodicity may be extended by command headquarters.

9. **Instructions for Use.**

a. **Tradesmen.** When the intermediate servicing becomes due tradesmen are to be detailed to perform the servicing items detailed in the appendix. On completion of servicing, they are to endorse F.656 or f.656 as applicable.

b. **NCOIC Servicing.** The NCOIC servicing is to ensure that details of servicing are entered on f.656 or F.656A, which is available in card size for use.

Composition of Intermediate Storage Servicing Schedule

10. The schedules for minor and major servicing are similar in construction. Minor servicing should normally be done every six months for vehicles in open storage and annually for vehicles in covered storage. Manor servicing should normally be carried out annually for vehicles in open storage and every two years for vehicles in covered. The schedule consists of a list of instructions explaining in detail the operations the tradesman are to perform in order to complete the satisfactory servicing of item. In special circumstances, the periodicity of the servicing may be varied by command headquarters.

Instructions for Use

11. a. **Trades Men.** The trade's men detailed to perform the servicing are to service each item in accordance with the detailed servicing instructions for that particular item. In the event of repair or replacement being found necessary the trade's men are to report the fact to the NCOIC servicing. The trade's men detailed to execute the repair or replacement is to inform the NCOIC servicing of work carried out and new or reconditioned items fitted. He is also to enter in the repair log on F.656 or F. 656A the details of work done and sign in the appropriate column.

b. **NCOIC Servicing.** The NCOIC servicing is to detail the tradesmen to perform the servicing according to their known capabilities. He is to ensure that the necessary tools and equipment are available. On completion of the servicing he is to ensure that the necessary entries are made on F.656 or F.656A and that the trade's men responsible sign as completion their respective tasks.

Minor and Major Servicing Schedule

12. **To be performed by the tradesmen detailed.** The servicing schedules for Minor and Major servicing of the stored vehicles are available in card size, as per appendix "A" and appendix "B" to chapter 20, Sec-3, of AP 3260A.

BAF BASE ZAHURUL HAQUE

(Aero Engg Trg Sqn)

Syllabus	**:**	**Automobile General Petrol and Diesel Technology**
Course	**:**	**Trade Training Advance, MTOF**
Subject	**:**	**Maintenance and Management**
Aim	**:**	**To study Towing Regulations**
Ref	**:**	**AFO-77**

TOWING REGULATIONS

Regulations

1. **The following regulations are applied when a vehicle tows another**:

a. Only qualified drivers are to act as a driver of towing vehicles or steer man is towed vehicle.

b. The speed of the towing vehicle is governed by the condition of the towed vehicle but in no case it is to exceed 20 MPH.

c. The maximum distance between the two vehicles is 15 feet and the tow bar, tops or chain must be made easily distinguishable to the other road users and pedestrians.

d. A wooden beard 18" X 10" with words "Caution-on-Two" painted in red over white background is to be hung on the tail board on the vehicle being towed.

e. The load of the towed vehicle should be transferred whenever possible, to some other vehicle.

f. The load of the towed vehicle would be transferred whenever possible to some other vehicle.

g. The tow rope should be attached at near side where possible diagonal pull should be avoided.

h. Select a suitable vehicle for towing. The weight of the towing vehicle must be equal or more than the towed vehicle but it must not be less than the towed vehicle.

j. Towing hooks are to be invariably used.

k. Gear of the towed vehicle should be moved to neutral prior to moving.

l. Driver of the towed vehicle must keep the tow rope in tension but avoid excessive breaker.

m. Signals given by the towing driver must be repeated by the towed driver.

Towing Precautions

2. **The following precautions are to be observed**:

a. Do not pull the tow rope through a bar hook or it will link or eventually break. Use the chain in stead of that.

b. Do not use the towing hook when a lose shackle is used.

c. Do not use towing hook into towing shackle from the above and put it from the below where it is more likely to stay when the ropes goes slack.

d. Do not use a two rope for towing a vehicle with faulty brakes use a tow bar.

BAF BASE ZAHURUL HAQUE

(Aero Engg Trg Sqn)

Syllabus	**:**	**Automobile General Diesel and Petrol Technology**
Subject	**:**	**Trade Training Advance, MTOF**
Course	**:**	**Maintenance and Management**
Aim	**:**	**To study the duty and responsibility of Inventory holder**
Ref	**:**	**AP 830 (P) Vol.1**

DUTIES AND RESPONSIBILITY OF INVENTORY HOLDER

Responsibility

1. **The inventory holder is responsible for the following:**

a. Inventory holders are all times responsible for the careful use, custody and maintenance of equipment on their charge.

b. When the equipment's are not under their immediate charge or supervision, they are to exercise control by means of F.668 and F/108 as appropriate and convenient.

c. F.668 is best maintained by means. It is not advisable to have all holding out on load.

d. Should any inventory holder consider that he can not adequately control the equipment on this charge, he will represent the facts in writing to his CO, who may take any remedial action necessary.

e. All changes of responsibilities will for the subject of BRO action. The station administrative office/OC Admin wing must therefore ensure that he is fully informed of the position and that he appoints new holder as and when necessary. For this purpose the station administrative officer/OC Admin Wg will maintain up-to-date record of inventory holder and will ensure that correct handing and taking over has been carried out before he clears any holder form the station.

f. Handing over and taking over certificate will be given, when all holding being check. Taking ever certificate includes responsibility being accepted for the accuracy of all loan records.

g. When a holder is temporarily absent from a temporarily holder will be appointed at the O C's desertion with authority to sign vouchers. The permanent holder will take steps on his return to each all the transaction which have taken places in his absence.

BAF BASE ZAHURUL HAQUE

(Aero Engg Trg Sqn)

Syllabus	**:**	**Automobile General Diesel and Petrol Technology**
Course	**:**	**Trade Training Advance, MTOF**
Subject	**:**	**Maintenance and Management**
Aim	**:**	**To study A**
Ref	**:**	**Numbers and title of AFOs, AFIS and AFLS etc**

AFO`S AFI`S AND AFLS ETC CONCERNING MT

Purpose

1. The purpose of this lesson is to enable to familiarise with the numbers and tile of various AFOs, AFIs and AFLs etc.

2. **The following AFOs, AFIs and AFLs are used in MT. AFO**

77-1 Miss-use of service transport.

77-2 Use of Motor cycle.

77-3 Use of mechanically operated vehicles in hangers containing A/Cs.

77-4 Recreations run general procedures.

77-5 Regarding of changes of drivers during a journey.

77-6 Utilisation of spare seating accommodation inBAF MT.

77-7 Loading/Unloading vehicles on railway wagon.

77-8 Operation of mobile crane.

77-9 Safe guard of MT Vehicles.

77-10 Conveyance of load on Mechanical Transport.

77-11 Serviceability of Speedo meter.

77-12 MT Modification.

77-13 Speed limitation BAF vehicles.

77-14 Hire of civil (Mechanical or Animal transport by BAF)

77-15 Speed limit in camp area.

77-16 Convey orders.

77-17 Organisation off BAF mechanical transport.

77-18 Mechanical Transport accident procedure.

77-19 Restriction on smoking in Air Force MT vehicles.

77-20 Mechanical Transport carrying capacity.

77-21 Procedure for the receipt repair and disposal BAF MT vehicles.

77-22 Provision of free service transport for airmen proceeding to or returning

77-23 From annual leave.

77-24 Read safety driving of MT at night.

77-25 Authority to drive BAF Mechanical Transport issue of MT driving licence

77-26 And permits.

77-27 MT driving towing regulations.

77-28 Running in new/Recondition vehicles.

77-29 MT driving on air field.

77-30 Requisitioning and recording of BAF MT.

77-31 MT servicing procedure.

77-32 Categorisation of M drivers.

77-33 Marking and identification of BAF MT.

77-34 Tender water fire crash use of.

77-35 Use of service MT for sports.

77-36 Weekly operational MT vehicles serviceability sate RCN/676

77-37 Breakage of wind screen and window/door glasses.

77-38 Use of service transport for blood donors.

77-39 Provisioning of free transport to forcing dignitaries members

77-40 Diplomatic corps and VIPS.

77-41 Economical life of MT specialist vehicles.

3. **AFLS NO**

22/47 Free use of service MT for duty journey.

78/45 Terms of service for civilian driver. (231/45 & 151/47).

268/46	Free use of Service MT for operational purpose.
21/49	Hire of service MT on repayment.
27/49	Use of staff car by senior officers.
21/50	Use of service Ambulance for conveyance of sick and injury BAF personnel.
34/53	BAF MT fuel consumption.
40/54	Free conveyance of officer on night duty.
97/50	Grant of overtime and night duty allowance.
45/59	To civilian drivers
82/52	Use of service MTT between residence station/Air booking centre/sea port.
82/55	Use of service transport for the conveyance of labours, workers etc during strike in defence service installation use of.
52/51	Issue of MT fuel to vehicles in storage or under repairing.
523A	Application for disposal of engine of specialist vehicles.

4. **AFI**

77-1	Weekly ops veh. S/A state (RCN-767).
77-2	Monthly.
77-4	MT daily progress record summary (F-347B).
77-5	Speedo meter u/s return.
77-7	Use of private vehicle for duty journey
77-8	Discipline driving by night
77-10	MT compression of F-813.

77-11 Use of service transport by S.M.O.

77-12 Dt 21-1-69 Monthly mileage target.

77-15 Care and prevention of MT vehicle in transit between East and West Pakistan.

77-16 Prevention of MT accident due to skidding

77-17 Calibration of T.P. gauge (after 90 days) if it shows 2 Lbs less or more tot be cat/RD and return to stare.

Note:

5. a. AFO 67-84 RCN 749 Mt moments return 1st of every month.

   b. APF 77-4 RCN 747 Mt daily progress record summary by 19th of every month F-347B.

   c. AFO 67-85 RCN 739 MT census return 30th June 31st Dec.

   d. AFO 77-34 RCN 767 weekly ops vehicle servey / return every Friday.

BAF BASE ZAHURUL HAQUE

(Aero Engg Trg Sqn)

Syllabus	**:**	**Automobile General Diesel and Petrol Technology**
Course	**:**	**Trade Training Advance, MTOF**
Subject	**:**	**Maintenance and Management**
Aim	**:**	**To study convoy procedure**
Ref	**:**	**AFO 77-16/1962**

CONVOY PROCEDURE

Definition

1. When there are five or more vehicles moving together under the command of an officer, MWO, WO, or SNCO is known as MT convey.

Composition of Convoy

2. a. Convoy commander

b. Vehicles and drivers
c. Motor cyclist
d. Break down party

Stations/Units to be Informed

3. Convey movement orders copies are despatch to all stations/ units where the convoy is required to halt enroute for refuelling or staying over night. In case of Army unit, officer commanding of the unit is informed well in advance.

Detailing of Convoy Commander

4. a. For five to ten vehicles a SNCO MTO is detailed as convoy commander and junior NCO MTF is i/c breakdown party.

b. For vehicle over ten and officer of any branch, or MWO or a WO (MTF/MTO) is detailed as convoy commander and a SNCO MTF accompanies the convoy along with additional fitters, mechanics and electricians as necessary.

c. MT drivers holding category 'B' are detailed for convoy duties. Civilian drivers can be detailed but 25% must be service personnel out of the total drivers. Spare drivers are also detailed on the basis of one driver per 15 vehicles.

d. Load may be convoyed to stations/Units enroute but not on vehicles employed on training duties.

Preparation

5. a. The convoy commander is informed about date of departure, number of vehicles, particulars of personnel detailed and route to be followed.

b. Current servicing of vehicle done

c. Vehicles are inspected for serviceability and particular attention paid to batteries, ignition and fuel system brakes and tyres. Vehicle may be road tested if necessary.

d. Drivers are detailed for vehicles are to carryout daily inspection. They are to fill fuel, oil and water and are to check tyre pressure.

e. **Convey commander are to collect the following:**

(1) Form 813 and current F.656

(2) F.748/1670 (If vehicles are to be delivered)

(3) Servicing equipment, tools, and P.O.L. properly accounted for.

(4) Spare batteries as required

(5) First aid box

(6) One blue flag for leading vehicle and green flag for the last vehicle and a white background board painted in red as follows:

‘CAUTION’
‘VEHICLES IN CONVEY AHEAD’

(7) And displayed on the tail board of the last vehicle.

Necessary arms and ammunition for convey guards and the convoy commander reports to the officer commanding for final briefing.

<u>Servicing</u>

6. The vehicles are serviced according to the length of the journey. A thorough check should be done of fuel system, batteries and lights.

Orders to Drivers

7. The drivers clearly briefed by the convoy commander in respect of their duties, responsibilities and action to be taken in case of air or ground attacks and a daily log book is maintained of the convoy movement and activities

<u>Convey Discipline</u>

8. Convoy is lead by the convoy commander and thus he controls the speed limit. A SNCO or airmen is placed in the rear of the convoy. Where civilian drivers are employed, the service personnel must be detailed at regular intervals to maintain discipline.

<u>Speed Limit</u>

9. Vehicles are not to be over speeded. The maximum speed limit is also laid down and governed by the slowest running vehicle which is generally 25 mph.

Break Down

10. If a vehicle can not keep it's place the driver is to pull the vehicle to the side of the road and stop. He will give signal the behind vehicle to overtake. The break down party at the rear will rectify the defect. The vehicle will proceed in front of the break down attained vehicle. In this case vehicles becomes u/s and can not be repaired it should be towed down to the nearest BAF station /unit or Army unit for repair. If necessary to leave the vehicle, it should be handed over to a responsible person and F.813; F.656 should be left with vehicle. All tools, loose equipment should be removed and retained by convoy commander.

Over Night Stay

11. The following procedure is carried out :-

a. Convoy is booked in at main guard room

b. List of personnel handed over to orderly room and meals & accommodation be arranged for all personnel

c. After working hours, the orderly officer is informed

d. When convoy is ready to move off, orderly room is informed during working hour and OC also informed

e. Before leaving station /unit the convoy is booked out at the main guard room

Discipline at Staging Posts

12. a. All ranks are informed by convoy commander against coming into conflict with the civil local inhabitants. Any fractions are reported to senior police officer and nearest army station staff officer. The matter is reported in writing to officer commanding unit as soon as possible.

b. Dwelling housed placed out of bound

c. Vehicle parked in a line abreast and not nose to tail.

d. Vehicle is safe guarded and guards are detailed. Civilian drivers are not to be detailed on guard duty.

e. Parking ground is left in a clean condition and all litters etc removed.

Medical

13. a. The convoy consisting of 50 to 100 men is accompanied by an experienced medical assistant. If more than 100 men then if practicable, accompanied by a medical officer with first aid out fits and drugs and equipment's,

b. A lecture on first aid to all personnel in convoy to arrange by convoy commander prior to leaving the unit.

c. Casualties, if any, are removed to nearest hospital.

d. Anti-malaria precautions strictly observed

e. Sterilised water used for drinking and cooking

f. Movement of convoy if possible be done in the cooler hours of the day

g. Daily distance covered not exceeds 100 miles and there should be one day halt for rest after 4 days on the move. Hot weather precautions as instructed, must be observed and alcohol is not to be consumed

h. Ample supply of water and salt should be available through out the journey

j. Normal accident procedure is to be adopted on occurrence of an accident according to AFO 77/18.

At Destination

14. a. On arrival at the destination the convoy commander is to inform his unit of the safe arrival of the convoy.

b. In case of delivery of vehicle of other unit , all vouchers, POL drawn, enroute handed over and proper handing and taking over is done and receipt (F.600 Red copy) obtained.

c. Any difficulty experienced at consignee unit is reported to officer commanding.

d. On return to parent unit the convoy commander is to submit in writing a full report to the officer commanding and hand over the receipt to the equipment officer.

MODED BY JAHID (474652)

INDEX

AND

BREAK DOWN OF SUBJECTS WITH ALLOTTED PERIODS TRADE TRAINING ADVANCE MTOF (MTM PART)

PRE-CTTB, MTM PART- III

<u>BAF BASE ZAHURUL HAQUE (TRG WG)</u>

(Aero Engg Trg Sqn)

Syllabus : Automobile General Diesel and Petrol Technology

Course : Trade training Advance, MTOF

Subject : Automotive Emission Controls

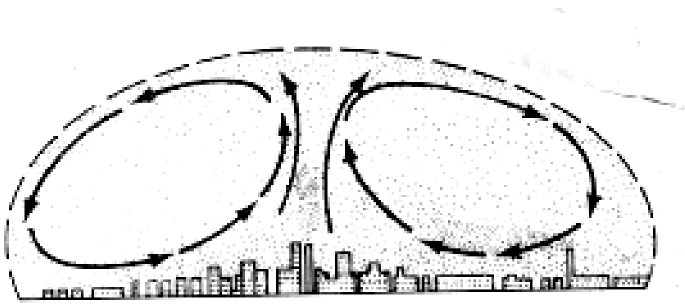
Aim : To study Automotive Emission Controls

Ref : Automotive mechanics by William H. Crouse, Page 336-356.

<u>AIR POLLUTION, SMOG AND THE AUTOMOBILE</u>

<u>Smog</u>

1. The word "smog" comes from "smoke" and "fog". Smog is a sort of fog with other substances mixed in. Smog has been here a long time. Billions of years ago, volcano's sent millions of tons of ash and smoke into the air. Winds whipped up dust clouds. Animal and vegetable matter decayed, adding polluting gases. When people came along, they began to produce their own kind of air pollution. They discovered fire, in the Middle Ages, people in cities such as London used soft coal to heat their homes. The smoke from these fires, combined with moisture in the air, produced dense layers of smog. The smog would blanket the city for days, particularly winter. The heat generated in large cities tends to circulate air within a dome-like shape, as shown in Fig -1.



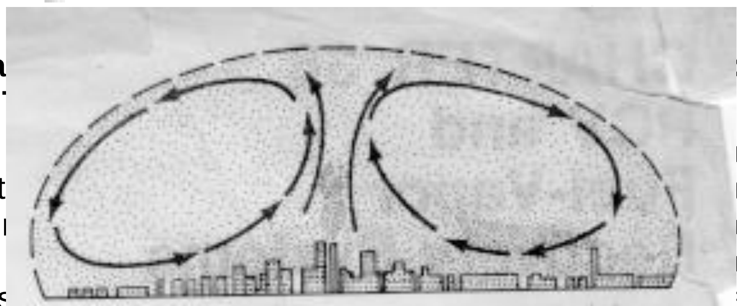


Fig-1: The Hea ... oduce A Circularly Air Pattern Which ...

This traps the ... e chemicals and other substances in it ... (Figs-2 and3). It irritates the eyes, the thr ... eople caught. Smog can make people ill. ... s been lined to eczema, asthma, emphys... ach cancer.

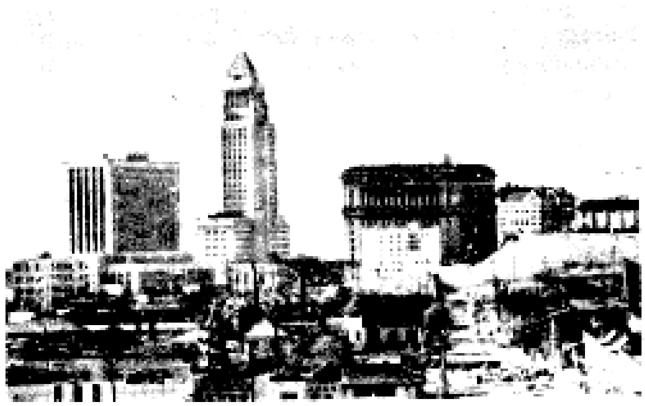


Fig-2: View of Los Angeles During a Clear Day.(Los Angel Country Air Pollution Control District)

It also has a harmful effect on the environment. Food crops and animals suffer. Paint may peel from houses. It is obvious that we must do everything possible to reduce man-made atmospheric pollutants and smog.

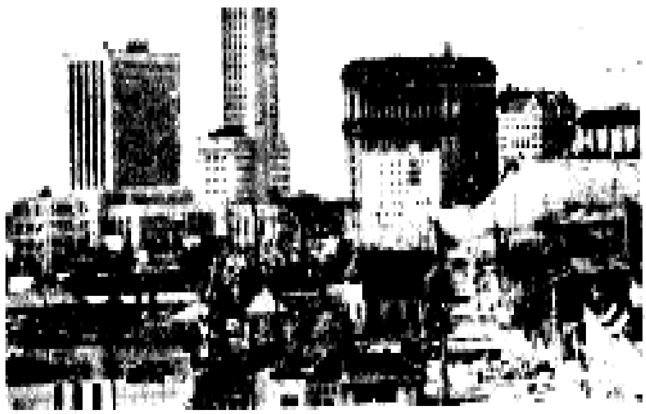


Fig-3: View of Los Angeles. During A Typical Smoggy Day. Note That Many Buildings Are Hidden.

<u>Not all Air Pollution is Smog</u>

2. Smog, along with smoke, is the most visible evidence of atmospheric pollution. But some atmospheric pollution is not visible and may not become visible until it is mixed with moisture. Lead compounds from leaded gasoline, hydrocarbons (unburned gasoline), carbon monoxide, and other gases may pollute the air without being seen.

Air Pollutants

3. All air is polluted to some extent. That is, all air carries some polluting substances. Much of it is natural: smoke and ash from volcano's, dust stirred up by the wind, compounds given off by growing vegetation, gases given off by rotting animal and vegetation matter, salt particles from the oceans, and so on. Man adds to these pollutants by burning coat, oil gas, gasoline, and many other things. It is these added substances that we are concerned with in this book-especially those that come from the automobile. Before we get to the automobile, however, let us review what we have learned about combustion. Most fuels, such as coal gasoline, and wood, contain hydrogen and carbon in various chemical combinations. During combustion, oxygen unites with the hydrogen and carbon to form water (H_20), carbon monoxide (C0), and carbon dioxide ($C0_2$). In addition, many fuels contain sulfur; this burns to produce sulfur oxides. Also in the heat of combustion, some of the nitrogen in the air combines with oxygen to form nitrogen oxides ($N0_x$). Some of the fuel may not burn completely, so that smoke and ash are formed. Smoke is simply particles of unburned fuel and soot, called particulate, mixed with air. Altogether, it is estimated that 200 million tons of man-made pollutants enter the air every year in the United States alone. This is about a ton for every man, woman, and child in the country. This man-made pollution is what clean-air laws are aimed at.

Los Angeles

4. Consider Los Angeles, a large city set in a basin, with about 7,000,000 inhabitants. It is surrounded on three sides by mountains and on the fourth by the Pacific Ocean. when the wind blows out over the ocean, it sweeps away pollutants. But at other times, the air is stagnant. Smoke and other pollutants from industry and automobiles do not blow away (Figs -2 and 3). They just build up into a thick, smelly, foggy layer of smog. The location of Los Angeles, plus all the people and industry there, make it one of the biggest "smog centers" in the country. And it is Los Angeles, which has led in measures to reduce smog. Los Angeles has banned unrestricted burning, for example, burning trash. Incinerators without pollution controls were outlawed. Industry was forced to change combustion processed and add controls to reduce pollutants coming from their chimneys. Laws were passed that required the addition of emission controls on automobiles.

Pollution from Automobiles

5. If not controlled, the automobile can give off pollutants from four places, as shown in Fig - 4. Pollutants can come from the fuel tank, the carburetor, the crankcase, and the tail pipe. Pollutants from the fuel tank and carburetor consists of gasoline vapors. Pollutants from the crankcase consist of partly burned air-fuel mixture that has blown by the piston rings. Pollutants from the tail pipe consist of partly burned gasoline HC), carbon monoxide (C0), nitrogen oxides (N0), and - if there is sulfur in the gasoline-sulfur oxides (S0). In the chapters that follow, we discuss the causes and cures for these pollutants.

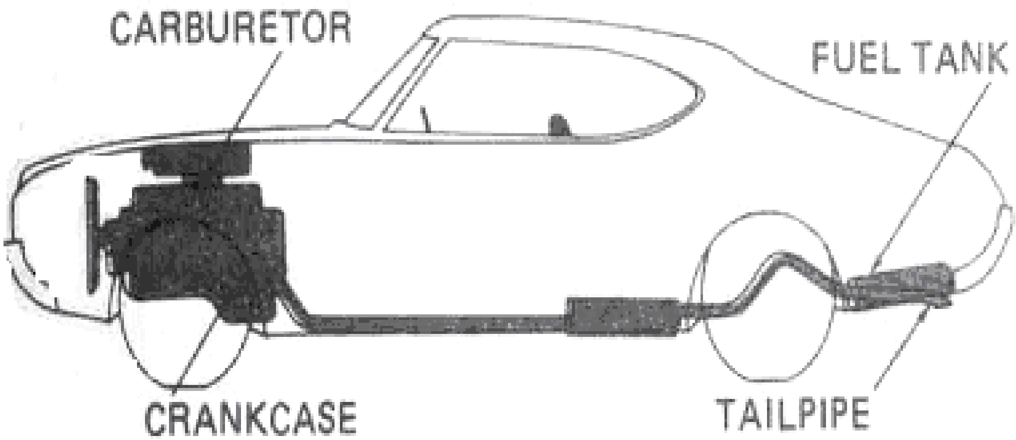


Fig-4: Pollutants Comes From Carburetor, Crankcase, & Fuel Tank

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Syllabus : Automobile General Diesel and Petrol Technology

Course : Trade training Advance, MTOF

Subject : PCV and Fuel-Vapor Recovery Systems

Aim : To study PCV and Fuel-Vapor Recovery Systems

Ref : Automotive Mechanics by Willium H. Crouse. Chapter 35 Page336

PCV AND FUEL-VAPOR RECOVERY SYSTEMS

Positive Crankcase Ventilation

1. We described the PCV system in the lubrication system. The system carries filtered air from the carburetor air filter through the crankcase. The air picks up blow-by and carries them to the intake manifold. The air then flows through the engine, where the blow-by and gasoline vapors are burned. The PCV valve is spring-loaded. At low speeds and idle, when intake-manifold vacuum is high, the vacuum holds the valve nearly closed. In this position, the valve passes only a small amount of air. This prevents the idle-mixture ratio from being upset and producing poor idle-mixture ratio from being upset and producing poor idling. Then when the throttle is opened wider and engine speed increases, the intake-manifold vacuum drops. Now, with less vacuum, the PCV valve opens, allowing more air to flow through the crankcase.

Need for Vapor recovery system

2. Both the fuel tank and the carburetor can lose gasoline vapor if the car does not have a vapor recovery system. The fuel tank "breathes" as temperature changes. That is, as the tank heats up, the air inside it expands. Part of the air is forced out through the tank vent tube, or through the vent in the tank cap. This air is loaded with gasoline vapor. Then, when the tank cools, the air inside contracts. More air enters the tank from outside. This breathing of the tank causes a loss of gasoline. The higher the tank temperature goes (for instance, when the car is parked in the sun), the more gasoline vapor is lost. The carburetor also can lose gasoline by evaporation. The carburetor float bowl is full whenever the engine is running. When the engine stops, engine heat evaporates some or all of the gasoline stored in the float bowl. Without a vapor recovery system, this gasoline vapor would pass into the atmosphere. A vapor recovery system captures these gasoline vapors and prevents them from escaping into the air. It thus tends to reduce atmospheric pollution. All modern cars are equipped with vapor recovery systems. They are called by various names: ECS (Evaporation Control System), EEC (Evaporation Emission Control). VVR (Vehicle Vapor Recovery, and VSS (Vapor Saver System). All work in the same general way.

Vapor Recovery Systems

3. Figures -5 and -6 show a typical vapor recovery system. The canister is filled with activated charcoal. Just after the engine is shut off, heat is entering the carburetor. The gasoline vapor from the carburetor float bowl passes through the canister and is adsorbed by the charcoal. "Adsorbed" means that the gasoline vapor is trapped by the charcoal particles. This is somewhat like the charcoal filters on cigarettes. Their purpose is to trap particles of tar and other substances, to prevent their entering the mouth and lungs of the smoker. Some carburetor float bows have a special vent, connected by a tube to charcoal canister. The vent and tube carry the float-bowl vapor directly to the canister. At the same time, vapor-laden air from the fuel tank is carried by a special emission-control pipe to the canister. As the air passes down through the canister, the gasoline vapor is trapped by the charcoal particles. The air exits from the bottom of the canister, leaving the HC (hydrocarbon) vapor behind. There is a filter at the bottom of the canister. It comes into action during the purge phase of operation. This occurs when the engine is started. Now, intake-manifold vacuum draws fresh air up through the canister. This fresh air removes, or purges, the gasoline vapor from the canister. It takes the HC through a purge line to a connection at the carburetor.

Fuel Return Line

4. Note, in Fig -5, that a fuel return line parallels the main fuel line. This fuel return line connects the pressure side of the fuel pump to the fuel tank. Thus, any excess gasoline being pumped by the fuel pump is returned to the fuel tank. This action removes any vapor that might develop in the fuel pump. It also maintains a flow of fuel through the fuel pump;. This keeps the fuel pump relatively cool and helps prevent vapor lock.

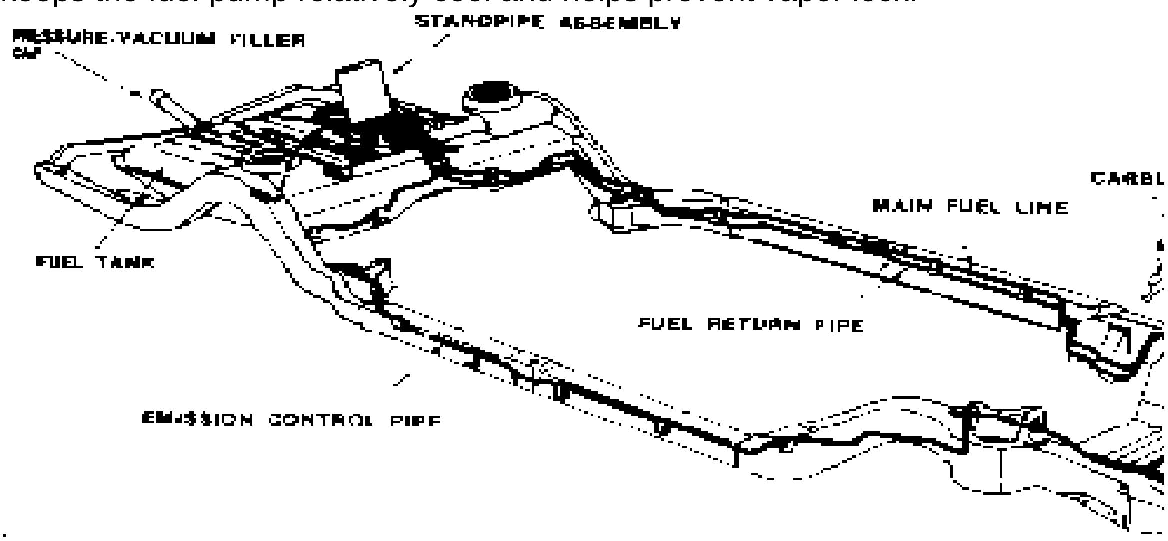

Fig-5: Fuel Evaporation Control, or Vapor Recovery, System. Vapor goes to the Canister. The fuel return pipe returns excess fuel, not used by the carburetor, to the fuel Tank. This Constant flow of excess fuel through the fuel pump helps Prevent Vapor Lock.

Charcoal Canister

5. A charcoal canister is shown in sectional view in Fig - 6. An actual canister is shown in Fig-7. The arrows in Fig6 show the flow of air and gasoline vapor. When the engine is running, intake-manifold vacuum draws air up through the canister and into the carburetor. This air cleans the gasoline vapor out of the canister. The charcoal canister in Fig-8 is for a six-cylinder engine. Note that it has a restrictive valve, also known as a purge valve. This valve limits the flow of vapor and air to the carburetor during idling. But it allows full air-vapor flow during part-to full-throttle operation. In the six-cylinder engine, full air-vapor flow from the canister could upset engine idling. At higher engine speeds, however, full air-vapor flow can be tolerated. The valve is operated by a vacuum signal from a drilled hole in the carburetor.

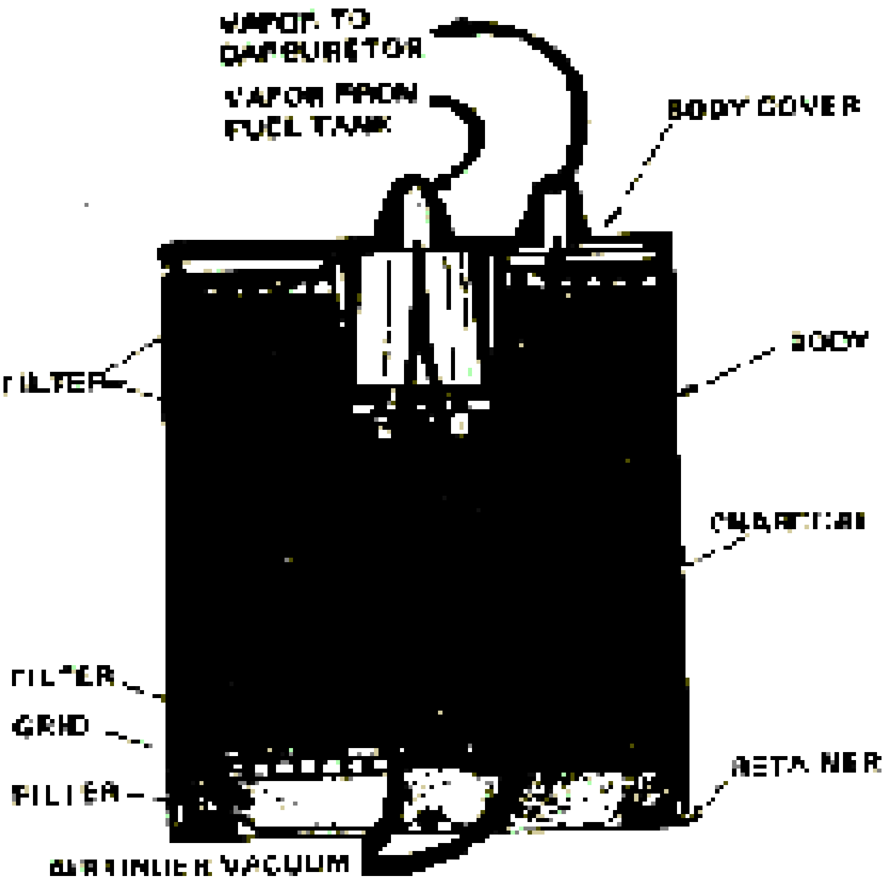

Fig-6: Sectional View of a Charcoal Canister for a V-8 Recovery System. (Olds Mobile Division of General Motors Corporation).

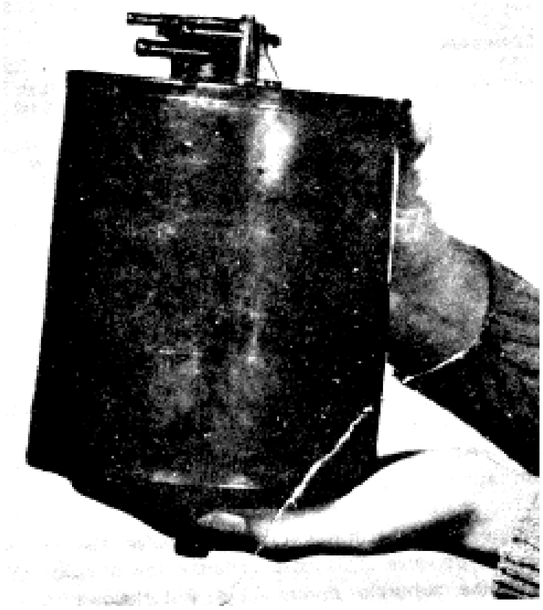

Fig-7: Charcoal Canister, Note it's Size

This hole is located just below the throttle valve when the throttle valve is closed. With the throttle closed and the engine idling, a high vacuum develops below the throttle. The vacuum causes the purge valve to limit the air-vapor flow. On some models, the purge line from the canister is connected to the air cleaner, as in Fig -9. The system operates in the manner already described.

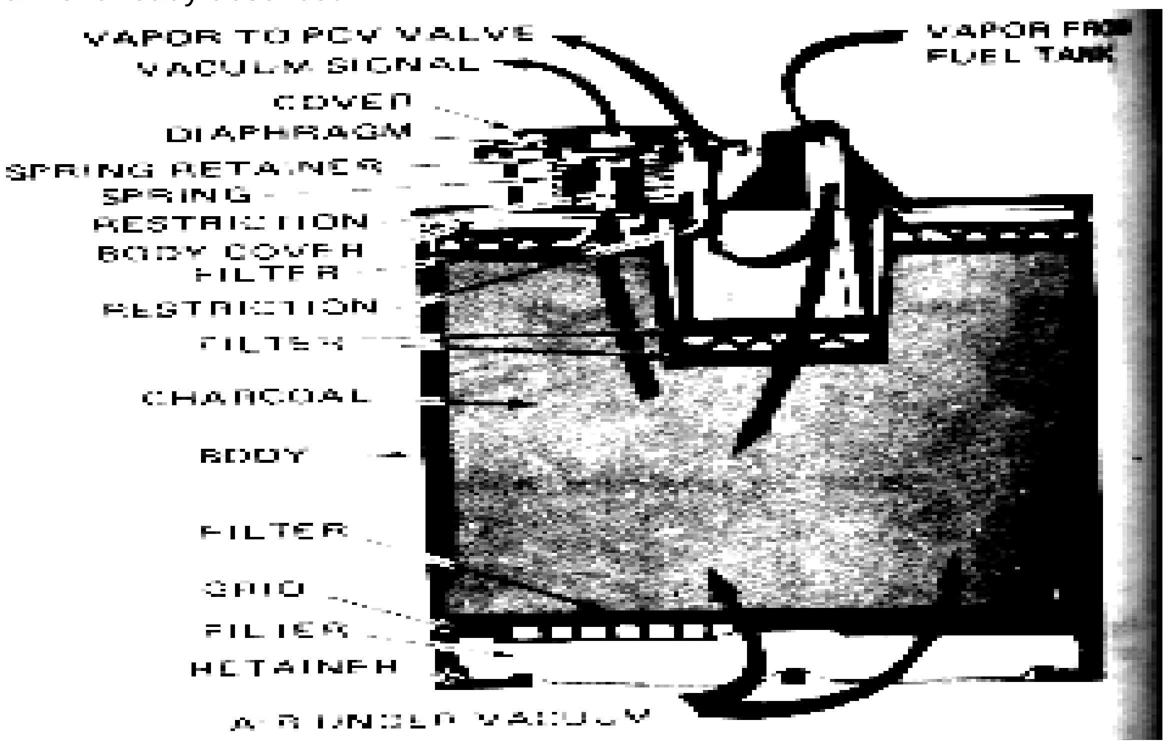

Fig-8: Sectional View of Charcoal canister for a six Cylinder engine Vapor Recovery System.

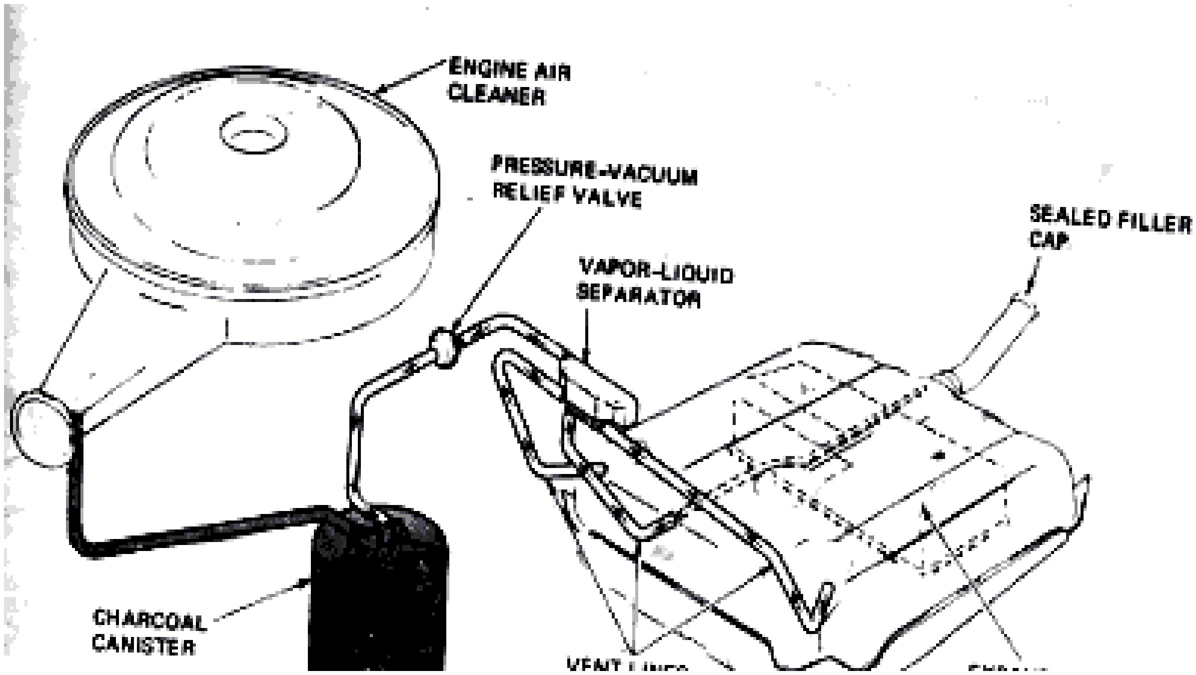

Fig-9: Vapor Recovery Systems, Shown Schematically. In This System, the Purge Line from the Canister Is connected to the Air-cleaner Snorkel.

Separating Vapor From Fuel

6. The fuel tank must have some way of separating the gasoline vapor from the liquid gasoline. Otherwise, liquid gasoline might flow to the canister and then out into the atmosphere. One system uses a standpipe assembly,. Figure -10 is a cutaway view of a standpipe assembly.

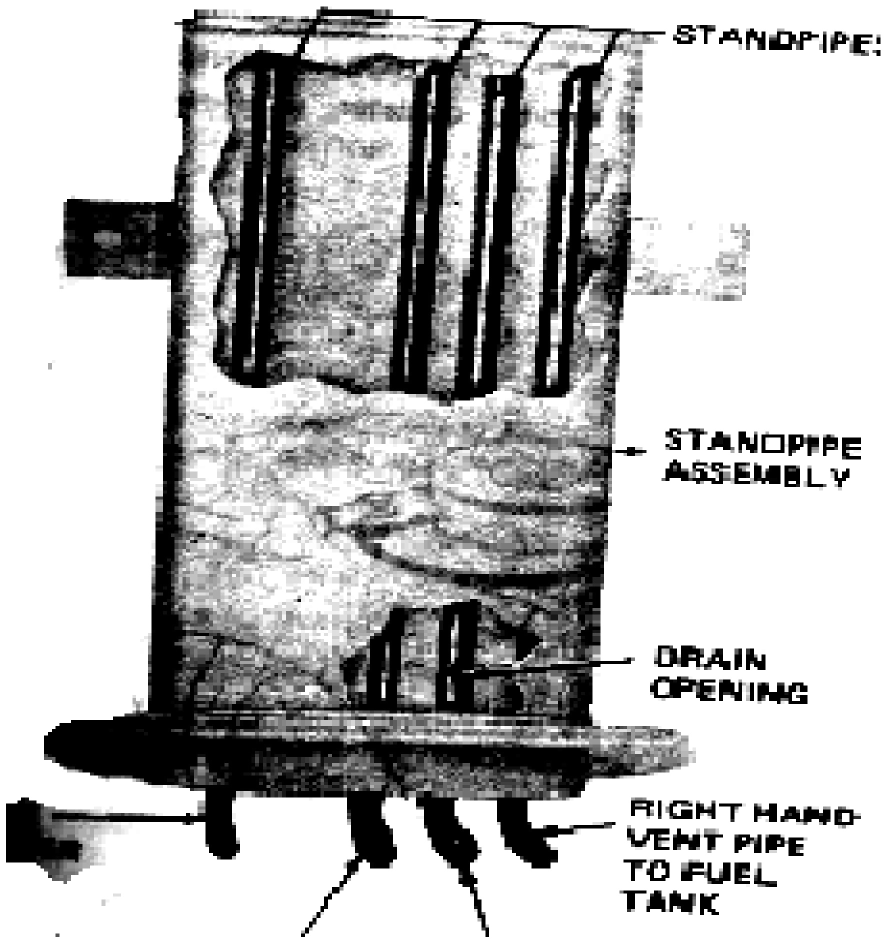

Fig-10: Cutaway View of a Standpipe assembly.

It contains a series of pipes with openings at the top. Three of these pipes are connected to the center and two sides of the fuel tank. These vents are shown in Fig -

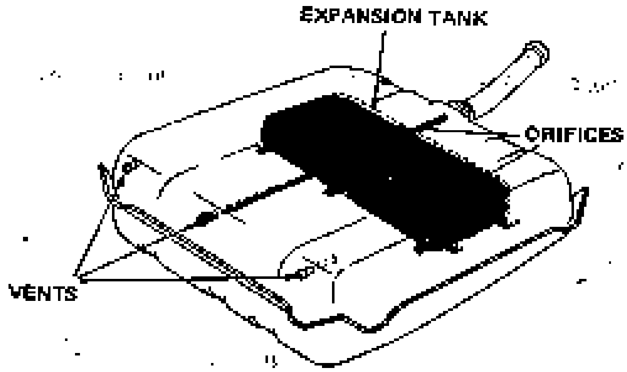

Fig 11. Fuel Tank

11.Used with a Vapor recovery system. the Two Sides Vents Are Short, But The Center Vent Goes All The Way To The Rear Of The Tank. With this system, at least one of the vents is always above the fuel level, regardless of the tilt of the car. Thus, air and fuel vapor can always pass up into the standpipe and through the vent line to the canister. Figure -12 shows a variation of the standpipe system. Here, a vapor-liquid separator is positioned above the fuel tank. Four vapor-vent lines connect from the separator to the four corners of the fuel tank. A still different Vapor-fuel separating arrangement is shown in Fig -13. In this system, a liquid check valve is used. It is connected by tubes to the two ends of the fuel tank. The liquid check valve will pass air but will not pass liquid gasoline. Another type of vapor separator is shown in Fig. -12. This separator is mounted on top of the fuel tank. It is filled with filter material that will pass vapor but not liquid gasoline. The vapor separator is mounted at the top center of the fuel tank. This minimizes the chances of liquid gasoline getting directly to the separator. Some systems use a domed fuel tank. The dome forms the high point of the tank, and the emission-control pipe is connected at this point.

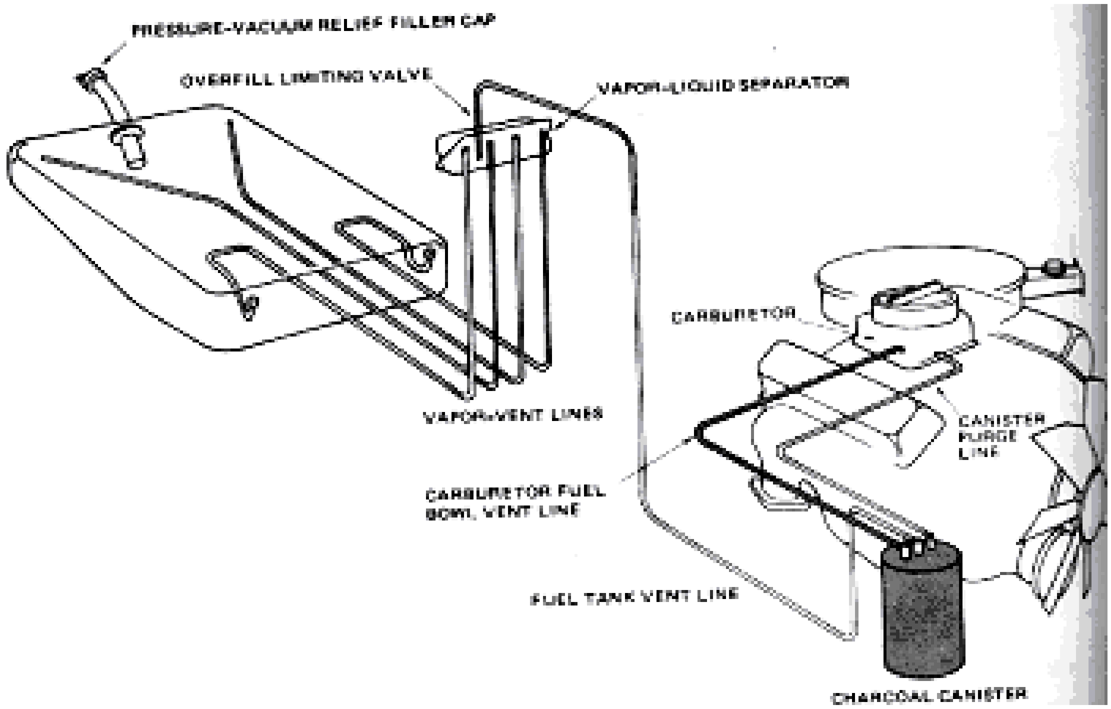

Fig-12: vapor Recovery System. Note The Vent Line Between The Carburetor Float Bowl And The Canister.

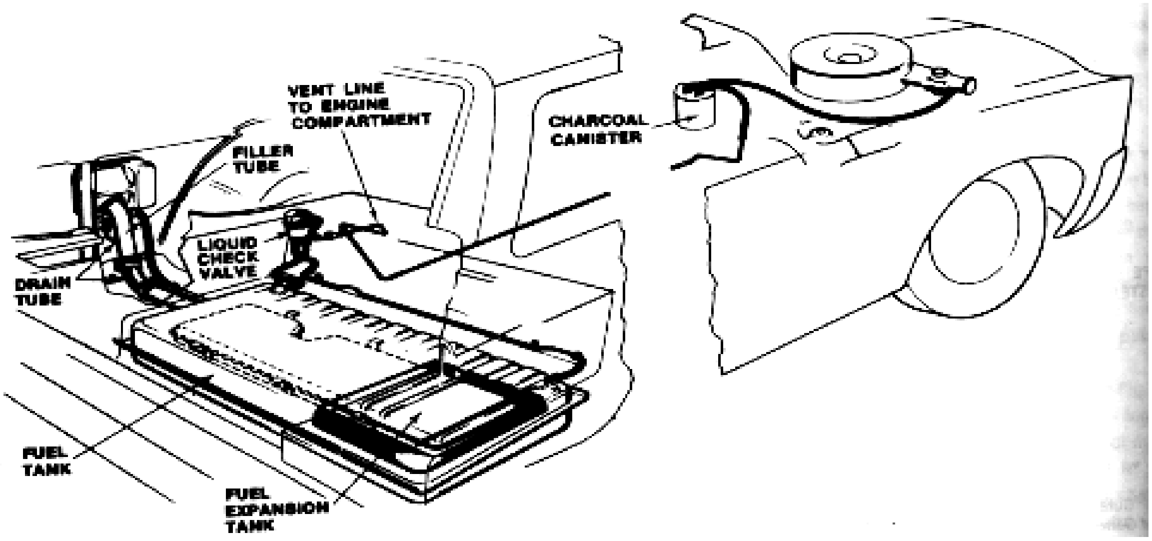

Fig-13: Vapor Recovery System Using A Liquid Check valve

Sealed Fuel Tank

7. Earlier fuel tanks had a vent pipe or a vent in the fuel tank cap. Modern automobiles, with vapor recovery systems, used a sealed fuel tank with a special cap.. The cap has a pressure-vacuum valve system. It is much like the pressure-vacuum cap used on the radiator of a pressurized cooling system. The cap valve opens if it too much pressure

develops in the tank. It also opens to admit air as fuel is withdrawn, so that a vacuum does not develop in the tank. Presario or vacuum in the tank could damage the tank.

Carburetor Insulator

8. Some carburetor uses an insulator to reduce heat flow from the engine to the carburetor. The insulator is placed between the carburetor and intake manifold. It forms a hear barrier between them. This reduces fuel evaporation from the float bowl after the engine has been turned off. Another arrangement uses an aluminum heat-dissipating plate which sticks out, as shown in Fig -15,

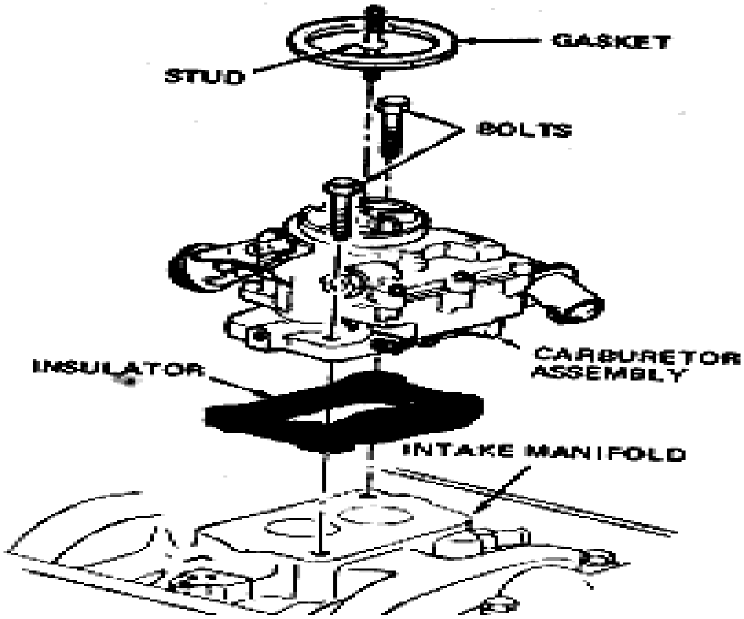

Fig-14: The carburetor Insulator Placed Between The Carburetor And The Intake Manifold

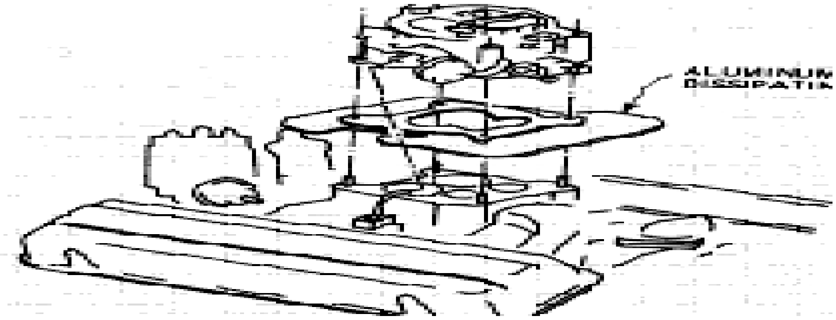

Fig-15: Insulator and Aluminum Heat-Dissipating Plate Between The carburetor And Intake Manifold, To Reduce Heat Flow to the Carburetor.

Vapor Storage in Crankcase

9. Some Chrysler Corporation car has used the crankcase to storage gasoline vapor from the fuel tank and carburetor. When the engine is stopped, gasoline vapors from the vapor separator at the fuel tank flow down in to the crankcase. At the same time, fuel vapors from the carburetor float bowl flow down into the crankcase. The vapors are two to four

times as heavy as air. Thus, they sink to the bottom of the crankcase. Then, when the engine is started, the positive crankcase ventilating system clears the crankcase of the vapors. The vapors are carried up into the intake manifold and then into the engine, where they are burned.

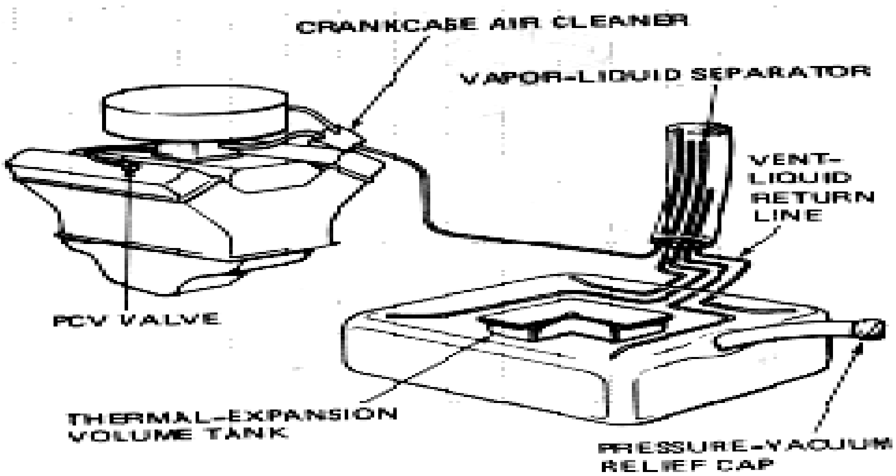

Fig-16: Vapor recovery system using the Crankcase for Fuel vapor Storage

Expansion Tank

10. You probably have noticed and so on, that the fuel tank has an expansion tanks. These tanks are there in case of a rise in fuel temperatures after the fuel tank has been filled. As fuel temperature goes up, the fuel expands. The expansion tank gives the fuel a place to go.

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Syllabus	**:**	**Automobile General Diesel and Petrol Technology**
Course	**:**	**Trade training Advance, MTOF**
Subject	**:**	**Cleaning up the exhaust gas**
Aim	**:**	**To study Cleaning the Exhaust Gas**
Ref	**:**	**Automotive Mechanics by William H. Crouse.**

CLEANING THE EXHAUST GAS

Controlling the Air Fuel Mixture

1. Gasoline has been changed to make it burn better. One of the changes is the elimination of lead. The tetraethyl lead has been added to gasoline to control knocking and

permit higher compression ratios. Lead is now being removed to permit the use of catalytic converters, which we shall discuss later in the chapter. Removing the lead has required a reduction of compression ratios. Basically controlling the air-fuel mixture has meant:

a. **Modifying the carburetor to deliver a leaner air-fuel mixture:** Modern carburetors have an idle limiter (Fig -20). The idle-mixture adjustment screw is adjusted at the factory. Then the idle-limiter cap is installed. The cap permits a small amount of adjustment of the idle-mixture adjustment screw. But it will not permit any adjustment that goes beyond the lean idle setting required by law. The cap can be removed, of course, if the carburetor requires a major overhaul.

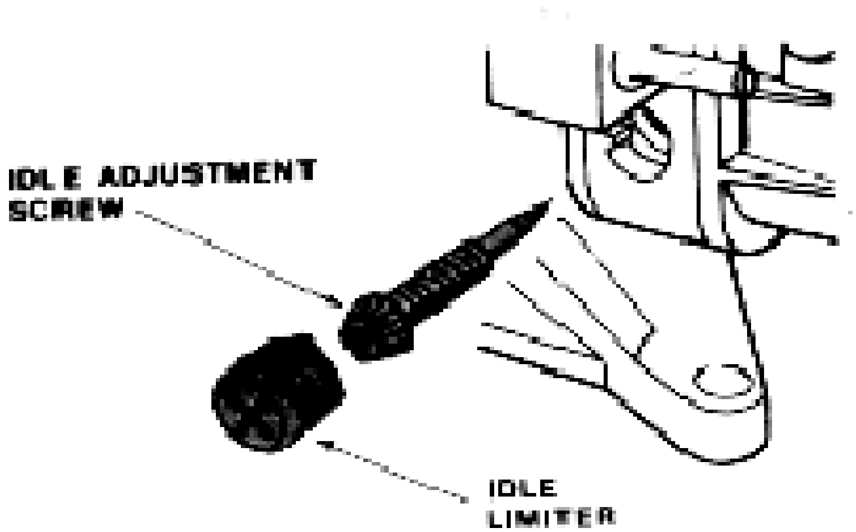


Fig-17: Location of the idle limiter in one model of carburetor

Faster warm-up and Heated Air system:

2. If the air-fuel mixture coming from the carburetor is cold, only part of the fuel will vaporize. This means that an extra-rich mixture is needed. Otherwise, the engine will not get enough gasoline vapors for it to run. of course, the situation changes as soon as the engine begins to run. Then, the hot exhaust gas circulating around the manifold heat-control valve begins to heat the intake manifold. However, this is too slow for the new systems. So a thermostatically controlled air cleaner is used to provide heated air quickly to the carburetor when the engine is cold. This system, called the heated-air system. Figure -18 shows the system installed on a V-engine. As you will recall, this system includes a control-damper assembly in the snorkel of the air cleaner. Also, it has a heat stove that surrounds the exhaust manifold. When the engine is cold, the temperature sensor in the air cleaner closes the damper. In this position, all air has to come from the heat stove. When the engine starts and the exhaust manifold begins to warm up, hot air is delivered to the carburetor. This improves cold and warm-up operation. As the engine begins to warm up, the ingoing-air temperature rises above 100 ^{0} F [37.8^0 C]. This causes the temperature sensor to admit manifold vacuum to the air-control motor. The air-control motor opens the control-damper assembly. Now air can enter from the engine compartment. This system allows the

engine to start and operate satisfactorily when cold, even though the idle mixture is lean.

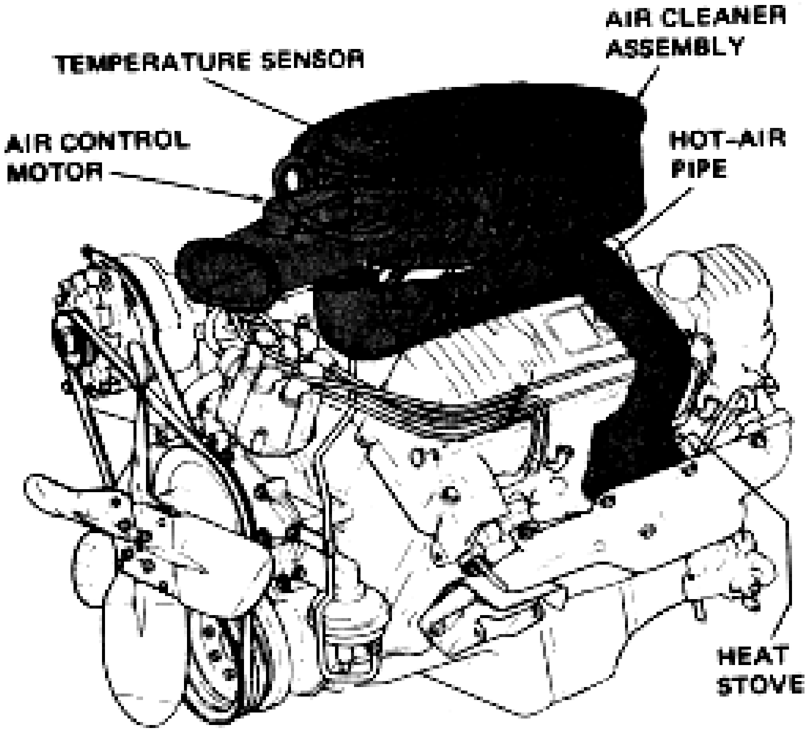


Fig -18, Heater air System

Exhaust Gas Recirculation (EGR)

3. If a small part of exhaust gas is sent back through the engine, it reduces the combustion temperature and lowers the formation of NO_x. The amount sent through the engine should vary according to operating conditions. A special passage connects the exhaust manifold with the intake manifold. This passage is opened or closed by an EGR valve. The upper part of this valve is sealed. It is connected by a vacuum line to a vacuum port in the carburetor. When there is no vacuum at the port, there no vacuum in the EGR valve. The spring holds the valve closed. No exhaust gas recirculates. This is the situation during idling, when formation of NO_x is near a minimum. However, when the throttle is opened, it passes the signal port. This allows the intake-manifold vacuum to operate the EGR valve. The vacuum raises the diaphragm in the valve. This lifts the valve of its seat. Now exhaust gas can pass into the intake manifold. There, it mixes with the air fuel mixture and enters the engine cylinders. The exhaust gas lowers the combustion temperature and thereby reduce the formation of NO_x . At wide open throttle, there is a little vacuum in the intake manifold. This produces a denser mixer which burns cooler. Therefore, at wide open throttle there is less need for EGR. With low vacuum, the EGR valve is nearly closed. A thermal vacuum switch on many late-model cars prevents exhaust-gas recirculation until

engine temperature reaches about 100^0F [37.8^0 C]. The thermal switch is connected into the vacuum line between the carburetor and the EGR valve. The thermal switch is mounted in the cooling-system thermostat housing, so it senses coolant temperature. If this temperature is below 100^0 F [37.8^0 c], the thermal switch remains closed. This prevents the vacuum from reaching the EGR valve, so exhaust gas does not recirculates. This improves cold-engine performance for the first few moments of operation. After the engine warms up to where it can tolerate exhaust-gas recirculation, the thermal valve opens. Now vacuum can get to the EGR valve, so that exhaust gas car recirculates. There are several variations of this basic system. For instance, some EGR valves have a second diaphragm. Its purpose is to produce increased exhaust-gas recirculation when the engine is heavily loaded, as during hard acceleration. Also, some high-performance engines use an additional modulator system to provide additional control based on car speed. One system of this type is shown in Fig. -19. The modulator system is enclosed in dashed lines.

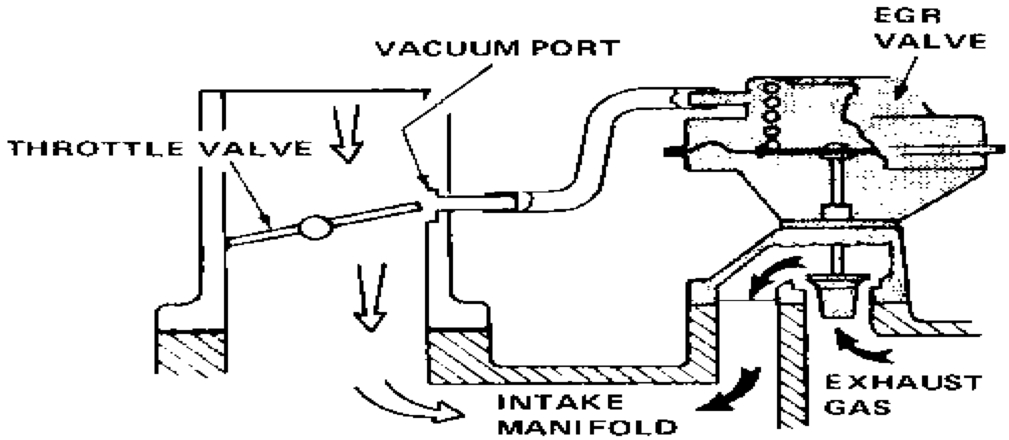


Fig-19-a: Exhaust Gas Recirculation System.

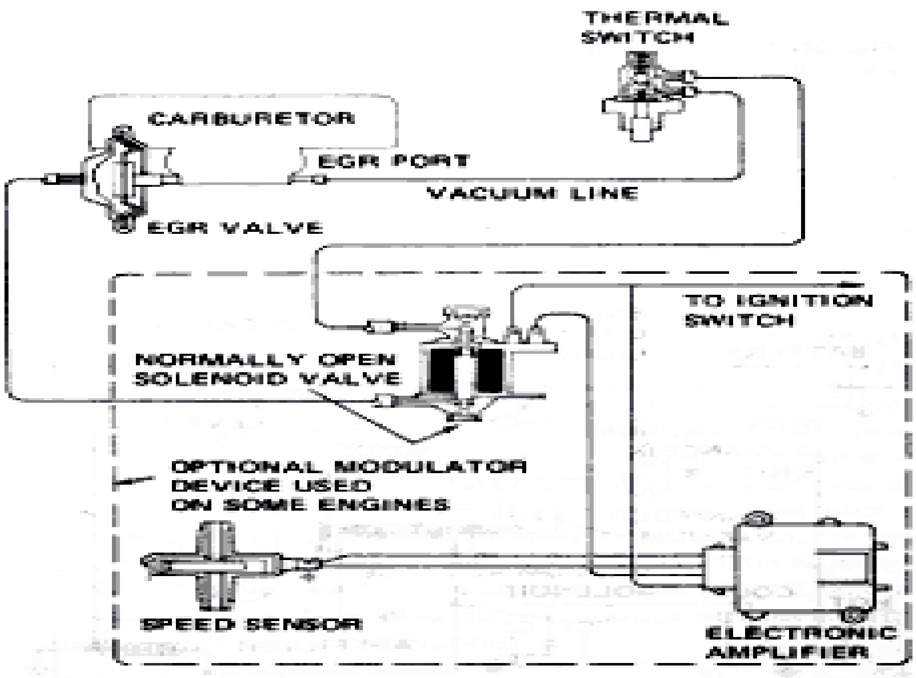


Fig-19-b: Exhaust Gas Recirculation System Showing Optional Modulator for Some Engine

It includes a solenoid valve that is Noreen dashed lines. It includes a solenoid valve that is normally open, allowing intake-manifold vacuum to pass through it. When engine temperature is high enough to open the thermal switch, and the throttle is partly opened, intake manifold can operate the EGR valve. Exhaust-gas recirculation results. However, when car speed reaches a certain level, the speed sensor sends a signal to the electronic amplifier. This causes the amplifier to close the solenoid valve. Now the vacuum line is closed, and exhaust-gas recirculation stops.

<u>Controlling the Combustion Process</u>

4. The combustion process seems simple at first glance. A mixture of air and gasoline vapor is compressed in the combustion chamber. A spark ignites it. It burns and produces the high pressure that pushes the piston down. However, the process is complicated. Here are some of the factors involved.

a. The layers of air-fuel mixture next to the relatively cool cylinder head and piston head do not burn. The metal surfaces chill these layers below the combustion point. So the unburned fuel is swept out of the cylinder on the exhaust stroke. This adds polluting HC to the atmosphere. There are two methods of combating this problem. One is to use stratified charge or fuel injection. The other is to reduce the surface area surrounding the combustion chamber. We shall come back to these two methods later.

c. Vacuum advance gives the air-fuel mixture a longer time to burn when the engine operates at part throttle. But it also gives more time for NO to form under certain operating conditions. So a means must be provided to kill the vacuum advance during these special operating conditions. We cover this in detail later.

TCS System

5. During part-throttle operation, the distributor vacuum advance operates. This provides more time for the leaner air-fuel mixture to burn. However, this added time also allows more NO_x to develop. Thus, a variety of controls have been used to prevent vacuum advance under certain conditions. For example, Chevrolet uses a transmission-controlled spark (TCS) system on cars with manual transmissions. The TCS system prevents-vacuum advance when the car is operated in reverse, neutral, or low forward gears. Under these special conditions vacuum advance could greatly increase the for motion of NO_x .Figure -20 shows the Chevrolet TCS system for a six-cylinder engine in a manual-transmission car. The diagram also shows the engine temperature switch (lower left) and the idle-stop solenoid. Figure -21 shows the situation during starting. Turning on the ignition switch energizes the idle-stop solenoid. The plunger extends to contact the throttle lever. This prevents the throttle from closing completely, so that idle speed stays high enough. When the engine is turned off, the idle-stop solenoid allows the throttle to close completely. This prevents "dieseling," or the engine running with the ignition off. Now, refer to Fig. -21 again.

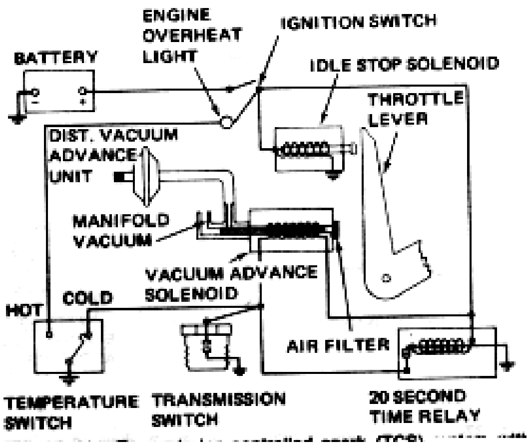


Fig -20: Transmission-controlled Spark System with Engine Off.

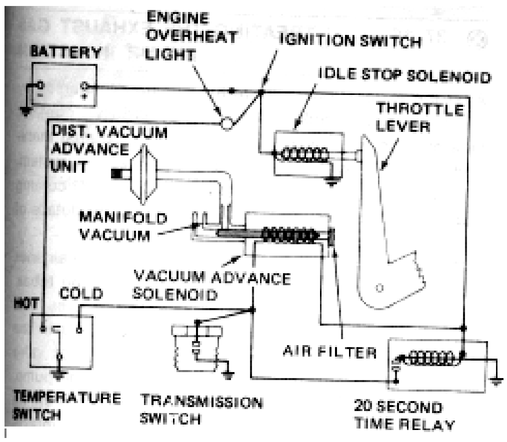


Fig-21:TCS System with Cold Engine Running.

Note that turning on the ignition switch completes the circuit through the vacuum advance solenoid and temperature-switch cold terminal. At the same time, the circuit to the 20-second time relay is completed. With either of these circuits complete, the vacuum advance solenoid is energized. Vacuum is admitted to the distributor vacuum advance mechanism so vacuum advance is obtained. Figure -22 shows the system in low-gear operation. If the engine temperature has gone up enough, the temperature-switch cold points have opened. Also, after 20 seconds, the time-relay switch points open. Thus, the circuit to the vacuum advance solenoid is opened by either of these conditions. The solenoid plunger moves to block vacuum to the distributor vacuum advance. No vacuum advance results.

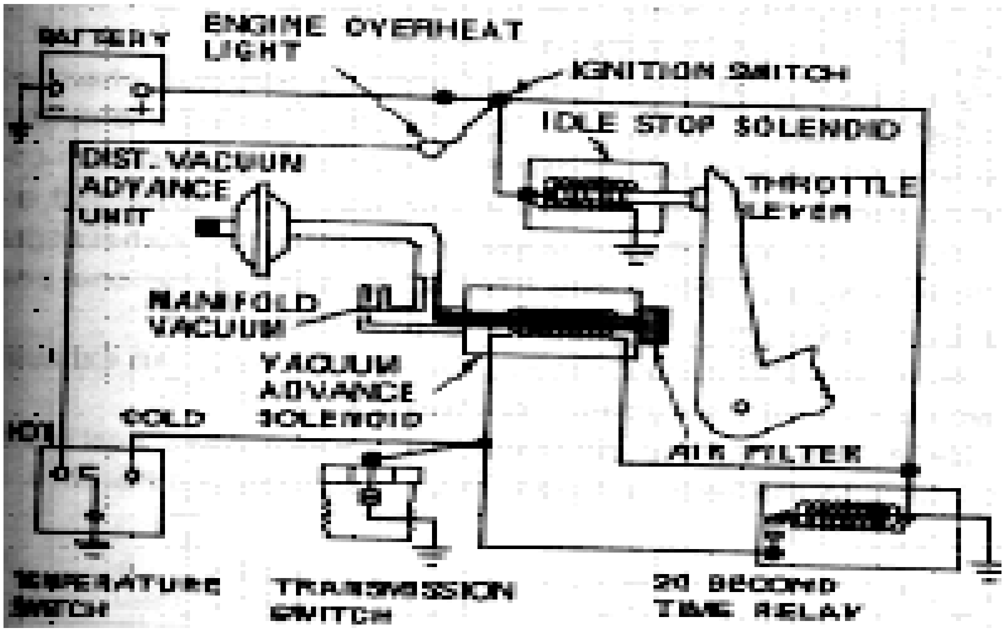


Fig-22: TCS System during Low Gear

Figure -23 shows the system in high gear. The transmission switch closes its points when the transmission is shifted into high. This energizes the vacuum advance solenoid so that vacuum is admitted to the distributor vacuum advance mechanism. Vacuum advance can then result. Some systems have a temperature override switch. This switch causes the system to provide vacuum advance under any condition if the engine begins to over-heat. This system is shown in Fig. -24. If the engine becomes too hot, the hot points in the temperature over-ride switch close. This energizes the solenoid so that vacuum is admitted to the distributor vacuum advance. With vacuum advance, engine speed increases, and improved cooling results.

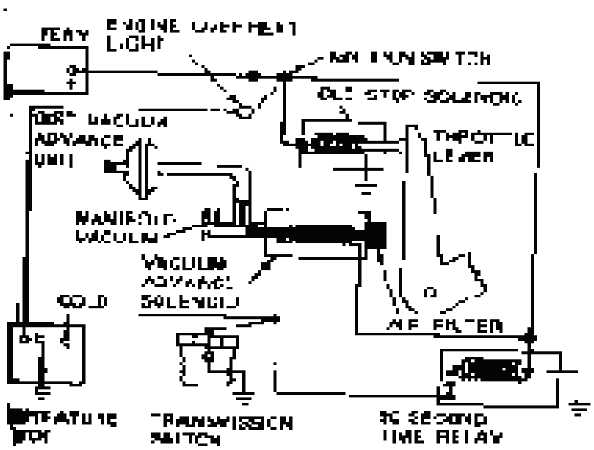


Fig-23: TCS System During Operation In High Gear.

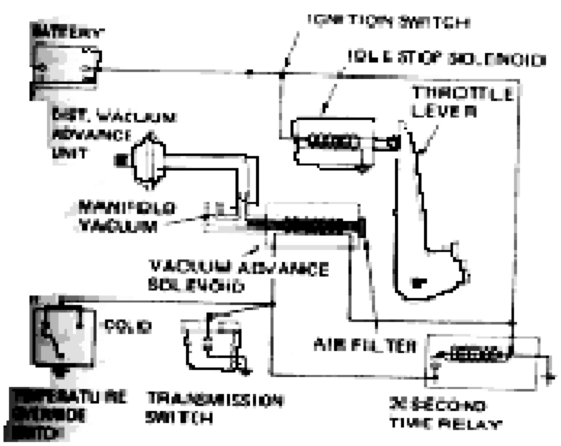


Fig-24: Schematic View Of The TCS System Which Uses A Thermostatic Temperature Override Switch.

Treating the Exhaust Gas by Air Injection

6. After the exhaust gases leave the engine cylinders, they can be treated to reduce the HC, CO, and NO_x content. One method is to blow fresh air into the exhaust manifolds. Such a system is called an air-injection system. It provides additional oxygen to burn HC and CO coming out of the cylinders. Figure -25 shows the details of the system.

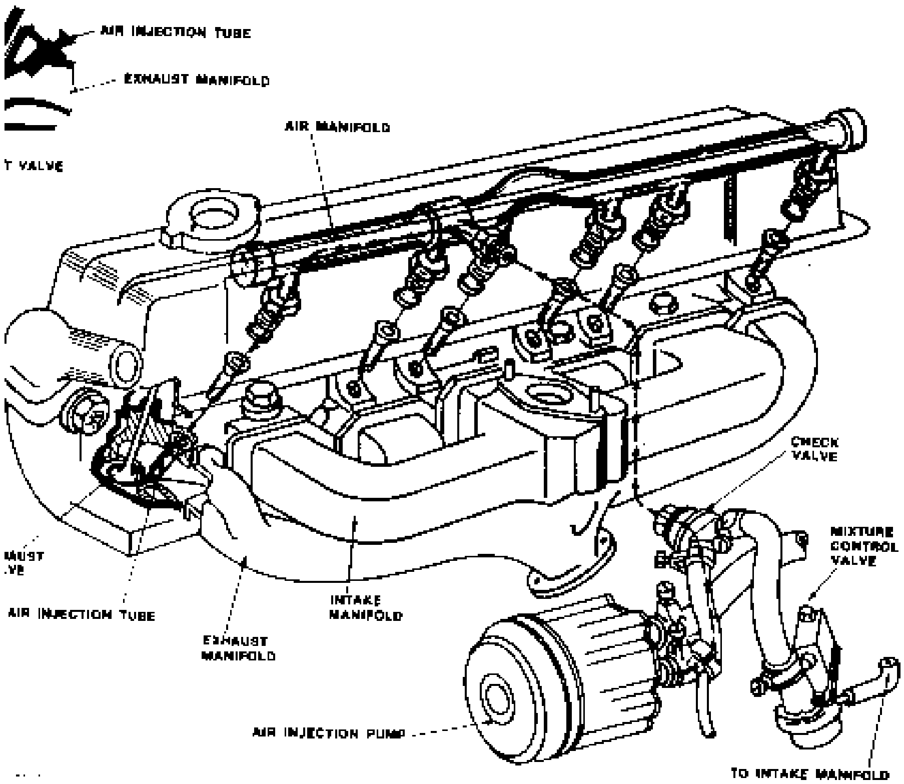


Fig-25: Air-Injection System

***Note*: Air Manifold And Other Parts of The System Are Shown Detached So They Can Be Seen Better. The Cylinder Has Been Cut away at the Front to Show the Air-injection Tube fits into the Head.**

The air-injection pump pushes air through the air lines and the air manifold into a series of air-injection tubes. These tubes are located opposite the exhaust valves. The oxygen n the air helps to burn any HC or CO in the exhaust gas in the exhaust manifold. The check valve prevents any backflow of exhaust gases to the air pump, in case of backfire. The air-by pass valve operates during engine deceleration. During deceleration, intake-manifold vacuum is high. The bypass valve momentarily diverts air from the air pump to the air cleaner, instead of the exhaust manifold. This tends to prevent backfiring in the exhaust system. A variation of this system uses a special chamber, called a thermal reactor (Fig. -26). In the V-B system shown, there are two thermal reactors, one for each cylinder bank. These reactors are basically enlarged exhaust manifolds. Being larger, they hold the exhaust gas a little longer. This gives the HO and CO additional time to burn with the oxygen in the pumped-in air. Note also that the air-injection system does nothing to the NO_x in the exhaust gas. NO_x requires a different sort of treatment.

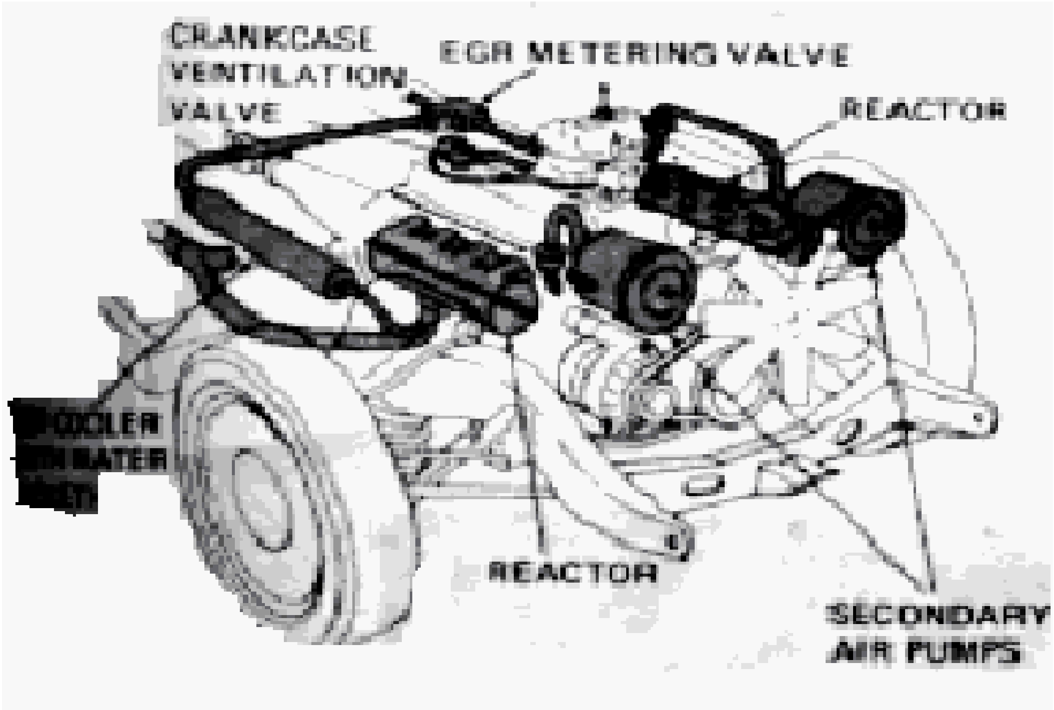


Fig-26: Thermal-Reactor System for Exhaust Emission Control

<u>Catalytic Converters</u>

7. A second method of treating exhaust gas uses catalytic converters. These convert harmful pollutants into harmless gases. A catalyst is a material that causes a chemical change without entering into the chemical reaction. In effect, the catalyst encourages two chemicals to react with each other. For example, in the HC / CO catalytic converter, the catalyst encourages the HC (Hydro carbon) to unite with oxygen to produce H_2O. It encourages the CO (Carbon monoxide) to change into CO_2. The catalyst in the NO_X converter splits the nitrogen from oxygen. The NO_X (Nitrogen oxides) therefore becomes harmless nitrogen and oxygen. The converter is filled with pellets of metal. They are coated with a thin layer of platinum or similar catalytic metal. The pellets form a matrix through which the exhaust gas must pass. As the exhaust gas flows through, the catalyst produces the chemical reaction. Another type of catalytic converter has a catalyst-coated honeycomb through the exhaust gas must pass. Cars with catalytic converters must use nonleaded gasoline. If the gasoline contains lead, the lead will coat the catalyst and converter will stop working. If this happens to pellet-type converter, there is a way to remove the old pellets. But on the honeycomb type, the complete catalytic converter must be replaced.

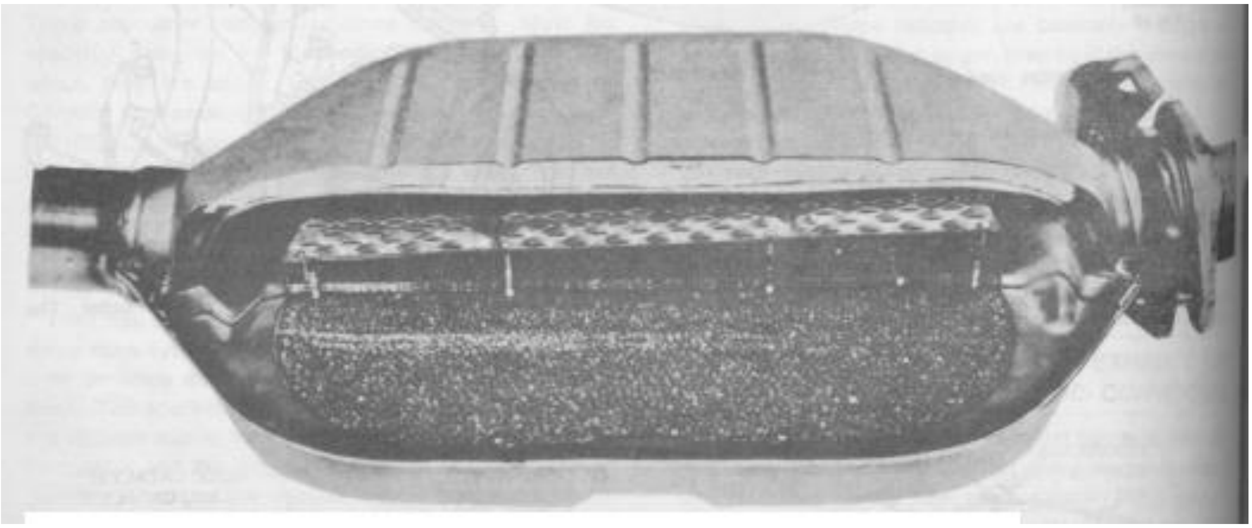


Fig-27: Cutaway View of the Catalytic Converter

Dual-bed and three-way catalytic converters

8. There are three general categories of catalytic converters. These are oxidizing, reducing and three ways. The oxidizing converter handles HC and CO, using platinum and palladium as the catalyst. To control NO_X, rhodium is used as reducing catalyst. It changes NO_X to harmless N_2 (Nitrogen). Instead of having two separate catalytic converters in the exhaust system, one for HC and CO and the other for NO_X most manufacturers use either a dual-bed catalytic converter or a three way catalytic converter. A dual-bed converter is like two bead-type converters in one housing with an air chamber between them. The exhaust gas first passes through the upper bed, reducing the NO_X and oxidizing some of the HC and CO. Then the exhaust flows through the air chamber to the lower bed, where the air pump is adding sufficient air for final oxidizing of the HC and CO.

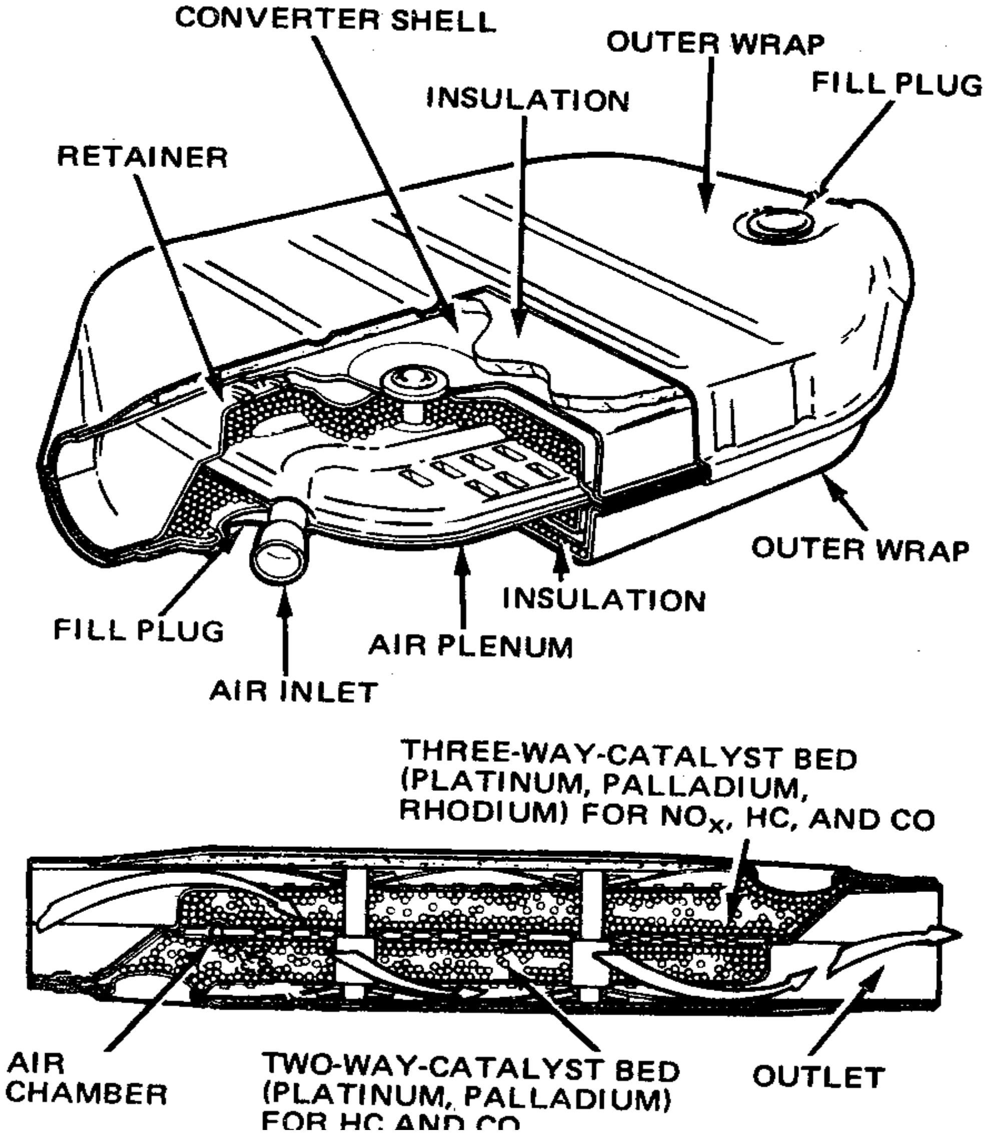


Fig-28: Dual-bed catalytic converters

A three-way catalyst is a mixture of platinum and rhodium (sometimes mixed with palladium). It acts on all three of the regulated pollutants (HC, CO and NO_X), but only when the air-fuel-mixture ratio is precisely controlled. If the engine is operated with the ideal or ***stoichiometric*** air-fuel ratio of 14.7:1, the three way-catalysts is very effective. It strips oxygen away from the NO_X to form harmless water and nitrogen. However, the air-fuel ratio must be precisely controlled if this action is to occur. For this reason, a closed loop fuel metering system (either feedback carburetor or fuel injection) must be used.

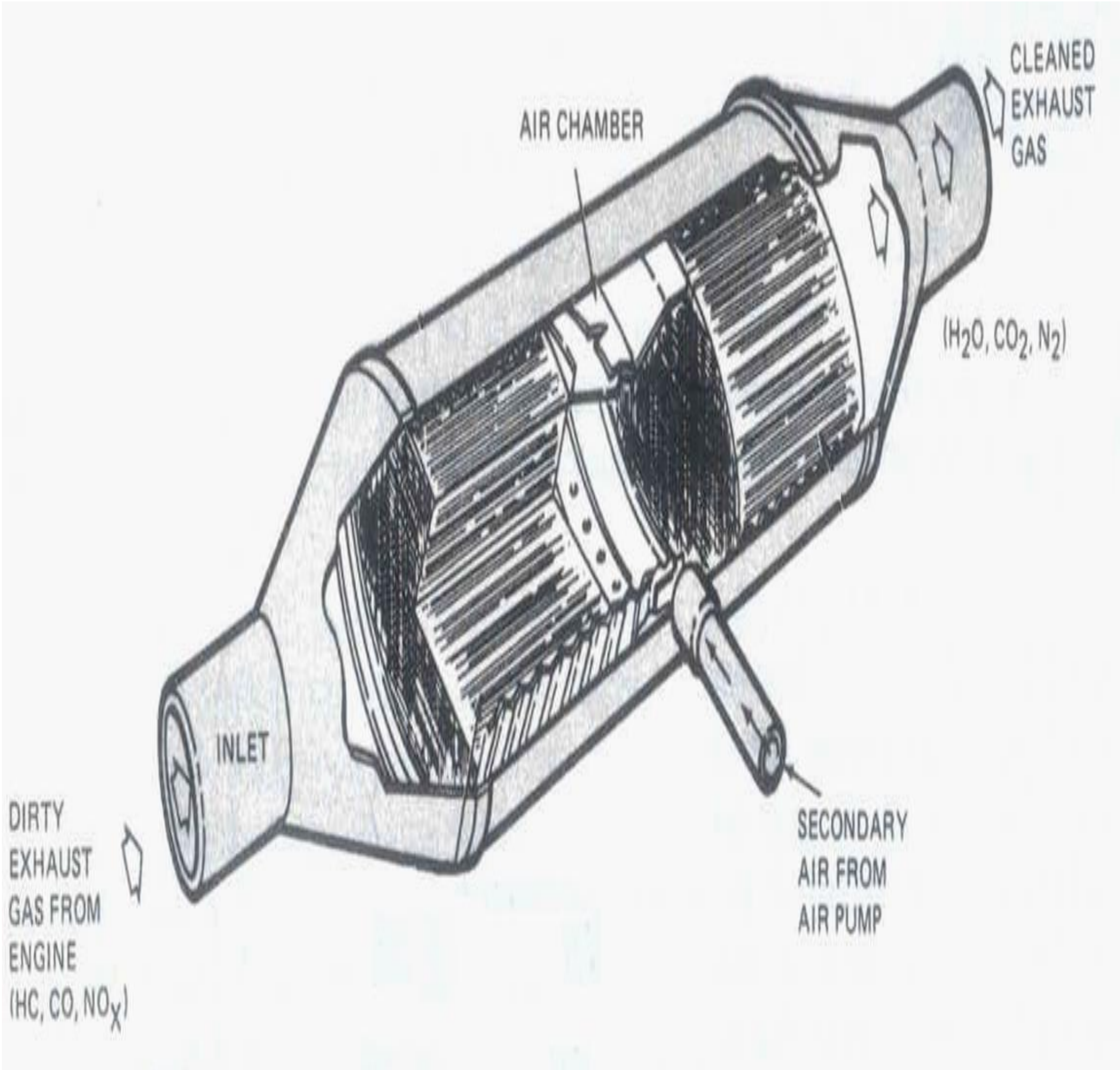


Fig-29: three way catalytic converters

There are two types of three- way catalytic converters. They have a mesh or honeycomb coated with catalyst. The front section (in the direction or gas flow) handles NO_X and partly handles HC and CO. The partly treated exhaust gas then flows through the air chamber into the rear section of the converter. There the gas mixes with the air being pumped in by the air pump. This is called secondary air. It puts more oxygen in the exhaust gas so that the two way catalyst can take care of the HC and CO.

(Aero Engg Trg Sqn)

Syllabus : Automobile General Diesel and Petrol Technology

Course : Trade Training Advance, MTOF

Subject : Gasoline & Electronic Fuel Injection System

Aim : To Study Gasoline & Electronic Fuel Injection System

Ref : Automotive Mechanics by William H Crouse (ninth Edition) & Internet Wikipedia

GASOLINE FUEL INJECTION SYSTEM

Fuel Injection System

1. The engine must have a continuous supply of combustible air-fuel mixture to run. In most engines, a carburetor mounted on the intake manifold supplies the mixture. This mixture then flows to the engine cylinders when the intake valves open. The amount of mixture that enters the intake manifold is controlled by the position of the throttle valves. Their position (from fully closed to wide open) determines the amount of air (actually, Air-fuel mixture) that can flow through into the intake manifold. An engine equipped with gasoline fuel injection has a throttle body mounted on the intake manifold, instead of the complete carburetor. The throttle body is very similar to the carburetor throttle body for one- or two- barrel carburetors. It has either one or two throttle valves. As in the carburetor, the position of the throttle valves determines the amount of air that flows through into the intake manifold. In the gasoline fuel-injection system, the fuel is injected into the intake manifold through fuel-injection valves. There are two basic arrangements, ***port injection*** and ***throttle body injection*** (TBI). These arrangements are also called ***multiple-point*** and ***single-point injection***. In port injection, there is an injection valve for each engine cylinder (Fig-1 a). Each injection valve is positioned in the intake port near the intake valve (Fig-1 b). In a TBI system, an injection valve is positioned slightly above each throat of the throttle body (Fig-2 a). The injection valve sprays fuel into the air just before it passes the throttle valve and enters the intake manifold (Fig-2 b).

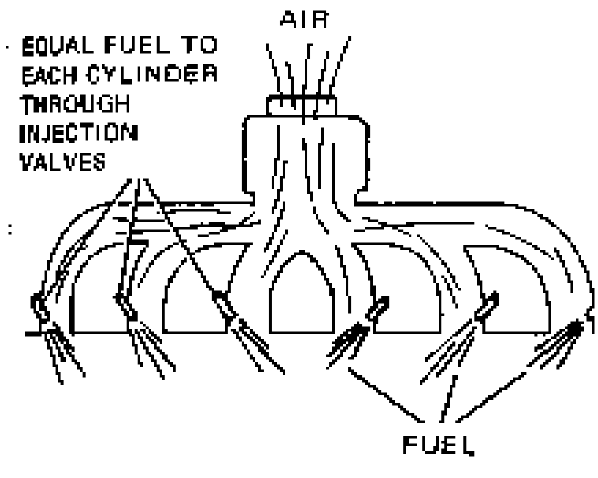


Fig-1-a: Port Injection

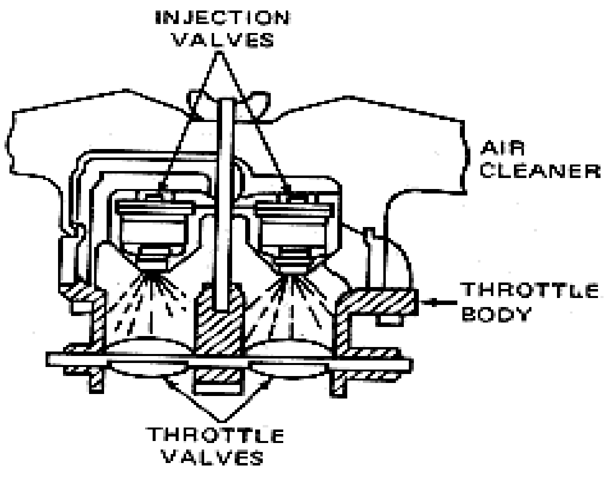
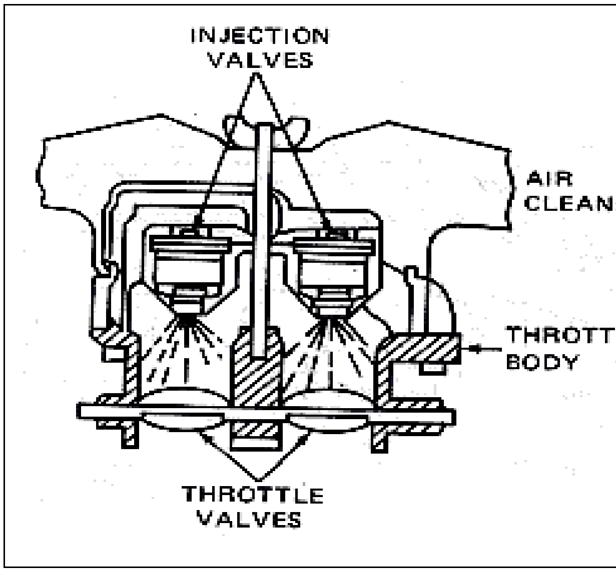


Fig-1-b: Port Injection



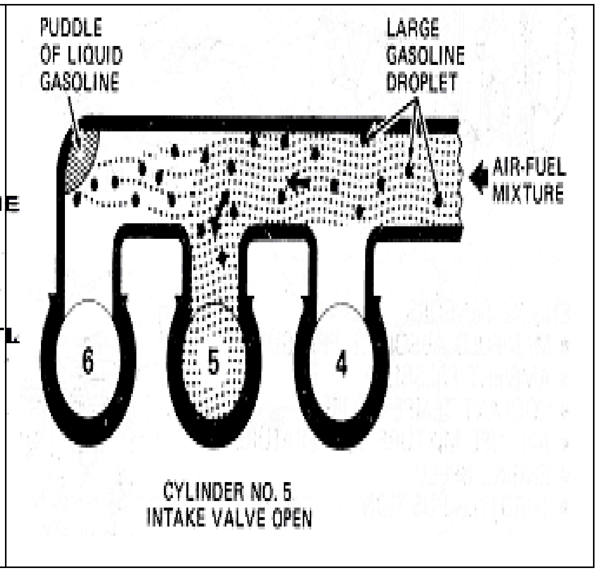


Fig-2-a: Throttle Body for TBI **Fig-2-b: Distribution in TBI System**

Timed and continuous Injection

2. Another way to classify fuel-injection system is by the injection action. Depending on the system, fuel sprays from the injection valves either in pulses (timed injection) or continuously. Port injection and throttle-body system maybe either pulses or continuous. In continuous injection system, fuel sprays continuously from the injection valves. With either system, the amount of fuel injected varies with engine speed and power demands.

Advantages of Port Fuel- Injection

3. Regardless of whether the port injection system is pulses or continuous, it eliminates several intake-manifold distribution problems. One of the most difficult problems in a carbureted system is to get the same amount and richness of air-fuel mixture to each cylinder. The problem is that the intake manifold acts as a sorting device, sending a richer air-fuel mixture to the end cylinders.. The air flows readily around corners and through variously shaped passages. However, the fuel, because it is heavier, is unable to travel as easily around the bends in the intake manifold. As a result, some of the fuel particles continue to move to the end of the intake manifold, accumulating or pudding there. This enriches the mixture going to the end cylinders. The center cylinders, closest to the carburetor, get the leanest mixture. The port fuel-injection system solves this problem because the same amount of fuel is injected at each intake-valve port. Each cylinder gets the same amount of air-fuel mixture of the same mixture richness. Another advantage of the port fuel-injection system is that the intake manifold can be designed for the most efficient flow of air only. It does not have to handle fuel. Also, because only a throttle body is used, instead of the complete carburetor, the hood height of the car can be lowered. With fuel injection, the fuel mixture requires no extra heating during warm-up. No manifold heat-control valve or heated-air system is required. Throttle response is faster because the fuel is under pressure at the injection valves at all time. An electric fuel pump supplies the pressure. The carburetor must depend on differences in air pressure (or vacuum) as the force that causes the fuel to feed into the air passing through.

Electronic Fuel Injection

4. The development of solid-state electronic devices such as diodes and transistors made electronic fuel injection possible. As early as 1968, some system began to appear on automobiles. Volkswagen began installing an electronic fuel-injection system that year. The system was developed by the Robert Bosch Corporation. In 1975, a version of the system appeared on some Cadillac's. Other companies also adopted variations of the system. This was a port injection system, known as the Bosch D-*type* electronic fuel-injection system. Later, Bosch developed the L-*type* system. This was also a port injection system. It was introduced by Porsche and Volkswagen in 1974. In this system, fuel metering is controlled primarily by engine speed and the amount of air that actually enters the engine. This is called *air-mass metering* or *airflow metering*. The airflow sensor in the air intake measures the amount of air that enters. Electronic throttle-body injection was first used by Cadillac and Ford on some 1980 cars (Fig-3) in this system; one or two injection valves are mounted in the throttle body. In operation, they spray fuel into the air passing through. Modern electronic fuel-injection systems include an oxygen sensor (Fig-4). The device measures the amount of oxygen in the exhaust gas and sends this information to the electronic control unit. If there is too much oxygen, the mixture is too lean. If there is too little, the mixture is too rich. In either case, the ECU adjusts the air-fuel ratio by changing the amount of fuel injected.

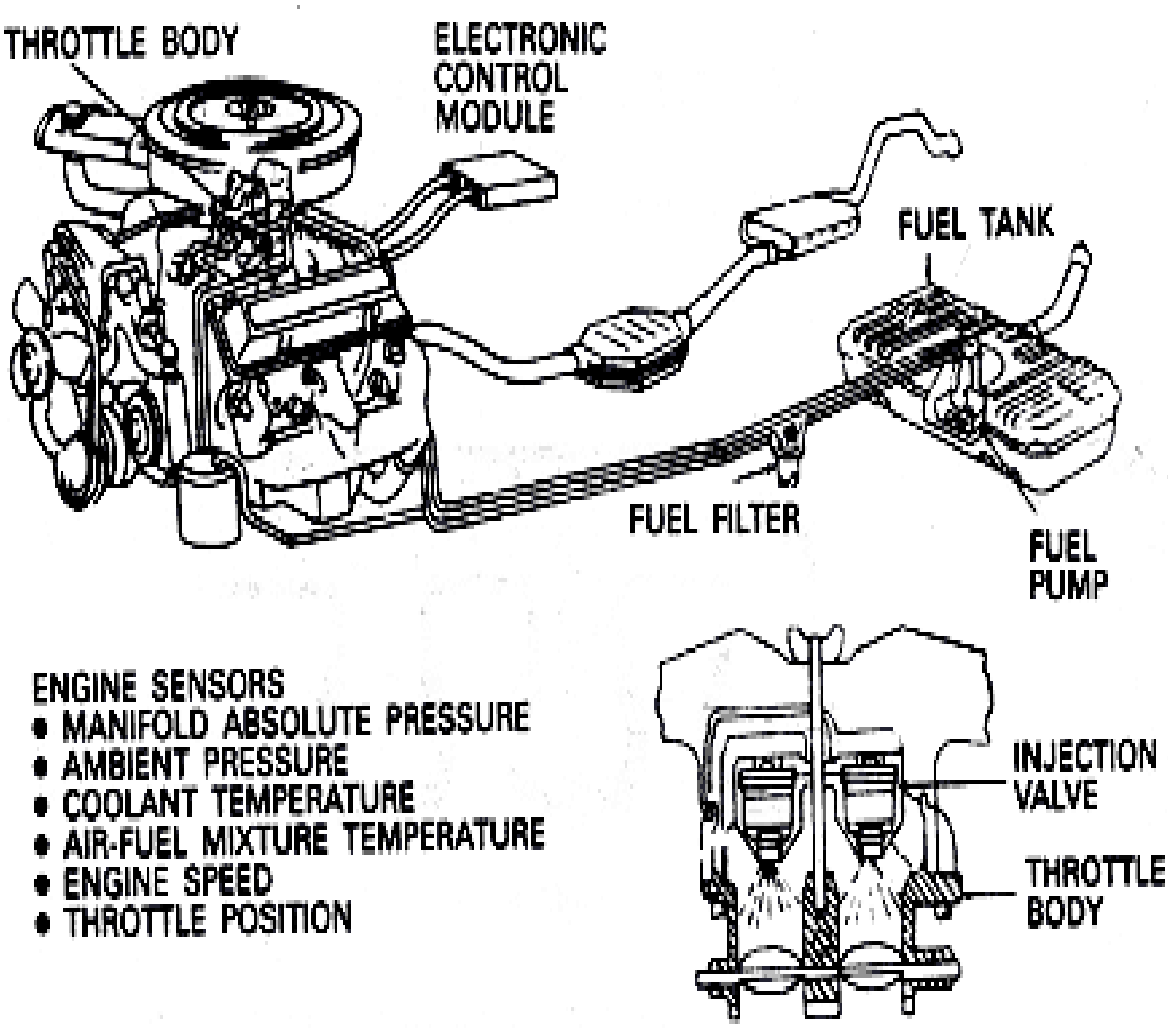


Fig-3: Digital Electronic Fuel-Injection

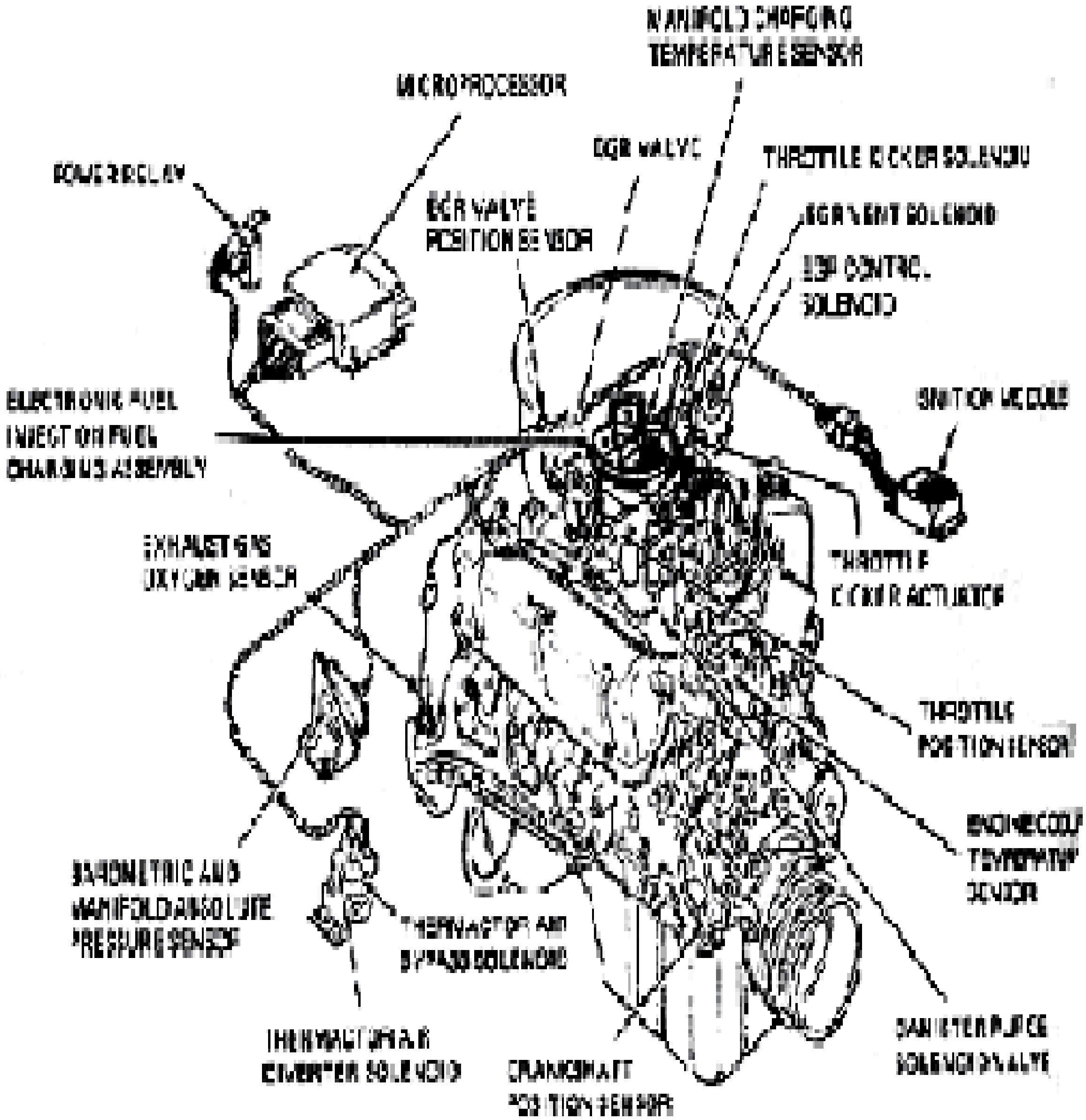


Fig-4 Oxygen Sensor

<u>How Electronic Fuel Injection Works</u>

Fig-5: Electronic Fuel Injectors and manifolds

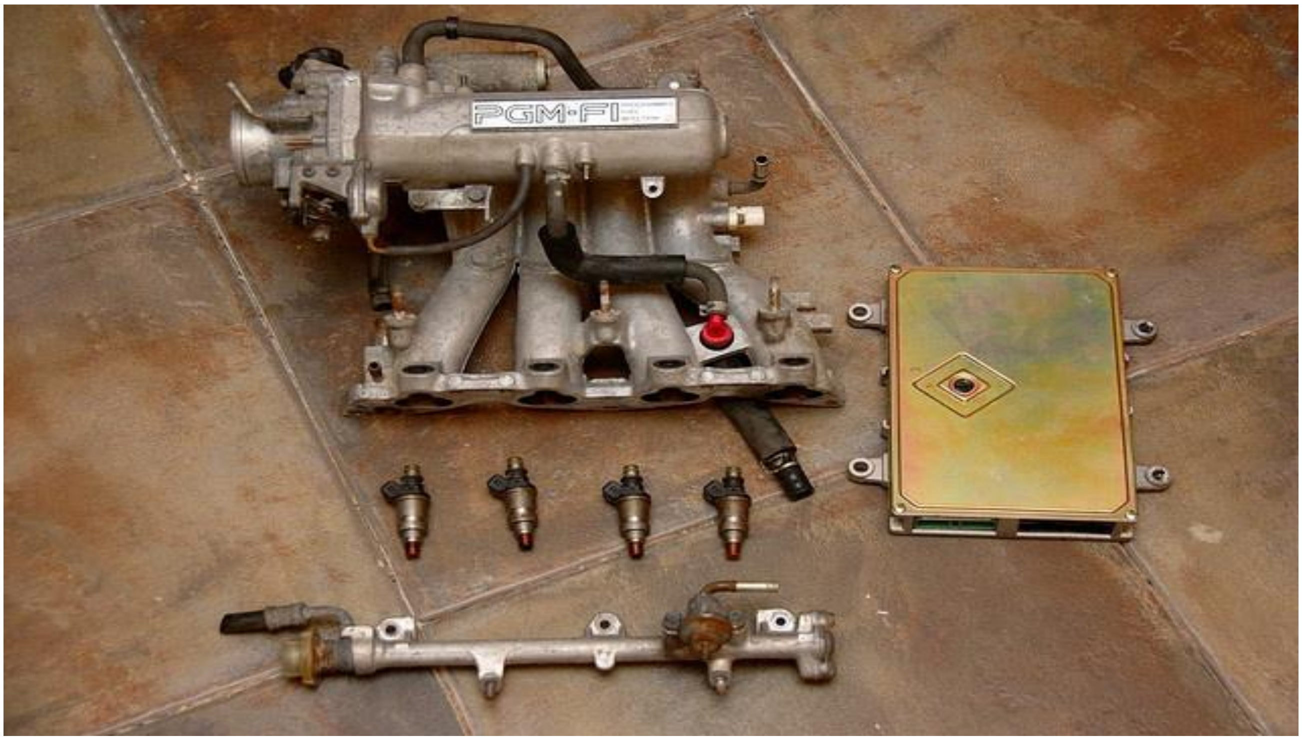


Fig-6: Electronic Fuel Injectors

<u>Electronic Fuel Injection</u>

5. If the heart of a car is its engine, then its brain must be the Engine Control Unit (ECU). Also known as a Powertrain Control Module (PCM), the ECU optimizes engine performance by using sensors to decide how to control certain actuators in an engine. A car's ECU is primarily responsible for four tasks. Firstly, the ECU controls the fuel mixture. Secondly, the ECU controls idle speed. Thirdly, the ECU is responsible for ignition timing. Lastly, in some applications, the ECU controls valve timing.

How Electronic Throttle Control Works

6. New cars are confusing. With all the computers, sensors, and gadgets, it may seem like there's some sort of magical witchcraft taking place. Before we talk about how the ECU accomplishes its tasks, let's follow the path of a gasoline droplet that enters your gas tank. Times have changed since the *Down the Gasoline Trail* video, so it's time for an update. Initially, after a gas droplet enters your gas tank (which is now made of plastic), it gets sucked up by an electric fuel pump. The electric fuel pump usually comes in an in-tank module that consists of a pump, a filter, and a sending unit. The sending unit uses a voltage divider to tell your gas gauge how much fuel you have left in your tank. The pump sends the gasoline through a fuel filter, through hard fuel lines, and into a fuel rail. A vacuum-powered fuel pressure regulator at the end of the fuel rail ensures that the fuel pressure in the rail remains constant relative to the intake pressure. For a gasoline engine, fuel pressure is usually on the order of 35-50 psi. Fuel injectors connect to the rail, but their valves remain closed until the ECU decides to send fuel into the cylinders. Usually, the injectors have two pins. One pin is connected to the battery through the ignition relay and the other pin goes to the ECU. The ECU sends a pulsing ground to the injector, which closes the circuit, providing the injector's solenoid with current. The magnet on top of the plunger is attracted to the solenoid's magnetic field, opening the valve. Since there is high pressure in the rail, opening the valve sends fuel at a high velocity through the injector's spray tip. The duration that the valve is open- and consequently the amount of fuel sent into the cylinder- depends on the pulse width (i.e. how long the ECU sends the ground signal to the injector). When the plunger rises, it opens a valve and the injector sends fuel through the spray tip and into either the intake manifold, just upstream of the intake valve, or directly into the cylinder. The former system is called multiport fuel injection and the latter is direct injection expand.

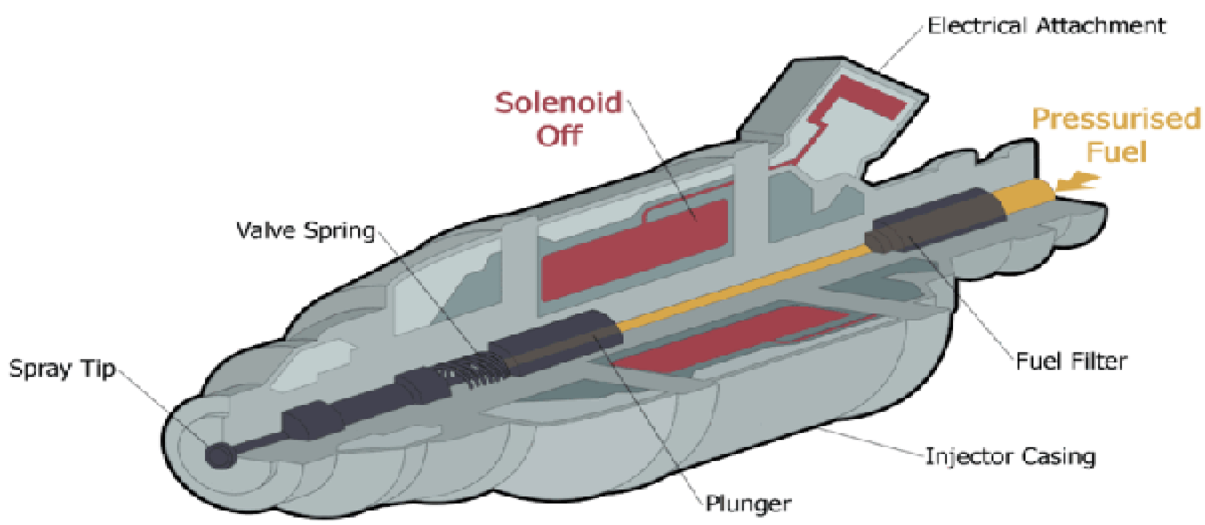


Fig-7: Cut view of electronic fuel injectors

Controlling Fuel Mixture

$$\underbrace{C_8H_{18}}_{\text{Gasoline}} + 12.5\,\underbrace{(O_2 + 3.776N_2)}_{\text{Air}} = \underbrace{8CO_2}_{\text{Carbon Dioxide}} + \underbrace{9H_2O}_{\text{Water}} + \underbrace{47.2N_2}_{\text{Nitrogen}}$$

Fig-7: Chemical reaction during combustion

Expanssion

7. We've already looked at how electronic throttle control works. We showed you that, when a driver pushes his or her gas pedal, an accelerator pedal position sensor (APP) sends a signal to the ECU, which then commands the throttle to open. The ECU takes information from the throttle position sensor and APP until the throttle has reached the desired position set by the driver. But what happens next? Either a mass air flow sensor (MAF) or a Manifold Absolute Pressure Sensor (MAP) determines how much air is entering the throttle body and sends the information to the ECU.

The ECU uses the information to decide how much fuel to inject into the cylinders to keep the mixture stoichiometric. The computer continually uses the TPS to check the throttle's position and the MAF or MAP sensor to check how much air is flowing through the intake in order to adjust the pulse sent to the injectors, ensuring that the appropriate amount of fuel gets injected into the incoming air. In addition, the ECU uses the o2 sensors to figure out how much oxygen is in the exhaust. The oxygen content in the exhaust provides an indication of how well the fuel is burning. Between the MAF sensors and the 02 sensor, the computer fine-tunes the pulse that it sends to the injectors.

Controlling Idle

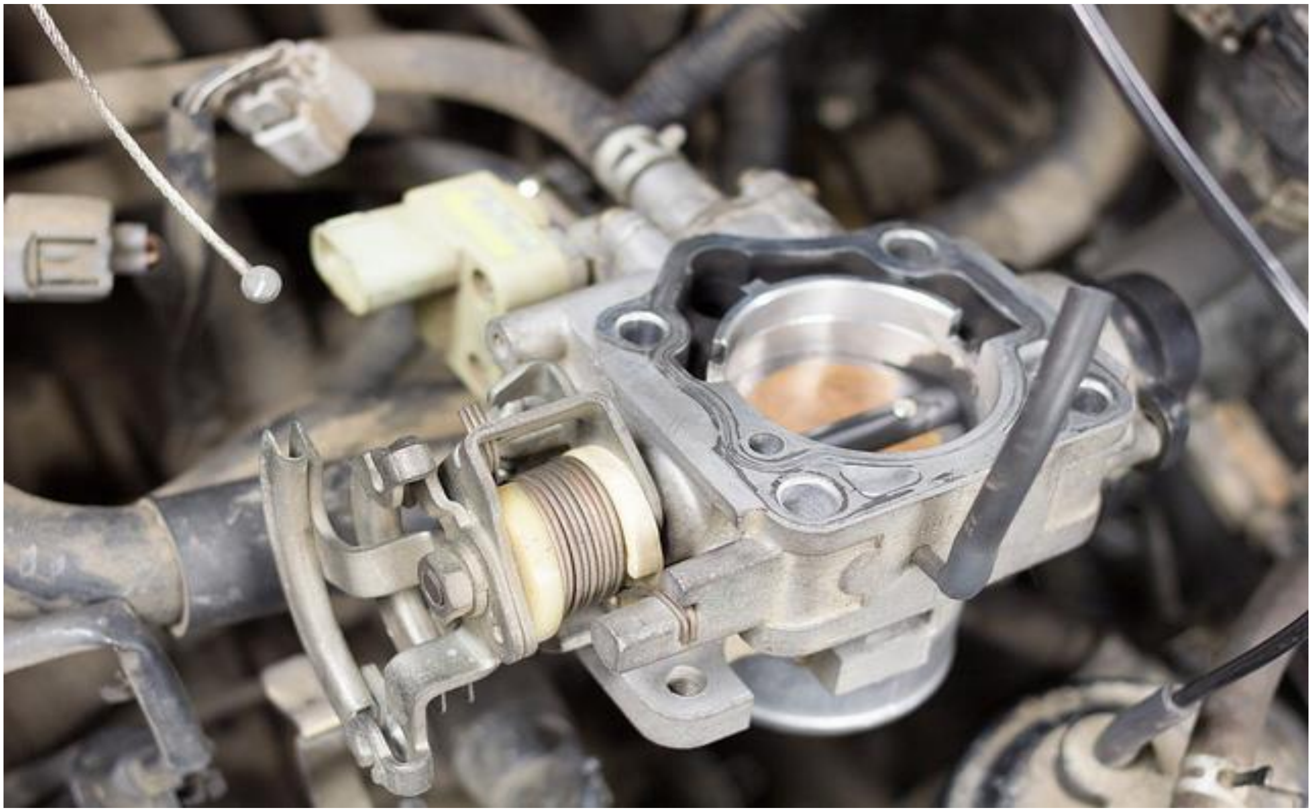


Fig-8: Induction Controlling in Idle running

8. Let's talk about idling. Most early fuel injected vehicles utilized a solenoid-based idle air control valve (IAC) to vary air flow into the engine during idle (see the white plug in the above image). Controlled by the ECU, the IAC bypasses the throttle valve and allows the computer to ensure smooth idle when the driver does not activate the accelerator pedal. The IAC is similar to a fuel injector in that they both alter fluid flow via a solenoid actuated pin. Most new cars don't have IAC valves. With older cable-controlled throttles, the air entering the engine during idle had to go around the throttle plate. Today, that's not that case, as Electronic Throttle Control systems allow the ECU to open and close the butterfly valve via a stepper motor.

The ECU monitors the rotational speed of the engine via a crankshaft position sensor, which is commonly a Hall Effect sensor or optical sensor that reads the rotational speed of the crank pulley, engine flywheel, or the crankshaft itself. The ECU sends fuel to the engine based upon how fast the crankshaft rotates, which is directly related to the load on the engine. Let's say you turn on your air conditioning or shift your vehicle into drive. The speed of your crankshaft will decrease below the threshold speed set by the ECU due to the added load. The crankshaft position sensor will communicate this decreased engine speed to the ECU, which will then open the throttle more and send longer pulses to the injectors, adding more fuel to compensate for the increased engine load. This is the beauty of feedback control. Why does your engine rev higher at startup? When you initially turn on the vehicle, the ECU checks the engine temperature via a coolant temperature sensor. If it notices that the engine is cold, it sets a higher idle threshold to warm the engine up.

Fig-9: Spark plugs

Controlling Ignition Timing

9. Now that we've mentioned the ECU’s tasks of maintaining engine idle speed, as well as maintaining a proper air/fuel mixture, let's talk about ignition timing. To achieve optimum operation, the spark plug must be provided with current at very precise moments, usually about 10 to 40 crankshaft degrees prior to top dead center depending on engine speed. The exact moment that the spark plug fires relative to the piston’s position is optimized to facilitate the development of peak pressure. This allows the engine to recover a maximum amount of work from the expanding gas.

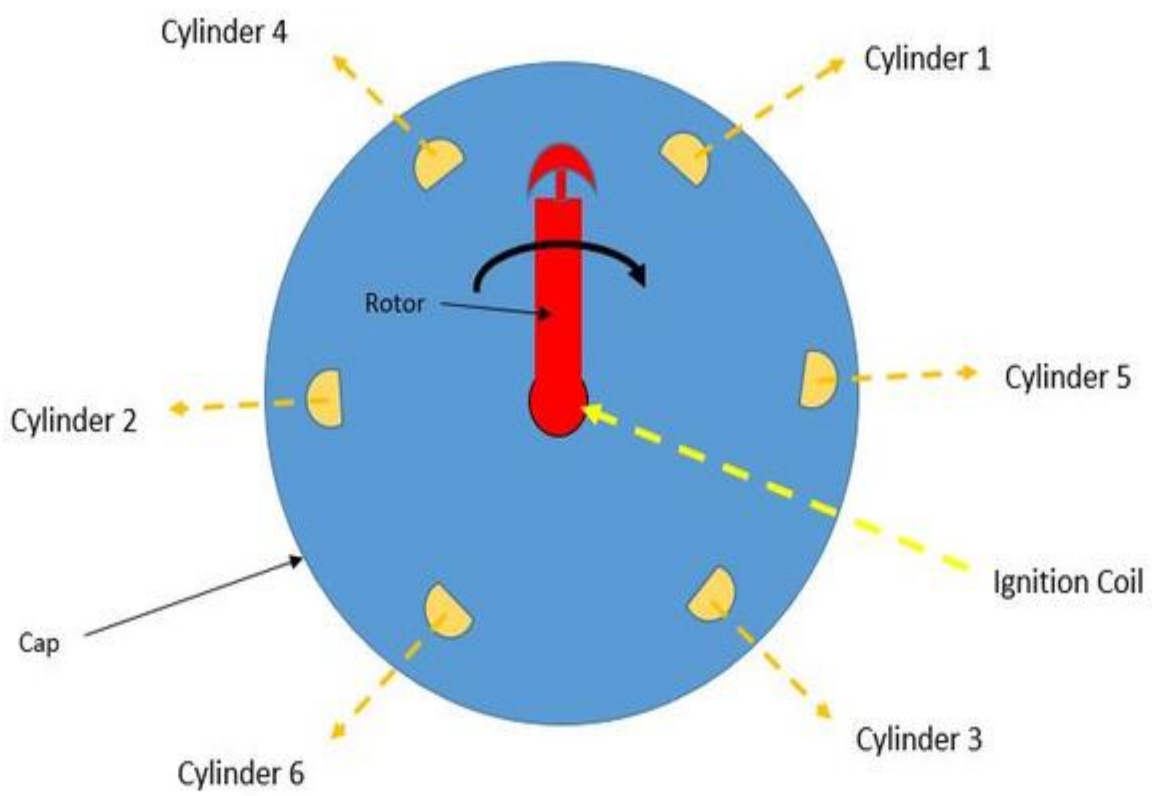


Fig-10: Electronic Distributor rotor and spark segments

Expanssion

10. Older engines (up until the mid 2000s) used distributors to control spark. Shown above, this system consists of a rotor and a distributor cap. The rotor is electrically connected to the ignition coil, which is basically a transformer that steps 12v up to over 10,000 volts needed for spark. The rotor is mechanically connected to the camshaft via a gear. As the camshaft spins, so does the rotor. As the rotor spins, it comes very close to copper posts (one for each cylinder). The current from the ignition coil jumps the small air gap between the rotor and the posts, sending high voltage through spark plug wires, to each cylinder's spark plug at a specific time. Note that these systems needed a way to alter timing. At high engine speeds, advancing spark is necessary. Early engines with distributors used engine vacuum or rotating weights to adjust timing. Later, transistor-based timing systems became more common. Modern vehicles don't use a centrally located ignition coil. Instead, these distributorless ignition systems (DIS) have a coil located on each individual spark plug. Based on input from the crankshaft position sensor, knock sensor, coolant temperature sensor, mass airflow sensor, throttle position sensor, and others, the ECU determines when to trigger a driver transistor, which then energizes the appropriate coil. The ECU is able to monitor the piston's position via the crankshaft position sensor.

The ECU continually receives information from the crankshaft position sensor and uses it to optimize spark timing. If the ECU receives information from the knock sensor (which is nothing more than a small microphone) that the engine has developed a knock (which is often caused by premature spark ignition), the ECU can retard ignition timing so as to alleviate the knock.

Controlling Valve Timing

11. The fourth major function of the ECU is to adjust valve timing. This applies to vehicles that utilize variable valve timing, which allows engines to achieve optimal efficiency at a multitude of engine speeds.

Troubleshooting Late-Model Cars-Diagnose Your EFI System

Fig-11: **Troubleshooting EFI System**

12. Possibly the most frustrating thing to deal with on an electronic fuel-injection car is the dreaded check engine light. Things were simpler with carburetors and distributors--you could hold the offending part in your hand and physically see the problem. Not so with computerized cars, though. Mysterious sensors and controllers contain circuit boards, resistors, diodes, and relays that can all fail, and you'd never know by looking. Still, EFI cars operate on the same principles as carbureted ones, and therefore you can diagnose any problems that arise. You just need a couple of extra tools in your arsenal and a thorough understanding of the affected system. To get a handle on trouble codes and data streams, we talked to our friends at Galpin Auto Sports, Galpin Ford, and Westech Performance Group. Fear not--it isn't as intimidating as you might think.


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Fig-12: ECM--Electronic Control Module. This is the computer that controls everything.

Background

13. Contrary to what some people believe, onboard diagnostic systems were not created by the

manufacturers to make it impossible for people to work on their own cars. Rather, they were developed in response to government regulations for tighter emissions controls. It all began with the requirement of catalytic converters in the exhaust. The cats clean up the exhaust gases by converting the carbon monoxide to carbon dioxide and breaking up the oxides of nitrogen, but they need to work within a certain air/fuel range, just like an engine. If the exhaust is too rich or too lean, the converters can overheat and fail. So to make the cats live, the manufacturers needed to abandon carburetors and distributors for electronically controlled fuel injections and distributorless ignitions. In the early systems, the computers that controlled the electronic carburetors and throttle-body fuel-injection systems were pretty advanced for their time, though they would be considered stone-age technology today. They used input from oxygen sensors in the exhaust stream to determine the proper air/fuel ratio the engine should run at to produce the least possible emissions and were capable of warning the car owner, via the check engine light, if the engine was generating exhaust emissions outside the range of what the catalytic converters could handle. Of the three domestic manufacturers, GM was the early pioneer in electronic controls, and its system was the most comprehensive and best organized--it used the same data link connector and trouble codes across its model line. GM also provided a scan tool (the Tech 1) to its dealership technicians, used to read the codes and diagnose the faults.

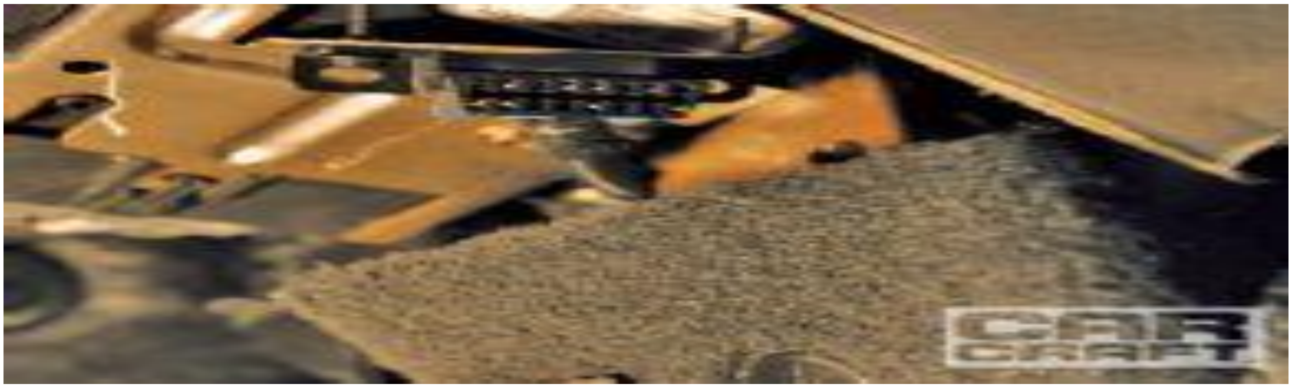

Fig-13**:** ALDL--Assembly Line Data Link. This is the plug used to connect with the ECM.

14. That's not to say the system was without problems. The number of trouble codes was limited and the descriptions were rather vague, often leaving technicians to guess at what the real cause of a trouble code was. Things were even more difficult for Ford and Chrysler technicians. The locations and shapes of the data connectors varied from car line to car line, as did the procedures for retrieving the trouble codes. Of course, their codes were different from GM's codes. Imagine what havoc that played on guys at independent repair shops. They had to have myriad scanners, connectors, cables, and adapters, plus the expensive software for each manufacturer. You can see how difficult and expensive diagnostic repairs are.

OBD-II

15. By the '90s, OBD-I systems had become much more sophisticated as they were put to use controlling multiport fuel-injection systems. But the systems still lacked uniformity among the manufacturers and accessibility to information to the aftermarket and independent repair shops. To remedy this situation, the government mandated a standardized system of trouble codes and required the manufacturers to give access to the codes and data stream to independent shops. The resulting system was dubbed OBD-II. It still operates much the same way as OBD-I, utilizing oxygen sensor readings to adjust fuel trim and deliver the most efficient air/fuel ratios, but it is much more sophisticated and features numerous redundant checks and monitoring systems. Simply put, the ECM has several ways to check most of the sensors to verify that they are

working correctly. As a result, the trouble code system was revised to four-digit codes instead of the two- (and in some cases three-) digit codes of the previous system. The other major change with OBD-II is the addition of a second oxygen sensor after the catalytic converter. This is to ensure the cats weren't removed and they are functioning properly and reducing harmful emissions. The new system requires a new set of scanners to read the date and trouble codes. You must use a scanner; there are no more jumper wires and blinking check engine lights. But the good news is one scanner can read any make or model, foreign or domestic, and all OBD-II cars have the same set of trouble codes and the same 16-pin data link connector.

Scanners and Scan Tools

16. Because the manufacturers were required to conform to a standardized set of DTCs, it is much easier for independent repair shops and the home mechanic to fix cars, and the scan tools needed to retrieve the codes are much more affordable than they used to be. Some, called code scanners (or simply scanners), can only read and possibly erase the engine computer's stored DTCs. The more expensive scan tools will read and erase codes but can also display live data from the sensors in real time with the engine running. This is an especially helpful feature to use to verify the proper operation of sensors and diagnose driveability problems.

Fig-14**:** PID--Parameter Identification Data information.

17. There are many different levels to choose from, and the more expensive the scan tool, the more it does. The tools the dealership guys have access to are top-shelf and would make even the most nerdy computer geek blush. We stopped by Galpin Ford, where technician Johnny Stein plugged his IDS scanner into the DLC of a new Mustang and gave us a tour of the various PIDs of the car's data stream and how he uses them to diagnose drive ability issues such as vacuum leaks, misfires, and hard starts. One of the coolest things Stein showed us was a relative compression test he performed in less than a minute without ever leaving the driver seat. Setting up his laptop for the compression test, Stein cranked the engine for about 10 seconds. If one cylinder makes less compression than the others, the crank will turn more quickly as that piston reaches TDC. This information is displayed in graph form on his screen, and he can determine which cylinder he should test further for ring wear or valve seating issues.

Diagnosing a problem

18. A scan tool of some sort, fixing a late-model car should be easy. "Just because the computer is giving a code for a certain sensor, don't automatically assume that the sensor is bad." So what to do if the check

engine light is on the car? "First, I'll erase the codes and start the car again." Once the ECM stores a trouble code and turns on the check engine light, it will stay on for a number of key cycles, even if the problem that triggered the code never happens again. By erasing the codes, the light is indicating a hard code--a problem that happens whenever the car is running--or a soft code, indicating an intermittent or one-time problem. "Next, the code sets again but then always checks the basics." Even if the trouble code is for a specific sensor, must step back and perform simple power and ground checks and also inspect any fuses related to that system. Replace sensors when the fault was in the electrical circuit of that system." Once verify the basic stuff, look to the code in a factory service manual and follow the diagnostic flow chart recommended in the book. "Sometimes, that doesn't always remedy the problem, but it's the best place to start."

Fig-15: Trouble codes with a scan tool and the proper connectors.

<u>Common Problem</u>

19. Stressed verifying the proper operation of the electrical and mechanical parts of the system because, in many instances, the electronics are working properly. "Most of the drivability problems are caused by vacuum leaks, which can trigger lean fuel misfire DTCs," with plugged fuel filters that triggers a random misfire code. On the scanner, the pump was delivering the proper fuel pressure, but the filter was so plugged, the pump couldn't deliver the proper volume of fuel, especially under heavy load." An Escalade brought in with random misfire and faulty MAF sensor codes, rather than automatically replacing the MAF, he checked the air filter and ducting and found a giant rat's nest clogging the inlet to the air box. Treat the scanner as another tool to use while diagnosing problems, not as only source of information. More often than not, it comes down to experience. The more you know about how a component or system is supposed to work; it will be easier to figure out how to fix any problem arises.

Fig-16**:** 10-pin GM OBD-I connector. Jump pins A and B to trigger the ECM's self-diagnostic

Fig-17: All OBD-II cars share the same connector.

Fig-18: Here are oxygen sensors before and after the catalytic converters verify the cats are work

Fig-19: The Actron 9185 Elite scan tool.

Fig-20: Galpin Ford's Johnny Stein demonstrates Ford's Integrated Diagnostic System, a PC-based EC

Fig-20: Auto digital scanner

20. It doesn't need to buy the latest, most expensive scan tool on the market, but we do recommend. We found the book how to use automotive diagnostic scanners by tracy martin to be especial. Look up the trouble code and follow the diagnostic chart in the service manual. DTC code descriptions are available at Actron's website. We also recommend buying a factor.

<u>Wiseco EFI Tuner Troubleshooting Guide</u>

21.

Sl No	Problem	Possible cause	Remedy
a.	Vehicle won't start	Dirty connectors Loose connections Bad ground	Clean all connectors Firmly snap all connectors together Clean ground lug and tighten ground bolt
b.	When first started, led's cycle from left to right to left for about 7 seconds, then 1 or 2 green led's remain displayed	Normal Wiseco EFI tuner start up diagnostic routine	None needed
c.	Flashing red and flashing green led's are displayed at start up	Controller not receiving proper injector signal due to bad connections	Check the wire connections for defects
d.	Engine stalls at idle, green led's are displayed	Green mode requires adjustment	Push center mode button once, adjust green mode
e.	Poor low speed running with light throttle application, green led's are displayed	Same as above	Same as above
f.	Hesitation when accelerating, yellow led's are displayed	Yellow mode requires adjustment	Push center mode button twice, adjust yellow mode
g.	Misfire at wide open throttle, red led's are displayed	Red mode requires adjustment	Push center mode button three times, Adjust red mode.
h.	When in adjustment modes, controller goes back to operational mode after 5 seconds	This is normal – controller is designed to automatically save adjustment after 5 seconds of inactivity in the adjustment modes	None needed
j.	Popping during deceleration	Lean air fuel/ratio	Adjust controller to add fuel
k.	Poor overall performance	Fuel controller improperly adjusted	Return controller adjustment to base settings provided with Wiseco EFI fuel controller or go to www.wiseco.com for base settings
l.	Vehicle hesitates – yellow led's are displayed	Yellow mode requires adjustment	Push center mode button twice, adjust yellow mode
m.	Vehicle seems sluggish at wide open throttle – red led's are displayed	Red mode requires adjustment	Push center mode button three times, adjust red mode
n.	Engine knocks during acceleration – yellow led's are displayed	Lean air/fuel ratio in yellow mode	Push center mode button twice, adjust controller to add fuel in yellow mode

p.	Engine knocks at wide open throttle - red led's are displayed	Lean air/fuel ratio in red mode	Push center mode button three times, adjust controller to add fuel in red mode

GM Digital Fuel Injection

22. This system is similar to the TBI system. Fuel flow from the injection valves is regulated by an electronic control module (ECM). The ECM monitors operating conditions so that the system will supply the correct air-fuel mixture for good drivability and exhaust emission control. The system uses an oxygen sensor. Fuel is delivered to the injection valves at a constant pressure. The amount of fuel the injection valves deliver is determined by the length of time that the valves are held open. This is controlled by the ECM, calculated from information supplied by the sensors.

Servicing Digital Electronic Fuel Injection

23. In this system (Fig-5, the ECM performs certain diagnostic and backup-system functions. The ECM detects certain system and component problems and identifies them through a coded digital readout. On some cars, diagnostic codes appear as a digital display on the instrument panel (Fiig-6). Other cars have only a check engine light (Fig-7). When the ECM detects an improper sensor signal, indicating failure, it takes over the job of the defective sensor. Substitute values from its stored memory replace the missing information from the sensor. If the ECM itself has failed, an analog backup circuit takes lover. This allows the car to be driven, but with severely reduced performance. The ability to determine the cause of its known trouble makes this a self-diagnosing system. An amber dash-mounted check engine light informs the driver that the ECM has detected a system malfunction (See fig-7). The condition may be related to the various sensors or to the ECM itself. If the fault clears up, the light resets automatically. However, the ECM stores the trouble code associated with the failure until the diagnostic system is cleared by the mechanic. To read lout the stored failure codes on a car with a digital display, the mechanic depresses the OFF and WARMER buttons on the ECM panel (see fig - 6. Then the code "88" will appear. This indicates the start of the diagnostic readout. Trouble codes stored in the ECM as a result of troubles that have occurred will now display, beginning with the lowest numbered code. Fig - 7- shows how the check engine light flashes the trouble code.

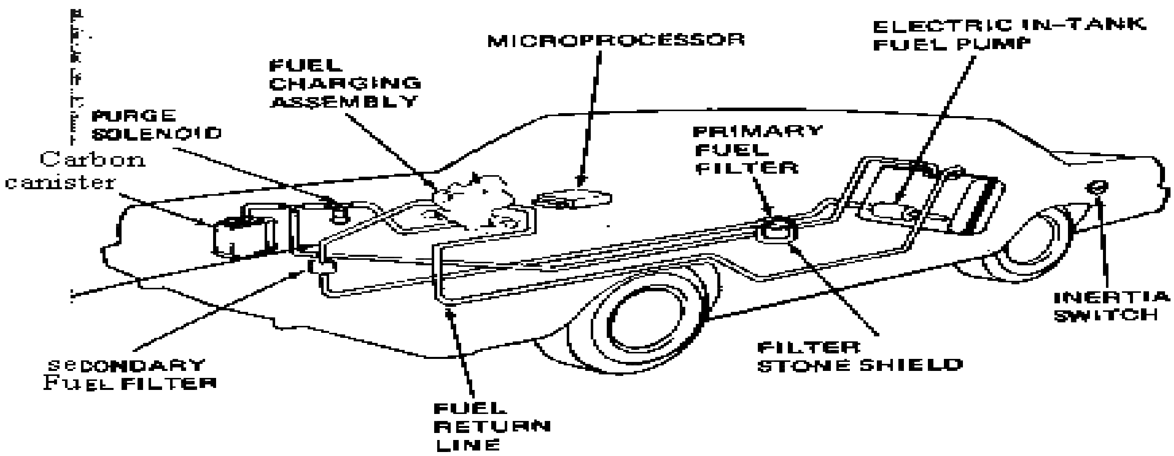

Fig-5 Location of the Components

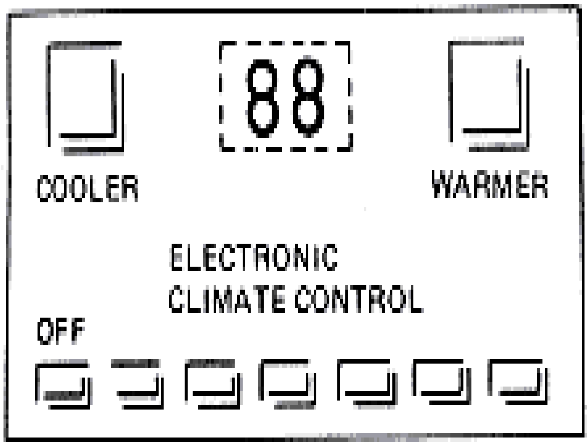

Fig-21: Digital Trouble-Code Display

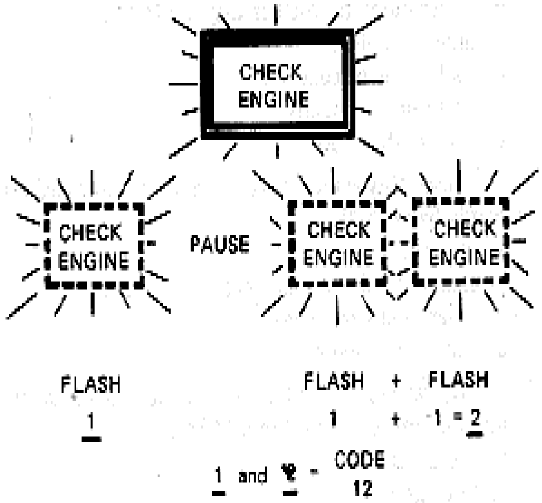

Fig-22: Check Engine

Servicing Gasoline Fuel-Injection Systems

24. When a car equipped with any type of gasoline fuel-injection system has a problem, first be certain that the ignition system or the engine itself is knot causing it. In troubleshooting, the fuel-injection system usually is the last place to look when an engine is not running properly. Basically, any fuel-injection system has the same job as the carburetor it replaces –to supply the cylinders with the proper mixture of air and fuel. How the fuel-injection system does this depends on its design. Although the fuel-injection systems in use today were designed by Bendix and Bosch, some car manufacturers make their own parts and have further adapted the systems to particular engines. Therefore, not all installations of the same type of fuel-injection system are identical in operation or appearance. For this reason, you should always have the manufacturer's service manual when you troubleshoot or service a fuel-injection system. When you have determined that the ECU has failed, replace it.

BAF BASE ZAHURUL HAQUE (TRG WG)

(Aero Engg Trg Sqn)

Syllabus : Automobile General Diesel and Petrol Technology

Course : Trade Training Advance, MTOF

Subject : Manual Transmission Trouble- Diagnosis & Service

Aim : To study Manual Transmission Trouble- Diagnosis & Service

Ref : Automotive Mechanics by William Crouse (Nint Edition)

MANUAL TRANSMISSION TROUBLE- DIAGNOSIS& SERVICE

Manual-Transmission Diagnosis Procedure

1. The type of trouble a transmission has is often a clue to the cause of that trouble. Before attempting any repairs, try to determine the cause. Driver complaints, their possible causes, and the checks or corrections to be made are listed and discussed in later sections. Internal transmission troubles are fixed by disassembling the transmission. Or the transmission can be replaced with a new, rebuilt, or used transmission. To accurately diagnose a complaint about a manual transmission, a procedure must be followed. During road tests of the car the owner to verify that the complaint exists in (Fig -1). R testing with the owner gives you the opportunity to identify the condition that the owner wants corrected. There are two general types of manual-transmission troubles. They are (I noise and (2) improper operation.

Fig-1 possible road test by the customer

CAUTION: *Do not drive a car unless you have a valid license. Do not make this test unless your Instructors Permission Then fasten your safety belt and conduct the test where designated by your instructor.*

2. During the road test, determine any related symptoms that may be occurring. Get all the facts. And service history possible from the owner. Then, as you drive, determine when, where, and how the symptoms occur. Immediately being to be analyzed the symptoms. Now you are performing the diagnosis step by answering the question "What is wrong?" As soon as you know, tell the owner what to expect. Then, with the owner's permission, perform the required adjustments or repairs. When the job is completed, road test the car again. This time make sure that the trouble you found on the first road test no longer exists. When proper operation has been restored, you know that the trouble has been corrected. This second road test serves as a quality-control check. As far as possible, it assures both you and the car owner that the job has been done right the first time. This helps prevent shop "come-backs" that may result from incorrect diagnosis, installation of defective parts, or faulty workmanship.

Manual Transmission Trouble- Diagnosis

3. Most internal transmission problems can be accurately diagnosed before disassembling the transmission. For example:

	Noise	Cause
a.	Periodic clunk	Broken teeth
b.	Growl or whine	Defective bearing or worn teeth
c.	Gear clash	Defective synchronizer

4. There are three general types of noise from a manual transmission (Fig -2). The noise provides you with information about what is taking place inside the transmission. A periodic clunking noise indicates broken teeth. A growl or whine indicates a defective bearing or worn contact faces on the gear teeth. Gear clash during shifting or when shifting is attempted indicates a defective synchronizer.

Note: *Certain clutch problems produce symptoms similar o the symptoms of transmission problems. Follow the trouble-diagnosis procedures for the transmission you are servicing to determine the actual cause of the problem before attempting any repair. It may be that what you thought was transmission trouble is actually a trouble located in some other part of the car.*

Manual-Transmission Trouble Diagnosis Chart

5. The chart that follows lists the various manual-transmission troubles together with their possible causes, and checks and corrections to be made. Most transmission troubles can be listed under a few headings, such as "hard shifting," "slips out of gear," and "noises."

Trouble Diagnosis Chart

Complaint	Possible Cause	Check or Correction
1. Hard shifting into gear	a. Gearshift linkage out of adjustment	Straighten replace defective parts
	b. Gearshift linkage needs lubrication	Replace defective gears
	c. Clutch not disengaging	Replace unit or defective parts
	d. Excessive clutch-pedal free play	Install springs properly
	e. Shifter fork bent 1	Correct tube alignment
	f. Sliding gears or synchronizer tight on shaft splines	Lubricate replace bushing
	g. Gear teeth battered	Replace
	h. Synchronizing unit damaged or springs Improperly installed (after overhaul)	Adjust
	k.. Shifter tube binding in steering column	Lubricate
	l. End of transmission input shaft binding in crankshaft pilot bushing	Adjust
2. Transmission sticks in gear	a. Gearshift linkage out of adjustment or disconnected	Adjust and reconnect
	b. Gearshift linkage needs lubrication	Lubricate
	c. Clutch not disengaging	Adjust
	d. Detent balls (lockouts) stuck	Free lubricate
	e. Synchronizing unit stuck	Free replace damaged parts
	f. Incorrect or insufficient lubricant in transmission	Replace with correct lubricant and correct amount

Complaint	Possible Cause	Check or Correction
	g. Internal shifter components damaged	Remove transmission to inspect and service shifter parts
3. Transmission slips out of gear	a. Gearshift linkage out of adjustment	Adjust
	b. On floor shift. shift boot stiff or shift- lever binding	Replace boot; adjust console to relieve binding
	c. Weak lock nut spring	Replace
	d. Bearings 0r, gears worn	Replace
	e. End play of shaft or gears excessive	*Replace worn or loose parts.*
	f. Synchronize, worn or defective	Repair; replace
	g. Transmissions looses on clutch housing or misalign	Tighten mounting bolts; correct alignment
	h. Clutch housing misalign	Correct alignment
	j. Pilot bushing in crankshaft loose or broken	Replace
	k. Input shaft retainer loose or broken	Replace
	l. Broken engine mount	Replace
4. No power through transmission	a. Clutch slipping	Adjust
	b. Gear' teeth stripped	Replace gears
	C. Shifter fork or other, linkage pan broke,	Replace
	d. Gear or shaft broken.	Replace
	e. Drive key or spline sheared off	Replace
5. Transmission noisy in neutral	a. Gears worn or tooth broken or chipped'0?	Replace gears
	b. Bearings worn or dry	Replace; lubricate
	c. Input shaft bearing defective	Replace
	d. Pilot bushing worn or loose in crankshaft	Replace

Complaint	Possible Cause	Check or Correction
	e. Transmission misaligned with engine	Realign
	f. Countershaft worn or bent. Or thrust plate or washers damaged	Replace worn or damaged parts
6. Transmission noisy in gear	a. Clutch friction disk defective	Replace
	b. Incorrect or insufficient lubricant	Replace with proper amount of correct lubricant.
	c. Rear main bearing worn or dry	Replace or lubricate
	d. Gears loose on main shaft	Replace worn parts
	e. Synchronizers worn or damaged	Replace worn or damaged parts
	f. Speedometer gears worn	Replace
	g. Any condition noted in item 5	See item 5
7. Gears clash during shifting	a. Synchronizer defective	Repair or replace
	b. Clutch not disengaging pedal free play incorrect	Adjust,
	c. Hydraulic system (hydraulic clutch) defective	Check cylinder; add fluid, etc.
	d. Idle speed excessive	Readjust
	e. Pilot bushing binding	Replace
	f. Gearshift linkage out of adjustment	Adjust
	g. Lubricant incorrect	Replace with correct lubricant

Complaint	Possible Cause	Check or Correction
8.Transmission noisy in reverse	a. Reverse idler gear or bushing worn or damaged	Replace
	b. Reverse gear' on main, haft worn or damaged	Replace
	c. Counter gear, worn or damaged	Replace
	d. Shift mechanism damaged	Repair, replace defective parts, and readjust
9. Oil leaks	a. Foaming due to incorrect lubricant	Replace with correct lubricant
	b. Oil singers damaged improperly installed or missing	Replace
	c. Drain plug loose b. Oil level too high	Replace
	d. Gaskets broken or missing	Replace correctly Use proper amount, no more
	e. Oil seals damaged or missing	
	f. Transmission retainer bolts loose	Tighten
	g. Transmission or extension case cracked	Tighten
	h. Speedometer gear retainer loose.	Replace
	j. Side rover loose	Tighten
	k. Extension housing seal worn or drive line yoke worn	Replace

Manual Transmission Overhaul

4. Manual-transmission construction varies considerably from car to car. Therefore, removal and servicing procedures also vary. Before attempting to disassemble a manual transmission, carefully study both the transmission and the transmission section in the manufacturer's service manual. If possible, locate the illustrations and exploded views for the transmission you are working on. Overhaul procedures differ for different transmissions. Follow the procedures for disassembly, service, and reassembly that are in the manufacturer's service manual.

Shift-Linkage Adjustments

6. The linkage between the selector lever and the shift levers on the transmission must be properly adjusted. This permits proper selection of gears and completion of the shifts. Typically, the adjustment is made with the transmission positioned in neutral. Then position the selector lever in neutral. The rods that were disconnected may require minor adjustment, but they will usually slip in and clip in. However, the rods may not fit if you disconnected the linkage at wrong points, bent the rods, or unnecessarily turned threaded clevis pins. If the linkage has been tampered with, or the rods do not fit into the shift levers on the transmission, then a linkage adjustment must be made. Follow the procedures in the manufacturer's service manual.

BAF BASE ZAHURUL HAQUE (TRG WG)

(Aero Engg Trg Sqn)

Syllabus : Automobile General Diesel and Petrol Technology

Course : **Trade Training Advance, MTOF**

Subject : **Servicing Emission Control**

Aim : **To Study Servicing Emission Control**

Ref. : **Automotive mechanics by William H. Crouse**

EMISSION CONTROL

Atmospheric pollution and the automobile

1. There are four Possible sources of atmospheric pollution from the automobile (Fig - 1). Without emission controls, the carburetor and fuel tank can emit fuel vapors, the crankcase can emit blow by gases and fuel vapor, and the tail pipe can give out engine exhaust gas with pollutants in it. All of the pollutants put various harmful substances into the air. Some contribute to the formation of smog. To reduce these pollutants, automotive vehicles are equipped with several emission controls:

a. Positive crankcase ventilation (PCV)

b. Evaporative emission control systems

c. Heated-air systems

d. Exhaust-gas recirculation (EGR)

e. Air-injection systems

f. Catalytic converters

In addition several changes have been made in the engine, fuel system and ignition system which have helped to reduce the pollutants in the exhaust gas.

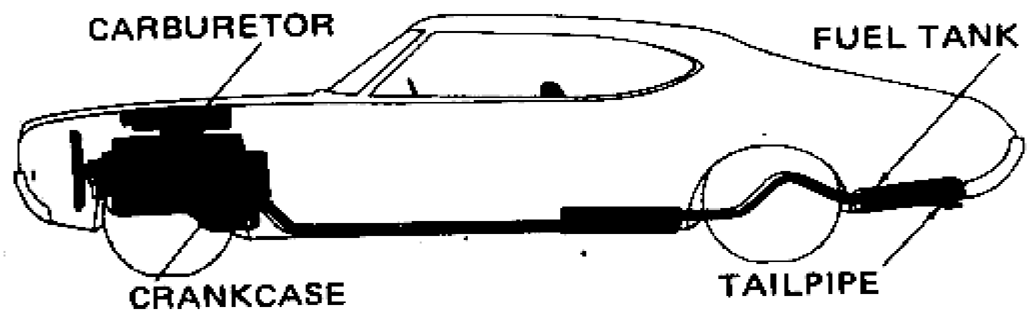

Fig-1: four possible source of atmospheric pollution from the automobile

Positive Crankcase Ventilating

2. The engine crankcase must be ventilated. Outside air must flow through the crankcase to remove blow by, this blow by gets past the piston rings during the compression and power strokes. Unless it is cleared from the crankcase. It will cause trouble. It can form sludge and acids. The sludge can clog oil lines and starve the lubricating system. This could ruin the engine. Acids corrode metal parts, and this can also ruin the engine. The removal process requires that the engine' must first heat up enough to vaporize the liquid gasoline and water that has collected in the crankcase. Then the circulating air can remove them, along with the blow by gases.

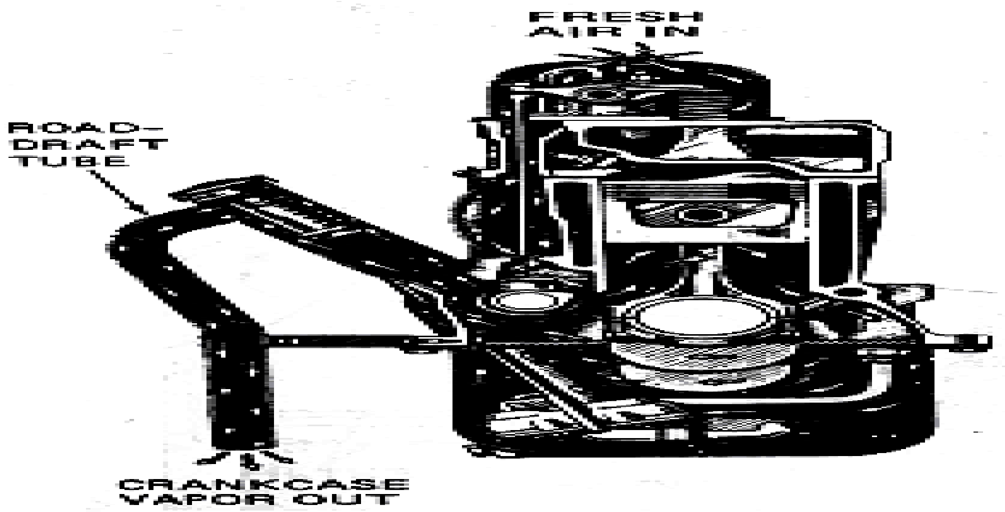

Fig -2: Open crankcase ventilation system

In older engines, the crankcase was ventilated by an opening at the front of the engine and a vent tube in the back. The forward motion of the car and the rotation of the crankshaft moved air through the crankcase, as shown in Fig-2. The air passing through removed the water, fuel vapors, and blow by. However, discharging these gases into the atmosphere caused air pollution. To prevent this pollution, engines now have a positive crankcase ventilating (PCV) system. Figure -3 shows a typical PCV system for a V-type engine. Filtered air from the carburetor air cleaner is drawn through the crankcase. In the crankcase, the air picks up the water and fuel vapors, and blow by. The air then flows back up to the intake manifold and enters the engine. There, unburned fuel is burned. Too much air flowing through the intake manifold during idling could upset the air-fuel ratio. This could cause poor engine idling and even stalling. To prevent this, a flow-control valve is used. The valve is called a PCV valve. The PCV valve allows only a small amount of air to flow through during idle. But as engine speed increases, reduced intake manifold vacuum allows the valve to open more. This allows more air to flow through Figure - 4 show the operation of the valve.

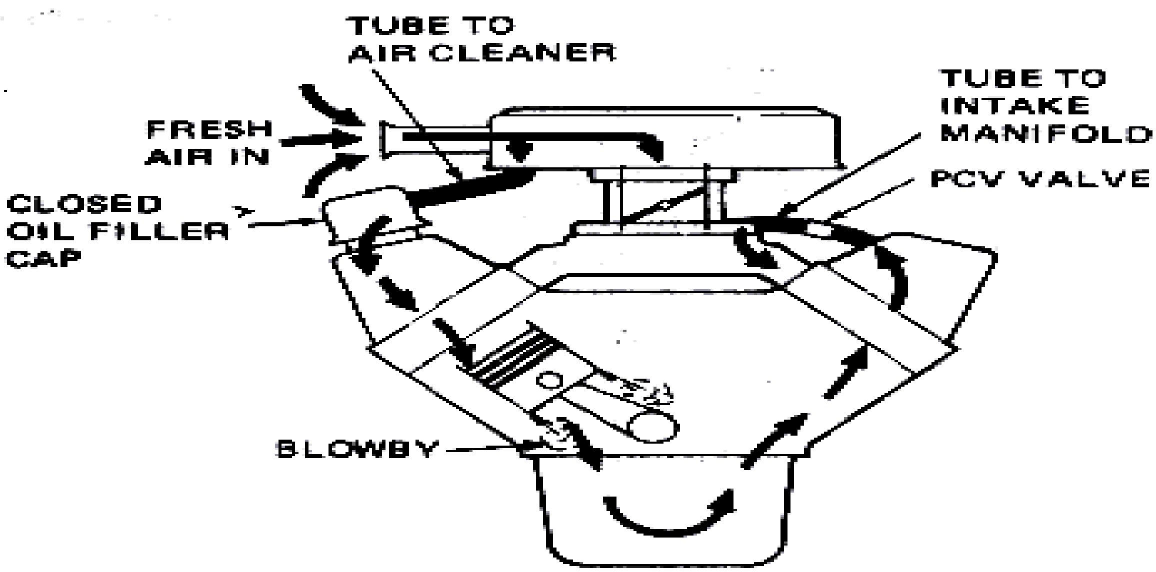

Fig- 3: Typical closed PCV system of V- Engine

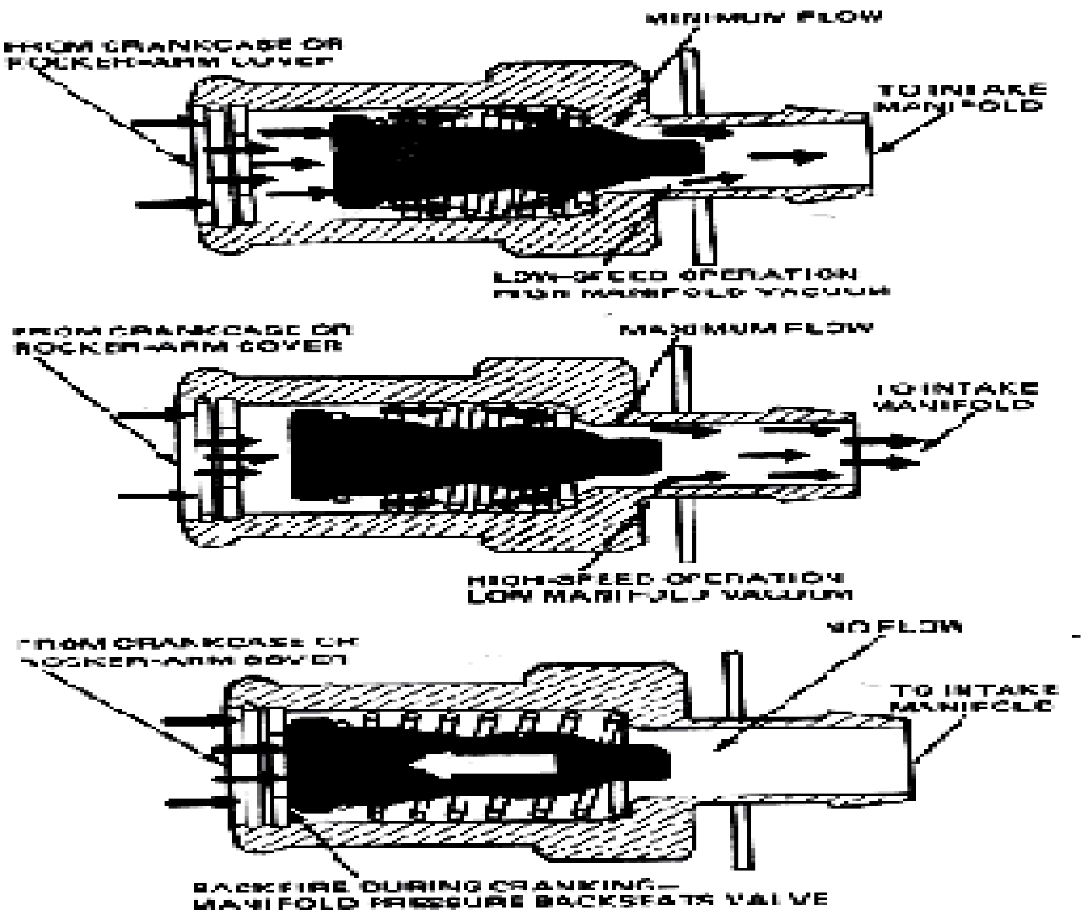

Figure – 4: Three position of the PCV valve

PCV System Service

3. The PCV valve should be checked periodically and replaced at specified intervals. There are special testers that can be used to check the operation of the PCV system. A simple way to check the system and the valve is to remove the valve or valve connection, with the engine running. Place your hand over the opening. You should feel a slight vacuum pull against your hand. If there is no vacuum, or if you can feel a positive pressure, then something is wrong. Check the PCV valve, hoses, and connections. Another method is the r*pm-drop test.* With the engine running at idle, connect a tachometer and note the engine idle speed. Then remove the PCV valve from the engine grommet, with hose attached. Block the opening of the valve, and note the change in engine speed. A decrease *of* less than 50 rpm indicates a plugged PCV valve or hose. A quick check of the PCV system can be made with the engine idling at normal operating temperature. Remove the PCV valve from the engine. The valve should hiss. You should be able to feel a strong vacuum when your finger is placed over the valve inlet. Reinstall the PCV valve, and remove the crankcase inlet air cleaner. Hold a piece of stiff paper over the opening of the rocker arm cover. After a few seconds, the paper should be drawn against the opening. Then stop the engine. Remove PC V valve from the rocker-arm cover, and shake it. It should rattle, indicating that the valve is free. If the system does not meet these tests, install a new PCV valve and try again. If the system still does not pass the tests, the hose may be clogged. It should be cleaned out or replaced. It may be necessary to remove the carburetor and clean the vacuum passage with an l/4-inch drill. Also, clean the inlet vent on the crankcase inlet-air cleaner that is connected by the hose to the engine air cleaner.

Fuel Vapor Emission Control Troubles

4. a. Here are troubles that might be caused by conditions in the fuel vapor emission control or lose of fuel could be caused by several of the conditions listed below.

(1) Overfilled fuel tank

(2) Leaks in fuel, vapor, or vent line

(3) Wrong or faulty fuel-tank cap

(4) Faulty liquid-vapor separator

(5) Excessively high fuel volatility

(6) Vapor-line restrictor missing

(7) Canister drain cap or hose missing

b. A collapsed fuel tank can result if the wrong fuel-tank cap is installed or if the vacuum valve in the cap sticks. Then no air can enter to replace fuel being withdrawn by the fuel pump. The result could be a vacuum in the fuel tank great enough to allow atmospheric pressure to crush the tank.

Excessive pressure in the fuel tank could result from a combination of high temperatures and a plugged vent line, liquid-vapor separator, or canister. Pressure can be released by turning the tank filler cap just enough to allow the pressure to slowly escape. Many different engine-idling problems can result from faulty or improper connections of a hose in the control system. A plugged canister, vapor-line restrictor missing, or high-volatility fuel can also cause poor idle.

Fuel Vapor Emission Control Service

5. These systems require little service. about the only troubles that occur are restriction of the fuel flow (so the engine is starved and stalls) and a collapsed fuel tank. Some types of charcoal canisters require periodic replacement of the air filter in the bottom of the canister (Fig-5).

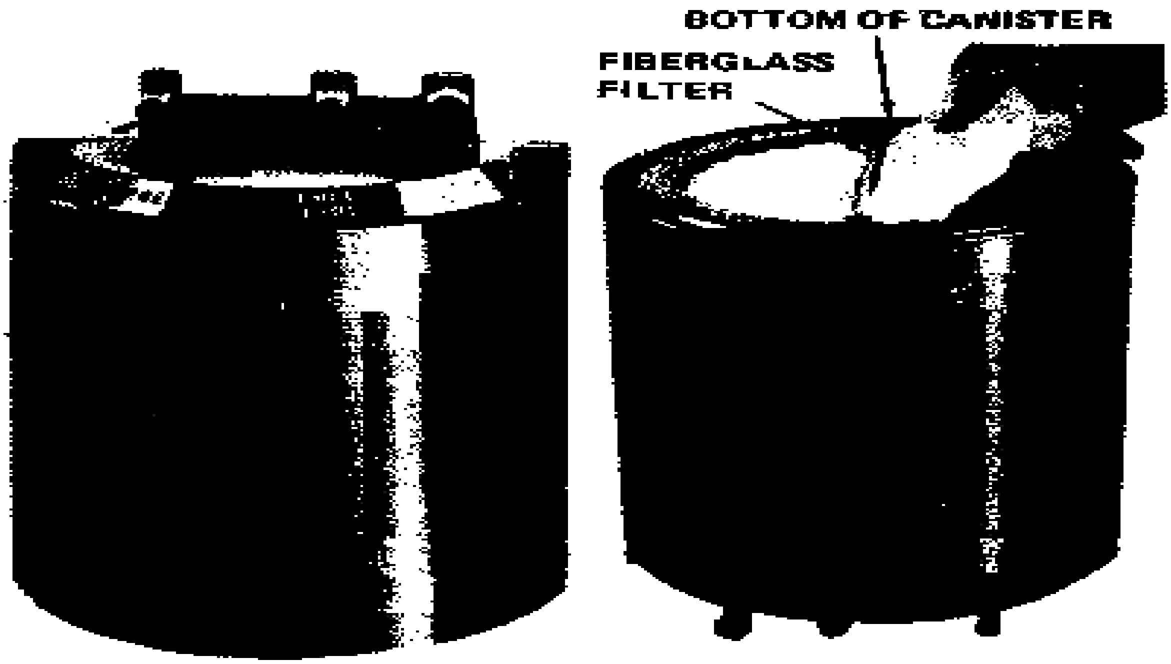

Fig- 5: Replacing the air filter in the charcoal canister

Air Injection System Trouble

6. Troubles related to the air-injection system (Fig-6) include noise, no air supply, backfire, and high HC and CO levels in the exhaust. Noise from the belt or air pump could result from a loose belt, loose air-pump mounting bolts, worn pump bearings or other internal trouble, or air leaks from the system. The pump is not repairable. It must be replaced if damaged. The air pump should be adjusted so that the belt has the correct tension. Do not pry on the pump housing because this can damage the pump. If you have to use a pry bar, pry as close to the pulley end as possible. If they are available, use a belt tensioner and a belt-tension gauge (Fig-7). Air leaks should be stopped by tightening hose

connections and replacing any hose that is defective. If no air is getting to the air manifold, the exhaust gas will probably be high in HC and CO. Causes of no or inadequate air include a loose belt, frozen pump, leaks in the hoses or connections, and failure of the diverter or check valve. A defective pump or valve must be replaced. They are not repairable. Backfire is usually caused by a defective diverter valve. It fails to block off the air supply under conditions of high in- take-manifold vacuum. The same thing happens if the vacuum hose becomes disconnected or blocked.

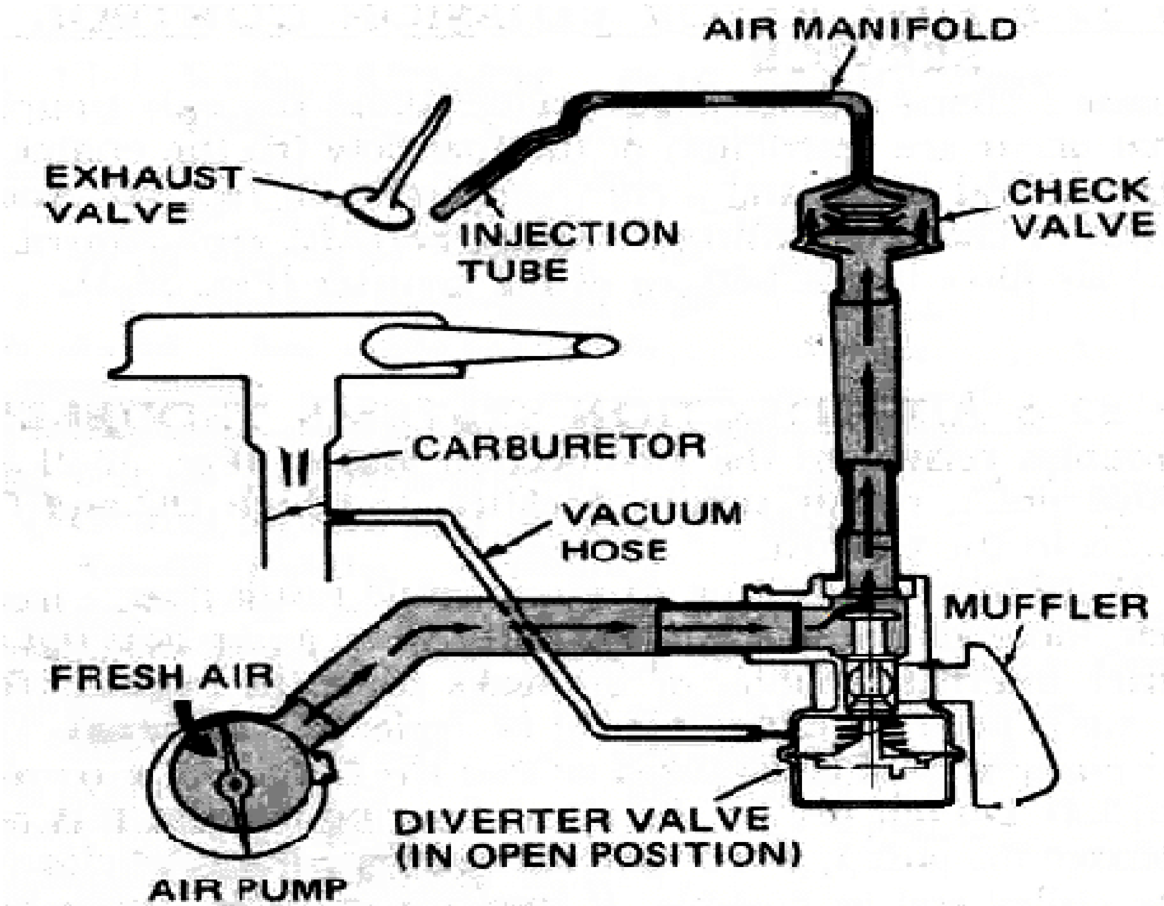

Fig-6: Components of the air injection system

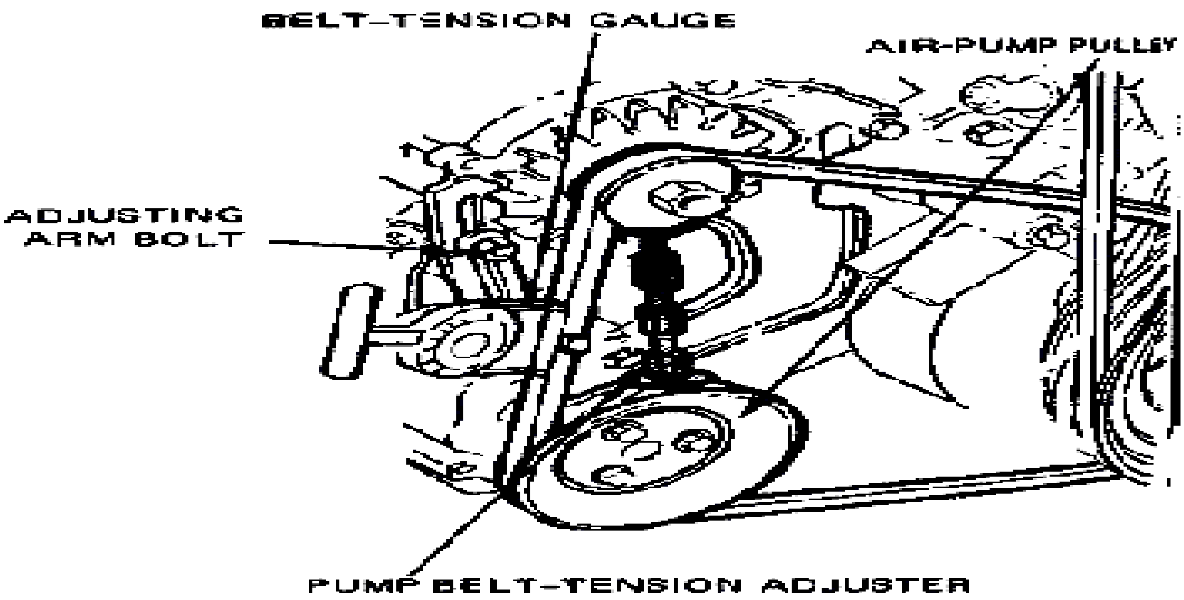

Fig-7: A belt tension adjuster

Air Injection System Service

7. No routine service is required on the air-injection system except to replace the air filter every 12,000 miles [19,312 km] on those systems using a separate air filter. Most air pump use a centrifugal filter which requires no separate service. The air-pump drive belt should be checked wear and tension. Replace any belts that brittle. Do not over tighten the air pump tightening can cause premature pump bearing failure.

Heated Air System Troubles

8. The heated air system adds heat to the air entering the carburetor almost as soon as the engine is started. This means the mixture is warm and the gasoline vaporizes better. If the heated-air system is not working to add heat, the control damper has closed off the hot-air pipe. The hot air pipe may be disconnected or have holes in it. As a result, the mixture is not getting warmed. The cold engine will hesitate or stumble, or even stall, because the mixture is too cold and lean to fire consistently. If the damper does not shut off the hot air pipe when the engine is hot, the mixture will be over heated. Then not enough mixture will get into the cylinders for full power. Check the operation of the damper by starting the engine cold. See whether the damper in the snorkel is closed or open. It should be wide open. Then, when the engine starts, it should close. This opens the hot-air pipe. As the engine warms up, the damper should move to the accurate check can be made with a temperature gauge or thermometer. If the damper does not perform properly, the trouble could be in the thermostat or vacuum motor to observe damper action. The heated-air system requires no routine service.

Exhaust Gas Recirculation Troubles

9. Trouble in the EGR system may cause poor engine performance. For example, rough engine idle and stalling could be caused by a leaky EGR valve or valve gasket that allows exhaust gas or air to enter the intake manifold during idling. A defective thermal vacuum switch could cause vacuum to operate the EGR valve when it should not. Poor part-throttle performance, poor fuel economy, and rough running on light acceleration could also be caused by a , defective thermal vacuum switch. In addition, a sticking or binding EGR valve, or deposits in the EGR passages, could cause these conditions. If deposits have clogged the EGR passages, remove the manifold to clean out the passages. if the engine stalls on deceleration, it could be due to a restricted vacuum line that is preventing the EGR valve from closing promptly. Detonation at part throttle could be caused by insufficient EGR. This could be due to clogged or damaged hoses, EGR valve, or a defective thermal vacuum switch.

Testing EGR Systems

10. There are three types of EGR valves. These are the ported-vacuum valve, the positive-back, pressure valve, and the negative. Back pressure valve. Many ported-vacuum EGR valves have the stem visible under the diaphragm (Fig-8). Check this type of valve with the engine warmed up, idling and transmission in neutral snap.

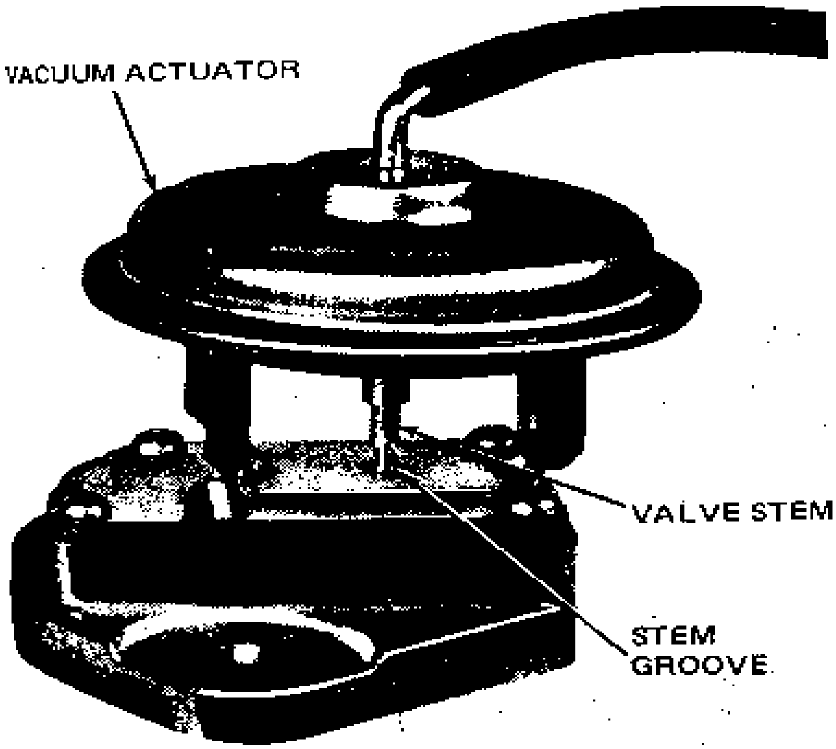

Fig-8: EGR valve With Exposed valve stem

11. The throttle opens to bring the engine rpm up to about 2,000. The valve stem should move up, indicating the valve has opened. If it does not, connect a hand vacuum pump to the vacuum tube of the valve. With the engine warmed up and idling, apply about 8 inches Hg [200 mm Hg] of vacuum to the valve. The valve should open. If it does not, it is either defective or dirty .You can tell when the valve opens because the engine will idle roughly and may even stall. To test the thermal vacuum switch, connect a vacuum gauge and a hand vacuum pump as shown in Fig. -9. With the engine cold, no vacuum should pass through the switch. When the engine warms up, vacuum should pass through. Before testing a back-pressure EGR valve you must determine whether it is a positive-back-pressure valve or; a negative back-pressure valve. There is a difference in the design of in the diaphragm for each type. Illustrations and identifying marks are in the manufacturer's service manual. The negative-back-pressure valve can be checked following the same procedure described above for the ported-vacuum valve. Check the positive-back-pressure valve, the valve must remove from the engine. With a hand-vacuum pump, apply a vacuum to the vacuum port. If the valve opens, it is defective and should be replaced.

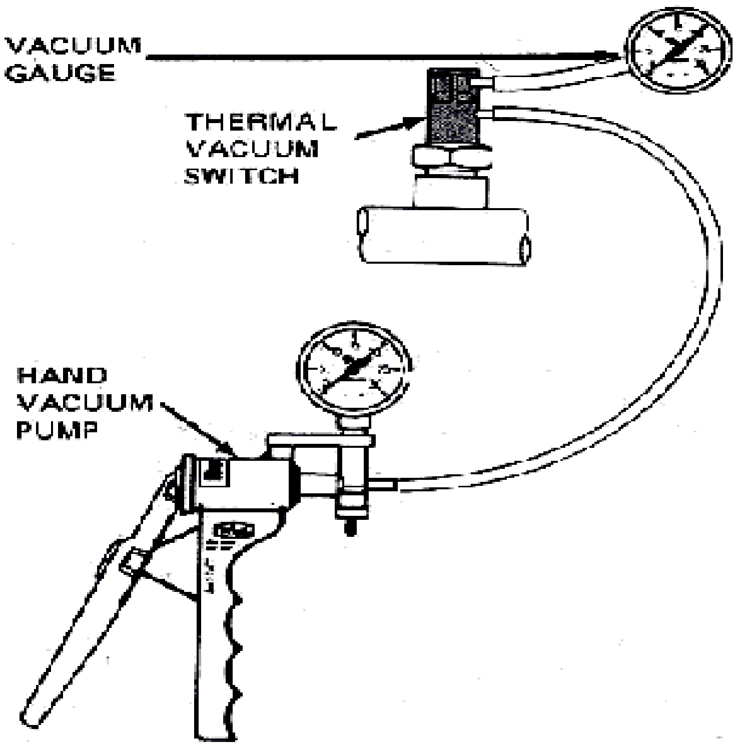

Fig-9: Testing the thermal vacuum switch in the EGR system

EGR-System Service

12. A typical service interval for EGR systems is every 12 months or 12,000 miles [19,312 km] if the car is running on leaded gasoline. If the car is running on unleaded gasoline, check the system half as often (24 months or 24,000 mi [38,624 km]). Some cars have an EGR-maintenance reminder light that comes on at 15,000 miles [24,140 km] remind the driver to have the system checked. However many cars do not require any regular check. Instead, if trouble develops, the system should be checked and the trouble corrected.

Transmission Controlled Spark (TCS) System Troubles

13. This system allows vacuum advance only when the transmission is in high gear. Engine stall at idle, car creeping excessively in idle, and engine dieseling can all be due to a defective or improperly adjusted idle-stop solenoid. Poor high-gear performance, stumble or stall on (starts, poor fuel economy, and backfiring during deceleration could be due to an inoperative vacuum-advance solenoid defective temperature or transmission switch, or failure the time relay to energize. If vacuum advance is obtained in all gears and there high levels of HC and NOx in the exhaust, consider the four possible causes discussed above. There may be a defective transmission switch, temperature switch, time relay, or vacuum-advance solenoid.

Other Vacuum-Advance Controls

14. The Ford TRS and the Chrysler OSAC systems work in a similar manner to the TCS system. Similar troubles can occur in all these systems. Failure of the system to work causes the conditions described earlier

Service Intervals For Vacuum-Advance Controls

15. No special servicing checks are usually required by the manufacturers. However, when a tune-up is performed, the system operation should be checked and the idle-stop solenoid adjusted. Inspection includes checking hoses for cracks, brittle- ness, or poor connections.

Servicing Electronic Spark Advance Controls

16. These systems develop very little trouble because everything is done electronically. Theoretically, transistors and diodes do not wear out. The manufacturers have developed special test- erg to check the components of EEC systems. Procedures and equipment are covered in the service manuals of the manufacturers.

Catalytic-Converter Troubles

17. Catalytic-converter troubles are indicated by noise, BB-size particles coming out the

tail pipe, a rotten-egg smell, high CO and HC levels in the exhaust gas, and possible loss of power due to a restricted converter. Noise could be due to loose exhaust-pipe joints, a damaged converter, or a loose or missing catalyst replacement plug in a bead-type converter. BB-size particles coming out the tail pipe means the converter has been overheated so the catalyst support has warped. This allows the beads to be blown out by the exhaust gas. The condition can happen only on the bead-type converter. The remedy is converter replacement. A rotten-egg smell comes from hydrogen sulphide (H2S) that the catalytic converter is producing. The S, or sulphur, is in the gasoline. Some gasoline's have more than others. Advise the driver to try a different brand of gasoline. Also, check the carburetor adjustments. The smell is more noticeable when a momentarily rich mixture enters a hot converter.

Catalytic Converter Service

18. a. Damaged or overheated converters must be replaced. They are not repairable. However, on the bead-type converter, the old beads can be removed and a fresh charge of beads installed. Figures 10 and 11 show the special devices required. The vacuum pump is turned on while the vibrator and the can are attached. It keeps the beads from falling out when the converter filler plug is removed.

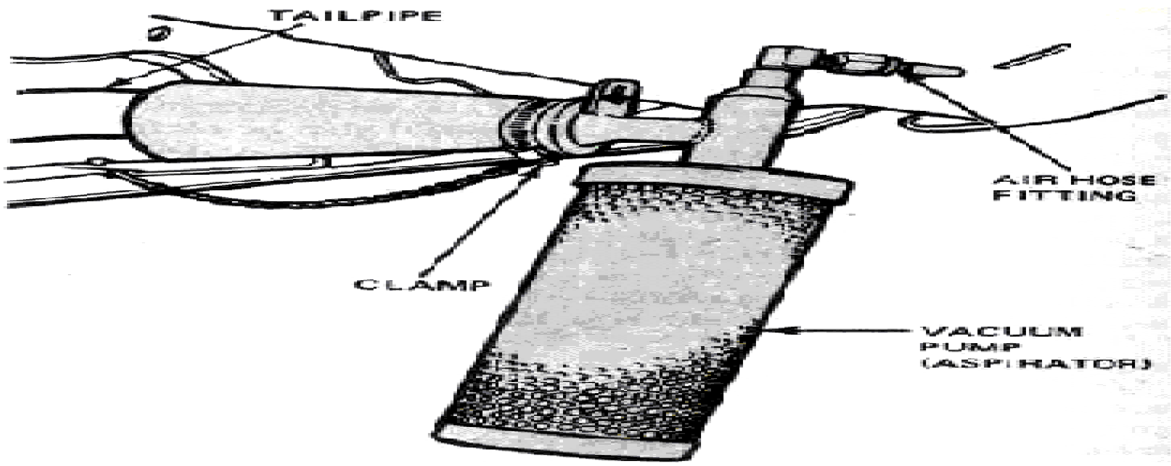

Fig- 10: Vacuum pump or aspirator

b. After the vibrator and can are attached, the vacuum is turned off. The air supply to the vibrator is turned on. Beads will now start falling in the can. It takes about 10 minutes to clear the converter. To install new beads**,** dump the old beads and fill the can with new beads. Attach the can to the vibrator. Turn on the air and vacuum lines. After the beads stop flowing, disconnect

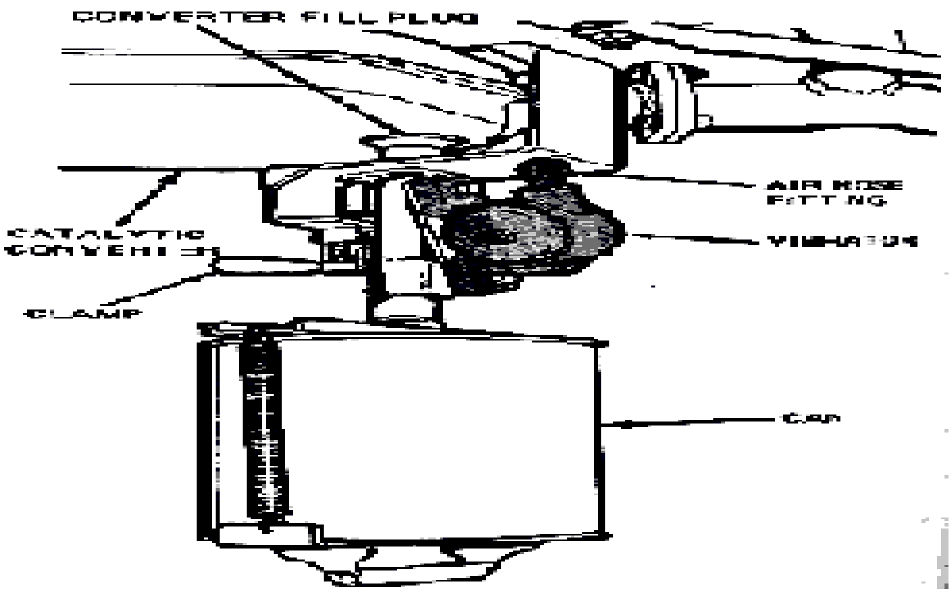

Fig -11: Vibrator Mounted on a catalytic converter

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Syllabus	**:**	**Automobile General Diesel and Petrol Technology**
Course	**:**	**Trade Training Advance, MTOF**
Subject	**:**	**Wheel Alignment & Balance**
Aim	**:**	**To study Wheel Alignment & Balance**
Ref	**:**	**Automotive mechanics by William H. Crouse & Internet Wikipedia**

WHEEL ALIGNMENT

Wheel Alignment

1. Sometimes referred to as breaking or tracking, is part of standard automobile maintenance that consists of adjusting the angles of the wheels so that they are set to the car maker's specification. The purpose of these adjustments is to reduce tire wear, and to ensure that vehicle travel is straight and true (without "pulling" to one side). Alignment angles can also be altered beyond the maker's specifications to obtain a specific handling characteristic. Motorsport and off-road applications may call for angles to be adjusted well beyond "normal" for a variety of reasons.

Fig-1: Wheel Alignment process being performed by an automotive technician.

Primary Angles

2. The primary angles are the basic angle alignment of the wheels relative to each other and to the car body. These adjustments are the camber, caster and toe. On some cars, not all of these can be adjusted on every wheel. These three parameters can be further categorized into front and rear (with no caster on the rear, typically not being steered wheels) so summarily the parameters are:

a. Front: Caster (left & right)

b. Front: Camber (left & right)

c. Front: Toe (left, right & total)

d. Rear: Camber (left & right)

e. Rear: Toe (left, right & total)

Secondary Angles

3. a. The secondary angles include numerous other adjustments, such as:

(1) SAI (Steering Axis Inclination) (left & right)

(2) Included angle (left & right)

(3) Toe out on turns (left & right)

(4) Maximum Turns (left & right)

(5) Toe curve change (left & right)

(6) Track width difference

(7) Wheelbase difference

(8) Front ride height (left & right)

(9) Rear ride height (left & right)

(10) Frame angle

(11) Setback (front & rear)

b. Setback is the difference between right side and left side wheelbase length. It can also be measured as an angle. Setback less than the manufacturer specified tolerance (for example about 6mm) does not effect car handling. That's because, when the vehicle is turning, one wheel is ahead of the other by several centimeters and therefore the setback is negligible. There are even some car models with different factory setting for right and left side wheelbase length, for various design reasons. An off-spec setback may occur because of a collision or a difference between right and left caster.

Measurement

4. A camera unit (sometimes called a "head") is attached to a specially designed clamp which holds on to a wheel. There are usually four camera units in a wheel alignment system (a camera unit for each wheel). The camera units communicate their physical positioning with respect to other camera units to a central computer which calculates and displays. Often with alignment equipment, these "heads" can be a large precision reflector. In this case, the alignment "tower" contains the cameras as well as arrays of LEDs. This system flashes one array of LEDs for each reflector whilst a camera centrally located in the LED array "looks for" an image of the reflectors patterned face. These cameras perform the same function as the other style of alignment equipment, yet alleviate numerous issues prone to relocating a heavy precision camera assembly on each vehicle serviced.

Camber, Toe, Caster, and Offset:

5. Maintaining proper alignment is fundamental to preserving both your car's safety and its tread life. Wheel alignments ensure that all four wheels are consistent with each other and are optimized for maximum contact with the surface of the road. The way a wheel is oriented on your car is broken down to three major components; camber, caster, and toe.

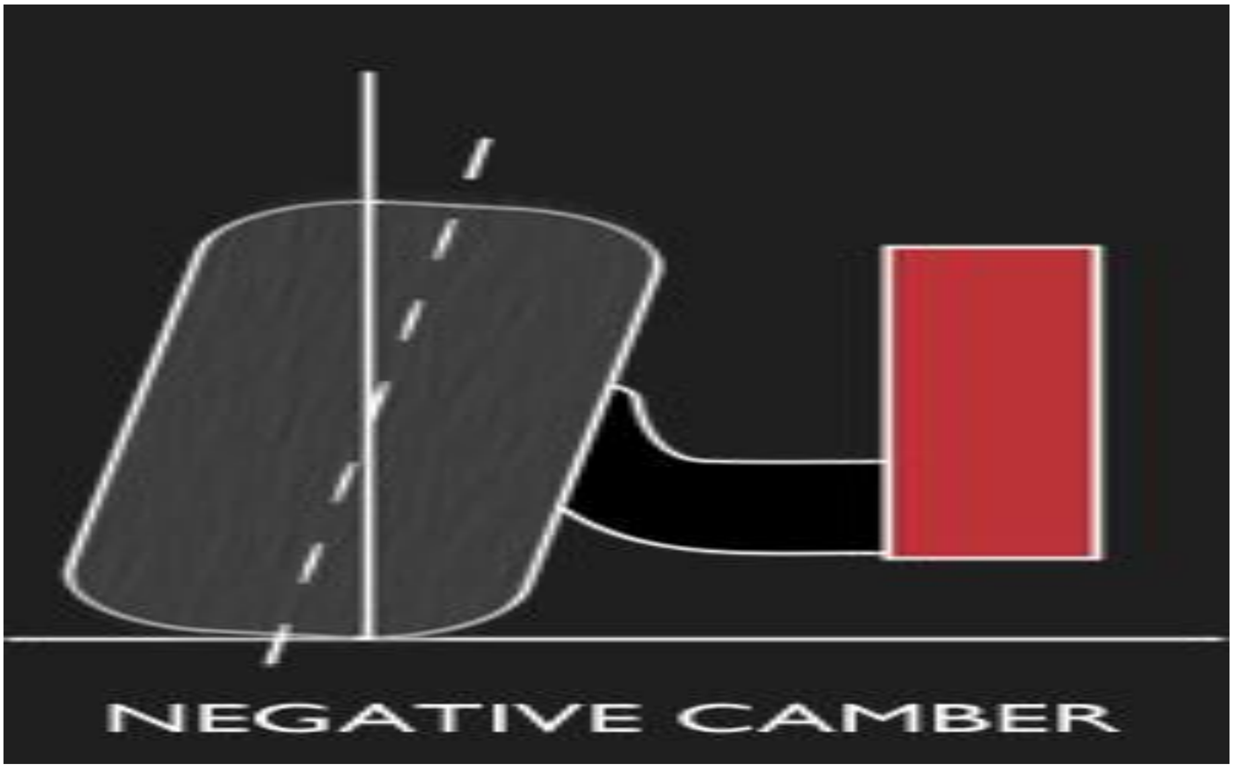


Fig-2: Negative wheel camber

6. The most widely discussed and controversial of the three elements is camber. Camber angle is the measure in degrees of the difference between the wheels vertical alignment perpendicular to the surface. If a wheel is perfectly perpendicular to the surface, its camber would be 0 degrees. Camber is described as negative when the top of the tires begin to tilt inward towards the fender wells. Consequently, when the top of the tires begin to tilt away from the vehicle it is considered positive. Negative camber is becoming increasingly more popular because of its visual appeal. The real advantages to negative camber are seen in the handling characteristics. An aggressive driver will enjoy the benefits of increased grip during heavy cornering with negative camber. During straight acceleration however, negative camber will reduce the contact surface between the tires and road surface. Regrettably, negative camber generates what is referred to as camber thrust. When both tires are angled negatively they push against each other, which is fine as long as both tires are in contact with the road surface. When one tire loses grip, the other tire no longer has an opposing force being applied to it and as a result the vehicle is thrust towards the wheel with no traction. Zero camber will result in more even tire wear over time, but may rob performance during cornering. Ultimately, optimal camber will depend upon your driving style and conditions the vehicle is being driven in.

Fig-3: Positive Caster Angle Measuring

Caster

7. Caster is a bit harder to conceptualize, but it’s defined as the angle created by the steering pivot point from the front to back of the vehicle. Caster is positive if the line is angled forward, and negative if backward. Typically, positive caster will make the vehicle more stable at high speeds, and will increase tire lean when cornering. This can also increase steering effort as well. Most road vehicles have what is called cross-caster. Cross castered vehicles have slightly different caster and camber, which cause it to drift slightly to the right while rolling. This is a safety feature so that un-manned vehicles or drivers who

lose steering control will drift toward the side of the road instead of into oncoming traffic.

Fig-4: Measurement of Toe-In or Toe-Out

Toe

8. Perhaps the easiest concept to visualize is toe. Toe represents the angle derived from pointing the tires inward or outward from a top-down view – much like looking down at your toes and angling them inward or outward. Correct toe is paramount to even tread wear and extended tire life. If the tires are pointed inward or outward, they will scrub against the surface of the road and cause wear along the edges. Sometimes however, tread life can be sacrificed for performance or stability Positive toe occurs when the front of both tires begins to face each other. Positive toe permits both wheels to constantly generate force against one another, which reduces turning ability. However, positive tow creates straighter driving characteristics. Typically, rear wheel drive vehicles have slightly positive tow in the rear due to rolling resistance – causing outward drag in the suspension arms. The slight positive toe straightens out the wheels at speed, effectively evening them out and preventing excessive tire wear. Negative toe is often used in front wheel drive vehicles for the opposite reason. Their suspension arms pull slightly inward, so a slight negative toe will compensate for the drag and level out the wheels at speed. Negative toe increases a cars cornering ability. When the vehicle begins to turn inward towards a corner, the inner wheel will be angled more aggressively. Since its turning radius is smaller than the outer wheel due to the angle, it will pull the car in that direction. Negative toe decreases straight line stability as a result. Any slight change in direction will cause the car to hint towards one direction or the other.

Types of Wheel Alignment

9. There are many types of wheel aligners. Some are mechanical types that attach to the wheel spindles (Fig-5). Some have light beams that display the measurements on a screen in front of t he car (Fig-6) others are electronic that indicate the measurements on meters, displays or printouts. When doing a front wheel alignment, you check and adjust (if needed) caster, camber, and toe. You also measure SAI and turning radius. These are not adjustable if they are out of specifications, it means parts are bent or damaged and must be replaced. However, before you make the alignment checks, the following pre-alignment inspection must first be made.

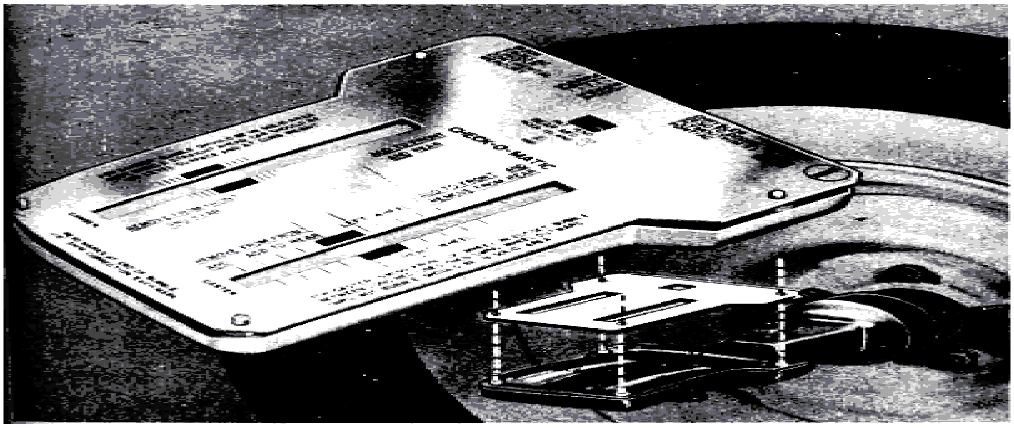
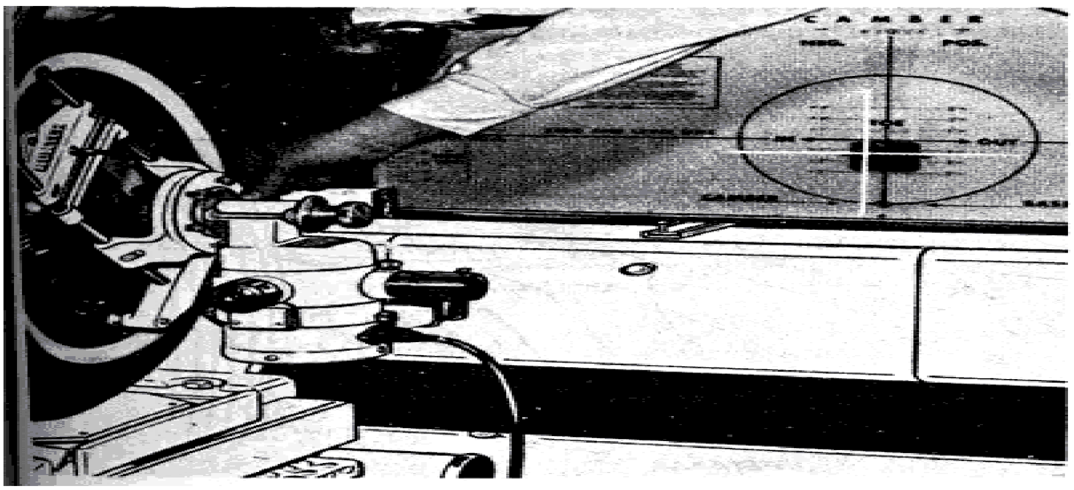


Fig-5: Mechanical caster camber gauge attach to the front wheel spindle.

Wheel Alignment Checking

10. a. Check correct tyre pressure
    b. Check and adjust wheel bearing
    c. Check and adjust wheel run –out
    d. Check ball joints and, if they are too loose, replace them
    e. Check steering linkages, and make any corrections necessary
    f. Check wheel balance, and correct it if necessary
    g. Check rear leaf springs for cracks, broken leaves, and loose U bolts. Make any corrections if necessary
    h. Check front-suspension height
    j. Check shock absorbers, and replace them if they are defective
    k. Check wheel tracking. This means checking where the rear wheels follow the front wheels or is off the track. If the wheels are off the track, it usually means a bent frame. The frame must be straightened before you can do a wheel alignment.



Fig–6: Adjusting the wheel gauge to make a wheel alignment check.

Wheel Balance

11. The wheel may be checked for balance on or off the car. This is done by either of two methods: static or dynamic. In static balancing, the wheel is taken off the car and put on a “bubble” balance or detect any imbalance (Fig-7). A wheel that is out of balance is heavier in one section. This will cause the bubble in the center of the balancer to move off center. To balance the wheel, weights are added to the wheel rim until the bubble returns to center.

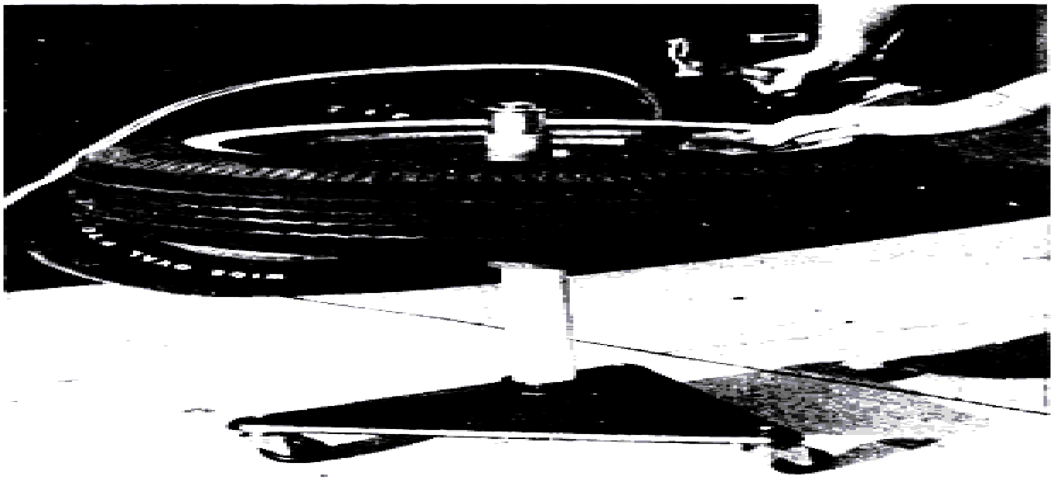


Fig – 7: Bubble or static type of wheel balancer

To dynamic- balance (or “”spin-balance”) a wheel, the wheel is spun either on or off the car. Fig -15 shows an electronic wheel balancer being used to balance a wheel on a car. Lack of balance shows up as a tendency for the wheel to move off center or out of line as it spins. If the wheel is out-of balance, one or more weights are installed on the wheel rim. In the shop, you will learn how to balance wheels.

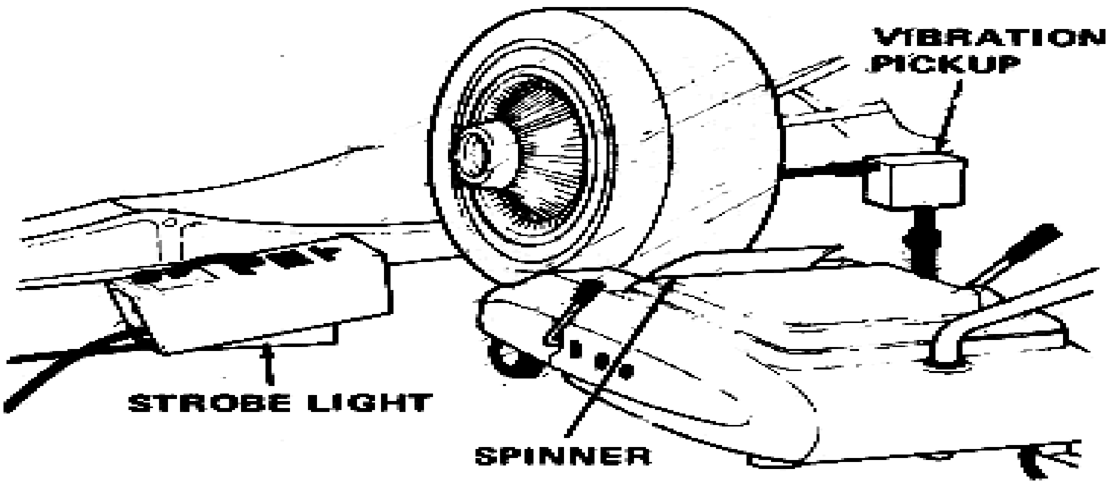


Fig -8: Electronic type dynamic wheel balancer

Adjusting Camber and Caster

12. Several different ways to adjust camber and caster have been used. Some of the methods include removing and installing shims, turning a cam, shifting the inner control-arm shaft, and changing the length of the strut rod.

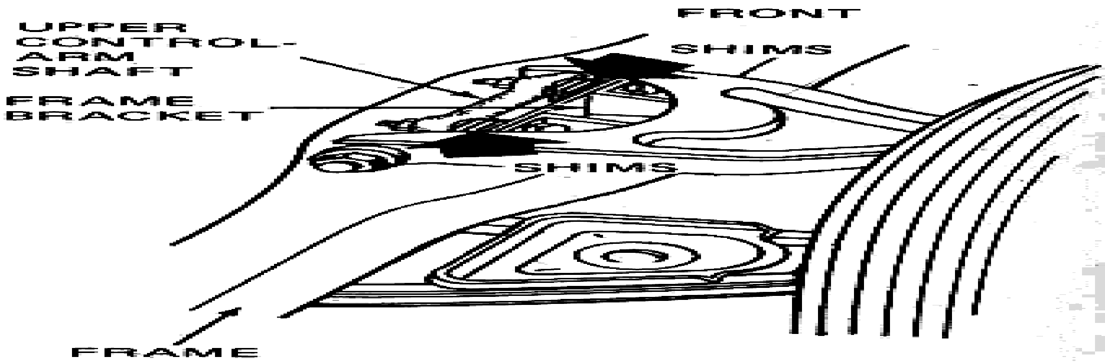


Figure -9: Location of caster and camber adjusting shims

a. **Adjustment by Installing or Removing Shims**. The shims are located at the upper control-arm shafts. They are placed either inside or out side the frame bracket. Fig-9 shows the location of the shims in many general motors cars. The shims are inside the frame bracket. Fig-10 shows the location of the shims in many ford cars. The shims are outside the frame bracket. When the shims are inside the frame bracket, adding shims moves the upper control arm inward. This reduces positive camber.

When the shims and shaft are outside the frame bracket, adding shims moves the upper control arm outward. This increases positive camber. If shims are added at one attachment bolt and removed the other, the outer end of the upper control arm shafts one way or the other. This will increase or decrease caster.

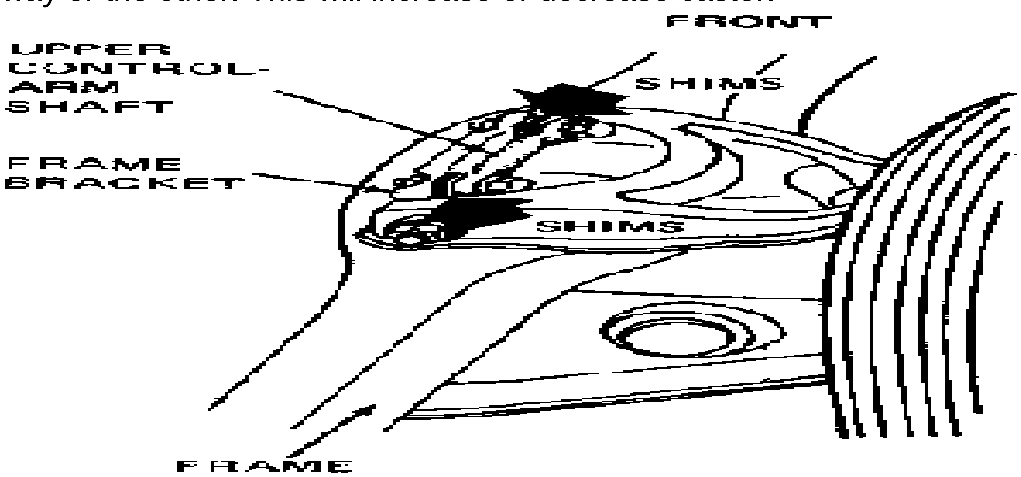


Figure -10: Location of caster and camber adjusting shims

b. **Adjustment by Turning a Cam.** There have been several variations of this method.Figure-18 shows the arrangement used on some Chrysler- built cars. The two bushings at the inner end of the upper control arm attached to the frame brackets by two attachment bolts and cam assemblies. When the cam bolts are turned, the camber and caster are changed. If both are turned the same amount and in the same direction, the camber will be changed. If only one can bolt is turned, or if the two are turned in opposite directions, the caster is changed.

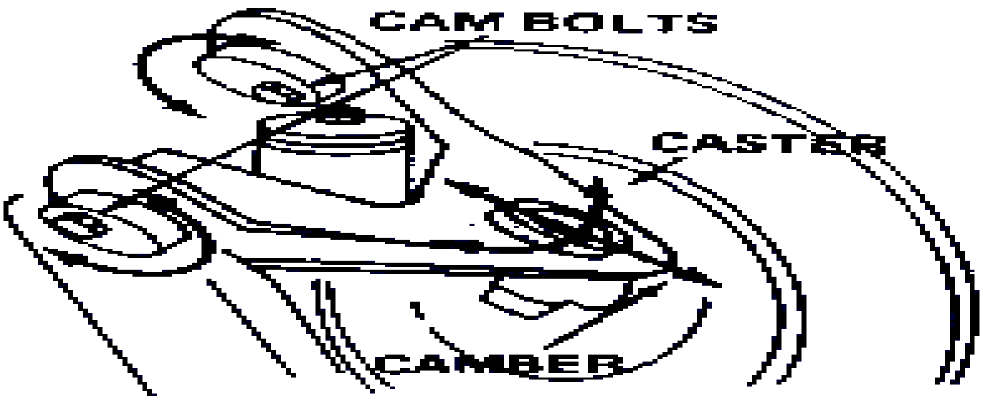


Figure -11: Turning the cam bolts

c. **Adjustment by Shifting Inner Shaft.** This system uses slots in the frame at the two points where the inner shaft is attached. When the attaching bolts are loosened, the inner shaft can be shifted in or out to change camber. Only one end is shifted to change caster.

d. **Adjustment by Changing Length of Strut Rod.** This type of adjustment is shown in fig -19.

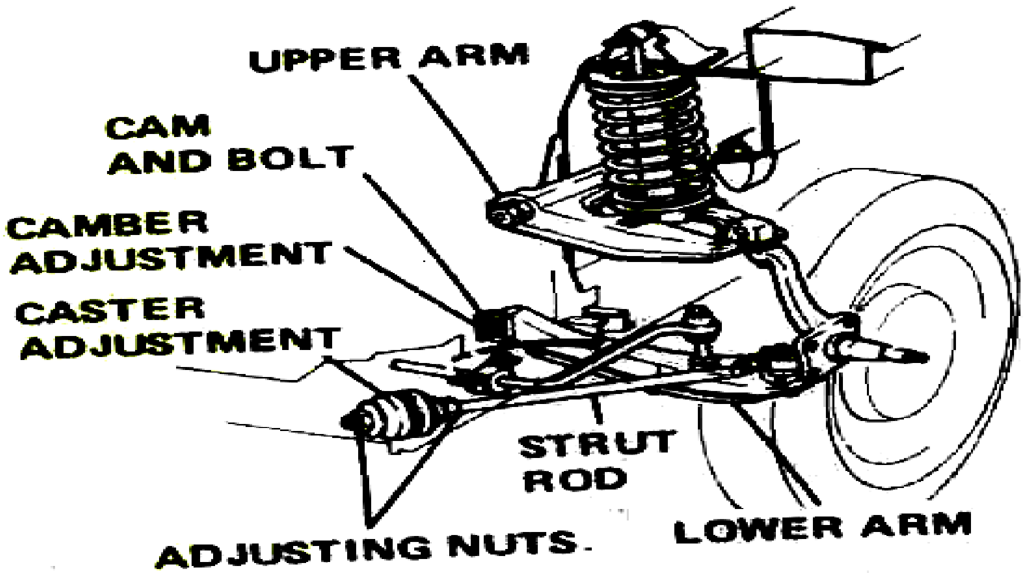


Fig -12: (50-25) Adjusting caster by Changing Length of Strut Rod

Adjusting toe

13. After correcting caster and camber, toe is adjusted. Place the front wheels in the straight-ahead position. Then check the positions of the spokes in the steering wheel. If they are not centered, they can be properly positioned when toe is set. Toe is adjusted by turning the adjuster sleeves in the linkage. If the adjuster sleeves are turned to lengthen the tie rods, the toe-in is increased.

Rear-wheel Alignment

14. On cars on front-wheel drive and cars with independent rear suspension. Such as the Chevrolet Corvette, the rear-wheel alignment can be checked. One method is to back the car onto the gauges used to align the front-wheels. Camber will read in the normal manner. But toe-in will read as toe-out, and toe-out will read as toe-in. Caster is usually set as zero originally and needs no adjustment. Check that the strut rods are straight. If they are bent, replace them.

a. **Camber Adjustment**. This is adjusted by turning the eccentric cam and bolt (Fig-20). Loosen the cam-bolt nut and turn the assembly to adjust the camber. Then tighten the cam-bolt nut.

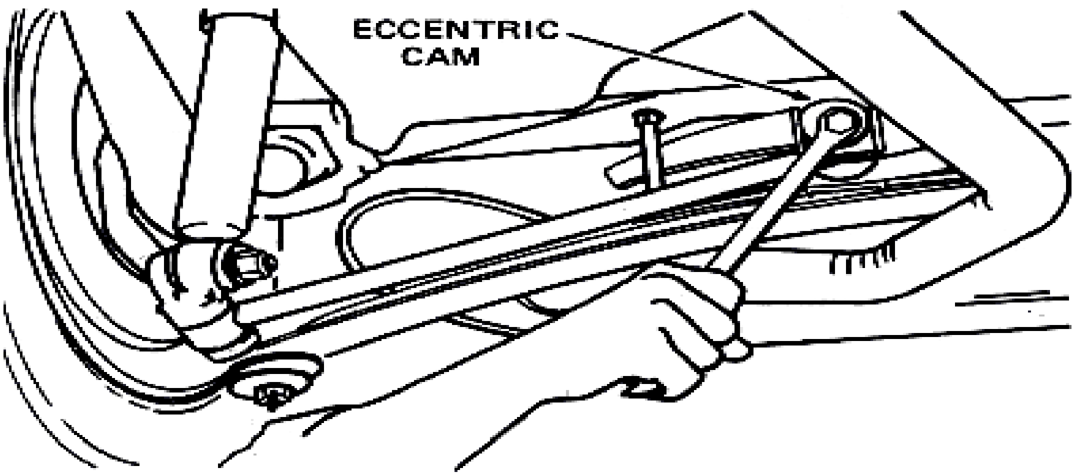


Fig- 13: Adjusting rear wheel camber

b. **Toe-in Adjustment**. Adjust toe-in by inserting shims inside the frame side member on both sides of the torque-control-arm pivot bushing.

Service Steering Linkages and Suspension

15. If any defects are found, causes must be determined and correction made before attempting to align the wheels. Servicing steering and suspension includes removal, replacement, and adjustment of tie rods; removing and replacement of other linkage parts, such as the steering idler and upper and lower control arms; removal and replacement of springs; and removal and reinstallation of wheel hubs and drums or disks. In addition, the steering gear may require adjustment, or removal for service. All of these services, if needed, must be performed before aligning the wheels. It does no good to do an alignment if the wheel bearings or other part is defective, worn out, or in need of adjustment. If service to any of the above components is required, refer to the manufacturer.

Servicing the Steering Gear

16. Manual steering gear has two basic adjustments. One adjustment the worm gear and steering-shaft-end play and The one adjustments the backlash or free play, between the worm and sector. Other adjustments are required on power-steering gears. Refer to the manufacturer's service manual for the procedures.

Conclusion

17. Vehicles are designed with manufacturer's settings for a reason. Countless hours of research and development go into designing suspension components and typically those numbers are the best to go with. Attempting to differ from the norm may result in dangerous conditions, especially for public road vehicles. As a tuner, your needs and desires may differ from the norm. In this case, be sure to exercise caution when modifying your suspension and to consult professionals prior to any major modifications. Bear in mind the differing results caused by altering your camber, caster and toe, and to remember that performance often comes at the cost of economy.

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Syllabus : Automobile General Diesel and Petrol Technology

Course : Trade training Advance, MTOF

Subject : Short Range Air Defence System (SHORAD)

Aim : To study Short Range Air Defence System (SHORAD)

Ref : Manuals Short Range Air Defence System (SHORAD)

SHORT RANGE AIR DEFENSE ALERT (SHORAD)

Introduction

1. The 6SD-M (6SD-MS) carriers (also called mechanically-driven wheeled carriers) are important ground equipment of the FM-90 air defense missile weapon system, and they are also carrying and combat platforms of the search and command system, tracking and guidance system and missile launching system. They have higher battlefield maneuverability. There are two types of carriers: 6SD-M carrier for the 6F-M FS and 6SD-MS carrier for the 6S-M SS. The FS is formed by installing four missiles-in-containers, launching turret, radar cabinet, information processing cabinet, power-on control cabinet and other equipment on the 6SD-M carrier. The SS is formed by installing the search antenna, radar cabinet, information processing cabinet and other equipment on the 6SD-MS carrier. The contents not specially marked “6SD-M” or “6SD-MS” in the document are applicable to both carriers.

Functions of the Carrier

2. The main functions of the carrier are described below (given in brackets is the main subsystem to realize the corresponding functions):

a) To provide maneuverability and cross-country capability for the weapon system, enable the weapon system to realize tactical maneuverability on road or in roadless area, improve the adaptability to various roads using the central inflating/deflating system, and provide good riding comfort for the electronic equipment, missile, etc. (chassis)

b) To provide a launching and combat platform with the required accuracy for the weapon system, and make ground clearance adjustment and attitude correction (hydraulic system)

c) To provide a favorable operating environment for the electronic equipment and operators (air-conditioning system)

d) To provide the combat power supply for the weapon system, and supply external power as the combat power supply (power supply system)

e) To provide dry and clean compressed air for the radar waveguide (waveguide air charging system)

f) To provide real-time azimuth information and three-dimensional position coordinates for the weapon system (positioning and orientation device)

Composition

3. The two types of carriers are both composed of 6 subsystems, i.e. chassis, hydraulic system, air-conditioning system, power supply system, waveguide air charging system and positioning and orientation device, and particular parts and components. They are basically identical in technical states, but different from each other in part, as shown below.

a) The chassis, hydraulic systems, air-conditioning systems and power supply systems of the two types of carriers are identical in technical states.

b) The waveguide air charging systems of the two types of carriers have the same hardware composition, but their output parameters are set to two different states by different requests of the FS and SS for the pressure and flow rate of air output from the waveguide air charging system.

c) The positioning and orientation devices of the two types of carriers have different hardware composition, that is, the positioning and orientation device of the 6SD-MS carrier is fitted with an inertial navigator, butthat of the 6SD-M carrier is not fitted. Besides, they are different from each other in functions and performances.

Operating modes

4. There are two operating modes of the carrier: running mode and combat mode.

a. Running mode

In this mode, the carrier, only taken as the transporting and carrying equipment of the weapon system, offers tactical maneuverability for the weapon system, provides good riding comfort for the electronic equipment and missile, and improves the cross-country capability through ground clearance adjustment and using the central inflating/deflating system. The chassis takes on main work. The hydraulic system to make ground clearance adjustment, personnel air conditioner and positioning and orientation device (of the 6SD-MS carrier only) will work as required.

b. Combat mode

In parking, the carrier provides the weapon system with a combat and launching platform, a comfortable operating environment, combat power supply, dry and clean air, and positioning and orientation functions. The following take on work: power system and rear transmission case of the chassis, hydraulic system, air-conditioning system, power supply system, waveguide air charging system and positioning and orientation device. There are deployment and withdrawal procedures in combat mode, as shown below.

Deployment procedure

5. a) Drive the carrier to the preset launching site, and don’t shut off its engine.

b) Connect the ground pile and GND line, and drive the former into the ground.

c) Install the protection plate against missile plume on the windshield in front of the driver.

d) Fold the side mirrors.

e) Turn on the changeover switch of the waveguide air charging system (inside the rear left maintenance door).

f) Operate the hydraulic switch on the display and control unit panel until the vehicle is leveled, and then turn it off.

g) Shut off the engine, and engage the 40kW generator.

h) Restart the engine, and operate the hand throttle and keep it at its maximum position.

i) Operate the power supply switch on the display and control unit panel for supplying power.

j) Turn on the cabinet air conditioner.

k) Power on the weapon system.

Withdrawal procedure

6. a) Power off the weapon system.

b) Turn off the cabinet air conditioner.

c) Power off the power supply system.

d) Reset the hand throttle to idle the engine.

e) Disengage the 40kW generator.

f) Operate the hydraulic switch on the display and control unit panel until the jacks (also called legs) retract.

g) Restore the changeover switch of the waveguide air charging system to the original position.

h) Unfold the side mirrors.

i) Take down the protection plate against missile plume from the windshield in front of the driver, and put it to the original position.

j) Take back the ground pile and GND line.

k) Drive the carrier away from the launching site.

Main Technical Parameters

7. This chapter gathers the main technical parameters of all the subsystems of the carrier from the view of the whole carrier. More detailed information is given in subsequent items relevant to the subsystems.

Operating Environmental Conditions

8. The operating environmental conditions of the carrier are given in the following Table.

Table-1: Operating environmental conditions

S/N	Environmental parameter	Environmental conditions	
		Operating condition	Withstanding condition
1	Temperature	0~+50ºC	–43~+65ºC
2	Humid heat	Relative humidity of 95% at the temperature of +35ºC	
3	Solar radiation	Maximum solar radiation intensity of 1120W/m^2, radiating continuously for at least 4h	

4	Low atmospheric pressure	70kPa (the atmospheric pressure at the altitude of 3km above sea level)	
5	Wind	Constant wind: 20m/s	Gust: 30m/s
6	Rain	/	Rain intensity of 5mm/min
7	Sand and dust	/	Sand grain size of 0.1~1mm and dust particle size of 1×10^{-4}~1×10^{-1}mm at the wind speed of 8m/s

S/N	Environmental parameter	Environmental conditions	
		Operating condition	**Withstanding condition**
8	Salt spray	Concentration of 5% (weight); PH value of 6.5~7.2 when the saline solution is at the temperature of +35ºC	
9	Fungus	The carrier has fungus-proof capability, with the fungus-growing grade not more than 2.The fungus includes as per gillusniger, as per gillusflavus, as per gillusversicolor, penicilliumfuniculosum and chaetomiumglobosum.	
10	Transportation environment	The carrier can withstand the transportation environments such as railway, water and road transportation.	
11	Fording	Fording depth: 1m	
12	Others	The carrier can also adapt to the natural environment factors such as snow, ice, hail, fog, thunderstorm, solarization, sand, dust and moisture.	

Overall dimensions of the whole carrier

10. a) L×W×H 7840×2875×2067 (mm) (at the ground clearance of 400mm)

b) Wheelbase 3600mm (between axles 1 and 2)+1420mm (between axles 2 and 3)

c) Wheel track 2450mm

d) Front overhang 1450mm

e) Rear overhang 1275mm

f) Approach angle 44°

g) Departure angle 37°

Main Technical Parameters of the Chassis

11. **Mobility Indexes**

a.	Dead weight of the carrier	17000kg
b.	Bearing capacity	6000kg
c.	Driving mode	6×6(changeable to 6×4)
d.	Maximum running speed	Not lower than 80km/h
e.	Maximum side slope	Not less than 14°
f).	Maximum grade ability	Not less than 25°
g.	Maximum cruising range on road	Not less than 700km
h.	Maximum fording depth	1.2m
i.	Trench width	0.9m
j.	Vertical obstacle	0.4m
k.	Braking distance	Not more than 10m, with braking deviations of not ore than 200mm (at speed of 30km/h)
l.	Minimum turning diameter	Not more than 21.9m
m.	Ground clearance (adjustable)	240mm, 400mm, 500mm

Engine and auxiliary system

12.	a.	Model	BF6M1015
	b.	Type	V-6 four-stroke supercharged water cooling diesel engine
	c.	Rated power	240kW (at 2100r/min)
	d.	Maximum torque	1470N·m (at 1300r/min)
	e.	Starting mode	Electric starting
	f.	Cooling system	Plate-fin flat-plate heat radiator

Transmission Device

13.	a. Gearbox model	ZF 16S-151
	b. Gears	8 forward gears and 1 reverse gear (with high and low gears each)

Braking System

14. a. Braking type Dual-line air braking

b. Braking mode Parking braking, exhaust braking

c. The system makes it possible to park the carrier on the slope of 20°.

Main technical parameters of the hydraulic system

15. a. Leveling mode Automatic, manual Leveling accuracy Not greater than 0.003rad (about 10′)

b. Automatic leveling time Not more than 2min (on the flat ground)

c. Leveling stability The carrier can meet the accuracy

requirement within 24h after being leveled.

D Leveling range (on side slope) Maximum slope 12% (in manual mode)

e. Ground clearance of the carrier in manual or automatic adjustment mode

500±50mm (for cross-country running or fording)

400±50mm (for running on road)

240±50mm (for transportation by railway or air)

Main technical parameters of the power supply system

16. a. It provides three-phase (three-wire) 200V 400Hz 40kW AC power supply.

b. It can continuously work for 12h (involving 1h under 10% overload) in rated operating mode.

c. At 95%~100% of rated voltage (at load terminal), the indexes are not more than the values given below.

Steady-state voltage regulation rate	±2%
Transient voltage regulation rate	+20%, -15%
Voltage stabilizing time	0.5s
Voltage fluctuation ratio	0.5%
Steady-state frequency regulation rate	±2%
Transient frequency regulation rate	±5%
Frequency stabilizing time	3s
Frequency fluctuation ratio	0.5%

Main technical parameters of the waveguide air charging system

17. a. For the 6SD-M carrier

(1) Air output pressure 0.02~0.03MPa

(2) Output flow rate Not less than 16L/min

(3) Dew-point temperature Not greater than -33°C

b. For the 6SD-MS carrier

(1) Air output pressure 0.135~0.165MPa

(2) Output flow rate Not less than 22L/min

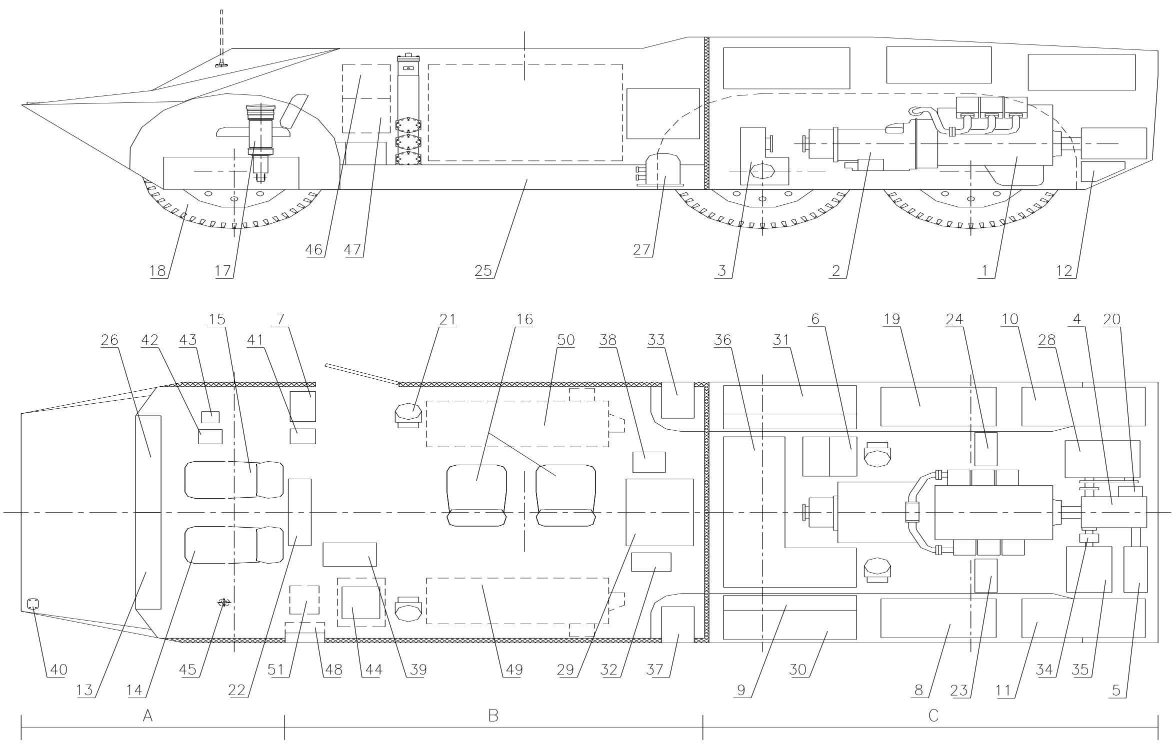
(3) Dew-point temperature Not greater than -33°C

Main Structure of the Carrier

18. Configuration of the Whole Carrier

This section mainly gives a description of general arrangement of its main equipment and the main equipment subordinate to the FS and SS on the carrier. The carrier body is of the truss light-armored structure. So it has features of great bearing capacity and light weight. There are driver's cab, fighting compartment and engine compartment from front to rear. Here, the driver's cab and fighting compartment are linked up completely, while the engine compartment is separated from them. The driver's cab is described below.In front of the driver's seat there is a dashboard, containing operation and control switches and light switches necessary for driving. On the left of the dashboard there is an operation and control box for the tire's central inflating/deflating system. In front of the co-driver's seat there is a display and control unit, containing control switches for the ground clearance adjustment and leveling performed by the hydraulic system and the display and operation of the power supply system. Above the left and right wheel housings there are the positioning and orientation device, communication radio, lightning arrester and other equipment. Here, the communication radio and lightning arresters are subordinate to the FS and SS. The fighting compartment is described below.

For the fighting compartment of the 6SD-M carrier, at the top there is the quadruple missile launching turret, on the left there are the radar cabinet and power-on control cabinet, on the right there is the information processing cabinet, and in the rear there is the air conditioner cabinet under which there is the cabinet air conditioner compressor unit and above which there is the dryer of the waveguide air charging system. On the floor there are the operator's seat and north-seeker, and in the middle under the floor (called "trough 500" for short) there are most of control components of the hydraulic system, mainly containing 2 integrated control units, adjustable accumulator, pressurization cylinder, liquid pendulum, hand pump and manometer unit. In front of the power-on control cabinet and information processing cabinet there are 2 front jacks. Here, the launching turret, radar cabinet, power-on control cabinet and information processing cabinet are subordinate to the FS. For the fighting compartment of the 6SD-MS carrier, at the top there is the search radar antenna tower, on the left there are the radar cabinet and the communication radio under which there is the inertial navigator, on the right there is the information processing cabinet, and in the rear there is the air conditioner cabinet under which there is the cabinet air conditioner compressor unit and above which is the dryer of the waveguide air charging system. On the floor there are the operator's seat and north-seeker, and in the middle under the floor (called "trough 500" for short) there are most of control components of the hydraulic system, mainly containing 2 integrated control units, adjustable accumulator, pressurization cylinder, liquid pendulum, hand pump and manometer unit. In front of the radar cabinet and information processing cabinet there are 2 front jacks. Here, the antenna tower, radar cabinet, communication radio and information processing cabinet are subordinate to the SS. The engine compartment is described below. In the rear of the carrier there are the engine, gearbox, central transmission case, rear transmission case, DC charger, accumulator, air cleaner, engine water radiator, fuel tank, air bottle, central inflating/deflating valve set, hydraulic oil tank, 2 rear jacks, rear-left and rear-right ground clearance adjustors, personnel air conditioner compressor unit, cabinet and personnel air conditioner condensing units, 40kW generator, check and control unit, etc.



A-driver's cab

B-fighting compartment

C-engine compartment

1-engine 2-gearbox 3-central transmission case 4-rear transmission case 5-DC charger 6-accumulator 7-fuse box 8-air cleaner 9-engine water radiator 10-fuel tank 11-air bottle 12-central inflating/deflating valve set 13-dashboard 14-driver's seat 15-co-driver's seat 16-combat and operation place 17-oleo-pneumatic spring 18-tire 19-hydrualic oil tank 20-hydraulic gear pump 21-jack 22-front ground clearance adjustor 23-rear-left ground clearance adjustor 24-rear-right ground clearance adjustor 25-trough 50026-display and control unit 27-cabinet compressor 28-personnel air conditioner compressor unit. 29-air conditioner cabinet 30-cabinet condensing unit 31-personnel air conditioner condensing unit. 32-air conditioner control box 33-ventilator unit 34-torque limiter 35-40kW generator.36-check and control unit 37-internal-external changeover switch 38-dryer 39-north-seeker. 40-GPS antenna 41-navigation display controller 42-navigation display43-ultra-short wave radio antenna 44-ultra-short wave radio 45-air radio. 46-external junction box 47-radar cabinet 48-information processing cabinet. 49-power-on control cabinet 50-lightning arrester. (Note: The products of S/N 43~50 are subordinate to the FS, and their approximate positions on the carrier are given in the figure.) *Continue*

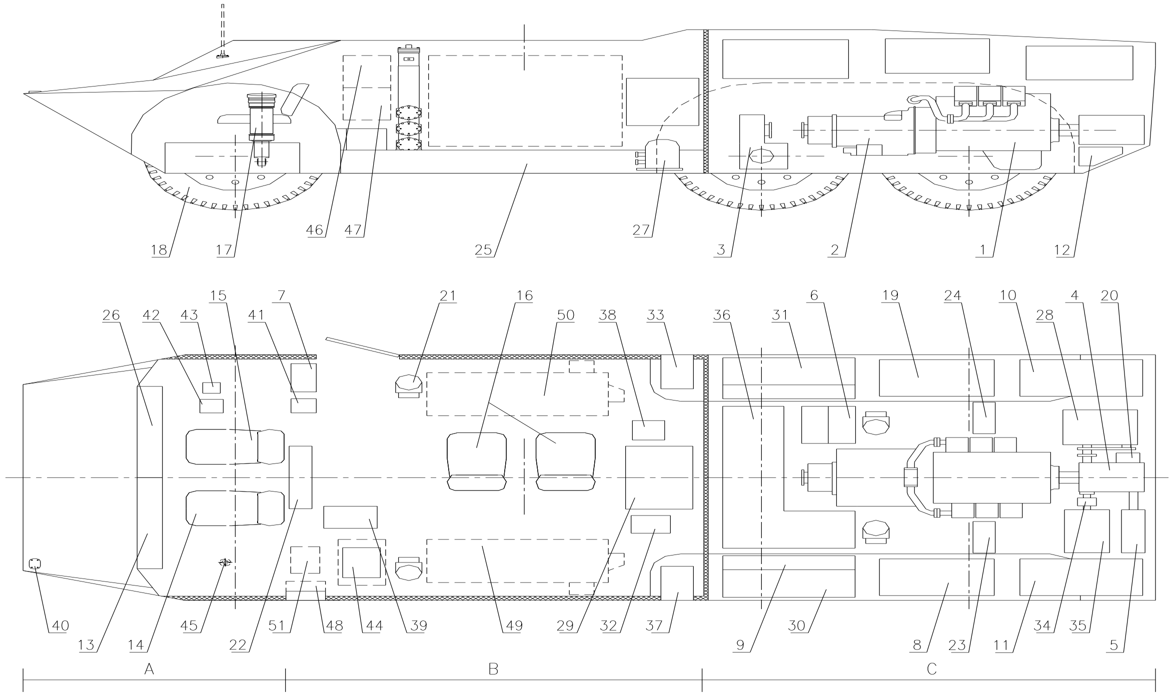


Fig: The configuration of the whole 6SD-M carrier. Schematic diagram of the configuration of the whole 6SD-M carrier.

A-driver's cab B-fighting compartment C-engine compartment

1-engine 2-gearbox 3-central transmission case 4-rear transmission case 5-DC charger 6-accumulator 7-fuse box 8-air cleaner 9-engine water radiator 10-fuel tank 11-air bottle 12-central inflating/deflating valve set 13-dashboard 14-driver's seat 15-co-driver's seat 16-combat and operation place 17-oleo-pneumatic spring 18-tire 19-hydrualic oil tank 20-hydraulic gear pump 21-jack 22-front ground clearance adjustor 23-rear-left ground clearance adjustor 24-rear-right ground clearance adjustor 25-trough 500 26-display and control unit 27-cabinet compressor 28-personnel air conditioner compressor unit. 29-air conditioner cabinet 30-cabinet condensing unit 31-personnel air conditioner condensing unit 32-air conditioner control box 33-ventilator unit 34-torque limiter. 35-40kW generator 36-check and control unit. 37-internal-external changeover switch 38-dryer 39-north-seeker 40-GPS antenna 41-navigation display controller 42-navigation display 43-altimeter 44-inertial navigator 45-ultra-short wave radio antenna 46-ultra-short wave radio. 47-air radio 48-external junction box 49-radar cabinet 50-information processing cabinet 51-lightning arrester.(Note: The products of S/N 45~51 are subordinate to the SS, and their approximate positions on the carrier are given in the figure.)

Engine

19. The BF6M1015 supercharged water cooling diesel engine made by DEUTZ Corporation is of high reliability, long lifetime, low noise and long maintenance interval. By virtue of these characteristics its maintenance cost is greatly decreased. Besides, it has Euro II effluent-quality standard.

Technical data

Type	:	BF6M1015
Cylinder arrangement	:	V-6

Cylinder diameter×stroke	:	132×145 (mm)
Displacement	:	11.906L
Overall dimensions (L×W×H)	:	985×925×970 (mm)
Net weight	:	830kg
Rated power	:	240kW (at 2100r/min)
Maximum torque	:	1473N·m (at 1300r/min)
Oil consumption	:	198g/kWh

Maintenance of the lubricating system

20. **Oil change period**

a. The oil change should be made for a new engine or for the engine through overhaul for about 50h for the first time.

b. The oil change period should be determined by operation condition of the engine and quality of the engine oil.

c. The oil change should be made at lease once a year if the working hours of the engine in one year are less than 125h.

Checking the engine oil level

21. a. Keep the engine or the carrier in a level position and make the engine run in an idle speed for about 2min before checking the engine oil level

b. Stop the engine.

c. Pull out the oil dipstick.

d. Wipe the front part of the oil dipstick dry with clean soft lint-free cloth.

e. Insert the oil dipstick back into the oil dipstick tube, and pull it out when making sure that it has reached the bottom.

f. Check whether the oil level is within the normal range. Supplement oil to the “Max.” mark if necessary. Add proper oil if the oil level is just above the “Min.” mark.

Replacing Engine Oil

22. a. Keep the engine or the carrier in a level position

b. Start the engine for preheating and increasing oil temperature.

c. Stop the engine.

d. Place a tray under the engine oil discharge outlet.

e. Unscrew the oil discharge threaded plug.

f. Discharge engine oil.

Oiling

23. a. Add CD15W/40 or CD10W/40 at temperature of above +5°C and CD10W/40 or CD5W/40 at temperature of +5~-30°C.

b. Start the engine, keep it running at an idle speed for about 5min, and observe the engine oil manometer, whose indication should be not less than 0.1MPa.

c. Stop the engine, and about 5min later, check the oil level, which should be not lower than the “Min.” mark.

Precautions:

1) Oil change should be made when the engine is stopped and the engine oil temperature is about 80℃.

2) The oil level should be not lower than the “Min.” mark.

3) Be cautious about hot engine oil and treat used engine oil properly for the environment-friendly considerations.

4) Do not use lubricating grease of different brands at one time.

Maintenance of the engine oil filter cartridge

24. The filter cartridge should be washed or replaced once every time the engine works for 200h. If the filter cartridge is of paper type, it cannot be washed but must be replaced. The maintenance method is given below.

a. Remove the check collar if there is one.

b. Take down the filter cartridge with a general tool.

c. Wash the filter cartridge in clean gasoline or fuel.

d. Wipe the surface of the filter cartridge fitting seat clean.

e. Fit a new filter cartridge or a clean one (which has been turned upside down to let oil trickle out or blown dry with compressed air) on the original position and tighten it.

f. Tighten the filter cartridge further by giving a half turn.

g. Fit the check collar on the original position and tighten it if there is one.

Fuel supply system

25. The fuel supply system functions to reliably deliver the fuel in the fuel tank to the engine low-pressure and high-pressure fuel transfer pumps, to return fuel of the engine high-pressure pump and injection pump to the fuel tank and to store sufficient fuel for ensuring the maximum running distance of the carrier.

Operation of the fuel supply system

26. The fuel supply system is of the connected structure, and its 3 fuel tanks are connected into a set. The fuel filler is located at the tail fuel tank and the fuel discharge port is located at the connecting pipe between the front right fuel tank and the front left fuel tank. No.10 military diesel is applied at ambient temperature of above -5°C. The fuel to be supplied should be pure without mechanical impurity or water.

Fuelling sequence

27. a) Open the armored cover on the fuel filler of the tail fuel tank and clear dirt off the window on the fuel filler and the fuel filler cap.

b) Unscrew the fuel filler threaded plug on the tail fuel tank.

c) Fill the system with fuel at the speed to be controlled according to the fuel flowing for avoiding fuel overflow.

d) After fuelling, check whether the sealing cushion on the fuel filler is intact and replace it if necessary, and then screw up the fuel filler cap and fit the armored cover.

Fuel discharge sequence

28. a) Clear dirt off the armored cover on the fuel discharge outlet at the carrier bottom, open the window on the fuel discharge outlet of the fuel tank and unscrew the fuel discharge threaded plug of the fuel tank.

b) Assemble the special joint (120.28.23-1) and hose (120.28.954-2A), insert the hose into the fuel tank, screw the joint into the fuel discharge outlet until fuel starts to flow out (unscrew the fuel filler threaded plug on the upper part of the fuel tank so as to discharge the fuel completely).

c) After discharging fuel, unscrew the joint, screw up the fuel discharge outlet threaded plug and fuel filler cap and fit the removed window and armored cover on the origination position.

Expelling of air in the system

29. The air in the system should be expelled using the following method before a loaded carrier or a carrier parked for a long time is started for the first time.

a) Loosen the air discharge screw at the top of the fuel secondary filter.

b) Press the hand pump continuously until the fuel without air bubbles flows from the air discharge screw hole, and then stop pressing the hand pump.

c) Tighten the air discharge screw at the tope of the fuel secondary filter.

Maintenance of the fuel supply system

30. a. **Check before traveling**

1) Check whether the fuel quantity is sufficient for the distance the carrier will travel.

2) Check whether the fuel filler and fuel discharge outlet threaded plugs are sealed reliably.

b. Check after traveling

Check the fuel quantity with the fuel quantity indicator and fill the system with fuel.

Maintenance of the fuel primary filter

31. The fuel primary filter should be washed once every time the engine works for 100h (it can be washed as required at any time when the fuel becomes dirty.)

a) Unscrew the fixing screw stem of the primary filter central shaft and take down the filter cartridge.

b) Wash the filter cartridge with gasoline or fuel.

c) Turn the filter cartridge upside down to let the fuel trickle out, fit it into the primary filter and screw up the fixing screw stem after the filter is filled with fuel.

Maintenance of the fuel secondary filter

32. The fuel secondary filter should be replaced once every time the engine works for 200h.

Cooling system

33. The cooling system functions to radiate heat of the parts and components of the engine and keep their temperature within the allowable range.

a. Operation of the cooling system

The switch for the heater (outputting heat for driver and operators in winter state) is turned off in summer but turned on in winter state.

The military engine full-time coolant or the common automobile antifreeze which can be purchased on the market, such as Chanchiang brand of coolant FD-2, can be applied to the cooling system, about 60L for the first time.

b. Coolant filling sequence

(1) Park the carrier at a level position (visually), open the left and right liquid filler caps on the top deck of the carrier and unscrew the liquid filler threaded plugs of the left and right radiators.

(2) Add coolant to the required position, which is 50mm higher than the liquid filler seat bottom surface, with a funnel. Start the engine and keep it running for 2~3min after filling, and supplement coolant to the required position.

(3) After filling, screw up the liquid filler threaded plugs and fit the liquid filler caps on the top deck.

c. Coolant discharge sequence

(1) Open the left and right liquid filler caps on the top deck and unscrew the liquid filler threaded plugs on the left and right radiators.

(2) Unscrew the liquid discharge outlet threaded plug on the bottom plate of the carrier.

(3) Assemble the special joint (120.28.23-1) and hose (120.28.954-2A), insert the hose into the radiator, screw the joint into the liquid discharge outlet until coolant starts to flow out.

(4) Drive the engine crankshaft to turn by some revolutions using the starting electromotor (not stepping on the gas pedal) in order to exhaust coolant.

(5) After exhausting coolant, screw up the liquid filler threaded plugs and fit the liquid filler caps on the top deck and screw up the liquid discharge outlet threaded plug on the bottom

plate of the carrier.

(6) The coolant should be discharged into a clean container when it is hot for reutilization.

Precautions:

1) Since coolant is poisonous generally, suctioning it by mouth is forbidden during in usage, hands must be washed with hot water and soap after contacting coolant and the container storing coolant should bear an obvious mark on its surface.
2) Be cautious not to mix engine oil and diesel into antifreeze in coolant filling and storage in order that no air bubble having a bad influence on engine radiation is produced in usage.

3) The liquid level of coolant should be checked once every time the carrier runs 1000km.

Maintenance method and sequence of the air cleaner cartridge

34. a. Open the carrier body cover plate on the left air cleaner chamber at the top of the engine compartment.

b. Open the air cleaner cover.

c. Screw the filter cartridge out of the connecting sleeve with a clamping-sleeve special spanner (BW122C.28.07).

d. Check whether there is dust in the filter cartridge internal cavity. If so, check whether there is crack or a hole in the filter cartridge by illuminating the filter cartridge. If so, replace the filter cartridge; if not, maintain it.

e. Blow loose dust off the filter cartridge with compressed air. Now, the pressure should be less than 0.65MPa, the distance between nozzle and filter cartridge should be more than 25mm and only blowing from the clean air end (i.e. blowing from the air cleaner internal cavity outwards) is allowed. Do not knock the filter cartridge with any object so as to avoid its damage. Keep it clean during maintenance and do not contaminate it.

f). Check whether there is a crack or hole in the filter cartridge by illuminating the filter cartridge after maintenance. If there is a recess in the expanded metal lath, take a strict and careful check around the recess. If a crack or hole is found, replace the filter cartridge.

g. Check whether the surface of the sealing rubber cushion of the air cleaner cover is smooth and straight. If the sealing rubber cushion has distorted permanently or it cannot provide good air tightness, replace it.

h. Clear dirt off the air cleaner internal cavity and cover and wipe all positions clean with clean cloth.

i. Fit the maintained filter cartridge into the secondary filter case: First fix the bolt and nut for the connecting sleeve on the terminal board, then screw the filter cartridge into the connecting sleeve and tighten it with the clamping-sleeve special spanner.

j. Fit the air cleaner cover plate. In fitting, the fixing lug is permitted to bend slightly but the clearances between the cover and the top upper board at all positions should be kept uniform.

k. Fit the air cleaner chamber cover plate.

Precautions:

1) When there is lots of oil stain on the paper filter cartridge or dust cannot be cleared off or after the filter cartridge is maintained several times (determined by actual conditions), the filter cartridge should be replaced with a new one.

2) Check the positions of the air cleaner and connecting pipe where leakage may occur.

3) Leakage may occur on the connecting position of the rubber bellow with the engine. Once leakage occurs, air bypasses the air cleaner and enters the engine directly, which may cause serious wearing or scuffing of the engine. So connections between bellow, engine and air cleaner are very important and be sure to make them tight so as to avoid leakage.

4) The sealing between the air cleaner cover and the secondary filter case is important too. It there is leakage, air bypasses the air cleaner too. So it is necessary to check and make sure that impressions of the sealing rubber cushion are uniform.
5) If the air cleaner is knocked in assembling or operation, it may cause crack or distortion of the air cleaner. So knocking should be avoided in assembling or operation.

Master clutch and gearbox

35. a. Operation of the master clutch

Since friction occurs often in operation of the master clutch, the parts are worn. To conduct correct operation and maintenance according to the requirements can reduce wearing and prolong the service life of the clutch.

a) Keep the engine speed within 800~1300r/min before engaging the clutch and increase oil supply quantity properly with change of engine speed in the process of starting the carrier.

b) Keep the speed difference between driving disk and driven disk of the clutch as small as possible in order to reduce slide wearing of the clutch.

c) When disengaging the clutch, the clutch pedal should be stepped to the limit. When engaging the clutch, the action should be quick in the first two-thirds stage and steady in the last one-third stage.

d) After being released, the clutch pedal should be returned to the normal position.

Precautions:
1) When disengaging the clutch, do not step on the clutch pedal slowly.
2) When changing gear, do not keep the clutch in disengaged state for a long time.

3) When engaging the clutch, do not release the pedal abruptly.

b. Operation of the gearbox

i) Gear change of the gearbox

Select a proper gear according to road conditions and terrain in running, keeping the engine rotation speed always within the range of 1200~1800rpm.

a) Speed up at the engine rotation speed of more than 1800rpm.

b) Slow down at the engine rotation speed of less than 1200rpm.

c) When changing gear, step on the clutch pedal to the limit.

d) When changing gear, especially when changing up into a low gear, do not act abruptly, keep pressing the gear shift with force until gear change is completed so as to shorten gear change time and avoid quick wearing of the synchronizer.

e) Changing to the reverse gear or gear 1 used for starting the carrier on a bad road can be performed only after the carrier stops reliably. Otherwise, the meshing gear might be damaged.

f) Stepping on the clutch pedal twice to change gear can prolong the service life of the synchronizer.

g) Keep the pressure of the compressed air system at 0.7MPa.

ii) <u>Gears</u>

a) Change gear using the front secondary gearbox low-speed gear set.

b) Change gear using the front secondary gearbox high-speed gear set.

c) 16 gears can be provided using the front secondary gearbox low-speed gear set and high-speed gear set alternately.

ii) <u>Gear Change</u>

The gear shift is between gears 3 and 4 or gears 5 and 6 when the gearbox is at neutral gear. The method to change between high and low gears is given below.

a) Step on the clutch pedal.

b) Set the gear shift to the neutral gear.

c) Apply a larger force of impact (by hand) to the gear shift to overcome the gear self-locking force in the gearbox when changing the gear shift between high and low gears. Here, L represents low gears, involving gears R (reverse) and 1~4, and H represents high gears, involving gears 5~8.

d) Change the gear shift to the required gear gently and uniformly.

e) Release the clutch pedal.

iv) <u>Gear change of the front secondary gearbox</u>

a) Select the low-speed gear set or high-speed gear set with the front secondary gearbox switch button.

b) Step on the clutch pedal to the limit and keep stepping until gear change is completed.

v) <u>Oil level check and oil change of the gearbox</u>

(1) <u>Oiling</u>

a) Supply gear oil 80W/90 at temperature of -15°C.

b) The oil level is kept at the lower edge of the oil filler hole in the gearbox. Supply oil from the oil filler hole if necessary.

(2) **Oil discharge**

a) Unscrew the oil discharge threaded plug at the bottom of the gearbox.

b) Wash the oil discharge threaded plug.

c) Replace the seal ring of oil discharge threaded plug.

Check and maintenance of the H-type transmission

36. a. **Oiling and oil level check**

a) Supply gear oil 80W/90 when the temperature of each transmission case is higher than -15°C.

b) Supply oil from the oil filler hole to the required oil level of each transmission case. The oil level is kept at the lower edge of the oil filler hole in the gearbox. Transmission case of the middle axle: The oil level is 120~125mm. Left and right transmission cases of the middle axle: The oil level is 95~100mm. Left and right transmission cases of the front axle and axle 3: The oil level is 90~95mm.

c) The oil level of each transmission case can be measured with the oil dipstick. Besides, the oil is supplied sufficiently when the oil flows out of the oil hole after the threaded plug in the observation oil hole is unscrewed.

b. **Oil discharge**

a) Unscrew the oil discharge threaded plug at the lower part of the transmission case

b) Wash the oil discharge threaded plug.

c) Replace the seal ring of oil discharge threaded plug.

d) Replace the sealing cushion on the threaded plug after oil discharge.

c. **Regular check**

Check and maintenance should be performed in the technical maintenance period of the carrier.

a) The breathers on the cases should be kept clean and ventilated. Otherwise, high pressure in the cases may lead to leakage. So the breathers should be washed in time if they are found clogged.

b) Lubricating oil pump, open the window cover at the middle axle of the carrier bottom, remove the lubricating oil pump in the transmission case of the middle axle, check whether the oil pump works normally and wash the oil pump filter screen.

Precautions:

When the oil temperature of the central transmission case is higher than 110℃, park the carrier and check whether the oil level of the case meets the requirement and whether the lubricating oil pump *works normally.*

Steering system

37. a. Operation of the steering system

The driver turns the steering wheel to deflect the driving wheel to a certain angle. Thus the carrier driving direction is changed. The power steering system can increase the force of the steering wheel transmitted to the steering knuckle through hydraulic power-assisted operation, thus lessening the driver's effort.

Precautions:

Coasting in stop state is forbidden so as to prevent the power steering system from coming out of action after the engine is stopped, and applying a force 5~7 times larger than the normal one to the steering wheel can change the carrier running direction. When making a sharp turn, slow down the carrier beforehand and change into a low gear in time to keep the engine rotation speed higher than 1200rpm. Thus the power steering system can be kept in good, easy, flexible and safe state. Since the power steering system may come out of action in running, be cautious at any time to prevent a traffic accident from happening.

b. Maintenance of the steering system

Check the oil level of the steering oil tank before the carrier is started each time, which should be between two scales when the engine runs and be 10~20mm higher than the upper scale when the engine stops. Turn the steering wheel to make a sharp turn after starting the engine, starting the carrier in gear 2 and keeping the engine speed within 1200~1400rpm. Now the steering wheel should be turned easily. If not, find the cause in time and remove the fault. The wheel deflection speed should change as the steering wheel turning speed in normal running. The larger the steering angle is, the larger the steering force is. If not, remove the fault. The mechanical transmission can be used for steering the carrier when the hydraulic power-assisted system fails, but it is required to apply a larger force to the steering wheel. At this time, find the fault of the hydraulic steering system and remove it.

c. Check and adjustment of the steering system

Take the following checks in the second-level technical maintenance. Check the sealing performance of the steering system hydraulic pipes. Check the clearance between draw-bar and draw-arm, looseness of the steering vertical shafts and fixing of all the bolts and nuts and make sure that all the bolts and nuts are fixed reliably and firmly. Check the locking of the fixing bolt on the steering device and make sure that it is not loose. Check the wheel toe-in and make adjustments if necessary.

Braking system

38. The braking system is used for slowing down the carrier compulsorily until the carrier is stopped, preventing the carrier speed from getting higher and higher when the carrier runs down slope and preventing the carrier from moving freely when it is parked on a slope.

a. Operation of the braking system

i) <u>Operation of the hand brake</u>

The hand brake is used for parking the carrier, and obstacles (such as stow-wood) can be also used if necessary to prevent the carrier from moving.

a) Putting on the hand brake: Pull the handle to the brake position (to make it wedged).

Now the hand brake indicator lights up. The handle can stop at any position by holding it by hand when it is pulled to the middle position. After it is released, it can return to the released position.

b) Releasing the hand brake: In order to release the hand brake completely, the pressure of the air bottle is kept not lower than 0.55MPa and the brake pressure warning indicator on the dashboard does not light up. Pull the handle from brake position to released position. At this time, the hand brake indicator goes out. Release the hand brake using the mechanical method (keeping the carrier stationary first) if the composite brake air chamber leaks.

<u>Starting the carrier and changing gear</u>

39. Do not start the carrier when either of pointers of the double-pointer manometer points at the value of less than 0.55MPa and the pressure warning indicator on the dashboard lights up.

<u>Precautions:</u>

Test the braking system (involving brake pedal and hand brake) on the road of good quality immediately after starting the carrier. If the brake is uniform with a sufficient brake force, it shows the braking system works well. Using the above simple method, it can be determined whether the carrier can run on the road normally. Use the exhaust brake but not the parking brake for a long time on a long slope so as to prevent the brake drum from getting so hot and prevent air pressure from getting so low that the defined efficiency is reduced. Use both the exhaust brake and the traveling brake on a long and abrupt slope. Use the parking brake only when the traveling brake fails. Since the braking efficiency is greatly lowered after water enters the brake in fording, step on the brake pedal gently several times so that the brake is dried by heat produced by friction of the brake shoe against the brake drum and restores to good braking state. Stop traveling even if the brake of only one wheel fails.

<u>Check and maintenance of the braking system</u>

40. Check leakage of the braking pipeline every running distance of 1000km and ensure that it is kept in a good state. Replace the braking pipeline even if there is only minimal damage on the braking pipeline. Replace the pipeline if it is found flattened or blocked. Check the pressure of the braking system. The pressure warning indicator should go out when the indication of the double-pointer manometer is higher than 0.55MPa. Check leakage of the braking pipeline after stepping on the brake pedal. If it leaks, remove the leakage. Check whether the engine stops immediately after the exhaust brake valve is stepped on when the engine is running. If not, check the performance of the exhaust brake valve. The carrier should be parked without downslide on a slope when the parking brake is used. Apply No.2 tank lubricating grease to the left and right brakes from their grease cups to the left and right cam arm supports regularly. Check intactness of the braking air chamber connecting pipeline. The pressure drop should be not larger than 0.02MPa after the brake pedal is stepped to the limit for 5min within 10min after the engine stops. Check whether there is oil in the brake drum. If so, find the cause and wipe the brake drum and brake shoe. The braking distance should be not larger than 10m at the carrier speed of 30km/h. Check the braking clearance with the feeler leaf and adjust it if necessary. The standard clearance between brake drum and brake shoe is 0.7~1.2mm. The adjusting method is given below.

1) Jack the carrier to enable the wheels to rotate freely. When it is required to adjust the braking clearance of only one wheel, jack the lower arm to enable the required wheel to rotate freely.

2) Turn the turbo shaft of the swinging arm clockwise with the S=19 spanner until the brake shoe friction disk contacts the brake drum so tightly that the wheel cannot rotate. Then give 1/3~1/2 counterclockwise turn, measure the clearance between brake shoe friction disk and brake drum with the feeler leaf at 20~30mm away from the brake shoe end in the sight hole, which should be within 0.7~1.0mm.

3) Do a test on a flat and straight road to check correctness of adjustment.

Function check of the fire-extinguishing installation

41. **a.** **Function check in “SEMI AUTO” state**

a) Turn the state switch to “SEMI AUTO” position.

b) Turn on the master power supply and “FIRE EXT” switch, the “ Power indicator” on the LKM1 fire-extinguishing control box should light up, but the fire alarm indicators and fire extinguisher state indicators should not light up.

c) Burn the thermal sensitive terminal of a flame sensor with an alcohol lamp, the corresponding fire alarm indicator on the LKM1 fire-extinguishing control box should light up within 5s and the horn should sound an alarm simultaneously.

d) Keep the alcohol lamp away from the flame sensor, the fire alarm indicator should go out later on and then the horn should stop sounding 5s later.

e) Check another 5 flame sensors using the above method.

b. **Function Check in “AUTO” state**

a) Disconnect the fire extinguisher cable plug CT2 from the LKM1 fire-extinguishing control box, insert the plug of the simulation test box into the socket CZ2 of the fire-extinguishing control box, and ground the negative wire nearby temporarily.

b) Turn the state switch on the LKM1 fire-extinguishing control box to “AUTO” position, turn on all the switches on the simulation test box, turn on the master power supply and “FIRE EXT” switch, the “Power indicator” on the LKM1 fire-extinguishing control box should light up, but the 3 fire extinguisher state indicators should not light up.

c) Burn the thermal sensitive terminal of the flame sensor G5 (or G6) with an alcohol lamp, the fire alarm indicator for engine compartment should light up within 5s, the warning horn indicator (white), engine stop indicator (green) and fan indicator (yellow) should light up simultaneously too, and then the electric squib indicator 1 for engine compartment and fire extinguisher state indicator 1 should light up 5s later, showing that the fire extinguisher 1 starts discharging extinguishing to the engine compartment. Keep burning the flame sensor, the electric squib indicator 2 for engine compartment and fire extinguisher state indicator 2 should light up simultaneously 10s later, showing that the fire extinguisher 2 starts discharging extinguishing to the engine compartment, and the electric squib indicator 3 for engine compartment and fire extinguisher state indicator 3 should light up simultaneously 10s later, showing that the fire extinguisher 3 starts discharging extinguishing to the engine compartment. Take away the alcohol lamp, 5s after the fire alarm indicator on the fire-extinguishing control box goes out, the warning horn indicator, engine stop indicator and fan indicator should go out too.

c. **Checking the function of each manual button and judgment on the used fire**

extinguisher

a) Turn the state switch to "SEMI AUTO" position, press a manual button, the fire alarm indicator should light up, and the warning horn indicator, fan indicator, electric squib indicator 1 for engine compartment and fire extinguisher state indicator 1 on the simulation test box should light up simultaneously too, showing that the fire extinguisher 1 starts discharging extinguishing. Release the manual button.

b) After the fire alarm indicator, warning horn indicator, fan indicator, electric squib indicator 1 for engine compartment and fire extinguisher state indicator 1 all go out, turn off the changeover switch 1 on the simulation test box. Now the fire extinguisher state indicator 1 should light up. Press the manual button again, the fire alarm indicator should light up, and the warning horn indicator, fan indicator, electric squib indicator 2 for engine compartment and fire extinguisher state indicator 2 on the simulation test box should light up simultaneously too, showing that the fire extinguisher 2 starts discharging extinguishing. Release the manual button.

c) After the fire alarm indicator, warning horn indicator, fan indicator, electric squib indicator 2 for engine compartment and fire extinguisher state indicator 2 all go out, turn off the changeover switch 2 on the simulation test box. Now the fire extinguisher state indicator 2 should light up. Press the manual button again, the fire alarm indicator should light up, and the warning horn indicator, fan indicator, electric squib indicator 3 for engine compartment and fire extinguisher state indicator 3 on the simulation test box should light up simultaneously too, showing that the fire extinguisher 3 starts discharging extinguishing. Release the manual button. After the fire alarm indicator, warning horn indicator, fan indicator, electric squib indicator 3 for engine compartment and fire extinguisher state indicator 3 all go out, turn off the changeover switch 3 on the simulation test box. Now the fire extinguisher state indicator 3 should light up too.

d) After the check ends, turn off the power supply switch, pull out the plug of the simulation test box, and insert the cable plug CT2 into the socket of the LKM1 fire-extinguishing control box.

d. Maintenance of the automatic fire-extinguishing installation

i) First-level maintenance

a) Clear dust and oil stain off the surfaces of the components, check the locking and wiring of them and check the completeness and intactness of the automatic fire-extinguishing installation.

b) After turning on the "FIRE EXT" switch, check the "Power indicator" on the LKM1 fire-extinguishing control box, which should light up but the other indicators not.

ii) Second-level maintenance

a) Conduct the first-level maintenance.

b) Conduct fire alarm detestability check and function check of the LKM1 fire-extinguishing control box of the fire-extinguishing installation in "SEMI AUTO" state.

iii) Third-level maintenance

a) Conduct the second-level maintenance.

b) Check the control functions of the fire-extinguishing installation in “AUTO” state and check control functions of the manual button for the engine compartment and judgment on the used fire extinguisher using the simulation test box.

e. <u>Special maintenance</u>

Blow the fire-extinguishing tubes and jets clean using compressed air in medium repair and overhaul.

<u>Electric system</u>

42. The WXZ208A chassis electric equipment includes the power supply and distribution system, instrument indication and warning system, lights and control system and some auxiliary electric appliances. Through mutual control and functional combinations, they form the electric system based on the electric network connection. The first 2 systems operate in automatic control mode, and the others operate in manual control mode.

<u>External equipment of the carrier</u>

43. a) Front head lights (up beam and low beam)

b) Front and rear turn lights

c) Front marker light

d) Fog light and blackout light

e) Waterproof electric horn

f) Rear combination light

g) External starting socket

h) Front axle left locking indicating switch

i) Front axle right locking indicating switch

<u>Operating method (of Electric System)</u>

44. a) In off state: he system is in off state when it is not powered on or it conducts no operation.

b) Operation in normal state: Make sure that the system is powered on normally without any fault first. Next turn the state switch to “NORMAL” position, the all-wheel inflation and deflation switches to “STOP” position. Then turn on the power supply, the display window and indicators start self-check.

In the process of self-check, the first two digitrons in the display window both come on, then all the six digitrons display numbers of 0~9 and the indicators flash in different colors in turn. After self-check, the display window is in operating mode and displays the values of all the monitoring points on corresponding road condition before shutdown circularly. Now the pressure display value of the air bottle should be higher than 0.7MPa and the inflation controller becomes available.

c) Operation in “GZ” operating mode: Select the road condition by pressing the “FUNC” key for road, “+” key for earth road, “-” for soft earth road or “CONFIRM” for muddy/sandy road. After that, the corresponding indicator becomes on. Press “START/STOP” key. Now the selected road condition indicator flashes, and pressure at all monitoring points is tested in turn. The monitoring points of No’s 1~6 represent left wheel 1, right wheel 1, left wheel 2, right wheel 2, left wheel 3 and right wheel 3 respectively, 9 represents main pipeline, A represents the air bottle. In test, the tested tire indicator lights up, and it appears yellow at normal pressure, red at overpressure and green at under pressure.

The last three digitrons in the display window display the tested pressure value. After the test, group the tires according to under pressure and overpressure. Inflate the tire at under pressure, and then deflate the tire at overpressure. During inflation, the indicator of the tire at overpressure goes out. After the tire pressure becomes identical with the preset pressure for the selected road condition through inflation or deflation, the controller turns to pressure maintaining control. Now the tire state indicator appears yellow. After one monitoring cycle, the controller performs cyclic monitoring according to the preset automatic tire pressure monitoring time if the “START/STOP” key is not pressed again; it exits from the automatic monitoring if the “START/STOP” key is pressed again. Now the display window displays the tested pressure values at all the monitoring points on the previous corresponding road condition circularly.

d) Operation in “CS” operating mode: Shift to “CS” operating mode with the mode key. Now select the tire by pressing “+” key or “-” key and test its pressure. The tires of No’s 1~6 represent left wheel 1, right wheel 1, left wheel 2, right wheel 2, left wheel 3 and right wheel 3 respectively. Start the test by pressing “CONFIRM” key. Now the tested tire indicator lights up, the road condition indicator flashes and the display window displays the tested tire pressure value.

e) Operation in “LK” operating mode: Caution: Once the “LK” parameters are set, non-professional technician is forbidden to modify them at will.

f) Operation in emergency mode: Turn the state switch to “EMER” position when the all-wheel inflation/deflation is required under failure of the computer, and perform inflation/deflation with the all-wheel inflation/deflation switch by adjusting the control pressure manually.

Start and stop of the engine

45. a. <u>Start of the engine</u>

a) Keep the gear shift handle at neutral position between gears 3 and 4 and turn on the master power switch. Now the low-gear indicator and power generation indicator should light up. When the pressure indication of the double-pointer manometer is less than 0.55MPa, the pressure warning indicator should light up.

b) When the parking brake handle is kept at parking position, the parking brake indicator should light up. The parking brake can be released only after the pressure exceeds 0.55MPa.

c) Press the button on the ammeter/voltmeter and check the accumulator voltage, which should be not lower than 22V.

d) Step on the clutch pedal, turn the ignition key switch from “0” directly to “2” and slowly step on the gas pedal simultaneously. Release the ignition key immediately after the engine is started. Now the engine runs at an idle speed, the power generation indicator goes out and the engine oil pressure indication is larger than 0.1MPa.

<u>Note:</u> The engine start time should be kept within 10s. If it cannot be started *for the first time, it can be started 1min later. If it cannot be started twice thrice continually, the cause should be found and the fault should be removed*.

b. <u>Stop of the engine</u>

a) The engine can be stopped by keeping stepping on the exhaust brake valve for 3~5s.

b) Release the exhaust brake valve and turn off the master power switch.

c) The engine cannot be stopped abruptly after it works under a large load. It can be stopped by stepping on the exhaust brake valve only after the engine runs at an idle speed for a short time and the indication of the oil temperature gauge does not drop quickly.

Start of the carrier

46. First preheat the engine, gearbox and transmission case after start of the engine, and then start the carrier.

a) Pull the gear shift handle to a neutral position after engine start, and keep the engine running at a medium speed for some time so that the engine temperature increases gradually. The cold engine is not allowed to run at a high speed. The parking brake can be released only after the indication of the double-pointer manometer exceeds 0.55MPa, and the carrier can be started only after the parking brake warning indicator goes out.

b) Step on the clutch pedal to the limit and start the carrier according to road condition, using gear 2 generally, gear 3 or below on a flat road, gear 2 or below on a slope and gear 1 on a sharp slope or on the cross-country road.

c) Start the carrier steadily after releasing the parking brake.

d) Drive the carrier at a medium speed, and then at full speed after the engine temperature becomes normal.

Periodical maintenance

47. a. **First-level maintenance**

a) Engine

Check the installation tightening of the engine.

b) Transmission

Check engagement of the clutch, fixing of the gearbox control device and gearbox, connection of the flange on the drive shaft. Additionally, check the breathers of all the transmission cases.

c) Suspension

Check fixing of the upper and lower wishbones and apply oil.

d) Steering system and braking system

Check oil level of the hydraulic system oil tank, fixing of the steering gear support and steering linkage, intactness and connection of the brake pipeline connecting hose, oil level of the brake oil tank. Besides, check and adjust the brake clearance.

e) Electric system

Check intactness of the cables.

Check performance of the generator, voltage regulator, starting electromotor, electromagnetic valves and control box.

b. Second-level maintenance

Besides check items in the first-level maintenance, the second-level maintenance involves the following items.

a) Engine Check intactness of the engine elastic support and leakage on the connecting position of the engine air inlet and outlet pipes with the cylinder. Clear the water tank radiator with compressed air. Check low-pressure fuel pump, replace the engine oil, maintain the air cleaner and wash the fuel primary filter and secondary filter. Additionally, perform other maintenance following the specifications given in "Operation instruction for the engine".

b) Transmission Check the tightening of the bolts of all the flanges pedal shafts and drive shaft.

Replace lubricating oil of the transmission case and axle 3 hub redactor.

c) Steering system and braking system

Check tightening of the link ball nuts of the steering system.

Check performance of the steering vertical shaft and air tightness of the steering gear.

Check the wheel toe-in.

d) Suspension

Check wearing of the suspension and apply lubricating oil through tire rotation.

e) Electric system Check charging condition of the accumulator. Check whether there is a bulge or leakage on the accumulator case. Check whether there is ablation on the joint of the generator, whether the bolts are loose and whether the belt is loose or damaged. Check whether the indications of the sensors and meters are normal and whether the lights and bulbs in them are intact. Check the joints, insulating layers, cables and battery connecting wires of the circuits of the whole carrier.

c. <u>Third-level maintenance</u>

Besides check items in the second-level maintenance, the third-level maintenance involves the following items.

a) Check tightening of all the connections of the carrier.
b) Check air tightness of all the doors, windows and check ports. Check the rubber air guiding pipes of all the brake cylinders and replace them if necessary.
c) Check intactness of the electrical circuits, meters and air pipes of the whole carrier.
d) Replace the triangle belt of the transmission and lubricating grease of the generator bearing when necessary.
e) Wash the exhaust turbocharger (by a professional technician)
f) Check tightness of the hub bearing.
g) Perform overall maintenance for the suspension.
h) Replace the parts and components with a great deal of wear.

i) Replace lubricating oil of the transmission case, gearbox and engine.

<u>Automatic recovering</u>

48. The hydraulic system performs the automatic recovering in the following steps.

a) Keep the leveled carrier in combat state, that is, the jacks support the carrier.

b) Start the engine and keep its rotation speed stable at 1450~1500r/min.

c) Turn the "General power supply" switch upward (now there is a horizontal signal indication on "Horizontal angle" and there is an indication on the "Hydraulic power source" meter, the "Retract" indicator is off, andthe “Locking”, “Front cylinder in position”, “Rear-left cylinder in position” and “Rear-right cylinder in position” indicators all come on.).

d) Turn the “Automatic/Manual” switch upward to “Automatic” position (with its handle up).

e) Press the “Recover” button to enter the automatic recovering process. When the “Recover” indicator comes on, it shows that automatic recovering is accomplished.

f) Turn the “Automatic/Manual” switch downward to “Manual” position (with its handle down).

g) Turn the “General power supply” switch downward (with its handle down). Now the carrier is restored to traveling state. See Table 5-4 for automatic (manual) recovering operation steps and conditions for turning to the next step.

Table: Recovering operation procedure

S/N	**Step**	**Purpose**	**Control component**	**Conditions for turning to the next step**
1	Pressure build-up	The hydraulic power source pressure builds up, and the accumulator 12 is charged with oil.	Electromagnetic valve 7	4~6s delay after the valve is turned on
2	Oil charging	The oleo-pneumatic suspension cylinders 62~67 are charged with oil.	Electromagnetic valves 7 and 45a~47a, and correction switch	15~20s delay after the valve is turned on
3	Unlocking	The jacks 39~42 are unlocked.	Electromagnetic valves 7 and 16a, and correction switch	Manometer 20a connection signal: Turn off the electromagnetic valve 16a if turning to the next step is not done 4s after it is turned on; 2s later, turn it on. Keep conducting above operations until turning to the next step is done.
4	Retraction	The jacks 39~42 retract quickly in position.	Electromagnetic valves 7, 16a, 28 and 31a~34a,speed regulating valve 25, and correction switch	All micro switches 39K~42K connection signals

5	Locking	The jacks 39~42 are locked.	Electromagnetic valves 7 and 16b, and correction switch	Manometer 20b connection signal
6	Carrier descending	The oleo-pneumatic suspension cylinders 62~67 discharge oil.	Electromagnetic valves 7 and 45a~47a, and correction switch	Proximity switches 59K~61K disconnection signals: When a proximity switch sends a disconnection signal, the corresponding electromagnetic valve is turned off immediately.
7	Correction	The carrier is restored to its original attitude.	Electromagnetic valve 7, and correction switch	20~30s delay
8	Pressure relief	The gear pump 8 is kept in no-load traveling state.	—	—

Manual Leveling

49. The hydraulic system performs the manual leveling in the following steps.

a) Keep the carrier in traveling state, that is, the ground clearance of the carrier is kept at 400±50mm.

b) Start the engine and keep its rotation speed stable at 1450~1500r/min.

c) Turn the “general power supply” switch upward (now there is a horizontal signal indication on “horizontal angle” and there is an indication on the “hydraulic power source” meter, the “retract” and “locking” indicators are both on, the “front cylinder in position”, “rear-left cylinder in position” and “rear-right cylinder in position” indicators are all off.).

d) Turn on the “pressure build-up” switch.

e) Turn the “unlocking/locking” switch to “unlocking” position (with its handle up) when the hydraulic power source pressure is above 14MPa. If the “unlocking” indicator comes on, it shows that unlocking is accomplished. If it is still off, turn the “unlocking/locking” switch to the middle (reset) position, and then turn it to “unlocking” position 5s later. Repeat the above operations until the “unlocking” indicator comes on.

f) Turn on the “rapid” and “high pressure” switches.

g) Turn on the “front-left leg stretch”, “front-right leg stretch”, “rear-left leg stretch” and “rear-right leg stretch” switches, and observe the “front-left leg in position”, “front-right leg in position”, “rear-left leg in position” and “rear-right leg in position” indicators. If any one of them comes on, turn the corresponding switch to the middle (reset) position.

h) Turn off the “rapid” and “high pressure” switches.

i) Turn on the “front cylinder down”, “rear-left cylinder down” and “rear-right cylinder down” switches and keep the locating rod in slot “240”. After the “front cylinder in position”, “rear-left cylinder in position” and “rear-right cylinder in position” indicators come on, turn on the “correction” switch, and hold it for 10s.

j) Turn on the “high pressure” switch. Level the jack of the shortest stretch, known by the data indication on the “horizontal angle”, by turning on the corresponding one of the “front-left leg stretch”, “front-right leg stretch”, “rear-left leg stretch” and “rear-right leg stretch” switches until the leveling error in any direction is kept within 5′.

k) Turn off the “high pressure” switch, but turn on the “front-left leg stretch”, “front-right leg stretch”, “rear-left leg stretch” and “rear-right leg stretch” switches. If the “touchdown” indicator goes out now, turn the above four switches to the middle (reset) positions after the “touchdown” indicator comes on. (If the “touchdown” indicator is still on after the switches are turned on, turn to the next step directly.)

l) Turn on the “connection” switch, and turn it off 2~4s later. Observe the leveling accuracy displayed on the “horizontal angle”. If it is within 10′, turn to the next step. Otherwise, repeat the step j).

m) Turn the “unlocking/locking” switch to “locking” position (with its handle down). If the “locking” indicator comes on, turn the “unlocking/locking” switch to the middle (reset) position.

n) Turn off the “correction” switch, and turn the “front cylinder down”, “rear-left cylinder down” and “rear-right cylinder down” switches to the middle (reset) position.

o) Turn on the “front-left leg retraction”, “front-right leg retraction”, “rear-left leg retraction” and “rear-right leg retraction” switches (with their handles down), and then turn them to the middle (reset) positions 5s later.

p) Turn off the “pressure build-up” switch, and turn the “general power supply” switch downward.

Cautions:

1) The “Locking” step must be performed after the “Connection” step. Otherwise, the jacks may bear load unevenly.

2) The “high pressure” switch is invalid unless the “unlocking/locking” switch is at “unlocking” position.

Manual Recovering

50. The hydraulic system performs the manual recovering in the following steps.

a) Keep the leveled carrier in combat state, that is, the jacks support the carrier.

b) Start the engine and keep its rotation speed stable at 1450~1500r/min.

c) Turn the “general power supply” switch upward (now there is a horizontal signal indication on “horizontal angle” and there is an indication on the “hydraulic power source” meter, the “retract” indicator is off, andthe “locking”, “front cylinder in position”, “rear-left cylinder in position” and “rear-right cylinder in position” indicators all come on.).

d) Turn on the “pressure build-up” switch. It is normal when the hydraulic power source pressure is above 14MPa.

e) Turn on the “front cylinder up”, “rear-left cylinder up” and “rear-right cylinder up” switches (with their handles up), the “front cylinder in position”, “rear-left cylinder in position” and “rear-right cylinder in position” indicators come on first, then go out and finally come on. The locating rod is kept at slot “500”.

f) Turn on the “correction” switch, and hold it for 15~20s.

g) Turn the “unlocking/locking” switch to “unlocking” position (with its handle up). If the “unlocking” indicator comes on, it shows that unlocking is accomplished. If it is still off, turn the “unlocking/locking” switch to the middle (reset) position, and then turn it to “unlocking” position 5s later. Repeat the above operations until the “unlocking” indicator comes on.

h) Turn on the “rapid” and “high pressure” switches.

i) Turn on the “front-left leg retraction”, “front-right leg retraction”, “rear-left leg retraction” and “rear-right leg retraction” switches, and turn them to the middle (reset) positions after the “retraction” indicator comes on.

j) Turn off the “rapid” and “high pressure” switches.

k) Turn the “unlocking/locking” switch to “locking” position (with its handle down). After the “locking” indicator comes on, turn the “unlocking/locking” switch to the middle (reset) position.

l) Turn on “front cylinder down”, “rear-left cylinder down” and “rear-right cylinder down” switches. If any one of the “front cylinder in position”, “rear-left cylinder in position” and “rear-right cylinder in position” indicators goes out, turn off the corresponding switch immediately (raising and descending the cylinders can be performed alternately until the requirements are met). Now the locating rod is kept in slot “400”. Turn to the next step 10s later.

m) Drive the carrier for a certain distance, and then turn off the “Correction” switch after the carrier attitude becomes stable.

n) Turn off the “Pressure build-up” switch, and turn the “General power supply” switch downward.

Automatic ground clearance adjustment

51. The hydraulic system performs the automatic ground clearance adjustment in the following steps.

a) Start the engine and keep its rotation speed stable at 1450~1500r/min.

b) Turn the “General power supply” switch upward.

c) Turn the “Automatic/Manual” switch upward to “Automatic” position (with its handle up).

d) Press the “Low” button to enter the automatic ground clearance adjustment process. When the “Low” indicator comes on, it shows that the carrier ground clearance is 240mm.

e) Press the “Mid” button to enter the automatic ground clearance adjustment process. When the “Mid” indicator comes on, it shows that the carrier ground clearance is 400mm.

f) Press the “High” button to enter the automatic ground clearance adjustment process. When the “High” indicator comes on, it shows that the carrier ground clearance is 500mm.

g) Turn the “Automatic/Manual” switch downward to “Manual” position (with its handle down).

h) Turn the “General power supply” switch downward.

Manual Ground Clearance Adjustment

52. The hydraulic system performs the manual ground clearance adjustment in the following steps.

a) Start the engine and keep its rotation speed stable at 1450~1500r/min.

b) Turn the "general power supply" switch upward.

c) Turn on the "pressure build-up" switch. It is normal when the hydraulic power source pressure is above 14MPa.

d) Turn on the "front cylinder up", "rear-left cylinder up" and "rear-right cylinder up" switches when raising the carrier (turn on the "front cylinder down", "rear-left cylinder down" and "rear-right cylinder down" switches when lowering the carrier) and keep the locating rod at the required one of the slots "240", "400" and "500" (raising and lowering the cylinders can be performed alternately until the requirements are met). At slot "400", the "front cylinder in position", "rear-left cylinder in position" and "rear-right cylinder in position" indicators are all off, while at slots "240" and "500", the above indicators all come on. Turn the above switches to the middle (reset) positions after the cylinders are all in position.

e) Turn on the "correction" switch.

f) Drive the carrier for a certain distance, and then turn off the "correction" switch after the carrier attitude becomes stable.

g) Turn off the "pressure build-up" switch, and turn the "general power supply" switch downward.

Maintenance

53. The maintenance of the hydraulic system is performed generally when the carrier is kept in original state, i.e. in traveling state, with its ground clearance of 400mm. The maintenance period and items are given below.

a) Check the oil level of the oil tank once a month. When it is lower than the defined level, supplement No.10 aviation hydraulic oil.

b) Check the nitrogen pressures of the adjustable accumulator, oleo-pneumatic suspension cylinders once every two months. When they are lower than the defined values, supplement pure nitrogen gas.

c) Check the fitting surfaces of all the pipes, joints, channel bodies and components regularly, and check whether there is leakage on the metal hoses and hoses of the oleo-pneumatic suspension cylinders.

d) Clear mud and sand off the dust rings and exposed cylinder surface with absolute ethyl alcohol regularly so as to ensure normal operation of the jacks and oleo-pneumatic suspension cylinders and reduce wearing of the moving surfaces of the components. After that, apply No.7014 aviation lubricating grease uniformly.

e) Wash the oil filters and air inlet caps of the oil tanks with aviation washing gasoline (it is recommended to use an ultrasonic washing machine) once every operation time of 2 years or 100h. If the filter cartridge is damaged locally or blocked extensively, replace it.

f) Check the oil contamination degree once a year. The solid particle contamination degree should be not more than 20/17 and moisture content should be not more than 120ppm. If the requirements are not met, treat oil using the filtering method or using the device for getting rid of moisture, or replace oil with new oil. The check method is given below.

1) Wash the 250ml sampling container according to the specifications.

2) Perform automatic leveling and automatic recovering thrice respectively to circulate oil fully.

3) Open the sampling port (the oil discharge threaded plug or other port convenient for sampling on the oil tank can be used as sampling port, and the oil filler of the oil tank can also be used for sampling with a special tool). First discharge 200~300ml oil, then hold oil in the container, with oil occupying 50%~70% of container volume.

4) Take away the container after oil specimen is enough, and then close the sampling port.

5) Cover the sampling container, stick a label bearing the product code and sampling time on it.

6) Measure quantity and size of the solid particles pollutant in oil and moisture content.

g) Calibrate all the manometers once a year.

h) Apply No.7014 aviation lubricating grease to the knuckle bearings of the oleo-pneumatic suspension cylinders once a year.

i) Apply No.7254 aviation lubricating grease to the jacks once a year.

j) The dynamic seal rings of the oleo-pneumatic suspension cylinders expire at the carrier running distance of 10000km. Replace them generally. Though it is allowed to use them for some more time if they do not leak, it is necessary to perform daily check from time to time and replace them in time if they start to leak.

k) Make power-on check on the electric system once a year generally, while once half a year in area and season of larger humidity, with power-on time of not less than 1h each time.

Fault Analysis and Removal

54. See Table 5-5 for the common faults and removal methods of the hydraulic loops. See Table 5-6 for the common faults and removal methods of the electric system.

Table: a. Common faults and removal methods of the hydraulic loops

SL No	Loop	Fault symptom	Possible cause	Removal method
a.	Hydraulic power source loop	The hydraulic power source pressure cannot be built up.	There is wear on the gear pump 8, and the volume efficiency drops.	Replace the gear pump.
		The hydraulic power source pressure is built up slowly and adjustment of the adjustable accumulator is too quick after pressure build-up.	The nitrogen gas pressure of the adjustable accumulator 12 is too low.	Supplement nitrogen gas until the pressure is up to the specified value, i.e. $8^{+0.5}_{0}$ MPa.

		The hydraulic power source pressure is built up slowly, adjustment of the adjustable accumulator is too slow, and the temperature of the gear pump case rises up sharply.	The oil filter 3 in the oil tank is blocked, and the hydraulic oil filter 9 is also blocked.	Clean or replace the oil filter 3, clean or replace the filter cartridge of the oil filter 9.
		The hydraulic power source pressure cannot reach the normal pressure range, and the temperature of the gear pump case rises sharply.	The engine rotation speed is lower than 1100r/min.	Increase the engine rotation speed.

SL No	Loop	Fault symptom	Possible cause	Removal method
b.	**Unlocking loop**	**The unlocking pressure cannot be built up.**	There is air in the pressurization cylinder and unlocking loop.	Expel air by the air discharge valve or through cyclic operation of unlocking and locking.
			The pressurization cylinder piston seizes up.	Make disassembling and check or replace the pressurization cylinder.
			There is air in the oil return pipe.	Expel air through one ground clearance adjustment.
		The unlocking pressure cannot be maintained.	The compartment or pipe leaks.	Find the leaking position and remove the leakage.
c.	**Leveling loop**	The jack does not move.	The jack is not unlocked.	See fault symptoms and removal methods in the unlocking loop.
			The jack seizes up.	Take a reverse check or replace the jack.

		The jack gives forth a sound and it vibrates in motion.	There is air in the leveling loop or in the cavity of the jack.	Perform stretch and retraction operations to make the jack reciprocate within a small stroke.
d.	**Ground clearance adjustment loop**	The locating rod moves so quickly that it is difficult to keep it in slot “ 400” .	The retaining nut of the cutoff valve 51 is loose.	Adjust the opening of the cutoff valve 51 properly and tighten the nut.
			There is air in the transposition loop.	Transfer the locating rod between slots “240” and “500” several times until no air is left.
		The signal of the in position indicator does not correspond with the slot.	The proximity switch is loose or damaged.	Adjust the proximity switch, proximity distance and tighten or replace the switch.
		The locating rod moves too slowly or it does not move.	The port of the cutoff valve 51 is blocked.	Adjust the opening of the cutoff valve 51 properly and tighten the nut.

SL No	Loop	Fault symptom	Possible cause	Removal method
		The carrier ground clearance is not up to the required value after adjustment.	The oleo-pneumatic suspension cylinder bears additional loads caused by internal friction between the movable parts of the suspension and friction between tire and ground.	Perform the correction function and drive the carrier forward or backward for a certain distance until the ground clearance meets the requirement.
		The carrier inclines after a long-term storage or in running.	There is leakage on the hydraulic operated cutoff valve of the attitude correction device.	Repair or replace the attitude correction device.
			The stretch of the oleo-pneumatic suspension cylinder changes with temperature.	Restore the carrier attitude through attitude correction.

e.	Ground clearance adjustment loop	The carrier is raised in long-distance running or cross-country running.	The stretch of the oleo-pneumatic suspension cylinder changes with temperature.	Restore the carrier attitude through attitude correction.
		The rigidity of the oleo-pneumatic suspension cylinder becomes larger locally.	There is nitrogen gas leakage on the oleo-pneumatic suspension cylinder.	Supply nitrogen gas until the nitrogen gas pressure is up to the defined value, i.e. 3.5±0.2MPa, or replace the oleo-pneumatic suspension cylinder.

Table : b. **Common faults and removal methods of the electric system**

SL No	Fault symptom	Possible cause	Removal method
f.	The " automatic state" indicator flashes after system power-on.	The jack state is inconsistent with the state shown by the "retract" indicator.	Check the micro switch on the jack, and adjust or replace it as required.
		The "unlocking" and "locking" indicators are in the same state.	Adjust "unlocking" or "locking" loop, shown in adjustment of the unlocking loop adjustment.
		The liquid pendulum output is incorrect.	Replace the liquid pendulum (together with the horizontal measurement instrument and electronic box).
		The carrier levelness exceeds 5°.	Park the carrier on a slope of below 5°.
g.	The indication of the horizontal angle is beyond the requirement after automatic leveling.	The liquid pendulum output is incorrect.	Replace the liquid pendulum (together with the horizontal measurement instrument and electronic box).

SL No	Fault symptom	Possible cause	Removal method
h.	The process cannot be exited smoothly in automatic operation.	The hydraulic loop is faulty.	See common faults and removal methods of the hydraulic loop.
j.	The jacks are not all retracted, but the "retract" indicator comes on.	The micro switch is faulty.	Replace or adjust the micro switch.
k.	The jacks are all retracted, but the "retract" indicator is still off.	The micro switch of the jack is not reset.	Adjust the micro switch.

Air-Conditioning System

55. General: The air-conditioning system is composed of 3 subsystems independent of one another: personnel air conditioner, cabinet air conditioner and ventilator. It is used for regulating the temperature of the electronic cabinets, driver's cab and fighting compartment and performing ventilation in internal power supply state, external power supply state and traveling state.

a. Operating mode

i) Personnel air conditioner

It is to regulate the temperature of the driver's cab and fighting compartment in vapor compression refrigeration—electric heating (with auxiliary water heating) forced ventilation and heat exchange mode.

a) It can keep the temperature of the driver's cab and fighting compartment within 14~35°C when the ambient temperature is -40~+42°C and the carrier heat-insulating property is kept good.

b) It can operate normally at the ambient temperature of 50°C.

c) It can operate in internal power supply state, external power supply state and traveling state.

ii) Cabinet air conditioner

It is to take closed-loop temperature control of the radar cabinet and information processing cabinet in vapor compression refrigeration electric heating (with auxiliary water heating) forced ventilation and heat exchange mode.

a) It is fitted with the cabinet compressor heater so as to ensure its stable refrigeration operation in winter state (with ambient temperature of below 10°C, the same below). The operating mode of the heater is under the control of the temperature relay.

b) It can operate in internal power supply state and external power supply state.

Ventilator

56. It is to keep the air in driver's cab and fighting compartment fresh, thereby ensuring personnel health by adopting multilayer and multistage filtering mode and taking reverse-flow prevention.

It has the function of air filtering, and its ventilation rate is 3.30m^3/min.

Composition

57. The air-conditioning system is composed of the personnel air conditioner, cabinet air conditioner and ventilator.

a. **Personnel air conditioner:** It is to regulate the temperature of the fighting compartment in totally manual control mode, thereby providing a comfortable operating environment for personnel. It is mainly composed of the personnel air conditioner compressor unit (the personnel air conditioner electromotor operates only in the external power supply state), personnel air conditioner condensing unit (the condensation fan operates only in the external power supply state), air conditioner cabinet (only involving the personnel air conditioner evaporator unit), left/right personnel air conditioner heater, water heater, refrigerating pipe, personnel air conditioner air pipes, air conditioner control box and control switches and indicators on the air conditioner cabinet.

b. **Cabinet air conditioner:** It operates in totally automatic control mode. It samples the air return temperature and air speed state via the temperature controllers fitted in left/right air return pipes, outputs and displays them, and also realizes operation of the air-conditioning equipment according to state control requirements, thereby realizing temperature regulation in the electronic cabinets in the fighting compartment. It is mainly composed of the cabinet compressor unit, cabinet condensing unit (the condensation fan operates only in the external power supply state), air conditioner cabinet (only involving the cabinet evaporator unit), left/right air supply/return pipes, electric heater, refrigerating pipe, air conditioner ocntrol box and control switches and indicators on the air conditioner cabinet.

Ventilator

58. It is used for expelling stale air from the fighting compartment and drawing in fresh air outside. It is mainly composed of the main body, filter screen, air enclosure, tripod, rubber seat, air duct, DC fan and air filtering pipe.

Operating Principle

59. The air-conditioning system is to regulate the temperature of the personnel compartments (including fighting compartment and driver's cab), radar cabinet and information processing cabinet, and to perform ventilation at a certain rate so as to keep air in the personnel compartments fresh.

Refrigeration

60. The air-conditioning system adopts the vapor compression cycle refrigeration mode. See Fig.6-1 for theoretical cycle. The air conditioning principle is to transfer heat through refrigerant phase change. The refrigeration system is composed of 4 main components: compressor, condenser, expansion valve and evaporator. The low-temperature and low-pressure gas refrigerant flows from the evaporator to the compressor and the gas is compressed and turns to high-temperature gas refrigerant. Then the gas comes into the condenser, exchanges heat with atmosphere air by radiating heat, and changes to liquid refrigerant. Then the liquid flows from the condenser to the expansion valve for throttling, pressure reduction, temperature reduction and refrigerant flow rate control, thereby keeping the system operating stably. The throttled liquid refrigerant flows into the evaporator, absorbs heat of air and turns back into gas. Since the refrigerant circulates in this way for continuous refrigerating output, the air temperature in the compartments gets low.

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INDEX

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BREAK DOWN OF SUBJECTS WITH ALLOTTED PERIODS
TRADE TRAINING ADVANCE
MTOF (MTM PART)

PRE-CTTB, MTM PART- IV

BAF BASE ZAHURUL HAQUE (TRG WG)

(Aero Engg Trg Sqn)

Syllabus	**:**	**Automobile General Diesel and Petrol Technology**
Course	**:**	**Trade Training Advance, MTOF**
Subject	**:**	**Automatic Transmission System**
Aim	**:**	**To study Automatic Transmission System**
Ref	**:**	**Automotive Mechanics by William H Crouse, Chapter No 49 page No 477- 493**

AUTOMATIC TRANSMISSION SYSTEM

Function of Automatic Transmissions

1. Automatic transmissions do the job of shifting gears without assistance from the driver. They start out in low as the car begins to move forward. They shift from low gear into intermediate and then high as the car picks up speed. Automatic transmissions operate hydraulically, that is, by oil pressure. There are two basic parts to the automatic transmission, the torque converter and the gear system. The torque converter passes the engine power to the gear system. Hydraulic pressure works on the gear system to produce the shifts.

Fig -1: Automatic Gear lever and Selection Marking

Fluid Coupling

2. The torque converter is a special type of fluid coupling. It uses a fluid to transmit rotation from one shaft to another. Two fans can be used to demonstrate a simple fluid coupling (Fig-2).

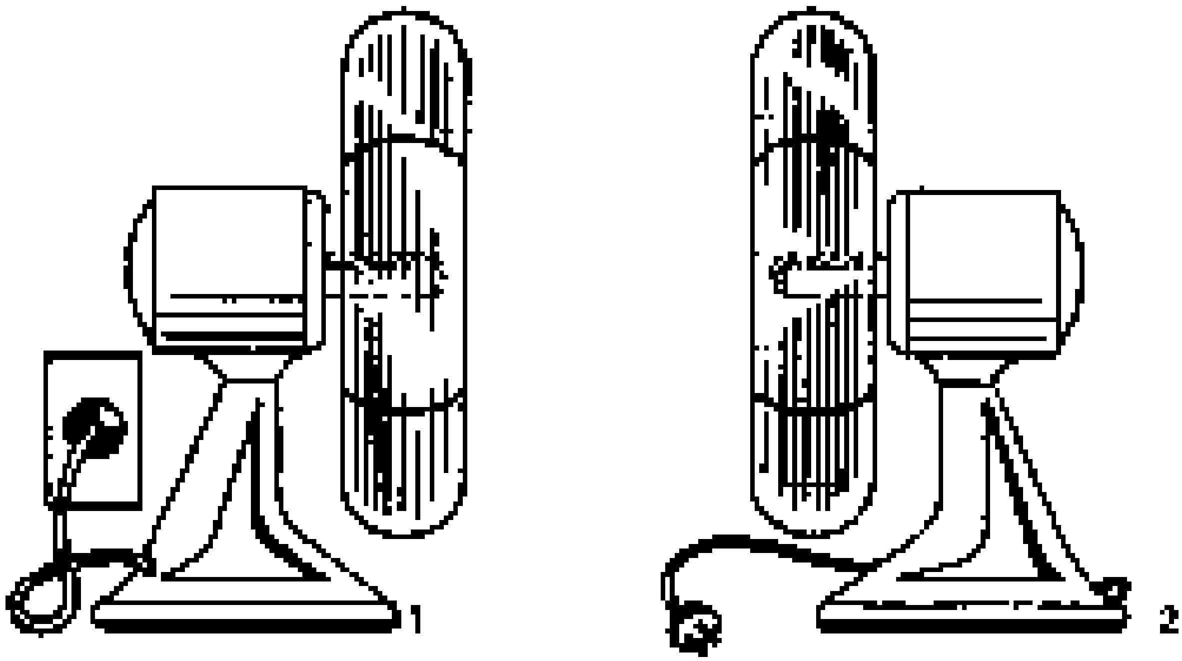

Fig-2: Rotation of Fan 1 Causes Fan 2 to Rotate

a. When one fan is turned on and faced toward the other the stream of air causes the second fan to rotate even though it is not plugged in. In this case, the "fluid" is air. To improve the efficiency of the fluid coupling, the two members must be closely coupled. A simple version of an actual fluid coupling is shown in (Fig -2).

b. The assembly is like a hollow doughnut, sliced in two. Each hollow half has a series of semicircular plates, called vanes. The two halves, or members, are enclosed in an outer.Cover that is attached to the flywheel. The driving half of the fluid coupling called the pump, or impeller, is attached to the crankshaft.

c. The driven half, called the turbine, is attached to the transmission shaft. There is no direct mechanical connection between the pump (driving member) and turbine (driven member). If there were no oil in assembly, the two members could rotate independently of each other. However, filling the fluid coupling with oil makes the difference.

d. When the pump rotates, the oil between the vanes of the pump is thrown out by centrifugal force. It is thrown into the turbine. Centrifugal force is the force that pushes things outward from a center around which they are revolving.

e. The oil caught between the vanes of the pump is thrown out. It has no place to go except into the turbine. The oil is thrown into the turbine with great force and it hits the vanes of the turbine at an angle. In other words, the moving oil applies pressure to the vanes of the turbine, forcing the turbine to turn.

Torque Converter

3. The torque converter is a special sort of fluid coupling. In the torque converter, the vanes are curved and not flat. Curving the vanes reduces "bounce-back" of the fluid. With flat vanes, the fluid, as it hit the vanes of the driven member, would tend to bounce back into the driving member. This would, in effect remove some of the driving torque and power would be lost. But with curved vanes, the fluid is unable to bounce back.

Third Member

4. The coupling would not be very efficient. The reason is that, as the fluid leaves the inner part of the turbine, it is thrown back into the pump in the wrong direction. That is, it opposes the rotation of the pump. As you can see by the arrows, the fluid hits the pump vanes in the direction opposite to which the vanes are moving. This greatly reduces the efficiency of the fluid coupling. That is, the pump has to overcome this opposing push to get the oil moving in the right direction again. To eliminate this, a third member, called a stator, is installed between the inner ends of the pump and the turbine vanes. The stator has curved vanes. They change the direction of the fluid coming out of the turbine to one that helps the rotation in a simplified form, how the third member changes the direction of the fluid to a helping direction. To the left, a jet of fluid is shown hitting a round bucket attached to a wheel. The fluid pushes on the bucket, but only a little. The fluid leaves the bucket with about the same energy it had when it entered. A single pass through the bucket does not give the bucket much of a push. However, if a curved vane is added, the fluid makes more than one pass through the bucket. That is, the curved vane redirects the fluid back into the bucket, giving the bucket an added push. Actually, the fluid could complete the circuit many times, adding a push to the bucket each time. This effect is what we mean by torque multiplication.

Stator Action

5. Stator action is as follows:

a. The stator as we have seen causes the torque converter to multiply torque when the pump is turning faster than the turbine. This speed difference and increase in torque have the same effect as a low gear in the manual transmission. They allow the engine to turn fast while the car wheels are turning slowly.

b. Thus, a high torque can be applied and the car can accelerate. However, as the car comes up to speed, the turbine beings to "catch up' with the pump. When this happens, the fluid leaving the trailing edges of the turbine vanes is moving at about the same speed as the pump. Therefore, it could pass directly into the pump in a helping direction, without being given an assist by the stator. In fact, under these conditions, the stator vanes are in the way.

c. The fluid begins to hit the backsides of the stator vanes. To allow the stator vanes to move out of the way, the stator is mounted on a freewheeling mechanism.

d. The freewheeling mechanism is a one-way clutch that allows the stator to revolve freely, or "freewheel," in only one direction. The mechanism locks the stator if the stator tries to turn in the other direction. The freewheeling mechanism uses an overrunning clutch.

e. The stator overrunning clutch is somewhat more complicated than that in the starting motor, it is also called a one-way clutch. It includes a hub, an outer ring that is part of the stator, and a series of rollers.

f. The rollers are located in notches in the outer ring. The outer ring is called the overrunning clutch cam. The notches are smaller at one end than at the other. The rollers have springs behind them. When there is a push on the front of the stator vanes from the fluid leaving the turbine, the stator attempts to roll backward. This causes the rollers to roll into the smaller ends of the notches. There, they jam and lock the stator to the hub.

g. Now the stator cannot turn backward. Instead, the stator vanes change the direction of the fluid into a helping direction, as previously explained. However, as the turbine speed approaches the pump speed, the direction of the fluid no longer has to be changed as it leaves the turbine.

h. The fluid now begins to hit the other side of the stator vanes. The stator begins to revolve in a forward direction. The rollers roll out of the smaller ends of the notches, and into the larger ends, there, they cannot jam, and the stator is able to run freely-to freewheel. That is, the vanes simply move forward to get out of the way of the fluid.

Planetary Gears

6. An automatic transmission has two or more planetary gear sets. The simple -looking planetary gear assembly, shown in (Fig. -3). Can do many things.
It can**:**

a. Increase speed and reduce torque

b. Reduce speed and increase torque

c. Reverse the direction of rotation

d. Act as a solid shaft

e. Disconnect the driving shaft from the driven shaft. The planetary gear set, or assembly, includes an internal gear (also called a ring gear), a sun gear, and two or more planet pinions on a carrier and a shaft before we describe how the planetary gear set does its job, let us review gears.

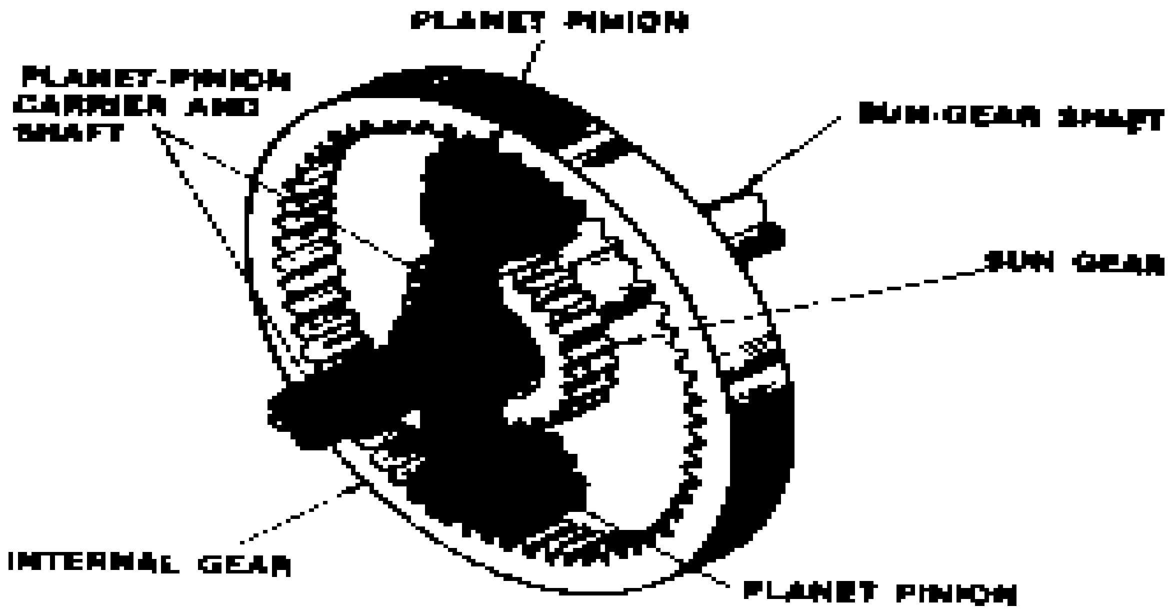

Fig-3: Planetary-Gear System

Gear Combinations

7. When two gears are in mash, they turn in opposite directions.

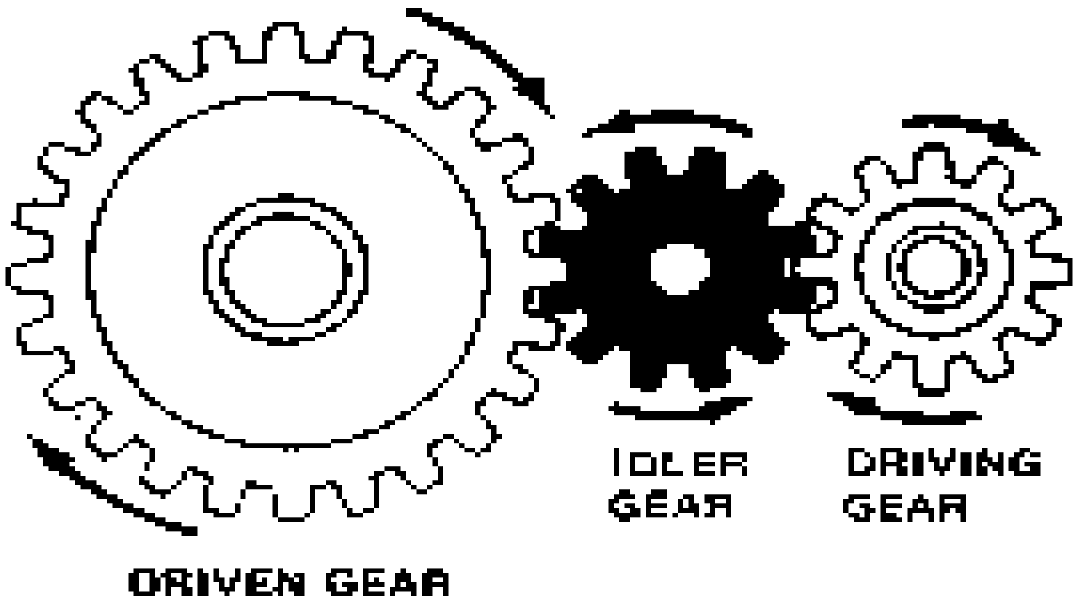

Fig -4: The Idler Gear Causes the Driven Gear to Turn in the Same Direction as the Driving Gear.

a. But if another gear is put into the gear train, as shown in (Fig -4), the two outside gears turn in the same direction. Not that the middle gear is called an idler gear. It doesn't do any work -it is idle.

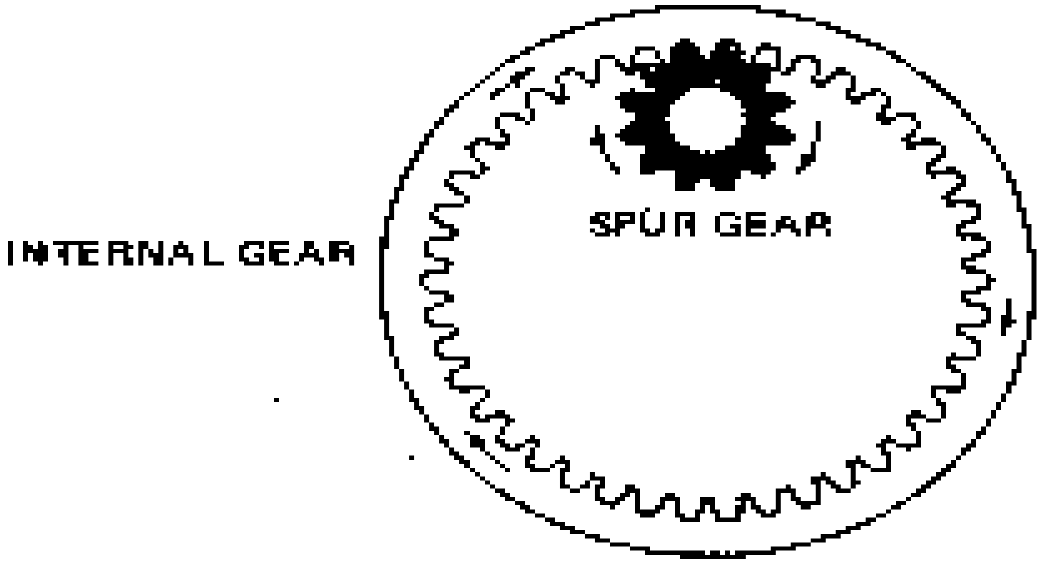

Fig-5: If one Internal Gear is Used with one External Gear, Both the Driving and Driven Gears Turn in the Same Direction

b. To get a combination of two gears to rotate in the same direction, you can use one internal gear. The internal gear, or ring gear, has teeth on the inside. The spur gear and the internal gear both rotate in the same direction (Fig, -5). Now, if another spur gear is added in the center and meshed with the small spur gear, the combinationis a simple planetary gear system Fig-

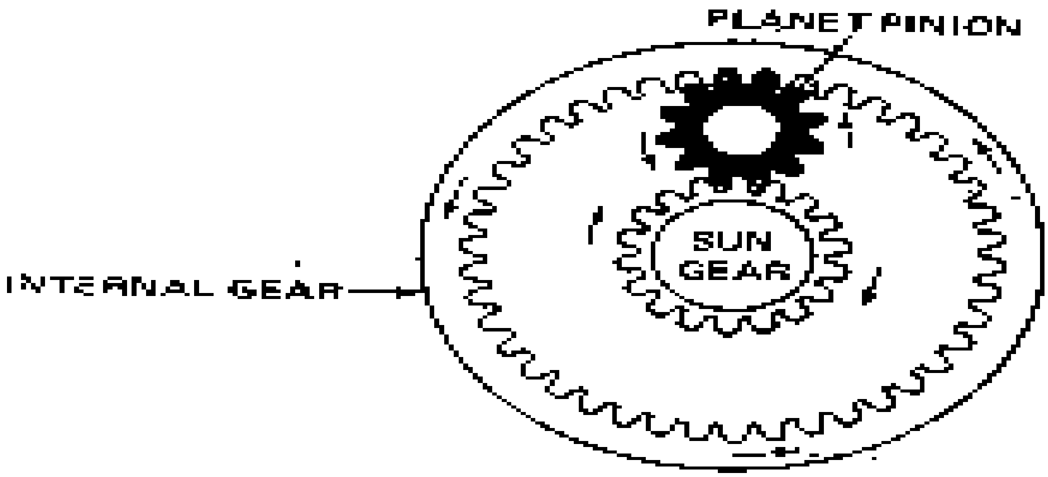

Fig-6: If a Sun Gear is Added to the Arrangement Shown in Fig -15, the Result is a Simple Planetary-Gear System.

c. The center gear is called the sun gear because the other gears revolve around it. This is similar to the way the planets in our solar system revolve around the sun. The spur gear between the sun gear and the internal gear is called the planet pinion. This is because it revolves around the sun gear, just as planets revolve around the sun. Now let's look at the planetary-gear system.

Fig-7: 2-Speed automatic Transmission Gearbox

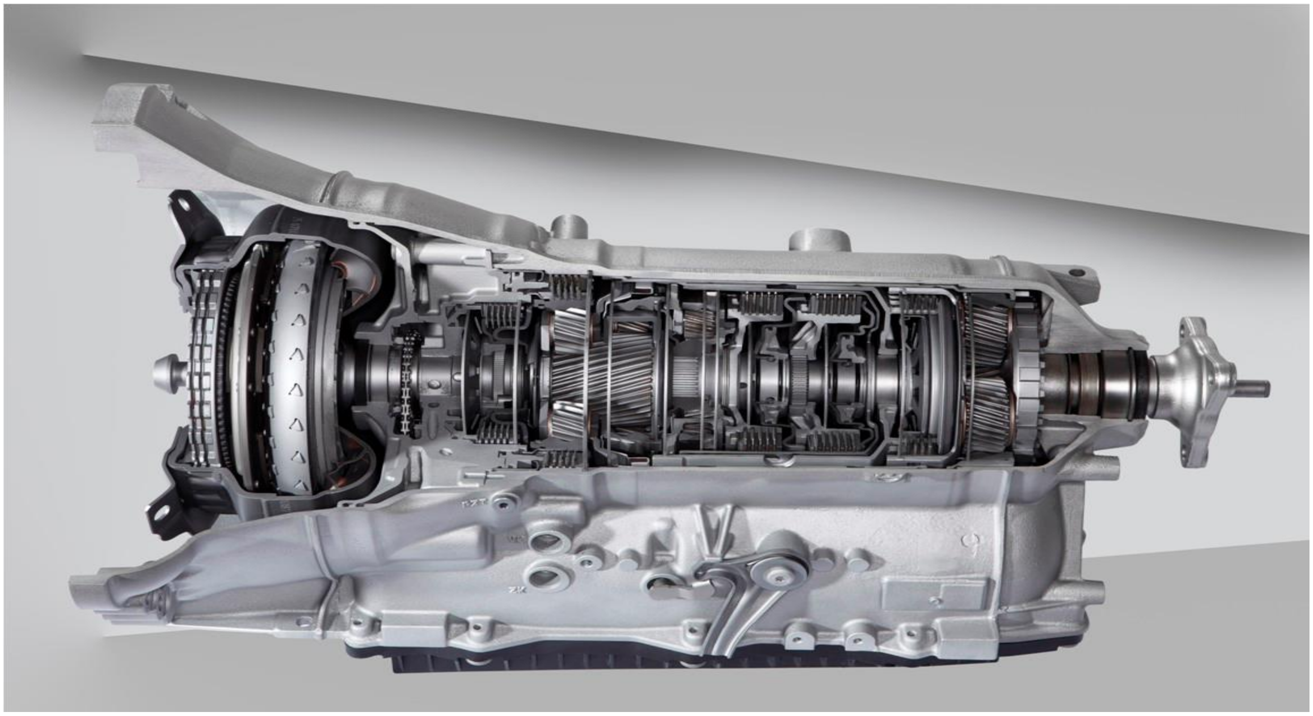

Fig-8 Cut view section of complete automatic Transmission Gearbox

Planetary Gear Operation

8. We complete the planetary-gear set by adding another planer pinion, as shown in (Fig-9). This gives us the combination shown in (Fig -3). The two planet pinions rotate on shafts that are a part of a planet-pinion carrier. There are thus three members in the planetary-gear set: internal gear, sun gear, and planet-pinion carrier assembly. As mentioned previously, the gear set can increase speed and reduce torque, reduce speed and increase torque, reverse the direction of rotation, act as a solid shaft, and disconnect the driving and driven shafts. If one member is held stationary and another is turned, there is a speed increase, a speed reduction, or reverse. If two members are locked together, the gear set acts like a solid shaft. If no members are locked, no power is transmitted through the gear set. Let's see how all this comes about.

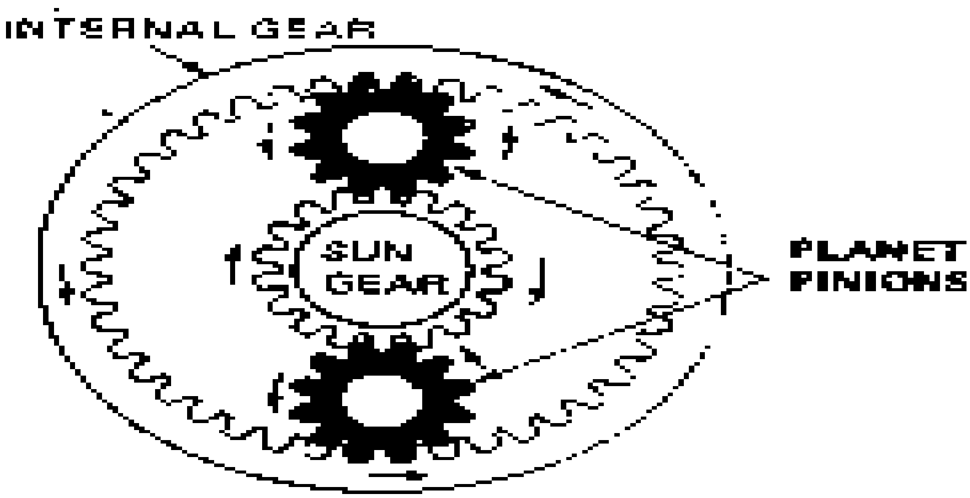

Fig-9: To Complete the Planetary-Gear System, a Second Planet Pinion Is added

a. **Speed Increase -1.** Suppose the sun gear is stationary, and the planet-pinion carrier turns. There would be a speed increase. Why? When the carrier revolves, it carries the planet pinions around with it. This movement makes the planet pinions rotate on their shafts. As the pinions rotate, they cause the internal gear to rotate also (see Fig.-5).

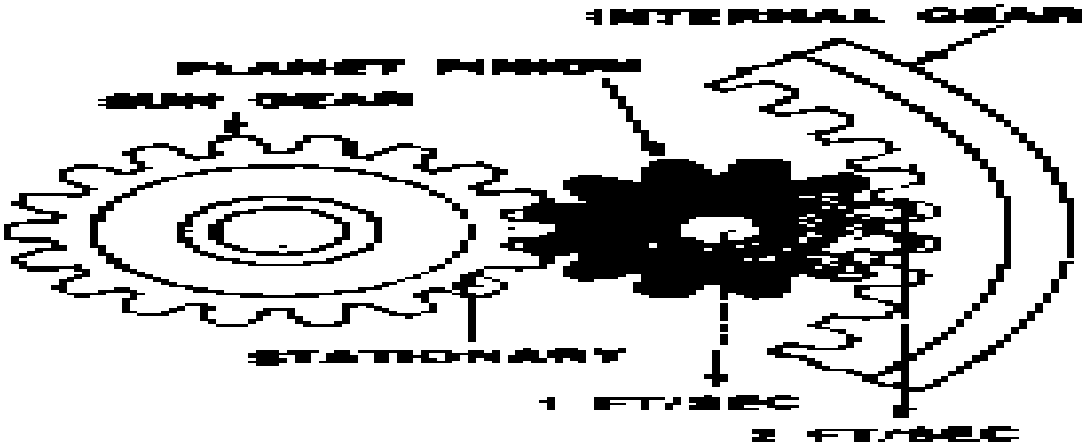

Fig-10: If The Sun Gear Is Stationary And The Planet-Pinion Carrier Is Turned, The Ring Gear Turns Faster Than The Carrier.

b. If the sun gear is stationary the planet-pinion carrier moves, carrying the pinions around with it, the planet pinions "walk around" the sun gear, which means they rotate on their shafts. The inside pinion tooth, meshed with the sun gear, is stationary because the sun gear is stationary. That means the outside pinion tooth, meshed with the internal gear, is moving twice as fast as the shaft on which the planet pinion is turning. If the planet-pinion shaft is moving at 1 foot per second (0.305 meter per second), the outer tooth is moving at 2 feet per second (0.610 meter per second). In other words, speed increases.

c. **Speed Increase - 2.** Another combination is to hold the internal gear stationary and turn the planet-pinion carrier. In this case, the sun gear is forced to rotate faster than the planet-pinion carrier, and there is a speed increase just as in case 1.

c. **Speed Reduction -1.** If the internal gear turns while the sun gear is held stationary, the planet-pinion carrier turns more slowly than the internal gear. This is just the opposite of what we described as speed increase 1. With the internal gear turning the planet-pinion carrier, the planetary-gear set acts as a speed-reducing system.

d. **Speed Reduction - 2.** If the internal gear is held stationary and the sun gear turns, there is speed reduction. The planet pinions must rotate on their shafts. They must also walk around the internal gear, since they are in mesh with it. As the pinions rotate, the planet carrier rotates. But it rotates at a slower speed than the speed at which the sun gear is turning.

e. **Reverse -1** To get reverse, the planet-pinion carrier can be held stationary, and the internal gear turned. In this case, the planet pinions acts as idlers and cause the sun gear to turn in the reverse direction. The system acts as a direction reversing system with the sun gear turning faster than the internal gear.

f. **Reverse-2.** A second way to get reverse is to hold the planet-pinion carrier stationary and turn the sun gear. The internal gear turns in the reverse direction, but slower than the sun gear.

g. **Direct Drive.** If any two members are locked together, then the entire planetary-gear system acts as a solid shaft. Locking two members' together locks up the system. The planetary-gear sets used in automatic transmissions are designed to give direct drive, speed reduction, and reverse.

Hydraulic shift controls.

9. We have seen how the power flows into the transmission through the torque converter, and how planetary gears operate. (Fig-11). There are two controls, a band and a clutch. The band consists of a brake band that surrounds a metal drum. The drum may be attached to the sun gear, or it may be the outer surface of the planetary ring (internal) gear. The clutch consists of a series of clutch plates. Half the plates are splined to an outer ring, called the clutch drum, and the other half are splined to the clutch hub. The clutch hub is splined to one of the members of the planetary-gear set. When oil pressure forces the two sets of clutch plates together, the clutch is engaged. That means the planetary-gear set is locked up, rotating as a single unit. When the oil pressure is released, the clutch is released. This means that the two sets of clutch plates can rotate independently.

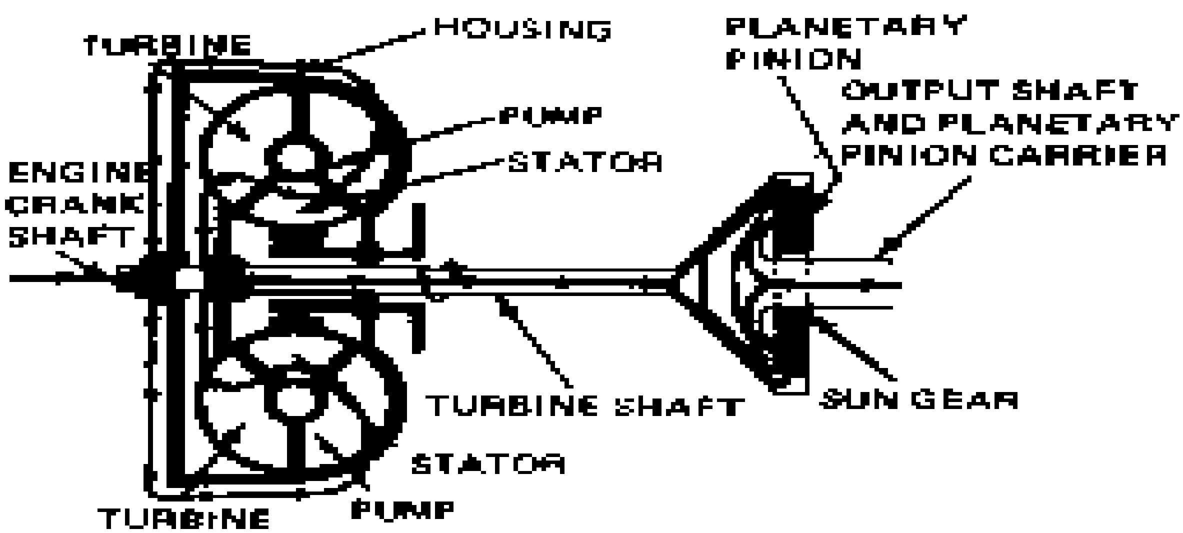

Fig-11: Power Flow Through Torque Converter To Planetary Gears

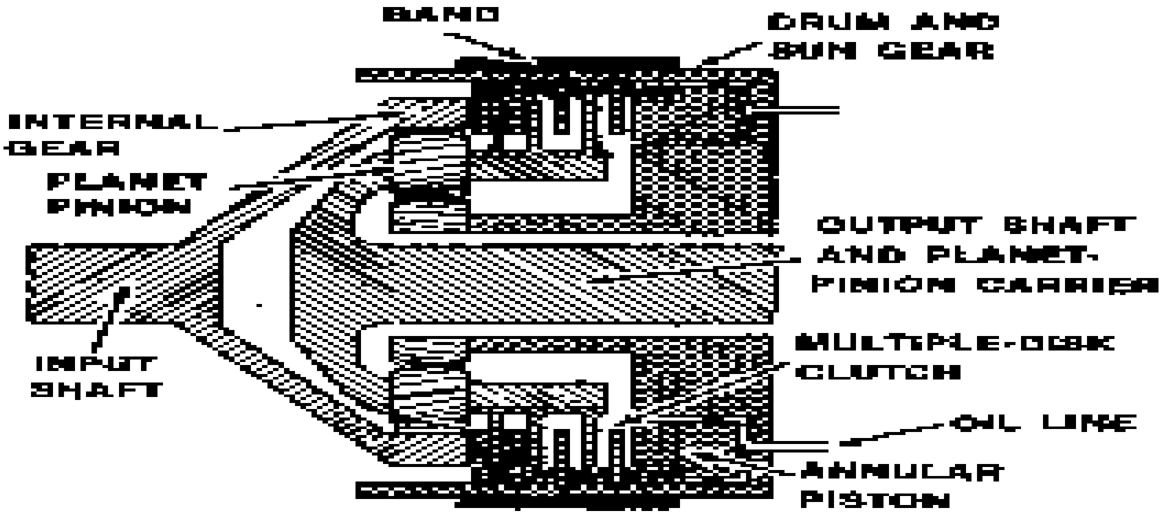

Fig -12: Sectional view showing the two controlling mechanism.

<u>Band and Clutch</u>

10. Let's put the two controls-the clutch and the band-onto the planetary-gear set. Fig -12 is a sectional view of a planetary-gear set with a band and clutch. We shall explain later how the band and clutch are applied. First, we want to see what happens when they are applied. The band is shown in (Fig-13). The band is positioned around the sun gear drum. When the band is applied, the sun gear is held stationary. This means that the planetary gear set acts as a speed reducer. The internal gear is turning-it is mounted on the input shaft. This arrangement forces the planet pinions to rotate. They walk around the stationary sun gear and carry the pinion carrier around with them. The carrier rotates at a slower speed than the internal gear. Now suppose that the clutch is applied instead of the band. Oil pressure that enters through the oil line causes the clutch to apply. The oil pressure forces the piston in the sun gear drum to the left. The clutch plates are pushed together so that the clutch is engaged. With this situation, the planet pinion carrier and the sun gear are locked together. The planetary gear set is now in direct drive. In other words, the system is locked up. (Figure -14), shows the clutch plates. Note that they are alternately splined to the drum and the sun gear).

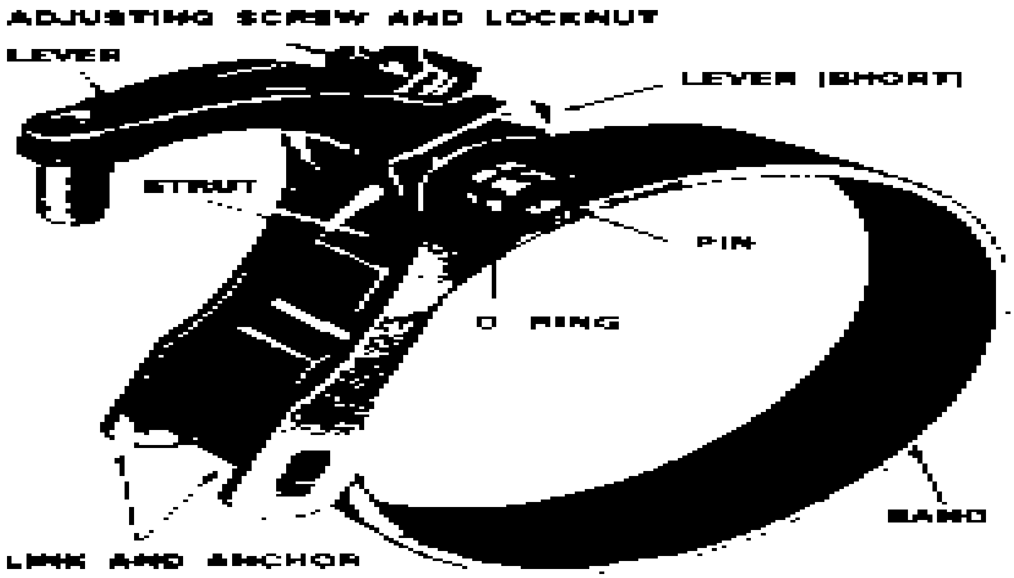

Fig-13 : Transmission Band.(Chrysler Corporation).

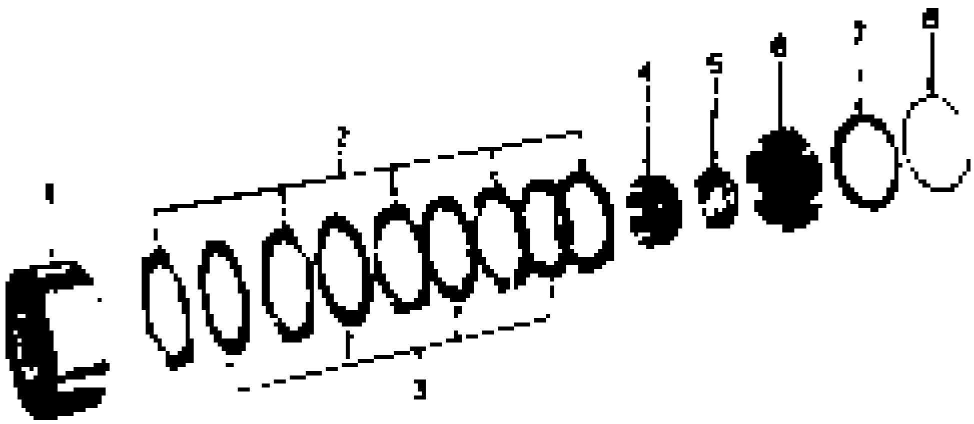

Fig-14: Parts of a clutch (Chevrolet Motor Division of General Motor Corporation)

<u>Key way to Fig -14</u>

1. Clutch drum assembly
2. Clutch driven plate
3. Clutch drive plate
4. Clutch hub
5. Clutch hub thrust washer
6. Low-sun-gear
7. Clutch flange assembly
8. Retainer snap ring

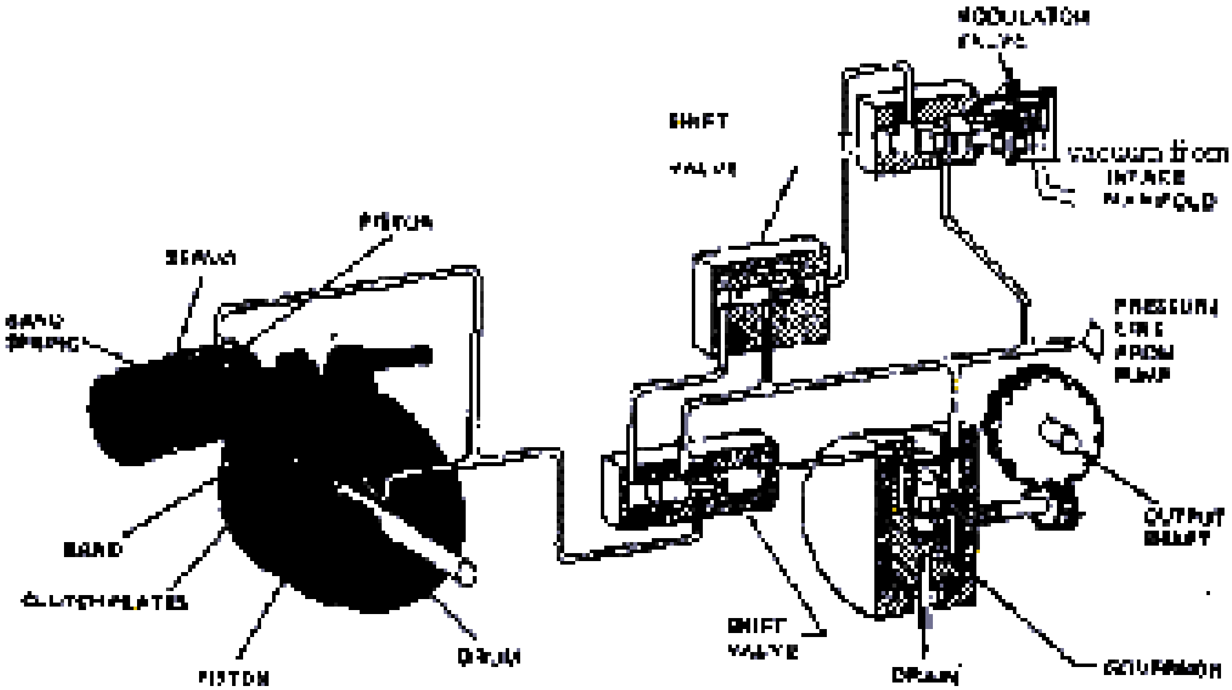

Fig-15: Sectional Diagram showing The Hydraulic Control System for the Brake-Band Servo and the Clutch.

<u>Hydraulic Circuits</u>

11. **Construction of hydraulic circuits:**

a. A simplified diagram of a hydraulic control circuit for a single planetary-gear set in an automatic transmission. Later we will look at the circuits for automatic transmissions that use two or more planetary gear sets. As we have noted, automatic transmissions use more than one planetary gear set. The major purpose of the hydraulic circuit is to control the shift from gear reduction to direct drive. The shift must take place at the right time, and this depends on car speed and throttle opening.

b. These two factors produce two varying oil pressures that work against the two ends of the shift valve. The shift valve is a spool valve inside a bore, or hole, in the valve body. (Fig-16), shows what the spool valve looks like. Pressure at one end of the spool valve comes from the governor pressure at the other end of the spool valve changes as the vacuum in the intake manifold changes. Let us explain.

c. First the governor pressure changes with car speed. The governor is driven by the output shaft from the transmission. As output-shaft speed and car speed go up, the governor pressure increases proportionally. This pressure works against the right end of the shift valve. The governor pressure is actually a modified line pressure. That is, a pump in the transmission produces the line pressure. This line pressure passes in to the governor.

d. The governor releases part of this pressure to the right end of the shift valve. The higher the car speed, the more pressure the governor releases. It is this modified pressure-the governor pressure-that works on one end of the shift valve. Working on the left end of the shift valve is a pressure that changes as intake-manifold vacuum changes. Line pressure enters the modulator valve at the upper right in Fig-15. The modulator valve contains a spool valve Attached to a spring-loaded diaphragm.

e. Vacuum increases in the intake manifold when the throttle is partly closed. This vacuum pulls the diaphragm in and moves the modulator spool valve to the right. The motion cuts of the line pressure going to the shift control valve. When, this happens, the shift control valve moves to the right, cutting off pressure from the left end of the shift valve. This means that the shift valve is pushed to the left by governor pressure. As a result, line pressure can pass through the shift valve. Therefore, line pressure is applied to the clutch and the servo at the planetary-gear set. With this condition, the band is released and the clutch is applied. This puts the planetary-gear set into direct drive.

f. Now let's put it all together and see how the hydraulic control circuit works. To start with, there is no pressure going to the planetary-gear controls. The clutch is released and the band is applied. The band is applied by the heavy spring in the servo. With the clutch released and the band applied, the planetary-gear set is in gear reduction, or low. As car speed increases more and more pressure. This pressure is applied to one end of the shift valve, as mentioned. The pressure on the other end of the shift valve depends on intake-manifold vacuum, that is, on engine speed plus throttle opening. As long as the throttle is held open, there is little manifold vacuum. The pressure on the left end of the shift valve is high. This hold the planetary-gear set in low for good acceleration. However, as car speed continues to increase, the governor pressure becomes great enough to push the shift valve to the left. This lets line pressure through the planetary-gear set.

g. Now the band is released and the clutch is applied. This shifts the planetary-gear set into the direct drive. The up shift will also take place if the throttle is partly closed after the car reaches intermediate speed. Closing the throttle increases the intake-manifold vacuum. The vacuum cuts of line pressure to the shift control valve. When this happens, the shift control valve moves to the right, cutting off pressure to the left end of the shift valve. The shift valve then moves to the left, pushed by governor pressure. This applies line pressure to the planetary-gear set. The clutch applies and the band releases.

h. Now the planetary-gear set goes into the direct drive. There is a reason for this roundabout way to getting pressure to the left end of the shift valve. It is to vary the point of up shift according to driving conditions. When the vehicle is accelerating, the drivers want high engine torque. That is, the gears must stay in low.

j. Then, when the car reaches the desired cruising speed, less torque is needed, so the driver eases up on the throttle. This increases intake-manifold vacuum so that the up shift takes place. As you can see, the up shift can take place at any speed from medium to high. Also, for fast acceleration, the driver opens the throttle. This reduces intake-manifold vacuum. As a result, the planetary-gear set drops into gear reduction to increase torque.

NOTE: *Remember that Fig-15 is a simplified version of the actual system found in modern automatic transmissions. In modern transmissions oil pressure is used to help the spring hold the band tight. The basic principles, however, are as shown in Fig-15.*

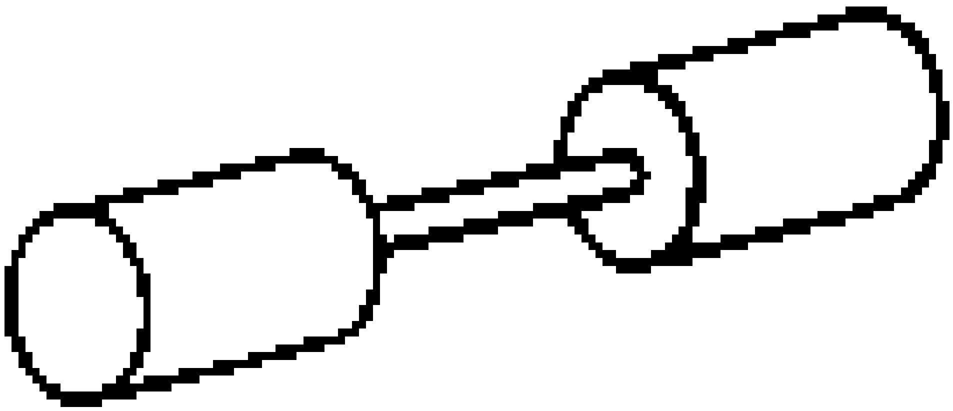

Fig-16: Spool Valve for a Shift Valve.

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Note: *A governor is device that controls, or governs, another device. In the hydraulic circuit, the governor controls pressure on the end of the shift valve.*

<u>BAF BASE AURAL HAGUE (TRG WG)</u>

(Aero Engg Trg Sqn)

Syllabus	**:**	**Automobile General Diesel and Petrol Technology**
Course	**:**	**Trade Training Advance, MTOF**
Subject	**:**	**Automatic Transmission and Transaxle Service**
Aim	**:**	**To Study Automatic Transmission and Transaxle Service**
Ref.	**:**	**Automotive Mechanics by William H. Crouse (Ninth Edition)**

AUTOMATIC-TRANSMISSION AND TRANSAXLES SERVICE

Servicing Automatic Transmissions and Transaxles

1. Automatic- transmission and transaxle service can be divided into four parts**.** These are normal_maintenance, trouble diagnosis, on-car repairs, and transmission overhaul. Before you undertake any of these procedures, refer to the manufacturers shop manual for the model of automatic transmission or transaxle you are about to work on. Then follow the procedures outlined. Because there are many models and designs, there are variations in the service procedures. Always follow the procedure recommended for the unit you are working on.

Normal Maintenance

2. a. Changing fluid and filter

   b. Checking fluid level

   c. Adding fluid if necessary

   d. Checking throttle and shift linkages

   e. Adjusting the neutral starting switch

   f. Possible band adjustment

The level of the automatic-transmission fluid should be checked every time the engine oil is changed. In addition, many car manufactures recommend changing the transmission fluid and filter at periodic intervals. The length of the intervals depends on how the car is used. For example, Chevrolet recommends changing the fluid and filter every 100,000 miles [160,000km] for normal service.
For severe service, as in taxis, in vehicles hauling trailers, in police vehicles in stop-and-go city driving, or in delivery service, Chevrolet recommends changing the fluid and filters every 15,000miles [24,000km]. Linkage and bands may require relatively frequent adjustment if the vehicle is in severe service.

Checking the Fluid

3. Check the fluid level in the transmission and also the condition of the fluid. This should be done at every engine-oil change.

a. **Checking Fluid Level**. Clean dirt from around the dipstick cap. Pull the dipstick, wipe it, and pull it out again. Note the level of the fluid on the dipstick. The level will vary under normal operating conditions as much as .75inch [19mm] from cold to hot. For example, as the temperature of the fluid goes up from 60^0F [16^0) C] to 180^0F [82^0C], the level of the fluid will rise as much as 0.75 inch [19mm]. This is the reason that many dipsticks are marked to indicate proper levels at different temperatures (Fig-1). Do not add too much fluid. Normally, not more than 1 pint [0.5L] should be required. Too much fluid will cause foaming. Foaming fluid cannot operate clutches and bands effectively. They will slip and probably burn. This could result in an expensive transmission overall. You can get a general idea of the fluid temperature by cautiously touching the transmission end of the dipstick to find out if it feels cold, warn, or hot. If the fluid feels cold, the fluid level on the dipstick should be on the low side of the dipstick. If the fluid warns, or hot (too hot to hold), the fluid level on the dipstick should be on the high side.

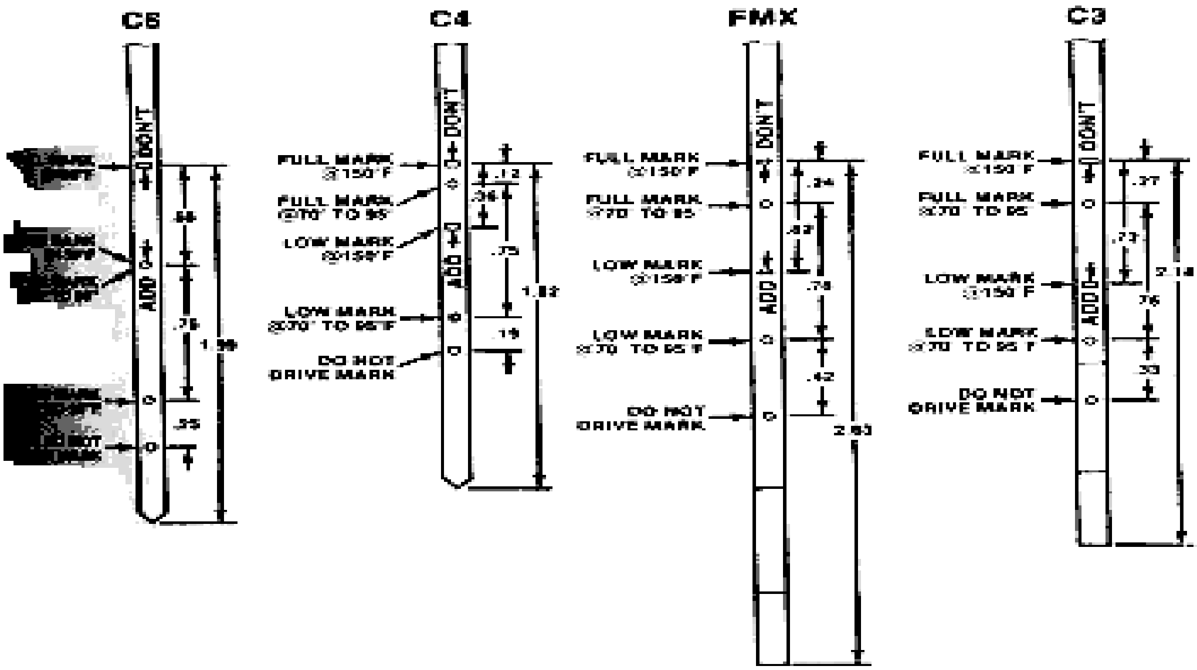

Fig-1 Dipsticks used in various automatic transmissions

b. **Condition of the Fluid.** The transmission fluid is normally in red color. If it is brown or black and has a burned odor, the transmission may be in trouble. Bands and clutch plate may have over heated and burned. Then, particles of friction material from the bands and clutch plates have probably circulated through the transmission and oil cooler. These particles can build up and cause valves in the valve body to hang. Shifts will be noisy or will not take place. Servos and clutches can mal function. The transmission may be jerky or may not take place. Or the transmission may slip. Use a piece of absorbent white paper such as facial tissue to wipe the dipstick (Fig-2). Examine the stain or for evidence of solids (specks on the paper) or for evidence of antifreeze leakage (gum or varnish on the dipstick. If the fluid in dark in color, or if you find speck on the paper or gum or varnish on the dipstick, remove the transmission- oil pan and look for further evidence of trouble. If you find contamination in the oil pan, it is added poof of transmission trouble. The transmission must be removed from the car for overhaul. Overhaul of specific transmission models is covered in the manufacturer's service manuals. When the fluid is contaminated, the oil cooler and lines must be flashed out. Also, the toque converter must be flashed out or replaced. Most manufacturers state that a torque converter cannot be flushed out to remove all debris. It must be replaced with a new or manufactured torque converter.

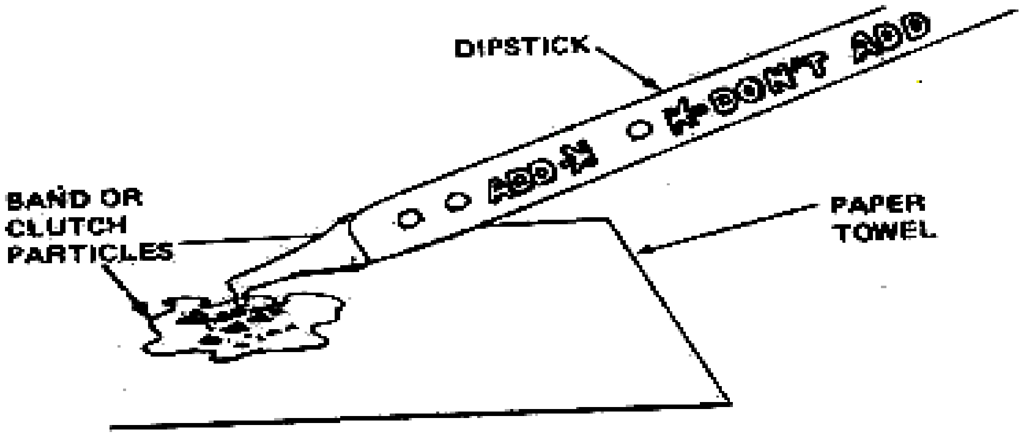

Fig-2 Checking the condition of fluid in an automatic transmission

c. **<u>Engine Coolant in Transmission Fluid.</u>** If engine coolant leaks in to the transmission fluid, the transmission must be removed or complete overhaul. This includes cleaning and replacement of seals, composition- faced clutch plates, nylon washer, and speedometer and governor gears. All these parts can be affected by coolant. The converter should be flushed out. The coolant in the engine radiator must be repaired or replaced. Then the cooler lines must be flushed out.

d. **<u>Checking for Transmission Leaks.</u>** If the transmission-fluid is low, suspect goes on leakage. Some fluid might be lost through the vent if it has formed. The fluid is red and this help in finding any place where a leak occurs. Here is one procedure.

(1) Clean the suspected area with solvent to remove all traces of fluid.

(2) Remove the converter shield, if present, to expose as much of the converter as possible.

(3) Spray the cleaned area with a spray can of white foot powder. This will show up the red fluid at the leaks points.

(4) Start and run the engine at high idle.

(5) If the leak does not show up immediately, have the owner bring the car back the next day or later. The recheck the suspected area.

(6) Repair any leak points found by replacing gaskets or seals, tightening attached bolts, or replacing porous casting.

<u>Trouble Diagnosis</u>

4. Each make and model of automatic transmission and transaxle has its own specific trouble- diagnosis guides. These are included in the manufacturer's service manual. The guides list the diagnostic procedure step by step. Locate the trouble-diagnosis section in the service manual covering the unit you are about he service. Before making operating tests of an automatic transmission and transaxle, be sure the engine is in good condition and operating normally. A sluggish or missing engine will not allow the transmission or transaxle to perform normally. Identify the make and model of transmission or transaxle in the vehicle you are about to check. Then study the specific reference that applies to that unit. Follow the procedure carefully. Any deviation from the procedure could damage the unit. You may be required by the service manual to make stall checks or operating checks. Observe the cautions outline in the references. Some manufacturers do not recommend stall tests. Others forbid them. Be very quick if you do make stall test. The stall test checks the torque converter and the holding ability of the transmission or transaxle clutches. It is performed by applying the car brakes, blocking the wheels, and measuring the engine speed with the transmission in drive and the throttle wide open. The check must be made within 5 seconds. To take longer risks damage to the transmission or transaxle.

Causes of Transmission Failure

5. The usual causes of automatic-transmission trouble are abuse and neglect. Following checks are to be carried out:

a. Most often these are overloading the transmission and not checking transmission fluid and adding or changing it if necessary. Extremes of heat and cold are also hard on transmissions. Long periods of idling in stop-and-go traffic can overheat the transmission fluid if the transmission is left in a driving range. This continues to whip the fluid in the torque converter and adds to the heat.

b. The remedy is to the shift to neutral or par if the car is to idle for more than a few seconds. The car, and transmission, may be overloaded when the car pulls a trailer, or when it is carrying extra weight. Revving the engine with the brakes applied and the transmission in a driving range also overloads the transmission. For mounting driving, either with a heavy load or when pulling a trailer, use the 2 (second) or 1 (low) select-lever position when on upgrades requiring a heavy throttle for ½ (half) mile [0.8km] or more.

c. This reduces transmission and converter heating. Working the transmission hard and overloading it can over heat the transmission fluid. The heat can eventually cause the fluid to deteriorate. Gum and varnish may from in the transmission. These could cause poor valve action and slippage of the bands and clutches. These can lead to further trouble. Neglect is the other abuse that can damage an automatic transmission. If the transmission is being worked hard (pulling a trailer, or on police, taxicab, or door-to-door delivery service), the fluid and filter should be changed frequently.

d. The bands should be adjusted frequently. Another problem may be caused by operation in consistently low temperature. For example, Ford recommends that the fluid be changed every 7500 miles [1200 km] if the vehicle is operated more than 60 days in temperature consistently below 10^0 F (-12^0c) and with short trips of less than 10 miles [16 km]. Even in normal, conservative operation, some manufacturers recommend changing the transmission fluid and filter periodically. For example, Chevrolet recommends changing these every 1000,000 miles [160,000 km].

Trouble-Diagnosis Charts

6. The purpose of trouble-diagnosis charts is to be helping you pinpoint the cause of trouble quickly. Trouble-diagnosis charts take different forms. Each manufacturer distributes a chart for each type of transmission it makes. The cart is given bellow:

Table-1: Trouble-Diagnosis and causes

Ser No	Trouble	Possible Causes
a.	No drive in drive range	Low oil pressure, (low oil, defective pump, screen or line plugged), Incorrect manual-valve-linkage adjustment, defective clutch or bands, or defective overrunning clutch.
b.	Does not shift automatically	Throttle-valve cable misadjusted, vacuum modulator defective, governor not working properly, 1-2 or 2-3 shift valves sticking, band or clutch defective, low oil pressure (low oil, defective pump, screen or line plugged)
c.	Transmission slips	Low oil pressure, defective band or clutch, misadjusted linkage, vacuum modulator defective.

There are other possible troubles, such as no breaking, in low 1 or low 2, no drive in reverse, rough shifts, and failure to hold in park. Each trouble can be caused by certain specific conditions. When you are trouble-diagnosing a transmission, your job is to first verify that the trouble exists. Road test the car if necessary. Then consider the various possible conditions that could cause the trouble. If the transmission has been recently overhauled, perhaps some [arts was left out or not assembled properly. If the transmission is older and had service, suspect worn bands, clutches, and bearings. Some troubles might be fixed with a minor repair or adjustment. Other troubles mean removing the transmission for a complete overhaul.

Trouble-Diagnosis Procedure

7. Most automatic-transmission troubles require some testing to verify the trouble and also to check oil pressure under different operating conditions. The tests can be made on the road, on a chassis dynamometer, or in the shop with the driving wheels either on or off the floor (Fig-3). All manufacturers do not recommend the same procedures. Before any test is made, the fluid level and condition should be checked and the control linkages checked and adjusted if necessary. The oil pressure in he hydraulic system is usually checked during the test procedure. This requires a pressure gauge with a long enough hose that it can be connected to the transmission and read from the driver’s seat. Test procedures for some transmission also require a tachometer to measure engine rpm. This is because some test is made at specific engine p\speeds. An engine lacks power can make a transmission perform improperly even thought nothing is wrong with it.

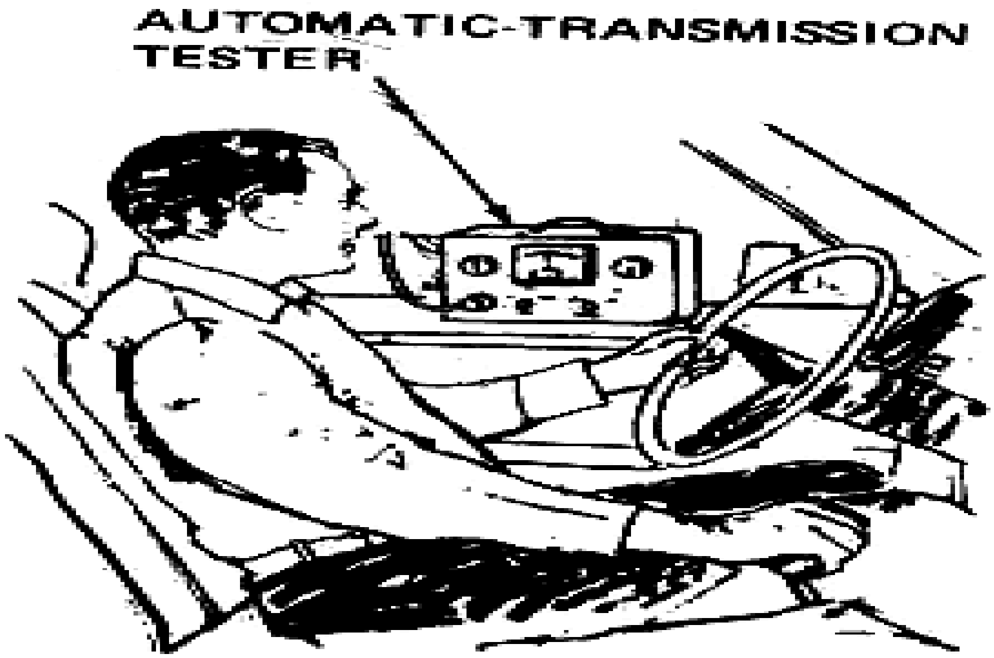

Fig-3 An automatic transmission tester.

The purpose of the diagnostic test is to operate the car at various speeds and check each gear position for slipping or incorrect shifting. For example, weak clutch springs cause the clutch to engage quickly and disengage slowly. Note the oil pressures and whether the shifts are harsh or spongy. Note also the speeds and throttle positions at which the shifts take place. Then compare the readings with the specifications in the manufacturer's service manual. Figure 45-5 is a typical pressure test-diagnosis chart.

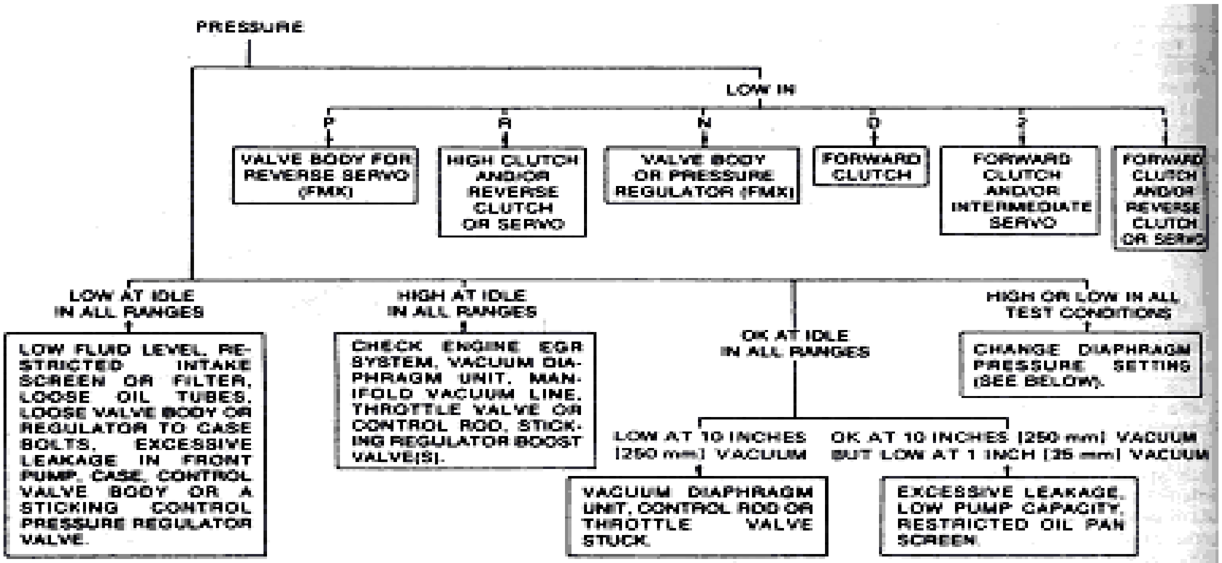

Fig-4 Pressure test diagnosis chart

a. **<u>Flare-up.</u>** Slipping or flare-up (engine speedup or runaway on a shift) usually means clutch, band or overrunning clutch trouble. Flare-up is a sudden surge or increase in engine speed before or during a shift. You can usually determine which band or clutch is slipping by pinpointing the gear position in which the slipping occurs. Figure 45-6 is a typical band-and-clutch application chart. It shows the combinations of bands and clutches that are applied or on in each gear position. To correct a slipping clutch, the transmission must be overhauled. Some bands can be adjusted. However, when an adjustment fails to stop a band from slipping, the band servo should be checked.

Range	Gear	Intermediate Clutch	Direct Clutch	Forward Clutch	Low-and-Reverse Clutch	Intermediate Overrun Roller Clutch	Low-and-Reverse Roller Clutch	Intermediate Overrun band
Park, neutral		Off	Off	Off	Off	Ineffective	Ineffective	Off
Drive	First	Off	Off	On	Off	Locked	Locked	Off
	Second	On	Off	On	Off	Locked	Overrunning	Off
	Third	On	On	On	Off	Overrunning	Overrunning	Off
Second	First	Off	Off	On	Off	Locked	Locked	Off
	Second	On	Off	On	Off	Locked	Overrunning	On
Low	First	Off	Off	On	On	Locked	Locked	Off
Reverse		Off	On	Off	On	Ineffective	Ineffective	Off

Fig-5 Clutch engagement and band application chart

b. **<u>Torque Converter.</u>** Poor acceleration could be caused by turned engine valves or by a clogged exhaust system. It could also be caused by slipping stator clutch in the torque converter. To check this out, accelerate the engine in N. If it reaches high rpm normally, the trouble could be that the stator clutch is slipping. Checked for poor performance in R and in D. If the one-way clutch is locked up, the result will be limited high vehicle speed and high engine rpm. The overheating may actually caused the converter to turn blue. If this happens, the torque converter must be replaced. Also, a locked-up or slipping one-way clutch requires a new torque converter. A one-way clutch cannot be required.

<u>Stall Test</u>

8. The stall test checks the holding ability of the torque-converter stator clutch and the transmission clutches. The test is made by applying the car brakes, shifting to different selector-lever positions, and opening the throttle wide to check the maximum engine speed or rpm (or the oil pressure, on some transmissions). A tachometer is required to accurately engine speed. The throttle should not be held wide open for more than a few seconds. Also, the front wheels should be blocked in addition to applying the car brakes. Be sure no one is standing in front or in back of the car! It could lurch forward as engine speed reaches

maximum, in spite of the brakes and blocks. (Not all manufacturers recommend the stall test.)

	Selector Position	Stall Speeds High (Slip)	Stall Speeds Low
Stall Test Results	D only	Transmission one-way clutch	
	D, 2, & 1	Forward clutch	
	D, 2, 1, & R	Control pressure test	Converter stator one-way clutch or engine performance
	R only	High and/or reverse clutch or reverse band	

Figure -6 is a chart showing how to diagnose band, clutch, and torque converter

On-the-Car Repairs

9. Each make and model of automatic transmission and transaxle has certain repairs that can be made with the transmission in the car. The manufacturer's service manual for unit you are about to service describes the operations that can be performed without removing the transmission or transaxle from the car. On most cars, these include linkages and band adjustments. However, if the repair is not one that can be done on the car, the unit must be removed.

Linkages and Band Adjustments

10. There are basically two linkages adjustments. These are the shift-linkage adjustment and the throttle or kick down-linkage adjustment.

a. **Shift-Linkage Adjustment.** When the selector lever is moved into any position, the manual valve in the transmission valve body must be exactly centered in its selected position. If the manual valve is not properly poisoned, delay's in shifting and slipping while operating can occur. Slipping of clutch plates or bands can soon damage the transmission so seriously that an overhaul is required. Adjustment procedures vary with different car and transmission models. The procedure is in the manufacturer's service manual.

b. **Throttle- or Kick down-Linkage Adjustment.** The throttle or kick down linkage causes the transmission downshift if the throttle is opened wide (within a certain speed range). Basically, the adjustment is correct if the throttle linkage is causes kick down linkage to produce the downshift when the throttle is opened to the full-throttle-stop position.

c. **Band Adjustment.** Some automatic transmissions is require periodic band adjustments if the transmission is used in severe service. Also, bands are always adjusted when the transmission is overhauled. Bands are adjusted by tightening and the loosen in the band-adjusting screw a 0specified number of turns. However, all bands are not adjustable. If a band is loose and worn through the lining, the band must be replaced.

Automatic-Transmission or Transaxle Overhaul

11. Rebuilding procedures vary considerably from model to model. These procedures also vary according to weather you are replacing one defective component or performing a complete overhaul. In the complete overhaul, you will discard all old gaskets, oil seals, O rings, metal sealing rings, clutch friction and steel disks, filters, and modulators. You will also inspect and replace, if needed, such parts as bands, bushings, pumps, gears, governor, linkage, and converter. The complete procedures are in the manufacturer's service manual.

Removing and Installing Automatic Transmissions and Transaxles

12. The removal and installation procedures vary with different cars. In general, here are the items may have to disconnect or remove. First, open the hood and disconnect the battery ground cable. This eliminates the possibility of causing an electric short-circuit. Other parts that may have to be removed or disconnected include the following:

a. Starting motor

b. Back-up light wire.

c. Neutral-park starting switch

d. Vacuum line to modulator

e. Oil lines t oil cooler

f. Shift linkages

g. Drive shaft

h. Torque-converter flexes plate bolts

j. Housing to engine bolts

There may be additional items to be disconnected or removed. Specific removal procedures are described in the manufacturer's service manual.

BAF BASE ZAURAL HAQUE (TRG WG)

(Aero Engg Trg Sqn)

Syllabus : Automobile General Diesel and Petrol Technology

Course : Trade Training Advance, MTO F

Subject : Servicing of Electronic Ignition System

Aim : Servicing of Electronic Ignition System

Ref. : Automotive Mechanics by William H. Crouse (Ninth Edition)

ELECTRONIC IGNITION SYSTEM SERVICE

Possible Causes of Electronic Ignition System Failure

1. Ignition-system failures can be grouped in to three categories. These are:

a. **Loss of Energy in the Primary Circuit. This could Result From.**

(1) Resistance in the primary circuit due to defective leads, bad connections or ignition switch, or open ignition coil primary winding.

(2) Discharged battery of defective alternator.

(3) Grounded primary circuit in ignition coil, wiring, or distributor.

(4) Defective ECU or sensor coil circuit to ECU.

b. **Loss of Energy in the Secondary Circuit, Due to.**

(1) Spark plugs fouled, defective, or improperly gapped.

(2) Defective high voltage wiring, which allows high voltage leakage.

(3) High-voltage leakage across ignition-coil head, distributor cap, or rotor.

(4) Defective connections in high voltage circuit.

c. **Out-of-time Ignition, Due to.**

(1) Timing not set properly.

(2) Centrifugal or vacuum advance defective.

(3) Pre ignition from spark plug of wrong heat range, fouled plugs, or carbon in combustion chambers.

(4) Electronic control unit (ECU) defective.

Electronic Ignition- System Trouble Diagnosis Chart

2. The chart that follows covers, in general, various possible troubles that might be caused by conditions in the electronic ignition system. However, many of these conditions could results from troubles in other components and systems of the engine.

a. **Table-1: Trouble Diagnosis and Remedy**

Condition	**Possible Cause**	**Check or Correction**
a. Engine cranks normally but fails to start.	(1) No voltage to ignition system	Check battery, ignition switch, wiring
	(2) ECU ground lead open, loose, or corroded	Repair as needed
	(3) Primary wiring connectors not fully engaged	Clean, firmly seat connectors
	(4) Ignition coil open or shorted	Test coil, replace if defective
	(5) Damaged armature (trigger wheel, reluctor) or sensor	Replace damaged part
	(6) ECU faulty	Replace
	(7) Defective distributor cap or rotor	Replace defective part
	(8) Fuel system faulty	Check fuel system
	(9) Engine faulty	Check the engine
b. Engine back fire but fails to start.	(1) Incorrect timing	Check and adjust timing
	(2) Moisture in distributor cap	Dry up
	(3) Cap faulty-voltage leakage across carbon parts	Replace cap

Condition	Possible Cause	Check or Correction
	(4) High-voltage cables not connected in firing order	Reconnect cables correctly

Condition	Possible Cause	Check or Correction
c. Engine run but misses-does not run smoothly	(1) Spark plugs fouled or faulty	Clean and re-gap or replace
	(2) Distributor cap or rotor faulty	Replace
	(3) High-voltage cables defective	Replace
	(4) Defective (weak) coil)	Replace
	(5) Bad connect on	Clean, tighten
	(6) High-voltage leakage	Check distributor cap, rotor, cables
	(7) Advance mechanism defective	Check advances, repair or replace distributor
	(8) Defective fuel system	Check fuel system
	(9) Defects in engine such as loss of compression or faulty valve action	Check the compression and valve timing.
d. Engine run but back fires	(1) Ignition timing off	Retime
	(2) Ignition cross-firing	Retime
	(3) Faulty anti-back fire	Retime
	(4) Spark plugs of wrong heat range	Check high-voltage cables, distributor cap, and rotor for leakage paths
	(5) Defective air-injection	Replace valve

Condition	**Possible Cause**	**Check or Correction**
	system	
	(6) Engine over heating	Install correct plugs
	(7) Fuel system not supplying proper air-fuel ratio	Check system
	(8) Engine defects such as hot valves, carbon etc	See item 5
Condition	**Possible Cause**	**Check or Correction**
e. Engine over heats	(1) Late ignition timing	Retime
	(2) Lack of coolant or other trouble in cooling system	Retime
	(3) Late valve timing or other engine conditions	Retime
f. Engine lacks power	(1)Ignition timing off	Retime
	(2) Exhaust system restricted	Clear
	(3) Heavy engine oil	Use correct viscosity oil
	(4) Wrong fuel	Use correct fuel
	(5) Excessive rolling resistance	Check tyres brakes, wheel bearings, alignment
	(6) Engine over heats	See item 5
g. Engine detonations, or pings	(1) Improper timing	Time ignition
	(2) Wrong fuel	Use correct fuel
	(3) Spark plugs of wrong heat range	Install correct plugs
	(4) Advance mechanism faulty	Rebuild or replace distributor

Condition	**Possible Cause**	**Check or Correction**
	(5) Carbon buildup in cylinders	Service engine
h. Spark plugs defective	(1) Cracked insulation	**Careless installation, install new plug**
	(2) Plug sooty	Install hooter plug, correct condition in engine causing oil burning or high fuel consumption
	(3) Plug white or gray, with blistered insulation	Install cooler plug
Condition	**Possible Cause**	**Check or Correction**
j. Engine runs on, or diesels	**(1) Idle-stop solenoid out of adjustment or defective**	**Readjust, replace as necessary**
	(2) Hot spots in combustion chambers	Service engine
	(3) Engine over heating	See item 5
	(4) Advance timing	Retime ignition

b. Today, most workshops have an oscilloscope. Using the oscilloscope is a quick way to analyze ignition systems and help in pinpoint trouble causes. Often, the first step in trouble diagnosis is to recharge or replace the battery. The driver may have run it down attempting to start the engine.

Ignition-System Quick Check

3. Several checks have been used in the past to help locate the cause of various troubles. For example, one test is the spark test. Remove a cable from a spark plug; insert a plug extender about 3/8 inch [10 mm] from the engine block with insulated pliers. Crank the engine and check for sparking (Fig-1) if no sparking occurs, there is trouble in the ignition system If there is a good spark, the failure to start is probably in the fuel system. This test is not recommended for use on all electronic ignition systems.

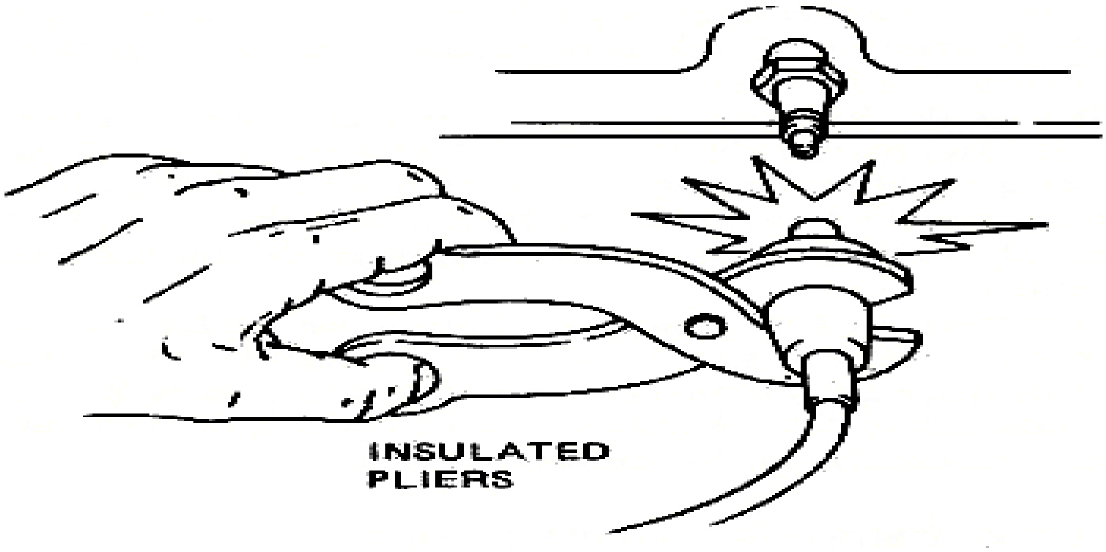

Fig-1: Checking for spark from sparking plug cable clip to engine

Engine Cranks Normally But Fails to Start

4. If there is no spark during the spark test, or if the oscilloscope fails to show a secondary voltage pattern, there are several possible causes. Se item 1 from the trouble diagnosis chart. If you get a good spark, the ignition primary and secondary circuits probably are okay failure to start could be due to fouled spark plugs or out of time ignition. However, failure to start with a good spark is more likely due to trouble In the fuel system the fuel system is not delivering the correct amount or ratio of air fuel mixture. Other conditions could prevent starting, such as malfunctioning valves lose of engine compression, and other engine troubles. Many manufacturers recommended marking the spark test only by using a spark tester (Fig-2). It is inserted between the end of the cable clip and the spark plug terminal. This prevents excessively high voltage from arcing across the rotor or cap and damaging.

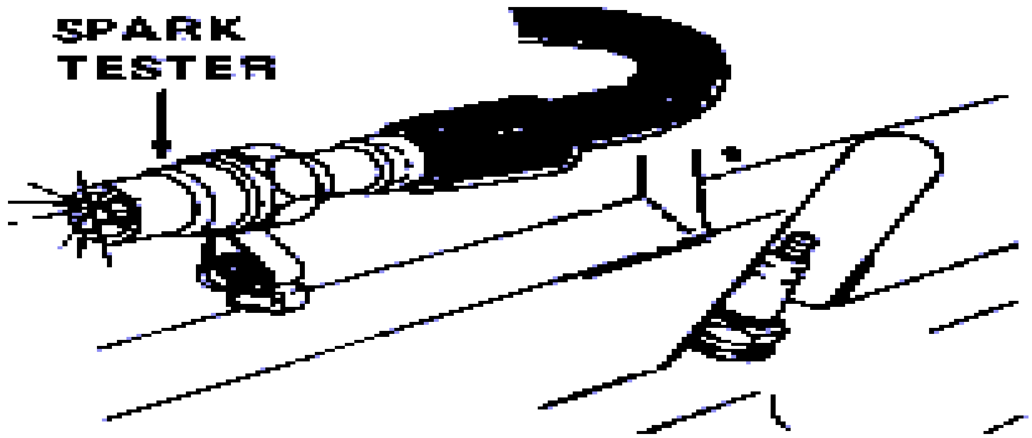

Fig-2: Spark test by spark tester

Engine Back Fires but Fails to Start

5. This can be caused by ignition or valve timing that is considerably off, by a faulty or wet distributor cap or rotor that lows high-voltage leakage from one terminal to another, or I the high-voltage cables being incorrectly connected.

Engine Runs but Misses

6. An engine that misses runs unevenly and does not develop full power. It is sometimes difficult to tell by listening whether one cylinder is missing, or whether the miss is intermittent and jumping around from one cylinder to another. If "one cylinder is do miss fire, the cause could be a defective spark plug or high-voltage cable, a bad connection, or high-voltage leakage across the distributor cap or through the cable insulation. In the engine, the miss could be due to a stuck or burned valve or loss of compression resulting from broken piston rings. If the miss jumps around, the cause could be defects in the electronic part of the system the ECU and the sensor coil in the distributor. This requires checking out as explained in later sections on specific systems. Another cause of a jump-around miss is the advance mechanisms not working properly so the advance is erratic. Also, a defective fuel system that is delivering too rich or too-lean a mixture can cause missing. An excessively lean mixture will not fire. An excessively rich mixture can wet or foul the plugs, causing them to misfire.

Engine Runs but Backfire

7. Backfiring is a "pop" or "bang" in the exhaust manifold or intake manifold. It can be caused by several conditions in the ignition system. If the ignition timing is considerably off, or if ignition crosses firing occurs, ignition may result before the intake valve closes. This produces a backfire. There will be a pop back through the air cleaner. Cross firing is spark jump over from one terminal to another or from one high-voltage cable to another. Cracked or damaged cable insulation can allow spark jumpover. If a spark plug runs too hot, it may glow enough to ignite the air-fuel mixture before the intake valve closes. This produces a backfire, or pop back through the air cleaner. This action is called pre-ignition. It can also be caused by excessively hot valves or carbon deposits in the combustion chamber. Incorrect air-fuel ratios can also cause backfiring. A lean mixture tends to cause backfiring through the air intake. A rich mixture and burned exhaust valves can cause backfire in the exhaust system. A defective air-injection system can also cause backfiring in the exhaust system.

Engine Overheats

8. Most of the engine overheating caused by loses of coolant through leaks in the cooling system. Other causes include a loose or too broken fan belt, a defective water pump, clogged water jackets in the engine, a defective radiator hose, and a defective thermostat or fan clutch. Late ignition or valve timing, lack of engine oil, overloading the engine, or high-speed, high-altitude, or hot-climate operation can cause engine overheating. Freezing of the coolant can cause lack of coolant circulation, resulting in hot spots and

boiling. Also, if a faulty TCS system prevent vacuum advance in any gear, or if the distributor vacuum advance is defective, overheating may result.

Engine Lacks of Power

9. Many conditions can cause the engine to lose power wrong ignition timing, or any of the conditions discussed earlier which cause the engine to miss, will reduce engine power. Also, a restricted exhaust system can create excessive back pressure which will prevent normal exhaust flow from the engine. The cylinders will retain pressure and will not take in a full air-fuel charge during the intake strokes. Heavy engine oil, the wrong fuel, or excessive rolling resistance can also give the impression of low engine power.

Engine Detonates or Pings

10. Detonation or pinging (also called spark knock), .is often blamed on the ignition system. But there are many other possible causes. In the ignition system, detonation may be caused by excessively advanced ignition timing, faulty advance mechanisms (which can cause excessive advances), and spark plugs of the wrong heat range. Fuel with an octane rating too low for the engine can cause pinging, or detonation. Carbon buildup in the engine combustion chambers can result in detonation in two ways. First, the carbon may glow or become so hot that it can cause pre-ignition. This can result in ping. Second, the carbon buildup increases the compress ion ratio. This can also cause detonation.

Engine Diesels or Runs on

11. Engines with emission controls require a fairly high hot idle speed for best operation. This makes run-on, or dieseling, enough air fuel mixture getting past a slightly opened throttle valve, can keep the engine running. The hot spots act as the spark plugs, igniting the mixture in the combustion chambers. Hot spots could be from hot spark plug or exhaust valves, or from carbon deposits in the combustion chambers. Dieseling can damage an engine. To prevent dieseling, many engines have an idle-stop solenoid. It closes the throttle valve completely when the ignition switch is turned off. If an engine runs on, or diesels, first check the idle-stop solenoid. Make sure it is releasing when the ignition switch is turned off to allow the throttle to close completely. Make sure the engine idle speed is not set too high. Engine run-on could also be caused by-ignition timing

Servicing Electronic Ignition Systems

12. Although all electronic systems operate in a similar manner, they require somewhat different checking and servicing procedures. The General Motors HEL system, with its coil mounted in the distributor, requires Its own special procedure. Likewise, the Ford Duraspark systems and the Chrysler electronic system require their own individual testing and servicing procedures. For detailed, step-by-step procedures on how to test and service

these systems refer to the manufacturer's shop manuals. Some suggestions on the use of the oscilloscope and special points to watch when servicing electronic ignition systems follow.

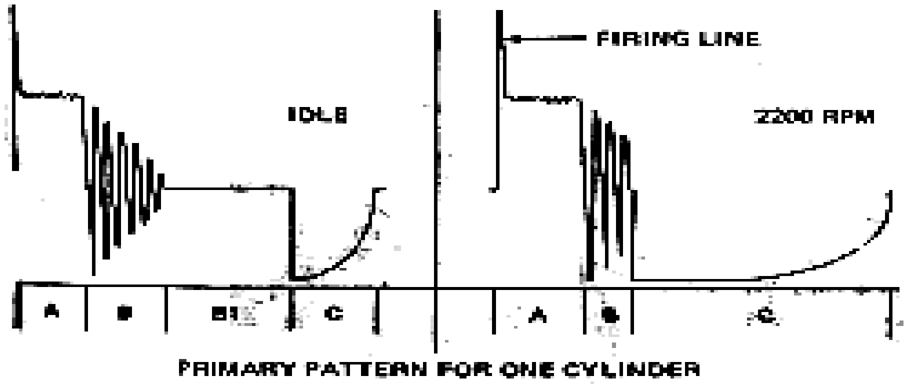

Fig-3: Primary pattern for one cylinder

<u>Oscilloscope Patterns</u>

13. The oscilloscope patterns for the various electronic ignition systems are not always the same. However, all have the common characteristic of increasing the dwell with speed.

a. The term dwell is a carryover from the contact- point system. In that system, dwell is the number of degrees that the contact points are closed. This is the number of degrees of distributor shaft rotation that the primary winding of the ignition coil remains connected to the battery.

In the electronic ignition system, it means that the same thing- the number of degrees of distributor- shaft rotation that the ignition –coil primary winding remains connected to the battery.

b. Dwell in the electronic ignition system increases with engine (and distributor-shaft) speed (fig-3). In this system, the dwell can vary considerably from cylinder to cylinder. This is considered normal in the HEI system. In some HEI ignition system Fig-4). The rotor air gap (gap between the rotor tip and inserts) has been increased to 0.120 inch [3 mm]. This was done to reduce radio noise. When testing these systems with the oscilloscope, you will see an increase in the voltage pattern when you check for cap- rotor wear.

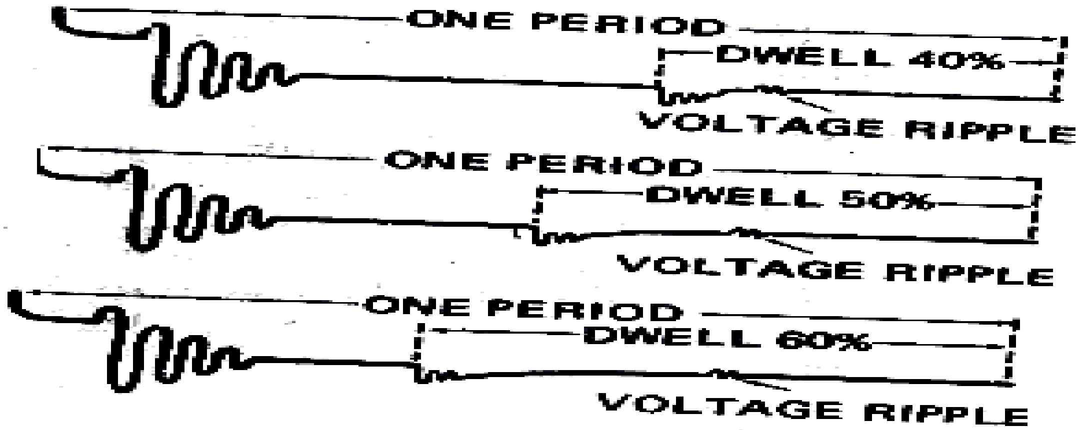

Fig-4: typical scope secondary patterns for different cylinder

Note: *Always follows the oscilloscope operating instructions when checking electronic ignition systems. The instruction booklets illustrate the various patterns for the different ignition systems.*

Service Tips for Electronic Ignition System

14. Many of the service procedures required for servicing electronic ignition systems are similar to those used in servicing contact- point ignition systems. However, there are some special points to watch when working on electronic ignition systems. The similarities and differences are described below.

a. **Spark plugs.** How to analyze or read spark plug condition is described earlier. Lead fouling should not be found if the engine has been running on unleaded gasoline.

b. **Timing.** The timing procedure for electronic ignition systems is similar to that for timing contact-point ignition systems. The vehicle emission control information label in the engine compartment is to be checked step by step according to the lists. The approved procedure for adjusting ignition timing, following are the steps:

c. **High-Voltage Cables.** These cable should be handled with care,. While the insulation is electrically strong to contain the 47,000 volts the electronic systems can produce, it is relatively soft. These cables should never be punctured or bent damage will allow the high voltage to leak and jump to the nearest ground so the plug will not fire. The cables should be disconnected only if they are suspected of being fault or if other tests of the system must be made.

d. **Silicone Grease.** Silicone grease is used to coat the rotor segment and cap electrodes on many distributors. Similar grease is used to coat the insides of the spark-plug boots. It is also used in harness connectors. The purpose of the grease in the distributor is to reduce radio interference from the high voltage arc as it jumps the rotor gap from the rotor segment to the cap electrodes. The grease greatly reduces this radio frequency interference (static). The grease also serves as added insulations against high-voltage leakage, and protects the connectors against corrosion.

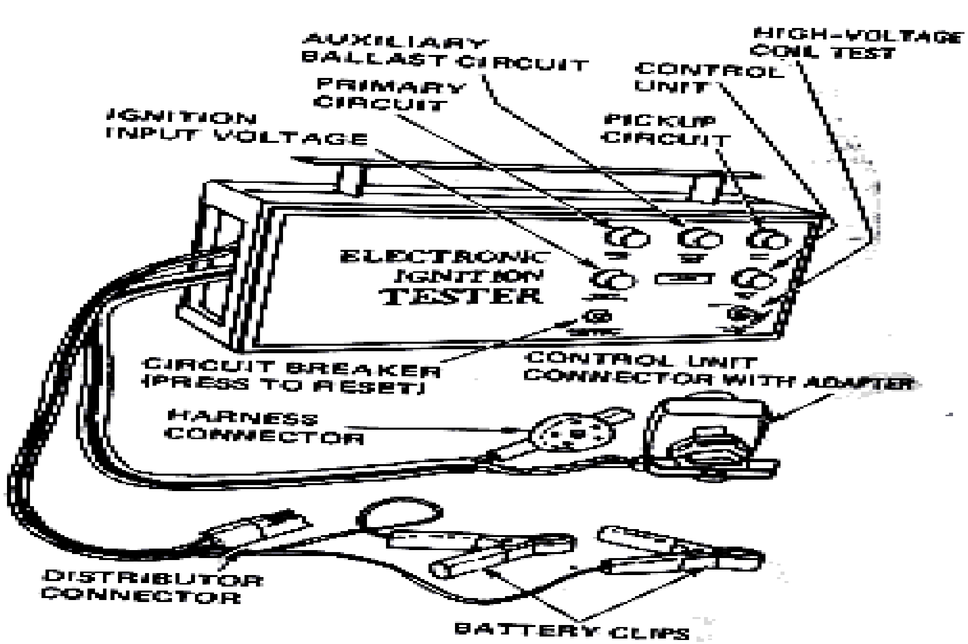

Fig-5: Electronic ignition system tester

e. **Visual Inspection.** Before proceeding with actual tests of the system, always make a visual inspection. Inspect the wiring and cables, distributor cap, coil, and retainers that hold the cables in place. Check all connections for tightness. If there are no obvious defects, then proceed with the test. The Chrysler, Ford, and General Motors electronic ignition system test procedures are different because the various systems are different. But all these systems work in the same general way. Refer to the manufacturers shop manual for instructions on the specific system you are working on. Figure -3 shows an electronic-system tester used on some Chrysler models. Figure -6 shows special adapters and procedures for testing different electronic ignition systems.

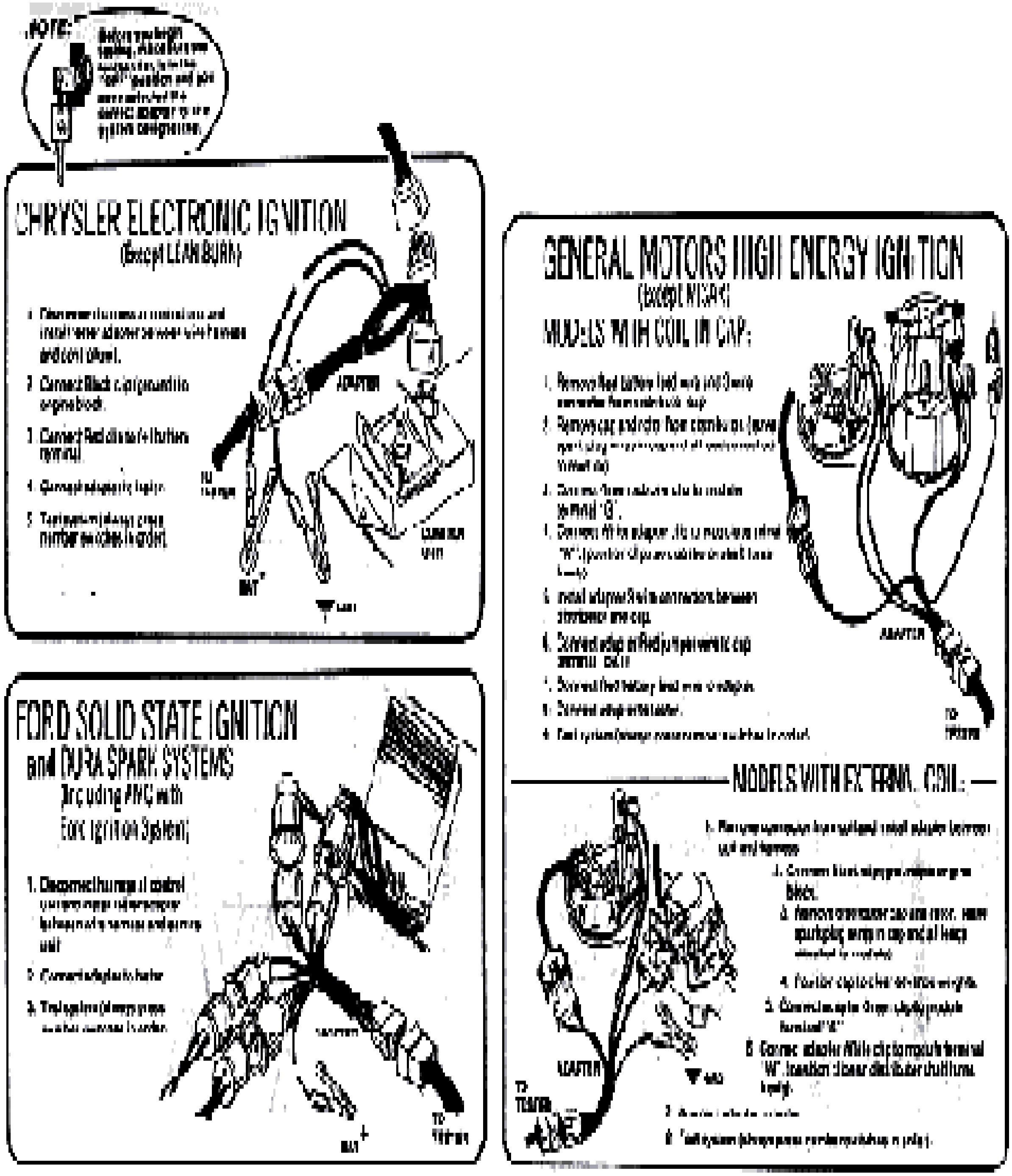

Fig-6: Special adapters and procedures for testing different electronic ignition system

f. **<u>Oscilloscope.</u>** Some oscilloscope patterns for electronic ignition systems are different from those for contact-point systems. Also, the patterns for the various electronic ignition systems may differ from one another. Follow the oscilloscope operating instructions. They illustrate the patterns, normal and abnormal, for the different systems.

g. **Cable Book.** When it is necessary to replace only a boot on a cable, cut off the old boot. Apply silicone lubricant to that part of the old cable that will be under the new boot. Use the special tool as shown in Fig. -7 to install the new boot. Push the tool through the new boot and in to the cable clip. Slide the boot onto the cable and remove the tool.

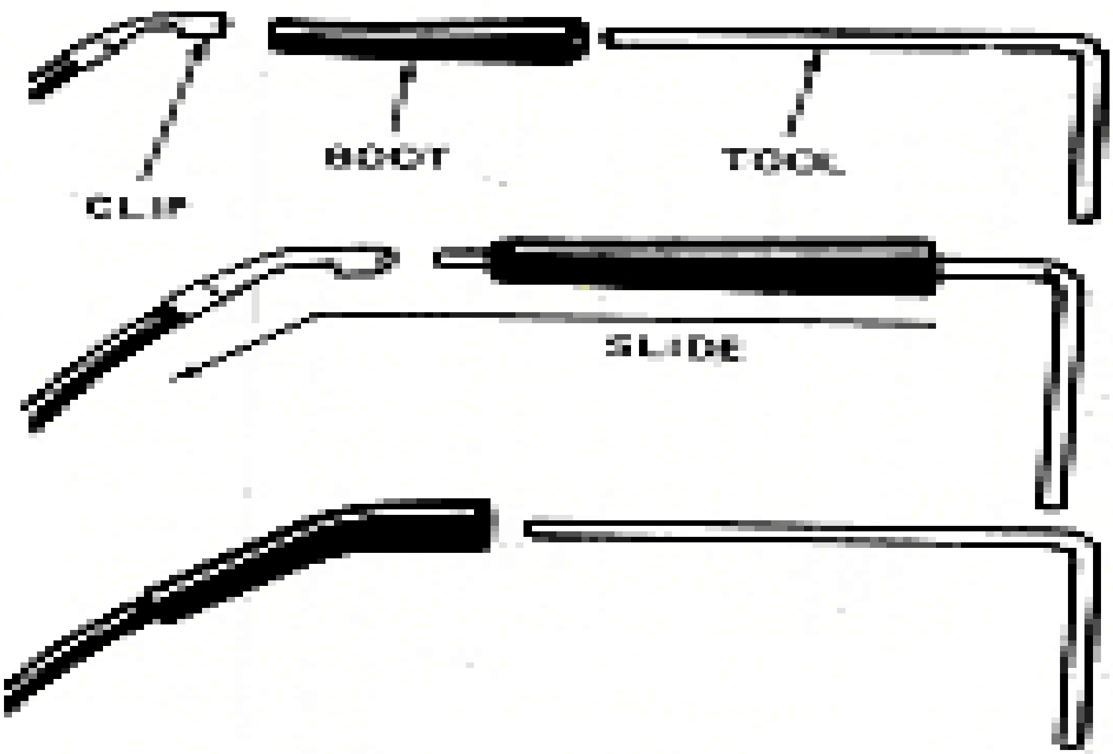

Fig-7 Using a Special tool to install a boot on a cable

Syllabus : Automobile General Diesel and Petrol Technology

Course : Trade Training Advance, MTOF

Subject : Maintenance of Specialist Vehicle

Aim : To Study Crush Tender
Ref : TO ATY-2ST-86

CRUSH TENDER

Description

1. The chassis is a type LAK 1924/46 made by Mercedes Benz. The fire fighting truck is provided with a 3 men crew cab left hand drive; all wheel drive semi-forward control design; wheel base 4600 mm; Mercedes-Benz hydro-power steering dual circuit dual-line airbrake; engine brake; mechanical parking brake with compressed air booster acting on 4 rear wheels; 24 V/27A generator; radiator and thermostat for the tropics, radiator and cab suspension oil bath air filter with cyclone type preflight rear axle ratio 6:6 disc wheels for types size 1200 X 20, 14 PR (reinforced) ; one spare wheel of the same type speedometer in km/h 1 trocicalized batteries of 88 Ah/12V; independent power-take of' NIVIV 90/1, ratio 1 : 1 03 illumination according to international rules including reverse drive beam.

a. Engine and Gearbox. **6-cylinder Mercedes –Benz diesel engine type OM –355 with direct injection developing 265 HP/SAE at 2200 rpm. Bore/stroke 128/50mm, Piston displacement 1: 588cm, Maximum torque-91kpm at 1300 rpm. 6- Speed constant mesh gearbox type AK 6-ac.**

b. Cabin. **The cabin is suited for a 3- men crow with front higher doors, crank windows made of safety glass, with dome light, ventilation, heating, defroster, big windscreen with wiper and washing device, 2 sun visors and 2 mirrors.**

c. Water and Foam Tank. **The tank is painted with special synthetic paint and inside covered with as epoxy paint which protects the tank corrosion the tank is made of 5 mm steel sheets, electrically welded and finished with all necessary connections for the pump. Above the tank suction pipes are anti-awhile plates. Both foam and water tank are equipped with baffle plates and mounted by means of rubber steel elements on the chassis. The water and foam tank is fitted with manholes 450 diameter. Both tanks are assembled with draining cocks. The water tank**

has two filling connections each $2^1/2$ J. Morris. The water tank has an overflow pipe as well as an under and excess pressure safety device. The foam tank is suitable for carrying protein foam compound as well as synthetic foam compound.

d. Centrifugal Fire Pump. **The pump type r-450 is rear mounted, driven by the vehicles PTO, one casting and made of aluminum. The pump delivers 4500 1/min at 8 bar (4500amp, gall at 8 bar), or course, depending on tank suction operation, on both sides there are delivery outlets $2^1/2$ J. Morris. At the pressure side of the pump a connecting hose is mounted for filling the water tank.**

e. **Automatic Foam Proportioner Type RVMA 230** The automatic foam proportion (ground-the- pump) are always adjusting the correct admixing ratio according to the required water output the proportioned can mix 3%--to 8% depending on maximum pump delivery power.

f. **Foam Filling Pump** . The truck is furnished with portable electric foam filling pump type LUX 408, 24v, to fill the foam tank. A 1-1/2 Morris coupling is mounted on the pressure side of the pump to provide the connection between the pump and foam tank by 1-1/2 pressure hose. The foam-filling pump is mounted in locker support.

g. **Water/ Foam Monitor** In the can roof there is a Rosen Bauer 'Fire master' combined water/foam monitor type RM.-24 mounted. It gives an output of 2700 1/min at 10 bars. The monitor is suited for operating inside the driver's can as well as from the roof. Drawing range with water 70 meters (230 ft, and with foam 50 metres –160 ft, the monitor rotates through 360^0 and is vertically adjustable from =150.

h. **Monitor Control Panel (Inside the cab)** It consists of a control switch for water supply line to the monitor and a controlled switch for foam operation. Actuating throttle control can control the pump output.

j. **Air Control Panel*.*** Consists of manometer, mano vacuum meter, temperature gauge, throttle, pneumatic control switch for tank, suction line, propelling water, main foam tank, control lever for first aid reels and filling the water tank, priming lever, water and foam level indicator***.***

k. **First Aid Hose Reel.** Both axial supplies with 40m of semi rigid hose and foam branch pipe.

l. **Door.** Can be walked upon on both sides, aluminum sheets on both sides, a step rail mounted on the tanks rear side***.***

m **Rocker Body.** Aluminum built, with lockable doors on both sides "of the vehicle Automatic.

n. **Centrifugal Water Pump.** The one-stage centrifugal pump is provided with an impeller for high water output delivery. The pump shaft is made of stainless steel and runs in the gearbox in two ball bearings. The pressure side mounted stuffing box with moldable special stuffing box packing seals the pump and of course the stuffing box is also repack able without dismounting by using, the re pack screw. (Note: repack only if pump is idling).

o. **Foam Proportioner Control** The centrifugal water pump is also equipped with a foam proportioned which operates to the injector principle, granting for correct foam admixing.

p. **Drive and Gear Box..** The rear mounted pump is driven by the central PTO by using an universal shaft and a gear box, the pump mounted gearbox delivers the needed capacity by a set ratio in relation to the engine's speed and output capacity.

q. **Suction Device**. The double action piston-priming pump is mounted on the pump gearbox and in driven by a tooth belt and an electro-magnetic clutch. The electro-magnetic clutch is only engaged during priming operation.

2. **Purpose.** Crush Tender is used as a fire fighting and rescue equipment or device to be applied for fire services at civil and military airfields. The vehicle carries various appliances which can cope up with aircraft including large jet liner burning in the vicinity of airport.

3. **Maintenance.** All schedule maintenance of crush tender is to be carried out as per respective maintenance manual. Normal inspection and servicing procedure is as follows:

a. Drain perfectly (except the water tank drain plug.)

b. Wipe off moisture on the outside.

c. Wipe unpainted surface using oil.

d. Turn the grease cap.

e. Inspect and refill the engine crankcase with lubricant.

f. Inspect and refill the priming pump lubricator.

g. Inspect and refill the fuel tank with diesel oil.

h. Inspect and keep clean the rubber packing of suction hose coupling and suction cap.

j. Service to discharge hose and suction hose.

k. Flush discharge hose with fresh water and dry in the sunshine.

l. Flush suction hose with fresh water and dry it in the shade.

m. Flush hose reel rubber hose with fresh water and dry it in the shade.

BASE ZAHURUL HAQUE (TRG WG)

(Aero Engg Trg Sqn)

Syllabus : Automobile General Diesel and Petrol Technology

Course : Trade Training Advance, MTOF

Subject : Maintenance of Specialist Vehicle

Aim : To Study Aircraft Refueller

Ref : Owners Manual

AIRCRAFT REFUELLER

Purpose

1. It is used for refueling and defiling the aircraft.

Maintenance and Safety

2. a. The scheduled maintenance services listed in this section are required because they are considered essential to the life and performance of the vehicle. These services are matters of day-to day care that are important to the proper operation of the vehicle. In addition to the conditions described in the owner maintenance checklist, be alert for any unusual noise, vibration or other indication that the vehicle may need service and attend to it promptly. Use only recommended fuels, lubricants, fluids and service parts conforming according to specifications. Motor craft parts are designed and built for best performance of the vehicle. Using these parts for replacement is assurance that specific quality stays in the vehicle.

b. To strictly maintain the following precaution:

(1) Prohibition of fire and shock. Avoid fire and shock without fail, whenever loading or unloading repair of tank truck should be done after vapor or liquid in the tank is let lout.

(2) Cotton cloth will be better to wear, because chemical fibers have tendency to generate static electricity.

(3) When unloading, confirm volume or residue in the opposite, and pay attention not to be flooded over.

(4) Pay full attention not to take a kind of liquid for another. Confirm the kind of liquid in every compartment of tank truck or underground tank.

(5) Before unloading, bond earth real installed at tank truck to ground surely. Earth plate on manhole over is used mainly for loading.

(6) Open the filling hatch when loading and unloading, care must be taken to not pressure 9positive or negative pressure).for tank inside. Make sure that cleaning and

inspection of the air vent valve are performed properly, when improper operation of valve occurred because of attaching the loading article.

BAF BASE ZAHURUL HAQUE(TRG WG)
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Syllabus : Automobile General Diesel and Petrol Technology

Course : MTO F Advance Trade Training

Subject : Maintenance of Specialist Vehicle

Aim : To Study Fork Lifter

Ref : To ATY-2ST-86

FORK LIFTER

Description

1 The various types of fork lift trucks in use in-the service conform generally to a similar design in which the lifting and tilting of the loads are performed by hydraulic pressure. The hydraulic pressure is derived from an oil pump driven by the vehicle engine or by an electric motor when the vehicle is battery powered.

Purpose

2. The lifting forks are fitted on a carriage, which is connected to two roller chains mounted on two sprockets on the upper and of the lift cylinder ram. The fork carriage is guided by mast, comprised of two rigidly connected up right posts which is capable of being tilted, forward and backward, about its base by the tilt cylinder ram, the roller chains are anchored to a cross-number on the mast. When the limits of Lifting and tilting are reached during the operation of the truck the hydraulic pressure is relieved by a bypass valve which is connected to the hydraulic fluid tank. The rated lifting capacities of the American forklift struck have been amended to conform to British practice and standards. In addition the angle of forward tilt of the American vehicles has been altered from 6° deg. to 3° deg by the addition of spacing washers in the tilt cylinder, to increase the margin of stability of the vehicle.

Operation

3. a. **Procedure for Testing**. During the overhaul of the truck, the two lifting chains should be removed from the truck and tested in a

tensile testing machine. The chains should be subjected to a load equal to twice the maximum safe working load on the chains. To comply with the current regulations the chain must be removed and examined annually.

b. **Road Test**. Prior to the application of the proof load tests the truck should be given a road test of from 2 to 3 miles to prove the road performance of power unit t and chassis to test. The steering locks of the truck should be made to perform a figure 1'811 within the limits of steering. On the completion of the test the truck should be examined for defect and repaired accordingly.

Maintenance & Safety

4. The fork lift truck is a heavy vehicle with a comparatively small wheel base, and is capable of being over turned on loose uneven ground, especially when heavily loaded. It is therefore imperative that the proof load tests should be performed when in vehicle is on a hard level surface, preferable on concrete floor. Some forklift trucks are fitted with solid tyres and others with pneumatic tyres. Before testing vehicles fitted with pneumatic tyre it is important to ensure that all the tyres are inflated to the specified pressure for the particular vehicle. A lower pressure or unequal pressure will have considerable effect on the stability of the vehicle when carrying a load on the forward lift to a dangerous degree beyond the pressurized angle for safe loading.

BAF BASE ZAHURUL HAQUE(TRG WG)

(Aero Engg Trg Sqn)

Syllabus : Automobile General Diesel and Petrol Technology

Course : Trade Training Advance, MTOF

Subject : Maintenance of Specialist Vehicle

Aim : To Study Mechanical Sweeper

Ref : To ATY-2ST-86

MECHANICAL SWEEPER

Description

1. It is a vehicle having a main engine (Vehicle engine) and an auxiliary engine situated behind the vehicle cabin, It has got the following sweeping equipments.

a. Wide sweep Brush.

b. Channel Brush.

c. Exhauster Fan.

d. Water Pump.

e. Body Discharge System.

f. Instrument Panel.

g. Instrument panel in the cabin.

h. Hydraulic Tank.

j. Hydraulic Pump.

k. Hydraulic Motor

Purpose

2. The purpose of Mechanical Sweeper is to sweep, wash, and clean the runway and tarmac of the aircraft.

Operation

3. Vehicle engine is started and the power is transmitted to the road wheel through the main gear box and the vehicle is being drive .The rear engine is started and drive is taken through the PTO Pump and auxiliary gear box to operating the different system of the mechanical sweeper (hydraulic pump, hydraulic motor, wide sweep brush, channel brush, exhauster fan, water pump etc.)

Maintenance

4. a. Visually Check oil Level in hydraulic reservoir.

b. Check oil level in auxiliary engine.

c. Grease pump drive shaft lubricator on water pump.

d. Check channel brush apron is correctly set above road surface.

e. Clean-nozzle jets with pricker provided.

f. Check and clean water filler.

g.* *Check serviceability of mesh guard inside body at rear. It is essential that this unit be in good. Condition and correctly positioned when operation.

h.* *Check Body baffle plate is intact and in good condition.

j. **Weekly Maintenance**

. *(1) Examine and clean auxiliary engine air filter at least once weekly in accordance with engine handbook. Because of possible dusty conditions it is most important the unit is reassembled. Correctly, ensure that there are no external air leaks.*

(2) Check oil level in JB transfer gearbox fitted no rear end of auxiliary engine.

(3) Check oil level in JB level gearbox fitted between auxiliary engine and exhauster fan.

(4) Check oil level in channel brush gearbox if fitted.

(5) Grease propeller shaft between J.B Gearboxes.

(6) Tighten nuts on all pro-shafts.

(7) Clean all water spray jets.

(8) Lubricate with grease gun and oil ken all grease nipples and joints rush link age /body lifting ramp/ body pivot/back door/and nozzle lift assembly.

(9) Check warring plate inside body and renew if necessary.

(10) Grease wandering hose turntable.

(11) Check exhauster fan impeller and ensure that there is no build up of foreign matter un the blades. Failure to do this or excessive wear can ensures the impeller to become out of balance, this will cause excessive vibration throughout the fan and Engine mounting with possible resultant fracture wash fan whilst running).

(12) Carry out visual check far mechanical damage to J.B. equipment.

(13) Carry out normal chassis maintenance.

(14) Keep auxiliary engine compartment clean.

(15) Check outing of all hydraulic and electrical service to auxiliary engine for chaffing etc.

k. **Monthly Maintenance**

(1) Check condition of hydraulic oil, drain, flush system and refill with fresh oil every 750 hours.

(2) Remove filters fitted in hydraulic reservoir and hydraulic reservoir and cleans if necessary. It is important that the filter is cleaned from centre to outside only. Filter must be dry before replacing; Access to filter is via -cover plate on reservoir.

(3) Thoroughly grease all remote control linkages.

BAF BASE ZAHURUL HAQUE(TRG WG)

(Aero Engg Trg Sqn)

Syllabus : Automobile General Diesel and Petrol Technology

Course : MTO F Advance Trade Training

Subject : Maintenance of Specialist Vehicle

Aim : To Study Crane

Ref : To ATY-2ST-86

CRANE

Description

1. It is a machine for raising and lowering the heavy loads. There are two types of crane in use. Such as static crane and mobile crane (crane extra heavy, crane heavy, crane light). Crane Heavy is lorry mounted, mobile Crane with a lifting capacity of maximum 6 tons. Its overall height with the jib in traveling is 13.6" with 7.9" and lifting height 24 feet. It is 6-cylinder diesel engine developing 41 H.P at 1750 R.P.M. It is electrically operated through the medium of 250 volts generator (variable) which is driven by 4-cylinder diesel engine. Main Components of crane are as follows:

a. **Jib** It carries a pulley on its forward and ever which the hoisting rope s supported and can travel freely.

b. **Rope** The hoisting rope carries a strong hood at its outer and its inner and is secured to the hoisting barrel.

c. **Sheave** A sheave is mounted on the jib fulcrum pinto ensures even winding of the hoisting rope.

d. **Fair Load** It is used for dragging wreckage which may be out of reach of the crane. A pulley is provided at the rear of chassis, the superstructure is allowed round until the jib is directly in line with the chassis and the crane hook, is over the fair load pulley. The locking pin is then in-serrated to look the superstructure. A rope is passed through the fair lead pulley and attached to the crane hook; Jib should be at the minimum radius. The hoisting rope is then operated and the load is raise from max 17 feet distance till the crane hook is in "OUT OFF" position.

e. **Sure Load Indicator** It is pulley type mounted on the inner side e of fulcrum pin, which operates the danger bell, and red light when 10% in excess of the rated load is reached. Thus .the load should be lowered immediately and jib adjusted.

f. **Electromagnetic Brake** These are fitted on each motor and are so designed that when motors are at rest or any remain "OFF" positions when the motors are in operation, thus it ensures safe operation. Limit switches are fitted in hoisting and derricking motors to prevent over Hoisting and over derricking.

Purpose

2. It is used for raising and lowering the heavy loads.

Operation

3. All operation are effected' from the cabin which is fitted on 8 turn table at the right side of the jib from where the operator is able to see all ground.

a. **Terms**

(1) **Derricking** Raising or lowering the crane jib about the pivot point of the jib is called Derricking.

(2) **Hoisting** Raising the load of a crane by using the lifting wire only is called Hoisting.

(3) **Slewing Motor.** The rotary motion of a crane jib 16 horizontal plane is called slowing.

b. **Power** The main generator excites as slowing, hoisting and derricking motor through their respective controls. The power developed is as follows: -

(1) Slowing Motor --------------------------------1 H.P. at 500 r.p.m

(2) Derricking Motor --------------------------------6 H.P. at 900 r.p.m

(3) Hoisting ------------------------------ 6 H.P. at 900 r.p.m.

c. **Controls in Operating Cabin**

(1) **Change over switch (Master Switch)** It connects the main generator with the motors.

(2) **Accelerator Pedal** It is two ways controlling switch to lift the load, lever is moved up and to lower it is moved downward.

(3) **Derricking Controller.** It is two ways controlling switch to lift the load, lever is moved up and to lower it is moved downward.

(4) **Hoisting Controller.** It is two ways selves controlling switch. to raise the hoisting rope the lever is moved “UP” and to owner the rope it is moved “DOWN”.

(5) **Slowing Controller** . It is two ways self controlling electrical switch. To slow the crane to right the lever' is moved “UP” and to slow to the left, it is moved "DOWN”.

d. **Precautions of Crane for Operation.** The following precautions are to be observed before operation.

(1) Ensure that the load is within the lifting capacity.

(2) Ensure that there is no overhead or side obstruction.

(3) Check the surface of the ground before the crane is operated.

(4) Ensure that the crane is on level ground.

(5) Ensure that the jib is at its correct radius. Ensure that no body is near or under the load.

(6) Ensure that no body is near or under the load.

e. **<u>Safety of Slings.</u>**

(1) Check all slings for' serviceability and strength.

(2) Frayed sling (damaged) are not to be used.

(3) Check the sling for balance, after lifting the load for about 6- inch give a shake to ensure the balance.

(4) Ensure that the sling used for lifting is of proper strength.

f. **<u>Operator’s Cap Drill.</u>**

(1) Ensure that relieving gear is released.

(2) Ensure that the slow lock pin is removed.

(3) Start up the engine and put the Master switch "ON.”

(4) Ensure that all the operating controls are working properly.

g. **<u>Precautions.</u>**

(1) They are only to be used when the load is 4 Ton or above.

(2) Wooden blocks are to be used underneath.

(3) Ensure that the surface of the ground is level and hard.

(4) Crane is not to be moved when outriggers are in use.

h. <u>Operation of Term</u>**.**

(1) **<u>Derricking.</u>** Move the controller handle upward and keeping the handle in this position, accelerator engine gradually till the jib is raised to the required position. Avoid over derricking to prevent running hard against the limit switch. To lower the jib the lever is moved downward.

(2) **<u>Hoisting.</u>** Move the hoisting controller handle sown to lower the hoisting rope (or load) and accelerate the engine gently. To lift the load up moves the lever up.

(3) **Slowing.** Move the Lever upward to slow to right and down to slow to left. Accelerate the engine gradually with the lever in required position, 'jib can be slowed completely round in either direction.

Note:-

(1). *The-foot should be takes off the accelerator pedal before moving the controller handle.*

2) *Crane can be moved forward and backward with jib in any position and load hoisted, the distance should not exceed the chassis length of crane.*

(3) *The crane jib can be derricked u*p *to 11/2 ton hoisted load.*

j. **Driving Crane on Road.**

(1) Ensure that the crane is in a fit state to be on road.

(2) Study the route before on road to ensure that there is no low bridge to obstruct.

(3) Wooden blocks are to be carried for emergency use, such at brake down on steep hill.

(4) **Driving on following roads are to be avoided as far as possible**.

(a) Low bridge.
(b) Roads with side obstructions.
(c) Narrow roads.
(d) City areas.
(e) While approaching a bridge check for clearance between height and width of the crane and bridge.

Maintenance

4. The object of this servicing is to ensure satisfactory maintenance and lubrication of close crane superstructure to increases its useful life.

a. **General Precaution**.

(1) Keep crane under cover when not in use.

(2) Protect bright parts with grease or oil.

(3) Use the oilcan on small pins, bonnet fasteners and the like. Most small fitting of this nature fail eventually through look of this small attention.

(4) Use the oil and the grease given on the recommendation chart keep them clean and do not mix various makes.

(5) Before putting the crane to work for the first time. Check right -through against the whole maintenance routine.

b. Maintenance (Daily)

(1) Check water in the radiator.

(2) Check oil level in engine sump and top up to mark on dipstick.

c. Every 50 Hours Use

(1) Hoisting, Derricking and slowing gear Boxes**. Fill the units with lubricant of the correct grade to the "F" mark on the dipstick.**

(2) Centre post bearing and centre post Busch: Grease with grease gun.

(3) Brake and clutch lever work generally**. Use oil can on moving parts.**

(4) Batteries. **Add distilled water if necessary, and test the specific gravity of each cell.**

(5) Engine (Petrol) Maintenance as applicable to MT petrol engine.

(6) **Engine Diesel**. Maintenance to be carried of the Engine as applicable to diesel engine MT vehicle

d. **Every 100 Hours Use.**

(1) **Controllers.** Examine and clean contacts. Grease contact surfaces lightly

(2) Blow cut any carbon dirt and inspect whilst running for Sparking at the brushes.

(3) **Hoist and Derrick Ropes.** Apply rope dressing compound when ropes are dry.

(4) **Propeller shafts.** Lubricate with oil of suitable grade.

(5) **Hoist Barrel shaft Bearing and Derrick Barrel Shaft bearing.** Use grease gun or a crow down grease cups.

(6) **Collector Column.** Blows cut any copper dust and apply a thin film of grease to the rings and the fingertips.

(7) **Derrick And Hoist Spur Gearing.** Apply grease of correct grade.

(8) **Jib stop Tubes.** (Strut type jib only) If these appear to be dry when Jib is at: maximum radius position, apply a liberal amount of grease to the inner tube.

(9) **All Rope shells.** Use grease gun where applicable.

(10) **Engine Petrol** Examine the oil for cleanliness, in the sump lubricate all the engine controls with oil can, etc.

(11) **Engine Diesel.** Examine the engine thoroughly and lubricate all the engine controls, and do the maintenance of engine applicable to the diesel engine.

(12) **Batteries.** Grease battery terminals with petroleum jelly.

(13) **Hoist Barrel brake and clutch control valves.** The perforated filter plate should be thoroughly cleaned and the fuel filter element either washed in clean paraffin of petrol or renewed.

e. **Procedures for Inspection**

(1) **Inspection.** Only engineers who have adequate understanding and experiences on the structure and handling of Truck Cranes should perform this inspection.

(2) **Inspection Method.** The inspection should be done with reference to this inspection sheet after reading through the relevant instruction and service manuals.

(3) **Measures for inspection results**

(a) Inspection results or items to be inspected should be recorded on the inspection sheet together with the inspection date.

(b) Any abnormal portion repaired to replaced according to the inspection results should be noted on "Remarks".

f. **Caution on servicing**

(1) If the hydraulic equipments have neither abnormality in operation check superior contaminants in the oil tank, avoid disassembling them as a rule.

(2) If any abnormality is found during inspection carried out according to the inspection sheet, take due measures (servicing) without fail.

BAF BASE ZAHURUL HAQUE (TRG WG)
(Aero Engg Trg Sqn)

Syllabus	**:**	**Automobile General Diesel and Petrol Technology**
Course	**:**	**MTO F Advance Trade Training**
Subject	**:**	**Maintenance of Specialist Vehicle**
Aim	**:**	**To Study Towing Tractor**
Ref.	**:**	**Operator's Manual (TG20-25, TD20-25)**

TOWING TRACTOR

Description

1. The life and the performance of the Toyota Towing Tractor will depend greatly on how it had been handled ad operated whilst it was still in the new vehicle stage. During the new vehicle stage, strict adherence to the instructions given below in addition to normal operational practices will not greatly reduce the wear and troubles in the engine and other parts, but will also enable you to get the maximum performance from your Toyota Towing Tractor.

a. Periodic inspection, service, and lubrication should be performed without fail. It may seem wasteful to spend time on such matters, but after all, it will result in rising operational time and cutting down on working cost.

b. Only the recommended fuel and lubricants should be used. Unless good grade fuel and lubricants are used, vehicle life will be shortened before you become aware of it.

c. The vehicle should always be warmed up before starting operations, and rough and reckless usage should be avoided.

d. If there is any abnormal noise or other unusual symptom, it should inspect and corrected with least possible delay.

Purpose

2. **Purpose of Towing Tractor is to carry aircraft and vehicle form one place to another place.**

Operation

3. a. **Before Operation Check.** Daily (8-Hour) Maintenance. To enable performing the day's work with safety, all operators of Towing Tractors should always perform the before-operation check before starting work.

Item	**Inspection Points**
1. Abnormal point of previous day	If something abnormal happened yesterday what was the reason?
2. External appearance	Is the vehicle tilted noticeably to one side? Are there any oil or water leakages, or any loosening or warping of parts?
3. Tires	Are the tires properly inflated and are they free from damage or abnormal wear? Are there any foreign matters on the tires? Are there any loose or broken hub bolts
4. Lights	Are they dirty or damaged? Do they turn on and off properly?
5. Radiator	Is the coolant up to proper level? Any water leakage?

6. Engine	Any water or oil leakages? Is oil up to proper level? How is viscosity and contamination? Is exhaust of proper color and is there any abnormal noise?
7. Foot brake	Is brake fluid up to roper level? Brake pedal reserve normal? Sufficient braking effect?
8. Clutch	Does clutch disengage properly? Pedal plays normal?
9. Parking brake	Has the lever proper pull reserve and braking effect?
10. Steering wheel	Any looseness or excessive play? Does it vibrate or pull to one side?
11. Horn	Does it operate? Is proper sound given off?
12. Meters	Are all operating normally?
13. Fuel	Is there sufficient fuel?

b. **Handling of a New Vehicle.** The performance and longevity of your Toyota Towing Tractor will be decided on how it has been handled while in the new vehicle condition. Up to the first 100 hours of operation, strict attention should be given to the following instructions.

(1) Unnecessary racing of the engine should be avoided.

(2) After starting the engine, it should be allowed to fully warm up before driving.

(3) Avoid rough driving and try not to place too much strain on the vehicle.

(4) Make sure to perform the period inspection in accordance with service booklet.

c. **Engine Starting Procedures** Set the transmission shift lever or control lever to neutral. Pull the parking brake lever to check if the vehicle is braked. For safety purposes, always start the engine in a well-ventilated area.

(1) When ignition switch is turned to the GLOW position, the glow plug controller will redden (about 20 seconds). (Diesel Models Only).

(2) When the ignition switch is turned to the "ON" position, check if the oil pressure warning lamp, charge warning lamp and temperature warning lamp lights, check fuel by fuel meter.

(3) Depress accelerator pedal slightly and turn ignition switch to the START position (for less than 5 seconds) and engine will start.

(4) After engine start, release hand from key. Key will automatically return to ON position. After engine starts, lightly depress accelerator pedal, check if engine oil pressure warning lamp and charge warning lamp goes out. Also check if meters are functioning properly.

d. **Operation of the vehicle** First step on either the class or brake pedal, and shift the gearshift or control lever into the proper gear. Release the parking brake, and while steeping on the accelerator slightly, release the clutch pedal slowly to operate the vehicle.

(1) Do not place your feet on the clutch or the brake pedal.

(2) Avoid starting the vehicle suddenly. This is very important when you are towing.

(3) When starting the vehicle whether you are towing or not, be sure to start in low gear. If you starting in high gear, this will shorten the vehicle's life.

e. **Towing**

(1) Slowly pull back towards the trailer so that the towing tractor's connection part faces the connecting part of the trailer.

(2) Pull the drove lever to connect the tractor to the trailer.

(3) Follow the instructions to start the tractor slowly.

(4) Check the brake first while driving at a slow speed.

(5) When connecting the trailer, confirmed that the draw bar pin is completely set in the draw bar bracket.

(6) When you tow the trailer (s), make sure that the loading of each trailer is proper and confirmed with the safety of the surrendering.

(7) When towing the function of the brake will differ. Therefore, check the brakes first while driving in low gear.

(8) The length from the front of the towing tractor to the end of the trailer will become very long. Be careful while driving specially at corners.

f. **Disconnecting** When you arrive at your destination, stop the vehicle completely and pull the draw-bar lever to disconnect the trailer.

Note: *Be sure that the vehicle comes to a complete stop be fore disconnecting the trailer. Otherwise it is very dangerous.*

g. Stop/Parking**Release the accelerator and step on the brake to bring the vehicle to a stop (while disengaging the clutch).**

(1) Be sure that the vehicle is completely stopped before dismounting. Do not dismount the vehicle while still in motion.

(2) While driving on upward slope, do not stop the vehicle by half clutching or using the torque converter. By doing this will cause increases wear of the clutch or rise in temperature of torque converter oil.

(3) When parking, park the vehicle in a designated lot. Make sure to pull the parking brake and remove the key.

Maintenance

4. In order to enable using Toyota Towing Tractor in good running condition at all times, it is necessary that it be given periodic maintenance. This periodic maintenance should be performed in accordance with the Toyota Towing Tractor Servicing Booklet. In this text, the assumption has been made that the Towing Tractor is being operated 8 hours a day under average working conditions. The relationship between the operating hours and the number of days will be then as follows:

4o hours---------------------------------1 week

170 hours-------------------------------1 month

500 hours-------------------------------3 months

1,000 hours---------------------------- 6 months

If the working environment and conditions are bed, it will be required to shorten the maintenance periods.

a. **Weekly Maintenance** Perform the following inspection and service in addition to the before-operation inspection. In regard to the weekly (every 40 hour) maintenance. The maintenance items listed below are concerned mainly with inspection and oil & grease replenishment. However, the oil and grease must be replaced if contaminated or contains foreign matter so that it is recommended that proper steps be taken at this time. The before operation inspection and weekly maintenance are centered around the user of the Towing Tractor himself. It is desired that adequate inspection be made to allow performing safe and sound work.

Table-1: Weekly Maintenance

Ser No	Inspection and Service item	Remarks
1.	Engine oil replacement	New vehicle only
2.	Air cleaner cleaning	Vehicle operating on paved road
3.	Tightening of bolts, nuts and cylinder rods	Perform at service shop
4.	Steering linkage grease up	Multipurpose grease
5.	Fan belt tension	
6.	Battery fluid level check	
7.	Torque converter oil check	

b. **Monthly (Every 170 Hour) Maintenance.** Perform the following work in addition to the before operation and weekly inspection and service items. The practice is to have the following maintenance performed at the service shop but the cleaning and inspection may be done by yourself. However, the work following the inspection and cleaning such as adjustment and replacement should be left up to the service shop.

Table-2: Monthly (Every 170 Hour) Maintenance.

Ser No	Inspection and Service Items
1.	Engine oil replacement
2.	Engine oil filter replacement (new vehicle)
3.	Engine slow and maximum speed inspection and adjustment
4.	Ignition timing inspection and adjustment
5.	Distributor point inspection and adjustment
6.	Tappet adjustment (new vehicle)
7.	Spark plug inspection
8.	Adding the governor diaphragm oil (2J)
9.	Fuel pipe line inspection
10.	Radiator inspection
11.	PCV valve inspection
12.	Steering linkage inspection and tightening
13.	Gear oils-inspection and replenishment
14.	Wheel bearing inspection and adjustment
15.	Clutch inspection and adjustment
16.	Stop switch inspection
17.	Shift lever and control lever inspection
18.	Piping inspection and tightening
19.	Draw bar inspection
20.	Fuel filter inspection

21.	Feed pump filter inspection and clean
22.	Parking brake inspection and adjustment
23.	Brake inspection and adjustment
24.	Steering knuckle king pin inspection

c. **Three Monthly (Every 500 Hour) Maintenance.** The maintenance items below refer mainly to replacement. The element and filter are parts that should always be replaced at this time. Failure to do so will eventually result in lowering the performance of the engine functional parts as well as causing unexpected trouble.

Table-3: Three Monthly (Every 500 Hour) Maintenance.

Ser No	Inspection and Service Items
1	Cooling water replacement
2	Engine oil filter replacement
3	Air cleaner element replacement
4	Battery specific gravity measurement
5	Propeller shaft inspection

d. **Six-Month (Every 1,200 Hours) Maintenance** The following maintenance work is the most important for Toyota Tractor. These are the maintenance items that are performed every six months or every 1,200 hours and these items are the most important on the towing tractor. Strict attention should be given and when necessary work should be performed by the Toyota Service Station.

Table-2: Six-Month (Every 1,200 Hours) Maintenance

Ser No	Inspection and Service Items

1.	Distributor point replacement (For gasoline model only)
2.	Spark plug replacement (For gasoline model only)
3.	Glow plug replacement
4.	Engine compression measurement, valve clearance adjustment
5.	Fuel filter, replacement
6.	Torque converter oil filter replacement
7.	Torque converter stall inspection
8.	All gear oil replacement
9.	Differential oil replacement
10	Wheel bearing (replace grease)

BAF BASE ZAHURUL HAQUE (TRG WG)

(Aero Engg Trg Sqn)

Syllabus : Automobile General Diesel and Petrol Technology

Course : Trade Training Advance, MTOF

Subject : Maintenance of Specialist Vehicle

Aim : To study Wrecker

Ref : Nissan Diesel Engine Model ND (T), PE (T) Operation & Maintenance Manual

WRECKER

Purpose

1. Purpose of wrecker is to lift off the vehicle from the road or clear the road for other users when vehicle is damaged by accident or brake down.

<u>Operation</u>

2. Starting Procedure (Automotive Use) is as flows: Apply the parking brake.

a. Place the transmission gear shift lever in **NEUTRAL**.

b. Insert the engine key into the key switch.

c. Fully depress the accelerator pedal, and turn the key to **ST**.

d. Do not hold the engine key in the ST position for more than 15 seconds at a time. Holding this position may shorten the life of battery, or damage the starting motor.

e. Be sure to wait about 20 seconds before trying again.

f. After starting the engine, release the key and at the same time, ease up on the accelerator pedal.

g. Turn the engine control button to adjust the idling speed, and then remove your foot from the accelerator pedal. Warm up the engine by letting it idle slight faster than the normal idling seed. Readjust the engine idling speed before driving. Never race the engine during warm up.

j. **<u>Starting Procedure in Cold Weather:</u>** when the automatic temperature is low and difficulty is encountered while starting the engine buy the above mention procedure, preheat the intake air by turning the starter key to HEAT before proceeding to step 4 above. The preheating period should be between 15 and 20 seconds. After preheating, immediately perform the operation of step 4 above to start the engine. Do not keep the starter key in the heat position for more than 40 seconds at a time. Before trying again, be sure to wait about 20 seconds.

k. **<u>Starting Procedure (Industrial Use)</u>**

(1) Insert the engine key into the key switch.

(2) Set the main switch at the “ON “position.

(3) While depressing the engine control button and pulling the adjusting screw all the way out, turn the engine key to the **START** position.

(4) Do not hold the engine key in the ST position for more than 15 seconds at a time. Holding this position may shorten the life of battery, or damage the starting motor.

(5) Be sure to wait about 20 seconds before trying again**.**

(6) When starting, release the engine key, and turn the adjusting screw to its original position.

(7) Turn the adjusting screw to adjus5t engine idling speed, and to perform warming up operation. In this case set engine speed slightly higher, and readjust the speed after warming up operation is over.

Note:- *Never race the engine during warming up period.*

(8) **<u>Starting Procedure in Cold Weather.</u>** when the atmospheric temperature is low and difficulty is encountered while starting the engine buy the above mention procedure, preheat the intake air by turning the starter key to PREHEAT before proceeding to step 3 above. The preheating period should be between15and20 seconds. After preheating, immediately perform the operation of step 3 above to start the engine. The air heater pilot light will remain on as long the starter key is kept in the PREHEAT position**.** *Do not keep the starter key in the HEAT position for more than 40 seconds at a time. Before trying again, be sure to wait about 20 seconds.*

(9) **<u>Caution During Operation.</u>** During engine operation, the warning light should remain off. If it comes on, immediately stop operation, and take the action that is described below. If any other abnormalities such as unusual noise, vibration or shocks are observed, again, stop operation and take the necessary action and repair.

l. **Stopping the Engine.** When operation of the engine is over, run the engine at engine at idling speed to lower the engine temperature before stopping.

(1) Using the engine control button, stop the engine.

(2) Return the key switch to the “OFF” position.

(3) Return the main switch to the “OFF” position. (Industrial Use)

Note:- *After heavy load operation or high speed driving, the engine tends to overheat. Allow the engine to idle to lower the engine temperature before stopping.*

m. **At Completion of the Day’s Operations.**

(1) Make sure that there is mo oil leak, water leak, or any other defects.

(2) Clean the exterior of the engine so that any oil leak, water leak, fuel leak or other defect may be easily detected.

(3) If antifreeze is not used in the cooling system in cold weather, be sure to discharge the cooling water to prevent freezing.

(4) Repair any faulty parts detected during operation.

Inspection and Maintenance

3. Periodic inspection and service will extend the life of an engine, and assure the maximum efficiency of its operation. After completing inspection and adjustment work, make sure that waste cloth, tools or any other foreign materials are not left on or near the engine.

a. **Inspection Interval** Initial inspection: 25hours or 1,000km,Subsequent inspections: Every 300 hours or 12000km.

b. **Valve Clearance**Standard clearance: when engine is cold Intake valve -------0.4 mm and Exhaust valve---------- 0.4mm.

c. **Inspection and Adjustment Procedure**

(1) Remove the rocker cover.

(2) Set the No-1or No-6 cylinder at top dead center (T.D.C.) in compression stroke.

(3) Open the flywheel pointer cover, and align the flywheel housing mark “1.6” with the needle of the pointer. If the marking on the injection pump housing is closely aligned with the timer marking, this indicates that the No.-1 cylinder is at T.D.C. position in compression stroke. (The cylinders are numbered as No-1, No-2 etc. starting from the fan side of the engine.) If the markings are opposite by 180^0, the No-6 cylinder is at the T.D.C. position in compression stroke. When the No-1(No-6) cylinder is at T.D.C. in compression stroke, the valves marked with a “O” can be adjusted.

(4) Check the valve clearance by inserting a feeler gauge between the valve stem and the rocker arm. If the clearance is incorrect, loosen the lock nut at the end of the rocker arm, and turn the adjusting screw with a screwdriver until the correct adjustment is obtained. After completing the adjustment, securely tighten the lock nut, and recheck the clearance.

(5) Thoroughly flush the inside of the cooling system, and use city water soft water in the system.

(6) When the cold season is over, thoroughly drain the cooling water, and flush the inside of the system.

BAF BASE ZAHURUL HAQUE (TRG WG)

(Aero Engg Trg Sqn)

Syllabus : Automobile General Diesel and Petrol Technology

Course : Trade Training Advance, MTOF

Subject : Aircraft Arresting Barrier type Aerazur

Aim : To study Textile brake, Textile assembly, stanchion System and Remote control system of Aircraft Arresting Barrier type Aerazur.

Ref : Technical Manual Operation and Service Illustrated Parts Breakdown.

TEXTILE BREAK AND NET

Introduction and General Information.

1. a. **Purpose.** The purpose of the emergency Aircraft Arresting System is to safely stop an aircraft, which, for any reason would otherwise overrun the limits of the runway. Braking is provided by the tearing of special textile straps of which the textile brake is composed.

b. **Limits.** The system is designed to operate at:

Ambient temperature range	:	- 40°C to + 70°C
Engaging velocities	:	≤ 190 knots
Energy absorbing capacity	:	38 M J
Run out distance	:	≤ 150 m.

c. **Description.**

(1) The Textile Brake consists of:

(a) A braking system comprising:

i. A braking line composed of two braking units each.

ii. Two extensions linking the braking units to the strops.

iii. Two strops for connecting the textile brake units to the net.

(b) The arresting system can be installed:

i. On concrete foundations (permanent installation). Or,

ii. Using earth anchors for temporary installation.

(c) The modules of the braking line must be from the same manufacturing lot in order to provide the same braking force on each side of the runway.

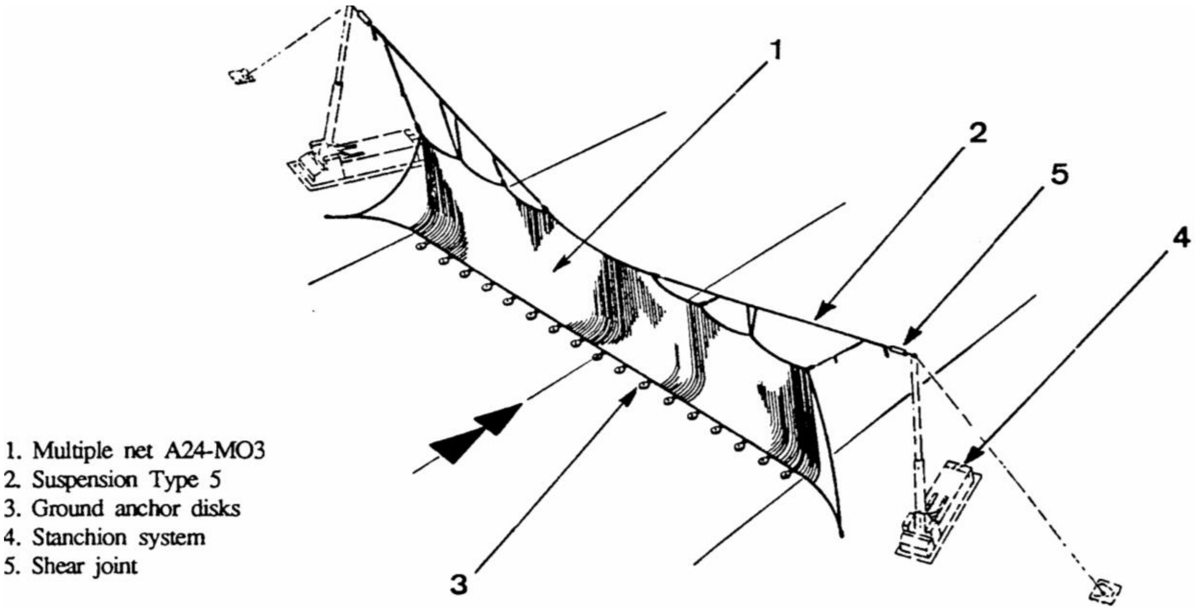

Fig-1: General View of Arresting Barrier with Multiple Net.

d. **<u>Textile Brake.</u>** The textile brake consists of:

(1) A brake line (Figure 1) composed of two braking units (Figure 2) installed on concrete foundations symmetrically to the runway centerline. A braking unit consists of a cover which accommodates the braking modules. A sample bag containing 4 samples for periodic tensile strength testing is fitted on top of the cover. The cover is maintained in position on the foundation by means of four adjustable straps located on either side of the cover, and by four lanyards passing through fastening lugs installed under the front part of the cover. A braking module (Figure 3) is made of two tear straps arranged for simultaneous activation. The tear strap consists of two elementary webbing woven together at the time of manufacture (figure 3). One elementary webbing of each of both tear straps is connected the harness by means of shackles. The two other elementary webbing are stitched together to form a loop for connection to the extension.

(2) Two extensions consisting of ten straps ending by loops and stowed in a protecting cover. The cover is fastened to the braking unit by hook and loop fasteners.

<u>e. **Strap Assembly.** This textile link is composed of three webbing straps saddle-stitched together and two reinforced eyes to receive the connecting link. A leather cover protects the link.</u>

Preparation of Use and Shipment.

2. a. **Aircraft Considerations.** The MB5O.10.N system is designed for safely stopping aircraft engaging at a maximum energy of 38 MJ.

b. **Positioning of the System on the Runway.** The system can be installed anywhere along the runway overrun provided that a run out distance of at least 150 m be available.

(1) The layout of the arresting system provides a sound operational system for the recovery of aircraft on take off as well as on landing.

(2) Areas of sufficient strength may be used to increase the end of run out distance.

c. **Topography.** A topographical survey of the installation site should be carried out prior to permanent installation. The following points are of particular importance.

(1) The installation site should be reasonably flat and grading should be planned if necessary.

(2) There should be no obstacles in the vicinity of the arresting area, (airfield lighting in particular).

(3) Shoulder elevations should be taken for preparation of the installation plan in relation to the centerline of the overrun area and to a known bench mark if possible. These should be at three meter intervals for the first 30 meters adjacent to the runway and ever 309 meters thereafter.

(4) Taxiways, perimeter roads, utilize and other facilities near the installation site should be carefully noted.

Operation Instruction.

3. a. **Operating Principle.** The Arresting system operates automatically. When the net is engaged, the aircraft is slowed down by the continuous tearing force provided by the 20 braking modules of the braking line. During braking, the protective cover of the modules remains attached to its anchor and the tear straps pay out as the aircraft moves forward.

b. **Operation.** Check that the covers and anchors are in good condition. Any anomaly should be reported as it may have an effect on the performance of the textile break and net aircraft arresting system. Check that there are no obstacles in the area swept by the straps when arresting the aircraft.

c. **Reconditioning after Engagement.** Before taking any action, disengage the aircraft from the net. Clear the area of used items. Check the anchors, lanyards and shackles and replaced any distorted items. It is imperative that the following items be changed:

(1) The two straps.

(2) The braking line.

(3) The extension.

If there is any doubt concerning any component, it should be changed. Later examination will determine if the item is serviceable or not.

Maintenance Instruction.

4. a. **Mandatory Maintenance Instructions.** Apart from periodical visual inspections this system only requires a sample test every two years when in service and every five years when stored. Its service life is ten years and its self-life is fifteen years.

b. **Inspection and Preventive Maintenance.**

(1) **Daily Inspection.** Carry out the operation described earlier.

(2) **Annual Inspection.** Clean and lightly grease all metal anchor components (avoid getting grease on textile components).

c. **Installation/Removal.**

(1) **Covers**.

(a) **Breaking Unit**.

i. Unfasten the extension cover.

ii. Open the zip fasteners.

iii. Unfasten the eight cover anchor straps and cut the lanyards passed through the fastening lugs.

iv. Remove the cover from the back by withdrawing the modules one by one from their housings without forgetting the test sample bag.

v. Install the new cover and insert the modules.

(b) **Extension**.

i. Disengage the extension from the strap and from the breaking units.

ii. Cut the closure cords and remove the damaged cover.

iii. Align the new cover and connect the cord inside the corresponding strap eyes in respective order. Don't invert the ends.

iv. Pull the cord to draw the straps into the cover taking care not to damage the whippings placed at one-meter intervals.

TEXTILE ASSEMBLY

Purpose of the Textile Assembly.

1. The purpose of the textile assembly is to confide the kinetic energy of the engaging aircraft to the energy absorbers. The present handbook only deals with the textile assembly and its ground anchors .For any information on the arresting gears, the remote control system and the stanchion system, refer to the relevant manuals. A complete Arresting Barrier consisting of following components:

a. A Textile assembly and the associated Stanchion System.

b. A remote control system.

c. An arresting gear.

Composition of the Textile Assembly.

2. The textile assembly is attached to the ground by 17 anchor discs secured by means of expansion bolts onto the runway. A textile assembly consists of following components:

a. 1 multiple net B24-MO3.

b. 1 suspension type 5.

General Description.

3. The multiple Net B24-MO3 is made of 24 separate net separate net elements superimposed on each other, displaying the general configuration as seen in figure. The net elements are primarily made of polyamide treated against abrasion and UV rays and assembled into one multiple net.

Measurements.

4.

Total Length	:	58m
Height	:	5.50m
Working	:	47m
Normal working height at the centre	:	4.73m ± 0.2

Nominal Resistance.

5.

Vertical Strap.	: 3000 daN
Horizontal Strap.	: 3000 daN

Weights.

6. a. Textile assembly stored on its reel : 690 kg.

b. 17 ground anchors : 40 kg.

Net Element.

7. Each net element is made up of an upper horizontal strap and two bottom horizontal straps. These straps are connected to one another by 22 vertical straps; spaced according the values provided in table on figure 1-2 sheet 1 of 2. All are made of polyamide treated against UV and abrasion. Nominal strength is 3000 daN per vertical (width 30 mm), and 2000 daN per horizontal (width 25 mm). The top horizontal is connected on each side of the net to the two lower horizontals to form two loops intended for coupling to the energy absorbers. In addition, the top horizontal straps are fitted with loops for attachment of the net to the suspension. Incorporated into each end of the horizontals are rendering elements

or shunts detailed in figure 1-2, sheet 2 of 2, detail f. Their breaking strength is rated at 700 daN.

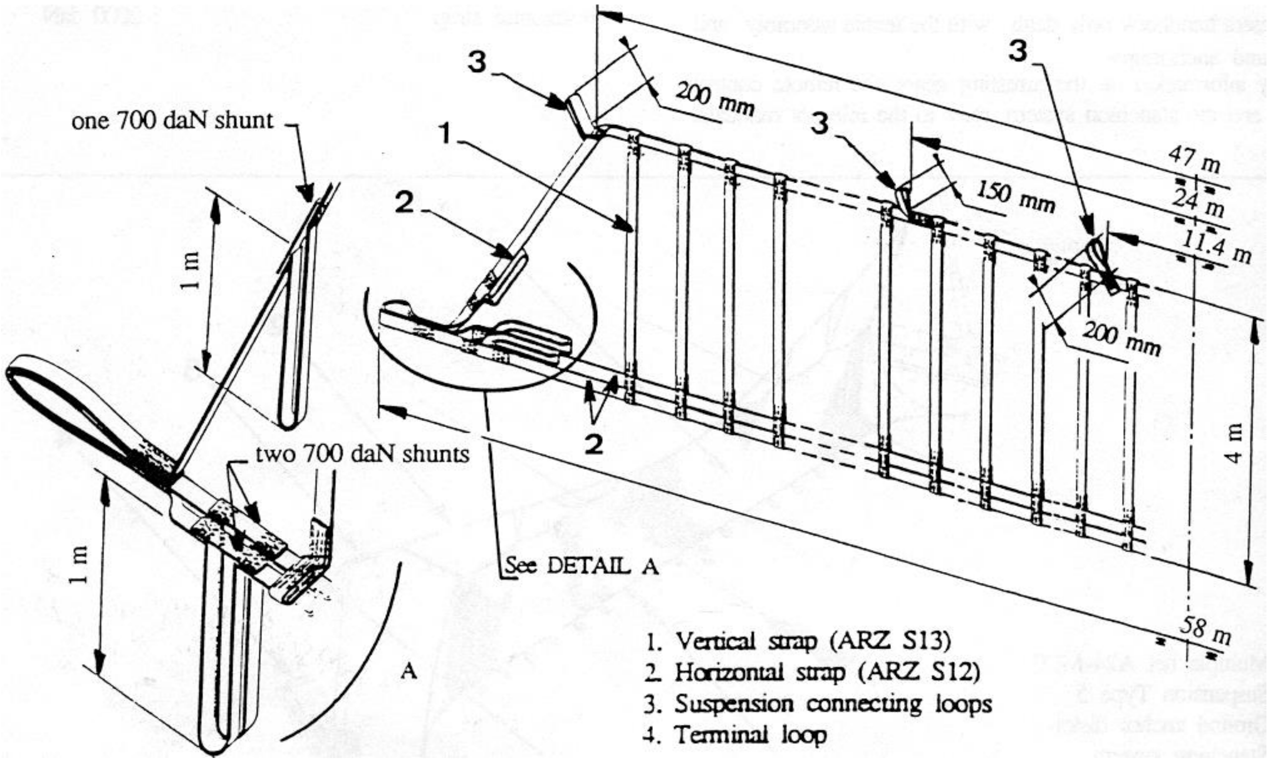

Fig-2: Net Element.

a. **Assembly.** The 24 net elements are grouped by 6 and joined together at their terminal loops at each of their lower ends. The four groups of net elements (groups A to D) are joined together to form a complete net. The assembly is made by attaching a R707 A445 cord (550daN) around the horizontals with a square knot secured by a loop knot, spaced approximately by 2 meters from one another.

b. **Ground Anchoring Straps.** The lower horizontal straps of the net are attached to the ground by 17 anchoring straps to which they are attached by cord loops (R707 A445).

c. **Net Marking.** The assembly is marked as follows:

(1) **On each Element.** At the centre and on the edges, on the upper part of the horizontal strap, the element number: A1- A2 …. B5 - B6 …. D24 is indicated.

(2) On the Net. **The centre of the net is marked in red, width 300 mm, on the upper and lower parts of the horizontal strap of the first and last element.**

(3) The letters G/LH and D/RH are marked in white on the upper part, down side, on the horizontal strap of the last element.

(4) The net series number is marked in white at the top right of the first horizontal strap and at the left near the snub above the first loop of the net.

d. Operation.

(1) General. **For highest efficiency of the textile assembly, following tests should be performed:**

(a) Inspect the net assembly stretched out across the runway.

(b) Check ground anchor straps inserted into the anchor discs.

(c) Check upper horizontals connected to the suspension, itself connected to the shear pins.

(d) Check net terminals loops connected to the energy absorbers.

(2) Erection Phase.

(a) If all preceding checks have been performed satisfactorily, including those concerning other components.

(b) If no electrical or mechanical hindrance is apparent either at the control tower or on the installation site.

(c) If all safety conditions have been respected.

(3) Net. **The aircraft engages the net while the suspension is stretched until the shear joins give way. When these have broken, the net is no longer attached to the stanchion system but remains**

connected to the energy absorbers through its terminal loops. The 24 net elements unfurl over the aircraft separately, allowing all constituent straps to be dispersed. The lower horizontal straps then separate from the ground anchor straps in a chain reaction, breading the 408 loops made of breaking cord. The net is dragged by the aircraft, which activates the energy absorbers. Each net element is solicited according to its position on the aircraft structure. The resulting effort at each terminal loop is limited to a value of 1400 daN by the possible breaking of purpose designed shunts on the lower horizontals (2 shunts in parallel on each side of each net element) and to 700 daN on the oblique terminal horizontal (1 shunt only).

Use.

8. a. Performance Characteristics. **The performance characteristics of an AERAZUR aircraft-arresting barrier, particularly as far as the textile assembly is concerned, are as follows:**

(1) Normal height of a 24 element net assembly in dry or wet condition, not frozen to the ground or covered with snow, when raised is: 4.73 ± 0.2 meters.

(2) Temperature operating range: – 40° C to + 70° C.

(3) Engagement of the net by an aircraft up to a speed of 190 knots.

Note**: To avoid any risk, which could result from the presence of the net permanently raised at the end of the runway, it is recommended that the net be erected only when required, event in the case of manual remote control.**

b. Preparation of Net and Suspension for Use. **Personal in charge of the daily maintenance of the stanchion system should at the same time perform following checks on the textile assembly:**

(1) Ensure that all textile connections and all breaking components are in good condition:

(a) Anchoring straps of the net to ground.

(b) Connection of the net to suspension.

(c) Connection of the net to the energy absorbers.

(d) Ensure that the straps are not twisted.

Trouble Shooting.

9. This section contains instructions for troubleshooting. The following trouble shooting chart describes service troubles that might be encountered, their probable causes, and the recommended corrective action.

Trouble	Probable Cause	Check Required	Remedy
Net not stretched normally	**Net improperly set on ground anchors.**	**Check position of ground anchoring straps from centre of runway.**	**Set them in place and check condition of breaking cords.**
	Suspension straps too loose or too tight	**Check strap attachments.**	**Retighten suspension or guy wire**
Insufficient net height.	**Suspension straps too loose or too tight.**	**Check that suspension components are set correctly.**	**Tighten or loosen the suspension (or guy wire)**

Maintenance.

10. a. General. **This section includes checking and maintenance operations to ensure that the textile assembly is in operating conation.**

b. Daily Operations. **Perform the checks listed in paragraph (Preparation of net and suspension for use).**

c. Bi-Monthly Operations. **An erection of the arresting barrier shall be performed according to the instructions provided in the technical manual relating to the stanchion system. After erection:**

(1) Check the net.

(2) Check the net height.

(3) Check the suspension.

d. Semi-Annual Operations. **Remove one horizontal sample strap and one vertical sample strap from the sample assembly. These samples should be sent to the manufacturer and subjected to laboratory tests for remaining tensile strength. The manufacturers will for ward the results of**

these tests to the customer as soon as the y is performed. Minimum acceptable strength is:

(1) 1300 daN for horizontal straps.

(2) 1900 daN for vertical straps.

STANCHION SYSTEM

Introduction.

1. The purpose of the stanchion system type 7 is to provide support and remote control movement for a barrier net, which serves as an engaging device for arresting non-hook equipped aircraft, which for any reason, would otherwise overrun the limits of the runway. The stanchion system type 7 is basically designed for permanent installation on-grade or below-grade. It is operated by remote control either from the tower or from the installation site (Refer to Technical Manual 256-701 issued as basic instruction for operation and service of the Remote Control Assembly Type 7.

General Description.

2. Figure below shows a complete aircraft arresting barrier installation consisting of the Type 7 stanchion system with multiple elements net and the energy absorber units .The stanchion system Type 7 is compatible with all Absorber types as Friction Brakes, Hydraulic Rotary Brakes and Textile Brakes. Each assembly consists of (see figure below):

a. A base assembly	b. A cylinder.
c. A reservoir.	d. A pneumatic power Assembly.
e. An electrical assembly	f. An actuator
g. A stanchion manual locking assembly	h. An interface assembly
j. A guy assembly	

Composition of Arresting Barrier.

3.	a. Multiple element net.	b. Aerazur M6 energy absorber unit.
	c. Guy Wire Assembly.	d. Suspension Line.
	e. Net Support.	f. Release system.
	g. Stanchion.	h. Tape Connector.
	j. Remote Control Assembly.	k. Warming Panels.

***Note**. This figure shows the connection with the mechanical brake AERAZUR M6. The Stanchion Type 7 is compatible with all friction brakes, hydraulic rotary brakes, and textile brakes with similar installation.*

Particulars of Stanchion System.

4. a. **Overall Dimensions.**

Length	:	2.85 meters.
Width	:	0.92 meters.
Height	:	0.60 meters.

b. Length of the mast : 7.00 meters.

c. Total weight (less option items) : 1.250 kg.

d. Pneumatic system operating pressure : 31 to 47 bar.

e. Pressure reducer nominal setting : 41± 1 bar (1), 37 bar (2), 24 to 25 bar

Notes. *(1) As per 40 element Net.*

(2) As per 30 element Net.

(3) As per 24 element Net.

f. Power supply : 24 VDC (through remote Control system).

g. Power requirement for one “UP “cycle : 150 W approx.

h. Ambient temperature operating range : - 40°C to + 70°C.

j. “UP’’ cycles with one cylinder : 18 (pressure setting: 24 bars/cylinder: 250 bars).

k. Nominal Shear Link Strength : 4.000 daN

l. **Cycle Time.**

“UP’’ cycle	:	1 second.
“DOWN’’ cycle	:	7 seconds.

m. Net Maximum Center Height : 3.70 m ± 0.20.

n. Maximum Engaging Velocity : 190 knots.

p. Optional Manual Erect Stanchion System weight: 50 kg approx.

General System of Operation.

5. When emergency stopping of an overrunning aircraft is anticipated, the stanchions connected to the net are erected by remote control from the tower. When installed, the flashing warming light confirms the erection. Operation of the remote control energizes solenoid valves of the power assembly which supplies pneumatic energy to an actuator connected to the stanchion .The net envelops the aircraft as the arrestment progresses. After coming to a stop, the aircraft is disengaged from the net and the barrier brought back to the ready stand by status.

Detail Description.

6. a. **Base Assembly.** The base assembly is a welded frame made of iron section. The longitudinal steel sections fitted to the bottom of the base act as rails for the roller f the stanchion actuator. A cross frame supports the ball joint of the actuator piston rod. The stanchion is hinged on a vertical frame at the rear part of the base. A limit switch installed on the frame supplies the control system with the stanchion “UP” information. All sub assemblies are mounted on the base and protected by removable covers. Lifting of the assembly is enabled by four eyebolts installed on the upper side of the frame.

b. **Cylinder.** The cylinder supplies the system with pneumatic energy. It contains 55 liters nitrogen at 250 bar (12.5 cu. meter expanded). The cylinder allows 18 cycles at the 25 bar rated pressure.

c. **Auxiliary Cylinder Assembly.** This optional item consists of two additional cylinders, identical to the previous one. They are installed in parallel with the basic cylinder and fix on a separate frame located close to the base assembly. Approximately 50 cycles are permitted with three cylinders installed.

d. **Reservoir.** The pneumatic energy for the stanchion erection is stored in the reservoir. After erection, the replenishment occurs automatically as soon as the stanchions have reached the ‘UP’ position. It includes a manual bleed valve also equipped with a silencer.

e. **Electrical Power Assembly.** A terminal block constitutes the interface between the remote control assembly and the stanchion system. Following wire harnesses and cables connect the terminal block to the solenoid valves, limit switches and pressure gauges.

(1) 1 wire harness for connection.

(2) 1 power harness is connecting the 8 cables to the terminal block.

(3) 1 cable for the “UP” limit switch.

(4) 1 cable for "LOCKED" limit switch.
(5) 1 cable for "DOWN" limit switch.

(6) 1 cable for "UNLOCK" limit switch

Operation Instruction.

7. a. **Pre Operation Check.** Prior to operation, perform the daily checks.

b. **Safety Precautions**. In order to prevent injury during inspection due to inadvertent rising, it is MANDATORY to lick the system before allowing the maintenance personnel to approach. Locked status of the system can be evaluated by the position of the flag on each of both assemblies:

(1) Flag HORIZONTAL – Stanchion assembly UNLOCKED.

(2) Flag VERTICAL - Stanchion assembly LOCKED.

(3) Never erect the stanchions without the net. This would damage the system, in particular the mast assembly.

(4) Never charge the reservoir to a pressure above 47 bars. Otherwise the normal service limits would be exceeded for certain components of the pneumatic power system. To avoid any risks, a relief valve is installed on the pneumatic manifold assembly. It is advised to adjust the pressure reducer to 47 bar by increasing pressure, continuously checking the level reached.

c. **Lowering of Stanchions.** The stanchions are lowered by activating the mast- lowering switch on the control panel.

d. **Check of Equipment Condition.** Normally no parts should be damaged following an engagement. However particularly thorough inspection of the mechanical condition of the equipment is equipment is required.

e. **Erection Tests.** After installation of the new net, it must be checked that operation of the field stanchion system is satisfactory. This is done by performing two consecutive erections from the field cabinet control panel, using EV-EV selection of the solenoid valves.

f. **Operation With Manual Erect Stanchion System** The optional manual erect stanchion system provides a mans to keep the stanchion assembly usable for fail safe operation. In the event of a pressure failure or of any defect with the remote control system, a tension is applied to the upper part of the mast, by means of the manually activated winch (Tirfor) pulling the wire rope and its hook locked to the mast. In first step carry out by a hand lift of each upper part of the mass so as to obtain a sufficient angle of wire rope alignment versus the horizontal. Then operate in same manner both winches to lift the masts up to the right position of the net.

Periodic Inspection, Maintenance and Lubrication.

8. a. **General.** In order to maintain the stanchion the system in peak operating condition, operation personnel should observe the complete equipment after arrestment to detect any possible malfunctions and correct these potential causes of trouble. During arrestment personnel should carefully watch for any sluggishness or erratic movements in the equipment. Any abnormalities detected in operation should be brought to the attention of proper maintenance personnel.

b. **Periodic Inspection and Preventive Maintenance**. Operational UP/DOWN operations which are scheduled are conducted in conjunction with the remote control assembly type-7 operations (for this latter assembly instruction refers to the technical manual 256-701).

Scheduled Inspections.

c.

Operation	**Interval(Most Frequent Applies)**				
	Daily	**Each Arrestment**	**Day**	**Yearly**	**Every 3 Years**
1. Check high pressure gauge (Recharge if necessary).	x	x			
2. Check low pressure gauge (Adjust pressure Reducer if necessary).	x	x			
3. Functional check–Up cycle Operate the stanchion system (two times). One operation from Tower control Panel, the other from field cabinet, change position of EV or EV every two weeks, setting with use of solenoid valve test control.		x	15		

Operation	**Interval(Most Frequent Applies)**				
	Daily	**Each Arrestment**	**Day**	**Yearly**	**Every 3 Years**
4. Check rod condition and backpressure chamber vent on actuator assy. (Close the plug tight after checking).		x	15		
5. Inspect guy wires and attachments (wear and damage).		x	15		
6. Inspect tube condition of the mast and mast retaining assembly.		x	15		
7. Inspect flag and control levers of locking system (check for damage).		x	15		
8. Inspect anchor assemblies for security.		x	15		
9. Inspect piping and fitting condition.		x	15		
10. Inspect electrical interconnections on the pneumatic power assembly side.		x	x	x	
11. Check runway at barrier site and surrounding of stanchion system to be clear of obstruction	x				
12. Check and recalibrate all the outer and inner side of reservoir and main actuator (see part 2-overhaul instructions.				x	
13. Operate UP/DOWN cycle as indicated at step 3. Check all solenoid valves.					x

Operation	**Interval(Most Frequent Applies)**

	Daily	Each Arrestment	Day	Yearly	Every 3 Years
14. Check for regulations conformity the outer and inner side of reservoir and main actuator (see part 2-overhaul instructions.					x
15. Check shear link to be good condition.	x				
16. If manual –erect stanchion is used inspect wire rope, which and attachments.		x		x	

Table for Periodic Inspection and Preventive Maintenance.

Scheduled Preventive Maintenance. *Table Continued*

Ser No	Operation	Interval
1.	Operate pressure reducer hand wheel.	Yearly
2.	Clean and lubricate all the anchors of the stanchion system. Check anchors tightening (torque 15 daN.m).	Yearly
3.	General lubricate, and in particular for actuator rods and guy wires.	Yearly
4.	Clean exhaust filters (silencers) with suitable cleaning agent.	Yearly
5.	Replace pressure reducer rupture disc (tighten rupture disc attaching nut to torque of 3 daN.m).	Yearly
6.	Change flags indicating locking of barrier	Yearly
7.	Replace seals and parts included in the associated maintenance kit on the actuator.	Every three years
8.	Prior to resemble components of step 7. Clean and lubricate with OCCLUBE ANTISEIZE compound or similar.	Every three years

Ser No	Operation	Interval
9.	Replace all the seals which become accessible during	Every three

	parts replacement	years
10.	Replace seals and parts of pressure reducer (included in its maintenance kit).	Every three years
11.	Replace pressure by new ones (or by manufacturer's overhauled specimen).	Every three years
12.	Replace solenoid valves by new ones (or by manufacturer's overhauled specimen).	Every three years
13.	Replace all the flexible hose	Every three years
14.	Replace pressure relief valve (with seal) on pneumatic manifold and vent manual bleed valve or reservoir.	Every three years
15.	Prier reassembles components of reservoir lubricant and assembles new seals (included in maintenance kit).	Every three years
16.	Change frame protectors of reservoir supply hoses.	Every three years
17.	Change a refilling spherical gate valve (on control panel)	Every three years
18.	Change shear link assembly	Every six months or every 40 erections.
19.	If manual-erect stanchion system is used, general lubricate for wire rope and TIRFOR winch mechanism	Yearly

REMOTE CONTROL SYSTEM

Purpose.

1. a. **Function.** Main Functions of the Remote Control Assembly are:

(1) To generate raising and lowering orders for the stanchion system type 7.

(2) To monitor the operational status of the stanchion system type 7.

b. **Actuation.** Actuation is possible:

(1) From a main control panel located in the ATC Tower (operation configuration)

(2) From a control panel, located in the field cabinet close to the stanchion system (maintenance configuration).

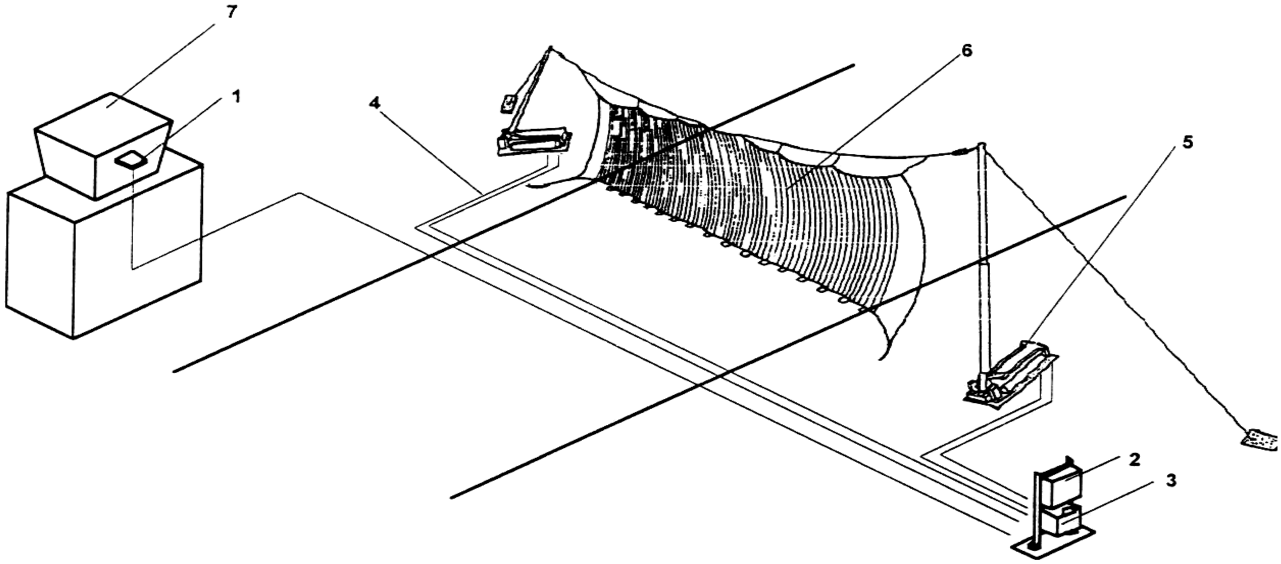

Fig-3: Stanchion System type 7 and Remote Control Assembly

1. Remote control assembly tower control panel.	2. Remote control assembly field cabinet.
3. Remote control assembly battery enclosure.	4. Embedded hardwire network.
5. Embedded hardwire network	6. Embedded hardwire network.
7. ATC Tower.	

General Description.

2. To control one stanchion system type 7, at one end of the runway, the remote control assembly mainly consists of (refer to figure below).

a. **At the ATC Tower.** A tower control panel.

b. **Close to the Stanchion System Type 7:**

(1) A field cabinet

(2) A battery enclosure

c. An embedded hardwire network (4) that connects these three subassemblies to the two sanction assemblies.

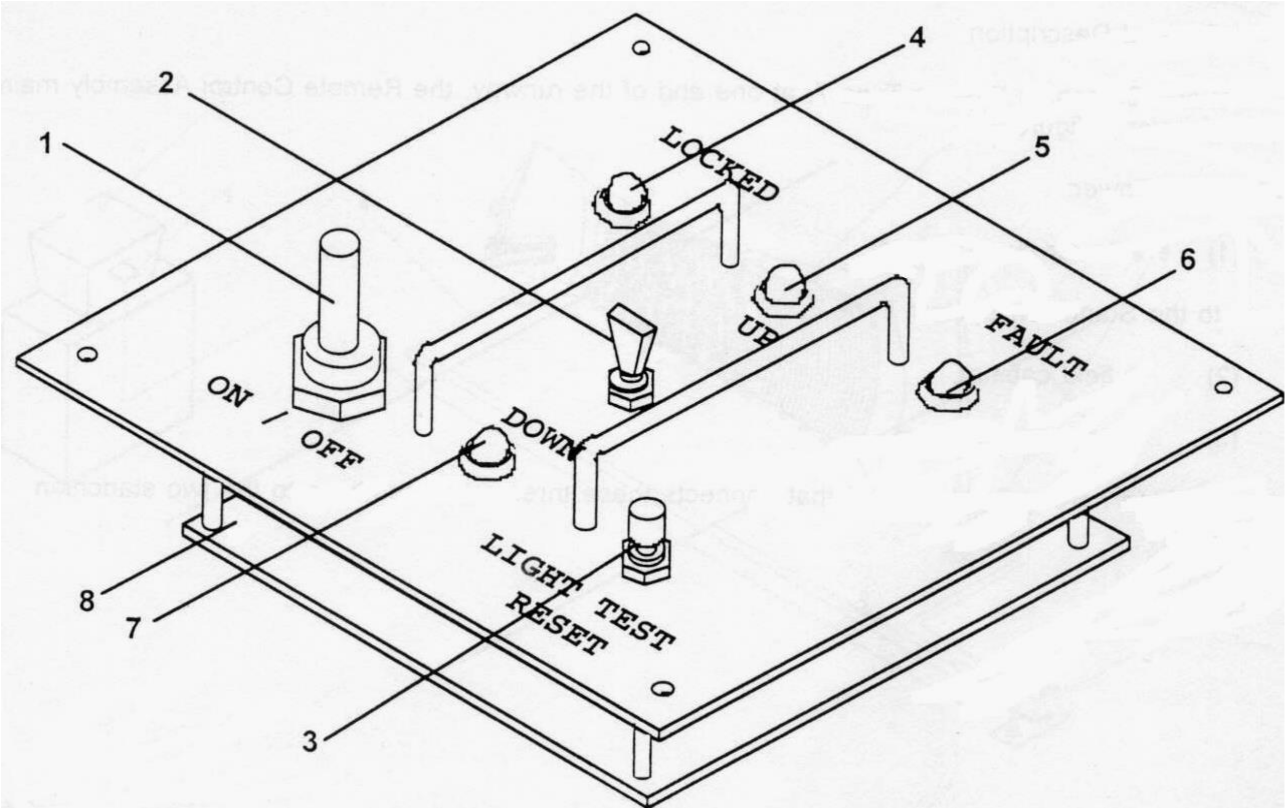

Fig-4: Tower Control Panel

1. On/Off switch.
2. On/Off switch.
3. Light Test Reset push button.
4. Locked red led.
5. Up green Led .
6. Fault red Led.
7. Down blue Led.
8. Down blue Led.

Detailed Description.

3. a. **Tower Control Panel.** The tower control panel consists of a metallic front plate; holding on it's underneath a printed circuit board. This board integrates actuation and control devices for the control and monitor components located on the front plate. The control component consists of:

(1) A two position switch S1 "ON/OFF" for activating or deactivating the remote control assembly for one end of the runway.

(2) A two position switch S2 "UP/DOWN " designed to control the raising and lowering of the two stanchion assembly masts.

(3) A black pushbutton S3 "LIGHT TEST RESET" designed to:

(a) Test all the indicator LED s of the tower control panel and activate the optional horn.

(b) Turn off the optional horn in case of a stanchion system failure.

(4) The monitor components consist of:

(a) A red LED "LD1": "LOCKED" indicating when lit, that one of the two stanchion assemblies is locked.

(b) A green LED "LD2": "UP" indicating when lit, that the two stanchion assembly masts are in the UP position.

(c) A red LED "LD3": "FAULT" indicating when lit, that one or more of the following events has occurred:

i. The low pressure of one of the stanchion assemblies is lower than the preset threshold.

ii. The control switch "SITE/TOWER/ MAINTENANCE" of the field control panel is not on the TOWER position.

iii. The battery voltage is lower than a preset threshold.

(d) A blue LED "LD4": "DOWN" indicating when lit, that the two stanchion assembly masts are in the DOWN position.

Field Cabinet.

4. The field cabinet is a waterproof stainless steel case, attached to galvanized mounting frame. This mounting frame, also holding the battery enclosure, is installed on a specific concrete pad close to the stanchion system. Field cabinet components mainly consist of:

a. A field control panel (4).

b. A Field printed circuit board (110.

c. AC voltage circuit.

d. DC voltage circuit.

e. A battery charger printed circuit board (10).

f. Connectors (16).

The field cabinet also integrates a heating resistor designed to reduce temperature variation and to dry out the inside of the cabinet. It is designed to easily and quickly disconnected from the other arresting system subassemblies, and from the power supply network. Al connectors are fully water proof and equipped with sealed covers. In case of any problem occurring to the ATC tower the remote control assembly can still be operated. The tower control panel will be removed from the ATC tower, and installed into the field cabinet. It will be connected by specific cable to the field printed circuit board, and the cable going from the ATC tower to the field cabinet will be unplugged from the underneath of the cabinet. Action of the stanchion system will be possible either from the field control panel or from the tower control panel.

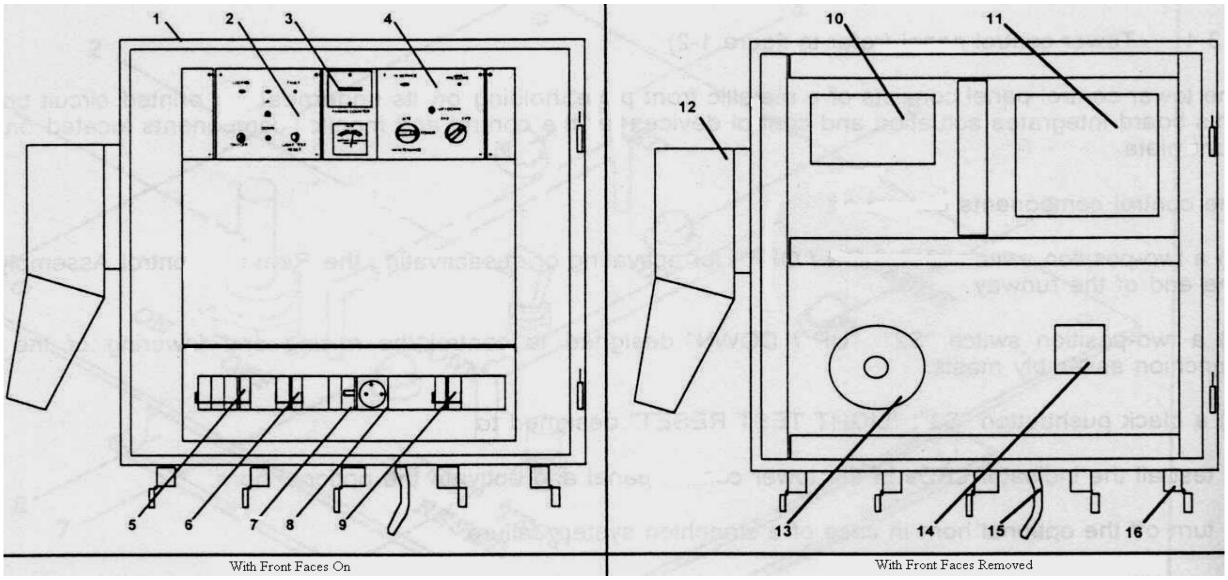

Fig-5: Field Cabinet.

1. Field cabinet.	2. Tower control panel
3. Field control panel extension.	4. Field control panel.
5. AC fused circuit breakers F1 to F4.	6. Heating resistor fused circuit breakers F5 and F6.
7. 220 V AC outlet differential breaker F7.	8. 220 V AC convenience outlet.
9. Battery breakers F8 and F9.	10. Battery charger printed circuit board.
11. Field printed circuit board.	12. 220 V AC power supply inlet.
13. 220 V AC / 30 V DC power supply	14. Heating resistor transformer.
15. Battery cable.	16. Connectors.

Circuits.

5. a. The AC circuit (220 VAC/50 Hz) of the field cabinet consists of:

(1) A power supply inlet (12) that can be connected to a 330 VAC or 220 VAC power supply network.

(2) Four fused circuit breakers (5) F1 to F4 general protection.

(3) A 220 VAC to 2 x 15 VAC transformer (13) “TR1”. From the secondary wiring of “TR1”, a voltage of 30 V AC is supplied to the battery charger printed circuit board.

(4) A convenience outlet (8), 220 VAC, limited to 16 A and protected by safety differential switch (7) F7,

(5) Heating resistor (14) “HR1”, protected by two fused circuit breakers (6) F5 and F6.

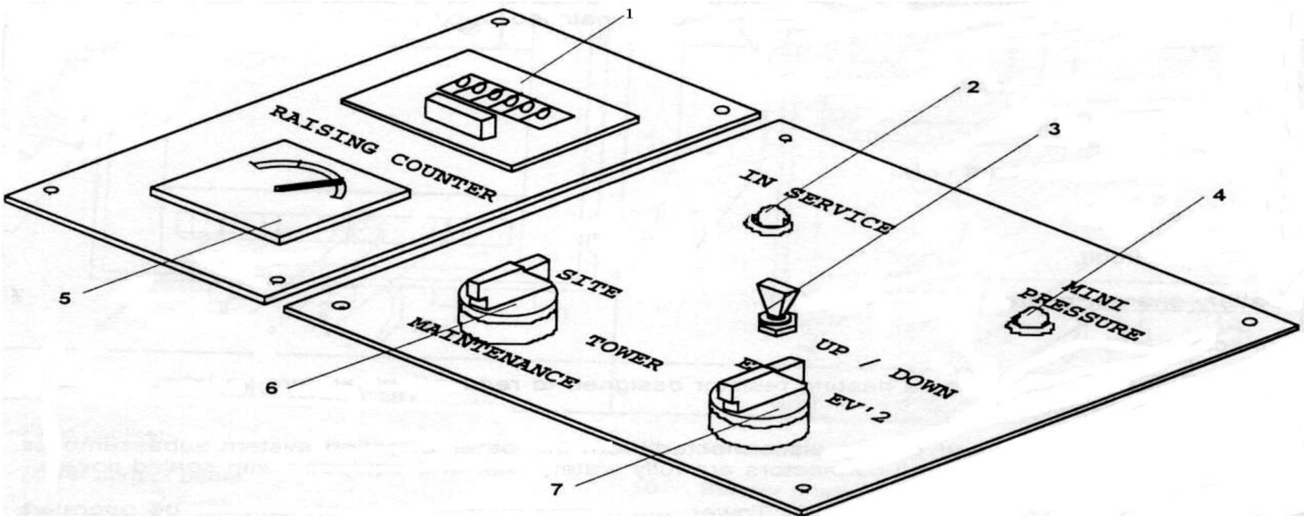

Fig-6: Field Control Panel.

1Raising	2. “In Service” green led
3. “Up / Down “ switch	4. “Mini Pressure” red led
5. Battery voltmeter	6. “Site / Tower / Maintenance” switch
7. “EV 2 / EV 2” switch	

DC Circuit.

6. a. The DC supply circuit consists of:

(1) A battery cable (15) coming from the battery consoler.

(2) Two fused circuit breakers (9) F8 and F9 protecting the DC circuit.

From these breaker, battery voltage (24 VDC is supplied to the battery charger printed board (10)

<u>Field Control Panel</u>.

7. a. The field control pane consists of two metallic front plates. They include the following components:

(1) A 6 digit raising couture CPT1 designed d to automatically count stanchion assembly masts rising. The counter is equipped with a manual reset pushbutton. This counter is designed to help maintenance personnel in knowing when to replace stanchion system shear links (every 40 raisings).

(2) A green LED “D6” IN SERVICE “indicating when lit that the remote control assembly is in service (the switch “S1” on the tower control panel is in the “ON” position”.

(3) A two-position switch “S2”: “UP/DOWN “designed to control the raising and lowering orders for the two stanchion assembly masts.

(4) A red LED “LE5” “MINI PERSSSURE” indicating when lit that the remaining voltage of the battery is lower than a preset threshold.

(5) A battery voltmeter “V1” designed to monitor to maintenance personnel remaining battery voltage. This voltmeter is divided int0 three coloured areas: red, yellow and green. In case of a long-term power supply failure, this voltmeter is to be considered as an indication that the batteries can remain in service, or need to be recharged.

(6) A three position switch “S1” SITE /TOWER /MAINTENANCE” designed to control which panel is actuating the stanchion system.

(a) As “S1”is in the SITE position, control of the stanchion system is from the field cabinet. No actuation is possible from the tower control panel.

(b) As “S1” is in the Tower position, control is from the tower pane. No actuation is possible from the field cabinet.

(c) Maintenance is a safety position for maintenance operations: no actuation is possible from any panel.

(7) A two position switch “S3”: “EV2/EV2”: designed for the separate testing of the duplicate raising solenoid valves.

<u>Field Printed Circuit Board.</u>

8. a. The printed circuit board integrates all the control components and the: Following monitoring LEDS indicating when lit that:

(1) “LD1”on, relay “K8” is energized, and power is supplied to the two solenoid valves ‘EV’3.

(2) LD2”on, relay “K5” is energized, and power is supplied to the two solenoid valves EV’2.

(3) LD3”on, relay “K6” is energized, and power is supplied to the two solenoid valves EV’2.

(4) LD4”on, relay “K9” is energized, and power is supplied to the two solenoid valves EV’3.

b. The field board is equipped with 11 connector receptacles as follows:

(1) “J1”: connected to the cable transmitting orders to solenoid valves of one stanchion assemble,

(2) “J2”: connected to the cable transmitting orders to solenoid valves of other stanchion assemble,

(3) “J3”: connected to the cable receiving switches signals from one stanchion assembly.

(4) “J4”: connected to the cable receiving switches signals from one stanchion assembly

(5) “J5”: connected to the cable going to the tower control panel

(6) “J6”: connected to the cable going to the field control panel.

(7) “J7” connected to “-” 24 V DC cable coming from the battery charger board.

(8) “J8” connected to “+”24 V DC cable coming from the battery charger board.

(9) “J9” connected to “-”24 V DC cable going to the raising counter.

(10) “J10” connected to “+” 24 V DC cable going to the raising counter.

(11) “J11” connected to the MINI VOLTAGE cable conning from the battery charger board.

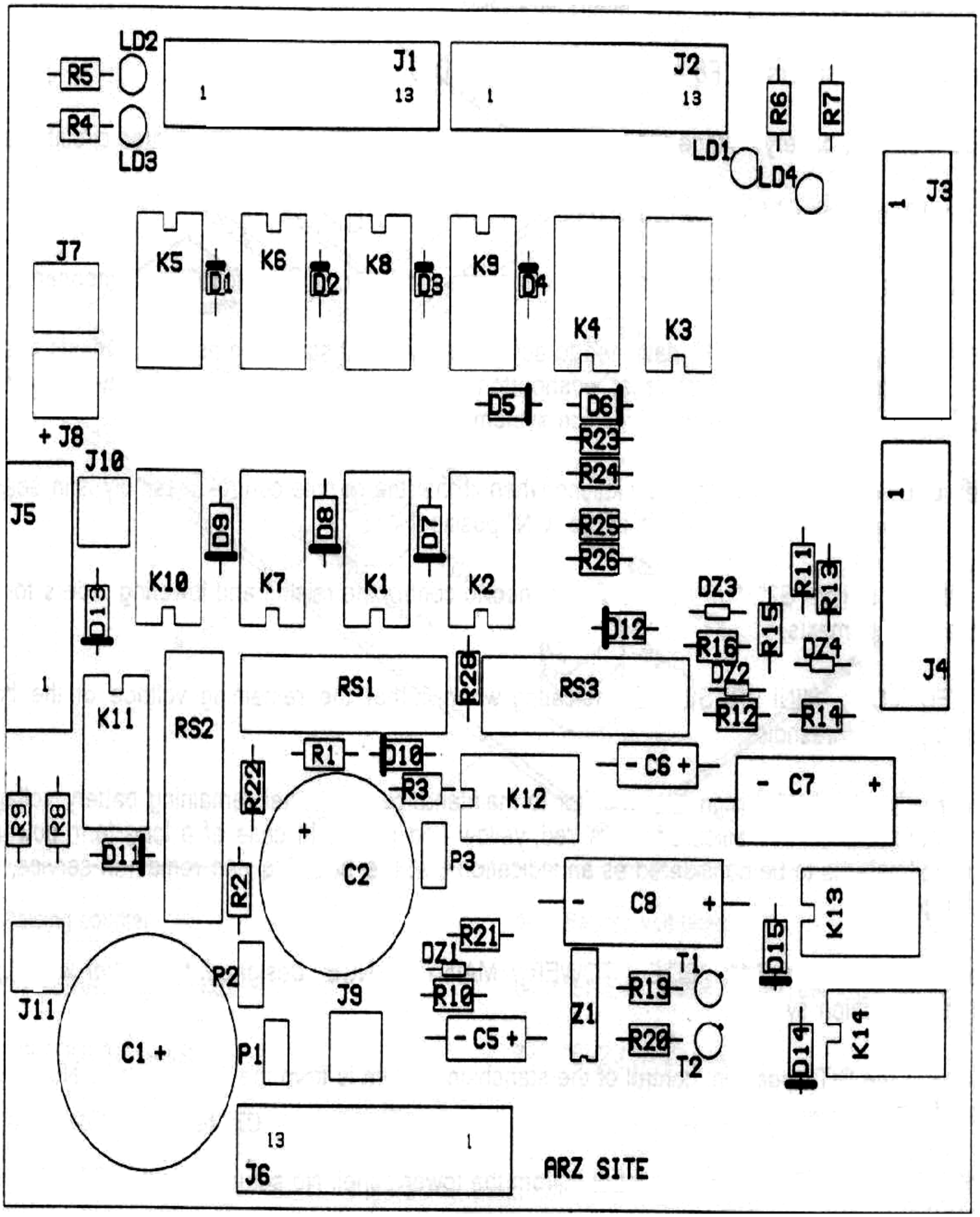

Fig-7: Field Printed Circuit Board

Battery Charger Printed Circuit Board.

9. a. The battery charger is designed to automatically charge the two batteries as they reach a preset voltage threshold. It is in form of a printed circuit board associated to an extension holding three heat radiant components.

(1) The battery charger is wording as follows:

(2) In case of a 220 V AC failure, the charge will automatically connect the batteries so that they will supply the field board.

(3) As the 220V AC is on, the charge will detect if batteries are connected, and will discharge the batteries so that they reach a preset voltage threshold.

(4) As this threshold is reached, charging process will be activated for 2 hours. A temperature probe, located on top of one batter, is connected to the charge.

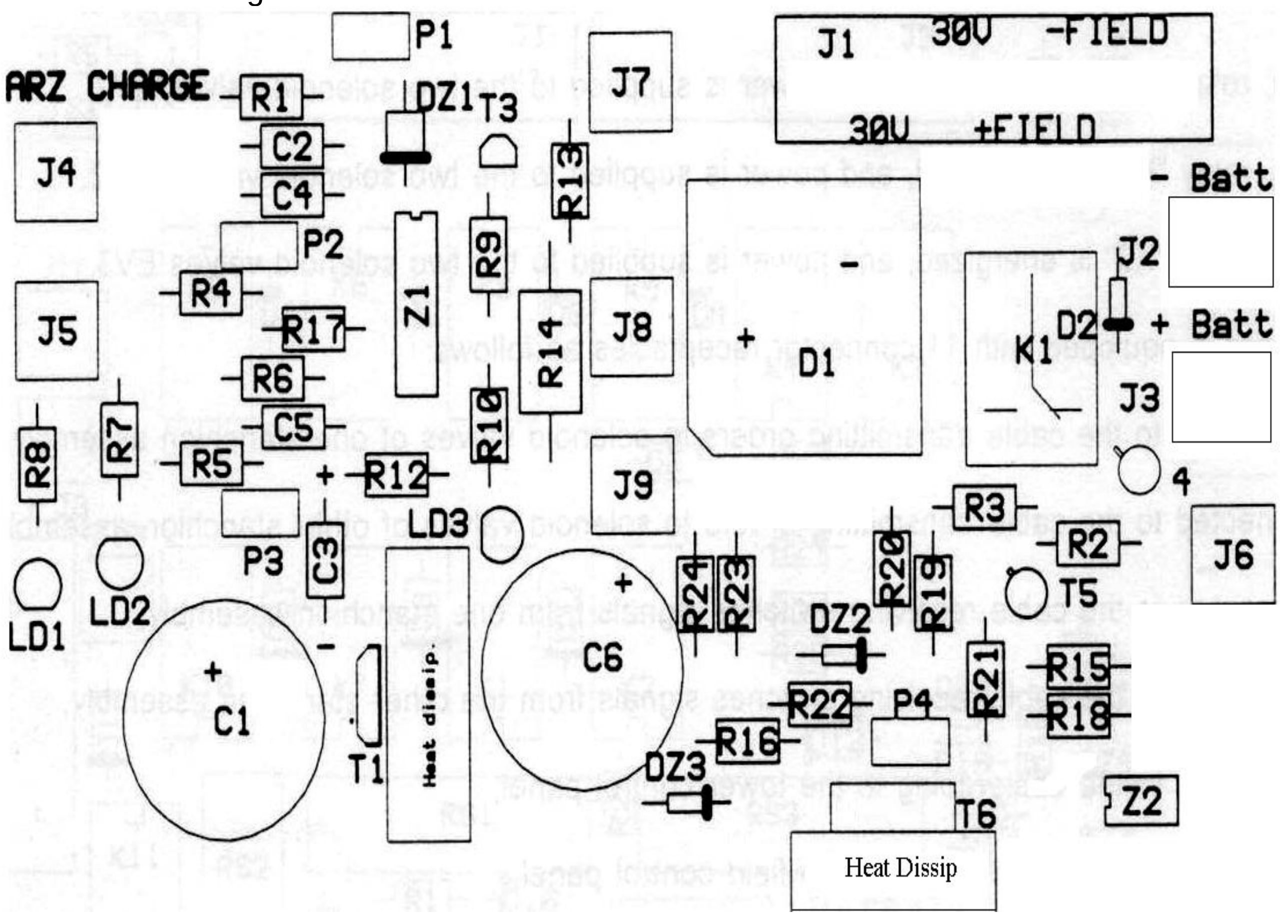

Fig-8: Battery Charger Printed Circuit Board.

(5) Charging process is ended in case of an over voltage or over temperature of the batteries, or if the charging time has elapsed.

(6) As the charging time has elapsed, the charger will maintain a pulsed trickle charge to the batteries.

b. The printed circuit board integrates battery-charging components, and the following monitoring LED s indicating when lit that:

(1) Red LED”LD1” blinking, charging is active.

(2) Red LED”LD1”steadily on, charging time has elapsed, trickle charging is active.

(3) Green LED “LD2” blinking, discharging is active.

(4) Green LED “LD2” steadily on; no batteries are connected to the board.

c. The charger board is equipped with 9 connector receptacles as follows:

(1) “J1” connected to cables coming from the transformer “TR1” ,going to the field prince circuit board,

(2) “J2” connected to the “-” 24 V DC cable coming from the batteries.

(3) “J3” connected to the “+” 24 V DC cable coming from the batteries

(4) “J4” connected to the “-” 24 V DC cable going to the battery temperature probe.

(5) “J5” connected to the cable going to the battery temperature probe.

(6) “J6” connected to the MINI VOLTAGE cable going to the field printed circuit board.

(7) “J7” connected to the battery charger extension board.

(8) “J8” connected to the battery charger extension board.

(9) “J9” connected to the battery charger extension board.

<u>Battery Enclosure.</u>

10. The battery enclosure is a stainless steel rectangular ease, that is mounted on the lower part of the field cabinet mounting frame. Natural ventilation is ensured by lovers locate

on two sides of the ease. The cover is removable by an opening handle, and cables e be padlocked. The 24V storage battery consists of 2 series connected lead batteries. Nominal capacity of each is 115 Ah (100h). A temperature probe is located on to of one of the battery. Electrical isolation of the battery can be obtained by opening two fuse cut out units “F9”provided.

Preparation of Use and Shipment.

11. a. **General.** The arresting system is permanently installed on concrete foundations. Installation configuration is described and illustrated in the Stanchion System Type 7 Technical Manual. It is recommended to carry out the installation of terminals remote control assembly at the same time than the stanchion system type 7 as these installations will affect airfield 0perations. Selection of the particular system arrangement and the planning of its installation must be carried out by personnel familiar with operational requirements. The remote control assembly is usually installed with respect to ATC Tower location, to available power supply sources, and to the accessibility of the equipment. Installation must be conducted with regard to the particular indications of the prime contractor, of following the installation drawings provided by the manufacturer.

b. **System Location.** The tower control panel is to be installed in the ATC tower at a place defined with ATC tower operators. The field cabinet and the battery enclosure are bolted on a mounting frame. The mounting frame is installed and anchored on a specific concrete foundation locate close to the stanchion system, at the end of the active runway. Hardwire cables are to be embedded in the ground.

c. **Power Requirements.** The field cabinet must be supplied with 220 V ± 10% and ground (2.5 max consumed powers). The power supply inlet provided is designed to receive power supply up to 380 V AC, 63 A. To maintain the batter fully charged, the field cabinet must be permanently powered from the 220 V AC net works, regardless of the state of the stanchion system type-7 (in service, out of service, masts raised or lowered.

d. **Field Ground Connection.** A ground connection near the field cabinet will be made available by the user. The ground resistance of this point shall not exceed 100 ohms in all seasons. During installation, the field is to be connected to this outlet before connection to the 220 V AC network.

e. **Battery.** Two 12 V acid lead batteries, series connected are provided with the remote control assembly.

Warning. *Electrolyte is an acid liquid mixture. Operate refilling in a well ventilated condition. Avoid contact with skin and eyes. Don’t smoke or permit naked flames near the batteries. Don’t allow metal objects to rest on battery.*

Caution. *Only refill batteries with distilled water. Keep the batteries upright. Wear goggles and protective clothing when working with batteries. Use tools with instated handles.*

f. **In the Event of an Accident.** Wash skin burns with copious amount of clean water hen cover immediately with dry gauze. For the eyes, wash out with copious amount of clean water followed by a wash of saline solution (prepared from two level table spoons of salt dissolved in one pint of purified water). This should be available wherever electrolyte is handled. In all cases obtain immediate medical attention.

g. **Maintenance.**

(1) Ensure that charging is adequate in relation to the duty.

(2) Avoid over discharging.

(3) Keep the electrolyte at the proper level by adding dematerialize or pure distilled water only, and do not overfill.

(4) Keep the batteries and the enclosure clean and dry.

(5) Keep the vent caps closed except when topping up.

h. **Utilization.** In the event of a 220 V AC network failure, the standby batteries make it possible to operate the stanchion system type-7 from the field cabinet as well as from the tower control pane. As the autonomy: 2 weeks of operational use or 50 rising cycles, first limit reached. As the autonomy time is reached, and if the 220 V network is still not available, batteries are to be removed from operational service, and recharged.

Operation Instructions.

12. a. **General.** The stanchion system type–7 is equipped with a licking mechanism. Each mast can be mechanically licked in the down position, by a pin-preventing rising. As soon as one of the two reporting devices is no longer operated, an alarm is given at the tower control panel. Rising is then possible. Each pin operates.

(1) An unlocking reporting device, in the mast unlocked and frees position.

(2) A locking reporting device, in the locked and blocked position.

b. **Stanchion System Locking.** The stanchion system type 7 is equipped with a manual locking mechanism. The licking /unlocking pin is to be actuated by rotating the flag mast on each stanchion system. As it is decided to put one stanchion system in service, the two assemblies are to be manually unlocked.

c. **Operation Automatic Locking.** The stanchion system can be equipped, upon request, with an automatic locking mechanism. The locking pin is actuated by an electrical motor that rotates the mast. As the remote control assembly is put into service from the lower control panel (main switch S 1 on the "ON" position) the two stanchion assemblies are automatically unlocked. They will be locked as turned backed to "OFF". They can also be licked as the switch "S1" of the field control panel is on the "Maintenance" position.

d. **Pre Operation Check.** Prier to operation performs the daily checks.

e. **Safety Precaution.** In order to prevent injury during inspection due to inadvertent rising, it is MANDATORY to lock the two stanchion assemblies before allowing the maintenance personnel to approach. Locked status of one assembly can be checked by the position of the flag:

(1) Flag HORIZONTAL --> stanchion assembly unlocked (rising possible).

(2) Flag VERTICAL --> stanchion assembly unlocked (rising not possible).

Precautions

1) Never erect the net without allowance from ATC tower operators.

2) Before raising ensure all personnel are clear of path of stanchion masts guy wris and net.

f. **Operation.** In case of a manual licking mechanism, the two stanchion assemblies are to be manually unlocked first The putting into service of the remote control assembly is carried out by switching "S1" of the tower panel to the "ON" position.. If the stanchion assemblies are provided with the optional automatic locking device, they will be automatically unlocked at that step. As the two stanchion assemblies are unlocked, the "LOCKED LED "LD1" of the tower panel is not lit anymore. Pushing on the "LIGHT TEST RESET" button "S3" lit all the LED's, and sounds the option horn.

g. **Operational Use from Tower Control Panel.** The operator is at the ATC tower. Switch "S1" of the field panel is the "TOWER" position. No actuation is then possible from the field panel. The following light up at the tower panel.

(1) "DOWN "BLUE led "LD4", if the two masts are in the DOWN position.

(2) "UP" green LED "LD2", if the two masts are in the UP position.

(3) "FAULT" red LED "LD3", in case of one or more of the following events:

(a) The low pressure of one of the stanchion assembly is below the preset threshold.

(b) Switch "S1" of the field panel is not in the "TOWER" position

(c) The battery voltage is below the threshold.

h. **Normal Operation from Field Control Panel.**

(1) **Raising**.

(a) Switching the "UP/DOWN" switch "S2" to the UP position actuates the raising of the (actuation of duplicated solenoid valves EV2 and EV'2 in the two stanchion assemblies) and increases the raising counter.

(b) During rising, the "FAULT" LED "LD3" shall be lit as one low pressure shall be below the threshold. If supplied, the optional horn shall sound. The "DOWN" LED is not lit.

(c) As the net is raised, the "UP" LED is lit.

(2) **Lowering.** Lowering can be ordered immediately after raising, or even during raising in that case, the raising will be interrupted, and the lowering will take place. Switching the "UP/ DOWN" switch "S2" to the DOWN position actuates the lowering of the net (actuation of duplicated solenoid valves EV3 and EV'3 in the two stanchion assemblies).

j. **Maintenance Operation.**

(1) **Operator is at the Field Cabinet**. During maintenance operations, any raising or lowering can be inhibited from any panel, by switching "S1" switch of the field panel to the "MAINTENACE" position. For safety reasons, the two stanchion assemblies are to be manually locked, if they are not supplied with the optional automatic locking device.

k. **Periodic Inspection and Maintenance.**

Table: Periodic Scheduled Inspections and Maintenance Chart.

Ser	**Operation**	**Interval**

No		
1.	Tower control panel operations: a. Operate the LIGHT TEST RESET pushbutton. b. Verify that all LED s and optional horn are working.	Daily
2.	Put the remote control assembly in service. Raise and lower the net from tower control panel.	Refer to the periodicity for rising specified by the Technical Manual (publication 256-702), of the associated stanchion system type 7.
3.	Field cabinet operations: a. Check that all LED s are working (as the remote control assembly is operated). b. Depending on ambient temperature, check if field cabinet heating resistor is working. c. Check battery voltmeter.	Daily
4.	Put the remote control assembly in service. Raise and lower the net from field control panel.	Refer to the periodicity fore rising specified by the Technical Manual (publication 256-702), of the associated stanchion system type.