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# Haynes TECHBOOK

# ROCHESTER
## Carburetor Manual

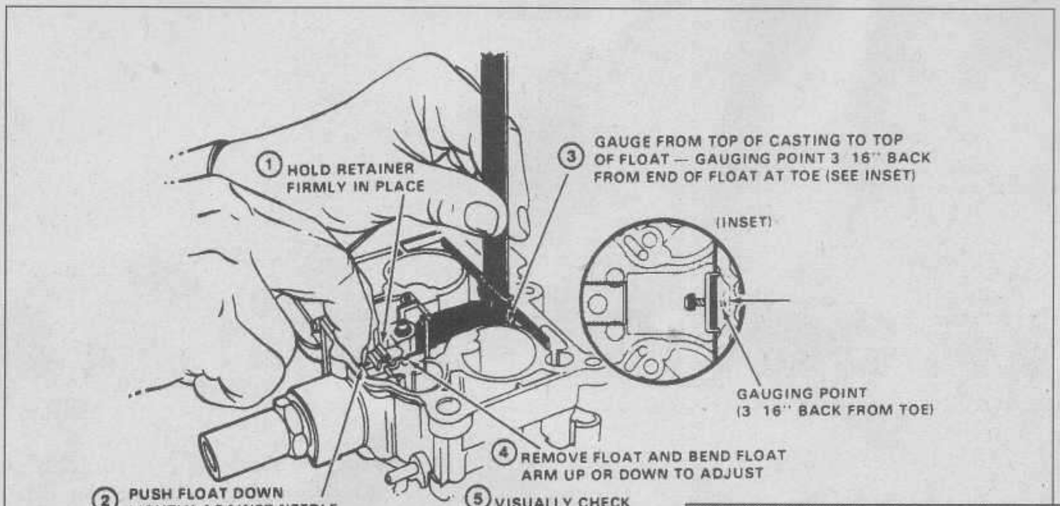
*Over 340 step-by-step photos*

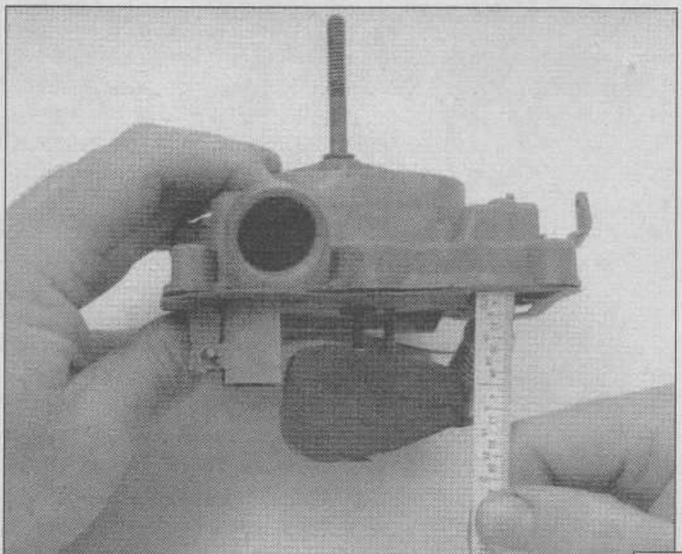
- 1-Barrel • 2-Barrel • 4-Barrel
- Tuning • Repair
- Overhaul • Modifications

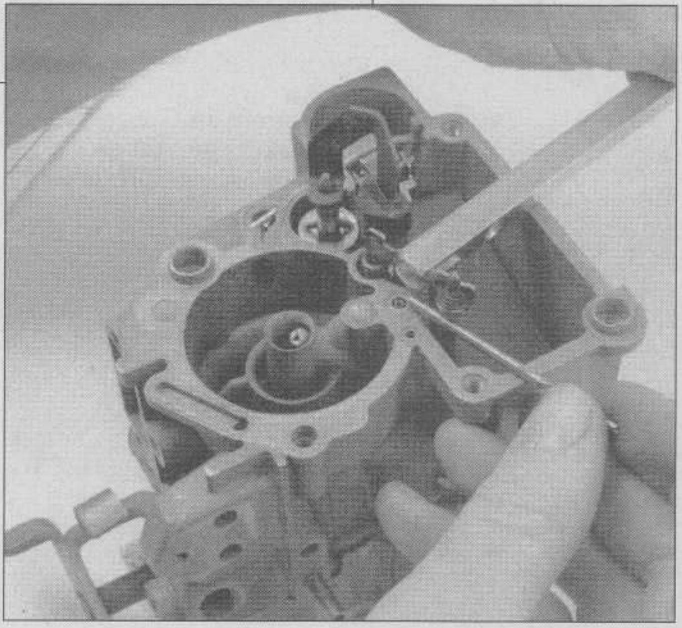
Haynes

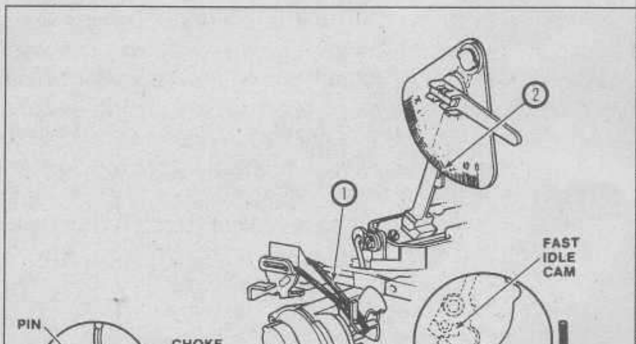
TECHBOOK

# Contents


① HOLD RETAINER FIRMLY IN PLACE
② PUSH FLOAT DOWN LIGHTLY AGAINST NEEDLE
③ GAUGE FROM TOP OF CASTING TO TOP OF FLOAT — GAUGING POINT 3 16'' BACK FROM END OF FLOAT AT TOE (SEE INSET)
(INSET)
GAUGING POINT (3 16'' BACK FROM TOE)
④ REMOVE FLOAT AND BEND FLOAT ARM UP OR DOWN TO ADJUST
⑤ VISUALLY CHECK FLOAT ALIGNMENT AFTER ADJUSTING






②
①
FAST IDLE CAM
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CHOKE COVER
③ LOCKOUT LEVER
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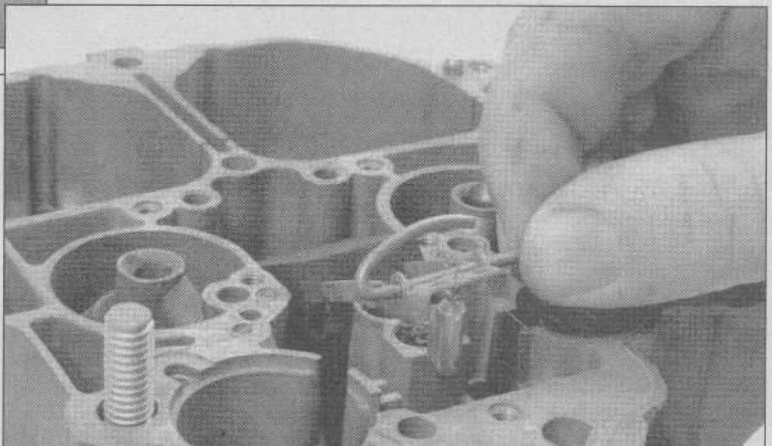


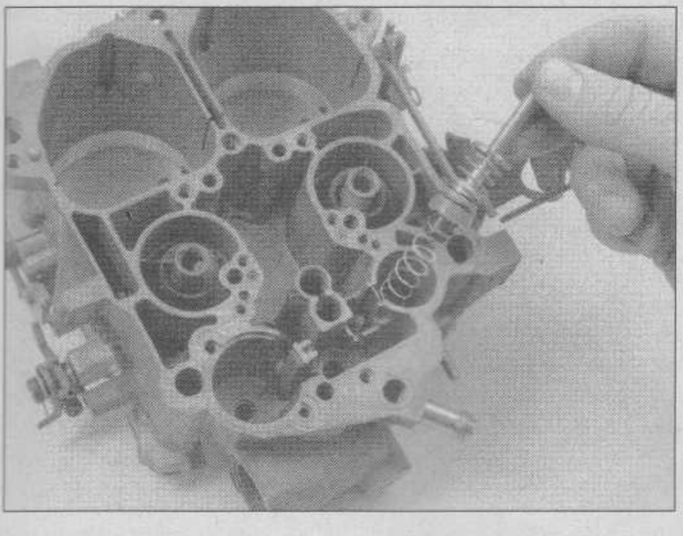
# 1 Introduction

## About this manual

The goal of this manual is to help you obtain the very best your Rochester carburetor has to offer, whether it be performance or economy. Since these carburetors are fine precision instruments, the manual assumes that you already have a basic understanding of how an engine works and are fairly competent with the use of tools and safe working procedures.

For many, the carburetor represents a portion of a vehicle that just shouldn't be tampered with, and because of this repairs or modifications to the carburetor are usually left to someone else. A considerable amount of money can be saved and much knowledge can be gained by taking on these tasks yourself. This will help you better understand what your vehicle is doing under certain operating conditions, and you'll be able to tune your carburetor to correct certain problems and extract the maximum performance from you engine.

Although these carburetors will primarily be found on General Motors vehicles (Rochester is a subsidiary of GM) they have been used by other manufacturers, too. Of the millions of these carburetors in existence, all of them will need attention sooner or later. All of the carburetors covered by this manual are very well made, are relatively simple to overhaul and easy to tune (although tuning a carburetor is usually a trial-and-error proposition). This manual unlocks the "mystery" of the Rochester carburetor. Included are chapters on tools, fundamentals of operation, carburetor identification, troubleshooting, removal and installation, overhaul and adjustments, and selection and modifications. At the end of the manual there's a glossary of terms used throughout the book. In short, everything you need to know to successfully deal with your Rochester carburetor and realize its full potential!



## How to use this repair manual

The manual is divided into Chapters. Each chapter is subdivided into sections, some of which consist of consecutively numbered paragraphs (usually referred to as "Steps", since they're normally part of a procedure). If the material is basically informative in nature, rather than a step-by-step procedure, the paragraphs aren't numbered.

The first six chapters contain material on preparing for an overhaul, including tool selection and usage, safety and general shop practices. Chapter 7 covers the specifics of the overhaul procedure. Chapter 8 deals with selecting the proper carburetor for your application and also contains modification tips.

The term "see illustration" (in parentheses), is used in the text to indicate that a photo or drawing has been included to make the information easier to understand (the old cliche "a picture is worth a thousand words" is especially true when it comes to how-to procedures). Also, every attempt is made to position illustrations directly opposite the corresponding text to minimize confusion. The two types of illustrations used (photographs and line drawings) are referenced by a number preceding the caption. Illustration numbers denote chapter and numerical sequence within the chapter (i.e. 3.4 means Chapter 3, illustration number 4 in order).

The terms **"Note"**, **"Caution"** and **"Warning"** are used throughout the text with a specific purpose in mind - to attract the reader's attention. A **"Note"** simply provides information required to properly complete a procedure or information which will make the procedure easier to understand. A **"Caution"** outlines a special procedure or special steps which must be taken when completing the procedure where the Caution is found. Failure to pay attention to a Caution can result in damage to the component being repaired or the tools being used. A **"Warning"** is included where personal injury can result if the instructions aren't followed exactly as described.

Even though extreme care has been taken during the preparation of this manual, neither the publisher nor the author can accept responsibility for any errors in, or omissions from, the information given.

## Automotive chemicals and lubricants

A wide variety of automotive chemicals and lubricants - ranging from cleaning solvents and degreasers to lubricants and protective sprays for rubber, plastic and vinyl - are available.

## Cleaners

### Brake system cleaner (sometimes used in place of carburetor cleaner)

Brake system cleaner removes grease and brake fluid from brake parts like disc brake rotors, where a spotless surfaces is essential. It leaves no residue and often eliminates brake squeal caused by contaminants. Because it leaves no residue, brake cleaner is often used for cleaning engine parts as well.

### Carburetor and choke cleaner

Carburetor and choke cleaner is a strong solvent for gum, varnish and carbon. Most carburetor cleaners leave a dry-type lubricant film which will not harden or gum up. So don't use carburetor cleaner on electrical components.

### Degreasers

Degreasers are heavy-duty solvents used to remove grease from the outside of the engine and from chassis components. They're usually sprayed or brushed on. Depending on the type, they're rinsed off either with water or solvent.

### Demoisturants

Demoisturants remove water and moisture from electrical components such as alternators, voltage regulators, electrical connectors and fuse blocks. They are non-conductive, non-corrosive and non-flammable.

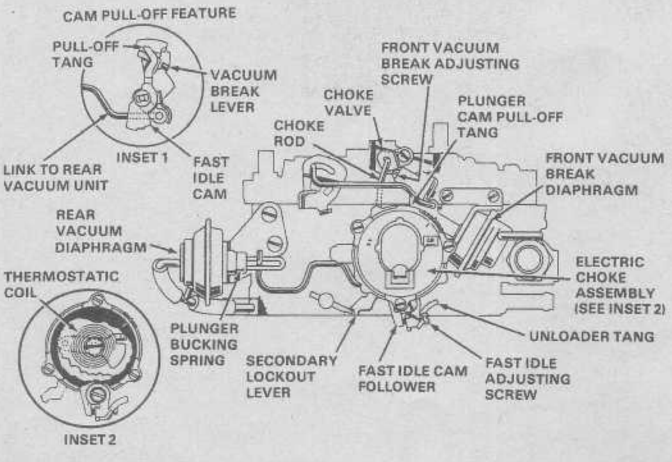
### Electrical cleaner

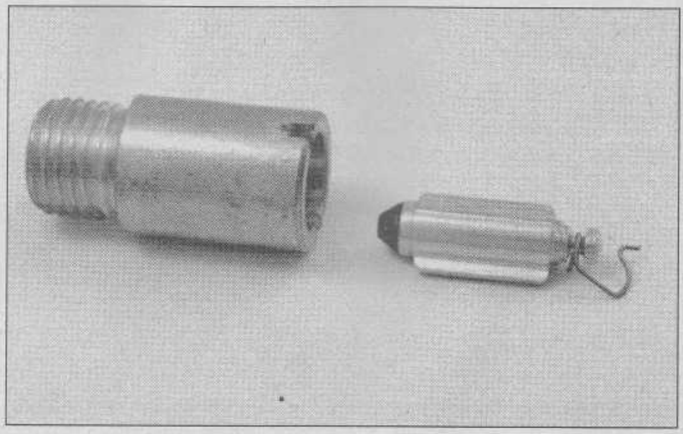
Electrical cleaner removes oxidation, corrosion and carbon deposits from electrical contacts, restoring full current flow. It can also be used to clean spark plugs, carburetor jets, voltage regulators and other parts where an oil-free surface is necessary.

## Lubricants

### Assembly lube

Assembly lube is a special extreme pressure lubricant, usually containing moly, used to lubricate high-load parts (such as main and rod bearings and cam lobes) for initial start-up of a new engine. The assembly lube lubricates the parts without being squeezed out or washed away until the engine oiling system begins to function.





### Graphite lubricants

Graphite lubricants are used where oils cannot be used due to contamination problems, such as in locks. The dry graphite will lubricate metal parts while remaining uncontaminated by dirt, water, oil or acids. It is electrically conductive and will not foul electrical contacts in locks such as the ignition switch.

### Heat-sink grease

Heat-sink grease is a special electrically non-conductive grease that is used for mounting electronic ignition modules where it is essential that heat is transferred away from the module.

### Penetrating oil

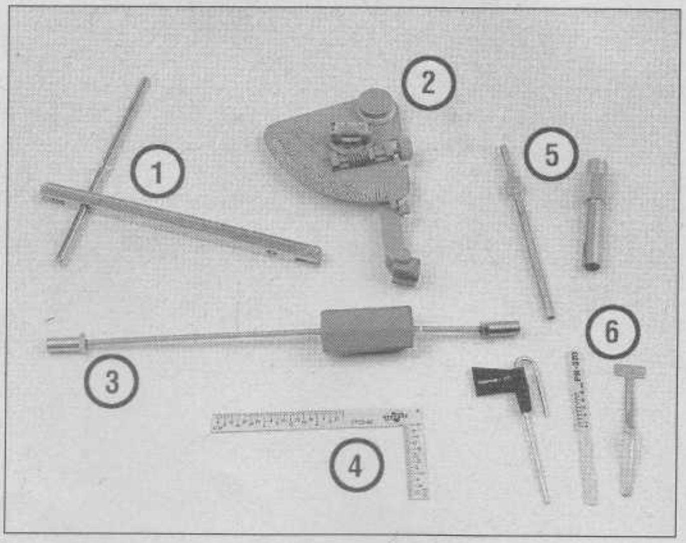
Penetrating oil loosens and lubricates frozen, rusted and corroded fasteners and prevents future rusting or freezing.

### Silicone lubricants

Silicone lubricants are used to protect rubber, plastic, vinyl and nylon parts.

### White grease

White grease is a heavy grease for metal-to-metal applications where water is present. It stays soft under both low and high temperatures (usually from -100 to +190-degrees F), and won't wash off or dilute when exposed to water. Another good "glue" for holding parts in place during assembly.



## *Sealants*

### Anaerobic sealant

Anaerobic sealant is much like RTV in that it can be used either to seal gaskets or to form gaskets by itself. It remains flexible, is solvent resistant and fills surface imperfections. The difference between an anaerobic sealant and an RTV-type sealant is in the curing. RTV cures when exposed to air, while an anaerobic sealant cures only in the absence of air. This means that an anaerobic sealant cures only after the assembly of parts, sealing them together.

### RTV sealant

RTV sealant is one of the most widely used gasket compounds. Made from silicone, RTV is air curing, it seals, bonds, waterproofs, fills surface irregularities, remains flexible, doesn't shrink, is relatively easy to remove, and is used as a supplementary sealer with almost all low and medium temperature gaskets.

### Thread and pipe sealant

Thread and pipe sealant is used for sealing hydraulic and pneumatic fittings and vacuum lines. It is usually made from a teflon compound, and comes in a spray, a paint-on liquid and as a wrap-around tape.

## *Chemicals*

### Anaerobic locking compounds

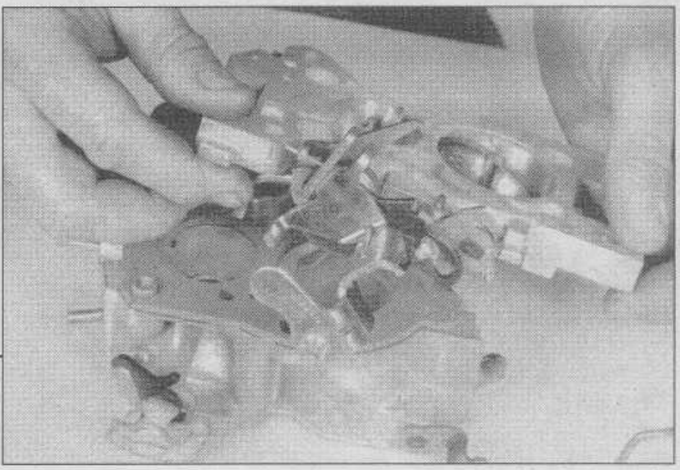
Anaerobic locking compounds are used to keep fasteners from vibrating or working loose and cure only after installation, in the absence of air. Medium strength locking compound is used for small nuts, bolts and screws that may be removed later. High-strength locking compound is for large nuts, bolts and studs which aren't removed on a regular basis.

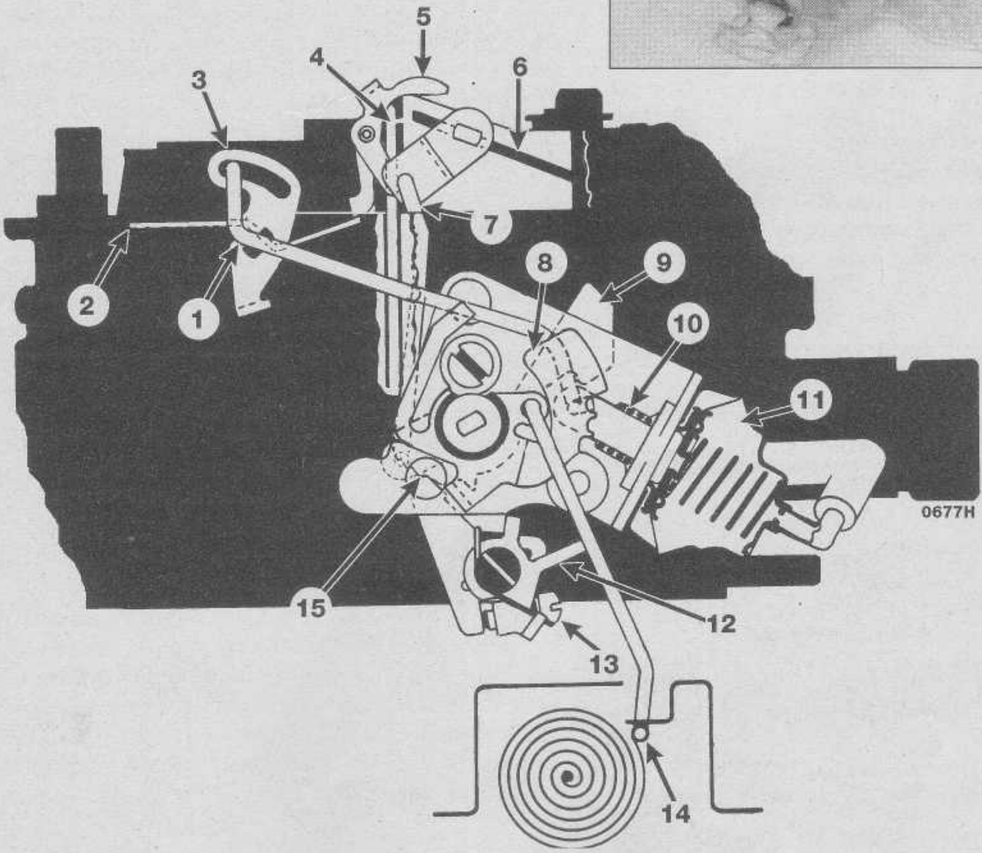
### Anti-seize compound

Anti-seize compound prevents seizing, galling, cold welding, rust and corrosion in fasteners. High-temperature anti-seize, usually made with copper and graphite lubricants, is used for exhaust system and exhaust manifold bolts.

### Gas additives

Gas additives perform several functions, depending on their chemical makeup. They usually contain solvents that help dissolve gum and varnish that build up on carburetor, fuel injection and intake parts. They also serve to break down carbon deposits that form on the inside surfaces of the combustion chambers. Some additives contain upper cylinder lubricants for valves and piston rings, and others contain chemicals to remove condensation from the gas tank.





## Safety first!

Regardless of how enthusiastic you may be about getting on with the job at hand, take the time to ensure that your safety is not jeopardized. A moment's lack of attention can result in an accident, as can failure to observe certain simple safety precautions. The possibility of an accident will always exist, and the following points should not be considered a comprehensive list of all dangers. Rather, they are intended to make you aware of the risks and to encourage a safety conscious approach to all work you carry out on your vehicle.

## Essential DOs and DON'Ts

**DON'T** rely on a jack when working under the vehicle. Always use approved jackstands to support the weight of the vehicle and place them under the recommended lift or support points.

**DON'T** attempt to loosen extremely tight fasteners (i.e. wheel lug nuts) while the vehicle is on a jack - it may fall.

**DON'T** start the engine without first making sure that the transmission is in Neutral (or Park where applicable) and the parking brake is set.

**DON'T** attempt to drain the engine oil until you are sure it has cooled to the point that it will not burn you.

**DON'T** touch any part of the engine or exhaust system until it has cooled sufficiently to avoid burns.

**DON'T** siphon toxic liquids such as gasoline, antifreeze and brake fluid by mouth, or allow them to remain on your skin.

**DON'T** allow spilled fluids or lubricants to remain on the floor - wipe it up before someone slips on it.

**DON'T** use loose fitting wrenches or other tools which may slip and cause injury.

**DON'T** push on wrenches when loosening or tightening nuts or bolts. Always try to pull the wrench toward you. If the situation calls for pushing the wrench away, push with an open hand to avoid scraped knuckles if the wrench should slip.

**DON'T** rush or take unsafe shortcuts to finish a job.

**DON'T** allow children or animals in or around the vehicle while you are working on it.

**DO** wear eye protection when using power tools such as a drill, sander, bench grinder, etc. and when working under a vehicle.

**DO** keep loose clothing and long hair well out of the way of moving parts.

**DO** make sure that any hoist used has a safe working load rating adequate for the job.

**DO** get someone to check on you periodically when working alone on a vehicle.

**DO** carry out work in a logical sequence and make sure that everything is correctly assembled and tightened.

**DO** keep chemicals and fluids tightly capped and out of the reach of children and pets.

**DO** remember that your vehicle's safety affects that of yourself and others. If in doubt on any point, get professional advice.

## Batteries

Never create a spark or allow a bare light bulb near a battery. They normally give off a certain amount of hydrogen gas, which is highly explosive.

Always disconnect the battery ground (-) cable at the battery before working on the fuel or electrical systems.

## Fire

We strongly recommend that a fire extinguisher suitable for use on fuel and electrical fires be kept handy in the garage or workshop at all times. Never try to extinguish a fuel or electrical fire with water. Post the phone number for the nearest fire department in a conspicuous location near the phone.

## Fumes

Certain fumes are highly toxic and can quickly cause unconsciousness and even death if inhaled to any extent. Gasoline vapor falls into this category, as do the vapors from some cleaning solvents. Any draining or pouring of such volatile fluids should be done in a well ventilated area.

When using cleaning fluids and solvents, read the instructions on the container carefully. Never use materials from unmarked containers.

Never run the engine in an enclosed space, such as a garage. Exhaust fumes contain carbon monoxide, which is extremely poisonous. If you need to run the engine, always do so in the open air, or at least have the rear of the vehicle outside the work area.

## Household current

When using an electric power tool, inspection light, etc., which operates on household current, always make sure that the tool is correctly connected to its plug and that, where necessary, it is properly grounded. Do not use such items in damp conditions and, again, do not create a spark or apply excessive heat in the vicinity of fuel or fuel vapor.

## Keep it clean

Get in the habit of taking a regular look around the shop to check for potential dangers. Keep the work area clean and neat. Sweep up all debris and dispose of it as soon as possible. Don't leave tools lying around on the floor.

Be very careful with oily rags. Spontaneous combustion can occur if they're left in a pile, so dispose of them properly in a covered metal container.

Check all equipment and tools for security and safety hazards (like frayed cords). Make necessary repairs as soon as a problem is noticed - don't wait for a shelf unit to collapse before fixing it.

## Accidents and emergencies

Shop accidents range from minor cuts and skinned knuckles to serious injuries requiring immediate medical attention. The former are inevitable, while the latter are, hopefully, avoidable or at least uncommon. Think about what you would do in the event of an accident. Get some first aid training and have an adequate first aid kit somewhere within easy reach.

Think about what you would do if you were badly hurt and incapacitated. Is there someone nearby who could be summoned quickly? If possible, never work alone just in case something goes wrong.

If you had to cope with someone else's accident, would you know what to do? Dealing with accidents is a large and complex subject, and it's easy to make matters worse if you have no idea how to respond. Rather than attempt to deal with this subject in a superficial manner, buy a good First Aid book and read it carefully. Better yet, take a course in First Aid at a local junior college.

# 2 Tools and equipment

## Introduction

For some home mechanics, the idea of using the correct tool is completely foreign. They'll cheerfully tackle the most complex procedures with only a set of cheap open-end wrenches of the wrong type, a single screwdriver with a worn tip, a large hammer and an adjustable wrench. Though they often get away with it, this cavalier approach is stupid and dangerous. It can result in relatively minor annoyances like stripped fasteners, or cause catastrophic consequences like blown engines. It can also result in serious injury.

An assortment of good tools is a given for anyone who plans to work on cars. If you don't already have most of the tools listed below, the initial investment may seem high, but compared to the spiraling costs of routine maintenance and repairs, it's a deal. Besides, you can use a lot of the tools around the house for other types of mechanical repairs. We've included a list of the tools you'll need and a detailed description of what to look for when shopping for tools and how to use them correctly.

## Buying tools

There are two ways to buy tools. The easiest and quickest way is to simply buy an entire set. Tool sets are often priced substantially below the cost of the same individually priced tools - and sometimes they even come with a tool box. When purchasing such sets, you often wind up with some tools you don't need or want. But if low price and convenience are your concerns, this might be the way to go. Keep in mind that you're going to keep a quality set of tools a long time (maybe the rest of your life), so check the tools carefully; don't skimp too much on price, either. Buying tools individually is usually a more expensive and time-consuming way to go, but you're more likely to wind up with the tools you need and want. You can also select each tool on its relative merits for the way you use it.

You can get most of the hand tools on our list from the tool department of any large department store or hardware store chain that sells hand tools. Blackhawk, Craftsman, KD, Proto and SK are fairly inexpensive, good-quality choices. Specialty tools are available from mechanics' tool companies such as Snap-on, Mac, Matco, Cornwell, Kent-Moore, Lisle, OTC, etc. These companies also supply the other tools you need, but they'll probably be more expensive.

Also consider buying second-hand tools from garage sales or used tool outlets. You may have limited choice in sizes, but you can usually determine from the condition of the tools if they're worth buying. It's a cheap way of putting a basic tool kit together.

Until you're a good judge of the quality levels of tools, avoid mail order firms (excepting Sears and other name-brand suppliers), flea markets and swap meets. Some of them offer good value for the money, but many sell cheap, imported tools of dubious quality. Like other consumer products counterfeited in the Far East, these tools run the gamut from acceptable to unusable.

If you're unsure about how much use a tool will get, the following approach may help. For example, if you need a set of combination wrenches but aren't sure which sizes you'll end up using most, buy a cheap or medium-priced set (make sure the jaws fit the fastener sizes marked on them). After some use over a period of time, carefully examine each tool in the set to assess its condition. If all the tools fit well and are undamaged, don't bother buying a better set. If one or two are worn, replace them with high-quality items - this way you'll end up with top-quality tools where they're needed most and the cheaper ones are sufficient for occasional use. On rare occasions you may conclude the whole set is poor quality. If so, buy a better set, if necessary, and remember never to buy that brand again.

In summary, try to avoid cheap tools, especially when you're purchasing high-use items like screwdrivers, wrenches and sockets. Cheap tools don't last long. Their initial cost plus the additional expense of replacing them will exceed the initial cost of better-quality tools.

# Hand tools

## A list of general-purpose hand tools you need for general carburetor work

*Allen wrench set (1/8 to 3/8-inch)*
*Ball peen hammer - 12 oz (any steel hammer will do)*
*Box-end wrenches*
*Brushes (various sizes, for cleaning small passages)*
*Combination (slip-joint) pliers - 6-inch*
*Center punch*
*Cold chisels - 1/4 and 1/2-inch*
*Combination wrench set (1/4 to 1-inch)*
*Extensions - 1- and 6-inch*
*E-Z out (screw extractor) set*
*Feeler gauge set*
*Files (assorted)*
*Gasket scraper*
*Hacksaw and assortment of blades*
*Locking pliers*
*Magnet*
*Phillips screwdriver (no. 2 x 6-inch)*
*Phillips screwdriver (no. 3 x 8-inch)*
*Phillips screwdriver (stubby - no. 2)*
*Pin punches (1/16, 1/8, 3/16-inch)*
*Pliers - needle-nose*
*Pliers - locking (Vise-grip)*
*Pliers - diagonal cutters*
*Ratchet*
*Razor blades (industrial)*
*Scribe*
*Socket set*
*Standard screwdriver (1/4-inch x 6-inch)*
*Standard screwdriver (5/16-inch x 6-inch)*
*Standard screwdriver (5/16-inch - stubby)*
*Steel ruler - 6-inch*
*Tap and die set*
*Thread gauge*
*Torx drivers (only necessary on some later models)*
*Universal joint*

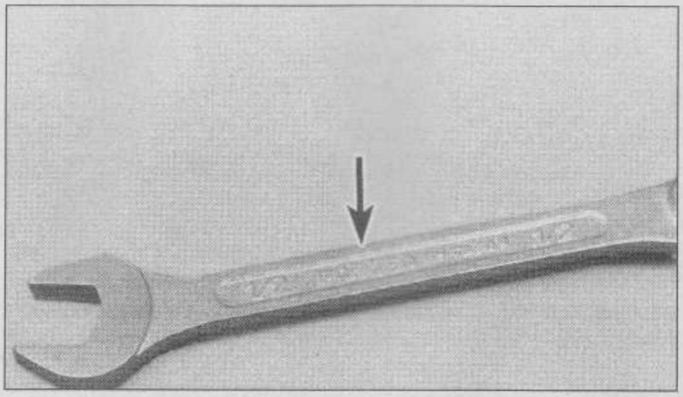
# What to look for when buying hand tools and general purpose tools

## Wrenches and sockets

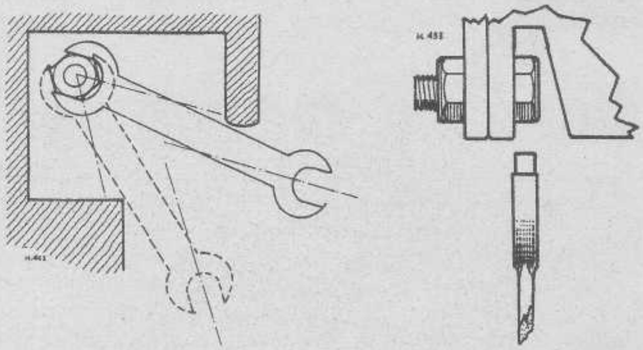
Wrenches vary widely in quality. One indication of their quality is their cost: The more they cost, the better they are. Buy the best wrenches you can afford. You'll use them a lot.

Wrenches are similar in appearance, so their quality level can be difficult to judge just by looking at them. There are bargains to be had, just as there are overpriced tools with well-known brand names. On the other hand, you may buy what looks like a reasonable value set of wrenches only to find they fit badly or are made from poor-quality steel.

With a little experience, it's possible to judge the quality of a tool by looking at it. Often, you may have come across the brand name before and have a good idea of the quality. Close examination of the tool can often reveal some hints as to its quality. Prestige tools are usually polished and chrome-plated over their entire surface, with the working faces ground to size. The polished finish is largely cosmetic, but it does make them easy to keep clean. Ground jaws normally indicate the tool will fit well on fasteners.



**2.1 One quick way to determine whether you're looking at a quality wrench is to read the information printed on the handle - if it says "chrome vanadium" or "forged," it's made out of the right material**



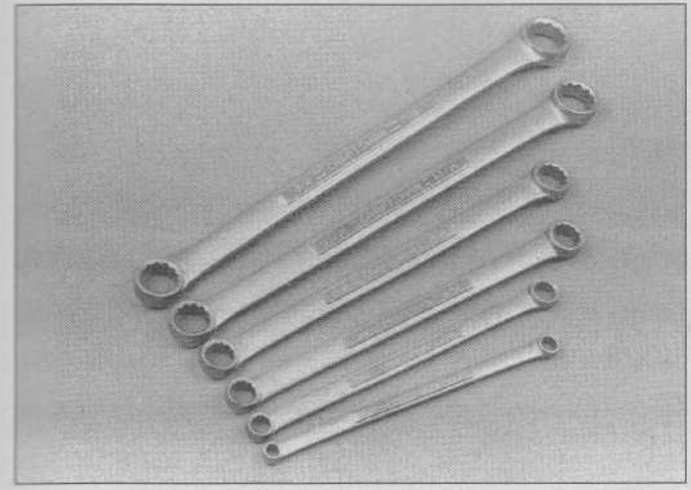
**2.2 Open-end wrenches can do several things other wrenches can't - for example, they can be used on bolt heads with limited clearance (above) and they can be used in tight spots where there's little room to turn a wrench by flipping the offset jaw over every few degrees of rotation**

A side-by-side comparison of a high-quality wrench with a cheap equivalent is an eye opener. The better tool will be made from a good-quality material, often a forged/chrome-vanadium steel alloy **(see illustration)**. This, together with careful design, allows the tool to be kept as small and compact as possible. If, by comparison, the cheap tool is thicker and heavier, especially around the jaws, it's usually because the extra material is needed to compensate for its lower quality. If the tool fits properly, this isn't necessarily bad - it is, after all, cheaper - but in situations where it's necessary to work in a confined area, the cheaper tool may be too bulky to fit.

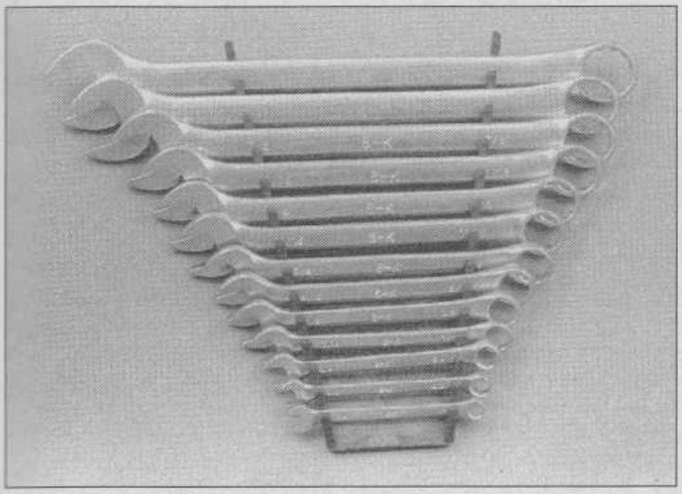
## Open-end wrenches

Because of its versatility, the open-end wrench is the most common type of wrench. It has a jaw on either end, connected by a flat handle section. The jaws either vary by a size, or overlap sizes between consecutive wrenches in a set. This allows one wrench to be used to hold a bolt head while a similar-size nut is removed. A typical fractional size wrench set might have the following jaw sizes: 1/4 x 5/16, 3/8 x 7/16, 1/2 x 9/16, 5/8 x 11/16 and so on.

Typically, the jaw end is set at an angle to the handle, a feature which makes them very useful in confined spaces; by turning the nut or bolt as far as the obstruction allows, then turning the wrench over so the jaw faces in the other direction, it's possible to move the fastener a fraction of a turn at a time



2.3 Box-end wrenches have a ring-shaped "box" at each end - when space permits, they offer the best combination of "grip" and strength



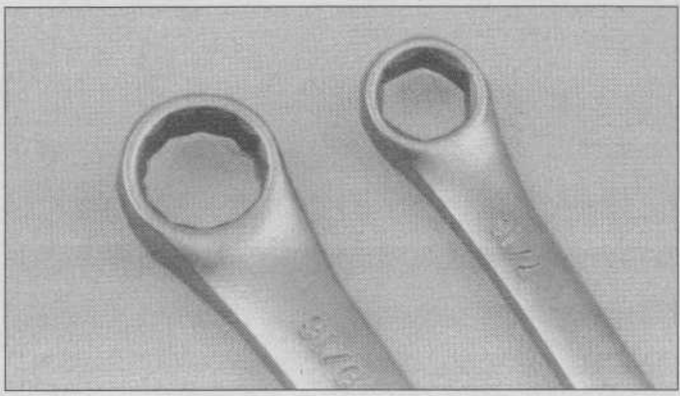
2.5 Buy a set of combination wrenches from 1/4 to 1-inch

**(see illustration)**. The handle length is generally determined by the size of the jaw and is calculated to allow a nut or bolt to be tightened sufficiently by hand with minimal risk of breakage or thread damage (though this doesn't apply to soft materials like brass or aluminum).

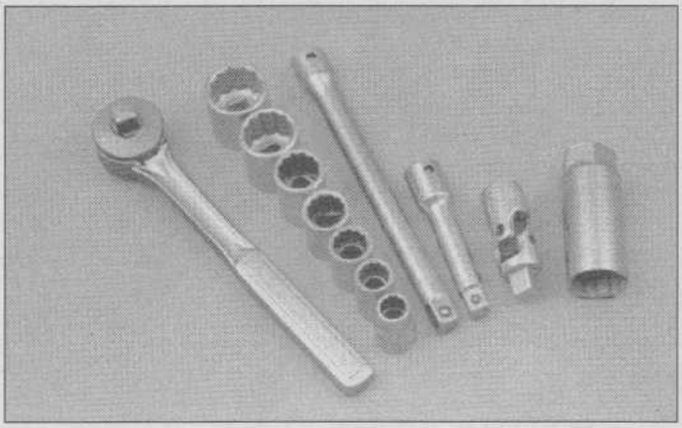
Common open-end wrenches are usually sold in sets and it's rarely worth buying them individually unless it's to replace a lost or broken tool from a set. Single tools invariably cost more, so check the sizes you're most likely to need regularly and buy the best set of wrenches you can afford in that range of sizes. If money is limited, remember that you'll use open-end wrenches more than any other type - it's a good idea to buy a good set and cut corners elsewhere.

## Box-end wrenches

Box-end wrenches **(see illustration)** have ring-shaped ends with a 6-point (hex) or 12-point (double hex) opening **(see illustration)**. This allows the tool to fit on the fastener hex at 15 (12-point) or 30-degree (6-point) intervals. Normally, each tool has two ends of different sizes, allowing an overlapping range of sizes in a set, as described for open-end wrenches.



2.4 Box-end wrenches are available in 12 (left) and 6-point (right) openings; even though the 12-point design offers twice as many wrench positions, buy the 6-point first - it's less likely to strip off the corners of a nut or bolt head



2.6 A typical ratchet and socket set includes a ratchet, a set of sockets, a long and a short extension, a universal joint and a spark plug socket

Although available as flat tools, the handle is usually offset at each end to allow it to clear obstructions near the fastener, which is normally an advantage. In addition to normal length wrenches, it's also possible to buy long handle types to allow more leverage (very useful when trying to loosen rusted or seized nuts). It is, however, easy to shear off fasteners if not careful, and sometimes the extra length impairs access.

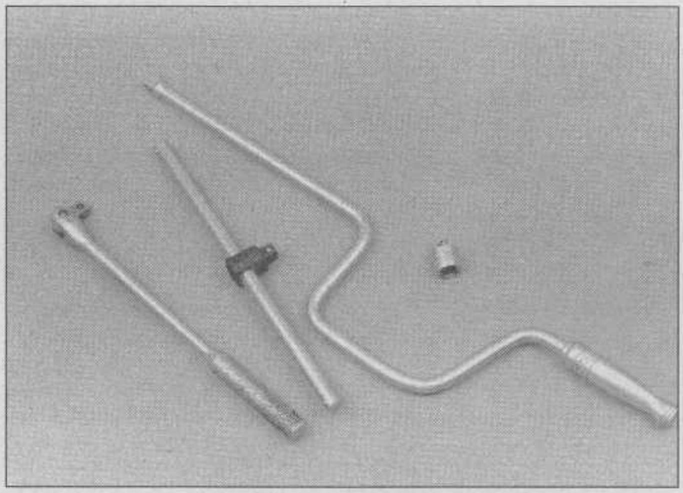
As with open-end wrenches, box-ends are available in varying quality, again often indicated by finish and the amount of metal around the ring ends. While the same criteria should be applied when selecting a set of box-end wrenches, if your budget is limited, go for better-quality open-end wrenches and a slightly cheaper set of box-ends.

## Combination wrenches

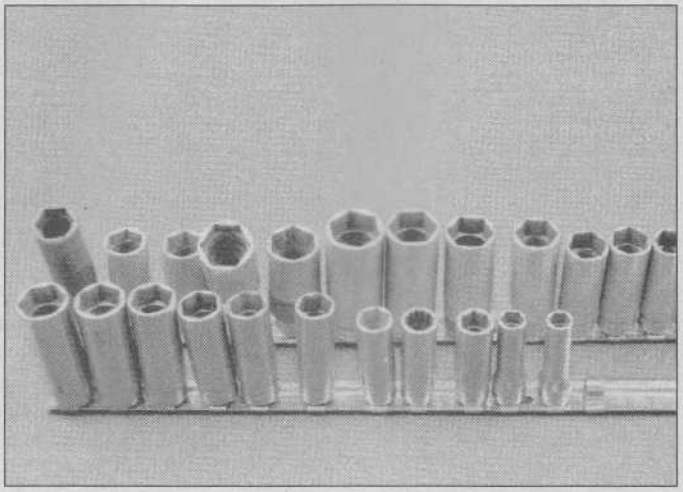
These wrenches **(see illustration)** combine a box-end and open-end of the same size in one tool and offer many of the advantages of both. Like the others, they're widely available in sets and as such are probably a better choice than box-ends only. They're generally compact, short-handled tools and are well suited for tight spaces where access is limited.

## Ratchet and socket sets

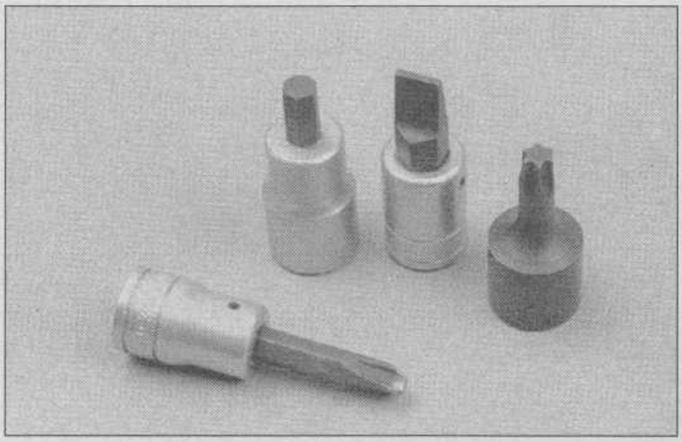
Ratcheting socket wrenches **(see illustration)** are highly versatile. Besides the sockets themselves, many other interchangeable accessories - extensions, U-drives, step-down



2.7 Lots of other accessories are available for ratchets: From left to right, a breaker bar, a sliding T-handle, a speed handle and a 3/8-to-1/4-inch adapter



2.8 Deep sockets enable you to loosen or tighten a nut with a long bolt protruding from it



2.9 Standard and Phillips bits, Allen-head and Torx drivers will expand the versatility of your ratchet and extensions even further

adapters, screwdriver bits, Allen bits, crow's feet, etc. - are available. Buy six-point sockets - they're less likely to slip and strip the corners off bolts and nuts. Don't buy sockets with extra-thick walls - they might be stronger but they can be hard to use on recessed fasteners or fasteners in tight quarters.

A 3/8-inch drive set is the most versatile, but for carburetor work you may want to consider a 1/4-inch drive set.

Interchangeable sockets consist of a forged-steel alloy cylinder with a hex or double-hex formed inside one end. The other end is formed into the square drive recess that engages over the corresponding square end of various socket drive tools.

The most economical way to buy sockets is in a set. As always, quality will govern the cost of the tools. Once again, the "buy the best" approach is usually advised when selecting sockets. While this is a good idea, since the end result is a set of quality tools that should last a lifetime, the cost is so high it's difficult to justify the expense for home use.

As far as accessories go, you'll need a ratchet, at least one extension (buy a three or six-inch size), a spark plug socket and maybe a T-handle or breaker bar. Other desirable, though less essential items, are a speed handle, a U-joint, extensions of various other lengths and adapters from one drive size to another **(see illustration)**. Some of the sets you find may combine drive sizes; they're well worth having if you find the right set at a good price, but avoid being dazzled by the number of pieces.

Above all, be sure to completely ignore any label that reads "86-piece Socket Set," which refers to the number of pieces, not to the number of sockets (sometimes even the metal box and plastic insert are counted in the total!).

Apart from well-known and respected brand names, you'll have to take a chance on the quality of the set you buy. If you know someone who has a set that has held up well, try to find the same brand, if possible. Take a pocketful of nuts and bolts with you and check the fit in some of the sockets. Check the operation of the ratchet. Good ones operate smoothly and crisply in small steps; cheap ones are coarse and stiff - a good basis for guessing the quality of the rest of the pieces.

One of the best things about a socket set is the built-in facility for expansion. Once you have a basic set, you can purchase extra sockets when necessary and replace worn or damaged tools. There are special deep sockets for reaching recessed fasteners or to allow the socket to fit over a projecting bolt or stud **(see illustration)**. You can also buy screwdriver, Allen and Torx bits to fit various drive tools (they can be very handy in some applications) **(see illustration)**.

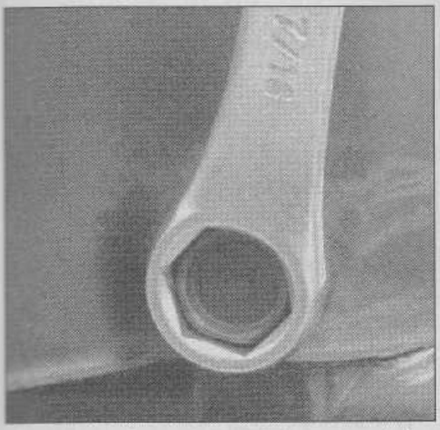
## Using wrenches and sockets

Although you may think the proper use of tools is self-evident, it's worth some thought. After all, when did you last see instructions for use supplied with a set of wrenches?

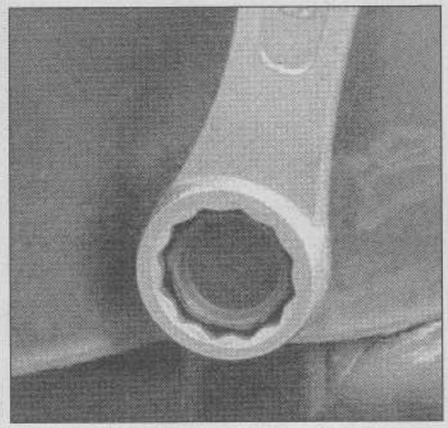
### Which wrench?

Before you start tearing things apart, figure out the best tool for the job; in this instance the best wrench for a hex-head fastener. Sit down with a few nuts and bolts and look at how various tools fit the bolt heads.

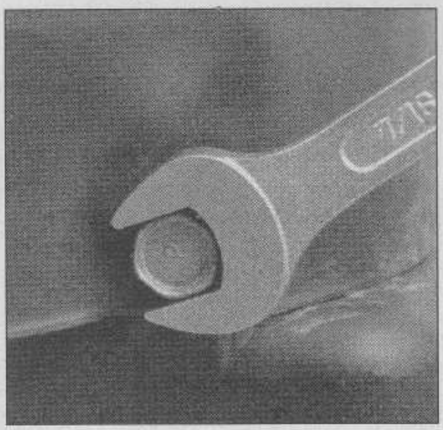
A golden rule is to choose a tool that contacts the largest area of the hex-head. This distributes the load as evenly as possible and lessens the risk of damage. The shape most closely resembling the bolt head or nut is another hex, so a 6-point socket or box-end wrench is usually the best choice **(see illustration)**. Many sockets and box-end wrenches have double hex (12-point) openings. If you slip a 12-point box-end wrench over a nut, look at how and where the two are in contact. The corners of the nut engage in every other point of the



**2.10 Try to use a six-point box wrench (or socket) whenever possible - its shape matches that of the fastener, which means maximum grip and minimum slip**



**2.11 Sometimes a six-point tool just doesn't offer you any grip when you get the wrench at the angle it needs to be in to loosen or tighten a fastener - when this happens, pull out the 12-point sockets or wrenches - but remember: they're much more likely to strip the corners off a fastener**



**2.12 Open-end wrenches contact only two sides of the fastener and the jaws tend to open up when you put some muscle on the wrench handle - that's why they should only be used as a last resort**

wrench. When the wrench is turned, pressure is applied evenly on each of the six corners **(see illustration)**. This is fine unless the fastener head was previously rounded off. If so, the corners will be damaged and the wrench will slip. If you encounter a damaged bolt head or nut, always use a 6-point wrench or socket if possible. If you don't have one of the right size, choose a wrench that fits securely and proceed with care.

If you slip an open-end wrench over a hex-head fastener, you'll see the tool is in contact on two faces only **(see illustration)**. This is acceptable provided the tool and fastener are both in good condition. The need for a snug fit between the wrench and nut or bolt explains the recommendation to buy good-quality open-end wrenches. If the wrench jaws, the bolt head or both are damaged, the wrench will probably slip, rounding off and distorting the head. In some applications, an open-end wrench is the only possible choice due to limited access, but always check the fit of the wrench on the fastener before attempting to loosen it; if it's hard to get at with a wrench, think how hard it will be to remove after the head is damaged.

The last choice is an adjustable wrench or self-locking pliers/wrench (Vise-Grips). Use these tools only when all else has failed. In some cases, a self-locking wrench may be able to grip a damaged head that no wrench could deal with, but be careful not to make matters worse by damaging it further.

Bearing in mind the remarks about the correct choice of tool in the first place, there are several things worth noting about the actual use of the tool. First, make sure the wrench head is clean and undamaged. If the fastener is rusted or coated with paint, the wrench won't fit correctly. Clean off the head and, if it's rusted, apply some penetrating oil. Leave it to soak in for a while before attempting removal.

It may seem obvious, but take a close look at the fastener to be removed before using a wrench. On many mass-produced machines, one end of a fastener may be fixed or captive, which speeds up initial assembly and usually makes removal easier. If a nut is installed on a stud or a bolt threads into a captive nut or tapped hole, you may have only one fastener to deal with. If, on the other hand, you have a separate nut and bolt, you must hold the bolt head while the nut is removed.

In most cases, a fastener can be removed simply by placing the wrench on the nut or bolt head and turning it. Occasionally, though, the condition or location of the fastener may make things more difficult. Make sure the wrench is square on the head. You may need to reposition the tool or try another type to obtain a snug fit. Make sure the component you're working on is secure and can't move when you turn the wrench. If necessary, get someone to help steady it for you. Position yourself so you can get maximum leverage on the wrench.

If possible, locate the wrench so you can pull the end towards you. If you have to push on the tool, remember that it may slip, or the fastener may move suddenly. For this reason, don't curl your fingers around the handle or you may crush or bruise them when the fastener moves; keep your hand flat, pushing on the wrench with the heel of your thumb. If the tool digs into your hand, place a rag between it and your hand or wear a heavy glove.

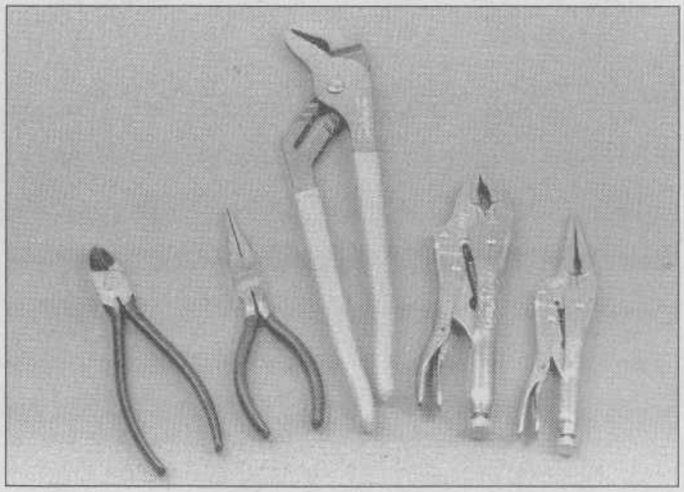
If the fastener doesn't move with normal hand pressure, stop and try to figure out why before the fastener or wrench is damaged or you hurt yourself. Stuck fasteners may require penetrating oil, heat or an impact driver or air tool.

Using sockets to remove hex-head fasteners is less likely to result in damage than if a wrench is used. Make sure the socket fits snugly over the fastener head, then attach an extension, if needed, and the ratchet or breaker bar. Theoretically, a ratchet shouldn't be used for loosening a fastener or for final tightening because the ratchet mechanism may be overloaded and could slip. In some instances, the location of the fastener may mean you have no choice but to use a ratchet, in which case you'll have to be extra careful.

Never use extensions where they aren't needed. Whether or not an extension is used, always support the drive end of the breaker bar with one hand while turning it with the other. Once the fastener is loose, the ratchet can be used to speed up removal.

## Pliers

Some tool manufacturers make 25 or 30 different types of pliers. You only need a fraction of this selection **(see illustra-**



**2.13 A typical assortment of the types of pliers you need to have in your box - from the left: diagonal cutters (dikes), needle-nose pliers, Channel-lock pliers, Vise-Grip pliers, needle-nose Vise-Grip pliers**

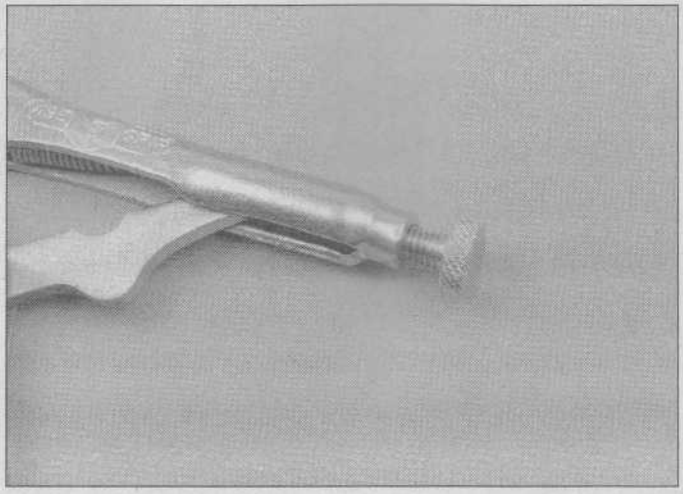
**tion)**. Get a good pair of slip-joint pliers for general use. A pair of needle-nose pliers is handy for reaching into hard-to-get-at places. A set of diagonal wire cutters (dikes) is essential for electrical work and pulling out cotter pins. Vise-Grips are adjustable, locking pliers that grip a fastener firmly - and won't let go - when locked into place. Parallel-jaw, adjustable pliers have angled jaws that remain parallel at any degree of opening. They're also referred to as Channel-lock (the original manufacturer) pliers, arc-joint pliers and water pump pliers. Whatever you call them, they're terrific for gripping a big fastener with a lot of force.

Slip-joint pliers have two open positions; a figure eight-shaped, elongated slot in one handle slips back-and-forth on a pivot pin on the other handle to change them. Good-quality pliers have jaws made of tempered steel and there's usually a wire-cutter at the base of the jaws. The primary uses of slip-joint pliers are for holding objects, bending and cutting throttle wires and crimping and bending metal parts, not loosening nuts and bolts.

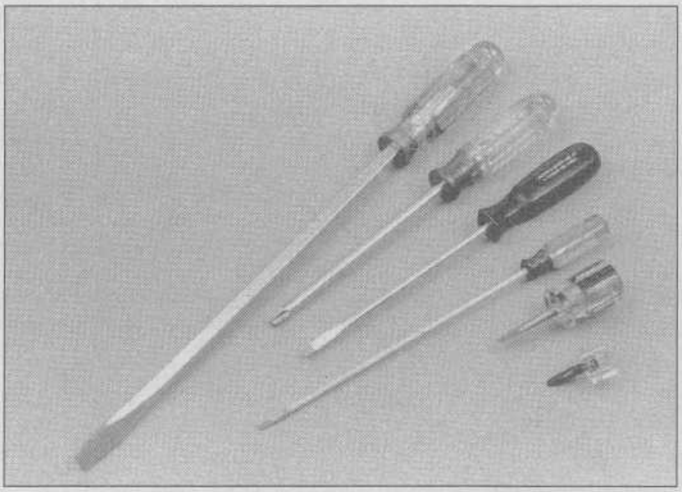
Arc-joint or "Channel-lock" pliers have parallel jaws you can open to various widths by engaging different tongues and grooves, or channels, near the pivot pin. Since the tool expands to fit many size objects, it has countless uses for engine and equipment maintenance. Channel-lock pliers come in various sizes. The medium size is adequate for general work; small and large sizes are nice to have as your budget permits. You'll use all three sizes frequently.

Vise-Grips (a brand name) come in various sizes; the medium size with curved jaws is best for all-around work. However, buy a large and small one if possible, since they're often used in pairs. Although this tool falls somewhere between an adjustable wrench, a pair of pliers and a portable vise, it can be invaluable for loosening and tightening damaged fasteners .

The jaw opening is set by turning a knurled knob at the end of one handle. The jaws are placed over the head of the fastener and the handles are squeezed together, locking the tool onto the fastener **(see illustration)**. The design of the tool allows extreme pressure to be applied at the jaws and a variety of jaw designs enable the tool to grip firmly even on damaged heads. Vise-Grips are great for removing fasteners that have been rounded off by badly-fitting wrenches.



**2.14 To adjust the jaws on a pair of Vise-Grips, grasp the part you want to hold with the jaws, tighten them down by turning the knurled knob on the end of one handle and snap the handles together - if you tightened the knob all the way down, you'll probably have to open it up (back it off) a little before you can close the handles**



**2.15 Screwdrivers come in a myriad of lengths, sizes and styles**

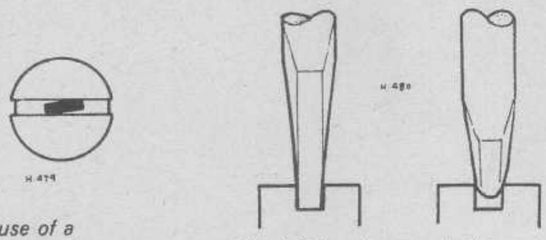
As the name suggests, needle-nose pliers have long, thin jaws designed for reaching into holes and other restricted areas. Most needle-nose, or long-nose, pliers also have wire cutters at the base of the jaws.

Look for these qualities when buying pliers: Smooth operating handles and jaws, jaws that match up and grip evenly when the handles are closed, a nice finish and the word "forged" somewhere on the tool.

## Screwdrivers

Screwdrivers **(see illustration)** come in a wide variety of sizes and price ranges, but stay away from cheap screwdriver sets at discount tool stores. Even if they look exactly like more expensive brands, the metal tips and shafts are made with inferior alloys and aren't properly heat treated. They usually bend the first time you apply some serious torque.

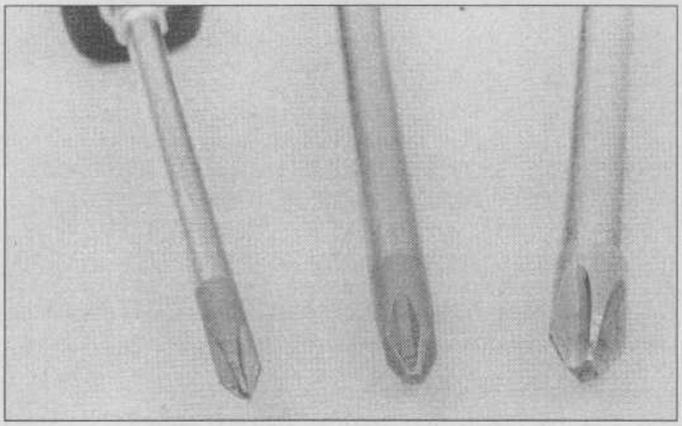
A screwdriver consists of a steel blade or shank with a drive tip formed at one end. The most common tips are standard (also called straight slot and flat-blade) and Phillips. The other end has a handle attached to it. Traditionally, handles



*Misuse of a screwdriver – the blade shown is both too narrow and too thin and will probably slip or break off*

*The left-hand example shows a snug-fitting tip. The right-hand drawing shows a damaged tip which will twist out of the slot when pressure is applied*

**2.16 Standard screwdrivers - wrong size (left), correct fit in screw slot (center) and worn tip (right)**



**2.17 The tip size on a Phillips screwdriver is indicated by a number from 1 to 4, with 1 the smallest (left - No. 1: center - No. 2; right - No. 3)**

were made from wood and secured to the shank, which had raised tangs to prevent it from turning in the handle. Most screwdrivers now come with plastic handles, which are generally more durable than wood.

The design and size of handles and blades vary considerably. Some handles are specially shaped to fit the human hand and provide a better grip. The shank may be either round or square and some have a hex-shaped bolster under the handle to accept a wrench to provide more leverage when trying to turn a stubborn screw. The shank diameter, tip size and overall length vary too.

If access is restricted, a number of special screwdrivers are designed to fit into confined spaces. The "stubby" screwdriver has a specially shortened handle and blade. There are also offset screwdrivers and special screwdriver bits that attach to a ratchet or extension.

The important thing to remember when buying screwdrivers is that they really do come in sizes designed to fit different size fasteners. The slot in any screw has definite dimensions - length, width and depth. Like a bolt head or a nut, the screw slot must be driven by a tool that uses all of the available bearing surface and doesn't slip. Don't use a big wide blade on a small screw and don't try to turn a large screw slot with a tiny, narrow blade. The same principles apply to Allen heads, Phillips heads, Torx heads, etc. Don't even think of using a slotted screwdriver on one of these heads! And don't use your screwdrivers as prybars, chisels or punches! This kind of abuse turns them into very bad screwdrivers.

### Standard screwdrivers

These are used to remove and install conventional slotted screws and are available in a wide range of sizes denoting the width of the tip and the length of the shank (for example: a 3/8 x 10-inch screwdriver is 3/8-inch wide at the tip and the shank is 10-inches long). You should have a variety of screwdrivers so screws of various sizes can be dealt with without damaging them. The blade end must be the same width and thickness as the screw slot to work properly, without slipping. When selecting standard screwdrivers, choose good-quality tools, preferably with chrome moly, forged steel shanks. The tip of the shank should be ground to a parallel, flat profile (hollow ground) and not to a taper or wedge shape, which will tend to twist out of the slot when pressure is applied **(see illustration)**.

All screwdrivers wear in use, but standard types can be reground to shape a number of times. When reshaping a tip, start by filing the very end flat at right angles to the shank. Make sure the tip fits snugly in the slot of a screw of the appropriate size and keep the sides of the tip parallel. Remove only a small amount of metal at a time to avoid overheating the tip and destroying the temper of the steel.

### Phillips screwdrivers

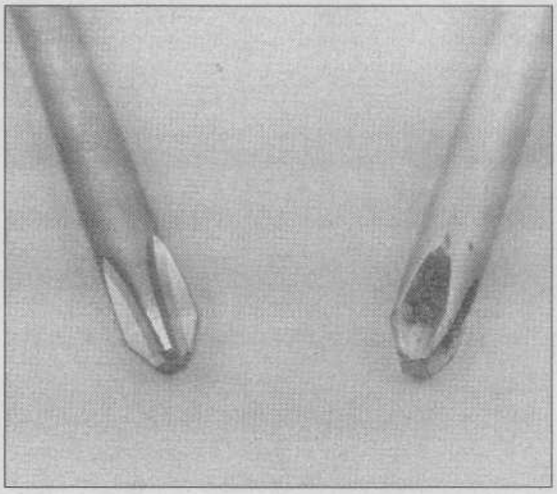
Phillips screws are sometimes installed during initial assembly with air tools and are next to impossible to remove later without ruining the heads, particularly if the wrong size screwdriver is used. And don't use other types of cross-head screwdrivers (such as Posi-drive, etc.) on Phillips screws - they won't work.

The only way to ensure the screwdrivers you buy will fit properly is to take a couple of screws with you to make sure the fit between the screwdriver and fastener is snug. If the fit is good, you should be able to angle the blade down almost vertically without the screw falling off the tip. Use only screwdrivers that fit exactly - anything else is guaranteed to chew out the screw head instantly.

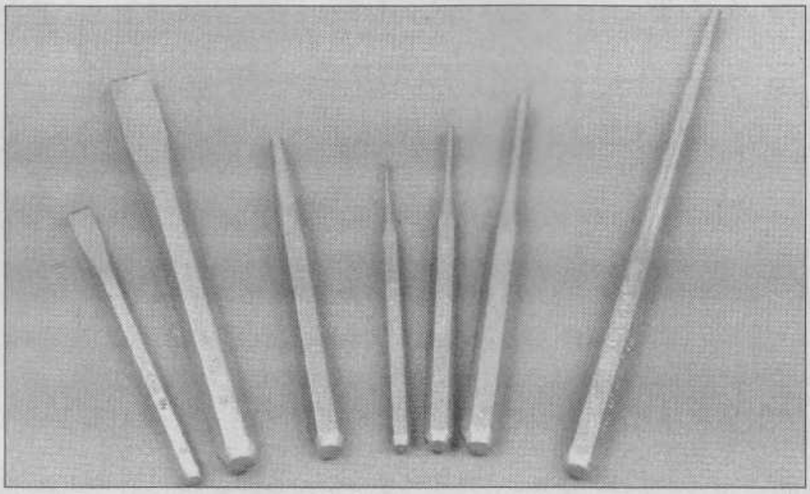
The idea behind all cross-head screw designs is to make the screw and screwdriver blade self-aligning. Provided you aim the blade at the center of the screw head, it'll engage correctly, unlike conventional slotted screws, which need careful alignment. This makes the screws suitable for machine installation on an assembly line (which explains why they're sometimes so tight and difficult to remove). The drawback with these screws is the driving tangs on the screwdriver tip are very small and must fit very precisely in the screw head. If this isn't the case, the huge loads imposed on small flats of the screw slot simply tear the metal away, at which point the screw ceases to be removable by normal methods. The problem is made worse by the normally soft material chosen for screws.

To deal with these screws on a regular basis, you'll need high-quality screwdrivers with various size tips so you'll be sure to have the right one when you need it. Phillips screwdrivers are sized by the tip number and length of the shank (for example: a number 2 x 6-inch Phillips screwdriver has a number 2 tip - to fit screws of only that size recess - and the shank is 6-inches long). Tip sizes 1, 2 and 3 should be adequate for engine repair work **(see illustration)**. If the tips get worn or damaged, buy new screwdrivers so the tools don't destroy the screws they're used on **(see illustration)**.

Here's a helpful hint that may come in handy when using Phillips screwdrivers - if the screw is extremely tight and the tip



2.18 **New (left) and worn (right) Phillips screwdriver tips**



2.19 **Cold chisels, center-punches, pin punches and line-up punches (left-to-right) will be needed sooner or later for many jobs**

tends to back out of the recess rather than turn the screw, apply a small amount of valve lapping compound to the screwdriver tip so it will grip the screw better.

## Punches and chisels

Punches and chisels **(see illustration)** are used along with a hammer for various purposes in the shop. Punches are available in various shapes and sizes and a set of assorted types will be very useful. One of the most basic is the center punch, a small cylindrical punch with the end ground to a point. It'll be needed whenever a hole is drilled. The center of the hole is located first and the punch is used to make a small indentation. The indentation acts as a guide for the drill bit so the hole ends up in the right place. Without a punch mark the drill bit will wander and you'll find it impossible to drill with any real accuracy. You can also buy automatic center punches. They're spring loaded and are pressed against the surface to be marked, without the need to use a hammer.

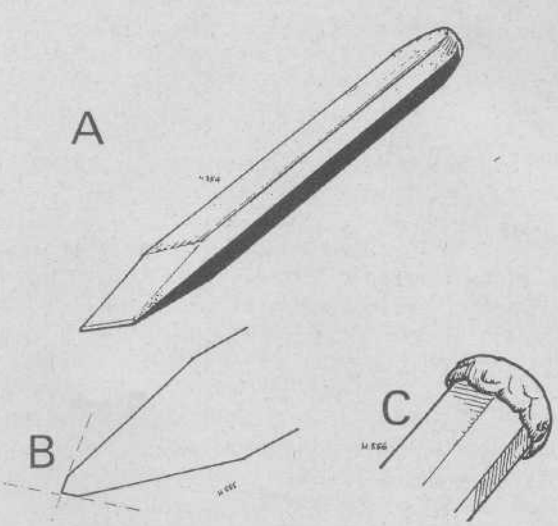
Pin punches are intended for removing items like roll pins (hollow spring steel pins that fit tightly in their holes). Pin punches have other uses, however. You may occasionally have to remove rivets by cutting off the heads and driving out the shanks with a pin punch. They're also very handy for aligning holes in components while bolts or screws are inserted.

Of the various sizes and types of metal-cutting chisels available, a simple cold chisel is essential in any mechanic's workshop. One about 6-inches long with a 1/2-inch wide blade should be adequate. The cutting edge is ground to about 80-degrees **(see illustration)**, while the rest of the tip is ground to a shallower angle away from the edge. The primary use of the cold chisel is rough metal cutting - this can be anything from removing concealment plugs to cutting off the heads of seized or rusted bolts or splitting nuts. A cold chisel is also useful for turning out screws or bolts with messed-up heads.

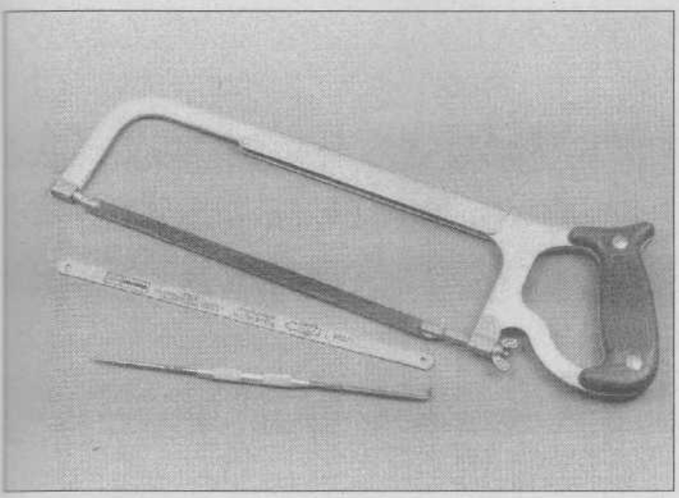
All of the tools described in this section should be good quality items. They're not particularly expensive, so it's not really worth trying to save money on them. More significantly, there's a risk that with cheap tools, fragments may break off in use - a potentially dangerous situation.

Even with good-quality tools, the heads and working ends will inevitably get worn or damaged, so it's a good idea to maintain all such tools on a regular basis. Using a file or bench grinder, remove all burrs and mushroomed edges from around the head. This is an important task because the build-up of material around the head can fly off when it's struck with a hammer and is potentially dangerous. Make sure the tool retains its original profile at the working end, again, filing or grinding off all burrs. In the case of cold chisels, the cutting edge will usually have to be reground quite often because the material in the tool isn't usually much harder than materials typically being cut. Make sure the edge is reasonably sharp, but don't make the tip angle greater than it was originally; it'll just wear down faster if you do.

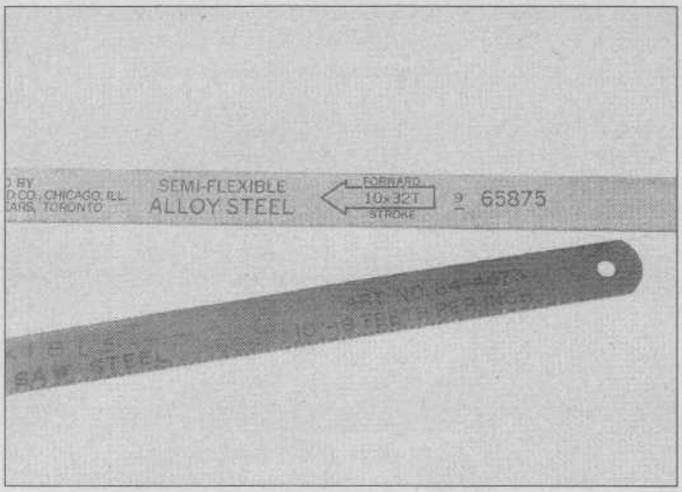
The techniques for using these tools vary according to the job to be done and are best learned by experience. The one common denominator is the fact they're all normally struck with a hammer. It follows that eye protection should be worn. Always make sure the working end of the tool is in contact with the part being punched or cut. If it isn't, the tool will bounce off the surface and damage may result.



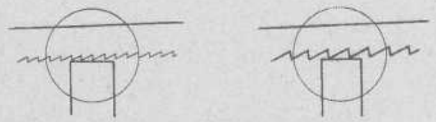
2.20 **A typical general purpose cold chisel (A) - note the angle of the cutting edge (B), which should be checked and sharpened on a regular basis; the mushroomed head (C) is dangerous and should be filed to restore it to its original shape**



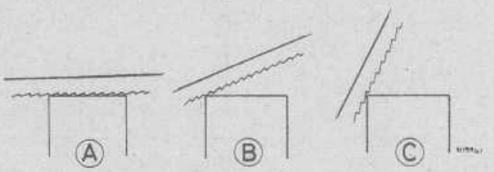
**2.21 Hacksaws are handy for little cutting jobs like sheet metal and rusted fasteners**



**2.22 Hacksaw blades are marked with the number of teeth per inch (TPI) - use a relatively course blade for aluminum and thicker items such as bolts or bar stock; use a finer blade for materials like thin sheet steel**



*When cutting thin materials, check that at least three teeth are in contact with the workpiece at any time. Too coarse a blade will result in a poor cut and may break the blade. If you do not have the correct blade, cut at a shallow angle to the material*



*The correct cutting angle is important. If it is too shallow (A) the blade will wander. The angle shown at (B) is correct when starting the cut, and may be reduced slightly once under way. In (C) the angle is too steep and the blade will be inclined to jump out of the cut*

**2.23 Correct procedure for use of a hacksaw**

**2.24 Good quality hacksaw blades are marked like this**

## Hacksaws

A hacksaw **(see illustration)** consists of a handle and frame supporting a flexible steel blade under tension. Blades are available in various lengths and most hacksaws can be adjusted to accommodate the different sizes. The most common blade length is 10-inches.

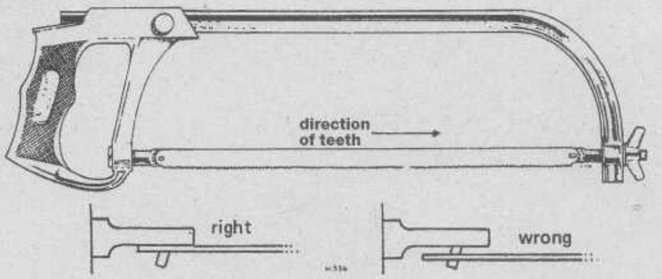
Most hacksaw frames are adequate. There's little difference between brands. Pick one that's rigid and allows easy blade changing and repositioning.

The type of blade to use, indicated by the number of teeth per inch (TPI) **(see illustration)**, is determined by the material being cut. The rule of thumb is to make sure at least three teeth are in contact with the metal being cut at any one time **(see illustration)**. In practice, this means a fine blade for cutting thin sheet materials, while a coarser blade can be used for faster cutting through thicker items such as bolts or bar stock. When cutting thin materials, angle the saw so the blade cuts at a shallow angle. More teeth are in contact and there's less chance of the blade binding and breaking, or teeth breaking.

When you buy blades, choose a reputable brand. Cheap, unbranded blades may be perfectly acceptable, but you can't tell by looking at them. Poor quality blades will be insufficiently hardened on the teeth edge and will dull quickly. Most reputable brands will be marked "Flexible High Speed Steel" or with a similar term to indicate the type of material used **(see illustration)**. It is possible to buy "unbreakable" blades (only the teeth are hardened, leaving the rest of the blade less brittle).

Sometimes, a full-size hacksaw is too big to allow access to a frozen nut or bolt. On most saws, you can overcome this problem by turning the blade 90-degrees. Occasionally you may have to position the saw around an obstacle and then install the blade on the other side of it. Where space is really restricted, you may have to use a handle that clamps onto a saw blade at one end. This allows access when a hacksaw frame would not work at all and has another advantage in that you can make use of broken off hacksaw blades instead of throwing them away. Note that because only one end of the blade is supported, and it's not held under tension, it's difficult to control and less efficient when cutting.

Before using a hacksaw, make sure the blade is suitable for the material being cut and installed correctly in the frame



2.25 Correct installation of a hacksaw blade - the teeth must point away from the handle and butt against the locating lugs

**(see illustration)**. Whatever it is you're cutting must be securely supported so it can't move around. The saw cuts on the forward stroke, so the teeth must point away from the handle. This might seem obvious, but it's easy to install the blade backwards by mistake and ruin the teeth on the first few strokes. Make sure the blade is tensioned adequately or it'll distort and chatter in the cut and may break. Wear safety glasses and be careful not to cut yourself on the saw blade or the sharp edge of the cut.

## Files

Files **(see illustration)** come in a wide variety of sizes and types for specific jobs, but all of them are used for the same basic function of removing small amounts of metal in a controlled fashion. Files are used by mechanics mainly for deburring, marking parts, removing rust, filing the heads off rivets, restoring threads and fabricating small parts.

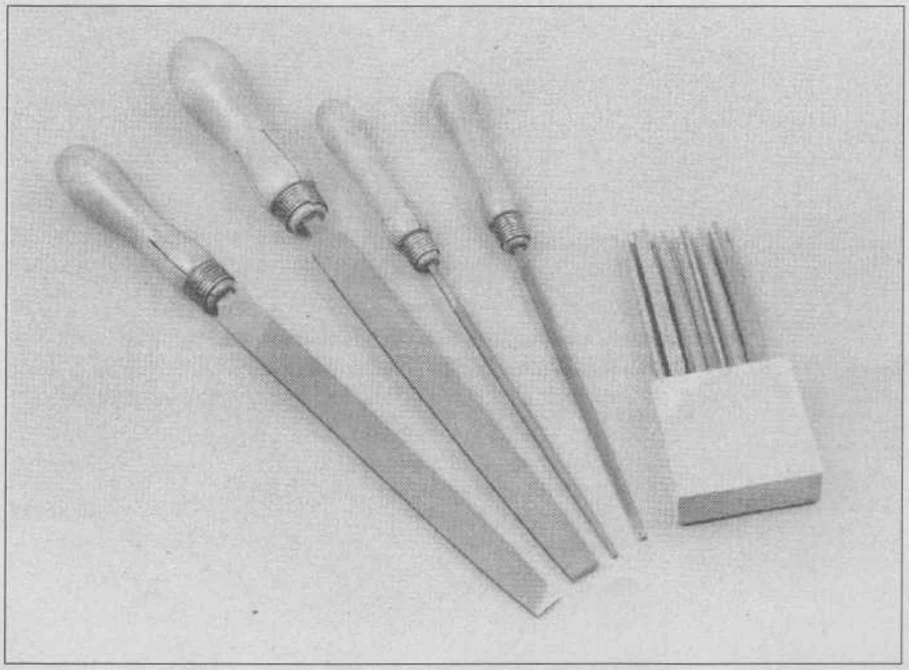
File shapes commonly available include flat, half-round, round, square and triangular. Each shape comes in a range of sizes (lengths) and cuts ranging from rough to smooth. The file face is covered with rows of diagonal ridges which form the cutting teeth. They may be aligned in one direction only (single cut) or in two directions to form a diamond-shaped pattern (double-cut) **(see illustration)**. The spacing of the teeth determines the file coarseness, again, ranging from rough to smooth in five basic grades: Rough, coarse, bastard, second-cut and smooth.

You'll want to build up a set of files by purchasing tools of the required shape and cut as they're needed. A good starting point would be flat, half-round, round and triangular files (at least one each - bastard or second-cut types). In addition, you'll have to buy one or more file handles (files are usually sold without handles, which are purchased separately and pushed over the tapered tang of the file when in use) **(see illustration)**. You may need to buy more than one size handle to fit the various files in your tool box, but don't attempt to get by without them. A file tang is fairly sharp and you almost certainly will end up stabbing yourself in the palm of the hand if you use a file without a handle and it catches in the workpiece during use. Adjustable handles are also available for use with files of various sizes, eliminating the need for several handles **(see illustration)**.

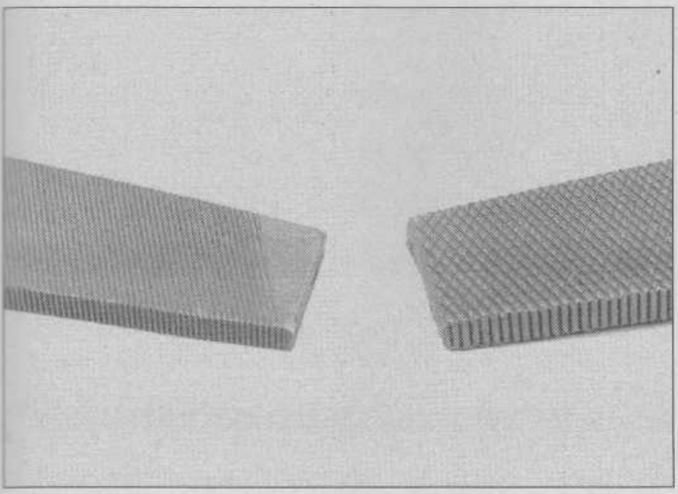
Exceptions to the need for a handle are fine swiss pattern files, which have a rounded handle instead of a tang. These small files are usually sold in sets with a number of different shapes.

The correct procedure for using files is fairly easy to master. As with a hacksaw, the work should be clamped securely in a vise, if needed, to prevent it from moving around while being worked on. Hold the file by the handle, using your free hand at the file end to guide it and keep it flat in relation to the surface being filed. Use smooth cutting strokes and be careful not to rock the file as it passes over the surface. Also, don't slide it diagonally across the surface or the teeth will make grooves in the workpiece. Don't drag a file back across the workpiece at the end of the stroke - lift it slightly and pull it back to prevent damage to the teeth.

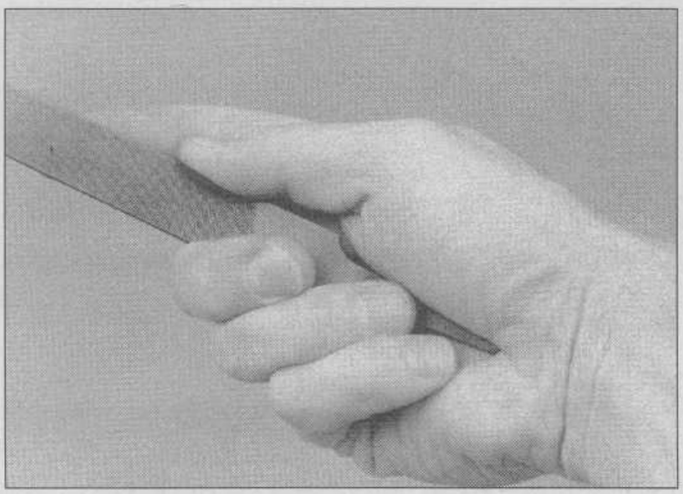
Files don't require maintenance in the usual sense, but they should be kept clean and free of metal filings. Steel is a



2.26 Get a good assortment of files - they're handy for deburring, marking parts, removing rust, filing the heads off rivets, restoring threads and fabricating small parts

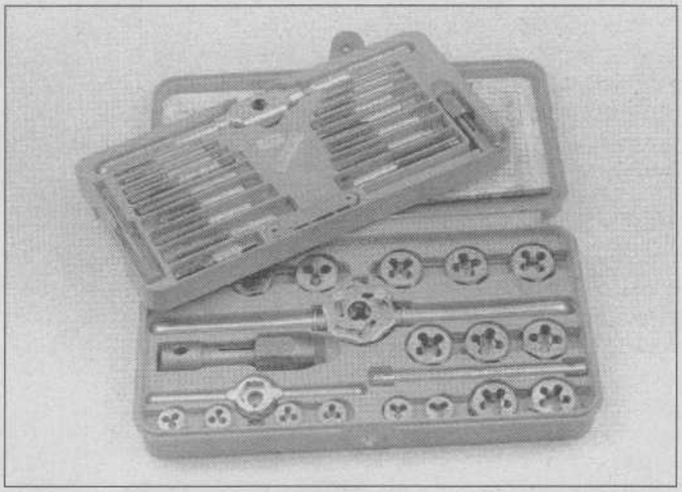


2.27 Files are either single-cut (left) or double-cut (right) - generally speaking, use a single-cut file to produce a very smooth surface; use a double-cut file to remove large amounts of material quickly



2.28 Never use a file without a handle - the tang is sharp and could puncture your hand

2.29 Adjustable handles that will work with may different size files are also available



2.30 Tap and die sets are available in inch and metric sizes - taps are used for cutting internal threads and cleaning and restoring damaged threads; dies are used for cutting, cleaning and restoring external threads

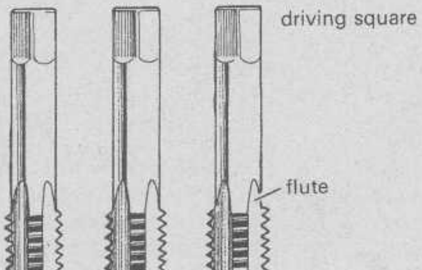
reasonably easy material to work with, but softer metals like aluminum tend to clog the file teeth very quickly, which will result in scratches in the workpiece. This can be avoided by rubbing the file face with chalk before using it. General cleaning is carried out with a file card. If kept clean, files will last a long time - when they do eventually dull, they must be replaced; there is no satisfactory way of sharpening a worn file.

## Taps and dies

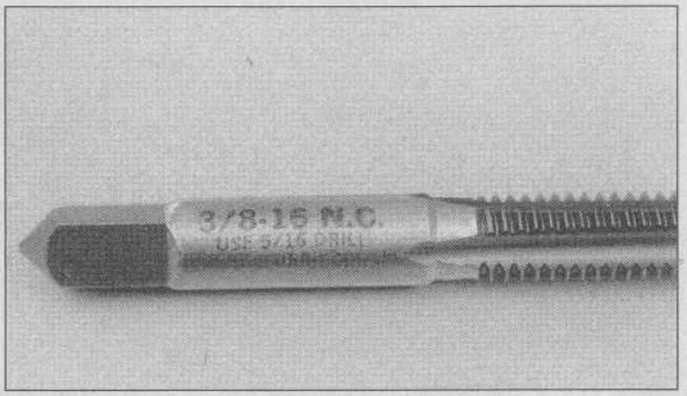
### Taps

Tap and die sets **(see illustration)** are available in inch and metric sizes. Taps are used to cut internal threads and clean or restore damaged threads. A tap consists of a fluted shank with a drive square at one end. It's threaded along part of its length - the cutting edges are formed where the flutes intersect the threads **(see illustration)**. Taps are made from hardened steel so they will cut threads in materials softer than what they're made of.

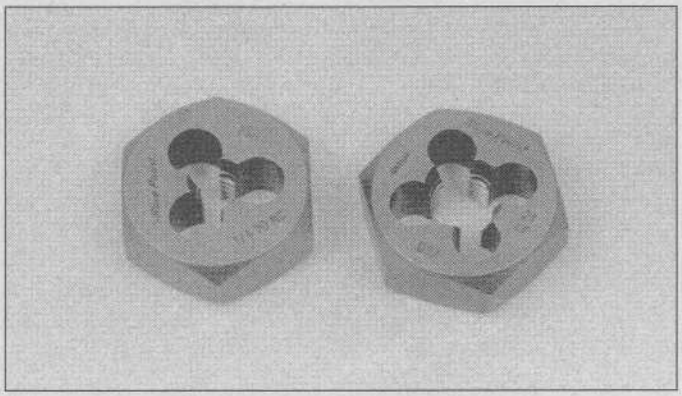
Taps come in three different types: Taper, plug and bottoming. The only real difference is the length of the chamfer on the cutting end of the tap. Taper taps are chamfered for the first 6 or 8 threads, which makes them easy to start but pre-



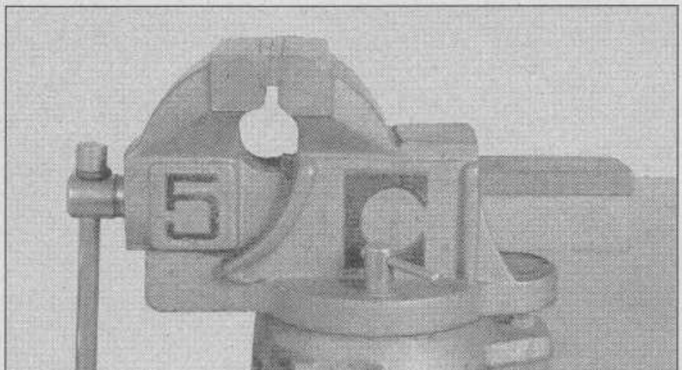
2.31 Taper, plug and bottoming taps (left-to-right)



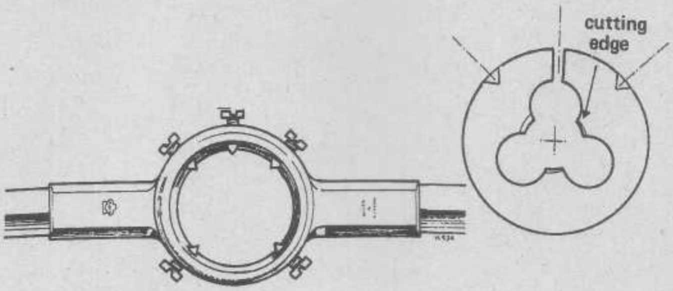
2.32 If you need to drill and tap a hole, the drill bit size to use for a given bolt (tap) size is marked on the tap



2.34 Hex-shaped dies are especially handy for mechanic's work because they can be turned with a wrench



2.35 A bench vise is one of the most useful pieces of equipment you can have in the shop - bigger is usually better with vises, so get a vise with jaws that open at least four inches



2.33 A die (right) is used for cutting external threads (this one is a split-type/adjustable die) and is held in a tool called a die stock (left)

vents them from cutting threads close to the bottom of a hole. Plug taps are chamfered up about 3 to 5 threads, which makes them a good all around tap because they're relatively easy to start and will cut nearly to the bottom of a hole. Bottoming taps, as the name implies, have a very short chamfer (1-1/2 to 3 threads) and will cut as close to the bottom of a blind hole as practical. However, to do this, the threads should be started with a plug or taper tap.

Although cheap tap and die sets are available, the quality is usually very low and they can actually do more harm than good when used on threaded holes in aluminum engines. The alternative is to buy high-quality taps if and when you need them, even though they aren't cheap, especially if you need to buy two or more thread pitches in a given size. Despite this, it's the best option - you'll probably only need taps on rare occasions, so a full set isn't absolutely necessary.

Taps are normally used by hand (they can be used in machine tools, but only in machine shop applications). The square drive end of the tap is held in a tap wrench (an adjustable T-handle). For smaller sizes, a T-handled chuck can be used. The tapping process starts by drilling a hole of the correct diameter. For each tap size, there's a corresponding twist drill that will produce a hole of the correct size. This is important; too large a hole will leave the finished thread with the tops missing, producing a weak and unreliable grip. Conversely, too small a hole will place excessive loads on the hard and brittle shank of the tap, which can break it off in the hole. Removing a broken off tap from a hole is no fun! The correct tap drill size is normally marked on the tap itself or the container it comes in **(see illustration)**.

### Dies

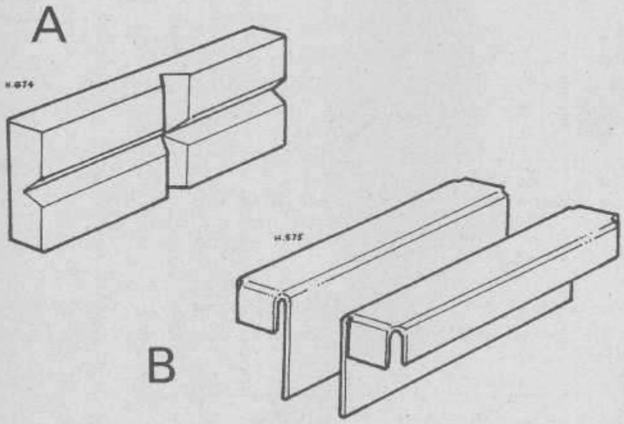
Dies are used to cut, clean or restore external threads. Most dies are made from a hex-shaped or cylindrical piece of hardened steel with a threaded hole in the center. The threaded hole is overlapped by three or four cutouts, which equate to the flutes on taps and allow metal waste to escape during the threading process. Dies are held in a T-handled holder (called a die stock) **(see illustration)**. Some dies are split at one point, allowing them to be adjusted slightly (opened and closed) for fine control of thread clearances.

Dies aren't needed as often as taps, for the simple reason it's normally easier to install a new bolt than to salvage one. However, it's often helpful to be able to extend the threads of a bolt or clean up damaged threads with a die. Hex-shaped dies are particularly useful for mechanic's work, since they can be turned with a wrench **(see illustration)** and are usually less expensive than adjustable ones.

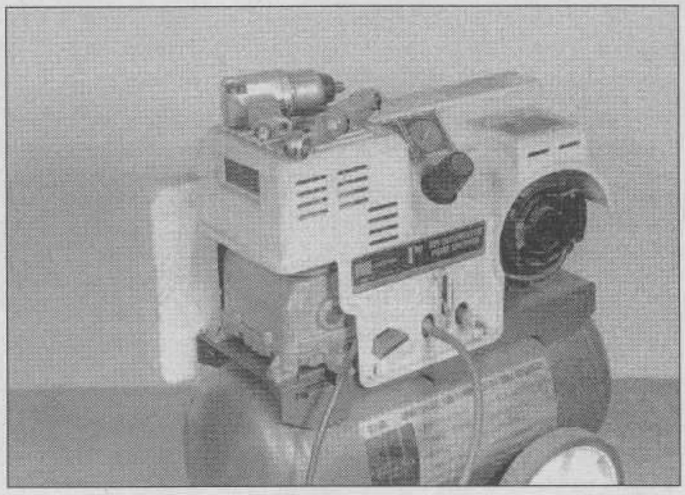
The procedure for cutting threads with a die is broadly similar to that described above for taps. When using an adjustable die, the initial cut is made with the die fully opened, the adjustment screw being used to reduce the diameter of successive cuts until the finished size is reached. As with taps, a cutting lubricant should be used, and the die must be backed off every few turns to clear swarf from the cutouts.

### Bench vise

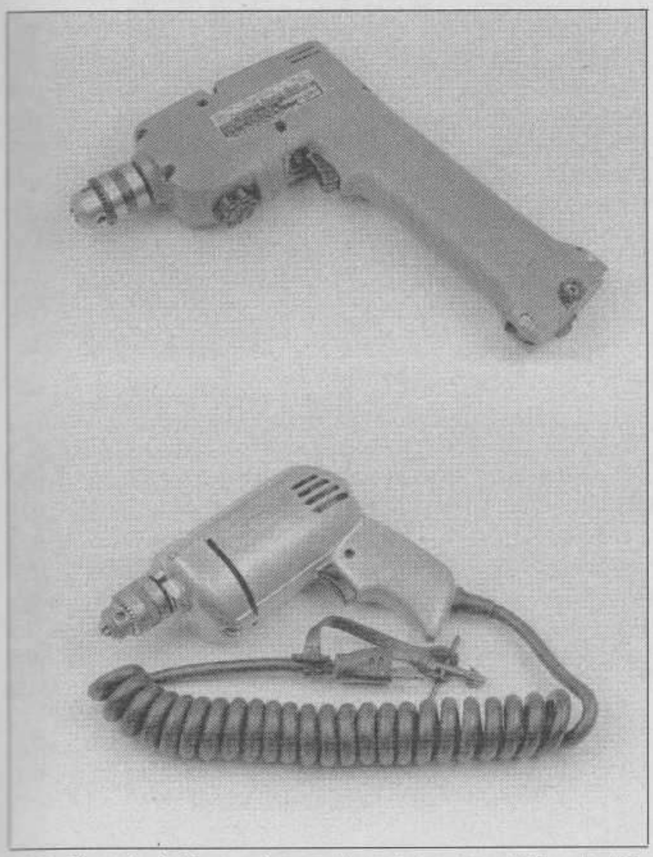
The bench vise **(see illustration)** is an essential tool in a shop. Buy the best quality vise you can afford. A good vise is



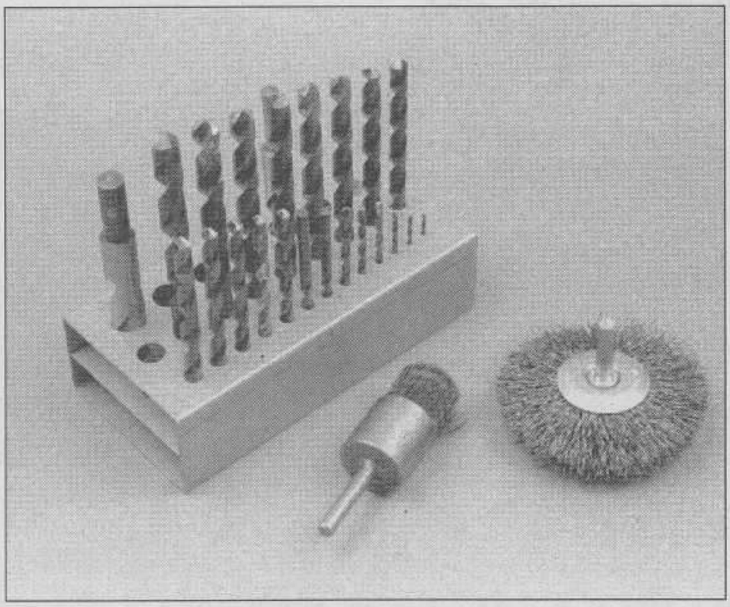
2.36 Sometimes, the parts you have to jig up in the vise are delicate, or made of soft materials - to avoid damaging them, get a pair of fiberglass or plastic "soft jaws" (A) or fabricate your own with 1/8-inch thick aluminum sheet (B)



2.37 Although it's not absolutely necessary, an air compressor can make many jobs easier and produce better results, especially when air powered tools are available to use with it



2.38 Electric drills can be cordless (above) or 115-volt, AC-powered (below)



2.39 Get a set of good quality drill bits for drilling holes and wire brushes of various sizes for cleaning up metal parts - make sure the bits are designed for drilling in metal

expensive, but the quality of its materials and workmanship are worth the extra money. Size is also important - bigger vises are usually more versatile. Make sure the jaws open at least four inches. Get a set of soft jaws to fit the vise as well - you'll need them to grip parts that could be damaged by the hardened vise jaws **(see illustration)**.

## *Power tools*

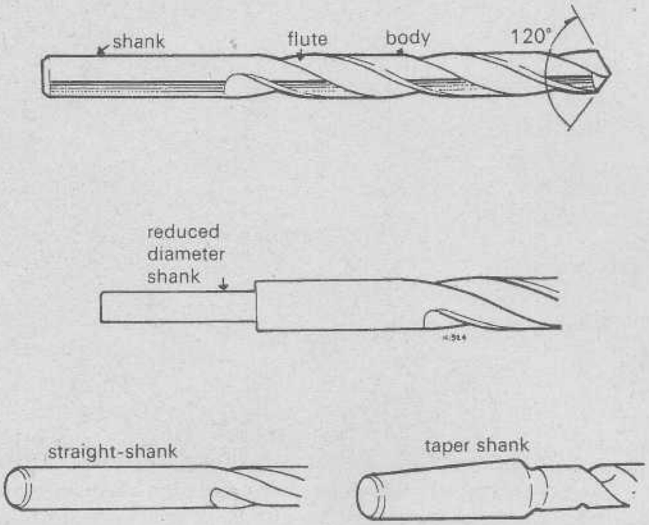
Really, the only power tool you may need is an electric drill. But if you have an air compressor and electricity, there's a wide range of pneumatic and electric hand tools to make all sorts of jobs easier and faster.

### Air compressor

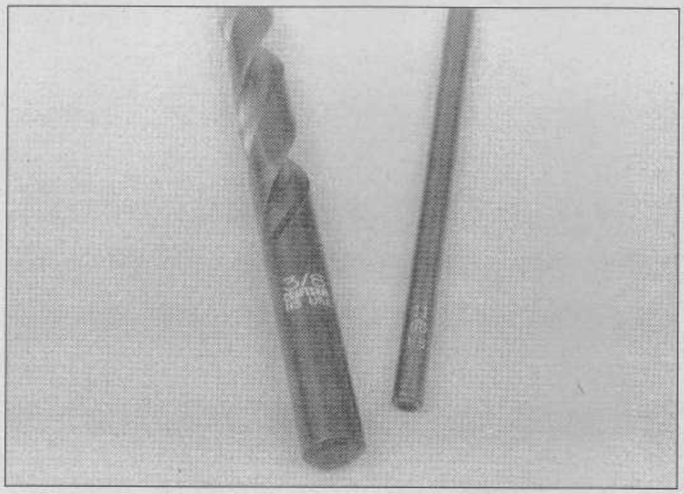
An air compressor **(see illustration)** makes most jobs easier and faster. Drying off parts after cleaning them, blowing out passages, running power tools - the list is endless. Once you buy a compressor, you'll wonder how you ever got along without it.

### Electric drills

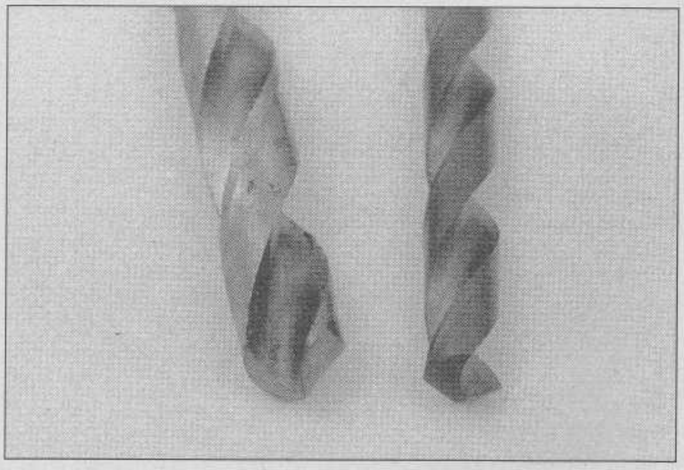
A drill motor with a 3/8-inch chuck (drill bit holder) will handle most jobs **(see illustration)**. Collect several different wire brushes to use in the drill and make sure you have a complete



**2.40 A typical drill bit (top), a reduced shank bit (center), and a tapered shank bit (bottom right)**



**2.41 Drill bits in the range most commonly used are available in fractional sizes (left) and number sizes (right) so almost any size hole can be drilled**



**2.42 If a bit gets dull (left), discard it or re sharpen it so it looks like the bit on the right**

set of sharp drill bits **(see illustration)**. Cordless drills are extremely versatile because they don't force you to work near an outlet. They're also handy to have around for a variety of non-mechanical jobs.

## Twist drills

Drilling operations are done with twist drills, either in a hand drill or a drill press. Twist drills (or drill bits, as they're often called) consist of a round shank with spiral flutes formed into the upper two-thirds to clear the waste produced while drilling, keep the drill centered in the hole and finish the sides of the hole.

The lower portion of the shank is left plain and used to hold the drill in the chuck. In this section, we will discuss only normal parallel shank drills **(see illustration)**. There is another type of bit with the plain end formed into a special size taper designed to fit directly into a corresponding socket in a heavy-duty drill press. These drills are known as Morse Taper drills and are used primarily in machine shops.

At the cutting end of the drill, two edges are ground to form a conical point. They're generally angled at about 60-degrees from the drill axis, but they can be reground to other angles for specific applications. For general use the standard angle is correct - this is how the drills are supplied.

When buying drills, purchase a good-quality set (sizes 1/16 to 3/8-inch). Make sure the drills are marked "High Speed Steel" or "HSS". This indicates they're hard enough to withstand continual use in metal; many cheaper, unmarked drills are suitable only for use in wood or other soft materials. Buying a set ensures the right size bit will be available when it's needed.

### Twist drill sizes

Twist drills are available in a vast array of sizes, most of which you'll never need. There are three basic drill sizing systems: Fractional, number and letter **(see illustration)** (we won't get involved with the fourth system, which is metric sizes).

Fractional sizes start at 1/64-inch and increase in increments of 1/64-inch. Number drills range in descending order from 80 (0.0135-inch), the smallest, to 1 (0.2280-inch), the largest. Letter sizes start with A (0.234-inch), the smallest, and go through Z (0.413-inch), the largest.

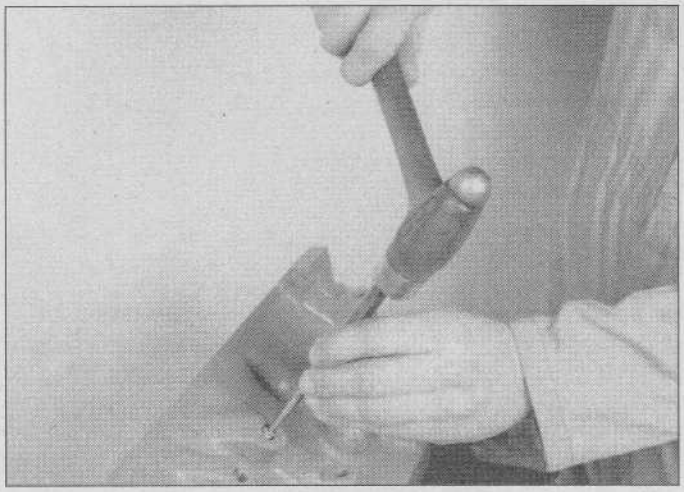
This bewildering range of sizes means it's possible to drill an accurate hole of almost any size within reason. In practice, you'll be limited by the size of chuck on your drill (normally 3/8 or 1/2-inch). In addition, very few stores stock the entire range of possible sizes, so you'll have to shop around for the nearest available size to the one you require.

### Sharpening twist drills

Like any tool with a cutting edge, twist drills will eventually get dull **(see illustration)**. How often they'll need sharpening depends to some extent on whether they're used correctly. A dull twist drill will soon make itself known. A good indication of the condition of the cutting edges is to watch the waste emerging from the hole being drilled. If the tip is in good condition, two even spirals of waste metal will be produced; if this fails to happen or the tip gets hot, it's safe to assume that sharpening is required.

With smaller size drills - under about 1/8-inch - it's easier and more economical to throw the worn drill away and buy another one. With larger (more expensive) sizes, sharpening is a better bet. When sharpening twist drills, the included angle of

**2.43 Inexpensive drill bit sharpening jigs designed to be used with a bench grinder are widely available - even if you only use it to re sharpen drill bits, it'll pay for itself quickly**



**2.44 Before you drill a hole, use a center punch to make an indentation for the drill bit so it won't wander**

the cutting edge must be maintained at the original 120-degrees and the small chisel edge at the tip must be retained. With some practice, sharpening can be done freehand on a bench grinder, but it should be noted that it's very easy to make mistakes. For most home mechanics, a sharpening jig that mounts next to the grinding wheel should be used so the drill is clamped at the correct angle **(see illustration)**.

## Drilling equipment

Tools to hold and turn drill bits range from simple, inexpensive hand-operated or electric drills to sophisticated and expensive drill presses. Ideally, all drilling should be done on a drill press with the workpiece clamped solidly in a vise. These machines are expensive and take up a lot of bench or floor space, so they're out of the question for many do-it-yourselfers. An additional problem is the fact that many of the drilling jobs you end up doing will be on the engine itself or the equipment it's mounted on, in which case the tool has to be taken to the work.

The best tool for the home shop is an electric drill with a 3/8-inch chuck. Both cordless and AC drills (that run off household current) are available. If you're purchasing one for the first time, look for a well-known, reputable brand name and variable speed as minimum requirements. A 1/4-inch chuck, single-speed drill will work, but it's worth paying a little more for the larger, variable speed type.

Most drill motors require a key to lock the bit in the chuck, but some have keyless chucks which are tightened by hand. When removing or installing a bit, make sure the cord is unplugged to avoid accidents. Initially, tighten the chuck by hand, checking to see if the bit is centered correctly. This is especially important when using small drill bits which can get caught between the jaws. Once the chuck is hand tight, use the key to tighten it securely - remember to remove the key afterwards!

## Preparation for drilling

If possible, make sure the part you intend to drill in is securely clamped in a vise. If it's impossible to get the work to a vise, make sure it's stable and secure. Twist drills often dig in during drilling - this can be dangerous, particularly if the work suddenly starts spinning on the end of the drill.

Start by locating the center of the hole you're drilling. Use a center punch to make an indentation for the drill bit so it won't wander. If you're drilling out a broken-off bolt, be sure to position the punch in the exact center of the bolt **(see illustration)**.

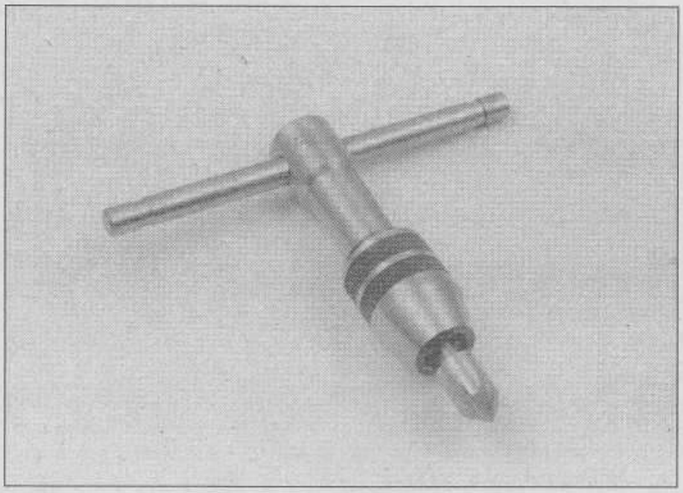
If you're drilling a large hole (above 1/4-inch), you may want to make a pilot hole first. As the name suggests, it will guide the larger drill bit and minimize drill bit wandering. Before actually drilling a hole, make sure the area immediately behind the bit is clear of anything you don't want drilled.

## Drilling

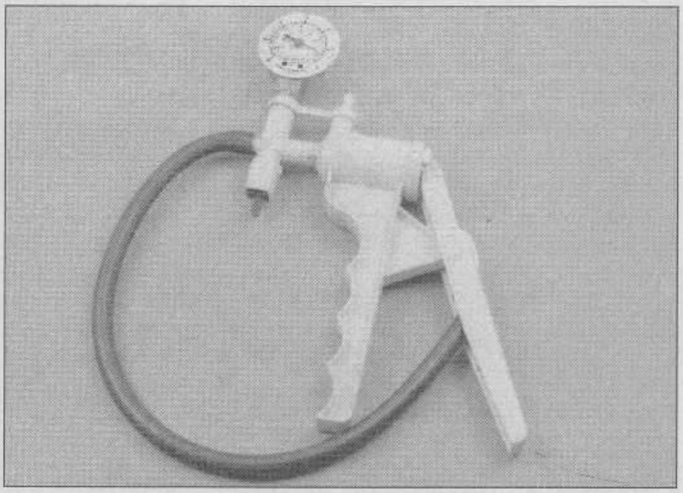
When drilling steel, especially with smaller bits, no lubrication is needed. If a large bit is involved, oil can be used to ensure a clean cut and prevent overheating of the drill tip. When drilling aluminum, which tends to smear around the cutting edges and clog the drill bit flutes, use kerosene as a lubricant.

Wear safety goggles or a face shield and assume a comfortable, stable stance so you can control the pressure on the drill easily. Position the drill tip in the punch mark and make sure, if you're drilling by hand, the bit is perpendicular to the surface of the workpiece. Start drilling without applying much pressure until you're sure the hole is positioned correctly. If the hole starts off center, it can be very difficult to correct. You can try angling the bit slightly so the hole center moves in the opposite direction, but this must be done before the flutes of the bit have entered the hole. It's at the starting point that a variable-speed drill is invaluable; the low speed allows fine adjustments to be made before it's too late. Continue drilling until the desired hole depth is reached or until the drill tip emerges at the other side of the workpiece.

Cutting speed and pressure are important - as a general rule, the larger the diameter of the drill bit, the slower the drilling speed should be. Also, the harder the material is, the slower the drilling speed should be. With a single-speed drill, there's little that can be done to control it, but two-speed or variable speed drills can be controlled. If the drilling speed is too high, the cutting edges of the bit will tend to overheat and dull. Pressure should be varied during drilling. Start with light pressure until the drill tip has located properly in the work. Gradually increase pressure so the bit cuts evenly. If the tip is sharp and the pressure correct, two distinct spirals of metal will emerge from the bit flutes. If the pressure is too light, the bit won't cut properly, while excessive pressure will overheat the tip.



2.45 Use a large drill bit or a countersink mounted in a tap wrench to remove burrs from a hole after drilling or enlarging it



2.47 The vacuum/pressure pump can create a vacuum in a circuit, or pressurize it, to simulate the actual operating conditions

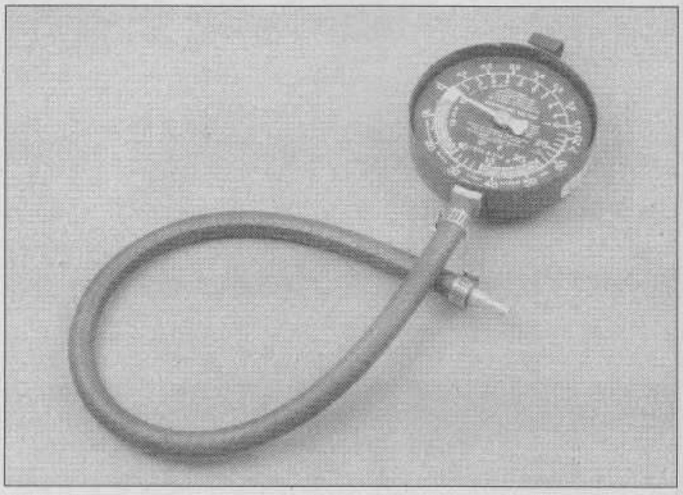
Decrease pressure as the bit breaks through the workpiece. If this isn't done, the bit may jam in the hole; if you're using a hand-held drill, it could be jerked out of your hands, especially when using larger size bits.

Once a pilot hole has been made, install the larger bit in the chuck and enlarge the hole. The second bit will follow the pilot hole - there's no need to attempt to guide it (if you do, the bit may break off). It is important, however, to hold the drill at the correct angle.

After the hole has been drilled to the correct size, remove the burrs left around the edges of the hole. This can be done with a small round file, or by chamfering the opening with a larger bit or a countersink **(see illustration)**. Use a drill bit that's several sizes larger than the hole and simply twist it around each opening by hand until any rough edges are removed.

### Enlarging and reshaping holes

The biggest practical size for bits used in a hand drill is about 1/2-inch. This is partly determined by the capacity of the chuck (although it's possible to buy larger drills with stepped shanks). The real limit is the difficulty of controlling large bits by hand; drills over 1/2-inch tend to be too much to handle in anything other than a drill press. If you have to make a larger hole, or if a shape other than round is involved, different techniques are required.



2.46 The vacuum gauge indicates intake manifold vacuum, in inches of mercury (in-Hg)

If a hole simply must be enlarged slightly, a round file is probably the best tool to use. If the hole must be very large, a hole saw will be needed, but they can only be used in sheet metal.

Large or irregular-shaped holes can also be made in sheet metal and other thin materials by drilling a series of small holes very close together. In this case the desired hole size and shape must be marked with a scribe. The next step depends on the size bit to be used; the idea is to drill a series of almost touching holes just inside the outline of the large hole. Center punch each location, then drill the small holes. A cold chisel can then be used to knock out the waste material at the center of the hole, which can then be filed to size. This is a time consuming process, but it's the only practical approach for the home shop. Success is dependent on accuracy when marking the hole shape and using the center punch.

## *Troubleshooting tools*

### Vacuum gauge

The vacuum gauge **(see illustration)** indicates ported or intake manifold vacuum, in inches of mercury (in-Hg).

### Vacuum/pressure pump

The hand-operated vacuum/pressure pump **(see illustration)** can create a vacuum, or build up pressure, in a circuit to check components that are vacuum or pressure operated. It can also be used as a vacuum gauge.

## *Safety items that should be in every shop*

### Fire extinguishers

Buy at least one fire extinguisher **(see illustration)** before doing any maintenance or repair procedures. Make sure it's rated for flammable liquid fires. Familiarize yourself with its use as soon as you buy it - don't wait until you need it to figure out how to use it. And be sure to have it checked and recharged at regular intervals. Refer to the safety tips at the end of this chapter for more information about the hazards of gasoline and other flammable liquids.

### Gloves

If you're handling hot parts or metal parts with sharp

**2.48 Buy at least one fire extinguisher before you begin work - make sure it's rated for flammable liquid fires and KNOW HOW TO USE IT!**

edges, wear a pair of industrial work gloves to protect yourself from burns, cuts and splinters **(see illustration)**. Wear a pair of heavy duty rubber gloves (to protect your hands when you wash parts in solvent).

### Safety glasses or goggles

Never use a drill, hammer and chisel or grinder without safety glasses **(see illustration)**. Don't take a chance on getting a metal sliver in your eye. It's also a good idea to wear safety glasses when you're washing parts in solvent or carburetor cleaner.

## *Storage and care of tools*

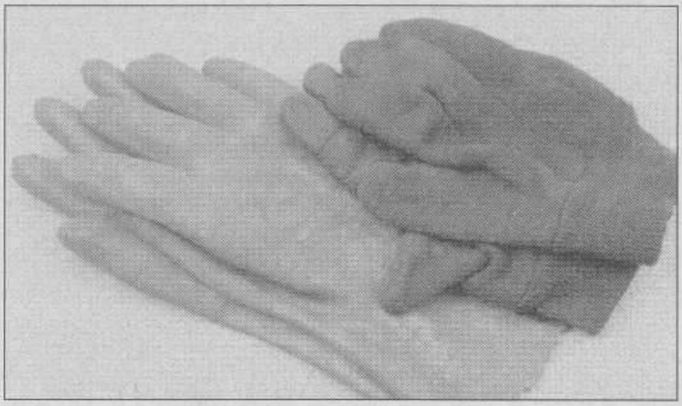
Good tools are expensive, so treat them well. After you're through with your tools, wipe off any dirt, grease or metal chips and put them away. Don't leave tools lying around in the work area. General purpose hand tools - screwdrivers, pliers, wrenches and sockets - can be hung on a wall panel or stored in a tool box. Store precision measuring instruments, gauges, meters, etc. in a tool box to protect them from dust, dirt, metal chips and humidity.

## *Maintenance and repair techniques*

There are a number of techniques involved in maintenance and repair that will be referred to throughout this manual. Application of these techniques will enable the home mechanic to be more efficient, better organized and capable of performing the various tasks properly, which will ensure that the repair job is thorough and complete.

### Fasteners

Fasteners - nuts, bolts, studs and screws - hold parts together. Keep the following things in mind when working with fasteners: All threaded fasteners should be clean and straight, with good threads and unrounded corners on the hex head (where the wrench fits). Make it a habit to replace all damaged nuts and bolts with new ones. Almost all fasteners have a locking device of some type, either a lockwasher, locknut, locking tab or thread adhesive. Don't reuse special locknuts with nylon or fiber inserts. Once they're removed, they lose their locking ability. Install new locknuts.



**2.49 Get a pair of heavy work gloves for handling hot or sharp-edged objects and a pair of rubber gloves for washing parts with solvent or carburetor cleaner**

**2.50 One of the most important items you'll need in the shop is a face shield or safety goggles, especially when you're hitting metal parts with a hammer, washing parts in solvent or grinding something on the bench grinder**

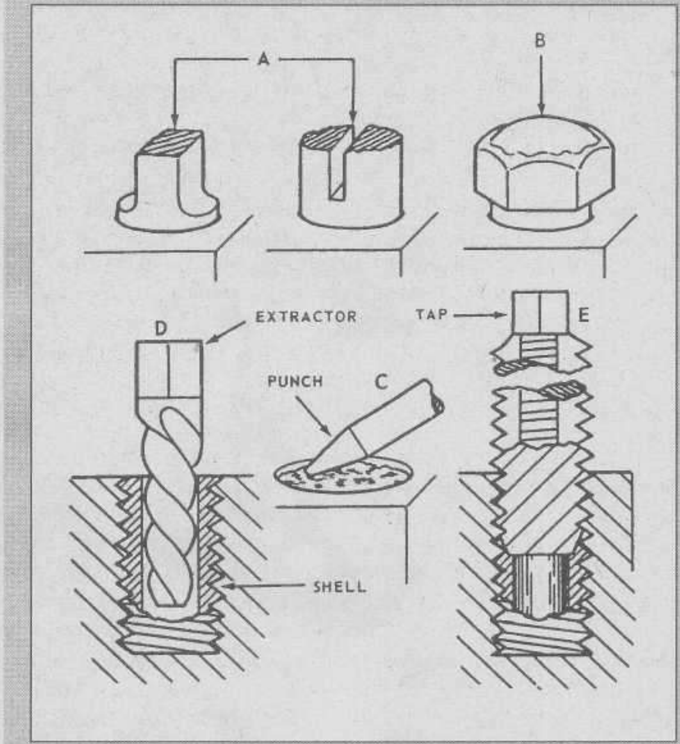
Flat washers and lockwashers, when removed from an assembly, should always be replaced exactly as removed. Replace any damaged washers with new ones. Never use a lockwasher on any soft metal surface (such as aluminum), thin sheet metal or plastic.

Apply penetrant to rusted nuts and bolts to loosen them up and prevent breakage. Some mechanics use turpentine in a spout-type oil can, which works quite well. After applying the rust penetrant, let it work for a few minutes before trying to loosen the nut or bolt. Badly rusted fasteners may have to be chiseled or sawed off or removed with a special nut breaker, available at tool stores.

If a bolt or stud breaks off in an assembly, it can be drilled and removed with a special tool commonly available for this purpose. Most automotive machine shops can perform this task, as well as other repair procedures, such as the repair of threaded holes that have been stripped out.

## Tightening sequences and procedures

First, install the bolts or nuts finger-tight. Then tighten them one full turn each, in a criss-cross or diagonal pattern. Then return to the first one and, following the same pattern, tighten them all one-half turn. Finally, tighten each of them one-quarter turn at a time until each fastener has been tightened to the proper torque. To loosen and remove the fasteners, reverse this procedure.



**2.51 There are several ways to remove a broken fastener**

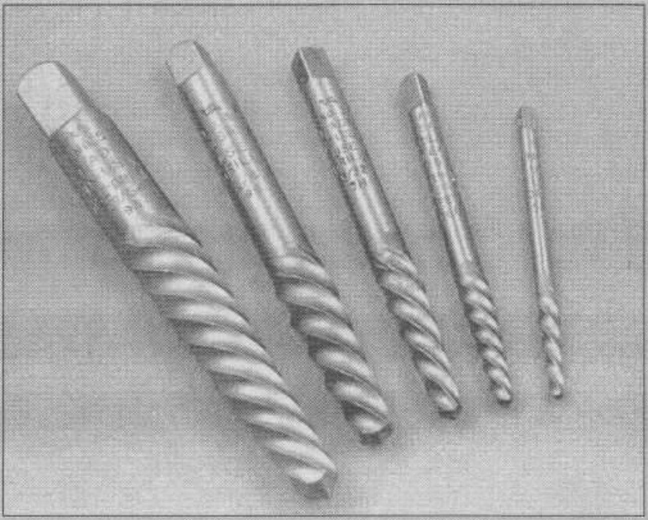
A *File it flat or slot it*
B *Weld on a nut*
C *Use a punch to unscrew it*
D *Use a screw extractor (like an E-Z-Out)*
E *Use a tap to remove the shell*

## How to remove broken fasteners

Sooner or later, you're going to break off a bolt or screw inside its threaded hole. There are several ways to remove it. Before you buy an expensive extractor set, try some of the following cheaper methods first.

First, regardless of which of the following methods you use, be sure to use penetrating oil. Penetrating oil is a special light oil with excellent penetrating power for freeing dirty and rusty fasteners. But it also works well on tightly torqued broken fasteners.

If enough of the fastener protrudes from its hole - and if it isn't torqued down too tightly - you can often remove it with vise-grips or a small pipe wrench. If that doesn't work, or if the fastener doesn't provide sufficient purchase for pliers or a wrench, try filing it down to take a wrench, or cut a slot in it to accept a screwdriver **(see illustration)**. If you still can't get it off - and you know how to weld - try welding a flat piece of steel, or a nut, to the top of the broken fastener. If the fastener is broken off flush with - or below - the top of its hole, try tapping it out with a small, sharp punch. If that doesn't work, try drilling out the broken fastener with a bit only slightly smaller than the inside diameter of the hole. For example, if the hole is 1/2-inch in diameter, use a 15/32-inch drill bit. This leaves a shell which you can pick out with a sharp chisel.



**2.52 Typical assortment of E-Z-Out extractors**

If that doesn't work, you'll have to resort to some form of screw extractor, such as E-Z-Out **(see illustration)**. Screw extractors are sold in sets which can remove anything from 1/4-inch to 1-inch bolts or studs. Most extractors are fluted and tapered high-grade steel. To use a screw extractor, drill a hole slightly smaller than the O.D. of the extractor you're going to use (Extractor sets include the manufacturer's recommendations for what size drill bit to use with each extractor size). Then screw in the extractor, making sure it's centered, and back it - and the broken fastener - out. Extractors are reverse-threaded, so they won't unscrew when you back them out.

A word to the wise: Even though an E-Z-Out will usually work, it can cause even more grief if you're careless or sloppy. Drilling the hole for the extractor off-center, using too small or too big a bit for the size of the fastener you're removing, or breaking off an E-Z Out will only make things worse. So be careful!

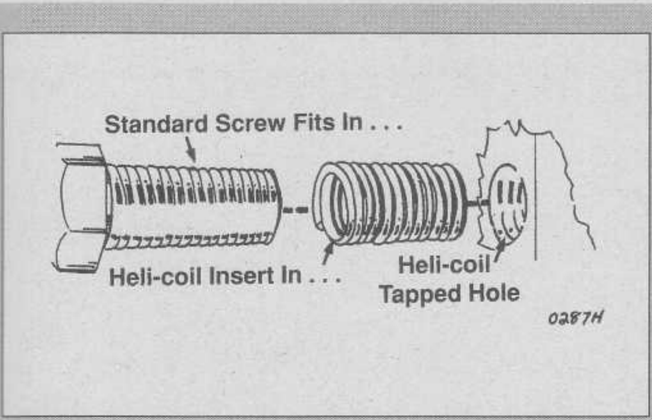
## How to repair broken threads

Sometimes, the internal threads of a nut or bolt hole can become stripped, usually from over tightening. Stripping threads is an all-too-common occurrence, especially when working with aluminum parts such as intake manifolds or other soft metals used in carburetor manufacturing.

Usually, external or internal threads are only partially stripped. After they've been cleaned up with a tap or die, they'll still work. Sometimes, however, threads are badly damaged. When this happens, you've got three choices:

1) Drill and tap the hole to the next suitable oversize and install a larger diameter bolt, screw or stud.

2) Drill and tap the hole to accept a threaded plug,



**2.53 To install a Heli-Coil, drill out the hole, tap it with the special included tap and screw in the Heli-Coil**

then drill and tap the plug to the original screw size. You can also buy a plug already threaded to the original size. Then you simply drill a hole to the specified size, then run the threaded plug into the hole with a bolt and jam nut. Once the plug is fully seated, remove the jam nut and bolt.

3) The third method uses a patented thread repair kit like Heli-Coil or Slimsert. These easy-to-use kits are designed to repair damaged threads in spark plug holes, straight-through holes and blind holes. Both are available as kits which can handle a variety of sizes and thread patterns. Drill the hole, then tap it with the special included tap. Install the Heli-Coil **(see illustration)** and the hole is back to its original diameter and thread pitch.

Regardless of which method you use, be sure to proceed calmly and carefully. A little impatience or carelessness during one of these relatively simple procedures can ruin your whole day's work and cost you a bundle if you wreck an expensive component.

## Component disassembly

Disassemble components carefully to help ensure that the parts go back together properly. Note the sequence in which parts are removed. Make note of special characteristics or marks on parts that can be installed more than one way, such as a grooved thrust washer on a shaft. It's a good idea to lay the disassembled parts out on a clean surface in the order in which you removed them. It may also be helpful to make sketches or take instant photos of components before removal.

When you remove fasteners from a component, keep track of their locations. Thread a bolt back into a part, or put the washers and nut back on a stud, to prevent mix-ups later. If that isn't practical, put fasteners in a fishing tackle box or a series of small boxes. A cupcake or muffin tin, or an egg crate, is ideal for this purpose - each cavity can hold the bolts and nuts from a particular area (i.e. carburetor mounting studs and nuts, fuel bowl components, etc.). A pan of this type is helpful when working on assemblies with very small parts, such as the carburetor or valve train. Mark each cavity with paint or tape to identify the contents.

When you unplug the connector(s) between two wire harnesses, or vacuum line connections, it's a good idea to identify the two halves with numbered pieces of masking tape - or a pair of matching pieces of colored electrical tape - so they can be easily reconnected.

## Gasket sealing surfaces

Gaskets seal the mating surfaces between two parts to prevent lubricants, fluids, vacuum or pressure from leaking out between them. Age, heat and pressure can cause the two parts to stick together so tightly that they're difficult to separate. Often, you can loosen the assembly by striking it with a soft-face hammer near the mating surfaces. When a part refuses to come off, look for a fastener that you forgot to remove.

Don't use a screwdriver or pry bar to pry apart an assembly. It can easily damage the gasket sealing surfaces of the parts, which must be smooth to seal properly. If prying is absolutely necessary, use an old broom handle or a section of hard wood dowel.

Once the parts are separated, carefully scrape off the old gasket and clean the gasket surface. You can also remove some gaskets with a wire brush. If some gasket material refused to come off, soak it with rust penetrant or treat it with a special chemical to soften it, then scrape it off. You can fashion a scraper from a piece of copper tubing by flattening and sharpening one end. Copper is usually softer than the surface being scraped, which reduces the likelihood of gouging the part. The mating surfaces must be clean and smooth when you're done. If the gasket surface is gouged, use a gasket sealer thick enough to fill the scratches when you reassemble the components. For most applications, use a non-drying (or semi-drying) gasket sealer.

## Hose removal tips

**Warning:** *If the vehicle is equipped with air conditioning, do not disconnect any of the A/C hoses without first having the system depressurized by a dealer service department or a service station (see the Haynes Automotive Heating and Air Conditioning Manual).*

The same precautions that apply to gasket removal also apply to hoses. Avoid scratching or gouging the surface against which the hose mates, or the connection may leak. Take, for example, radiator hoses. Because of various chemical reactions, the rubber in radiator hoses can bond itself to the metal spigot over which the hose fits. To remove a hose, first loosen the hose clamps that secure it to the spigot. Then, with slip-joint pliers, grab the hose at the clamp and rotate it around the spigot. Work it back and forth until it is completely free, then pull it off. Silicone or other lubricants will ease removal if they can be applied between the hose and the outside of the spigot. Apply the same lubricant to the inside of the hose and the outside of the spigot to simplify installation. Snap-On and Mac Tools sell hose removal tools - they look like bent ice picks - which can be inserted between the spigot and the radiator hose to break the seal between rubber and metal.

As a last resort - or if you're planning to replace the hose anyway - slit the rubber with a knife and peel the hose from the spigot. Make sure you don't damage the metal connection.

If a hose clamp is broken or damaged, don't reuse it. Wire-type clamps usually weaken with age, so it's a good idea to replace them with screw-type clamps whenever a hose is removed.

## Notes

# 3 Carburetor fundamentals

## Introduction

Let's face it: Carbureted fuel systems have become rather complicated. When you open the hood of a modern vehicle, you're confronted by a nightmarish labyrinth of hoses, lines, linkages, rods, springs, tubes, valves and wires, most of them attached directly to the carburetor. Yet, for all its seeming complexity, the carburetor itself needn't be that difficult to understand. Like any mechanical component that looks formidable when viewed as a single assembly, the carburetor is simpler if you break it down into its individual parts and subsystems. Each of these parts and subsystems is, by itself, pretty elementary.

You probably already know something about carburetors. At the very least, you know the carburetor is a mechanical device that mixes gasoline with air to form a combustible mixture. And you may even be familiar with some of the bits and pieces - floats, jets, etc. - that constitute the modern carburetor. But the fact that you're reading this manual means you probably want to know more.

How does a carburetor really work? This question has stumped weekend do-it-yourselfers and professional mechanics alike at one time or another. Everyone seems to have some working knowledge about carburetors. But as with so many other automotive components, a little knowledge about carbs can be a dangerous thing. So this Chapter goes back to square one and starts from scratch. That way - perhaps even at the risk of insulting your intelligence - we can eliminate any misconceptions you may have picked up somewhere. Once you fully understand the information in this Chapter, you'll have the kind of theoretical background it takes to make sound judgments regarding adjustments, rebuilds and modifications to any carburetor in this manual.

## What is a carburetor?

Basically, the carburetor is a device that "senses" the amount and speed of air flowing through it, then meters the proper ratio of "atomized" (spray of fine droplets) fuel into the airstream. And it must do all this while constantly varying the fuel ratio to match changes in engine speed and load determined by the demands of the driver and the engine's operating conditions.

The demands of the driver:

*Idle*
*Acceleration*
*Cruising*
*High speed*
*Deceleration*

The engine's operating conditions:

*Cold or warm start-up*
*Cold or warm operation*
*High or low engine load*
*High or low crankshaft speed*
*High or low manifold vacuum*
*High or low venturi vacuum*

Finally, it must do all the above quickly and accurately enough to ensure good driveability, mileage and performance, all the while providing an air/fuel ratio that produces tailpipe emissions low enough to comply with state and Federal law.

Obviously, carburetion on a modern automobile is a lot more complicated proposition than it was 50, or even 25, years ago. Does this mean you can no longer service your own carburetor? Absolutely not! Once you understand the basic operating principles of carburetors and the circuits they use to meet the above demands, you can rebuild and adjust any Rochester carburetor in this manual. So first, let's review those operating principles, then we'll examine the seven circuits you'll find on most of the carburetors covered in this book. Finally, we'll discuss some of the more typical features found on modern Rochesters.

# Basic operating principles

## *Pressure differential*

Many people think that an engine sucks air into its combustion chambers and the carburetor simply dumps some fuel into this airstream as it passes through the carb throat. In a sense, this is true. But ask them **why** - or how - it does this, and you're likely to get some vague answer about main jets and throttle valves and venturis.

What is really happening inside a carburetor during its operation? Quite a lot, actually. Most carburetors have seven different circuits to deal with every conceivable combination of driver demand and engine operating condition. But before we look at those circuits, let's review the three important factors that determine which circuit operates - and when. The first of these is **pressure differential**.

A gas or a liquid acted upon by two different pressures is pushed by the higher pressure toward the lower pressure area. In other words, a pressure differential causes the gas or liquid to move toward the lower pressure area.

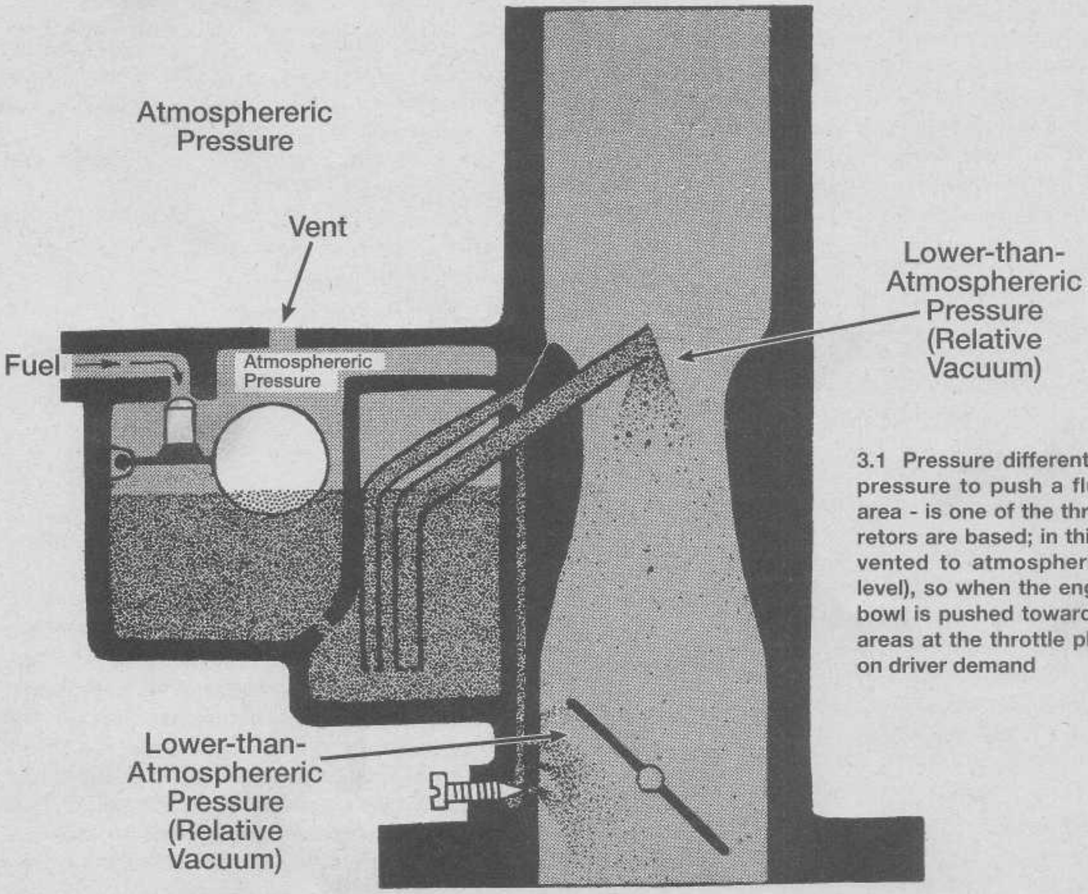
Let's look at an everyday example of how a pressure differential works. When you sip a drink through a straw, you're sucking the liquid up the straw, right? True, but what are you really doing when you suck on the straw? You're creating a pressure differential. The atmospheric pressure bearing down on the surface of the liquid in the glass is a constant 14.7 pounds per square inch (psi) at sea level. When you suck on the straw, you lower the atmospheric pressure in your mouth, creating a less-than-atmospheric (relatively low) pressure inside your mouth. In other words, you're creating a partial vacuum. So the liquid in the glass is forced up through the straw and into your mouth.

What's pressure differential got to do with carburetors? Everything. It's pressure differential that the idle and main circuits use to push fuel out of the float bowl (which is vented to atmospheric pressure), up through a tube or passage to the low-pressure throat of the carburetor where it's dispersed into the airstream moving through the venturi **(see illustration)**. We'll get to float bowls and main circuits in a moment. Now let's look at the second operating principle of the carburetor, **manifold vacuum**.

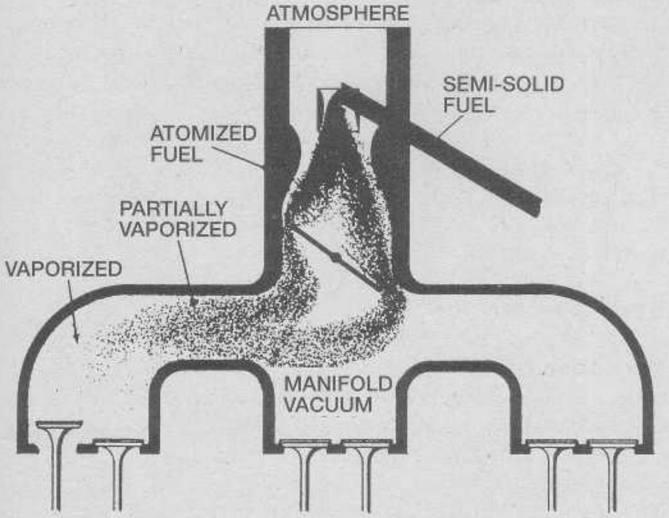
## *Manifold vacuum*

What is vacuum? In science, it's the total absence of air. In automotive circles, vacuum is the term used to describe the condition of lower-than-atmospheric pressure. Vacuum is usually expressed in inches of mercury (in-Hg). The numerically higher the figure for in-Hg, the higher the vacuum.

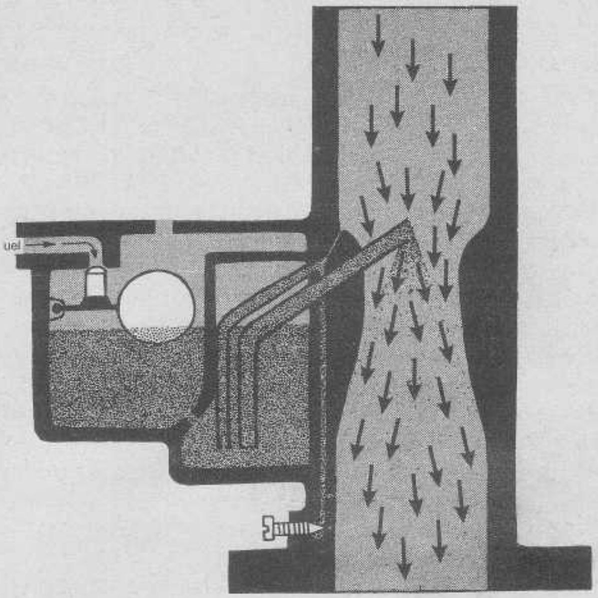
The term "manifold vacuum" refers to the condition of relative vacuum that exists in the intake manifold when the engine is running **(see illustration)**. When they're in operation, the intake and exhaust valves and the pistons work together to create an air pump. As the intake valve opens and the piston moves down on its intake stroke, a relative vacuum is created inside the volume displaced in the cylinder. Why? Because, the air at atmospheric pressure in the intake system upstream from the carburetor can't fill the cylinder as quickly as the piston can move downward toward the bottom of its stroke. So the vacuum inside the cylinder is fairly strong, not quite so strong in



**3.1 Pressure differential - the tendency of a higher pressure to push a fluid toward a lower pressure area - is one of the three principles on which carburetors are based; in this illustration, the float bowl is vented to atmospheric pressure (14.7 psi at sea level), so when the engine is running, the fuel in the bowl is pushed toward the relatively lower pressure areas at the throttle plate or the venturi, depending on driver demand**



3.2 Manifold vacuum is the difference in pressure between the atmosphere and the inside of the intake manifold caused by the obstruction of the throttle plate in the base of the carburetor: The more restricted the passage past the throttle plate, i.e. the more the throttle plate is closed, the greater the manifold vacuum



3.3 The venturi effect is the behavior of air molecules moving through a tube with a restricted orifice: When they get to the restriction (commonly known as the venturi), they speed up because they're forced closer together, so the pressure in the venturi area drops below atmospheric pressure

the intake manifold and weaker still as we get farther away from the empty cylinder and closer to the mouth of the intake system, where the air is at atmospheric pressure. However, there's always a significant difference in pressure between outside air and the air in the intake manifold. And if the choke plate is closed during engine warm-up, or if the carburetor throttle plate is closed, as it is at idle and during deceleration, the pressure difference is even more pronounced. Idle circuits in the carburetor use the high manifold vacuum condition to draw fuel from the float bowl and into the airstream during idle conditions.

### The Venturi effect

Another way a pressure difference is created is called the **venturi effect**. Imagine a tube with air flowing through it. If the walls of the tube are straight, i.e. the same diameter, from one end to the other, the air molecules flow through the tube at the same speed. But what if we pinch our tube in the middle somewhere? Now the air molecules must crowd together to get through the bottleneck. This bottleneck restriction is known as a *venturi* . When the air molecules arrive at the venturi, they not only crowd together, they also speed up. Once they get through the venturi, they slow down again and resume their original speed **(see illustration)**.

In physics, the venturi effect, which is named after G.B. Venturi, an Italian physicist (1746 to 1822) is expressed like this: "If gas velocity increases, gas pressure decreases." The molecules in any material, air included, are always moving around a lot. The molecules of air moving through our hypothetical tube are bouncing off the walls of the tube and off of each other, which is what creates the pressure. As they speed up through the venturi, they become more directional, so they have less time to bounce off the walls or each other, so the pressure decreases.

## Carburetor Circuits

### Introduction

A carburetor is basically a collection of cleverly designed circuits. These circuits provide various ways by which fuel can be atomized and mixed with incoming air for each specific operating condition. Some circuits, like the float circuit, work all the time; others, like the main or high-speed circuit, work only during certain operating conditions.

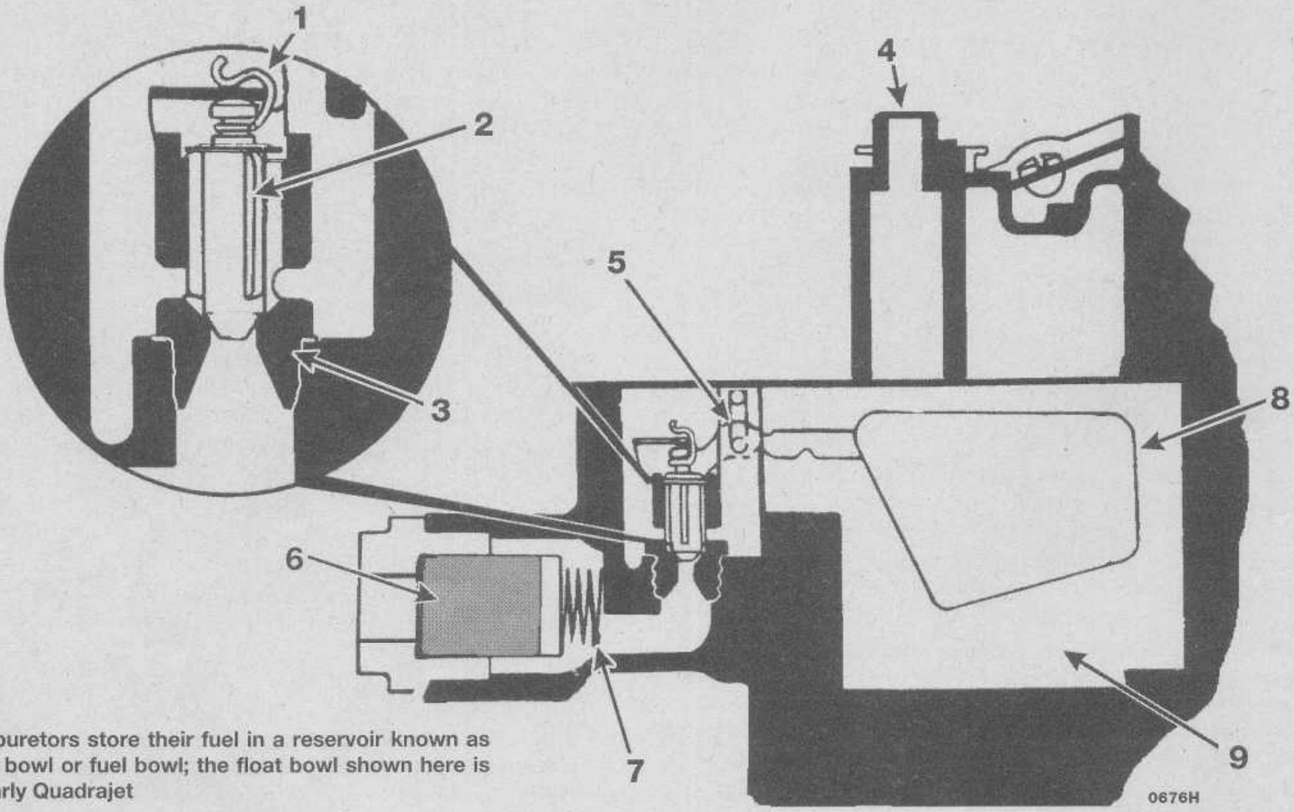
Most of the circuits listed below are found in every Rochester carburetor in this manual (and in most other carburetors as well):

- The fuel inlet system or the float circuit
- The idle circuit
- The off-idle circuit
- The high-speed or main metering circuit
- The power circuit
- The accelerator pump circuit
- The choke circuit

### Fuel inlet system or float circuit

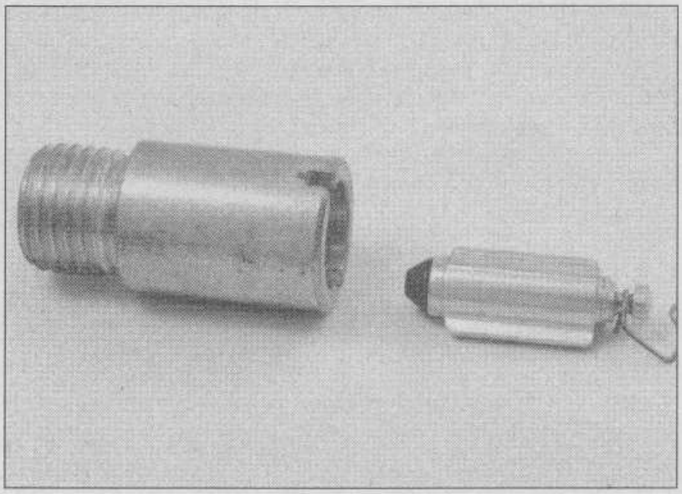
#### The float bowl

The carburetor stores its fuel in a reservoir known as the **float bowl** or **fuel bowl (see illustration)**. Staged two- and four-barrel Rochester carburetors have primary barrels that open during normal operation, and secondary barrels that open whenever extra power is needed. Unlike most big Holley carburetors, which use separate float bowls and circuits for the primary and secondary barrels, most Rochester carbs (except the 4G/4GC) use a single float bowl for both the primaries and secondaries. The Quadrajet's central float bowl is located between the two primary bores and adjacent to the two sec-



**3.4 Carburetors store their fuel in a reservoir known as the float bowl or fuel bowl; the float bowl shown here is for an early Quadrajet**

| | | | |
|---|---|---|---|
| 1 | *Pull clip* | 5 | *Float hinge pin* |
| 2 | *Float needle* | 6 | *Filter* |
| 3 | *Needle seat* | 7 | *Filter relief spring* |
| 4 | *Internal bowl vent to air cleaner* | 8 | *Float* |
| | | 9 | *Float bowl* |



**3.5 A typical inlet valve assembly: Screw-in, replaceable seat is on the left, tapered needle on the right; note the *viton* tip on the needle and the pull-clip which attaches the needle to the float lever arm**

ondary bores. This unique design assures adequate fuel delivery to all bores.

Fuel must be maintained at a certain level in the bowl to assure correct fuel metering under all operating conditions. The fuel circuits depend on the float system to maintain this specified level; they're calibrated to deliver the correct mixture only when the float level is adjusted correctly. The carburetor's ability to withstand sudden changes in attitude - turning, acceleration and deceleration - also depends on correct float height.

Let's look at how a typical float circuit works. Pressurized fuel enters the float bowl through an inlet valve or float valve. The inlet valve **(see illustration)** is a replaceable screw-in unit consisting of a tapered **needle** and a **seat**. As the fuel fills the bowl, it lifts the float. The float is attached to a hinged lever arm that pushes on the needle as the float rises. When the fuel rises to a preset level in the bowl, the needle seals against the seat, and no more fuel can enter the float bowl. But as engine operation drains the bowl, the float drops again, pulling the needle off its seat, and allowing more fuel into the bowl. When the fuel level rises to its maximum level, the float closes the needle against its seat again. And so on.

Thus, the fuel level in the float bowl is maintained at or very near the preset level by the continually rising and falling float. Maintaining the fuel in the float bowl at or near its maximum level is critical to the proper operation of the other circuits. In fact, the float level is the overall determinant of the air/fuel mixture.

After a hot soak (engine idling or stopped after it's been heated up), the fuel pump may deliver spurts of liquid fuel and intermittent pockets of fuel vapor. The float bowl capacity must be generous enough to supply fuel to all circuits until the pump is purged of vapor. But making the float bowl bigger than necessary can allow the fuel to slosh around during abrupt maneuvers. Besides, there are other ways of dealing with problems such as vapors, or fuel sloshing around in the bowl.

## Bowl vents

The float circuit also acts as a vapor separator. An air passage or **bowl vent** connects the float bowl to the carburetor's inlet air horn. Venting the float bowl to outside air (or to the charcoal canister on vehicles with emissions control systems) depressurizes the fuel being pumped into the float bowl by the fuel pump. Once inside the bowl, fuel is no longer pressurized; it's at vented pressure, which is about the same as the outside air. Vapors trapped in the fuel as it's pumped from the tank escape through the bowl vent so pressure doesn't accumulate inside the bowl. The vent is usually positioned as close to the center of the fuel bowl as possible - and high enough to prevent fuel from sloshing into the air horn during hard stops or high cornering speeds.

Some pre-emission-control models were equipped with a mechanical vent valve that released vapors into the engine compartment at curb idle and when the engine was stopped. On some pre-emission carbs, a bimetal-actuated vent released fuel vapor to the atmosphere only when it reached a certain temperature. These designs also maintained a constant near-atmospheric pressure in the float bowl, but they polluted the atmosphere.

On most 1970 and later Rochesters, the float bowl is vented to the evaporative emission control canister. When the engine is turned off and engine heat causes the fuel in the bowl to boil off, fuel vapors are directed to the evaporative canister, then drawn into the intake manifold when the engine is running. The vent to the vapor canister can be vacuum-operated, operated by vapor pressure from the bowl or mechanically actuated at idle.

## The float

On some older carburetors, the float is made of thin brass stampings soldered together. The trouble with brass floats is that they develop leaks, fill with gasoline and sink. A sunken float opens the fuel inlet valve, overfills the float bowl and causes an excessively rich air/fuel mixture. Newer floats are made from a closed-cell material that never leaks (though it can slowly absorb gasoline and lose its buoyancy) and is impervious to gasoline and fuel additives.

Whatever material is used, the float must be buoyant enough to shut the inlet valve when the bowl is full. One of the advantages of a closed-cell float is that the closed-cell material is more buoyant than brass, so a smaller float can maintain a constant fuel level as well as a larger brass float. The lever to which the float is attached is usually designed to provide a mechanical advantage to the buoyancy of the float itself: The longer the lever length, the greater the leverage of the float.

Float vibration is usually caused by engine or vehicle vibration or bouncing. A vibrating float can allow the inlet valve to admit fuel into the float bowl even when the bowl is full, which can cause wide variations in the amount of fuel available to the other circuits. On some models, a float spring is added under the float or on a tang to minimize float vibration. This device is known as a **float bumper spring**. The float spring is especially helpful in preventing *float drop*, which sometimes opens the inlet valve during radical maneuvers such as accelerating or decelerating through a sharp turn. Some high performance carbs use a small spring inside the inlet valve itself instead of - or in addition to - the float bumper spring.

Every Rochester carburetor has a specified **float height** or float setting. This setting must take into consideration such things as fuel pressure, float buoyancy, seat size (the size of the inlet needle orifice) and, of course, the required fuel level. How does the manufacturer decide how high to set the float? It must be high enough to provide fuel to all the circuits, even during fast starts and stops and high cornering speeds, but not so high that it will spill fuel when driven or parked on an 18-degree slope (a 30-percent grade). On most Rochesters, the float height is set by measuring the float position in relation to a gasket surface while the carburetor is disassembled. On some models, you can adjust the float with a special tool without disassembling the carburetor.

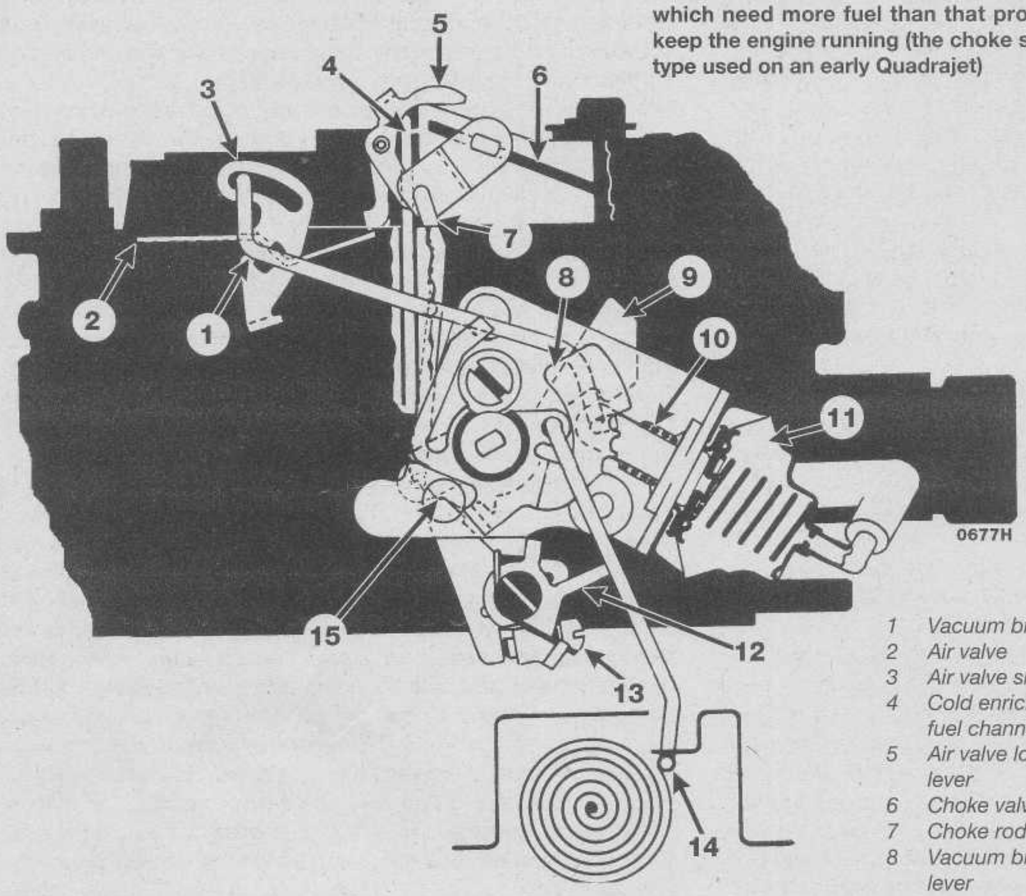
A *center-pivot* float (pivot axis *parallel* with the vehicle axles) is the best design for high-speed cornering. *Side-hung* floats (pivot axis *perpendicular* to the axles) work better than center-pivot designs under heavy acceleration and heavy braking conditions. Rochester two-barrels and Monojets use side-hung floats; Quadrajets and 4GCs have center-pivot types.

Float design alone isn't always capable of preventing fuel in the bowl from sloshing back-and-forth and side-to-side as the vehicle changes its attitude, direction or speed. Extreme changes in any of the above can even cause the fuel to splash out of internal vents into the air horn or uncover the main jet. So Rochester carburetors also use three other ways to stabilize the fuel. The bowl may use baffles to break the bowl into small "compartments," isolating fuel slosh to tiny areas. Or the carburetor may use semi-solid air-horn gaskets which are solid in the area immediately below the vent opening, preventing fuel from splashing out of the vents. And some fuel bowls are stuffed with inserts that reduce bowl volume to prevent splashing. For example, the Quadrajet uses a plastic filler block in the float chamber just above the float valve to prevent sloshing - and possible stalling - during heavy braking. It also reduces total fuel capacity, thereby reducing fuel vapor to the atmosphere.

The rounded end of the needle rests against the float lever arm, or is attached to the arm by a small pull clip, or hook. As the float rises, the tapered end of the needle closes against the inlet-valve seat. Some inlet needles are hollow; inside, a small damper spring and pin insulate the needle against road shock and vehicle vibration so it can meter fuel smoothly. Most modern Rochester inlet valves use a steel needle with a tapered seating surface tipped with *viton*. Viton-tipped needles resist dirt and conform well against the valve seat even with low closing pressures.

A number of different inlet valves are available for inlet-orifices of various sizes. However, the orifice size isn't marked. And the only way you can measure them is with plug gages or drill bit shanks, but only if you have all number and fractional bit sizes between 0.060 and 0.140-inch.

Seat diameter and orifice length are the determinants of fuel flow at a certain pressure: A larger opening flows more fuel; a smaller opening flows less. Seat size must be generous enough to fill the bowl quickly for quick acceleration after a *hot-soak* period (sitting parked with a hot engine) and for extended periods of high fuel demand, such as wide open throttle at high rpm. Smaller needle seats are better than larger seats at controlling hot fuel in the lines because vapor pressure in the fuel line has less area to push against to force the needle off its seat. So always use the smallest possible inlet valve that will work. And remember: You must readjust the float height anytime you change the needle-and-seat, because you're changing the fuel-pressure forces against which the float must be balanced.



3.6 The choke plate blocks off air entering the intake through the carb; the low pressure area that occurs underneath it provides enough vacuum to pull fuel through the main jet and main nozzle during cold warm-ups, which need more fuel than that provided by the idle discharge port to keep the engine running (the choke system shown above is an automatic type used on an early Quadrajet)

| | |
|---|---|
| 1 | *Vacuum brake rod* |
| 2 | *Air valve* |
| 3 | *Air valve shift lever* |
| 4 | *Cold enrichment fuel channel* |
| 5 | *Air valve lock-out lever* |
| 6 | *Choke valve* |
| 7 | *Choke rod* |
| 8 | *Vacuum brake lever* |
| 9 | *Fast idle cam* |
| 10 | *Bucking spring* |
| 11 | *Vacuum brake diaphragm unit* |
| 12 | *Unloader tang* |
| 13 | *Fast idle adjusting screw* |
| 14 | *Thermostatic choke coil & rod* |
| 15 | *Cam follower* |

## *The choke system*

When it's cold, an engine doesn't start easily, nor does it run right while it's warming up. Gasoline doesn't atomize well when it's cold, especially when it's flowing through cold metal passageways in the intake manifold. And the starter spins the engine at such a low speed (50 to 75 rpm) that there's little manifold vacuum available to pull fuel from the float bowl until the engine catches and goes to fast idle. Obviously, cold starts pose a formidable problem to the carburetor. Without a good strong vacuum signal, little fuel will be drawn from the float bowl, and what little fuel does dribble into the carburetor throat will likely condense back to a liquid state as soon as it contacts the cold metal walls of the intake manifold runners and the cylinders.

### The choke plate

When the throttle plate on a carburetor is almost closed, there's a high vacuum below the plate. This high vacuum draws fuel from the idle discharge port below the plate, as well as pulling air past the partially open throttle plate. The available air/fuel mixture is adequate for warm engine idling. But the idle circuits alone cannot provide a sufficiently rich mixture during cold starts. So there's another plate in the upper end of the carburetor bore, above the main nozzle. When it's closed, this plate, which is known as the **choke plate** or **choke valve (see illustration),** partially blocks off the airhorn. The vacuum that occurs beneath the choke plate, although not as strong as the vacuum below the throttle plate, is sufficient to pull fuel from the main metering circuit (and sometimes even from the air bleed holes!). This extra fuel, added to the fuel being drawn out of the idle circuits just below the throttle plate, provides an extremely rich mixture (about five parts air to one part fuel). Why is such a rich mixture necessary? First, there's very little manifold vacuum to help vaporize the fuel. Second, the manifold is cold, so most fuel immediately recondenses and puddles onto the manifold surfaces. Third, the fuel itself is cold, so it's not very volatile. Fourth, the fuel from the main metering system is more liquid than vapor because there's little air velocity available to assist in atomizing it. Liquid fuel can't be evenly distributed to the cylinders. When it arrives there, it will not burn well. During starting, only a small portion of the fuel actually reaches the cylinders as a well-vaporized mixture.

### The vacuum break diaphragm

While the engine is starting, a thermostatic bimetal spring holds the choke plate tightly closed, to provide the rich mixture needed for starting, but as soon as the engine starts, the choke plate must be opened enough to let in some air so the engine can run on a slightly leaner mixture. This is accomplished in two ways: First, the off-center installation of the choke plate shaft on most models allows airflow to open the choke slightly to start leaning out the mixture as soon as the engine catches and starts. Second, the choke plate is pulled down to a preset position by a piston or a **vacuum break diaphragm** (also known as a **pull-off diaphragm** or **qualifying diaphragm**) as soon as vacuum is available (immediately after the engine starts). On some models, a temperature-modulated diaphragm varies this preset opening with ambient temperature. When the choke assumes this partially-open position, it's still providing a 20 to 50-percent richer-than-normal mixture as the engine warms up and the choke "comes off" (opens all the way).

On many older and some newer automatic choke designs, the choke plate is pulled down to its preset partial opening by a piston connected to engine vacuum. The piston pulls the choke plate to this partially open position as soon as the engine starts and vacuum is applied to the piston. In some older carburetors, this vacuum piston was internal, part of the choke housing or carburetor casting. The vacuum piston design was a source of several problems at one time. The piston gummed up and stuck; or the housing distorted because of engine heat, causing the piston to hang up; or the plug in the end of the piston bore fell out. When these problems occurred, the carburetor had to be pulled, the housing torn down and the piston freed. If the housing was warped, the piston bore had to be reamed so the piston could operate freely again. Many newer carburetors have abandoned the piston setup for an external bolt-on vacuum diaphragm unit that connects to the intake manifold by a hose. The diaphragm might leak or rupture, but not as frequently as the piston used to stick. And replacing a diaphragm is a lot easier than freeing a stuck piston. Now back to starting the engine!

### The fast idle cam

Depending on the ambient temperature, a richer mixture alone may be insufficient to keep the engine running during engine warm-up. Sometimes, a higher idle speed is needed to overcome the friction of all those cold parts rubbing together, or the engine will stall. So the choke plate is connected to a **fast idle cam** by a linkage rod. Before starting a cold engine, press the throttle all the way to the floor and release it. This allows the choke mechanism to close and positions the fast idle cam so the throttle plate is held partially open. While the fast idle cam is set, the engine idle is high (800 to 1100 rpm, or even higher, on a cold engine).

What if you absent-mindedly pump the throttle a few times while trying to start a cold engine? If you pump it too much, the engine floods. With the choke still closed on a cold engine, your chances of starting the engine aren't good. But if you push the throttle all the way to the floor, a little tang on the throttle lever called the **unloader** will contact the fast idle cam and push the choke open far enough to admit some additional air into the engine to lean out the mixture. The unloader can be bent to the desired adjustment so that it opens the choke the right amount.

As the engine warms up, the choke is gradually opened by the bimetal spring in an automatic choke (or by you, if the choke is a manual unit). This action also reduces the idle speed to a normal "curb idle."

### Automatic chokes

On high performance carburetors and on older street carbs with a manual choke, you must learn how much to choke the engine to get it started, and you must also learn how to not choke it so much that you flood it. You must also remember to turn off the choke as the engine warms up, or the fuel mileage will be so bad you'll be stopping at every other gas station. Modern street carburetor chokes do all this automatically. There are two basic types of automatic choke: *integral* and *divorced*.

#### Integral chokes

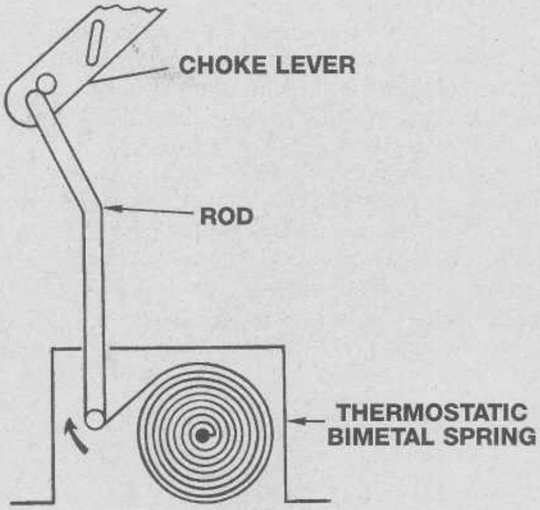
Integral chokes use a metal tube to route heated air from a stove around the exhaust manifold or the exhaust-heat crossover to a thermostatic bimetal spring inside a housing on the side of the carburetor. Some integral chokes use engine coolant or electricity to heat the bimetal.

An integral choke heated by hot air sometimes closes at the wrong time. A choke is unnecessary during hot starts. But because there's no flow of heated air past the bimetal spring while the engine is off - and because the thermostatic spring cools off significantly faster than the engine - the choke closes again, even though the engine could very well be warm enough for a choke-less start. Integral chokes heated by engine coolant - known as *hot water chokes* - suffer from the same problem. Another problem with integral chokes heated by hot air is deterioration with age. Carbon build-up in the hot air tube reduces or blocks the flow of heated air to the spring. When this happens, the choke either opens very slowly or doesn't open at all.

Integral electric chokes are usually found on aftermarket replacement carburetors which must fit a wide variety of intake manifolds. The spring housing contains a heating element that is connected to a 12-volt ignition-switch-controlled power source. When the engine is started, electrical current is applied to the heating unit and the spring undergoes the same type of bimetal reaction created by exhaust heat. Electric chokes allow for a great deal of versatility on custom carb/manifold installations; they're easy to hook up without plumbing or other attachments to the engine. They generally need only one wire, usually from the ignition switch. (Don't use the coil or other ignition components as an electrical power source; the current drain could adversely affect the operation of the ignition system.) But there are several disadvantages to electric chokes:

- Current is drained from the battery when power requirements are already high (during starting).
- An electric choke resets itself when the engine is turned off, even if it's already warmed up, so the choke comes back on when the engine is restarted.
- If the engine isn't started right after the ignition is turned on, the choke may open even though the engine is still cold (powering the choke from the alternator circuit - so it only gets power when the engine is actually operating is a quick fix for this problem).
- The choke can come off while the engine is still cold.

Choke assemblies are adjusted and set at the factory for the make and model vehicle on which they're installed. The phenolic housings on integral automatic chokes have index marks to help you adjust the choke plate setting. The factory setting closes the choke on a new carburetor when the choke bimetal spring is about 70-degrees F. If you want to readjust the choke angle setting at this temperature, tap the carb slightly to overcome any shaft friction and allow the choke plate to rotate to the angle established by the bimetal spring. If you want less or more choke, move the choke index one mark, then try it. Don't make big choke adjustments all at one time. On most carburetors, arrows on the housing tell you which way to move the index to change the choke operating characteristic (either LEAN or RICH). Rotating the housing in the rich direction increases spring preload, causing the choke plate to open more slowly; turning it in the lean direction has the opposite effect. You will seldom need to move a choke more than one index mark from the factory setting. Finally, be forewarned!



**3.7 Typical divorced (or remote) type choke setup. The bimetal spring sits in a well in the intake manifold**

The choke covers on many emissions-era carburetors are riveted to prevent tampering. If you're modifying a carb for off-road or competition use, you may decide to drill out the rivets and replace them with sheet metal screws.

### Divorced or remote-type chokes

**Divorced** or **remote-type** chokes use a thermostatic bimetal spring mounted right on the intake manifold or in a well in the exhaust-heat passage of the intake manifold **(see illustration)**. A mechanical linkage rod from the bimetal spring operates the choke lever on the carburetor. Divorced chokes respond accurately to actual engine operating conditions because the choke only operates when the engine is cold. The choke is gradually closed by a thermostatic spring as the engine warms up. Engine vacuum is used to draw heated air from a *stove* on the exhaust manifold into the choke housing, causing the spring to relax and allowing the choke to open. Most choke plates have an offset shaft, so that the choke will open by its own weight if there is no spring pressure holding it closed. To adjust a divorced choke, you simply change the length of the rod by bending it. For example, shortening the rod applies more closing force to the choke so it closes at a higher ambient temperature and stays shut longer.

### Electrically-assisted chokes

Limiting the duration of choke on-time to the absolute minimum is critical because of hydrocarbon and carbon monoxide emission levels. At first, engine heat was used to control the choke plate. Some earlier designs used a water-heated cap choke design in which a heater hose was routed directly against the choke cap. Others ran the heated coolant directly through the cap. Newer designs have exchanged the water-heated choke for one with an electric assist. Cap-type chokes use a ceramic heating element hooked to the choke coil and to a bimetallic temperature switch which draws power from the alternator on a constant basis. At a temperature below, say, 60-degrees F, the switch stays open, preventing current from reaching the ceramic heating element, and allowing normal choking action to take place using the thermostatic coil. But as the temperature climbs above this cutoff point, the sensor switch closes to let current pass to the heating element, causing the choke coil spring to pull the choke plates open within 90 seconds.

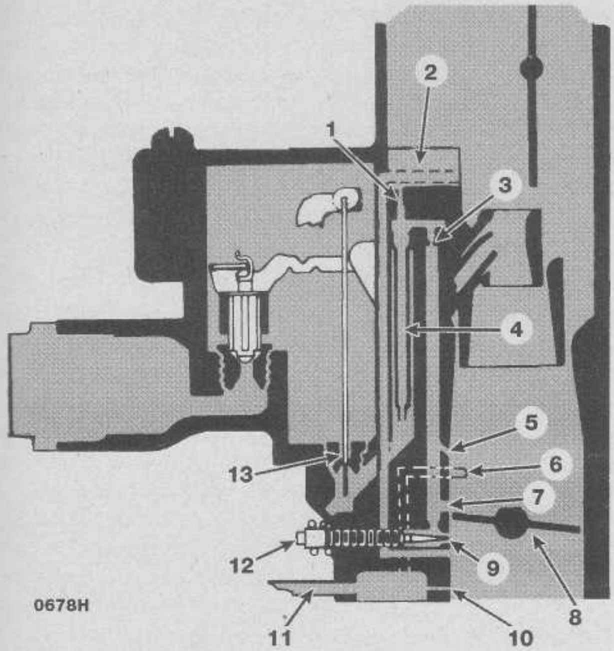
Divorced, or remote, well-type chokes with an electric assist operate in a similar manner, but the heating element is separate from the choke and is wired to an external control switch, which is connected to the ignition switch. Turning the key to the "On" position activates the sensor, which passes current at about 60-degrees F, but cuts it off at 110-degrees F.

## *The idle and off-idle circuit*

The engine requires a richer mixture at idle than it does during part-throttle operation. Unless the idle mixture is rich enough, slow and irregular combustion will occur, mainly because of the dilution of the intake charge by residual exhaust gases that occurs during idle. It's the idle circuit's job to provide this rich mixture. The idle system must also keep the engine running at the specified idle speed even when accessories such as the alternator, air-conditioning compressor or power-steering pump are dragging down rpm. And, on vehicles with an automatic transmission, the idle system has to compensate for the load on the engine imposed by the transmission.

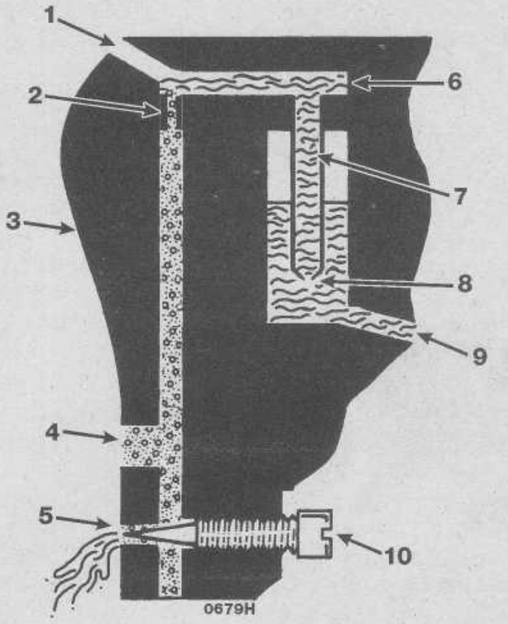
Recall that the carburetor delivers fuel into the incoming airstream because of the difference in pressure between the air in the float bowl, which is vented to atmosphere, and the air below the throttle plate, which is under a relative vacuum the strength of which is contingent on the angle of the throttle plate. The idle circuit is a good example of how this works. At idle and low speeds, insufficient air is drawn through the venturi to operate the main metering system. However, intake-manifold vacuum is high on the engine-side of the throttle plate because the nearly closed plate restricts airflow through the carburetor. This high vacuum creates the pressure differential needed to operate the idle system.

The idle circuit **(see illustration)** begins at the main jet, through which fuel enters the **idle well**. The fuel level in the idle well is established by the float system. Anytime the engine is turned off, or the throttle plate is open too much to create a low-pressure area at the curb-idle port, the fuel in the idle well remains at this level. But when the engine is at idle, *i.e.* the throttle plate is closed or almost closed, fuel is drawn up through an **idle tube** from the idle well. The lower end of this tube may have a calibrated hole in it. This hole is known as the **idle feed restriction**, **idle orifice** or **idle jet**. The idle jet usually picks up fuel after it has already passed through the main jet, but the main jet is considerably larger in diameter than the idle jet, so it has no effect on the idle circuit. Once the fuel reaches the top of the idle tube, it flows through a crossover passageway which is higher than the level of fuel in the float bowl. At the point where it turns the corner and heads back down toward its final destination, outside air is introduced into the idle circuit through one or two **idle air bleeds**. From here, the air/fuel *emulsion* (the fuel is no longer in liquid form; it's *trimmed*, or leaned out, into an emulsion of globules of fuel droplets and air bubbles) heads down, through another passageway, toward the vacuum side of the throttle plate. Increasing the size of the idle air bleed orifice(s) reduces the pressure differential across the bleed(s), which decreases the amount of fuel pulled over from the idle passage. Increasing idle air bleed size leans out the idle mixture, even if the idle-feed restriction is unaltered. Conversely, decreasing idle air bleed size increases pressure drop in the system and richens the idle mixture. On some Rochester carburetors, auxiliary air bleeds, located downstream from the usual idle air bleed, accomplish



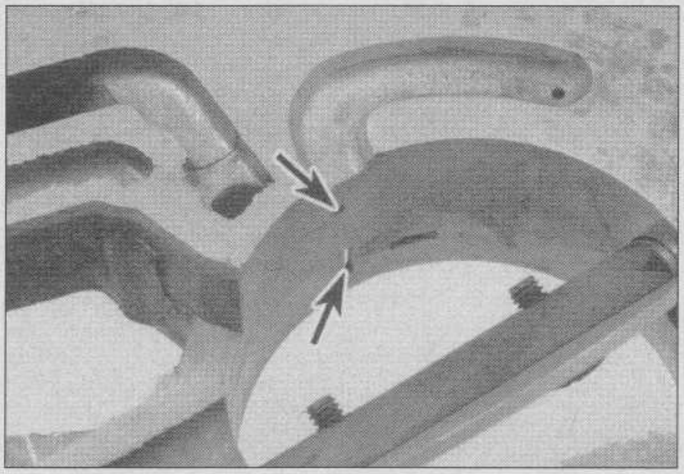
**3.8 Typical idle circuit (early Quadrajet)**

*1 Idle air bleed*
*2 Fixed idle air by-pass*
*3 Idle channel restriction*
*4 Idle tub*
*5 Lower idle air bleed*
*6 Variable bleed (canister purge)*
*7 Off-idle port*
*8 Throttle valve*
*9 Idle discharge hole*
*10 Constant bleed (canister purge)*
*11 Canister purge tube*
*12 Idle mixer screw*
*13 Main metering jet*



**3.9 The idle circuit functions much like a small main metering circuit**

*1 Air bleed (think of it as the venturi)*
*2 Channel restriction*
*3 Venturi*
*4 Off-idle port*
*5 Curb-idle port*
*6 Idle cross passage*
*7 Idle tube*
*8 Idle orifice is system's fuel metering jet*
*9 Fuel from main jet*
*10 Idle mixture needle (consider it the throttle in conjunction with the curb-idle hole and off-idle port)*



**3.10 Typical curb-idle discharge port (upper arrow) and off-idle slot (lower arrow); the curb-idle port is always the one closest to the flange**

the same thing - lean out the mixture - as opening up the primary bleed.

On some carburetors, a calibrated **channel restriction (see illustration)** is located just below the idle air bleed(s), instead of or in addition to the one at the lower end of the idle tube. Depending on the carburetor, this secondary metering for the idle system can affect transition metering anywhere from 25 to 40 mph.

It should be noted that - although idle circuits all function the same way - the actual routing of idle fuel and air/fuel emulsion differs somewhat from one model to another. On Rochester carburetors, the idle circuit is in the main body casting (unlike some "modular" Holley carburetors, for example, in which the idle circuit is actually inside a removable "metering block"). However, one thing all idle passages do is direct the fuel up toward the top of the carburetor, where bleed air is admitted, before bringing it back down a vertical feed passage to the curb-idle and off-idle discharge ports. Why? Because the fuel in the idle circuit must be raised to a level higher than the level of the fuel in the float bowl. Otherwise, the curb-idle discharge port would just drain the float bowl!

## The curb-idle port and the mixture adjusting screw

The idle mixture enters the airstream flowing past the throttle plate at the **idle discharge hole** or **curb-idle port (see illustration).** The amount of mixture that can flow through the curb-idle port is determined by the strength of the pressure differential at the mouth of the discharge hole, by the area of the port exposed by the throttle plate and by an adjustable needle, known as the **idle mixture needle** or **mixture adjusting screw**, situated right at the discharge hole. The needle tip of the screw protrudes into the curb-idle port. The mixture screw simply controls the amount of fuel emulsion allowed to flow through the curb-idle port. If the screw is turned in (clockwise), it allows less mixture to pass; if it's turned out, it allows more mixture to pass. When the air/fuel emulsion boils out into the air flowing past the partially open throttle plate, it atomizes into the actual mixture that allows the engine to idle. There's a mixture screw for each primary bore in the carburetor. Turning the mixture screws in leans the mixture; turning them out richens it. But mixture screws have very little effect on engine idle speed, which is controlled by the angle of the throttle plate opening.

The angle of the throttle plate opening is set by a **throttle stop screw**, not by the throttle bore itself. This prevents the throttle from sticking in the bore. It also makes the idle system less sensitive to mixture adjustments. The idle airflow specification of each Rochester carburetor is set at the factory. It should not be readjusted to seat the throttle in the bore.

By the late Seventies, idle-mixture adjustment had been virtually eliminated. The factory idle adjustment was protected by an **idle limiter cap**, or the idle-mixture adjustment screw was hidden beneath a plug. This cap or plug, which is installed at the factory after the idle mixture has been set, prevents tampering with the idle mixture adjustment by limiting idle mixture screw adjustment to about 1/2-turn (caps) or eliminating it altogether (plugs).

The curb-idle ports on some emissions carburetors may also be smaller than than those used on pre-emission carburetors. For example, pre-1971 Quadrajets use a 0.095-inch diameter curb-idle port; 1971 and later Q-jets have 0.080-inch ports. This makes it impossible to over-richen the mixture by backing out the mixture adjustment screws.

### The off-idle port

At this point, the engine is idling smoothly on air entering around the throttle plate, combined with an emulsified mixture of air and fuel entering each carb throat through an idle port with an adjustable mixture screw. Now the problem is how to obtain a smooth transition from curb idle to cruising speed. As the throttle opens, vacuum diminishes at the idle port, so less fuel will be drawn from this port. So a second hole, known as the **off-idle port** or **idle transfer port** or **idle transfer slot** is drilled into the vertical passage feeding the curb-idle discharge port, only a little higher up, closer to the venturi, right above the edge of the throttle plate at its idle position. When the idle circuit is metering fuel through the curb-idle port, the off-idle port serves as a lower air bleed air for the idle system. This extra bleed leans the air/fuel mixture further, which improves its ability to atomize when it's discharged through the curb-idle port.

When the engine is idling, i.e. the throttle plates are closed, the off-idle port or slot is *above* the vacuum that occurs just below the throttle plate at idle. But as the throttle plate is opened, the off-idle slot is progressively uncovered. The vacuum just below the edge of the plate moves up, growing progressively weaker at the curb-idle discharge port and stronger in the area of the off-idle port. The off-idle port ceases its function as the lower air bleed for the curb-idle port and begins to discharge air/fuel emulsion. As the throttle plate opens wider, vacuum at the curb-idle port grows weaker and weaker. Less and less fuel is drawn out of the curb-idle port, while more and more fuel comes out of the off-idle slot, because it's closer to the area of stronger vacuum right below the plate. At some point, the throttle is open far enough - and there's enough airflow through the venturi - so that fuel begins to flow out of the main nozzle. On a well-designed carburetor, the transition from the idle and off-idle ports to the main circuit is smooth and unnoticeable.

Notice that we use the terms "port" and "slot" when referring to off-idle holes. That's because they can be a series of holes or a single slot. Both approaches provide correct air/fuel mixtures and both operate in a similar and satisfactory manner. Slots are more typical, however, because they're cheaper to machine. But ports or a slot, this is the important thing to keep in mind: When the port/slot is above the throttle plate, it's an air bleed; when it's below the plate, it's a fuel discharge port.

Another peculiarity of off-idle systems is the adjustable off-idle air bleed used on some emissions carburetors. A separate air channel bleeds air past an adjustment screw into the idle system. The correct off-idle air/fuel mixture ratio, i.e. the ratio that meets emission control requirements, is determined by the factory and set accordingly.

### The idle-air bypass system

Some two and four-barrel Rochester carburetors have an idle-air bypass system that allows the throttle plates to be virtually closed at idle. Gum, varnish and carbon deposits around the throttle plates of conventional systems often disrupt an engine's idle stability, but Rochester's design allows a steady idle even when the carburetor is dirty.

How does it work? At idle, some of the air moving through the carburetor takes a detour right above the venturi and goes around the closed throttle plates through a separate air channel, reentering the carburetor bore just below the throttle plates. The amount of bypassed air is regulated by an adjustment screw in the idle-air bypass channel. This screw is located at the rear of the float bowl casting. Turning the screw in (clockwise) decreases idle speed; backing it out increases idle speed.

The idle air bypass system reduces an annoying phenomenon known as *nozzle drip.* When an engine is idling at a higher-than-normal idle speed (as is usually the case on emissions era motors), the pressure drop near the booster venturi for the main circuit - caused by higher-than-normal idle air speed through the booster - pulls a small but unwanted amount of fuel through the main metering circuit and out the discharge nozzle. On a carburetor with an idle-air bypass system, most of the idle air misses the venturi. Nozzle drip is particularly annoying on large-displacement engines operating at the higher speeds required for emission control.

Air is supplied to idle-air bypass systems by a combination of fixed and adjustable pathways. Two-barrel carburetors use a hole in each throttle plate to provide a constant flow of air for some of the idle-air bypass requirements. The idle-air adjustment screw controls the rest of the idle air - and idle speed. Some Quadrajets have fixed idle-air passages which begin at the air horn and end at a point below the throttle plates. With the additional air provided by these channels, the throttle plates can be almost closed at idle, which lowers the air speed through the carburetor, reducing the signal applied to the main fuel nozzles by the venturi booster.

### Idle air compensator

When engine operating temperatures are extremely high, fuel percolation causes an inordinate amount of fuel vapors to enter the intake manifold, enriching the mixture excessively. Under these conditions, the engine can idle poorly or stall. Some Rochester two-barrel carburetors use an **idle-air compensator** to offset the enriching effects of these excessive fuel vapors. The compensator, which is mounted above the main venturi or at the rear of the float bowl, is a thermostatically-controlled valve operated by a temperature-sensitive bimetal strip. Under normal operating conditions, the compensator blocks off an air passage leading from the carburetor venturi to a point just below the throttle plates. At a preset temperature, the bimetal strip bends and unseats the valve, which uncovers the compensating air passage between the carburetor venturi and the underside of the throttle plates. Only enough air is added to offset the too-rich condition and maintain a smooth idle. When the engine cools and the extra air is no longer needed, the bimetal strip closes the valve. If you're setting the idle speed or adjusting the mixture on a carburetor with an idle-air compensator system, make sure the valve is *closed* to ensure correct adjustments.

### Off-idle operation

The off-idle discharge ports just above the throttle plates act as air bleeds for the idle system while fuel is flowing through the curb-idle discharge ports. But as the throttle plates open further to admit more air, they gradually uncover the slotted off-idle ports, which are now below the throttle plates and exposed to the same high manifold vacuum as the curb-idle discharge ports. This high vacuum pulls extra fuel from the off-idle ports, richening the denser charge moving through the carburetor. Without this correction provided by the off-idle slots during the transition from idle to the main metering system, driveability suffers. At best, you experience a lag in throttle response as the mixture leans out; at worst, the engine backfires as a result of incomplete combustion. The accelerator pump helps, of course, but only when throttle movement is quick enough to activate it. As the throttle plates open still further, the air velocity through the venturi causes the low pressure area to move up the bore to the vicinity of the lower idle-air bleeds, which begin discharging fuel. They continue to do so throughout part-throttle operation all the way up to wide open throttle. Meanwhile, the idle and off-idle system taper off and finally quit as air velocity through the carb increases and moves the low-pressure area farther from the throttle plates and closer to the venturi.

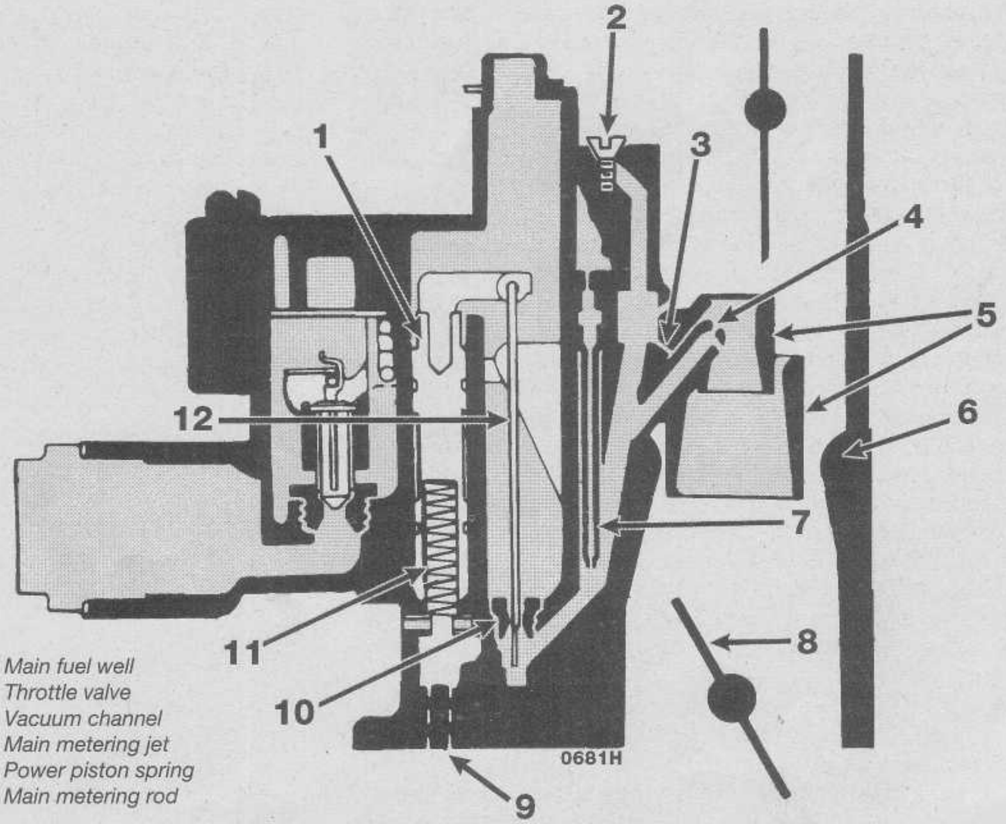
### Hot-idle compensator

The hot-idle compensator, which was used on Q-jets from 1967 to the late '70s, is a thermostatically-controlled valve that uses a heat-sensitive bimetal strip. The compensator is a small chamber located either at the rear of the float bowl, adjacent to the secondary bores, or in the primary side of the float bowl. It closes off an air channel leading from a vent in the air horn to a point below the secondary throttle valves, offsetting an overly rich mixture caused by excessive fuel vapors during hot-engine operation. The compensator valve is held closed by the bimetal strip's tension. During extremely hot operating conditions, excessive fuel vapors entering the engine manifold richen the mixture excessively, causing a rough idle and stalling. When extra air is needed to offset this richening effect of fuel vapors, the bimetal strip bends at a preset temperature, unseating the compensator valve. The air channel opens, air is drawn through the passage into the intake manifold, the rich mixture is leaned out and the idle smooths out. When the engine cools down and extra air is no longer needed, the bimetal strip closes the valve and normal operation resumes.

## *The cruising or main-metering or high-speed circuit*

### Introduction

Once the engine speed or airflow increases to the point at which the idle and accelerating pump systems are no longer needed, the **main-metering system (see illustration)** takes over. This circuit supplies the correct air/fuel mixture to the engine during cruising-and-higher speeds.



**3.11 Typical main metering circuit (early Quadrajet)**

| | | | |
|---|---|---|---|
| 1 | *Power piston* | 7 | *Main fuel well* |
| 2 | *Air bleed adjustment screw* | 8 | *Throttle valve* |
| 3 | *Main well air bleeds* | 9 | *Vacuum channel* |
| 4 | *Main discharge nozzle* | 10 | *Main metering jet* |
| 5 | *Boost venturi* | 11 | *Power piston spring* |
| 6 | *Main venturi* | 12 | *Main metering rod* |

### The throttle plate

When you step on the gas pedal, you open the **throttle valve** or **throttle plate** in the base of the carburetor. Interestingly, the throttle shaft is slightly offset in the throttle bore (about 0.020-inch on primaries and about 0.060-inch on secondaries). In other words, the throttle plate area on one side of the throttle shaft is larger than the area on the other side of the shaft. Why? Because, believe it or not, the throttle plates are actually *self-closing*! There are two reasons why they're set up this way. First, because of the sizable closing force generated when manifold vacuum is high - which it is at idle - throttle plates with offset shafts return to idle more consistently. Second, offset shafts are a safety measure. In the event you should accidentally fail to reconnect the linkage or throttle return spring, they prevent over-revving the engine because airflow past the throttle plates tends to close them.

One popular misconception about the throttle is that it controls the *volume* of air/fuel mixture that goes into the engine. Actually, engine displacement never changes, so the volume of air pulled into the engine is constant for any given speed. What the throttle controls is the *density* or *mass flow* of the air pumped into the engine by piston action: The charge density is lowest (the air/fuel mixture is thinner), at idle, and highest (air/fuel mixture is thicker) at WOT. Put another way, the cylinder can fill its volume more completely when the throttle plate is open. A dense charge has more air mass, so higher compression and burning pressures - and higher power output - can be achieved. The throttle controls engine speed and power by varying the density of the charge - not the volume of air - supplied to the engine.

### The venturi

The partial vacuum created by the downward stroke of the pistons draws air into the air cleaner and through the carburetor where the air picks up fuel, and goes into the engine. As the air passes through the bore of the carb, it goes through a smooth-surfaced restriction - the **venturi** - that's slightly narrower than the rest of the carb bore. The venturi pinches down this flowing column of air, then allows it to widen back to the diameter of the throttle bore. This inrushing air column has a certain pressure. To get through the constricted area, it must speed up. Remember that in a venturi, there's a pressure drop, or relative vacuum, which increases in proportion to the speed of the air flowing through it (which in turn is determined by engine speed and throttle position). A gentle diverging section - which starts at the smallest area of the venturi and continues to the lower edge of the tapered section - recovers most of the pressure.

If you take a hollow tube and run it in a straight line from inside the fuel bowl to this low-pressure area, the suction of the partial vacuum will draw fuel out of the bowl. The venturi supplies fuel in proportion to the mass of air moving through it. The size of the venturi determines the pressure difference available for the main metering system: The smaller the venturi, the greater the pressure difference, the sooner the main system is activated and the better the mixture of fuel and air. The engine speed at which the main system begins to feed fuel into the venturi depends on the displacement of the engine that's pulling air through the carburetor.

For a given engine size, a bigger carb needs a higher engine speed to activate the main system, a smaller carburetor, a lower rpm. Venturi size also determines the maximum amount of air available at wide-open throttle. If the venturi is too small, top-end horsepower is reduced, even though the carburetor may provide a good fuel/air mixture at cruising speeds. So manufacturers compromise. They use carbs with smaller-than-optimal airflow capacities to get good fuel atomization, vaporization and good distribution, which enhances economy for the stop-and-go and cruising speeds at which most of us drive most of the time. High performance carburetors have a small *primary* venturi with a bigger *secondary* venturi for better top-end flow.

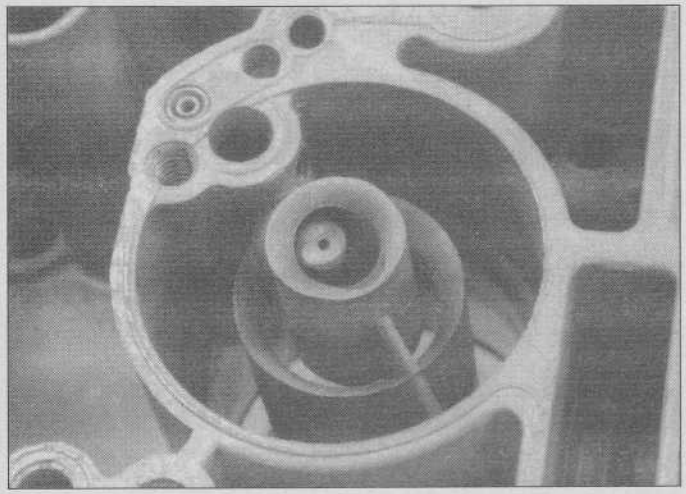
Although it might seem reasonable to assume that the theoretical low-pressure point and the point of highest velocity would be at the venturi's minimum diameter, fluid friction moves this point about 0.030-inch below the point of smallest diameter. This low-pressure, high velocity point of maximum suction is known as the *vena contracta*. Most modern carbs have double, even triple, venturis known as venturi *boosters* (which we'll get to in a minute) to strengthen the suction at the vena contracta The center of the discharge nozzle or the trailing edge of the booster venturi is always placed at this point because it supplies the strongest vacuum *signal* for the main metering system. This signal travels to the main and power systems via an *aspirator channel*. The aspirator channel is always plumbed to the point of greatest "depression" (i.e. the lowest vacuum) in the booster venturi on an upward angle to the vertical fuel pickup channel. This passage, in turn, delivers fuel from the main and power circuits to the booster venturi.

### The main jet and the main fuel well

Fuel for the main-metering circuit is stored in a special chamber known as the **main fuel well**,or simply the **main well**, a vertical passage cored into the main casting. The amount of fuel that enters the main well from the float bowl is determined by the **main jet**, a calibrated orifice screwed into the bottom of the well, through which fuel must travel from the float bowl to the main well. The size *and* the shape of this hole determine how much fuel can pass through the jet for a given pressure difference. At a low pressure difference, little fuel flows through the main jet. And since the jet provides very little restriction to low flow, little turbulence is created as the fuel comes out of the jet into the main fuel well. But as the throttle is opened further, higher airflow through the venturi creates a greater pressure difference in the main metering system. As the flow through the main jet increases, more fuel must go through the small hole in the main jet, creating greater turbulence. Interestingly, as the pressure difference increases across the main jet, the proportion of fuel flowing through it for a given pressure difference is less. So the air/fuel mixture at higher speeds becomes leaner. Up to a point, this increased leanness improves fuel economy. Of course, if you open the throttle still further, the fuel supplied by the main-metering circuit may be insufficient; under these conditions, the power circuit or the accelerator pump circuit, or both, may have to be activated. We'll get to those two circuits in a moment.

The passage from the main well to the venturi is called the **main discharge nozzle**. When the air velocity in the venturi reaches the point at which it produces a vacuum signal strong enough to create a difference in pressure between the nozzle tip and the (vented-to-atmosphere) fuel in the main well, fuel in the discharge nozzle is pulled from the main well to the venturi.

With low pressure in the venturi acting in the same manner as a suction pump, there is no reason why fuel should exit the discharge nozzle in anything other than a liquid state. Remember our pressure difference analogy of sucking fluid through a



**3.12 A Quadrajet triple-booster venturi (the main venturi plus two concentric boosters); that hole in the center booster is an air bleed for the main metering circuit discharge nozzle (the nozzle actually faces down)**

straw? Suction alone initiates flow, but it doesn't provide any means of converting liquid gasoline to a spray mist. Some atomization occurs when a stream of liquid is introduced into a column of fast-moving air. But many of the gasoline droplets are still too large to be atomized thoroughly enough for complete combustion. What's needed is a complete liquid-to-mist breakdown between the fuel bowl and the discharge nozzle. This process is known as **pre-atomization** or **emulsification**. An emulsion is a light, frothy mixture of fuel and air.

### The main well air bleed

The **main well air bleed**, also known as a **high speed bleed** makes this emulsification possible. The main well air bleed "senses" total air pressure; it's unaffected by airflow variations. With an air passage leading from the air bleed to the passage for the discharge nozzle, the same suction (low pressure) force that causes fuel flow now draws *air* into the discharge nozzle passage as well as fuel. The effect is similar to what happens when you try to suck up the last little bit of liquid in the bottom of an iced drink with a straw: Much of the liquid that surrounds the ice cube is drawn up the straw with some amount of air. In some instances, the liquid breaks down into smaller droplets as it travels up the straw.

However, the air bleed's function isn't just emulsifying the fuel. It also exerts control over fuel flow by "bleeding off" some of the suction force or "signal" which exists at the discharge nozzle. By varying the size of the bleed, the amount of suction (vacuum) required to initiate fuel flow can be specified. As bleed size is enlarged, vacuum necessary to initiate fuel flow is increased. Conversely, a reduction in bleed size reduces vacuum requirements. The air bleeds contained in production carburetors are precisely measured restrictions, sized such that fuel flow is started at specified airflow rates.

The main air bleed is the part of the main metering circuit that affects the air/fuel ratio. Because of the pressure difference created by the venturi (and the booster venturi, which we'll get to in a minute), this small precisely machined hole draws air into the main well. If the pressure difference is strong enough, the level of fuel in the well drops below the level of fuel in the float bowl and air is added to the fuel via the main air bleed. When this happens, the final mixture is leaned out. As air volume through the carburetor increases, so does the leaned-out mixture ratio. If the vehicle is pushed to a very high speed, the main metering circuit alone will deliver a very lean mixture.

Most main air bleeds used in production Rochesters are fixed-dimension restrictions, sized so that fuel flow is initiated at specific vacuum levels. Rochester engineers advise against modifications to bleed size. Without the sophisticated equipment needed to analyze fuel flow, it's impossible to accurately assess the result of such alterations.

*The level of fuel in the float bowl - and, therefore, the main well - is critical to the main-metering circuit*. If it's correct, there will be fuel available just below the tip of the main nozzle, ready to be sucked into the venturi. But if the fuel level in the float bowl is low, the fuel level inside the main nozzle will also be low, i.e. too far below the tip of the main nozzle. This condition will delay the introduction of fuel from the nozzle into the venturi for a brief instant when you step on the throttle, and the engine will run lean or have a *flat spot*. If the fuel level in the bowl is too high, fuel will actually drip from the end of the nozzle, whether the engine is running or shut off. This condition can seriously affect mileage when the engine is running, and fill the oil pan with gasoline when it isn't. In other words, the float level determines the distance the fuel must be lifted to flow out the main delivery tube and into the venturi area. The lower the float level, the greater the pressure difference necessary to move fuel up into the main delivery tube. And a higher float level lets more fuel flow for a given airflow through the carburetor, which makes the mixture richer; a lower float level setting causes the mixture to be leaner. Obviously, the float level affects not only the idle and off-idle circuits, as discussed previously, but it also has a marked effect on the main-metering circuit as well.

### The main nozzle

The tube from the main mixing well to the venturi is called the **main delivery tube** or **main nozzle.** When the air velocity in the venturi reaches the point at which it produces a vacuum signal strong enough to create a difference in pressure between the nozzle tip and the (vented-to-atmosphere) fuel in the mixing well, the fuel in the delivery tube begins traveling from the well to the venturi.

### The booster venturi

If the discharge nozzle in the venturi were nothing more than a tube, an unacceptably high airflow would be needed to develop a signal strong enough to pull fuel from the main well. Unless it's necked down to a configuration that would strangle the engine at high speed, the venturi alone cannot provide a pressure difference great enough to pull the emulsified air/fuel mix out of the tube at low air velocities. The pressure difference must be amplified somehow. And that's what the **boost** or **booster venturi (see illustration)** does - it's a signal amplifier. By amplifying the signal available for main system operation, the boost venturi enables the main circuit to function well even at lower speeds and, therefore, lower airflows. This ability is even more advantageous in high-performance carburetors because a boost venturi doesn't seriously impede the carburetor's airflow capacity.

Booster venturis have a number of advantages, the most important of which are the following. First, the trailing edge of the booster venturi discharges at the low-pressure point (vena contracta) in the main venturi. So boost venturi airflow is always accelerated to a higher velocity because it "sees" a greater pressure differential than does the main venturi. The air/fuel mixture which emerges from the boost venturi is traveling faster than the surrounding air, so there's a "shearing" effect between the two airstreams which enhances fuel atomization.

Booster venturis also enhance cylinder-to-cylinder fuel distribution.The "ring" of air flowing between the booster and the main venturis channels the charge toward the center of the airstream, which means less of it ends up clinging to the carb wall below the venturi, and more of it reaches the hot intake manifold where it can be further vaporized before being sucked through each individual intake runner into a cylinder. Bottom line: More air/fuel mixture actually *gets* to the cylinders. The intensity and direction of the air/fuel mixture can be tailored to each specific carb/intake manifold/engine combination in the dyno room by varying the shape of the booster and by adding bars, cut-outs, tabs and/or wings to the basic booster shape.

Some of these boosters are less-than-ideal at distributing fuel evenly around the throttle bore. Poor manifold designs on some vehicle have exacerbated this problem, so Rochester engineers either added a tab, bar or wing to get the desired directional effect for good cylinder-to-cylinder distribution with a particular manifold. These modifications "shape" the low-pressure area so that the fuel is pulled into a more effective distribution pattern as it exits the discharge nozzle.

Finally, it's difficult to build a carburetor with a correctly *shaped* main venturi that will still fit under the hood of a typical modern automobile. Ideally, manufacturers want a 20-degree entry angle and a 7 to 11-degree diverging angle below the vena contracta. However, it's usually impossible to make a carburetor tall enough to permit such a configuration. Booster venturis allow a much *shorter* main venturi so the carb can fit under the hood. Carburetor designers achieve essentially the same results with one or two booster venturis stacked in the main venturi as they can achieve with a single longer venturi of the "optimal" length.

Every booster design creates a vacuum signal of a different intensity, so you can see that fuel metering requirements and air bleed dimensions must also vary from one carburetor to the next, even though they may have identical throttle bore and venturi diameters. By juggling these variables, Rochester engineers can create a wide array of fuel delivery characteristics.

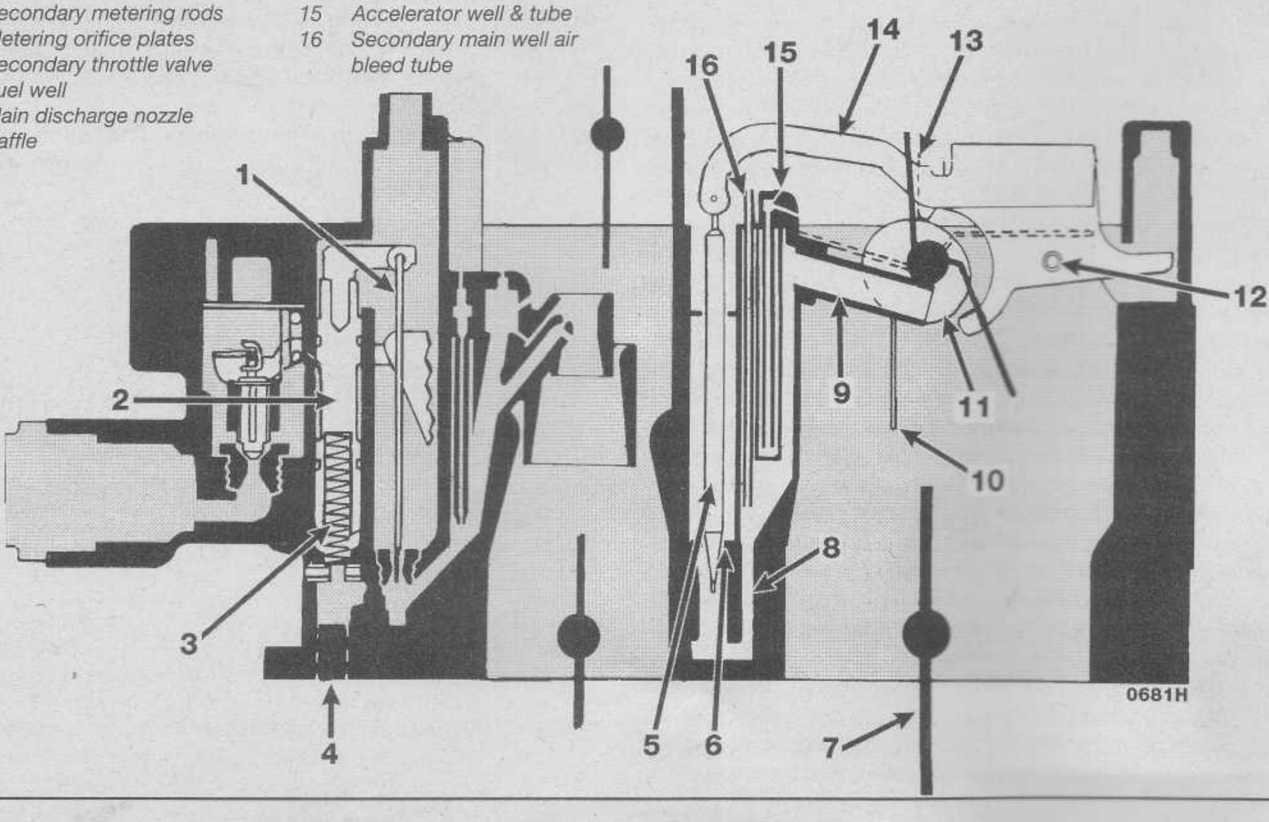
But that doesn't mean *you* should try to fiddle with air bleed dimensions or booster venturis. Without the proper tools and diagnostic equipment, altering either bleeds or boosters is virtually impossible. Bleeds aren't designed to be modified. Period. And neither are boosters. Reckless, misguided enthusiasm can ruin a perfectly functioning carburetor. If you want to fiddle with the main metering circuit, experiment with replacing the main jets (see Chapter 8). Swapping jets is the only way a do-it-yourselfer can alter fuel flow characteristics in the main metering circuit.

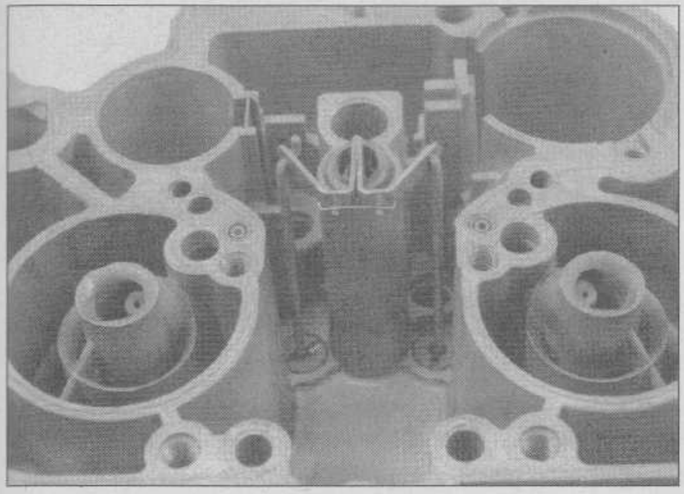
### The power circuit

When you want extra power from your engine for acceleration or passing, the power circuit **(see illustration)** provides the richer mixture that's needed to do the job. Here's how it works. Manifold vacuum is a very good indicator of engine

**3.13a A typical power circuit on an early Quadrajet**

1 *Primary main metering rod*
2 *Power piston*
3 *Power piston spring*
4 *Engine manifold vacuum*
5 *Secondary metering rods*
6 *Metering orifice plates*
7 *Secondary throttle valve*
8 *Fuel well*
9 *Main discharge nozzle*
10 *Baffle*
11 *Eccentric cam*
12 *Hinge pin*
13 *Air valve*
14 *Metering rod lever*
15 *Accelerator well & tube*
16 *Secondary main well air bleed tube*





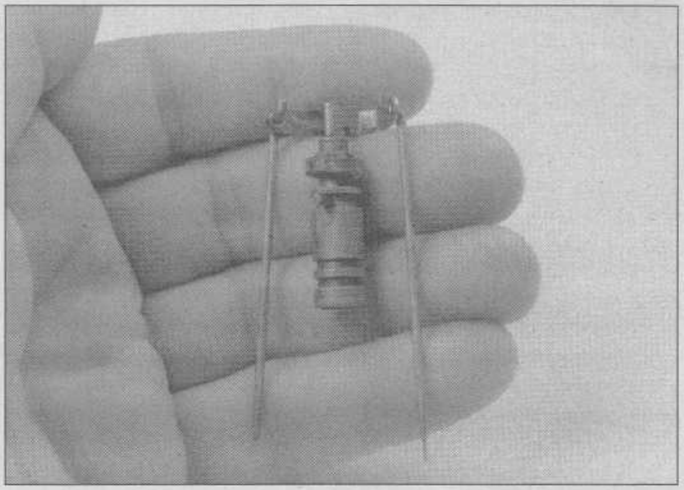
**3.13b The tapered tips of the main metering rods in a Quadrajet stick down into the main jets in the floor of the float bowl; the vacuum-actuated power piston and spring are inside the cylindrical casting in the middle**

load. Vacuum is usually stronger at idle, weaker at open throttle. Think of the power piston and metering rods or the power valve as a "switch" operated by manifold vacuum. As the load increases - you come to a hill, for example, or pull out to pass another car - you must open the throttle valve more to maintain a certain speed or to increase your speed. But as you open the throttle plate, manifold vacuum drops because, with the throttle plates open, there's less restriction to the air flowing through the carburetor. In fact, if it weren't for the power circuit, this condition would normally result in a *leaner* air/fuel mixture just when you need a richer one.

## Power valve (2G and 4G series)

A vacuum passage in the carburetor directs manifold vacuum to the power valve, which usually consists of a spring-loaded, vacuum-actuated piston. At idle and normal cruising speeds, manifold vacuum holds the piston closed against spring pressure. But when the throttle plate is opened, manifold vacuum drops. This drop in manifold vacuum is the signal to the power circuit to open up. Below a preset point, usually about six inches of mercury (in-Hg), there's insufficient vacuum to keep the piston closed. The spring overcomes manifold vacuum and opens the valve. Fuel flows through the power valve and through a restriction to merge with the fuel already flowing into the main well from the main jet. The result is a richer mixture. How much richer depends on the size of the restriction, a tiny hole located in the power valve passage between the float bowl and the main well. The diameter of this restriction, not the size of the power valve, regulates the amount of fuel admitted through the circuit. When you no longer need the extra power, you lift the accelerator pedal, the throttle plates close, manifold vacuum rises and the vacuum signal acts on the piston to overcome spring tension, closing the power valve and shutting off the extra fuel supply.

Manifold vacuum fluctuates significantly at idle and low speed on some high-performance engines in response to *valve timing* as well as throttle position or engine load. If vacuum dips low enough in response to swings in valve timing, the power valve can start metering extra fuel at idle! Power valves on a racing carburetor may have to be modified so they don't open and close in response to valve timing variations.



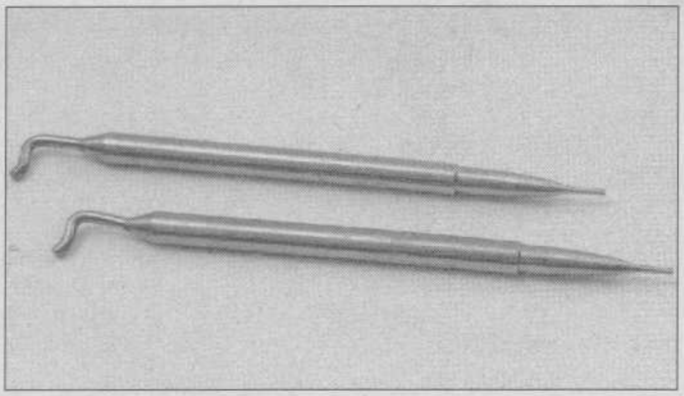
**3.13c Here's what the primary-side metering rods and power piston assembly look like out of the carburetor. This is a rather unique arrangement, since it controls the power "circuit" as well as the main metering circuit (in other words, the power circuit is just an enrichened main circuit!)**

## Power piston and metering rods (Monojet, Varajet, Dualjet and Quadrajet series)

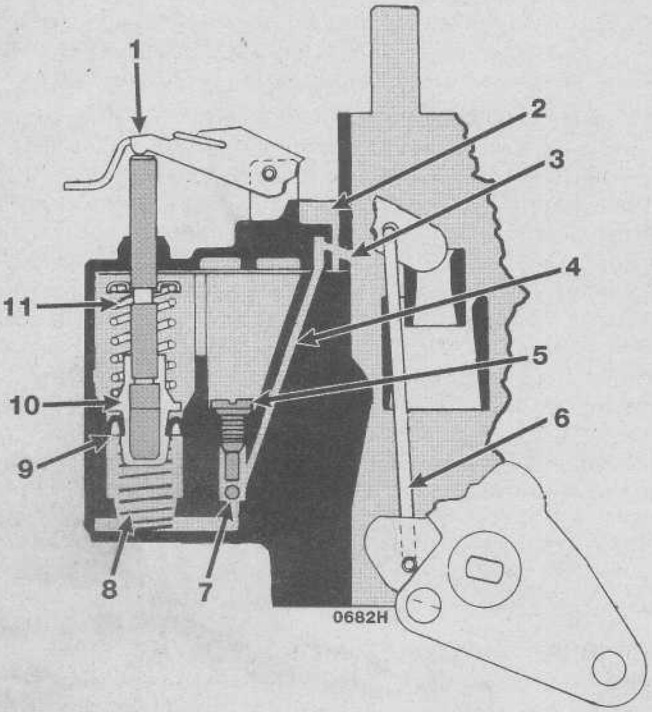
The primary side power circuit is operated by a vacuum piston in a cylinder connected to intake manifold vacuum by a passage **(see illustrations)**. When intake manifold vacuum is high, the piston is pulled down against spring tension, which pulls the thicker part of the main metering rod ends into the main metering jets **(see illustration)**. This provides a mixture sufficient for the operating condition but lean enough for good fuel economy.

As you increase the opening of the throttle plates (when the engine is under load), manifold vacuum starts to drop off and the fuel mixture starts to lean out. With no vacuum sucking the piston down, the piston is pushed up by its spring, raising the metering rods, which allows more fuel to flow through the main jet (because it isn't as restricted as it was), enrichening the fuel mixture.

On the Quadrajet, a similar system is used on the secondary side of the carburetor, but it isn't actuated by vacuum.



**3.14 A set of typical secondary metering rods. These rods all look similar, but they're not. There are three types: pre-1968 rods have a single taper at the tip; 1968 and later rods have a double taper at the tip; but there are two types of double-taper rods - 1968 through 1974, and 1975 through 1980 models. Don't mix them up!**

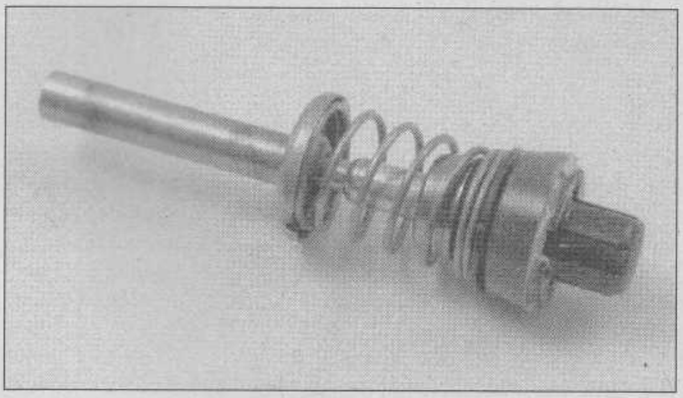


1 *Pump lever*
2 *Pump suction breaker*
3 *Pump jet*
4 *Discharge passage*
5 *Discharge ball retainer*
6 *Pump rod*
7 *Discharge check ball*
8 *Pump return spring*
9 *Cup seal*
10 *Pump plunger*
11 *Duration spring*

The secondary metering rods **(see illustration)** are attached to a cam that is operated by the air valve (the plate at the top of the air horn that covers the secondary throttle bores. So, when airflow past the secondary throttle plates is sufficient to open the air valve a certain amount, the secondary metering rods are lifted up, which allows more fuel to flow through the secondary metering orifices.

## Accelerator pump circuit

Fuel is quite heavy compared to air. Remember that the only thing that keeps it well vaporized at idle is the high manifold vacuum produced by the closed throttle plate. But when you open the throttle abruptly to accelerate from idle, manifold vacuum drops to zero. Also recall that the only thing that keeps fuel well vaporized at cruising speeds is the high venturi vacuum produced by the speed of the air rushing through the carburetor. But when you open the throttle quickly to accelerate from cruising speeds, airspeed through the carb - and therefore venturi vacuum - lags behind engine speed momentarily. In either case, some of the bigger fuel droplets in the vaporized air/fuel mixture condense back into liquid form (an especially thorny problem on big-port and large-plenum manifolds since there's more surface area for fuel to condense onto). A throttle bore that's suddenly opened needs a significant increase in fuel to replace the fuel which falls out of suspension. But the throttle plate is already too far past the idle and idle-transfer ports for them to help out. And, without a strong vacuum signal in the venturi area, the main circuit can't flow a drop. The result? Air rushes through the carburetor, but fuel flow is momentarily halted, so the mixture sucked into the cylinders is ultra-lean. A moment later, some pressure difference returns to activate the main circuit, but by then it's too late - the engine hesitates or stumbles on the lean mixture.



**3.15 A typical accelerator pump circuit on an early Quadrajet**

In other words, when the throttle is moved quickly, there's a time lag between demand (throttle opening) and main system activation. Part of the reason for this phenomenon is engine load. Put the transmission in neutral, rev out the engine and what happens? The engine accelerates smoothly. Why? Because when the throttle is opened in the absence of a load, engine speed can build smoothly and quickly. So manifold vacuum returns to its normal 14 to 17 in-Hg rather quickly. But put the transmission in gear and do the same thing. Now the engine may stumble badly if the accelerator pump isn't operating properly. Why? Because when the engine is put under a load, airflow and vacuum stay low for a lot longer than when the engine is unloaded. During this period, the carburetor flows little fuel because without airflow and vacuum, the regular circuits can't do much.

The **accelerator pump** system **(see illustration)** makes up for this deficiency by squirting a stream of raw fuel into the carburetor right above the venturi. The mechanically-actuated accelerator pump **(see illustration)** is linked to the throttle lever to provide a squirt of fuel each time the throttle is opened quickly. When you open the throttle, the pump linkage pushes down on a plunger and piston inside a pump well. This raises the fuel pressure in the pump well, which (on mid-60s Rochesters) forces the **pump-inlet check ball** inside the plunger head onto its seat so fuel won't escape from the pump well. Some models have an inlet check ball at the bottom of the pump well, at the mouth of the passage from the float bowl to the pump well, instead of in the plunger head. The rise in fuel pressure also raises the **discharge check ball** off its seat, allowing fuel to be injected or discharged through a pump jet or **"shooter"** into the venturi. Some shooters are aimed at the throttle plate or against the bore. But on carbs with venturi boosters, shooters are usually aimed right at the booster. The shot is pulled toward the trailing edge of the booster by air streaming into the carb, breaking up the fuel for better vaporization.

As the throttle moves toward its closed position, the throttle-to-pump linkage returns to its original position, pulling the piston back to its "at-rest" position and creating a vacuum in the pump cavity, which pulls the pump-inlet check ball valve off its seat to allow the pump well to refill from the float bowl. This vacuum in the pump well also pulls the discharge needle or check ball onto its seat, so the next shot of fuel pulled from the float bowl stays in the pump well until the next squirt. The discharge needle or ball is really a check valve. It is fit into the pump discharge passage to allow fuel from the pump to be discharged - but not to allow air to enter the passage when the pump piston is returning to its "up" position. If there were no check valve, air could flow through the pump shooter, down the passage and into the space under the pump piston as it rose and no fuel would flow into the pump well from the float bowl. The weight of a discharge check needle is sufficient to keep it closed against the vacuum signal created by the air rushing by the shooter nozzles, so fuel won't be pulled out of the pump circuit.

Later models - -in fact, all current Rochesters - use a **"floating-cup"** pump inlet valve instead of a check ball in the plunger head or in the bottom of the accelerator pump well. This design fills the pump well through the center of the pump cup. The cup is designed to fit on the plunger with a small amount of vertical clearance. During the delivery stroke, the cup is forced up against the piston face, sealing off a fill hole in the face. As the plunger and piston travel upward on the return stroke, the cup drops a few thousandths of an inch from the piston face, and fuel enters through the hole in the face, filling the well for the next shot. The pump can refill and fire at intervals of two to three seconds.

## Secondary systems

So far, we've covered the primary side of the carburetor. Many two-barrel carburetors only have primary throttle bores - both throttle plates share the same throttle shaft and open at the same time. These are known as *single stage* carburetors and were used for many years. Basically, a single-stage two barrel is like two one-barrel carburetors mounted side-by-side and operating at the same time.

To better regulate the air/fuel mixture and enhance performance over the entire rpm range of the engine, *staged* carburetors were developed. In this design, one side of the carburetor handles all of the primary functions. The other side comes into play when additional air/fuel mixture is needed.

The primary and secondary main metering circuits in staged Rochester carburetors are somewhat alike. Think of the secondary system in a staged carburetor as another carburetor in parallel with the primary system, but as stated before, operating only when required. This "parallel-carburetor" strategy expands the metering range of the carburetor significantly.The secondary has a main metering circuit and some secondaries have an idle system (Quadrajets don't). The differences in their design are determined by what they're used for and when they're used. Staged carbs use smaller primary venturis to get the main metering system going, and to provide good vaporization and air/fuel mixing during cruising and light load, i.e. lower rpm, conditions. Then they use larger venturis for top-end power at higher engine speeds. The primary side of a staged carb is similar to a single-stage carb. The slightly smaller venturi size is the only obvious visual difference. The two secondary barrels are operated only when maximum airflow is needed for more power. In effect, the secondary side is simply another carburetor that opens later than the primary side. It has its own main metering system and (on some models) its own idle system. Varajets and Quadrajets also use a variable metering system which alters the diameter of the secondary main metering orifice(s), effectively enriching the main metering circuit in a manner similar to a power valve (for more information on this system, refer to *The power circuit* described previously).

Rochester secondary systems are activated by mechanical linkage with velocity (or auxiliary) valves (4GC) or mechanical linkage with air valves (Quadrajet).

### Mechanical secondaries with velocity valves

On 4G and GC carburetors (used on GM vehicles from 1952 to 1967), **velocity valves** (or *auxiliary valves*) are located above the secondary throttle plates. The secondary throttle plates are connected by a linkage to the primaries. When the primaries reach a 45-degree opening angle (approximately), the secondaries begin to open. Not much air flows past the secondaries until the manifold vacuum under the velocity valves is strong enough. The velocity valves delay the airflow through the secondaries, so there isn't a "flat spot" as the secondary throttle plates open. When engine speed is high enough, the velocity of the air rushing through the secondaries can force the spring-loaded velocity valves open in half a second once the primary throttles are completely opened. When full throttle is applied at low engine speeds, the velocity valves start to open but close quickly (under their own spring tension) because there's insufficient airflow through the secondaries to force them open.

### Mechanical secondaries with an air valve

The mechanical secondaries on Quadrajets and Varajets are controlled by an **air valve**, which is a large plate mounted above the venturis (it looks a bit like a choke plate). When the primaries reach an opening angle of about 35-degrees, the secondaries start to open. But no air can flow through the secondaries until the vacuum under the air valve is strong enough to allow it to open. The air valve opens only far enough to handle the additional airflow needed by the engine. The rate at which it opens is controlled by a damping diaphragm and linkage rod, so bogging doesn't occur **(see illustration)**.

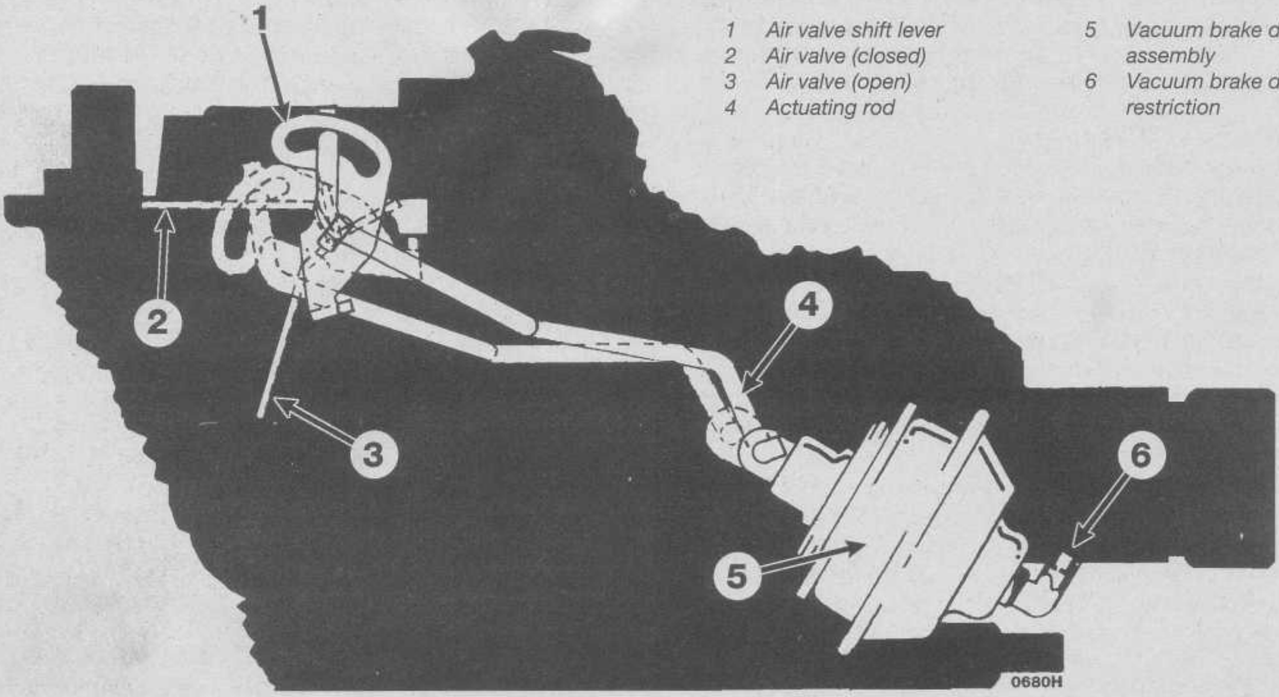
# Carburetor controls

At this point, we have a carburetor that will do the job. But modern carburetors must not only do their job - they must do it cleanly enough to satisfy state and Federal emissions regulations. And they must offer good driveability. To accomplish these often conflicting goals, a number of gadgets have been hung on Rochester carburetors. The most important of these devices are described below.

## Anti-dieseling solenoids

Have you ever turned the ignition off, only to discover that the engine kept running in a kind of jerky, jumpy way? Then you're already acquainted with run-on, or *dieseling*. Dieseling problems were virtually unheard of before the smog-reduction era began. Nowadays, with the lean mixtures and high idle speeds needed to keep engines from puffing out smog at idle, it's not uncommon to turn the key off and have the engine keep running, especially when it's really hot. Why does the engine do this? Because the throttle is opened so far. To fix it, Rochester engineers designed a gadget which closes the throttle all the way when you turn off the ignition. It's called an **anti-dieseling solenoid**.

When the ignition is on, the solenoid is energized and the plunger protruding from the end of the solenoid holds the throttle open at its normal curb idle. Idle speed is adjusted either by screwing the solenoid in or out of its bracket or by adjusting the threaded plunger. While the plunger is energized,



3.17 **Typical air valve setup (early Quadrajet)**

1 *Air valve shift lever*
2 *Air valve (closed)*
3 *Air valve (open)*
4 *Actuating rod*
5 *Vacuum brake diaphragm assembly*
6 *Vacuum brake diaphragm restriction*

the idle-speed screw is held off its seat. Turning the ignition off de-energizes the solenoid, which retracts the plunger and lets the throttle drop back so that the idle-speed screw goes against its seat on the carburetor. So there are two idle adjustments on solenoid-equipped carburetors: The curb idle is set at the solenoid; the key-off idle is set with the usual idle-speed screw. To operate properly, the solenoid must be wired so that it goes off with the ignition switch. If it is mistakenly wired so that it is hot all the time, then it won't drop back when the key is turned off, and the engine will diesel.

## Anti-stall dashpot

Let's say your vehicle has an automatic transmission, and you accelerate away from a light by stomping authoritatively on the throttle, then suddenly change your mind as you realize that you're on a collision course with an 18-wheeler which also wants to occupy the same intersection at the same time as you. You have no choice but to lift your foot off the accelerator pedal and stomp on the brakes. And your engine, of course, dies - unless you have an **anti-stall dashpot** fitted to your carburetor. On a vehicle with a manual transmission, this situation would never occur, because you'd quickly declutch and the engine would simply rev up a little. But an automatic doesn't disengage when you lift your foot off the gas; it immediately pulls the engine down to a normal idle. This kills the engine because a big glob of air/fuel mixture is still on the way to the cylinders. In effect, the combustion chambers are flooded by this mixture. The anti-stall dashpot solves this problem by letting the engine return to its normal idle *slowly*, giving the combustion chambers time to burn off the extra-rich mix.

Dashpots used on Rochester carburetors are mounted on the carburetor. A dashpot is easy to identify: It consists of a chamber, diaphragm and spring. A plunger protrudes from the chamber and just touches the throttle linkage. When the throttle pushes against the plunger, the diaphragm tries to force air out of the chamber, but the only exit is through a small hole, which lets the plunger in slowly. The spring returns the plunger for the next stroke.

Dashpots are adjustable, usually by varying the length of the plunger with a screw. The dashpot should let the throttle return slowly enough so that the engine doesn't die, but not so slowly that the vehicle tries to keep going through an intersection!

## Bowl vents

The **external bowl vent** allows hot fuel vapors to escape from the float bowl through a hose which routes the fumes to the evaporative emissions control system (i.e. the charcoal canister). If these vapors were not vented from the bowl, they could get through the internal vent, which could create too rich a mixture during idling and make hot starts difficult.

An **internal bowl vent** is a tube that looks something like a main nozzle, except that it is larger and is located up high near the choke plate. Any fuel vapors that escape from the float bowl during acceleration and cruising conditions are allowed to escape right into the carburetor, where they're sucked into the intake manifold along with the air/fuel mixture and burned. The internal bowl vent is placed in the airstream through the carburetor at an angle so that air is forced into the float bowl above the fuel level. This slightly pressurizes the fuel in the bowl and helps to push the fuel out the main nozzle.

## Deceleration controls

During deceleration, particularly when you snap the throttle plate shut very quickly, a high vacuum is created in the intake manifold. This high vacuum is caused by the engine turning over at higher-than-idle speeds with the throttle plate closed, which pulls extra fuel out of the idle circuit, creating a very rich mixture, so rich that the engine misfires. And misfiring increases emissions.

One way to reduce this high emission-causing manifold vacuum is to have the throttle held open slightly. Another solution is to provide a special passage to let air bypass the throttle valve. Air allowed past the throttle valve reduces the manifold vacuum. Then the mixture will lean out. The device on the carburetor that holds the throttle open slightly during deceleration is known as the **dashpot** or throttle controller.

### *Hot idle compensators*

A cold engine needs a very rich mixture because the gasoline doesn't vaporize well when surrounded by all that cold metal. In order to get enough gasoline vaporized so that a cold engine will run, we choke the carburetor to provide a rich mixture. Logically, you might think that if a cold engine needs more fuel, then an extremely hot engine needs less fuel. This is true. When an engine is idling in traffic on a hot day, underhood temperatures are hot enough to cook on. Engines start to run rough at idle when they get this hot because the increased temperature can improve fuel vaporization so well that the mixture is just rich enough to upset the idle.

The **hot idle compensator** is a little air valve that allows fresh air to enter the manifold and lean the mixture when the engine is hot. Various types of hot idle devices are used on Rochester carburetors. Some models use a bimetal thermostatically controlled air bleed valve which admits additional air into the idle system and relieves overrich idle conditions during prolonged hot idling (and subsequent high engine temperatures). On these models, you'll find a small bimetal spring housed in a little recess in the carb casting right above the throttle linkage. When the engine is hot, this spring opens the small check ball built into the end of the spring, which opens an air passage in the carb casting. The hot idle compensator valve can be replaced by removing the access plate and cork gasket. Although the location of the hot idle compensator valve may vary from model to model, they all look and work pretty much alike.

## Feedback carburetors

Internal combustion engines which use gasoline for fuel produce three toxic emissions - hydrocarbons (HC), carbon monoxide (CO) and oxides of nitrogen (NOx). How much HC, CO and NOx a vehicle is allowed to emit is determined by Federal and state laws which began in the late Sixties and which have since then become progressively stricter. Carburetor development evolved accordingly.

In 1975, the catalytic converter was introduced as a means of reducing HC and CO. The first generation of cats were known as *oxidation* catalysts because they converted HC and CO emissions into harmless byproducts by adding oxygen to them. Carbon monoxide was converted to carbon dioxide (CO2) (which is a "greenhouse" gas, though it's otherwise harmless) and hydrocarbons were converted into water (H2O) and carbon dioxide. Oxides of nitrogen were reduced by lowering compression ratios and adding an exhaust gas recirculation (EGR) valve that lowered combustion temperatures by diluting the fresh intake charge of air/fuel mixture with a small portion of exhaust gases.

These modest measures worked for a few years. Then, in the late Seventies, the Environmental Protection Agency (EPA) mandated much stricter regulations regarding exhaust emissions and fuel economy standards. These stringent new regulations left carburetor manufacturers like Rochester in a quandary. Should they scrap their highly-refined line of carburetors they had developed over many years, and make the technically and financially costly jump to electronic fuel injection? Or should they develop more accurate fuel metering systems for their existing product lines? Most carburetor manufacturers, including Rochester, decided that the technology, the parts suppliers and public acceptance for electronically-controlled fuel injection were still a few years off. Rochester elected to stick with carbs for a few more years. The result was the **feedback carburetor system**, which is worth looking at not just because it's the state-of-the-art in current carburetor design - and probably the final stage in the long evolution of the carburetor - but because it's probably what you have on the family car if it was manufactured in the early to mid-Eighties.

To achieve the further reductions in NOx mandated by the late-Seventies EPA regs, auto manufacturers turned to a more sophisticated type of catalytic converter known as the *three-way* catalyst. A three-way cat not only oxidizes HC and CO, it *removes* oxygen from NOx emissions. This portion of the TWC, which is located in the front portion of the cat, is known as a *reduction* catalyst. Here's how it works: Oxygen released from NOx combines with HC and CO. NOx becomes just plain nitrogen (N2), which is an inert gas, and the HC and CO become water and carbon dioxide, just like an oxidation catalyst. The only catch was, for a TWC to work right, the engine had to emit the right *balance* of HC, CO and NOx. This balance occurs when the air/fuel mixture ratio is close to the **stoichiometric** ratio of 14.7:1.

### *The Computer Command Control system*

To achieve this goal, Rochester engineers turned to a **closed-loop** or **feedback** system of engine information sensors supplying data to a microprocessor (computer) that manipulates a **mixture control (M/C) solenoid** in the carburetor. The **Computer Command Control (CCC)** system debuted on GM California passenger vehicles in 1980; in 1981, it was installed on GM 49-state vehicles as well. Various versions of the CCC system have been used on Dualjet, Varajet and Quadrajet carburetors. The following description of a typical system is the one used on Quadrajets, but it applies equally to two-barrels as well. All CCC systems use an array of information sensors, a microprocessor, a **mixture control (M/C) solenoid** and, on some models, a **throttle position sensor** and an electronic **idle speed control**.

The microprocessor controlling the CCC system is known as the Electronic Control Module (ECM). The ECM, a solid-state computer in a metal box, is located in the passenger compartment behind a kick panel or somewhere under the dash. The ECM monitors a wide variety of engine operating conditions such as the amount of oxygen in the exhaust stream, manifold absolute pressure, coolant temperature, throttle angle and engine rpm. The ECM is nothing more than a fast-acting switching device, taking in information, making a quick decision and sending voltage signals to a circuit or connecting a circuit to ground at the right time to turn it on or off. These voltage values and time values, which are programmed into the ECM's memory, differ from one engine to another. For example, if the ECM "reads" a voltage value for the correct length of time, it performs a certain function, such as turning on the EGR system as the engine warms up. However, if the voltage or time interval isn't correct, the ECM recognizes this and does not perform its function. And it may even turn on a "CHECK ENGINE" light on the dash to let you know something is wrong.

To make accurate decisions, the ECM requires extremely accurate voltage signals from the sensors. If battery voltage were used, any load on the electrical system - even slight ones such as changes in engine speed - would raise or lower sensor-voltage output. Even slight variations can create a false signal to the ECM. To avoid this, the ECM sends a five-volt reference signal to the sensors. This low voltage level is impervious to slight or even significant fluctuations in battery voltage.

The ECM operates the CCC system in one of the following five modes:

1 **Shutdown mode** - This mode makes sure no current is supplied to the M/C solenoid when the engine is stopped or insufficient voltage is supplied to the ECM to allow proper operation of the M/C solenoid. If the engine speed is less than 200 rpm and battery voltage is less than nine volts, the system goes into shutdown mode.

2 **Start-up enrichment mode** - This mode provides a rich signal to the M/C solenoid for a short time after any start up. The length of this mode is determined by the temperature of the coolant sensor when started. It overrides the next three modes.

3 **Open-loop mode** - This is the operating mode of the system when the engine and the oxygen sensor are warming up, but haven't yet reached operating temperature.

4 **Closed-loop mode** - This is the regular operating mode of a warmed-up engine and an oxygen sensor warm enough to generate a working signal to the ECM (the system also waits a predetermined amount of time before going to closed loop). On some vehicles, a few minutes at idle causes the $O_2$ sensor to cool and the system to return to open loop; on these vehicles, the system may even switch back and forth as the $O_2$ sensor temperature rises and falls.

5 **Enrichment or near-WOT mode** - When the system is in open or closed loop modes and the throttle is opened to near WOT, the ECM sends a steady power enrichment signal to the mixture solenoid.

The ECM has a built-in timer clock which provides time delays for various functions. If a sensor circuit fails to function at its programmed time, the ECM recognizes the malfunction and turns on the Check Engine light and stores the related trouble code. Other malfunctions, such as open circuits, grounds or shorts, or incorrect oxygen sensor voltage level, will also store codes.

The **oxygen ($O_2$) sensor**, which is installed in the exhaust manifold or the exhaust pipe (before the catalytic converter), is the most important information sensor because the amount of oxygen in the exhaust varies in proportion to the air/fuel mixture ratio. Which means the oxygen content of the exhaust gas can be used to *adjust* the air/fuel mixture. The $O_2$ sensor compares the oxygen content in the exhaust with the oxygen content in the outside air. The difference between the two is expressed as a low-voltage *analog* signal (a variable voltage output). This analog signal is sent to an electronic control module (ECM) that converts it to a *digital* signal and interprets it by comparing it to a *map* (program) stored inside its memory. If the oxygen content increases - exhaust gas is lean - the voltage output decreases; if the oxygen content decreases - exhaust gas is rich - the voltage output increases. The ECM looks at this data and alters the air/fuel mixture accordingly by energizing the M/C solenoid.

As long as the CCC systems keeps the air/fuel ratio close to stoichiometric, the three-way cat can do its job of removing harmful pollutants from the exhaust. If the mixture gets too lean, NOx goes up; if the mixture gets too rich, HC and CO go up. It's a neat system, but there's a catch. The oxygen sensor must be heated up - usually to around 500-degrees F - before it will work correctly. So the closed-loop system is worthless during cold starts. Under these conditions, the system must revert to **open-loop control**. Mixture control is set at a fixed value by the program in the ECM memory until the engine is sufficiently warmed up and the oxygen sensor is ready to go to work. A **temperature sensor** in the engine water jacket monitors engine coolant temperature and tells the ECM when the engine is warmed up and ready for **closed-loop control**.

During open-loop operation, the ECM can only "guesstimate" the correct air/fuel mixture ratio. It pulses the M/C solenoid 10 times a second. The mixture ratio would be more accurate if the solenoid could be cycled on and off at a quicker rate, but it can't. In fact, it can't even respond quickly enough to this 10-times-per-second rate. So it compromises. When the ECM signals for more fuel, the plunger pulsates upward; when the ECM signals for less fuel, the plunger pulsates downward. Because it's constantly moving up and down as it tries to keep up with the ECM, it's actually producing an *average* of the required air/fuel mixture. In other words, the plunger never really supplies a perfect mixture. This averaged mixture was good enough for emission standards in the early and mid-Eighties, but it's no longer acceptable. This is why electronic feedback carburetors were finally replaced by fuel injection systems.

The CCC system also goes into open-loop mode when a heavy load is placed on the engine (wide-open throttle (WOT) conditions, pulling a heavy load up a hill, etc.). The engine requires a richer mixture during these conditions than it does when it's operating under normal conditions (normal rate of speed on a level road). The CCC system determines engine load by monitoring manifold vacuum. A **Manifold Absolute Pressure (MAP) sensor** in the intake manifold detects changes in manifold vacuum and sends a variable analog signal to the ECM, which converts this information to digital data, processes it and alters the air/fuel mixture ratio by raising or lowering the M/C solenoid.

The ECM also computes the correct air/fuel mixture ratio by monitoring the amount of throttle opening - idle, part throttle, wide open throttle, etc. - with a **Throttle Position Sensor (TPS).** If the TPS tells the ECM that the engine is being operated at WOT, the ECM puts the system into **enrichment mode** (ignores oxygen sensor feedback) and supplies a steady rich mixture based on instructions stored in the computer program. When the heavy throttle condition ends, the ECM returns the system to closed-loop mode.

Another condition which has a strong bearing on the mixture required by the engine is engine speed (an engine doesn't need as much fuel when it's operating at idle as it does when it's operating at high rpm). The ECM monitors engine speed via a tachometer signal from the distributor. Now let's look at the two basic carburetors used with the CCC system, the Varajet E2SE and the Dualjet E2ME/Quadrajet E4ME.

## The Varajet E2SE

The Varajet E2SE M/C solenoid, an electrical device located in the float bowl, controls fuel flow from the float bowl to the main well and also controls an idle circuit air bleed. The solenoid coil and plunger are mounted in a housing attached to the air horn. The tip of the plunger stem is seated in the bottom of the float bowl, where it controls a passage between the bowl and the main well. It functions as a metering valve that can be opened or closed at a rate of ten times per second. The upper end of the solenoid rod plunger is a viton-tipped valve that also opens and closes rapidly. When the solenoid is energized, the plunger moves down, opening the idle air bleed and closing the main well passage, leaning out both the idle and main metering mixtures; conversely, when the solenoid is de-energized, the plunger moves up, closing the idle air bleed and opening the main well passage, richening the idle and main metering mixtures.

Fuel from the float bowl enters the main well area through two paths: It enters through a **lean mixture screw** assembly, a factory-adjusted main metering jet. And it enters through the solenoid-controlled passage, which is also regulated by a factory-adjusted **rich mixture screw**. The rich mixture screw limits its maximum fuel flow through the solenoid valve when the valve is de-energized.

Once inside the main well, fuel follows the normal path through the remainder of the idle circuit: It flows past an upper air bleed, through an idle channel restriction, past a lower air bleed, past an off-idle port and down to an idle port with a mixture screw. However, the amount of air which can enter the upper air bleed is varied by the solenoid upper valve. Filtered air from the air cleaner flows past - or is blocked by - the solenoid valve. It then flows past a factory-adjusted idle air bleed screw. This screw limits the size of the air bleed; the solenoid turns the air bleed on and off. And since the amount of idle fuel flow is less than the minimum flow of the metering jet(s), idle mixture is controlled by this variable air bleed.

During the transition period between the idle and the main metering systems, the variable idle air bleed still controls the mixture ratio because fuel is still delivered through the off-idle port. Once the main metering system takes over, fuel is delivered from the main well through the main discharge nozzle into the venturi area. At this point, enough fuel is moving through the two paths described above to exceed the capacity of the lean mixture screw passage. Now, the M/C solenoid controls the mixture by regulating the level of fuel in the main well. The lower the main well fuel level, the leaner the mixture delivered to the main discharge nozzle. And vice-versa.

The M/C solenoid varies the air fuel ratio based on an electrical input from the ECM. When the solenoid is on, fuel is restricted and air is admitted. This produces a lean air fuel ratio of about 18:1. When the solenoid is off, fuel is less restricted. This produces a richer air fuel ratio of about 13:1. During closed-loop operation, the ECM tries to produce an average air/fuel ratio of about 14.7:1 by determining how long the M/C solenoid should be turned on, then off, then on, then off, etc. Its only limitation is its maximum cycling rate of ten times per second.

The ECM also needs to know the position of the throttle plate to regulate the M/C solenoid, electronic spark timing, idle speed control and (on some models) the torque converter clutch. It gets this information from the throttle position sensor (TPS), a variable resistor mounted in the float bowl. The sensor shaft contacts the pump extension lever. As the throttle position varies, so does the voltage signal to the ECM, which measures this output. At closed throttle, voltage is one volt or less. As throttle opening increases, voltage increases to about five volts at WOT.

### The Dualjet E2ME and Quadrajet E4ME

The M/C solenoid on the Dualjet E2ME and Quadrajet E4ME is also located in the float bowl (in the same location as the power piston on conventional Dualjets and Q-jets). It uses a spring-loaded plunger that moves up and down like a power piston, but much more rapidly. The underside of this spring-loaded plunger pushes against a pair of stepped metering rods, the lower ends of which are inserted into the main jets. Each jet has an extension that acts as a metering rod guide and spring seat. The upper side of the solenoid plunger head contacts an idle air bleed valve. Every time the plunger moves up or down, it actuates both the metering rods and the idle air bleed valve.

Here's how the system works: When exhaust oxygen content decreases, i.e. when the exhaust mixture is richened, the analog voltage signal from the 02 sensor goes up, the ECM energizes the M/C solenoid, the plunger moves down to its lean position, the metering rods move back into the main jets and the idle air bleed opens. Lowering the metering rods into the jets restricts fuel flow to the main well; opening the idle air bleed plunger adds air to the idle circuit. Both actions reduce fuel flow.

When oxygen content increases, i.e. when the exhaust mixture is leaned, the analog voltage signal from the $O_2$ sensor drops, the ECM de-energizes the M/C solenoid, the plunger moves up to its rich position, the metering rods move up and the idle air bleed closes. Raising the metering rods out of the jets increases fuel flow to the main well; closing the idle air bleed plunger reduces air to the idle circuit. Both actions increase fuel flow.

The travel of the plunger head is critical. If it's too much or too little, the mixture will be too lean or too rich, respectively. So plunger travel is determined by a couple of factory-adjusted stop screws. The solenoid lean stop screw locates the solenoid coil body and provides a down travel stop. The rich stop screw provides the plunger up stop.

The idle circuit itself is quite different than a conventional idle circuit. Air moves into the side of the air bleed valve, down the center to the plunger seal area, then out side holes to passages to each idle circuit, between the idle tube and the channel restriction. An O-ring seal prevents leaks between the "air in" and "air out" areas of the bleed valve.

The main metering circuit is similar to other main metering circuits, except that the metering rods are controlled more rapidly and precisely by the solenoid.

The throttle position sensor on a Dualjet E2ME or a Q-jet E4ME is identical to the TPS employed by the Varajet E2SE. For a description of the TPS, refer to the previous description of the E2SE.

### Idle speed controls

Because of the extremely lean idle mixtures mandated by emissions regulations, it's become necessary to increase idle speeds. Higher idle speeds reduce misfiring caused by lean mixtures and they reduce emissions. The CCC system needs an accurate way to control idle speeds for driveability and for fuel economy, especially on smaller displacement engines. It achieves this goal with the **Idle Speed Control (ISC)** system. The ECM monitors and processes the output data from several information sensors, then alters idle speed accordingly with a reversible electric motor, regardless of any load - the air conditioner, for example - imposed on the engine.

Here's how it works: The temperature sensor (previously described in the section of the CCC system) tells the ECM the temperature of the engine coolant. When the engine is cold, the ECM directs the ISC motor to maintain a higher idle speed until the engine coolant is warm enough, at which point it reduces the idle speed. The fast idle cam indexes the fast idle when the engine is cold. When a cold signal is received at the ECM, the ISC motor extends only slightly more than the normal (warm engine) idle speed. On a warm engine, the ECM programs a normal idle speed. If the engine gets hot, the ECM increases idle speed to help cool down the engine.

How does the ECM know what the actual idle speed is? It monitors the distributor speed sensor signal. If the actual idle speed is too low, the ECM directs the ISC motor to increase the idle; and vice-versa. The idle speed motor tells the plunger to either extend (increase idle speed) or to retract (decrease idle speed).

How does the ECM know when to put the engine under ISC control? The ISC idle speed motor has a throttle switch or nose switch which feeds inputs to the ECM to tell the ECM whether the throttle lever is resting against the ISC motor plunger. When the throttle lever is resting on the plunger, the ECM controls the idle speed. When the throttle lever isn't touching the plunger, the driver controls engine speed.

There are several other circumstances under which the ECM can direct the ISC motor to increase idle speed. First, an air conditioning clutch signal tells the ISC plunger to increase idle speeds when the air conditioning system is in operation, to maintain the normal engine idle speed under the load imposed by the air conditioning compressor. Second, a battery signal is used to sense system operating voltage at the ECM. If the voltage signal falls below a pre-determined level, the ECM instructs the ISC plunger to extend, increasing engine speed. This increases alternator speed and alternator output (assuming the charging system is functioning correctly). Finally, a park-neutral switch tells the ECM of a pending transmission change, which affects engine loading and, therefore, engine idle speed. This prevents, for example, uneven engine idle speeds as the transmission selector is moved from neutral to reverse.

#### Idle speed control operation

Engine speed is always under closed-loop control of the ECM during closed throttle operation, regardless of engine temperature or accessory loads. The normal engine idle speed is programmed into the ECM - it can't be adjusted. The ECM continuously monitors engine idle speed and issues commands to the ISC to move the throttle stop to maintain the correct idle speed.

Idle speed is maintained by a small reversible electric motor. The ECM sends commands to the motor to maintain the idle speed required for a particular operating condition and the motor changes the throttle-plate opening angle by moving the position of the idle stop in and out.

But how does the ISC system know when to control throttle position? The position of a throttle switch in the ISC motor determines whether the ISC should control idle speed or not. When the accelerator pedal is released, a tang on the throttle lever contacts the ISC plunger, closing the throttle switch; throttle plate angle - and, therefore, idle speed - is put under ECM control. When the throttle lever moves off the ISC actuator, the throttle switch opens, the ECM extends the actuator and idle speed commands from the ECM cease. Idle speed is back under driver control.

Signal inputs are used to either increase or decrease throttle plate angle in response to engine load. For example, as the transmission is shifted from Neutral to Reverse, a signal from the park/neutral switch tells the ECM to anticipate a higher load and raise the engine idle speed as the shift occurs. The system also anticipates certain loads placed on the engine such as the air conditioner, alternator, etc. For example, there's a time lag between the point at which an accessory switch is flipped on and the point at which the added load it creates is actually placed on the engine. During this time lag, the ISC adjusts the plunger to maintain the correct engine idle speed.

Some 1982 and later models use an ISC relay. The purpose of this relay is to make sure the idle speed control plunger retracts fully when the engine is shut off.

An incorrectly adjusted ISC motor will raise or lower the curb idle speed outside of its correct setting. It can also cause engine roughness or lag when the vehicle is put into gear or when the air conditioning compressor comes on. For a complete description of the ISC adjustment procedure, refer to Chapter 7.

#### Idle load compensator (ILC)

The idle load compensator (ILC) is a non-ECM-controlled alternative for controlling curb idle speed. The compensator detects changes in engine load by sensing changes in manifold vacuum. It compensates for these changes by adjusting curb idle speed with a spring-loaded, vacuum-sensitive diaphragm with a plunger. If manifold vacuum decreases, the spring overcomes the low vacuum in the diaphragm and the plunger extends, opening the throttle plate; if vacuum increases, the diaphragm compresses the spring, the plunger retracts and the throttle plate closes.

A delay valve in the vacuum hose to the ILC delays the vacuum signal to the ILC when the throttle is closed suddenly. This delay valve performs the same function as an anti-stall dashpot.

#### Idle stop solenoid (ISS)

The idle stop solenoid (ISS) was originally installed to prevent *dieseling* or *run-on*: For an instant after the ignition was turned off, the engine continued to turn over because of the inertia of its moving parts. And since the throttle plates were still open, air-fuel mixture continued to flow through the carburetor to the cylinders. If the cylinders were hot enough to burn the mixture, the engine continued running *without* ignition! This phenomenon, which became known as dieseling, occurred because high idle settings kept the throttle plates cracked open. Under these conditions, there was no way to stop the engine.

When an ISS-equipped engine is idling, the idle stop solenoid forces the throttle plates open to what would be the normal idle position on an engine without ISS. However, when the ignition is turned off, power to the solenoid is cut off and the throttle plates close far enough to preclude any possibility of run-on.

#### Air-conditioning speed-up solenoid

The air-conditioning speed-up solenoid is identical in appearance to the idle stop solenoid. In fact, they're identical parts! But the air-conditioning speed-up solenoid has a different purpose: When the air conditioner is turned on, the speed-up solenoid raises the idle slightly to compensate for the added load imposed on the engine at idle by the air conditioning compressor.

To positively identify an air conditioning speed-up solenoid, turn the ignition switch to the On position and listen for the solenoid to click on.An idle stop solenoid will click, but an air-conditioning speed-up solenoid won't. After turning the key to On, move the air conditioning control lever from its Off position to the air conditioning mode (do it two or three times). An air-conditioning speed-up solenoid will turn on and off as the air conditioning mode selector lever is moved from Off to air conditioning mode.

## Carburetor types

### One-barrel carbs

One-barrel carbs have one barrel, one throttle plate and one set of metering circuits to meet all air/fuel requirements. They usually have an airflow capacity of about 150 to 300 cubic feet per minute (cfm) and are used primarily on smaller four and six-cylinder engines.

### Single-stage two-barrel carbs

Single-stage two-barrel carbs are basically two one-barrel carbs with a common main body. They have one float bowl, float, choke and accelerator pump. The metering systems for both barrels work simultaneously, but the idle mixtures for each barrel are adjusted separately. Single-stage two-barrels have two throttle valves that open and close together on a common shaft. These carbs have airflow capacities of about 200 to 550 cfm and are used on many six and eight-cylinder engines.

### Two-stage two-barrel carbs

Two-stage two-barrel carbs were introduced in the early Seventies to improve fuel economy and performance and to lower emissions on four and small six-cylinder engines. They use a single float and float bowl but have two barrels and two throttles that operate semi-independently of one another. The primary barrel is smaller than the secondary barrel. It has idle and off-idle circuits and supplies the air/fuel mixture at low and moderate loads and speeds. The primary barrel also usually includes the main metering and power systems and the accelerator pump.

The throttle of the secondary barrel opens at higher speeds and loads when the primary throttle is about half-open. The secondary barrel supplies additional fuel and air to the engine. It includes off-idle, main metering and power systems. The secondary throttle is operated by a mechanical linkage. Most two-stage two-barrel carbs have airflow capacities of about 150 to 300 cfm (they're usually used on small engines).

### Four-barrel carbs

Four-barrel carbs are used mostly on V-8 engines. They have airflow capacities of about 400 to 800 cfm (and some high-performance models can flow over 1000 cfm!). Four-barrels have two primary and two secondary barrels in a single body. At low and moderate loads and speeds, the two primary barrels work together like a single-stage two-barrel carb. At higher speeds and loads, the secondary barrels work in a fashion similar the the secondary barrels on a two-stage two-barrel.

The primary barrels have idle, low-speed, high-speed and power systems. They also contain the choke and accelerator pump. The secondary barrels have separate high-speed and power systems.

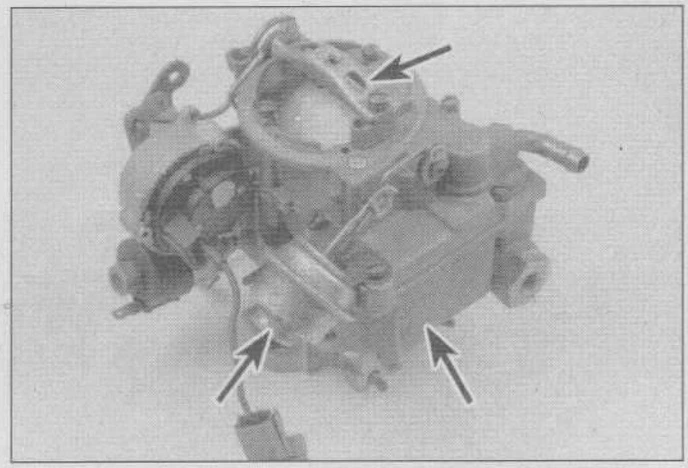
# Notes

# 4 Carburetor identification

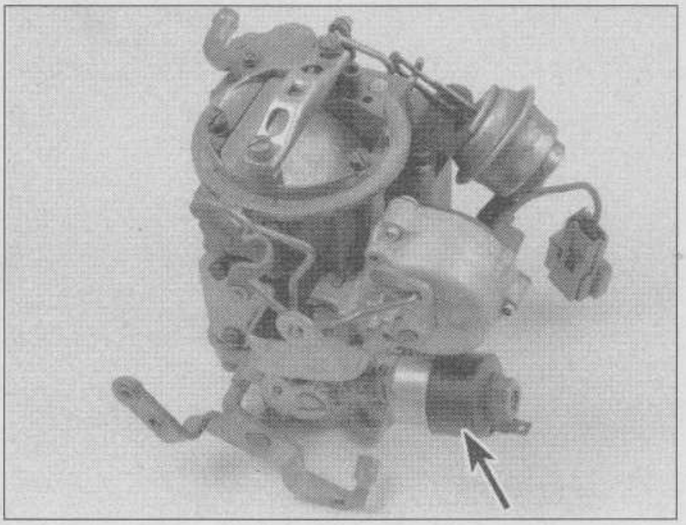
## *The Monojet*

The earliest Rochester one-barrel carburetors date back to 1950. However, this book's coverage begins with the Monojet, or 1M series **(see illustrations)** because it was the first Rochester designed to provide fuel metering sophisticated enough for the Federally-mandated emission and fuel economy standards which began to make greater demands on carburetor design during the '60s. The Monojet was the workhorse one-barrel for GM vehicles from the mid-60s to 1979, and - thanks to metering controls which could be modified to meet stricter emission standards - was still in use on some trucks through 1986.

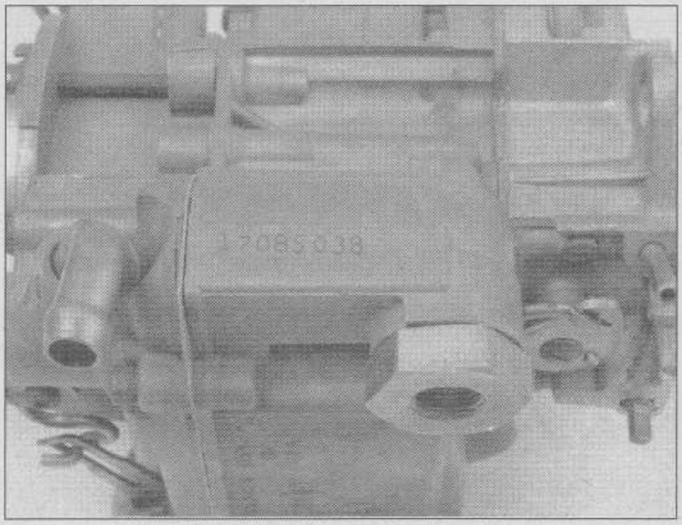
Manual choke Monojets are designated by the letter M; automatic choke models are designated MV. The letter V refers to the vacuum-break diaphragm on the carburetor. Some MVs have a thermostatic coil on the engine; others have an electrically heated element on the choke housing itself. Other ways to identify a Monojet: Look for a thick insulator gasket between the throttle body and the float bowl; this gasket protects the float bowl from engine heat. Monojets also have an internally-balanced vent hole in the air horn (an external idle-vent valve is also used on some 1971 models).



**4.1 You can identify a Monojet by the removable bracket (upper arrow) for the air cleaner stud and by the characteristic "Monojet" logo (lower right arrow) on the side of the float bowl; the diaphragm housing (lower left arrow) is the choke vacuum break unit; note the electrical connector for the electrically-heated choke coil**



4.2 **Many Monojets use an idle-stop solenoid (arrow) like this as an anti-dieseling device**



4.3 **The identification numbers on a Monojet are stamped into the end of the float bowl right above the fuel inlet**

A tube-type discharge nozzle dispenses fuel into a multiple-venturi booster. A mechanically and vacuum-operated variable-area main jet controls fuel flow through the main metering circuit. The jet's orifice is fixed; but its flow capability is varied by a tapered metering rod, connected by linkage to the main throttle shaft, which is raised to richen the mixture and lowered to lean it out. The metering rod is also vacuum operated by a power piston, providing it with what amounts to a power circuit. This clever design improves performance during moderate-to-heavy acceleration.

Some Monojets used in the early 1970's use a different setup. Instead of a metering rod and vacuum-operated power system, they have a conventional metering jet with an airflow-actuated power valve. This design was developed out of GM's desire to achieve better fuel mileage for the smallest engine installed in the Chevy Vega. This engine produced very little vacuum during acceleration and cruise, so a vacuum-controlled system would signal for fuel enrichment before it's needed.

The Monojet's main metering circuit is supplemented by the **Adjustable Part Throttle (APT) system**, a circuit which can be adjusted to control part-throttle fuel mixtures more accurately than a fixed orifice. APT fuel detours around the main jet, instead going directly from the float bowl to the discharge nozzle feed well.

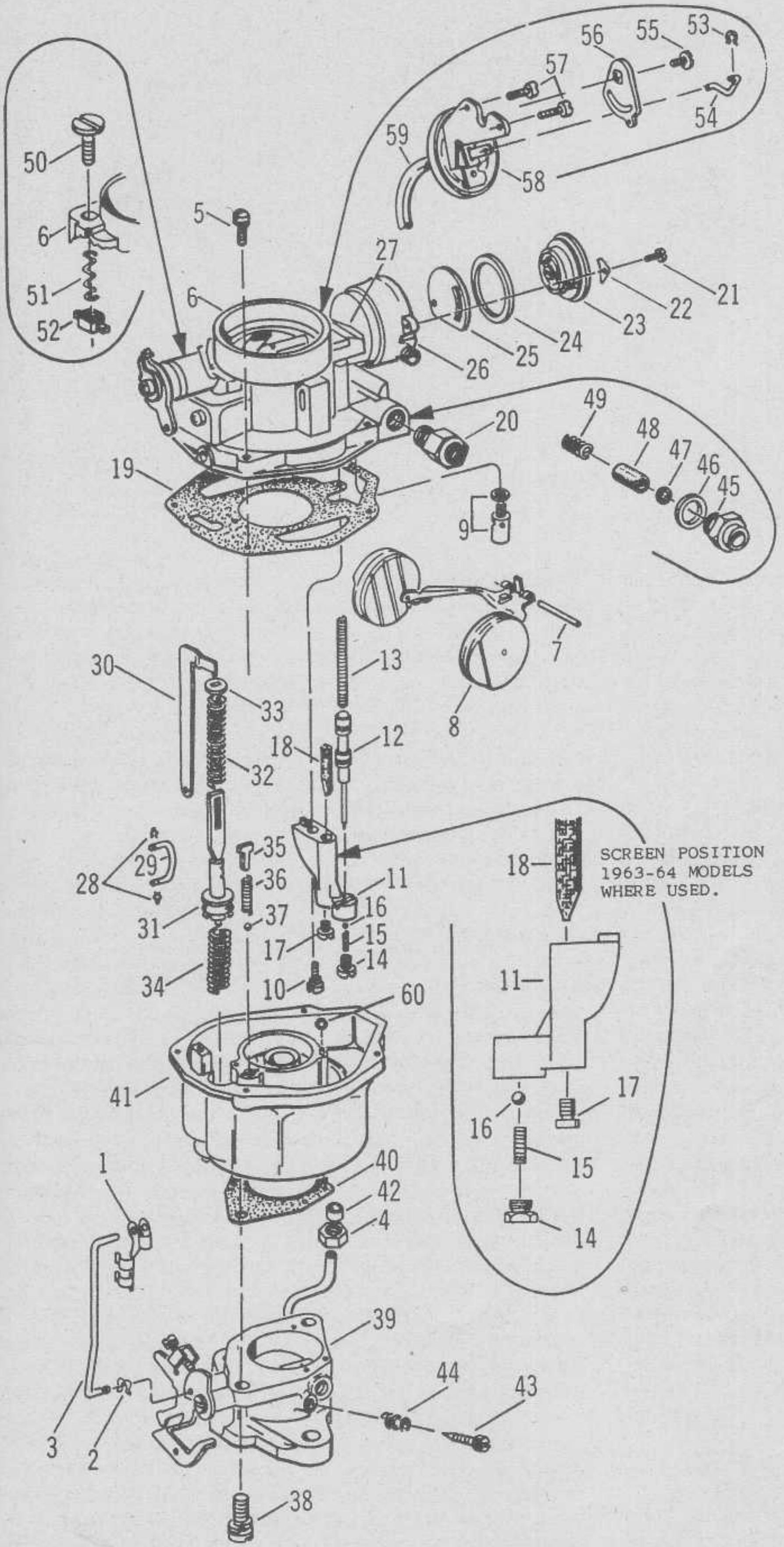
The power circuit is integrated into the main metering circuit. Fuel flow through both circuits is regulated by the same tapered metering rod in the main jet. At part-throttle and cruising speeds, high manifold vacuum holds the power piston against spring tension. The upper side of the power-piston groove is held against the top of the drive rod so the metering rod is kept low in the jet for maximum economy. When acceleration reduces manifold vacuum, the power-piston spring pushes the piston up, lifting the metering rod so more fuel can flow through the main jet.

## The Model B

The Model B one-barrel **(see illustration)** was installed on most Chevrolet six-cylinder engines produced from 1950 through 1967. Letter designations indicate the style of choke used: B series carbs have a manual choke and were used only on trucks; BC series units have an automatic thermostatic choke mounted on the air horn and were used on cars and trucks; BVs have a remote bimetal coil mounted on the exhaust manifold.

The Model B has a unique design: A donut-shaped float bowl forms a ring around the venturi. The combination of a circular float bowl and a centrally located nozzle prevents fuel spillover during quick turns or stops. All metering passages - except the idle passages - are in the air horn. These passages are insulated from engine heat by the air-horn gasket and the fuel in the float bowl, so B models provide consistent, steady fuel metering and are less likely to vapor lock than their predecessors.

The model B is different than most carburetors, in that it uses a *snatch-idle circuit*. A horizontal idle tube carries idle fuel from a vertical idle passage on the same side as the float bowl, across the top of the throttle bore and over to the other side of the carburetor, where it's pulled down another vertical idle passage to the idle and off-idle ports. Besides the two conventional air bleeds located on the upper side of the tube, an unusual third "bleed" faces straight down into the middle of the booster venturi. This arrangement allows the idle tube to do double duty as the main metering circuit discharge tube. Under idle conditions, vacuum is strong down at the throttle plate, so the downward facing bleed augments the two conventional bleeds in emulsifying the idle fuel on its way to the idle and/or off-idle ports. This system gets its funny name from the fact that fuel is "snatched" across the gap at this upside-down air bleed. As airflow through the carburetor picks up, the strong vacuum signal moves to the booster venturi, which pulls fuel from this bleed, which at this point becomes the discharge nozzle for the main metering circuit! The advantage of this setup is that the passage for the main discharge nozzle is always primed and ready to supply fuel the instant its gets a sufficiently strong vacuum signal from the booster venturi. In other words, throttle response is very good with this system. There's virtually no lag time between the point at which the off-idle discharge port ceases operation and the main metering circuit kicks in. And this, in turn, leads to another benefit: A small-capacity accelerator pump with a short stroke is more than adequate for this system.

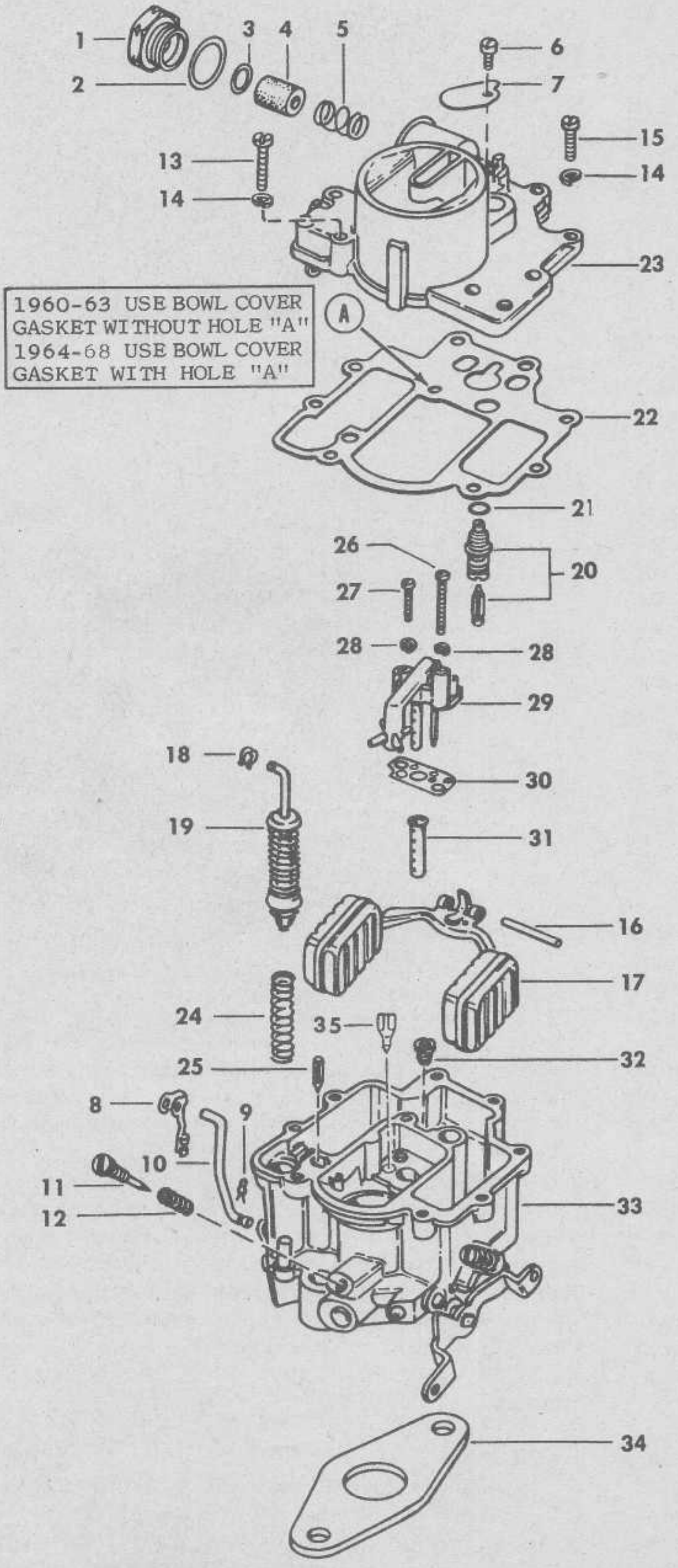


**4.4 An exploded view of a typical Model B/BC/BV carburetor**

| | |
|---|---|
| 1 | *Upper choke rod retainer* |
| 2 | *Lower choke rod retainer* |
| 3 | *Choke rod* |
| 4 | *Choke suction tube nut* |
| 5 | *Screw and washer-bowl cover* |
| 6 | *Bowl cover assembly* |
| 7 | *Pin-float lever hinge* |
| 8 | *Float and lever assembly* |
| 9 | *Rotary valve and gasket assembly* |
| 10 | *Main well support screw and washer* |
| 11 | *Main well support assembly* |
| 12 | *Power piston* |
| 13 | *Power piston spring* |
| 14 | *Power valve plug* |
| 15 | *Power valve spring* |
| 16 | *Power valve ball* |
| 17 | *Main metering jet* |
| 18 | *Main well support screen* |
| 19 | *Bowl cover gasket* |
| 20 | *Fuel inlet fitting* |
| 21 | *Stat cover screw* |
| 22 | *Stat cover retainer* |
| 23 | *Stat cover and spring assembly* |
| 24 | *Stat cover gasket* |
| 25 | *Choke baffle plate* |
| 26 | *Choke housing* |
| 27 | *Choke housing gasket (not shown)* |
| 28 | *Pump link retainer* |
| 29 | *Pump link* |
| 30 | *Pump rod* |
| 31 | *Pump plunger* |
| 32 | *Pump plunger spring* |
| 33 | *Pump spring washer* |
| 34 | *Pump return spring* |
| 35 | *Pump discharge ball guide* |
| 36 | *Pump discharge ball spring* |
| 37 | *Pump discharge ball* |
| 38 | *Throttle body-to-bowl screw and washer* |
| 39 | *Throttle body assembly* |
| 40 | *Body flange gasket* |
| 41 | *Float bowl* |
| 42 | *Choke suction tube packing* |
| 43 | *Idle adjusting needle* |
| 44 | *Idle adjusting needle spring* |
| 45 | *Fuel inlet fitting* |
| 46 | *Fuel inlet fitting gasket* |
| 47 | *Fuel filter gasket* |
| 48 | *Fuel inlet filter* |
| 49 | *Fuel inlet filter spring* |
| 50 | *Idle vent valve (BV models)* |
| 51 | *Idle vent valve spring (BV models)* |
| 52 | *Idle vent valve nut (BV models)* |
| 53 | *Vacuum control rod retainer (BV models)* |
| 54 | *Vacuum control rod (BV models)* |
| 55 | *Stat rod lever screw (BV models)* |
| 57 | *Vacuum control attaching screw (BV models)* |
| 58 | *Vacuum break control (BV models)* |
| 59 | *Vacuum break control hose (BV models)* |
| 60 | *Vacuum channel tube O-ring (partial-starting 1965 models)* |

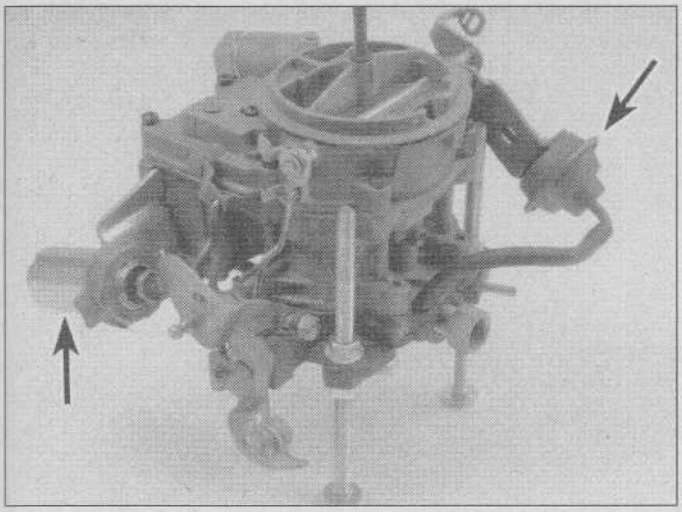
## *The Model H*

The Model H **(see illustration)** was used on only one vehicle - the Chevrolet Corvair. It was installed in either a twin or four-carb configuration. Four-carb setups are linked progressively. The Model H is an inexpensive and simple design. Like motorcycle carburetors, the float bowl and throttle body are combined into one integral casting. So maintenance and overhauls are a snap.

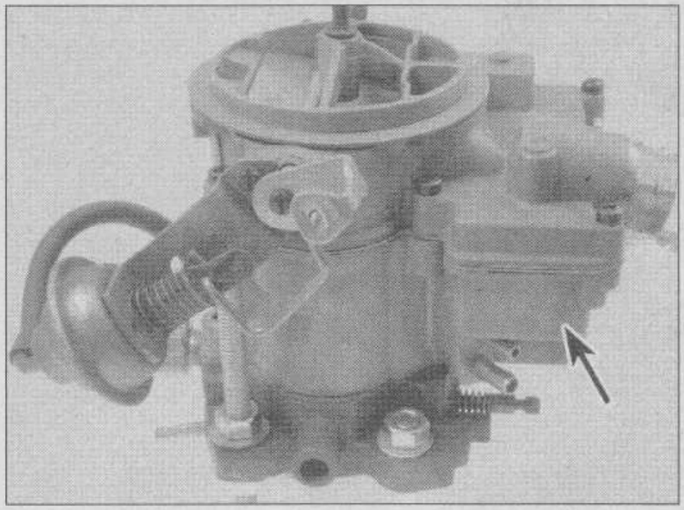


**4.5 An exploded view of a typical Model H carburetor (used only on Corvairs)**

| | |
|---|---|
| *1* | *Fuel inlet filter nut* |
| *2* | *Fuel inlet nut gasket* |
| *3* | *Fuel inlet filter gasket* |
| *4* | *Fuel inlet filter* |
| *5* | *Fuel inlet filter spring* |
| *6* | *Cover screw* |
| *7* | *Cover* |
| *8* | *Pump rod retainer* |
| *9* | *Pump rod retainer (hairpin)* |
| *10* | *Pump rod* |
| *11* | *Idle adjusting needle* |
| *12* | *Idle needle spring* |
| *13* | *Air horn screw (long)* |
| *14* | *Lock washer* |
| *15* | *Air horn screw (short)* |
| *16* | *Float hinge pin* |
| *17* | *Float assembly* |
| *18* | *Pump plunger clip* |
| *19* | *Pump plunger assembly* |
| *20* | *Needle and seat assembly* |
| *21* | *Needle seat gasket* |
| *22* | *Air horn gasket* |
| *23* | *Air horn assembly* |
| *24* | *Pump return spring* |
| *25* | *Pump discharge needle* |
| *26* | *Venturi cluster screw (long)* |
| *27* | *Venturi cluster screw (short)* |
| *28* | *Lock washer* |
| *29* | *Venturi cluster assembly* |
| *30* | *Venturi cluster gasket* |
| *31* | *Main well insert* |
| *32* | *Main-metering jet* |
| *33* | *Body and bowl assembly* |
| *34* | *Heat insulator* |
| *35* | *Power Enrichment Needle (All 1965 through 1967 primary carburetors; not used in secondaries on 4-carb setups)* |



4.6 A typical Model 2GV carburetor with vacuum break diaphragm (upper arrow); the choke thermostatic coil isn't missing - it's located on the exhaust manifold. This is a later-model 2GV: Note the idle-stop solenoid (lower arrow)



4.7 The serial numbers (arrow) for a 2GV are located on the side of the float bowl right below the fuel inlet

One of the most innovative features of the Model H was its fuel discharge assembly for the main metering circuit. A **radial discharge nozzle** replaced the conventional boost venturi. This unique booster has four projections which discharge fuel near the outer circumference of the booster (Rochester-rival Holley didn't try this trick until 1976, when it introduced a "vane type" booster for its line of Economaster carbs).

Main-well-tube inserts help to emulsify the idle fuel mixture, which improves idle stability when the engine is hot and prevents fuel percolation and general hot starting problems.

There's no power system on early Model H carbs. Because of more stringent emissions control requirements, later models were equipped with a power system similar to the system used on the Monojet for the Vega engine.

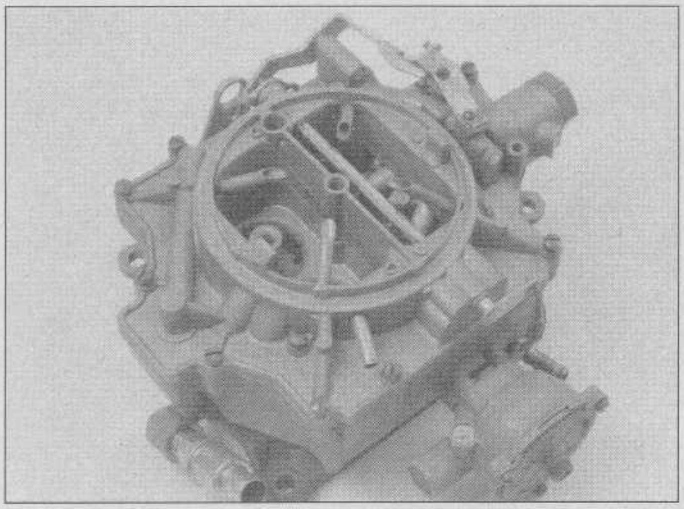
## *The Model 2G*

The Rochester 2G carburetor **(see illustrations)** was used on a wide variety of V8 engines from 1955 until 1978, when emission and fuel economy standards forced it into early retirement. G model carburetors are simple to service - most of the calibrated metering parts are in the venturi cluster assembly. And they're simple to understand: There are two throttle bores, two venturis and two identical metering systems - one per bore. There are three versions of the G model: The 2G, the 2GC and the 2GV.

The 2G is equipped with a manual choke. It was used in marine and truck applications. The 2GC is a 2G with an integral automatic choke (that's the "C"). The automatic choke housing and thermostatic coil are located either on the air horn or on the throttle body, depending on the application. The 2GV uses a divorced type automatic choke with the thermostatic coil on the exhaust manifold. It also uses a vacuum-break diaphragm instead of a conventional choke housing with a choke piston.

## *The 4G*

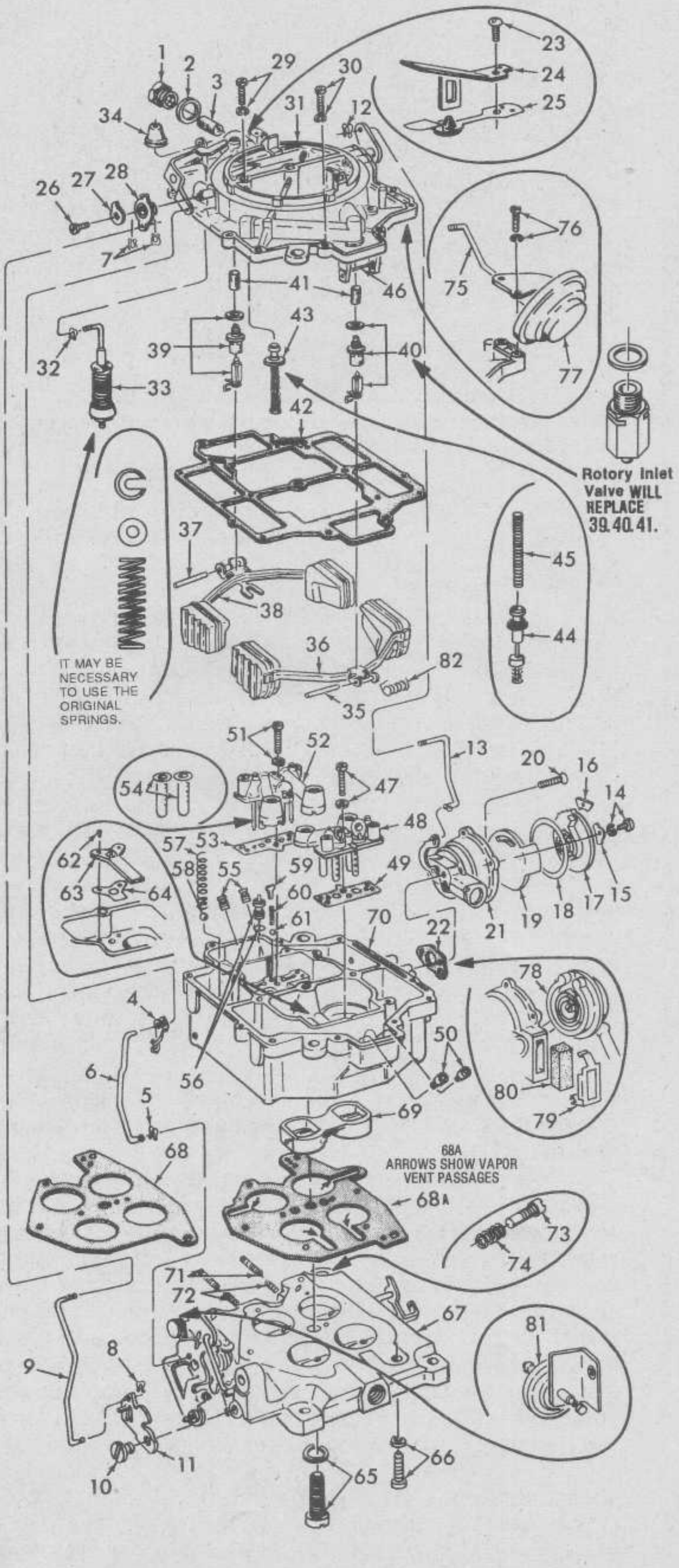
The 4G **(see illustrations)** was Rochester's first four-barrel carburetor. It was used from 1952 to 1967 on many GM vehicles. The impetus for its design was the dual need for lower hood lines and more power. The 4G was the result. It was basically two 2-barrel carburetors in tandem. The primary side contains all metering systems. The secondary side has separate float and power circuits for high-speed and passing conditions. The primary venturis are smaller - much smaller - than the secondaries. This keeps air velocity high enough to provide a strong vacuum signal during normal low-speed driving. Once the primary throttle plates reach and opening angle somewhere between 42 and 60-degrees, the secondary throttle begin to open. The linkage connecting the secondaries to the primaries is designed so that they're fully open by the time the primaries are fully open. The secondaries also use a spring-loaded auxiliary valve, or velocity valve, that provides further metering control (see Chapter 3 for a complete description of this device).



4.8 The Model 4G is easily identified by its four vents protruding from the air horn into the mouth of the carburetor

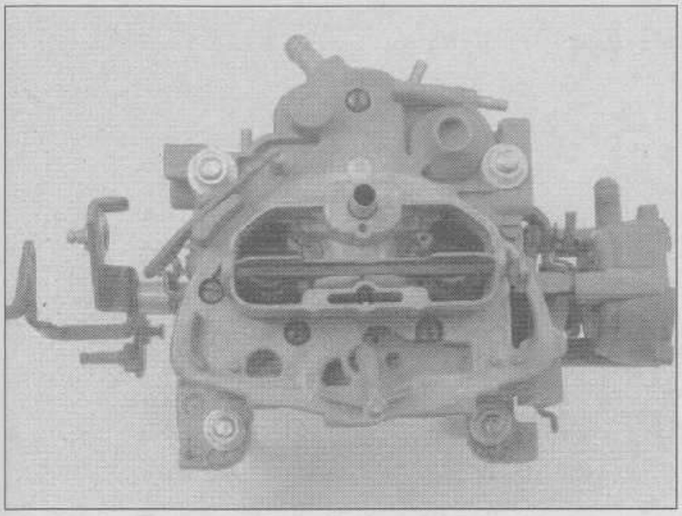
## *The Dualjet*

By the mid-Seventies, the two-barrel 2GC had reached the end of its development. New, stiffer emission standards were looming, but further improvements were impossible without a complete redesign. The primary side of a 2GC was sim-

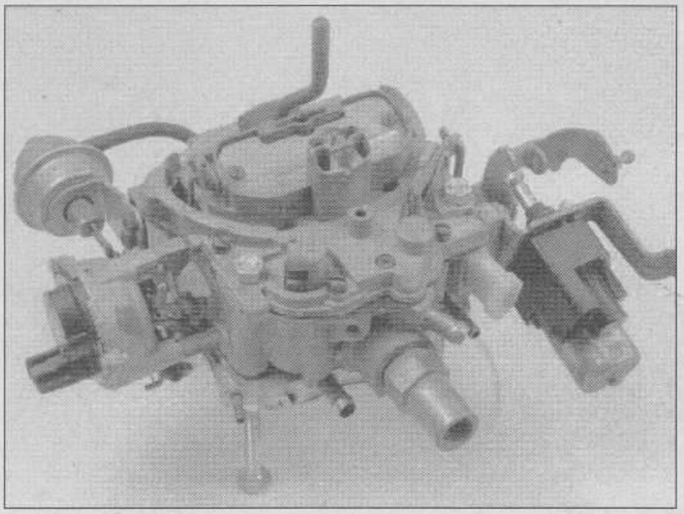


**4.9 An exploded view of a typical Model 4G or 4GC carburetor**

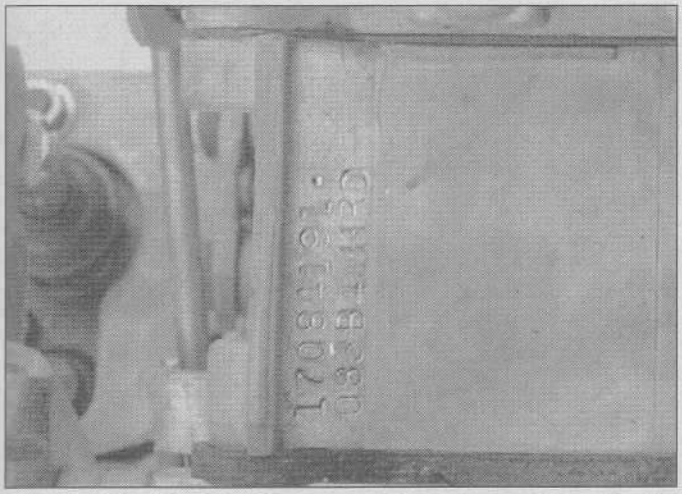
| | |
|---|---|
| 1 | *Fuel inlet fitting* |
| 2 | *Fuel inlet fitting gasket* |
| 3 | *Fuel inlet screen* |
| 4 | *Pump rod upper retainer* |
| 5 | *Pump rod lower retainer* |
| 6 | *Pump rod* |
| 7 | *Choke rod upper retainer* |
| 8 | *Choke rod lower retainer* |
| 9 | *Choke rod* |
| 10 | *Fast idle cam screw* |
| 11 | *Fast idle cam* |
| 12 | *Intermediate choke rod retainer* |
| 13 | *Intermediate choke rod* |
| 14 | *Stat retainer screw and lock washer* |
| 15 | *Stat cover plain retainer* |
| 16 | *Stat cover toothed retainer* |
| 17 | *Stat cover and spring assembly* |
| 18 | *Stat cover gasket* |
| 19 | *Choke baffle plate* |
| 20 | *Choke housing screw* |
| 21 | *Choke and piston assembly housing* |
| 22 | *Choke housing gasket* |
| 23 | *Idle vent valve screw* |
| 24 | *Idle vent valve shield* |
| 25 | *Idle vent valve* |
| 26 | *Trip lever screw* |
| 27 | *Trip lever* |
| 28 | *Choke lever and collar* |
| 29 | *Bowl cover screw and lock-washer* |
| 30 | *Bowl cover screw and lock-washer* |
| 31 | *Bowl cover assembly* |
| 32 | *Pump plunger retainer* |
| 33 | *Pump plunger* |
| 34 | *Pump plunger boot* |
| 35 | *Secondary float hinge pin* |
| 36 | *Secondary float and lever assembly* |
| 37 | *Primary float hinge pin* |
| 38 | *Primary float and lever assembly* |
| 39 | *Seat and gasket assembly primary needle* |
| 40 | *Seat and gasket assembly secondary needle* |
| 41 | *Needle and seat strainer screen* |
| 42 | *Bowl cover gasket* |
| 43 | *Power piston assembly* |
| 44 | *Power piston with float-assist spring assembly* |
| 45 | *Power piston spring* |
| 46 | *Float balance spring* |
| 47 | *Secondary venturi cluster screw and lock washer* |
| 48 | *Secondary venturi cluster* |
| 49 | *Secondary venturi cluster gasket* |
| 50 | *Secondary main metering jets* |
| 51 | *Primary venturi cluster screw and lock-washer* |
| 52 | *Primary venturi cluster* |
| 53 | *Primary venturi cluster gasket* |
| 54 | *Main well inserts* |
| 55 | *Primary main metering jets* |
| 56 | *Power valve and gasket assembly* |
| 57 | *Pump return spring* |
| 58 | *Ball-pump intake (Used in types with seat in casting)* |
| 59 | *Pump discharge ball guide* |
| 60 | *Pump discharge ball spring* |
| 61 | *Pump discharge ball* |
| 62 | *Idle compensator valve screw* |
| 63 | *Idle compensator valve* |
| 64 | *Idle compensator valve screw* |
| 65 | *Throttle body attaching screw and lock-washer (center hole)* |
| 66 | *Throttle body attaching screw and lock-washer* |
| 67 | *Throttle body assembly* |
| 68 | *Body flange gasket* |
| 68a | *Body flange gaskets with vapor vent slots (can replace No. 68)* |
| 69 | *Auxiliary throttle valve assembly* |
| 70 | *Float bowl assembly* |
| 71 | *Idle adjusting needles* |
| 72 | *Idle adjusting needle springs* |
| 73 | *Idle air adjusting needle (for bypass idle system)* |
| 74 | *Idle air adjusting needle spring* |
| 75 | *Vacuum control rod* |
| 76 | *Vacuum control attaching screw and lock-washer* |
| 77 | *Vacuum break control assembly* |
| 78 | *Hot water type choke stat cover and spring assembly* |
| 79 | *Filter retainer* |
| 80 | *Air intake filter* |
| 81 | *Throttle return check assembly* |
| 82 | *Float torsion spring* |



**4.10 A typical early model Dualjet with no electronic controls**



**4.11 A typical later model Dualjet with mixture-control solenoid and idle speed control (ISC) motor**



**4.12 You'll find the identification numbers stamped into a Dualjet on the flat side of the main body casting, near the left corner**

ply too inefficient to meet the new emissions requirements. At the time, the only Rochester with a primary side efficient enough to do the job was the Quadrajet. So Rochester engineers simply cut the Q-jet in half. The Dualjet **(see illustrations)** was introduced in 1976. Think of it as a Q-jet with no secondaries.

The first version of the Dualjet was the Model 200, or M2MC, introduced in 1977. It uses a separated main well for the main metering system, triple venturis and 1-3/8 inch bores. The model 210 was introduced In 1978. It was basically a 200 with a smaller 1-7/32 inch throttle bore. Model 210s were more suitable for smaller engines. Dualjets were widely used on GM engines during the mid-to-late Seventies, but never on anything bigger than a 305 V8.

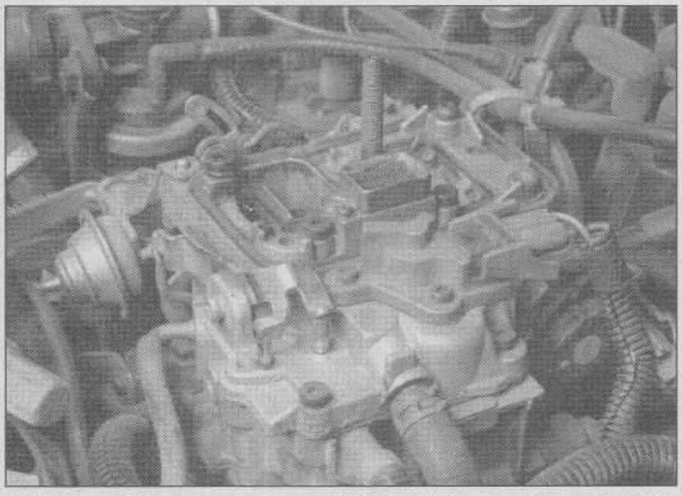
The Dualjet provides good - though hardly excellent, by today's standards - mixture ratios during idle, off-idle and part-throttle ranges. But when its jetting is leaned out for improved cruising and light-throttle operation, low-speed and medium-to-heavy acceleration are adversely affected. In the early '80s, electronic Dualjets eliminated this problem. On these models, a microprocessor controls the mixture ratio in all driving ranges. Refer to the discussions of Quadrajets in this Chapter and in Chapter 3 for a more complete look at Dualjets, which are, remember, nothing more than Quadrajets with no secondaries.

## *The Varajet*

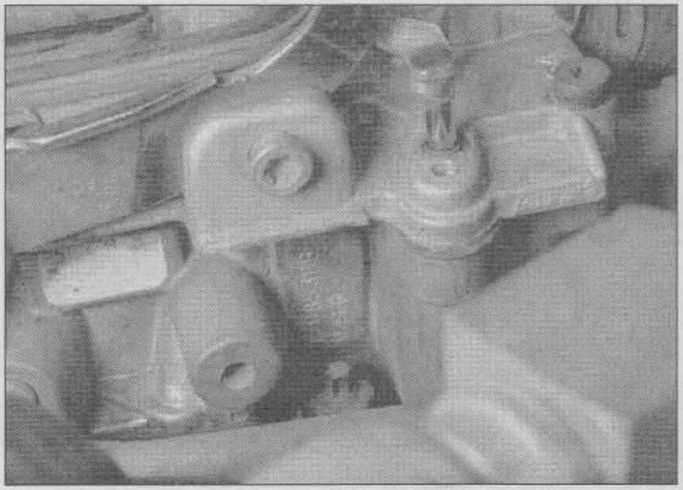
By 1978, Rochester engineers realized that there were limits to the Dualjet's versatility. Its adaptation to medium-size, low-performance GM vehicles had been only modestly successful. Further refinements to make it suitable for smaller engines were impossible. Rochester also looked at the ancient Monojet, but decided against fiddling with that design for largely the same reasons they had rejected the idea of trying to update the 2G and had decided instead to come out with the Dualjet: The idle, low speed and main metering circuits could not be controlled enough to meet late-'70s emission and fuel-economy standards. If the Monojet had been downsized enough, and the venturi had been redesigned so that it was sensitive enough to meet emission and fuel-economy requirements, it would have been too anemic during full-throttle conditions. Rochester concluded that an all-new carburetor was the only solution for the new, smaller engines that were being installed in compact front-wheel-drive vehicles. It would also have to be small enough to fit under the increasingly lower hood lines of modern vehicles. The 2SE Varajet **(see illustrations)** was introduced in 1979 in response to these requirements.

The 2SE Varajet was an all-aluminum staged two-barrel designed primarily for GM front-wheel-drive vehicles (although it was eventually used on rear-wheel-drive vehicles with small engines). The 2SE Varajet was used on all 2.5L "Iron Duke" fours and 2.8L V6s until GM began replacing it with first throttle body and later port fuel injection systems throughout the early to mid-Eighties. The 2SE had a 35mm primary bore for good throttle response and fuel metering control during idle and part-throttle conditions. The 46mm secondary bore was big enough to handle heavier throttle conditions. The secondary uses an air valve and a single tapered metering rod.

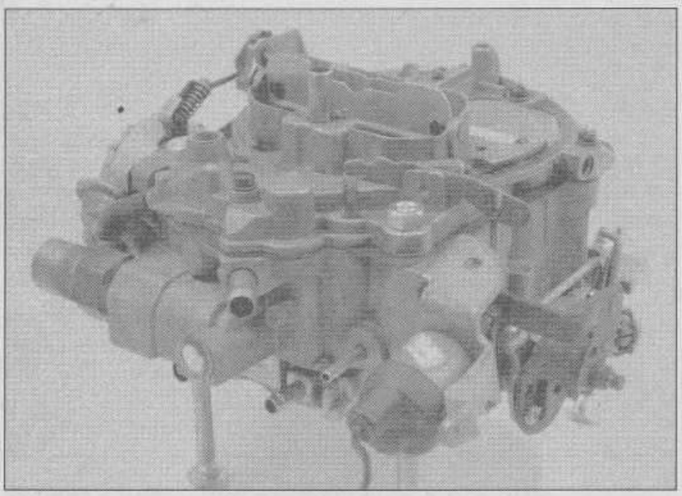
The first generation 2SE Varajet was a conventional carburetor. Less than two years later, a Computer Command Control (CCC) system with a mixture control solenoid and electronic idle-speed control was added to the 2SE Varajet. From that point it was known as the E2SE - the E stands for electronic control.



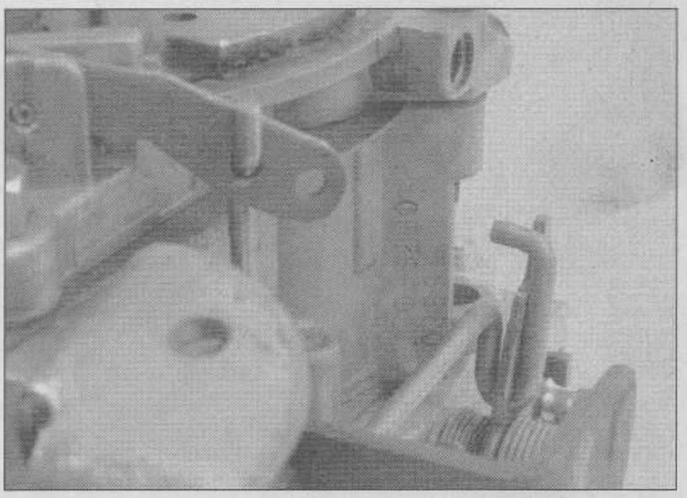
4.13 One of the more common E2SE Varajet applications, the 2.8L V6 used on many GM vehicles and even on other makes, such as this Jeep Cherokee



4.14 You'll find the 2SE Varajet identification numbers on the front of the main body casting



4.15 A typical earlier Quadrajet without electronic controls



4.16 The identification numbers for a Quadrajet are stamped into the main body casting adjacent to the throttle linkage

## The Quadrajet

The Quadrajet **(see illustrations)**, or Q-jet, as it's commonly referred to, has survived longer than any other Rochester carburetor. It debuted in 1965, and since that time has survived the cut over and over as the emissions era eliminated one carburetor after another. The basic design of the Q-jet was so good that subtle modifications and refinements were sufficient to keep it alive, even when fuel injection replaced carburetors on most vehicles. Three Q-jet models were built between 1965 and the late-Seventies. The 4M was the basic Q-jet with a manual choke; the 4MV got an automatic choke with a thermostatic coil mounted on the manifold; the 4MC also had an automatic choke, but the choke housing and thermostatic coil were mounted on the float bowl. Except for the various choke mechanisms, all these early Q-jets were virtually identical in operation until 1980. The Q-jets used on 1981 and later passenger vehicles perform the same functions but they don't work the same way because their mixture and metering functions are computer-controlled.

The main metering system is calibrated by its air bleeds and its tapered and stepped metering rods in the main jets. The vacuum-responsive power piston positions the metering rods in the jets to supply only enough fuel as required by various engine loads.

New emission standards in 1975 mandated alterations to the idle, off-idle and main metering circuits. An **Adjustable Part Throttle (APT) system**, first introduced on the Monojet, allowed closer adjustment at the factory (for an explanation of the APT system, refer to the description of the Monojet at the beginning of this Chapter). These more refined Q-jets were fitted first to passenger cars and, over the following six-year period, were installed on trucks and commercial vehicles as well. They're easily identified by a distinctively shaped air horn and the number 1 as the first digit of their part number.

The addition of an **aneroid altitude compensator** was another change that occurred in 1975. This device, which is installed integrally with the APT system, automatically controls the air/fuel mixture as the altitude increases. Basically, the compensator is a bellows device that contracts at lower altitudes and expands at higher altitudes, lowering or raising, respectively, the metering rods for the main metering system. The altitude compensator was short-lived, however, because improvements to ignition and emission hardware enabled manufacturers to comply with emissions regulations without it.

In 1981, the Q-jet was integrated into the the Computer Command Control (CCC) system to meet ever-more-stringent emission and fuel economy standards. This system included an array of information sensors, a microprocessor and a Q-jet modified for electronic control of the idle and part-throttle air/fuel mixture. Thus modified, this final iteration of the venerable Q-jet was still, amazingly enough, basically the same carburetor it had been a decade and a half earlier, albeit with a few important differences. Nearly every portion of the Q-jet had been subtly altered since its 1965 introduction, yet the basic design was unchanged.

## *Feedback carburetors*

There are three different Rochester feedback carburetors: the Varajet E2SE, the Dualjet E2ME and the Quadrajet E4ME. These electro-mechanical carburetors are easy to distinguish from other Rochester carburetors because they're equipped with electrical devices other than the choke, including a mixture control solenoid, a throttle position sensor (some models) and an idle speed control (ISC) motor (some models). They can also be easily identified by their 2-inch long inlet filters, capped idle mixture screws, riveted choke covers, extra air horn screws and plunger seals in the air horn for the accelerator pump and the TPS plunger.

# Notes

# 5 Troubleshooting

## *General information*

A malfunctioning carburetor can cause a variety of problems, ranging from obvious symptoms like a no-start condition or deiseling (run-on after the engine has been shut off) to problems that are harder to track down, such as an intermittent fuel smell, a flat spot at a certain engine rpm or decreased fuel mileage.

This Chapter provides a reference guide to the more common carburetor-related problems which may occur during the operation of your vehicle. However, many of the symptoms described could have causes related to other systems. Review the following list and make sure all of these criteria are met before attempting to diagnose carburetor problems.

### To operate properly, the carburetor requires:

*A constant fuel supply*
*All linkages and emission control systems hooked up*
*Good engine compression*
*Healthy ignition system firing voltage*
*Correct ignition spark timing*
*An airtight intake manifold*
*Engine at operating temperature*
*All carburetor adjustments performed correctly*

### Problems in the above areas can cause the following symptoms:

*Engine cranks but won't start, or is hard to start when cold*
*Engine is hard to start when hot*
*Engine starts, then stalls*
*Engine idles roughly and stalls*
*Engine runs unevenly or surges*
*Engine hesitates on acceleration*
*Engine loses power during acceleration or at high speed*
*Poor fuel economy*
*Engine backfires*

## Symptom-based troubleshooting

**Note:** *All adjustment procedures are contained in Chapter 7.*

### *Engine cranks but won't start, or is hard to start when cold*

- **Improper starting procedure is being used**
  Verify that the proper starting procedure - as outlined in the owner's manual - is being used.
- **There's no fuel in the gas tank**
  Add fuel. Check the fuel gauge for proper operation.
- **The choke valve is not closing sufficiently when cold**
  Adjust the choke.
- **The choke valve or linkage is binding or sticking**

Realign the choke valve or linkage as necessary. If you find dirt or "gum" (varnish), clean the linkage with carburetor cleaner spray. **Note**: *Do not oil the choke linkage.*

- **There's no fuel in carburetor**

  1 Disconnect the primary (low voltage) wires from the coil.

  2 Disconnect the fuel line at the carburetor. Connect a hose to the fuel line and run it into an approved fuel container.

  3 Crank the engine. If there is no fuel discharge from the fuel line, check for kinked or plugged lines.

  4 Disconnect the fuel line at the tank and blow it out with compressed air, reconnect the line and check again for fuel discharge. If there's still no fuel discharge, replace the fuel pump.

  5 If the fuel supply is okay, check the following:

    a) Inspect and - if plugged, replace - the fuel filter(s).

    b) If the fuel filter is okay, remove the air horn or fuel bowl and check for a sticking float mechanism or a sticking inlet needle. If they're okay, adjust the float level.

- **The engine is flooded**

  **Note:** *To check for flooding, remove the air cleaner. With the engine off, look into the carburetor bores. Fuel will be dripping off the nozzles and/or the carburetor will be very wet.*

  1 Verify that you're using the correct carburetor unloading procedure. Depress the accelerator to the floor and verify that the choke valve is opening. If it isn't, adjust the throttle linkage and unloader.

  2 Dirt in the carburetor preventing the inlet needle from seating. Clean the system and replace the fuel filter(s) as necessary. If you find excessive dirt, remove the carburetor, disassemble it and clean it.

  3 Defective needle and seat. Check the needle and seat for a good seal. If the needle is defective, replace it with a Holley matched set.

  4 Check the float for fuel saturation, a bent float hanger or binding of the float arm.

  5 Adjust the float.

## Engine is hard to start when hot

- **The choke valve is not opening completely**

  1 Check for a binding choke valve and/or linkage. Clean and free up or replace parts as necessary. **Note**: *Do not oil the choke linkage - use carburetor spray cleaner only*.

  2 Check and adjust the choke thermostatic coil.

  3 See if the choke thermostatic coil is binding in the well or housing.

  4 On an integral choke system, check for a vacuum leak.

- **The engine is flooded**

  Refer to the procedure under *Engine cranks but won't start*.

- **There's no fuel in the carburetor**

  1 Check the fuel pump. Run a pressure and volume test.

  2 See if the float needle is sticking to its seat, or if the float is binding or sunk.

- **The float bowl is leaking**

  Fill the bowl with fuel and check for leaks.

- **Fuel is percolating**

  Open the throttle all the way and crank the engine to relieve an over-rich condition.

## The engine starts, then stalls

- **The engine does not have a fast enough idle speed when cold.**

  Adjust the fast-idle speed.

- **The choke vacuum diaphragm unit is not adjusted to specification or it's defective.**

  1 Adjust the vacuum break to specification.

  2 If it's already correctly adjusted, check the vacuum opening for proper operation as follows. **Note**: *Always check the fast idle cam adjustment before adjusting the vacuum unit.*

- **The choke coil rod is out of adjustment (models with a divorced choke)**

  Adjust the choke coil rod.

- **The choke valve and/or the linkage is sticking or binding**

  1 Clean and align the choke valve and linkage. Replace it if necessary.

  2 If you have to replace the linkage, be sure to readjust it.

- **The idle speed setting is incorrect**

  Adjust the idle speed to specifications (refer to the VECI decal in the engine compartment).

- **There's not enough fuel in the carburetor**

  1 Check the fuel pump pressure and volume.

  2 Check for a partially plugged fuel inlet filter. Replace the filter if it's dirty.

  3 Check the float level and adjust, if necessary.

- **The engine is flooded**

  Refer to the procedure under *Engine cranks but won' t start*.

## The engine idles roughly and stalls

- **The idle mixture adjustment is incorrect**

  Adjust the idle mixture screws as described in the proper overhaul chapter.

- **The idle speed setting is incorrect**

  Reset the idle speed in accordance with the procedure outlined on the VECI decal in the engine compartment. Check the operation of the solenoid, if equipped.

- **The manifold vacuum lines are disconnected or improperly installed**

  Check all vacuum hoses leading to the manifold or carburetor base - make sure they're not leaking, disconnected or connected improperly. Install or replace vacuum lines as necessary.

- **The carburetor is loose on the intake manifold**

  Tighten the carburetor-to-manifold bolts to 100 in-lbs.

- **The intake manifold is loose or the gaskets are defective**

  Using a pressure oil can, spray light oil or kerosene around the manifold and the carburetor base. If the engine RPM changes, tighten the bolts or replace the manifold gaskets or carburetor base gaskets as necessary.

- **The hot-idle compensator (if equipped) is not operating**

  Normally, the hot idle compensator should be closed when the engine is running, but still cold, and open when the engine is hot (about 140-degrees F). Replace it if it's defective.

- **The carburetor is flooding**

  Refer to the procedure under *Engine cranks but won't start*.

  1 Remove the air horn and check the float adjustment.

  2 Check the float needle and seat for a good seal. If the needle is defective, replace it with a matched set.

  3 Check the float for fuel contamination, a bent float hanger or binding of the float arm. Adjust to specifications.

  4 If excessive dirt is found in the carburetor, clean the fuel system and the carburetor. Replace the fuel filter(s) as necessary.

## *The engine runs unevenly or surges*

- **There's a fuel restriction**

  Check all hoses and fuel lines for bends, kinks or leaks. Straighten and secure them if necessary. Check all fuel filters. If a filter is plugged or dirty, replace it.

- **There's dirt or water in the fuel system**

  Clean the fuel tank and lines. Remove and clean the carburetor.

- **The fuel level is too high or too low**

  Adjust the float. Verify that the float and float needle valve operate freely.

- **The main metering jet is loose or is the wrong size**

  Tighten or replace as necessary.

- **The power system in the carburetor is not functioning properly**

  1 A power valve or piston is sticking in the down position. Free it up or replace it as necessary.

  2 The power valve is loose, has the wrong gasket or is leaking around the threads. Tighten or replace as necessary.

  3 The diaphragm is leaking. Test it with a hand-operated vacuum pump and replace as necessary.

- **There's a vacuum leak somewhere**

  It is absolutely necessary that all vacuum hoses and gaskets are properly installed, with no air leaks. The carburetor and manifold should be evenly tightened to the specified torque values.

- **There is a problem with the ISC system**

  On feedback (ECM-controlled) carburetors, check the ISC motor and any codes that may have been detected by the self-diagnosis system.

## *The engine hesitates on acceleration*

- **The accelerator pump system is defective**

  1 A quick check of the pump system can be made as follows: With the engine off, remove the air cleaner, look into the carburetor bores and watch the pump stream while briskly opening the throttle valve. The pump jet should emit a full stream of fuel which strikes near the center of the venturi area.

  2 Remove the air horn and check the pump cup. If it's cracked, scored or distorted, replace the pump plunger.

- **There's dirt in the pump passages or in the pump jet**

  Clean and blow out the passages and jet with compressed air.

- **The fuel level is too high or too low**

  Check for a sticking float needle or binding float. Free up or replace parts as necessary. Check and reset the float level to specification.

- **The air horn-to-float bowl gasket is leaking**

  Tighten the air horn-to-float bowl fasteners.

- **The carburetor is loose on the manifold**

  Tighten the carburetor mounting bolts/nuts to:

  Long bolts - 84 in-lbs
  Short bolts - 132 in-lbs

- **The TPS is out of adjustment**

  On feedback (ECM-controlled) carburetors, check the adjustment of the TPS.

## *There's no power during heavy acceleration or at high speed*

- **The carburetor throttle valves aren't opening all the way**

  Push the accelerator pedal to the floor. Adjust the throttle linkage to obtain wide-open throttle.

- **The fuel filters are dirty or plugged**

  Inspect the filter(s) and replace as necessary.

- **The power enrichment system is not operating**

  **Piston type:**

  Check the power piston for free up-an-down movement. If the piston is sticking, check the piston and cavity for dirt or scoring. Check the power piston spring for distortion. Clean or replace as necessary.

  **Power valve type:**

  Check the power-valve for sediment buildup. Clean if necessary.

- **The float level is too low**

  Check and reset the float level to specification.

- **The float is not dropping far enough into the float bowl**

  Check for a binding float hanger and for proper float alignment in the float bowl.

- **The main metering jets are dirty or plugged, or are the wrong size**

  1 If the main metering jets are plugged or dirty, or if there's a lot of dirt in the fuel bowl, the carburetor should be completely disassembled and cleaned.

  2 Check the jet and metering rod (if equipped) sizes.

## *The engine is getting poor fuel economy*

- **The engine needs a complete tune-up**

  Check engine compression. Examine the spark plugs. If they're dirty or improperly gapped, clean and regap or replace them. Check the condition of the ignition points (if equipped) and the dwell setting. Readjust the points if necessary and check and reset the ignition timing. Clean or replace the air cleaner element if it's dirty. Check for restrictions in the exhaust system and inspect the intake manifold for leaks. Make sure all vacuum hoses are properly connected. Make sure all emission systems are operating properly.

- **The choke valve is not opening all the way**

  1 Clean the choke and free up the linkage.

  2 Check the choke thermostatic bimetal coil for proper adjustment. Adjust the choke if necessary.

- **Fuel is leaking somewhere**

  Check the fuel tank, the fuel lines and the fuel pump for any fuel leakage.

- **The main metering jet is defective or loose or is the wrong size**

  Replace as necessary.

- **The power system in the carburetor is not functioning properly. The power valve or piston is sticking in the up position**

  Free up or replace as necessary.

- **There's a high fuel level in the carburetor or the carburetor is flooding.**

  1 Inspect the needle and seat for dirt. If either is damaged, replace the needle and seat assembly with a Holley matched set.
  2 Check the float for fuel contamination.
  3 Reset the float to specifications.
  4 If there's a lot of dirt in the float bowl, clean the carburetor.

- **Fuel is being pulled from the accelerator pump system into the venturi through the pump jet**

  Run the engine at a speed sufficient to squirt fuel from the nozzle and watch the pump jet. **Warning:** *Use a mirror to do this. DO NOT look directly into the carburetor while the engine is running.* If fuel is feeding from the jet, check the pump discharge ball for proper seating by filling the cavity above the ball with fuel to the level of the casting. No "leak-down" should occur with the discharge ball in place. Restake/replace the leaking check ball, defective spring or retainer as necessary.

- **The air bleeds or fuel passages in the carburetor are dirty or plugged**

  1 Clean and, if necessary, overhaul the carburetor.
  2 If gum or varnish is present in the idle or high speed air bleeds, clean them with carburetor cleaner spray.

### The engine backfires

- **The choke valve is fully or partially open, or is binding or sticking**

  Free up the choke valve with carburetor cleaner spray. Realign or replace it if bent.

- **The accelerator pump is not operating properly**

  1 With the engine off, remove the air cleaner, operate the throttle and watch the pump discharge. Replace the pump cup if necessary.
  2 Adjust the pump stroke.
  3 Restake or replace the pump intake or discharge valve.

- **The spark plugs are old or dirty (fouled)**

  Clean or replace the spark plugs.

- **The spark plug wires are old or cracked**

  Test with a scope if possible, or watch the wires on a dark night with the engine running. Replace the wires if necessary.

- **The fuel filter is partially clogged.**

  Replace the filter.

- **The air pump diverter valve is defective (If the engine backfires on deceleration)**

  Check the hoses and fittings for tightness and leakage. Disconnect the diverter valve signal line. With the engine running, you should feel a vacuum. With the engine idling, hold your hand at the exhaust port. You shouldn't feel any air. If the valve or the hoses are defective, replace them.

### The secondary throttle valves don't open

- **The throttle valves are sticking**

  1 Readjust the secondary throttle valve stop screw.
  2 The throttle valves are nicked or the throttle shaft is binding.
  3 Repair or replace the throttle valve.
  4 Check the throttle body for warpage.
  5 Tighten the throttle body screws evenly.

### Engine diesels (continues to run) after shut-off

- **On non-feedback carburetors, check for an incorrectly adjusted idle speed, idle stop solenoid or dashpot.**

- **On feedback carburetor systems, check for the correct operation of the ISC solenoid or motor.**

## Basic vacuum troubleshooting

### What is vacuum?

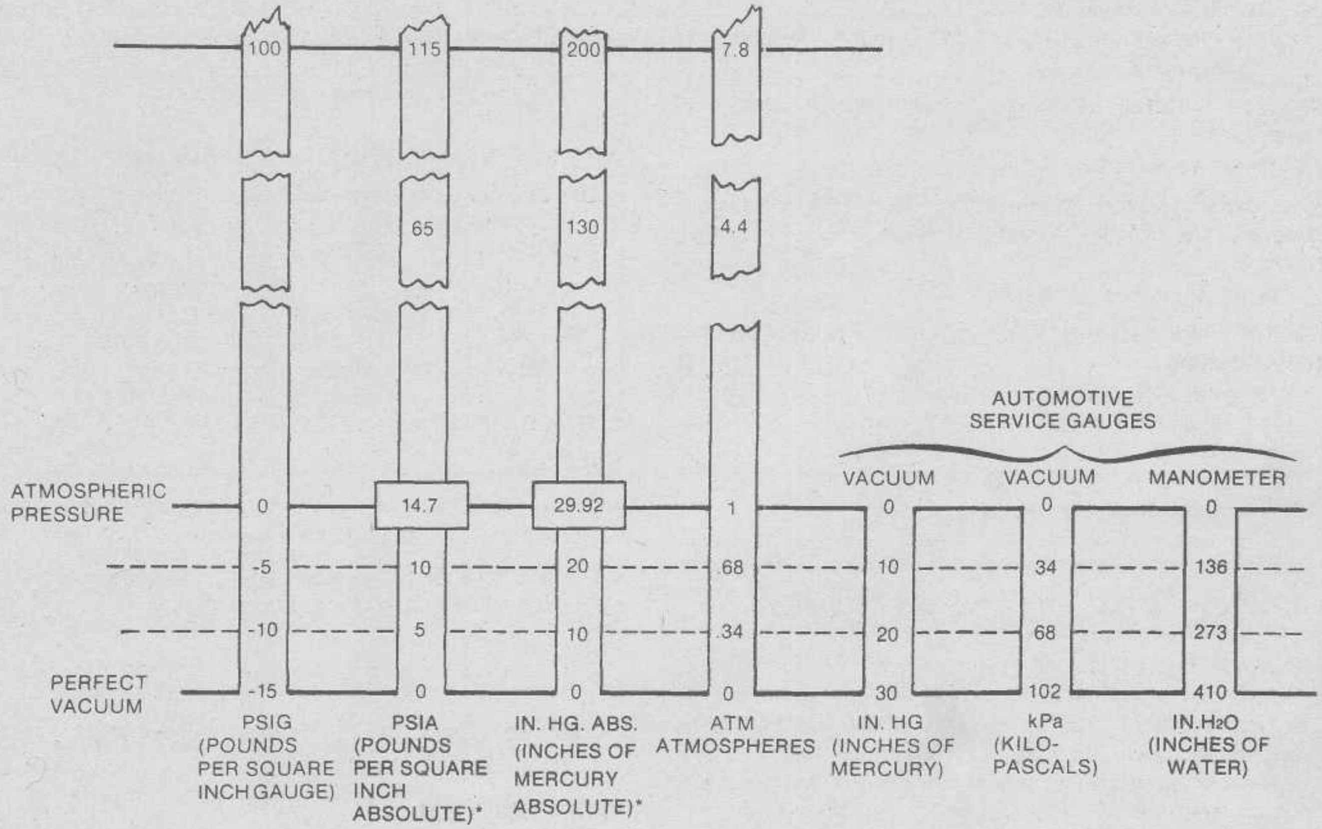
First, let's look at what vacuum is. In science, the term "vacuum" refers to a total absence of air; in automotive mechanics, vacuum refers a pressure level that's lower than the earth's atmospheric pressure at any given altitude. The higher the altitude, the lower the atmospheric pressure.

You can measure vacuum pressure in relation to atmospheric pressure. Atmospheric pressure is the pressure exerted on every object on earth and is caused by the weight of the surrounding air. At sea level, the pressure exerted by the atmosphere is 14.7 "pounds per square inch" (psi). We call this measurement system "pounds per square inch absolute" (psia).

But vacuum gauges don't measure vacuum in psia; instead, they measure it in "inches of Mercury" (in-Hg). Once in a while, you'll see another unit of measurement on some gauges; it's expressed in "kilopascals" (kPa). Another unit of measurement, used on manometers, is expressed in "inches of water" (in-$H_20$). The relationship of these confusing units of measurement is shown in the accompanying table **(see illustration).** In some Japanese factory manuals (and on our table), vacuum is referred to as "negative pressure." Don't let this term mislead you; the manufacturer is simply referring to in-Hg.

### How is vacuum created in an internal combustion engine?

Positive pressure always flows to an area with a "less positive," or lower, pressure. This is a basic law of physics. Viewed from this perspective, an engine is really nothing more than an air pump. As the crankshaft rotates through two full revolutions, the engine cycles through its intake, compression, power and exhaust strokes. The first and last of these strokes - the intake and exhaust strokes - are identical to the action of the intake and exhaust strokes of any air pump: The intake "pulls" in air; the exhaust expels it.



***ABSOLUTE PRESSURE . . . a pressure scale having as its zero point the complete absence of pressure. Atmospheric pressure on the absolute scale 14.7 psi or 29.92 inches of mercury (Hg).**

**5.1 This table shows the relationship of common units of measurement used for measuring vacuum**

During the intake stroke, the piston moves downward from its top dead center position. At the same time the exhaust valve closes and the intake valve opens. This downward movement of the piston in the cylinder creates a relative vacuum, drawing the air/fuel mixture into the cylinder through the open intake valve.

After the engine compression and power strokes are completed, the intake valve is still closed but the exhaust valve opens as the piston begins moving upward on its exhaust stroke. The rising piston forces the spent exhaust gases out through the open port.

The partial vacuum created by the engine's intake stroke is relatively continuous, because one cylinder is always at some stage of its intake stroke in a four, six or eight-cylinder engine. On carbureted engines, this intake vacuum is regulated, to some extent, by the position of the choke plate and the throttle valve. When the choke plate or throttle valve is in its closed position, airflow is reduced and intake vacuum is higher; as the plate or valve opens, airflow increases and vacuum decreases. The accompanying cutaways show how vacuum levels change during various engine loads **(see illustrations).**

## *Finding vacuum leaks*

Vacuum system problems can produce, or contribute to, numerous driveability problems, including:

*Deceleration backfiring*
*Detonation*
*Hard start condition*
*Knocking or pinging*
*Overheating*
*Poor acceleration*
*Poor fuel economy*
*Rich or lean stumbling*
*Rough idling*
*Stalling*
*Won't start when cold*

The major cause of vacuum-related problems is damaged or disconnected vacuum hoses, lines or tubing. Vacuum leaks can cause problems such as erratic running and rough idling.

For instance, a rough idle often indicates a leaking vacuum hose. A broken vacuum line allows a vacuum leak, which allows more air into the intake manifold than the engine is calibrated for. Then the engine runs roughly due to the leaner air/fuel mixture.

Another example: Spark knock or pinging sometimes indicates a kinked vacuum hose to the EGR valve. If this hose is kinked, the EGR valve won't open when it should. The engine, which requires a certain amount of exhaust gas in the combustion chamber to cool it down, pings or knocks.

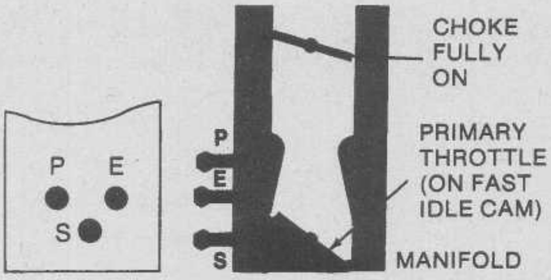
Here's another: A misfire at idle may indicate a torn or ruptured diaphragm in some vacuum-activated unit (a dashpot or EGR valve, for instance). The torn diaphragm permits air move-

## TABLE 1 — VACUUM LEVELS DURING VARIOUS ENGINE LOADS

### COLD START-UP, OPERATION AT FAST IDLE

The throttle plate opening uncovers the "S" then the "E" and "P" ports. Vacuum pressure at these ports and the manifold port is equal. The choke is full on.

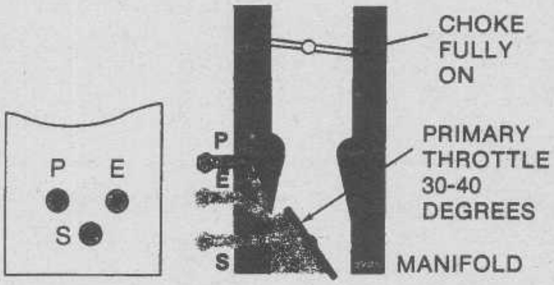
| Port | Vacuum Level |
|---|---|
| • "E" port<br>• "P" port<br>• "S" port<br>• Manifold | STRONG (MAXIMUM) |



### COLD DRIVEAWAY, LIGHT THROTTLE

The throttle plate is farther open and vacuum decreases slightly. Vacuum will be strong with the choke plate closed and moderate when the choke starts to open.

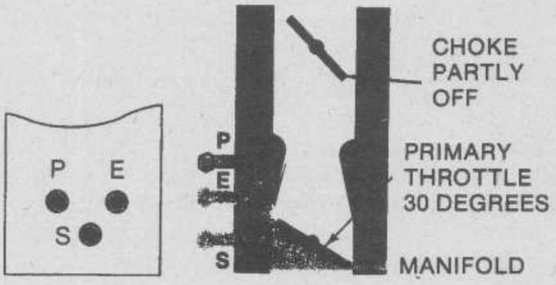
| Port | Vacuum Level |
|---|---|
| • "E" port<br>• "P" port<br>• "S" port<br>• Manifold | STRONG to MODERATE |



### WARMUP DRIVEAWAY, OR CRUISE, PART THROTTLE

The choke is partly off and the throttle plate has opened to a point where vacuum signals are equal and fairly strong.

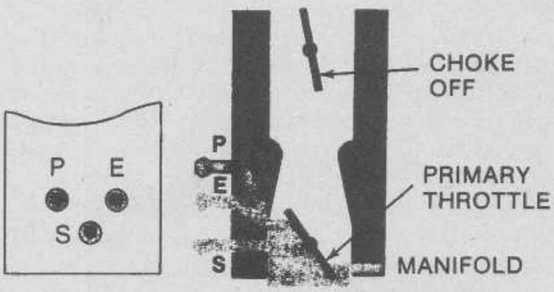
| Port | Vacuum Level |
|---|---|
| • "E" port<br>• "P" port<br>• "S" port<br>• Manifold | STRONG to MODERATE |



### HOT CRUISE, PART THROTTLE

Vacuum at the manifold, "P" and "S" ports is equal and moderately strong. Even though the "E" and "P" ports are closely positioned, "E" port vacuum is weakened because it "bleeds" off in the EGR valve integral transducer control.

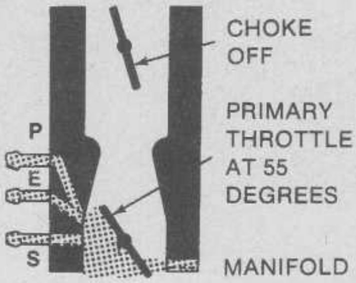
| Port | Vacuum Level |
|---|---|
| • "E" port | MODERATE to WEAK |
| • "P" port<br>• "S" port<br>• Manifold | STRONG to MODERATE |



5.2a These cutaways (this and facing page) of a typical carburetor show how vacuum levels change during various engine loads

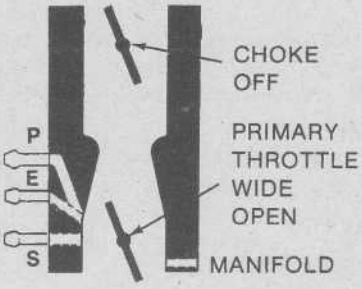
At this relatively "heavy" throttle positioning with the choke open, the vacuum level at all ports is weak.

"E" port
"P" port
"S" port
Manifold } WEAK



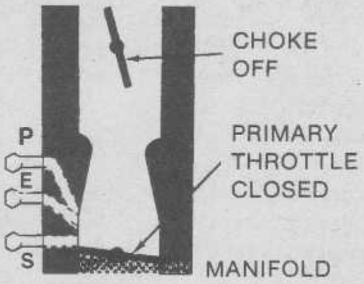
With the choke off and the throttle wide open, vacuum signals are very weak to none.

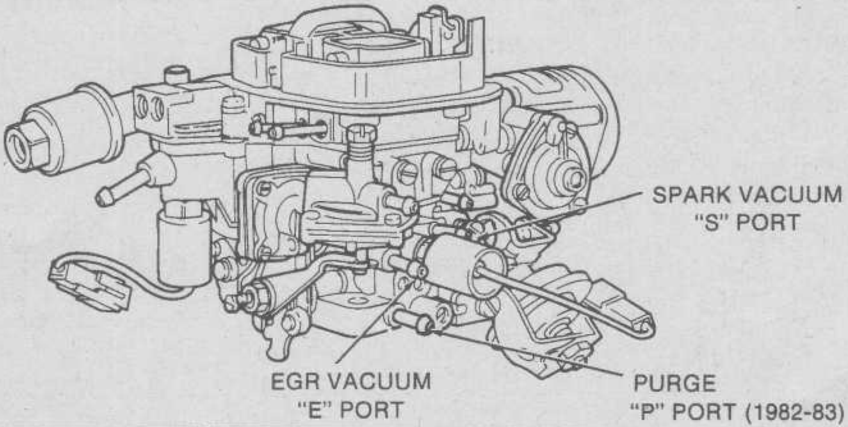
"E" port
"P" port
"S" port
Manifold } WEAK to ZERO



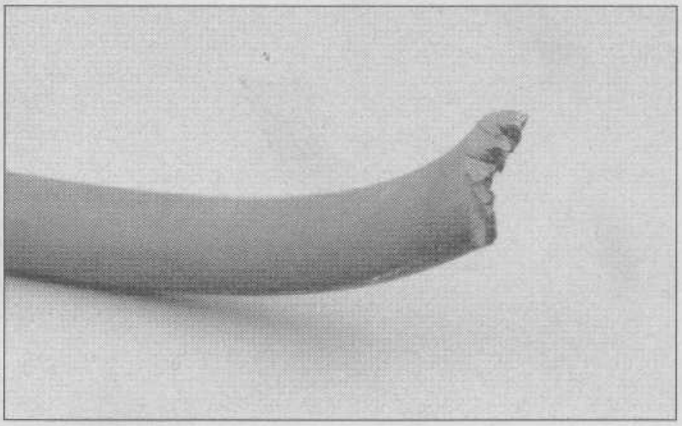
With the throttle closed and choke off, the "E," "P" and "S" ports are cut off from vacuum signals (below the throttle plate). Manifold vacuum is very strong.

"E" port
"P" port
"S" port } ZERO
Manifold .......................... MAXIMUM

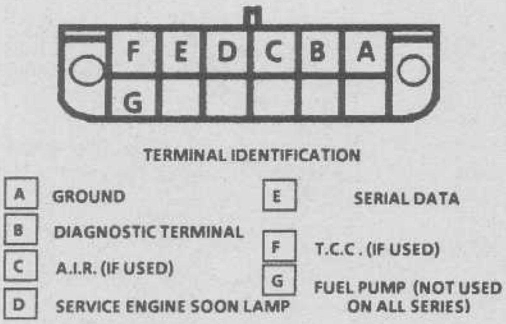




5.2b Carburetor cutaways (continued)



**5.3 This vacuum hose was routed too close to an exhaust manifold - after being overheated repeatedly, it finally cracked and broke**



**5.4 On most GM models the ALDL connector is located under the dash, usually on the driver's side - to output trouble codes, jump terminals A and B with the ignition key ON**

ment into the intake manifold below the carburetor. This air thins out the already lean air/fuel mixture at idle and causes a misfire. A misfire may also indicate a leaking intake manifold gasket or a leaking carburetor or throttle body base gasket. If a leak develops between the mating surfaces of the intake manifold and the cylinder head, or between the carburetor base gasket and the intake manifold, the extra air getting into the engine below the gasket causes a misfire.

If you suspect a vacuum problem because one or more of the above symptoms occurs, the following visual inspection may get you to the source of the problem with no further testing.

- Make sure everything is routed correctly - kinked lines block vacuum flow at first, then cause a vacuum leak when they crack and break.
- Make sure all connections are tight. Look for loose connections and disconnected lines. Vacuum hoses and lines are sometimes accidentally knocked loose by an errant elbow during an oil change or some other maintenance procedure.
- Inspect the entire length of every hose, line and tube for breaks, cracks, cuts, hardening, kinks and tears **(see Illustration).** Replace all damaged lines and hoses.
- When subjected to the high underhood temperatures of a running engine, hoses become brittle (hardened). Once they're brittle, they crack more easily when subjected to engine vibrations. When you inspect the vacuum hoses and lines, pay particularly close attention to those that are routed near hot areas such as exhaust manifolds, EGR systems, reduction catalysts (often right below the exhaust manifold on modern FWD vehicles with transverse engines), etc.
- Inspect all vacuum devices for visible damage (dents, broken pipes or ports, broken tees in vacuum lines, etc.
- Make sure none of the lines are coated with coolant, fuel, oil or transmission fluid. Many vacuum devices will malfunction if any of these fluids get inside them.

What if none of the above steps eliminates the leak? Grab your vacuum pump and apply vacuum to each suspect area, then watch the gauge for any loss of vacuum.

And if you still can't find the leak? Be sure to check the intake manifold or the base gasket between the carburetor and the manifold. To test for leaks in this area, squirt carburetor cleaner spray or WD-40 along the gasket joints with the engine running at idle. If the idle speed smooths out momentarily, you've located your leak. Tighten the intake manifold or the carburetor fasteners to the specified torque and recheck. If the leak persists, you may have to replace the gasket. An alternative to spraying solvent is to use a short length of vacuum hose as a sort of "stethoscope," listening for the high-pitched hissing noise that characterizes vacuum leaks. Hold one end of the hose to your ear and probe close to possible sources of vacuum leakage with the other end. **Warning:** *Stay clear of rotating engine components when probing with the hose.*

## Feedback carburetor troubleshooting

**Note:** *Because engine management systems may differ from year-to-year, certain trouble codes may indicate different problems from one year to the next. Not all of the codes listed apply to all models. Since this is the case, it would be a good idea to consult your dealer or other qualified repair shop before replacing any electrical component, as they are usually expensive and can't be returned once they are purchased.*

The first step in diagnosing any feedback carburetor driveability problem is to use the self-diagnosis system and check for any codes that have been stored in the computer. This system is a big help for the home mechanic because it eliminates many tedious and involved testing procedures and "trial and error" methods of diagnosing a driveability problem.

The "CHECK ENGINE" light on the instrument panel will come on whenever a fault in the system has been detected, indicting that one or more codes pertaining to this fault are set in the Electronic Control Module (ECM). To retrieve the codes, you must use a short jumper wire to ground the diagnostic terminal. This terminal is part of an electrical connector known as the Assembly Line Diagnostic Link (ALDL) **(see illustration).** On most models the ALDL is located under the dashboard on the driver's side. If the ALDL has a cover, slide it toward you to remove it. With the ignition key On, push one end of the jumper wire into the ALDL diagnostic terminal and the other into the ground terminal. **Caution:** *Don't crank the engine with the diagnostic terminal grounded - the ECM could be damaged.*

When the diagnostic terminal is grounded with the ignition On and the engine stopped, the system will enter Diagnostic Mode and the "CHECK ENGINE" light will display a Code 12 (one flash, pause, two flashes). The code will flash three times, display any stored codes, then flash three more times, continuing until the jumper is removed.

**Trouble code identification**

| Code | Probable cause |
|---|---|
| Code 12 | No distributor reference pulses to the ECM. This code is not stored in memory and will only flash while the fault is present |
| Code 13 | Oxygen sensor circuit. The engine must run up to five minutes at part throttle, under road conditions, before this code will set |
| Code 14 | Shorted coolant sensor circuit. |
| Code 15 | Open coolant switch circuit. |
| Code 21 | Throttle position sensor (TPS) circuit. The engine must run up to 25 seconds, at specified curb idle speed, before this code will set |
| Code 23 | Open or grounded mixture control (M/C) solenoid circuit |
| Code 24 | Vehicle speed sensor (VSS) circuit. The car must operate up to five minutes at road speed before this code will set |
| Code 32 | Barometric pressure sensor (BARO) circuit low, or altitude compensator low on J-car |
| Code 34 | Manifold absolute pressure (MAP) or vacuum sensor circuit. The engine must run up to 5 minutes, at the specified curb idle speed, before this code will set |
| Code 35 | Idle speed control (ISC) switch circuit shorted. Must operate over 50 percent throttle for over 2 seconds |
| Code 44 | Lean exhaust indication. The engine must run up to five minutes, in closed loop mode, at part throttle and road driving conditions before this code will set |
| Code 44 and 45 | If these two codes flash at the same time, there is a faulty oxygen sensor or circuit |
| Code 45 | Rich exhaust indication. The engine must run up to five minutes, in closed loop, at part throttle and road driving conditions before this code will set |
| Code 51 | Faulty calibration unit (PROM) or installation. |
| Code 54 | Shorted mixture control (M/C) solenoid circuit and/or faulty ECM |
| Code 55 | Grounded V reference (terminal 21). Faulty oxygen sensor or ECM |

**Note 1:** *This is a partial list of the available codes for feedback carburetor systems. The remaining codes (not listed) such as the EST system, ESC system etc. may not directly pertain to the fuel system, therefore, they are not listed. Refer to the proper HAYNES manual for your vehicle for additional information on the self-diagnosis system.*

**Note 2:** *Component replacement may not cure the problem in all cases. For this reason, you may want to seek professional advice before purchasing replacement parts.*

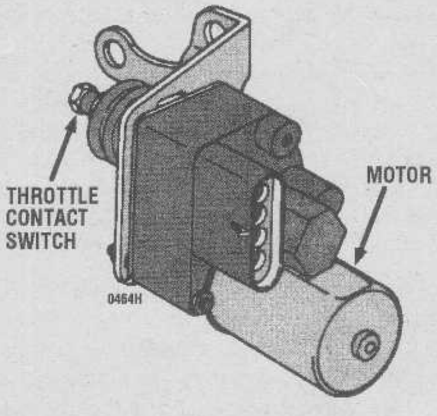
After checking the system, clear the codes from the ECM memory by interrupting battery power. Turn off the ignition switch (otherwise the expensive ECM could be damaged) disconnect the negative battery cable for at least ten seconds, then reconnect it.

Here are some simple checks for testing the main components (actuators and sensors) of the feedback carburetor system:

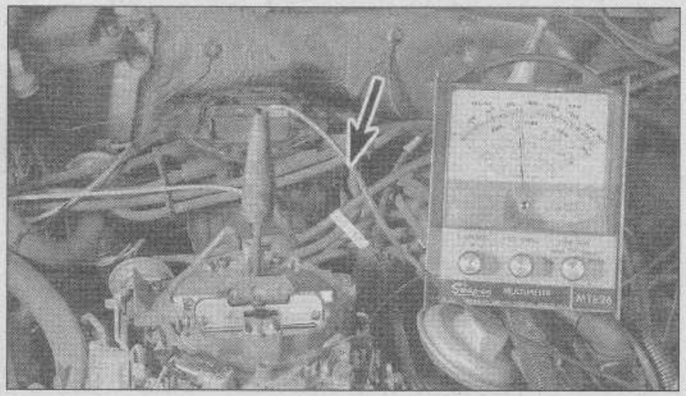
## Idle Speed Control (ISC) motor

### General description

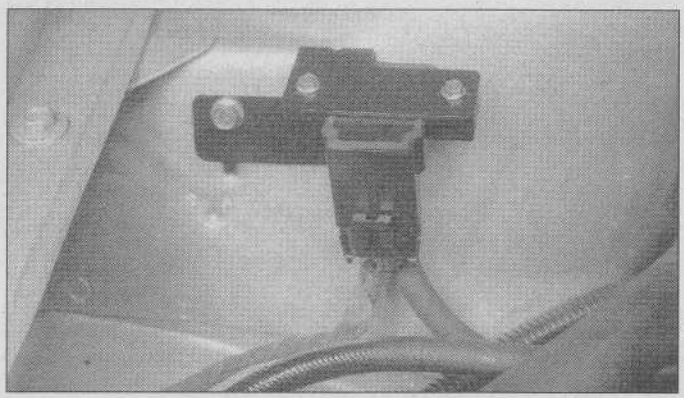
The ISC motor is a more advanced version of a throttle positioner **(see illustration)**. The motor is under direct control of the computer, which has the desired idle speed programmed into its memory. The computer compares the actual idle speed from the engine (taken from the distributor or crankshaft position sensor ignition impulses) to the desired rpm reference in



5.5 A typical ISC motor



5.6 Use a jumper wire (arrow) to connect the tachometer lead to the TACH terminal on the distributor (HEI systems only)



5.7 Typical MAP sensor - they're sometimes mounted on the firewall, like this one, or on the side of the air cleaner housing

memory. When the two do not match, the ISC plunger is moved in or out. This automatically adjusts the throttle to hold the idle speed, regardless of engine loads.

Many ISC motors have a throttle contact switch at the end of the plunger. The position of the switch determines whether or not the ISC should control idle speed. When the throttle lever is resting against the ISC plunger, the switch contacts are closed, at which time the computer moves the ISC motor to the programmed idle speed. When the throttle lever is not contacting the ISC plunger, the switch contacts are open and the ECM stops sending the idle speed commands and the driver controls engine speed.

### Check

With the engine warmed to normal operating temperature, remove the air cleaner assembly and any other components that obscure your view of the ISC motor. Hook up a tachometer **(see illustration)** in accordance with the manufacturer's instructions and check the VECI label under the hood to determine what the correct idle rpm should be.

Have an assistant start the engine. Check that the engine rpm is correct. Have your assistant turn on the air conditioning (if equipped), headlights and any other electrical accessories. If the vehicle is equipped with power steering, have your assistant turn the steering wheel from side-to-side. Note the reading on the tachometer. The engine speed should remain stable at the correct idle speed. If the vehicle is equipped with an automatic transmission, block the wheels and have your assistant set the parking brake, place his/her foot firmly on the brake pedal and place the transmission in Drive. Again the engine rpm should remain stable at the correct speed. **Warning:** *Do not stand in front of the vehicle during this test.*

If the ISC motor is not functioning as it should, first check the condition of the wiring and electrical connector(s). Make sure the connector is securely attached and there is no corrosion at the terminals. For further diagnosis of this system, refer to factory service manual for your particular vehicle or take the vehicle to a dealer service department or other qualified shop.

## MAP (Manifold Absolute Pressure) sensor

### General description

The MAP sensor (sometimes referred to as the pressure differential sensor) reports engine load to the computer which uses the information to adjust spark advance and fuel enrichment **(see illustration)**. The MAP sensor measures intake manifold pressure and vacuum on the absolute scale (from zero instead of from sea-level atmospheric pressure (14.7 psi) as most gauges and sensors do). The MAP sensor reads vacuum and pressure through a hose connected to the intake manifold. A pressure-sensitive ceramic or silicon element and electronic circuit in the sensor generates a voltage signal that changes in direct proportion to pressure.

Under low-load, high-vacuum conditions, the computer leans the fuel/air mixture and advances the spark timing for better fuel economy. Under high-load, low-vacuum conditions, the computer richens the fuel/air mixture and retards timing to prevent detonation. The MAP sensor serves as the electronic equivalent of both a vacuum advance on a distributor and a power valve in the carburetor.

### Check

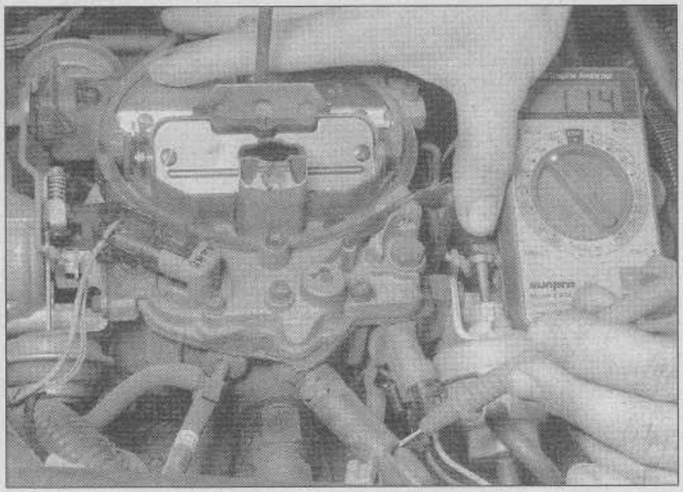
Anything that hinders accurate sensor input can upset both the fuel mixture and ignition timing. This includes the MAP sensor itself as well as shorts or opens in the sensor wiring circuit and/or vacuum leaks in the intake manifold or vacuum hose. Some of the most typical driveability symptoms associated with problems in the MAP sensor circuit include:

1) Detonation and misfire due to increased spark advance and a lean fuel mixture.
2) Loss of power and/or fuel economy and sometimes even black smoke due to retarded ignition timing and a very rich fuel mixture.
3) Poor fuel economy
4) Hard starts and/or stalling.

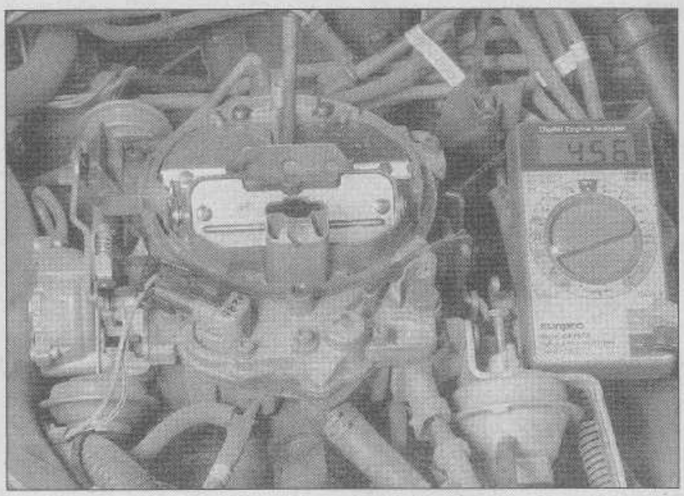
**Note:** *A vacuum leak in the hose to the MAP sensor causes the MAP sensor to indicate a higher than normal pressure (less vacuum) in the manifold, which makes the computer think the engine is under much more load than it really is. As a result, the ignition timing is retarded and the fuel mixture is richened.*

When a MAP sensor trouble code is detected, be sure to first check for vacuum leaks in the hoses or electrical connectors or wiring damage in the MAP sensor circuit. Kinks in the line, blockage or splits can occur and deter the sensor's ability to respond accurately to the changes in the manifold pressure. check for anything that is obvious and easily repaired before actually replacing the sensor itself.

A MAP sensor will typically produce a voltage signal that will drop with decreasing manifold pressure (rising vacuum). Test specifications will vary according to the manufacturer and engine type. A typical MAP sensor will read 4.6 to 4.8 volts with 0 in-Hg vacuum applied. Raise it to 5 in-Hg vacuum and the reading should drop to about 3.75 volts. Raise it up again to 20 in-Hg and the reading should drop to about 1.1 volts.



**5.8 Check the TPS signal voltage and observe that as the throttle opens, the signal voltage INCREASES**



**5.9 First check the TPS resistance with the throttle closed and . . .**

## *Barometric pressure (BARO) sensor*

### General description

The BARO sensor detects ambient pressure changes that occur as the result of changes in the weather and/or the altitude of the vehicle. It then sends an electronic signal to the ECM that is used to adjust the air fuel ratio and spark timing.

### Check

1 A problem with the BARO sensor will usually set a Code 32. To check the sensor, begin by checking the voltage from terminal A to terminal B at the sensor electrical connector. Compare your voltage reading with the chart below.

| Altitude (in feet) | Voltage range |
|---|---|
| Below 1000 | 3.8 to 5.5 |
| 1000 to 2000 | 3.6 to 5.3 |
| 2000 to 3000 | 3.5 to 5.1 |
| 3000 to 4000 | 3.3 to 5.0 |
| 4000 to 5000 | 3.2 to 4.8 |
| 5000 to 6000 | 3.0 to 4.6 |
| 6000 to 7000 | 2.9 to 4.5 |
| 7000 to 8000 | 2.8 to 4.3 |
| 8000 to 9000 | 2.6 to 4.2 |
| 9000 to 10000 | 2.5 to 4.0 |

2 Connect a hand-held vacuum pump to the port of the sensor (you may have to remove a small filter to do this), apply 10 in-Hg to the sensor and check the voltage again.

3 If the change is more than 2.3 volts, replace the sensor.

4 If the voltage change is less than 1.2 volts, check for a short between sensor terminals B and C. If there's no short, replace the sensor.

4 If the voltage change is between 1.2 to 2.3 volts, the problem lies in the wire to ECM terminal no. 1, a bad connection at the ECM or a defective ECM.

## *Throttle Position Sensor (TPS)*

### General description

The TPS is either mounted externally on the throttle body or inside of the carburetor. The TPS output voltage varies according to the angle of the throttle. Its job is to inform the computer about the rate of throttle opening and relative throttle position. A separate Wide Open Throttle (WOT) switch may be used to signal the computer when the throttle is wide open. The TPS consists of a variable resistor that changes resistance as the throttle changes its opening. By signalling the computer when the throttle opens, the computer can richen the fuel mixture to retain the proper air/fuel ratio. The initial setting of the TPS is very important because the voltage signal the computer receives tells the computer the exact position of the throttle at idle.

### Check

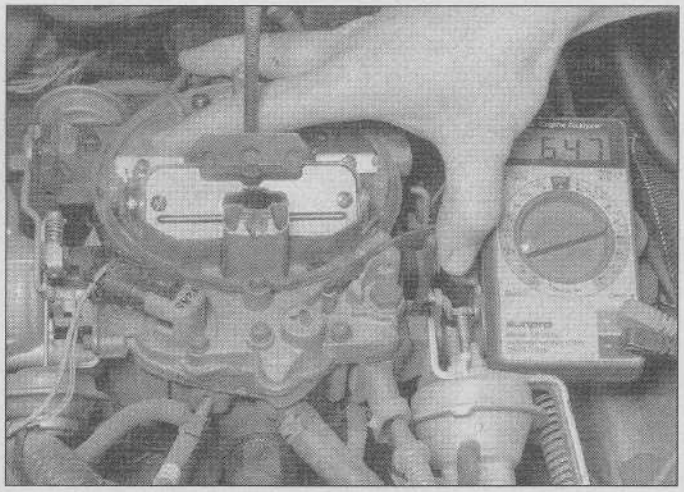
Throttle Position Sensors typically have their own types of driveability symptoms that can be distinguished from other information sensors. The most common symptom of a faulty or misadjusted sensor is hesitation or stumble during acceleration. The same symptom of a bad accelerator pump in a non-feedback, carbureted engine.

There are basically two voltage checks you can perform to test the Throttle Position Sensor. **Note:** *It is best to have the correct wiring diagram for the vehicle when performing the following checks.*

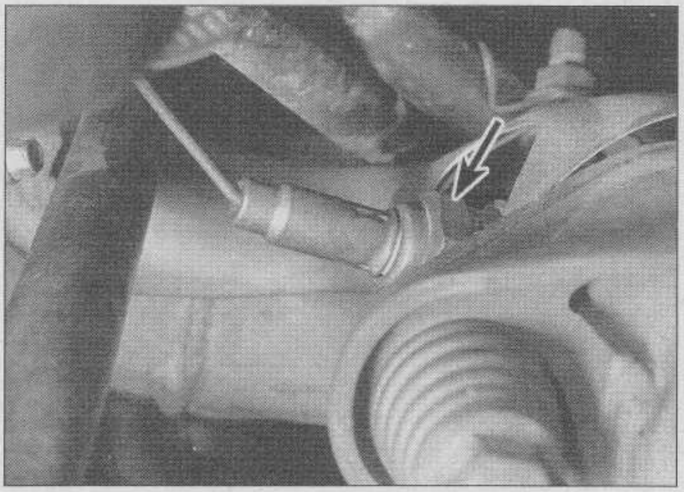
The first test is for the presence of voltage at the TPS supply wire with the ignition key ON. The sensor cannot deliver the correct signal without the proper supply voltage. You can determine the function of each individual wire (ground, supply, signal wire) by probing each one with a voltmeter and checking the different voltages. The voltage that remains constant when the throttle is opened and closed will be the supply voltage. If there's no voltage at any of the wires, there's probably an open or short in the wiring harness to the sensor.

The second check is for the proper voltage change that occurs as the throttle opens and closes. As the throttle goes from closed-to-wide open, the voltage at the signal wire should typically increase smoothly from 1 volt to 5 volts **(see illustration)**. To check the resistance of the sensor, unplug the electrical connector and hook up an ohmmeter to the supply and signal terminals. With the ignition key OFF, slowly move the throttle through the complete range **(see illustrations)**. Observe carefully for any unusual changes in the resistance (the change should be smooth) as it increases from low to high.

Also, be sure to check for trouble codes. Be sure you have checked all the obvious items before replacing the TPS.



5.10 . . . then with the throttle open. Resistance should INCREASE



5.11 A typical oxygen sensor (arrow) mounted in the exhaust manifold

## *Oxygen sensor*

### General description

The oxygen sensor is located in the exhaust manifold (or in the exhaust pipe near the exhaust manifold) and produces a voltage signal proportional to the content of oxygen in the exhaust **(see illustration)**. A higher oxygen content across the sensor tip will vary the oxygen differential, thereby lowering the sensor's output voltage. On the other hand, lower oxygen content will raise the output voltage. Typically the voltage ranges from 0.10 volts (lean) to 0.90 volts (rich). The computer uses the sensor's input voltage to adjust the air/fuel mixture, leaning it out when the sensor detects a rich condition or enrichening it when it detects a lean condition. When the sensor reaches operating temperature (600-degrees F), it will produce a variable voltage signal based on the difference between the amount of oxygen in the exhaust (internal) and the amount of oxygen in the air directly surrounding the sensor (external). The ideal stochiometric fuel/air ratio (14.7:1) will produce about 0.45 volts.

There are basically two types of oxygen sensors on the market. The most popular type uses a zirconia element in its tip. The latest type of oxygen sensor uses a titania element. Instead of producing its own voltage, the titania element resistance will alter a voltage signal that is supplied by the computer itself. Although the titania element works differently than the zirconia element, the results are basically identical. The biggest difference is that the titania element responds faster and allows the computer to maintain more uniform control over a wide range of exhaust temperatures.

Contamination can directly affect engine performance and life span of the oxygen sensor. There are basically three types of contamination; carbon, lead and silicon. Carbon buildup due to a rich-running condition will cause inaccurate readings and increase the problem's symptoms. Diagnose the fuel injection system or carburetor feedback controls for correct fuel adjustments. Once the system is repaired, run the engine at high rpm without a load (parked in the driveway) to remove the carbon deposits. Avoid leaded gasoline as it causes contamination of the oxygen sensor. Also, avoid using old-style silicone gasket sealant (RTV) that releases volatile compounds into the crankcase which eventually wind up on the sensor tip. Always check to make sure the RTV sealant you are using is compatible with modern emission systems.

Before an oxygen sensor can function properly it must reach a minimum operating temperature of 600-degrees F. The warm-up period prior to this is called "open loop." In this mode, the computer detects a low coolant temperature (cold start) and wide open throttle (warm-up) condition. Until the engine reaches operating temperature, the computer ignores the oxygen sensor signals. During this time span, the emission controls are not precise! Once the engine is warm, the system is said to be in "closed loop" (using the oxygen sensor's input). Some manufacturers have designed an electric heating element to help the sensor reach operating temperature sooner. A typical heated sensor will consist of a ground wire, a sensor output wire (to the computer) and a third wire that supplies battery voltage to the resistance heater inside the oxygen sensor. Be careful when testing the oxygen sensor circuit! Clearly identify the function of each wire or you might confuse the data and draw the wrong conclusions.

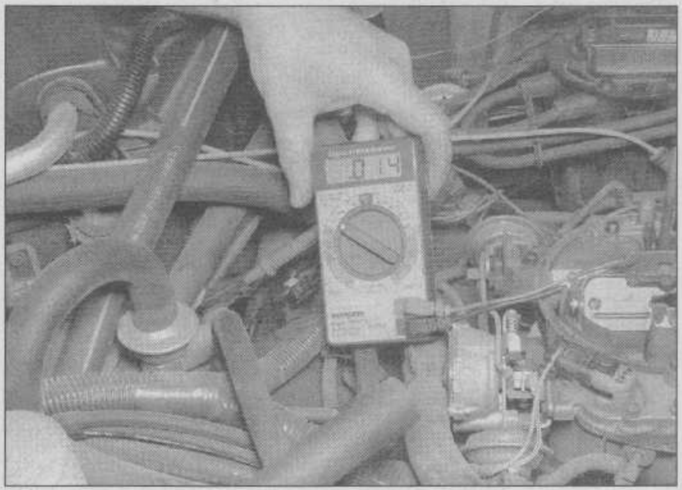
### Check

Sometimes an apparent oxygen sensor problem is not the sensor's fault. An air leak in the exhaust manifold or a fouled spark plug or other problem in the ignition system causes the oxygen sensor to give a false lean-running condition. The sensor reacts only to the content of oxygen in the exhaust, and it has no way of knowing where the extra oxygen came from.

When checking the oxygen sensor it is important to remember that a good sensor produces a fluctuating signal that responds quickly to the changes in the exhaust oxygen content. To check the sensor you will need a 10 mega-ohm digital voltmeter. Never use an ohmmeter to check the oxygen sensor and never jump or ground the terminals. This can damage the sensor.

Connect the meter to the oxygen sensor circuit. select the mV (millivolt) scale. If the engine is equipped with a later style (heated) oxygen sensor, be sure you are connected to the signal wire and not one of the heater or ground wires. Start the engine and let it idle. Typically, the meter will respond with a fluctuating millivolt reading when connected properly. Also, be sure the engine is in closed loop (warmed-up to operating temperature).

Watch very carefully as the voltage fluctuates. The display will flash values ranging from 100 mV to 900 mV (0.1 to 0.9 volt). The numbers will flash very quickly, so be observant.



**5.12 Check for a millivolt signal on the oxygen sensor electrical connector (usually located near the firewall)**

Record the high and low values over a period of one minute. With the engine operating properly, the oxygen sensor should average approximately 500 mV (0.5 volt) **(see illustration)**.

To further test the oxygen sensor, remove a vacuum line and observe the readings as the engine stumbles from the excessively LEAN mixture. The voltage should LOWER to an approximate value of 200 mV (0.2 volt). Install the vacuum line. Now, obtain some propane gas mixture (bottled) and connect it to a vacuum port on the intake manifold. Start the engine and open the propane valve (open the propane valve only partially and do so a little at a time to prevent over-richening the mixture). This will create a RICH mixture. Watch carefully as the readings INCREASE. **Warning:** *Propane gas is highly flammable. Be sure there are no leaks in your connections or an explosion could result.* If the oxygen sensor responds correctly to the makeshift lean and rich conditions, the sensor is working properly.

## *Mixture control (M/C) solenoid*

### General description

The mixture control (M/C) solenoid is a device that controls fuel flow from the bowl to the main well and at the same time controls the idle circuit air bleed.

The mixture control (M/C) solenoid is located in the float bowl where the power piston used to be. It is equipped with a spring loaded plunger that moves up and down like a power piston but more rapidly. Certain areas on the plunger head contact the metering rods and an idle air bleed valve. Plunger movement controls both the metering rods and the idle air bleed valve simultaneously.

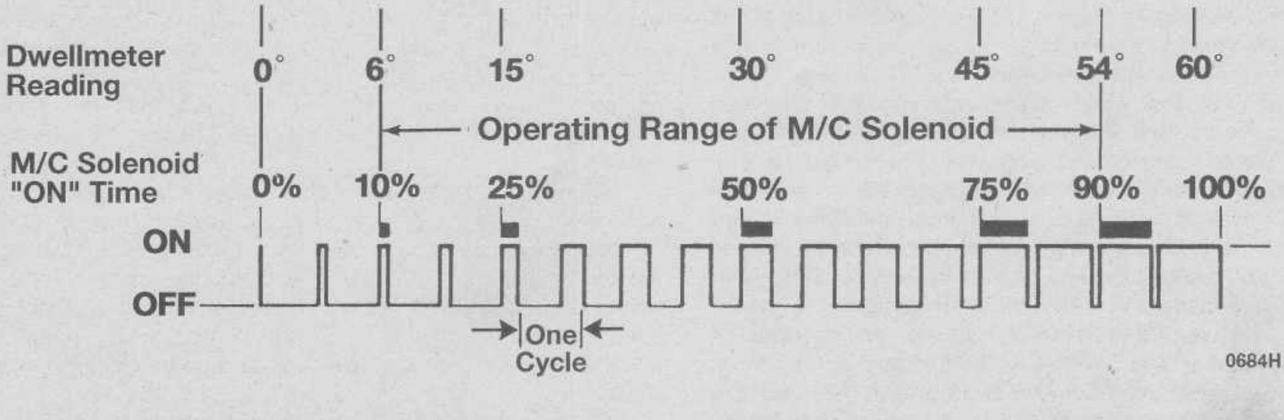
When the mixture control solenoid is energized it moves down causing the metering rods to move into the jets and restrict the flow of fuel into the main well. The idle air bleed plunger opens the air bleed and allows air into the idle circuit. Both these movements reduce fuel flow and thereby LEANS out the system.

When the plunger is de-energized, the M/C solenoid moves up, causing the metering rods to move out of the jets and allow more fuel to the main well, less idle air and increased fuel flow. Here the solenoid is in the RICH position.

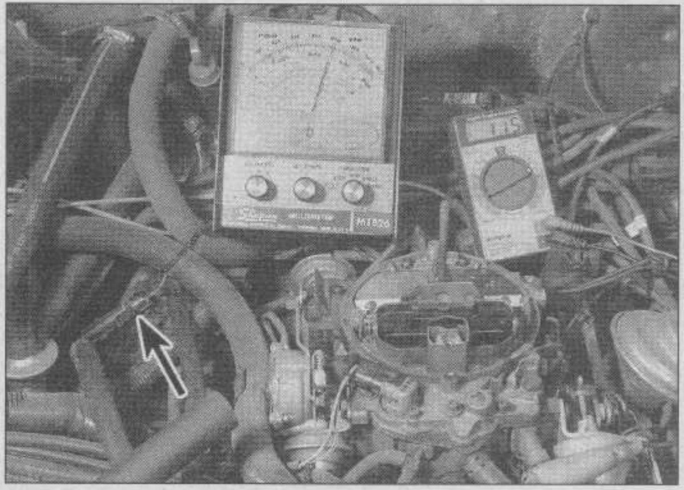
The mixture control solenoid varies the air/fuel ratio based on the electrical input from the ECM. When the solenoid is ON, the fuel is restricted and the air is admitted. This gives a lean air/fuel ratio (approximately 18:1). When the solenoid is OFF, fuel is admitted and the air/fuel ratio is approximately 13:1. During closed loop operation, the ECM controls the M/C solenoid to approximately 14.7:1 by controlling the ON and OFF time of the solenoid.

As the solenoid "***on time***" changes, the up time and down time of the metering rods also changes. When a lean mixture is desired, the M/C solenoid will restrict fuel flow through the metering jet 90-percent of the time, or, in other words, a lean mixture will be provided to the engine.

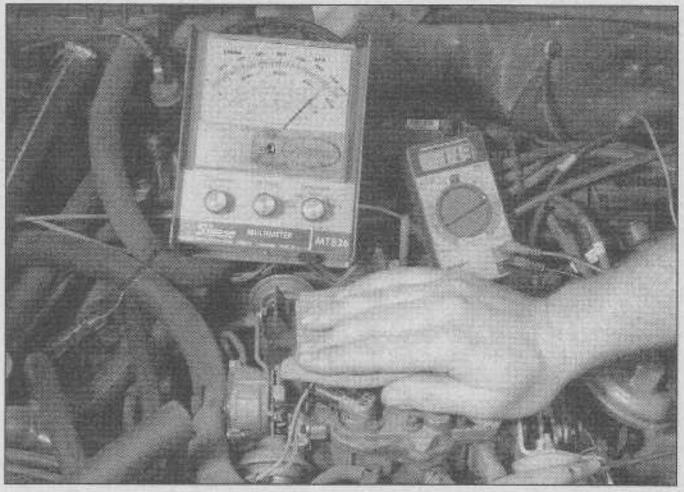
This lean command will read as 54-degrees on the dwell meter (54-degrees is 90-percent of 60-degrees), and means the M/C solenoid has restricted fuel flow 90-percent of the time **(see illustration).** A rich mixture is provided when the M/C solenoid restricts it only 10-percent of the time and allows a rich mixture to flow to the engine. A rich command will have a dwellmeter reading of 6-degrees (10-percent of 60-degrees); the M/C solenoid has restricted fuel flow 10-percent of the time. On some engines dwellmeter readings can vary between 5-degrees and 55-degrees, rather than between 6-degrees and 54-degrees. The ideal mixture would be shown on the dwellmeter with the needle varying or swinging back and forth,



**5.13 This chart indicates the relationship of dwellmeter readings to the mixture control solenoid cycling. It is important to select the 6 cylinder mode on the dwellmeter to obtain the correct reading**



5.14 Connect the dwellmeter connector to the electrical connector (arrow) near the carburetor and observe the engine rpm on one meter (right side) and the dwell on the other meter (left side)



5.15 Place a rag over the carburetor air horn and watch the dwell go LEAN to compensate for a rich running condition

anywhere between 10-degrees and 50-degrees. "Varying" means the needle continually moves up and down the scale. The amount it moves does not matter, only the fact that it does move. The dwell is being varied by the signal sent to the ECM by the oxygen sensor in the exhaust manifold.

A procedure called the "System Performance Check" is provided later in this Chapter. The procedure provides step-by-step instructions on how to determine if the M/C solenoid circuit, ECM, and various sensors (M/C system) are functioning properly. And, if not, the procedure indicates the steps to take to locate and repair the source of the trouble. The following checks assume the engine has been tuned and the ignition system is in order.

The dwellmeter is used to diagnose the M/C solenoid system. This is done by connecting a dwellmeter to the pigtail connector in the M/C solenoid wiring harness **(see illustration)**.

In the older style contact-points ignition systems, the dwellmeter reads the period of time that the points were closed (or "dwelled" together). That period of time was when voltage flowed to the ignition coil. In the feedback carburetor system, the dwellmeter is used to read the time that the ECM closes the M/C solenoid circuit to ground, allowing voltage to operate the M/C solenoid. Dwell, as used in feedback system performance diagnosis, is the time that the M/C solenoid circuit is closed (energized). The dwellmeter will translate this time into degrees. The "6-cylinder" (0-degrees to 60-degrees) scale on the dwellmeter is used for this reading. The ability of the dwellmeter to make this kind of conversion makes it an ideal tool to check the amount of time the ECM internal switch is closed, thus energizing the M/C solenoid. The only difference is that the degree scale on the meter is more like percent of solenoid "*on time*" rather than "degrees of dwell".

First set the dwellmeter on the 6-cylinder position, then connect it to the M/C solenoid dwell lead to measure the output of the ECM. Do not allow the terminal to touch ground, including hoses. You must use the 6-cylinder position when diagnosing all engines, whether the engine you're working on is a 4, 6, or 8 cylinder engine. **Note:** *Some older dwellmeters may not work properly on the feedback carburetor systems. Don't use any dwellmeter which causes a change in engine operation when it is connected to the solenoid lead.*

The 6-cylinder scale on the dwellmeter provides evenly divided points, for example:

15-degrees = 1/4 scale
30-degrees = midscale
45-degrees = 3/4 scale

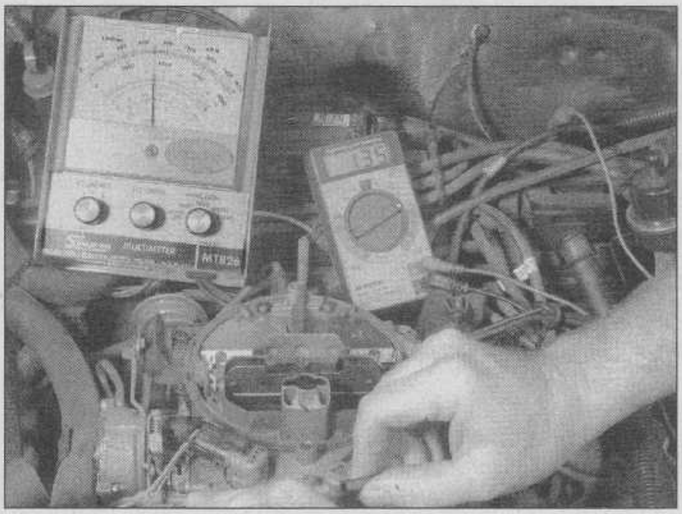
Connect the positive clip lead of the dwellmeter to the M/C solenoid pigtail connector. Attach the other dwellmeter clip lead to ground. Do not allow the clip leads to contact other conductive cables or hoses which could interfere with accurate readings.

After connecting the dwellmeter to a warm, operating engine the dwell at idle and part throttle will read between 5-degrees and 55-degrees and will be varying. That is, the needle will move continuously up and down the scale. What matters is that the needle does move, not how much it moves. Typical needle movement will occur between the 30 and 35-degree range in a normal operating feedback system. Needle movement indicates that the engine is in "closed-loop," and that the dwell is being varied by signals from the ECM. However, if the engine is cold, has just been restarted, or the throttle is wide open, the dwell will be fixed and the needle will be steady. Those are signs that the engine is in "open-loop."

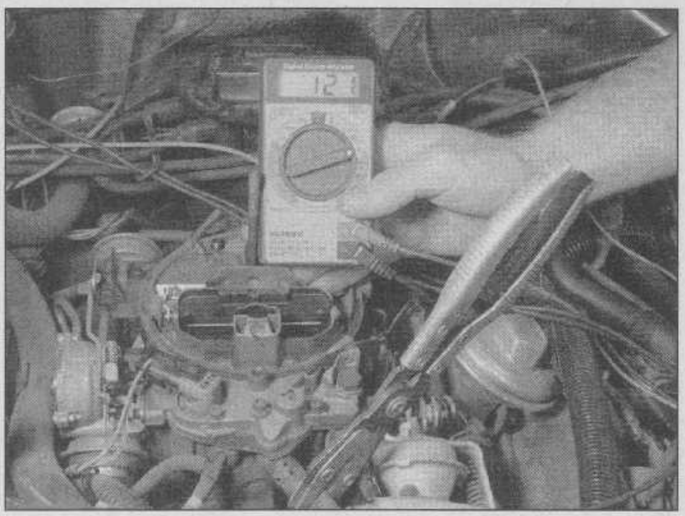
Diagnostic checks to find a condition without a trouble code are usually made on a warm engine (in "closed-loop") easily checked by making sure the upper radiator hose is hot. There are three ways of distinguishing "open" from "closed-loop" operation.

1. A variation in dwell will occur only in "closed-loop."
2. Test for closed loop operation by restricting airflow to the carburetor to choke the engine **(see illustration)**. **Warning:** *Use a thick rag (not your bare hand) and keep your face away from the carburetor. If the dwellmeter moves up scale, that indicates "closed-loop."*
3. If you create a large vacuum leak and the dwell drops down, that also indicates "closed-loop" **(see illustration)**.

Basically, "closed loop" indicates that the ECM is using information from the exhaust oxygen sensor to influence operation of the Mixture Control (M/C) solenoid. The ECM still considers other information such as engine temperature, RPM,



5.16 Disconnect a vacuum line and observe the dwell "on time" indicate rich (low reading) to compensate for the lean running condition



5.17 Install a clamp onto the purge hose from the charcoal canister to prevent entrance of vapors into the carburetor

barometric and manifold pressure and throttle position along with the exhaust oxygen sensor information.

During "open-loop" all information except the exhaust oxygen sensor input is considered by the ECM to control the M/C solenoid. Accurate readings from the oxygen sensor are not attained until the sensor is completely hot (600-degrees F).

It is important to note that the exhaust oxygen sensor may cool below its operational temperature during prolonged idling. This will cause an open loop condition, and make the diagnostic information not usable during diagnosis. Engine RPM must be increased to warm the exhaust oxygen sensor, and again re-establish "closed loop". Diagnosis should begin over at the first step after "closed-loop" is resumed.

## *System performance test*

First, start the engine and then ground the diagnostic terminal (terminals A and B) using a small jumper wire **(see illustration 5.4)**. This will allow the feedback system to run on the preset default values thereby not allowing the computer to make any running adjustments. **Caution:** *It is important NOT to crank the engine while the diagnostic connector is grounded.* Disconnect the purge hose from the charcoal canister and plug it (or simply clamp it shut) **(see illustration)**. Disconnect the bowl vent hose at the carburetor and plug the hose on the canister side. These two steps will not allow any recirculated crankcase vapors to enter the carburetor during testing. Connect a tachometer according to the manufacturers' instructions. Disconnect the M/C solenoid and ground the M/C solenoid dwell lead **(see illustration)**. Run the engine at 3,000 rpm and while holding the throttle steady, reconnect the M/C solenoid and observe the rpm. If the engine is equipped with an electric cooling fan, the rpm may lower when it turns on. Remove the dwell lead before returning to idle.

The test results will be either:

a) the engine will drop below 300 rpm
b) the engine will NOT drop below 300 rpm and may increase rpm

If the engine does not drop below 300 rpms, check the wiring on the M/C solenoid for any damaged connectors and if they are OK, check the carburetor on-vehicle adjustments for feedback carburetors in Chapter 7.

5.18 With the dwellmeter and tachometer properly installed, disconnect the M/C solenoid connector and observe the gauge. Rpm should drop below 300 from normal.

If the engine drops below 300 rpm, connect a dwellmeter to the M/C solenoid dwell lead **(see illustration 5.14)**. Be sure to read the information on "closed loop" operation and dwellmeters in the preceding sections. Set the carburetor on the high step of the fast idle cam and run the engine for one minute or until the dwell starts to vary (whichever happens first). Return the engine to idle and observe the dwell. In most cases the dwell should vary between 10 and 50-degrees but there are several types of problems that may occur. **Note:** *The following tests must be performed with the diagnostic connector still grounded (terminals A and B) unless otherwise indicated.*

### Fixed dwell under 10-degrees

This condition indicates that the feedback system is responding RICH to offset a very lean condition in the engine. One way to separate the problem is to choke the carburetor with the engine at part throttle. This will either increase or decrease the dwell.

If the dwell increases, check for a vacuum leak in the hoses, gaskets, AIR system etc. Also, check for an exhaust leak near the oxygen sensor, any hoses that are misrouted and an EGR valve that is not operating or that is leaking.

If the dwell does not increase, check the oxygen sensor, the wiring harness from the ECM to the oxygen sensor, TPS, TPS voltage and/or the ECM. If necessary, have the system diagnosed by a dealer service department or other repair shop.

### Fixed dwell between 10 and 50-degrees

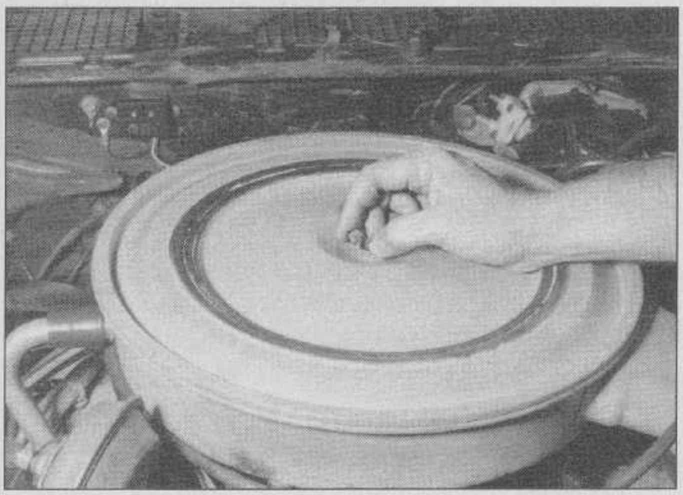
This condition indicates that the feedback system is stuck in one mode (open loop) because of a faulty coolant temperature sensor, oxygen sensor or TPS. Start the diagnosis by running the engine at part throttle for one minute. Then with the engine idling, observe the dwell, remove the connector from the coolant sensor and jump the terminals on the connector. This will ground the signal and indicate to the ECM that the sensors are functioning (grounded). The dwell reading should not be fixed with the sensor grounded. Check each sensor for the correct resistance and voltage signal from its respective electrical connector.

### Fixed dwell over 50-degrees

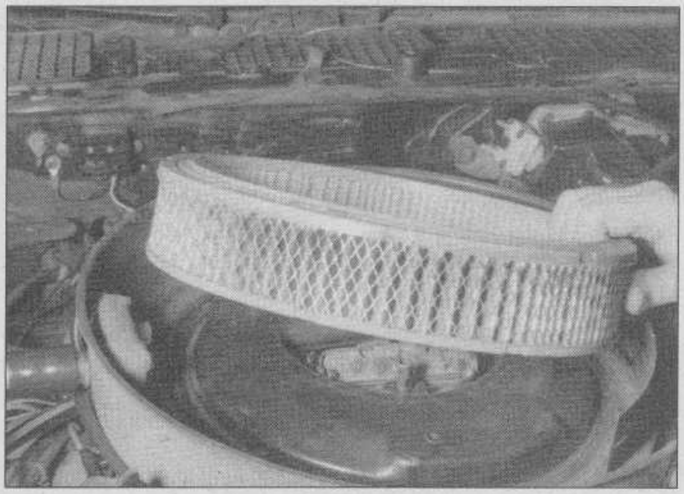
This condition indicates that the feedback system is responding LEAN to offset a very rich condition in the engine. Start the diagnosis by running the engine at fast idle for about two minutes and then let it return to idle. This procedure makes sure that the feedback system is in closed-loop (warmed-up). Next, disconnect the large vacuum hose to the PCV valve and cause a major vacuum leak. Do not allow the engine to stall. The dwell should drop by approximately 20-degrees. If it does, check the carburetor on-vehicle adjustments in Chapter 7. Also, check the evaporative canister for fuel overload or leaks in the purge control system that would cause an over-rich condition in the carburetor.

If the dwell does not drop, check the oxygen sensor, oxygen sensor signal voltage and their respective wiring circuits for any problems.

# 6 Carburetor removal and installation



**6.1 Remove the air cleaner housing cover**



**6.2 Remove, and in this case throw away the air filter element. An air filter element like this can be as harmful to performance and economy as a plugged fuel filter. Replace it!**

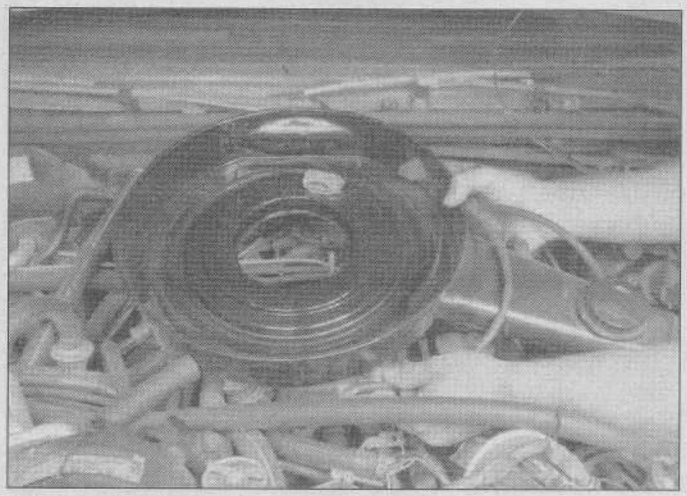
This chapter takes you through removal and installation procedures step-by-step. Not all the steps will apply to every vehicle and the carburetor you are working on may be equipped with some devices not shown here. This is a general removal and installation procedure which will otherwise work for all carburetors.

## *Removal*

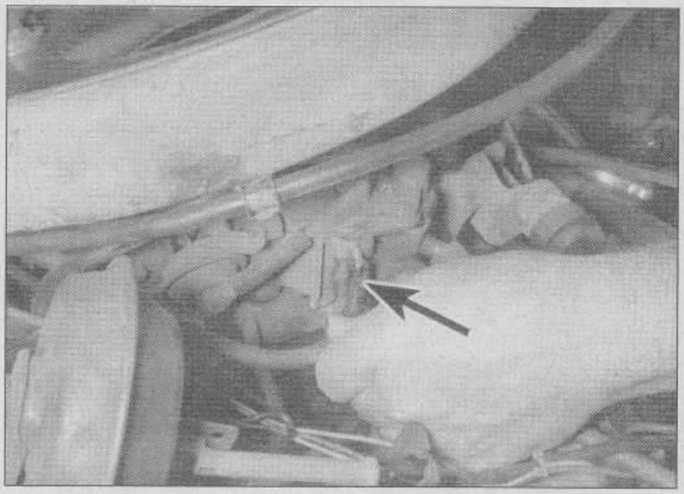
**Warning:** *Gasoline is extremely flammable, so take extra precautions when you work on any part of the fuel system. Don't smoke or allow open flames or bare light bulbs near the work area, and don't work in a garage where a natural gas-type appliance (such as a water heater or clothes dryer) with a pilot light is present. If you spill any fuel on your skin, rinse it off immediately with soap and water. When you perform any kind of work on the fuel system, wear safety glasses and have a Class B type fire extinguisher on hand.*

1 Remove the air cleaner **(see illustrations)**. Carefully detach all the vacuum lines going to the air cleaner, marking them with tape for easy identification.

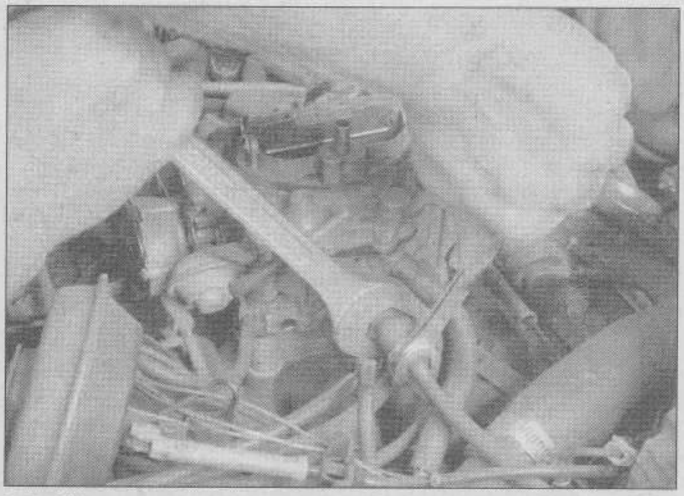
2 Carefully disconnect the fuel line from the carburetor inlet nut **(see illustration)**. Be sure to catch any excess fuel with a shop rag.



**6.3a Remove the air cleaner housing . . .**

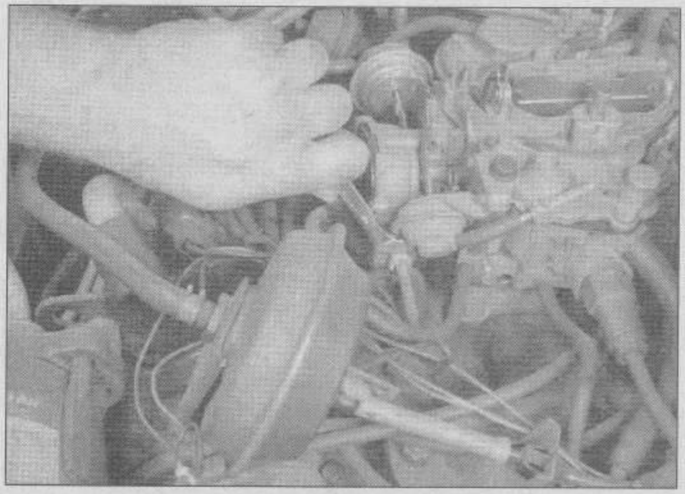


**6.3b . . . and detach any vacuum hoses connected from the air cleaner to the carburetor. Be sure to identify which hose goes to which connection by marking the lines or possibly drawing a diagram. If reconnected backwards, the control they operate may either work backwards or not at all.**



**6.4 When removing the fuel line always use the correct size wrenches, preferably a "flare-nut" wrench to avoid stripping the tube nut, and a "backup" wrench to keep the carburetor inlet nut from turning**

**6.5 Be sure to label each vacuum line and its corresponding port with a paint mark or pieces of numbered tape**



**6.6 Detach the choke heater line, if equipped**

3 Identify all the vacuum lines and electrical connectors going to the carburetor and carefully mark each one with tape or paint **(see illustration)**. Disconnect the lines and connectors.

4 Disconnect the PCV valve and hoses from the carburetor and valve cover or intake manifold.

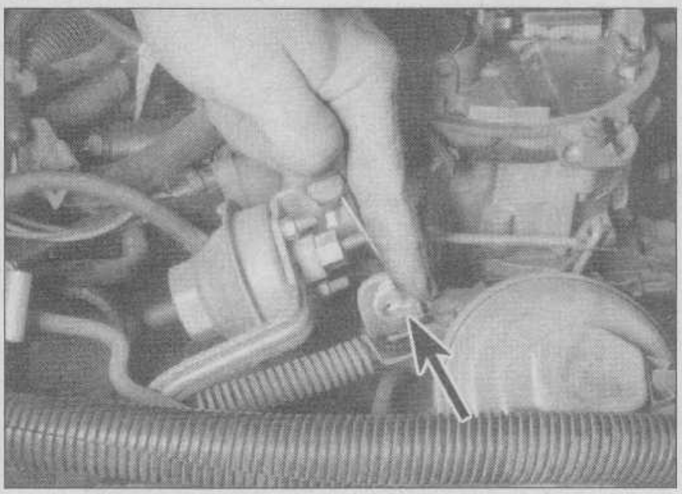
5 Disconnect the choke rod or heat tube from the carburetor **(see illustration)**.

6 Disconnect the throttle linkage from the carburetor **(see illustrations)**.

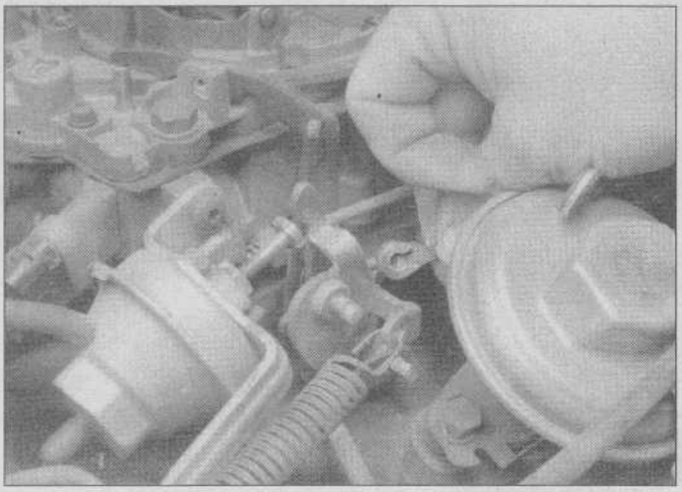
7 Remove the carburetor mounting bolts or nuts **(see illustrations)**.

8 Stuff clean shop rags or towels into the open intake manifold hole to prevent any dirt, tools, nuts or bolts from falling inside.

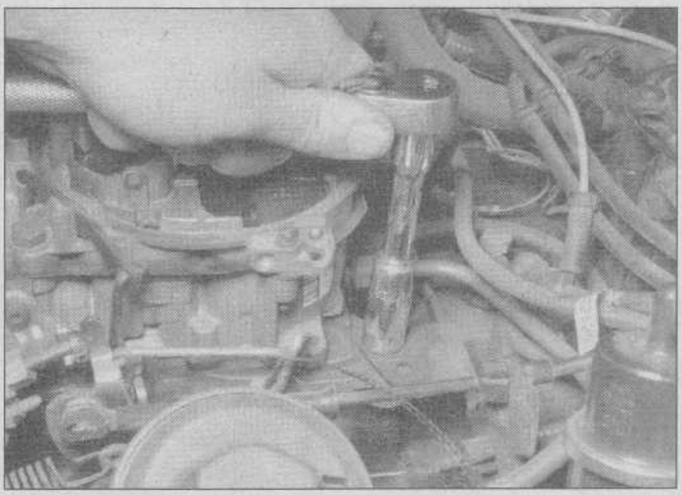
9 Remove the base plate gasket and the sealing gaskets from the intake manifold surface **(see illustration)** and from the bottom of the carburetor. It will probably be necessary to use a good, stiff scraper to remove the old gasket material. Be careful not to gouge the surface of the intake manifold or carburetor, since this will create vacuum leaks.



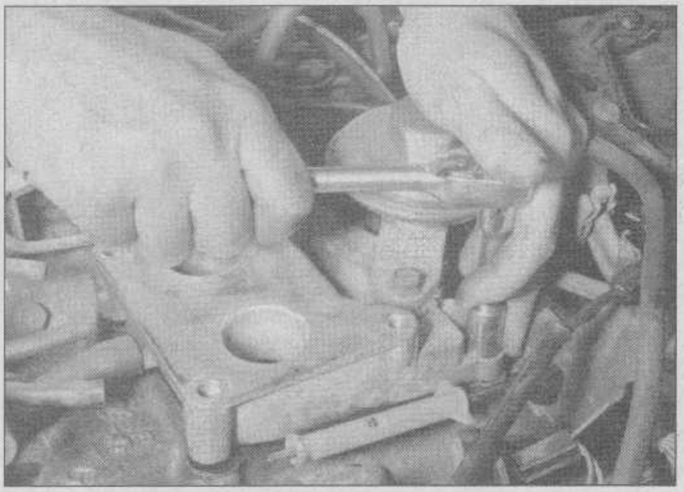
**6.7 On carburetors with this type of linkage connection, first remove the spring(s) and clips (arrow) from the throttle lever . . .**



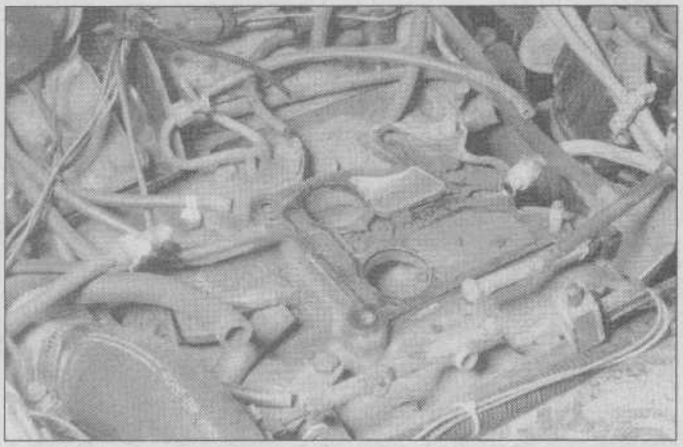
**6.8 . . . then remove the cruise control linkage (if equipped), the transmission kickdown (T.V.) cable, and the accelerator linkage from the throttle lever assembly (Quadrajet carburetor shown). Note:** *Be sure to remove and mark the location of any spacers and/or washers used to align the linkage for smooth operation.*



**6.9 Remove the carburetor mounting bolts or nuts**



**6.10 If you're working on a Dualjet carburetor, also remove the base plate bolts and remove the base plate**

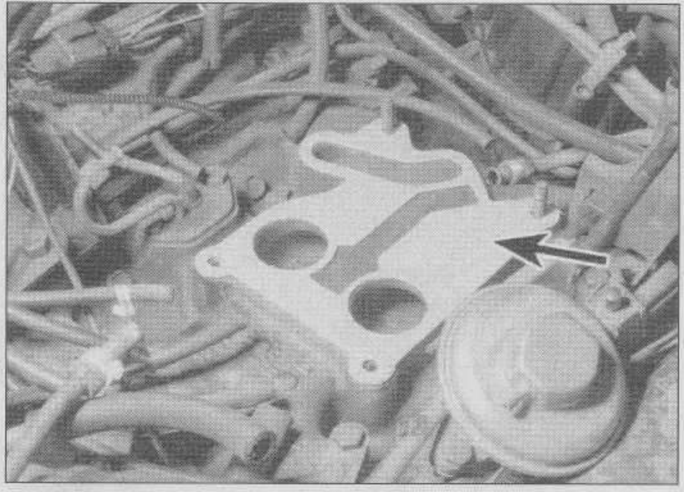


**6.11 Carefully scrape the gasket material off the surface of the manifold and the baseplate. Be careful not to gouge the manifold and be the cause of your vacuum leak! Note:** *Save as much of the gasket as possible in order to match it against one of the new ones provided in the overhaul kit.*

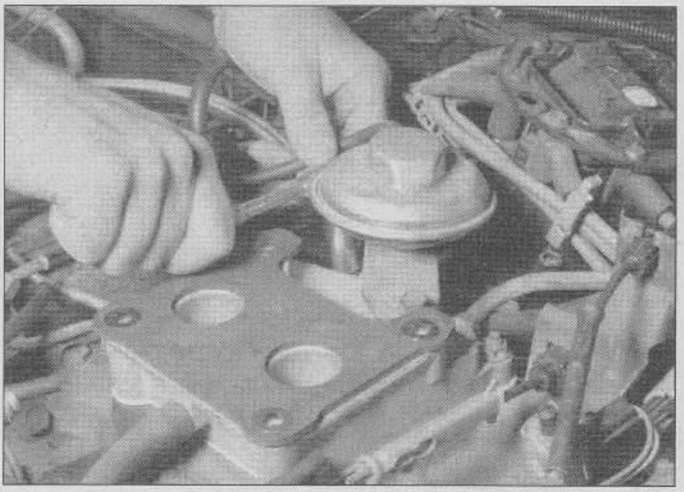
10 There are always a few things to watch out for after the carburetor has been removed. If any of the carburetor studs were removed from the intake manifold along with the nut(s), it is a good idea to replace them with new ones. If none are available, try to clean-up the threads with a die or with a special thread file. Use only two nuts (back-up) to lock the stud in place while removing the seized nut from the other end. Using a Vise-grip or pliers will only damage the threads making the original stud useless.

11 Many carburetors are equipped with a base plate gasket. This hardened material is made of either pressed paper, bakalite or phenolic (heat) insulating material. These gaskets or insulators can sometimes get warped or damaged due to heat, engine back-fire or from over-tightening. If there are any suspected vacuum leaks occurring around the base plate, replace it with a new one.

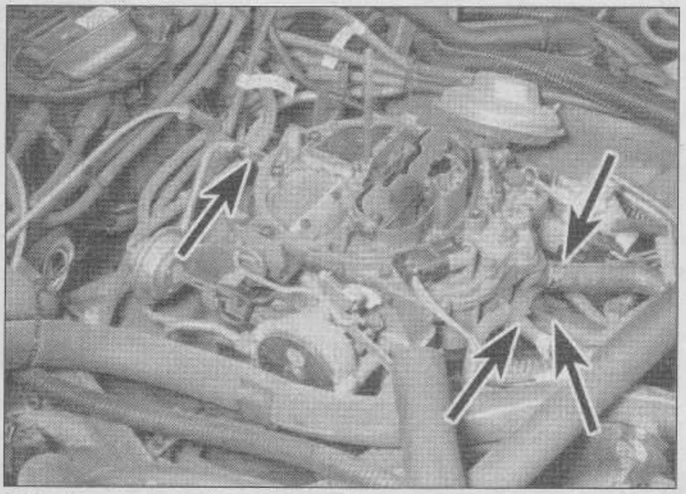
12 It is a good idea to locate the new base plate gaskets from your overhaul kit and compare them to the originals before scraping or replacing the base plate (if necessary). Many aftermarket kits will include several gaskets to cover different manifold designs for the same carburetor. Once the original gasket has been scraped and thrown out, it will be tough to decide which gasket is the correct one. Take a little time to get familiar



6.12 Always use a new carburetor base gasket (arrow). Old ones become crushed and hardened due to age and heat, and can't provide the kind of seal needed to prevent vacuum leaks (a very common source of driveability problems).



6.13 Install the base plate, if equipped



6.14 When reconnecting the hoses, always check for hoses that are cracked or hardened. Don't waste your time doing a detailed overhaul and then putting worn-out hoses back on the connections. Make sure the hose is fairly new and soft enough to seal properly.

with the parts from your overhaul kit and set the correct gaskets off to the side for use during installation.

## Installation

13 Make sure the carburetor mounting studs are correctly installed in the intake manifold. If new studs were installed, make sure they are the correct length. If an adapter plate or spacer will be installed, make sure the studs are long enough to work properly.

14 Remove the shop towels from the intake manifold and check for any objects that might have fallen into the intake manifold while the carburetor was off. Use a flashlight to look around before final approval.

15 Install the base gasket and base plate, if equipped, onto the intake manifold **(see illustrations)**. Some models use a bakelite, phenolic or pressed paper base plate, sandwiched between two thin gaskets.

16 Install the carburetor mounting nuts or bolts, tightening them to the specified torque:

Long bolts = 84 in-lbs
Short bolts = 132 in-lbs

17 Operate the throttle lever through its full range to make sure it works smoothly. If there is any binding, find out why and correct the cause before proceeding.

18 Connect the fuel line, tightening the tube nut securely. Don't forget to hold the inlet fitting with a wrench to prevent it from turning.

19 Connect the vacuum hoses and electrical connectors. If any of the hoses are cracked or hardened, replace all of them at this time, since they are probably all very close to the same condition and age **(see illustration)**.

20 Finally, install the air cleaner housing and a new filter element. Following all the overhaul procedures won't do any good if the engine can't breath.

## Carburetor adjustments

There is a wide range of carburetor adjustments that vary from model to model. There are four different overhaul Sections covered in this manual. At the end of each overhaul illustration sequence there are initial assembly or "dry" adjustments to be made as the carburetor is reassembled on the bench. Following these will be "on-vehicle" adjustments, which are made with the engine running and at operating temperature. Each adjustment will be identified by a heading preceding the Section. **Note:** *There are many variations to each control system throughout the manual and occasionally a specific adjustment for a limited feature will not be covered. When this happens, which will be rarely, please refer to the instructions that come with each overhaul kit.*

# 7

# Part A

# Overhaul and adjustments

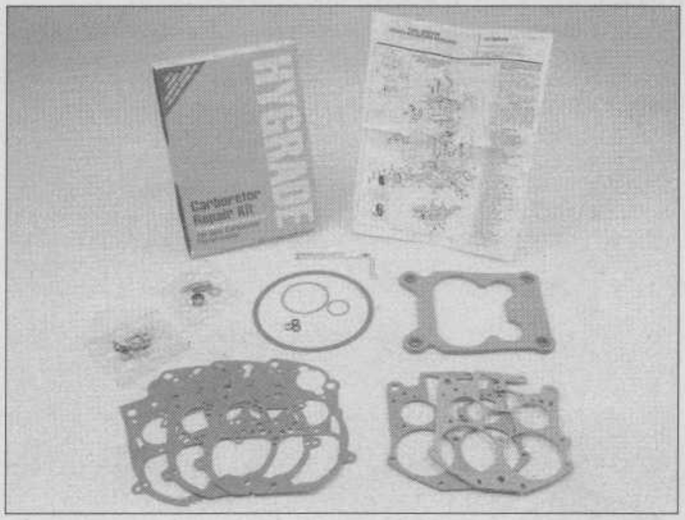
## Overhaul tools and preparation

**Note:** *The numbering system for the illustrations in the following overhaul Chapters is slightly different than in the other Chapters in this book. The illustrations for each overhaul Part have a letter from A through E, corresponding to the letter that designates the Part of each Chapter. Each Part has its own series of illustration numbers. For example, illustration 7D.11 is the 11th photo for the Quadrajet/Dualjet model overhaul sequence, which is Part D.*

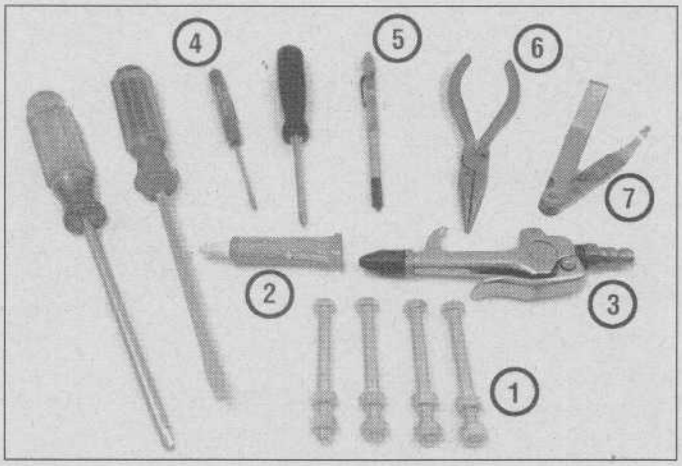
Regardless of which of the many one-, two- or four-barrel carburetors your are going to overhaul, the initial preparation is the same.

Take your time; think about what's involved. Nobody wants to or should have to do any more than is necessary. Are you going to be simply replacing a base gasket to correct a vacuum leak, or is the carburetor in desperate need of a complete overhaul? Short cuts or quick fixes are nice, but only when the problem is corrected. Organization, cleanliness, good lighting and some advanced planning are all very important parts to getting the overhaul done quickly and correctly the first time.

Many of the parts being dealt with during an overhaul are extremely small and can be easily lost or misplaced, especially if you're using compressed air to clean out passages or dry off parts. Take extra care to keep track of all of the many individual parts and store them in containers where they will not be lost.

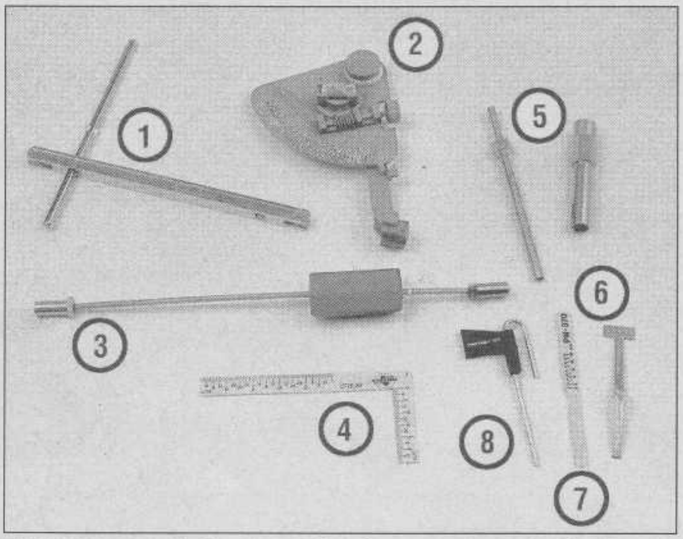


**7A.1 After you've read Chapter 4 and have identified the carburetor you have on your vehicle, write down all the numbers that the auto parts store will need to locate your overhaul kit. Overhaul kits, such as the one shown here, contain instructions and specifications, a new needle-and-seat assembly and the gaskets and seals you'll need for the overhaul. Many kits also include a stiff paper gauge you can use to measure the float level, etc.**



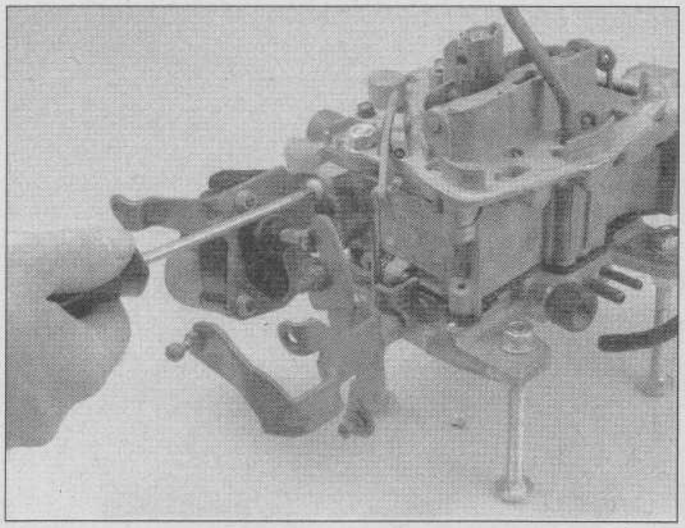
**7A.2 Besides the general tools discussed in Chapter 2, some special tools are helpful to make your carburetor work easier**

1. *Using common **5/16-inch nuts and bolts**, you can make a very stable work stand for all except the one-barrel models. **Note:** On Quadrajet and Dualjet models, the front two bolts need to be much longer because they must go all the way through the main body of the carburetor.*
2. *A **thread-locking compound** should be used on throttle-body screws during reassembly.*
3. *If using compressed air, a **blow gun** like this will be very helpful when blowing out carburetor passages.*
4. *A **small screwdriver or pick** is helpful for removing gaskets and small clips*
5. *A **screw starter** is a help during reassembly - it grips the screw until it is tightened*
6. ***Needle-nose pliers** help when removing and installing screws and clips in tight places*
7. *A **feeler gauge** can be used to measure clearances*

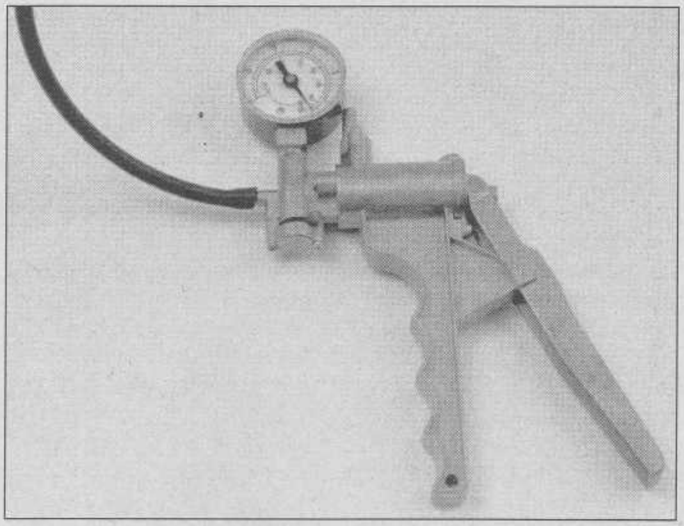


**7A.3 During and after assembly, there are several adjustments, both on the bench and on the vehicle, that require special tools. Where a "regular" tool can take the place of a special tool, it will be mentioned during the specific overhaul procedures.**

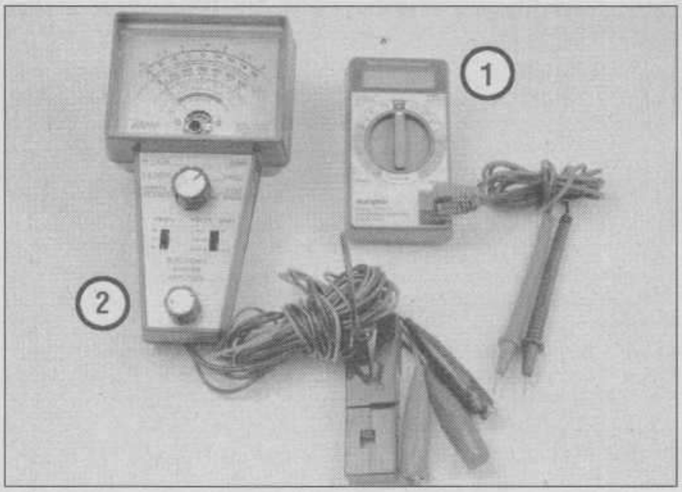
1. *A **bending tool** for the external linkage adjustments. In most cases, a pair of pliers can be used to bend linkage just as well as the tool shown.*
2. *An **angle gauge** with a magnetic base to attach to the choke plate. Some adjustments in the overhaul procedures will be shown using this tool, but a table is included in Part D that will allow you to come very close to the correct angles by using drill bits.*
3. ***Idle mixture screw adjustment tool**. Early models use Phillips-head screws, but later models have screws with special shapes, and a tool like the one shown has both the different shapes in one tool.*
4. *A **ruler** that has measurements broken down into at least 1/32 of an inch. **Note:** Most overhaul kits come with this small paper ruler in the kit.*
5. ***GM computer controlled components (feedback) adjustment tools**. **Note:** Both of these tools may not be required to adjust your feedback carburetor. They are often available at auto parts stores.*
6. ***Idle air bleed adjusting tool**. This tool is used for adjusting the idle air bleed on Quadrajet and Dualjet feedback carburetors.*
7. *This **gauging tool** is used for checking the "wet" float level on Quadrajet and Dualjet carburetors. It is also used for checking the mixture-control solenoid plunger travel on Quadrajet and Dualjet feedback carburetors.*
8. *This **gauging tool** is used for setting the mixture-control solenoid lean-stop on Quadrajet and Dualjet feedback carburetors.*



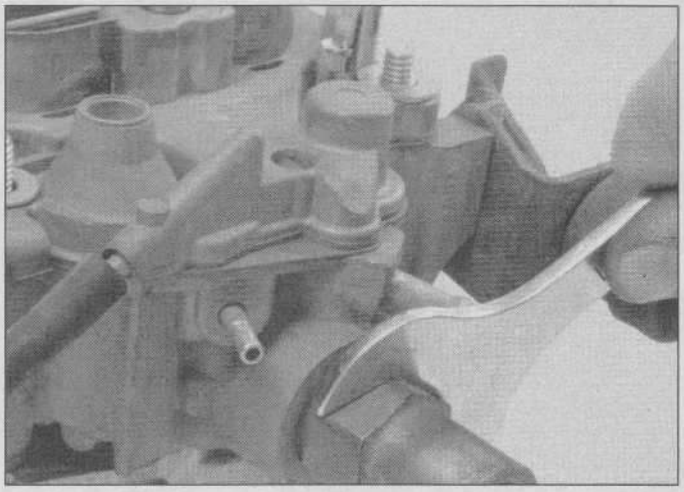
**7A.4 Many later models use some Torx-head screws, which require a special screwdriver (available from auto parts stores)**



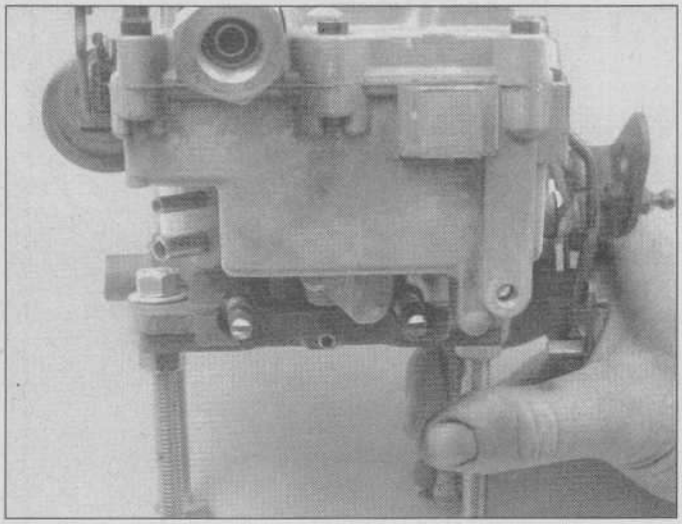
**7A.5 A hand-held vacuum pump is very helpful for checking the choke vacuum break(s) and the mixture-control solenoid on Quadrajet, Dualjet and Varajet carburetors**



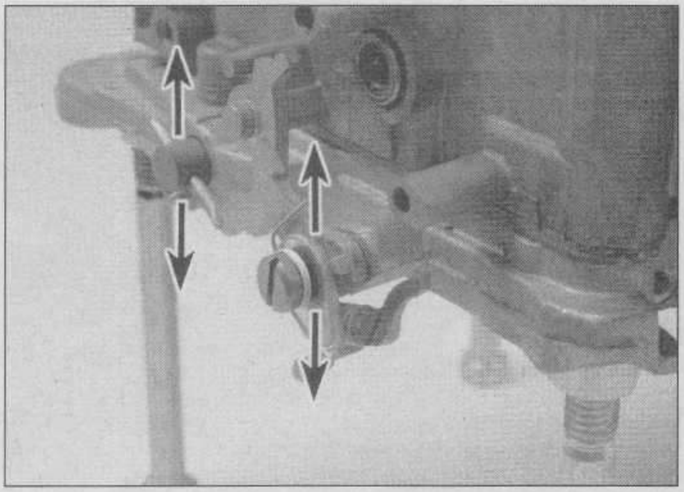
7A.6 If you have a computer-controlled (feedback) carburetor, you'll need a digital volt/ohm meter (1) and a tach/dwell meter (2) to check and adjust the electronic components



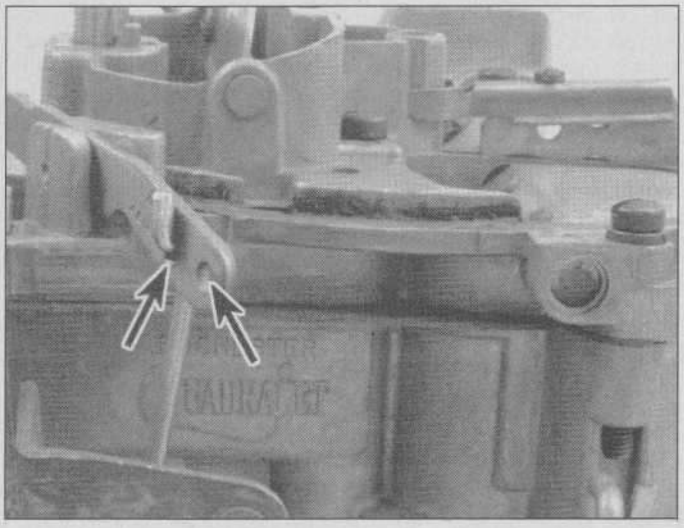
7A.7 Since the fuel inlet nut is usually on very tight, it's a good idea to loosen it while the carburetor is still installed on the vehicle



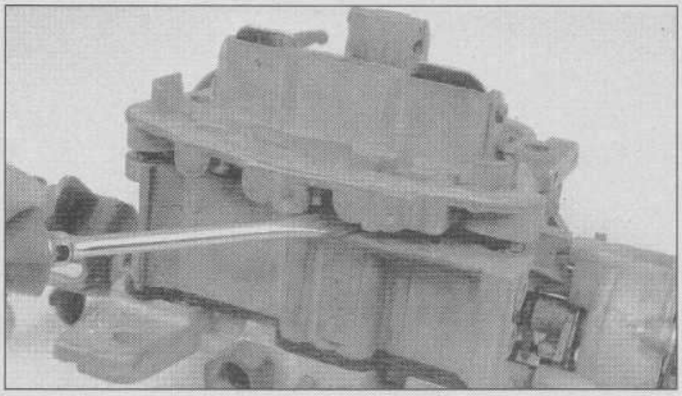
7A.8 Using common nuts and bolts, you can make a very stable work stand (this won't work on one-barrel models, however)



7A.9 Before disassembly, check for excessive throttle shaft wear by trying to move the shaft(s) up and down (arrows). Any movement should be almost imperceptible. If you can see and feel movement, there's enough wear to cause a vacuum leak; you'll have to find a replacement carburetor or have a carburetor overhaul shop install throttle-shaft bushings. We don't recommend removing the throttle shaft yourself, since the throttle plate screws are difficult to stake correctly on reassembly, and an improperly staked screw could vibrate loose and fall into the engine!

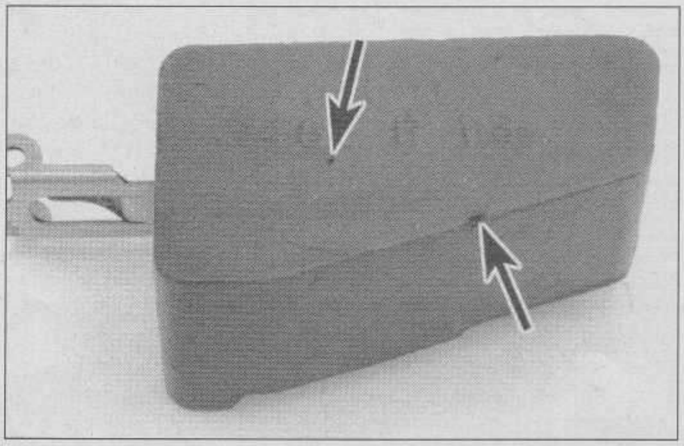


7A.10 Since carburetors are complex devices, it will be difficult to remember how all the linkage on the carburetor is assembled. It's a good idea to take notes on how everything looks before disassembly, and even take instant photographs from various angles. Accelerator pump arms often have two holes (arrows) so they can be assembled one of two ways, allowing adjustment. Normally, you'll want to reassemble these parts the same way they were before disassembly.

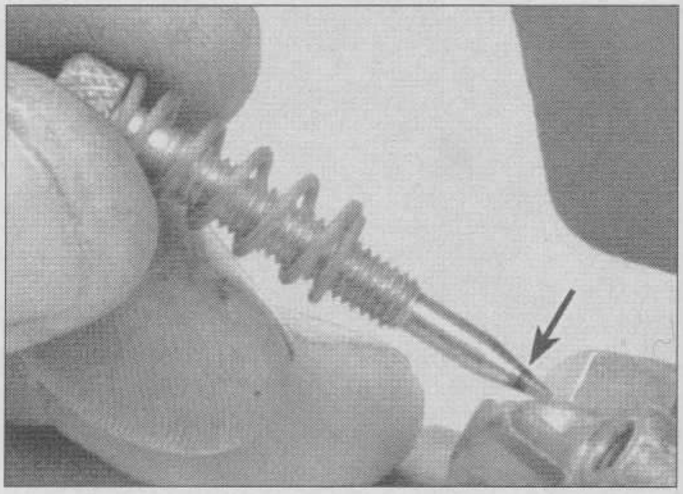


**7A.11 When removing a component where the gasket is holding the parts together, prying may become necessary. Always look for a casting protrusion or other external prying point rather than wedging a screwdriver between two the parts. Besides damaging a gasket surface, which could cause fuel or vacuum leaks, there is always a possibility that a hidden alignment dowel, tab or vent tube may be damaged or sheared off.**

**7A.13 If dips, which are water soluble, are used, it is necessary to use some type of compressed air to clean and dry off the parts after they have been rinsed off with water. You must be sure, regardless of how the parts are cleaned, that all air and fuel passages are clean and not plugged before reassembly. Compressed air is the most effective way to clear passages. If you don't have access to an air compressor, you can buy an inexpensive portable air tank, which can be filled at any service station, or buy a can of compressed gas designed for cleaning electronic parts. Warning:** *Always wear eye protection when using compressed air!*



**7A.12 Several different manufactures make cleaners and "dips" for cleaning parts. They come in individual spray cans or bulk cans with a basket for lowering parts into the can. Warning:** *Some cleaners are very strong caustic material and can damage your eyes or irritate your skin. Wear eye protection and wash your hands immediately after use of any cleaner.* **For thorough cleaning, we recommend soaking metal parts overnight in a dip tank. Cleaning solutions can damage non-metal parts, so be sure not to put plastic or electrical components into the dip tank. Before placing any parts into the dip tank, be sure to remove the old gasket material.**



**7A.14 Frequently during overhaul, you'll find damaged parts that aren't included in the overhaul kit, so be prepared to wait for special orders (If your local auto parts store can't get a part, a dealer service department often can). It's very common to find idle mixture screws that have had their needle end damaged like this through over-tightening. The idle mixture screw(s) . . .**

**7A.15 . . . and float(s) are usually not included in the overhaul kit. This Nitrophyl float is nicked in the areas shown by the arrows and should be replaced, since damage to the surface coating will eventually result in a soggy, sunken float. Hollow plastic and metal floats can also leak, with the same results. If your float is plastic or Nitrophyl, it's a good idea to replace it routinely at overhaul time. Shake metal floats next to your ear and listen for fuel inside. Also, make sure the metal float is not dented or otherwise damaged.**

# 7 Part D
## Overhaul and adjustments

## Quadrajet four-barrel models 4MC, 4MV, M4MC, M4MCA, M4MEA, M4MED, M4MEF, E4MC, E4ME
## Dualjet two-barrel models M2MC, M2ME, E2MC, E2ME

The models in this Chapter all share a similar design. The Dualjet two-barrel models are basically the primary side of a Quadrajet four-barrel model; some Dualjet models even use the same basic casting as a Quadrajet, with no functional components for the secondary half of the carburetor (at first glance, it looks like a four-barrel, but it functions as a two-barrel). Both the Quadrajet and Dualjet carburetors have "feedback" (electronically controlled) versions that appear on later model vehicles (beginning in about 1980). Overhaul of these carburetors is highly similar to non-feedback models, although special adjustments are required to ensure the system functions correctly.

The overhaul procedure is covered through a sequence of illustrations laid out in order from disassembly to reassembly and finally installation and adjustment on the vehicle. The captions presented with the illustrations will walk you through the entire procedure, one component at a time. **Note:** *Because of the large number of model variations, it is not always possible to cover all component differences. Overhaul Chapters only deal with disassembly, reassembly and basic adjustments of a typical carburetor in that model group. If you need further explanation about individual differences, refer to the exploded views in this Chapter or refer to Chapter 3.*

## *Warnings:*

### Gasoline

Gasoline is extremely flammable, so take extra precautions when you work on any part of the fuel system. Don't smoke or allow open flames or bare light bulbs near the work area, and don't work in a garage where a natural gas-type appliance (such as a water heater or clothes dryer) with a pilot light is present. A spark caused by an electrical short circuit, by two metal surfaces striking each other, or even by static electricity built up in your body, under certain conditions, can ignite gasoline vapors. Also, never risk spilling fuel on a hot engine or exhaust component. If you spill any fuel on your skin, rinse it off immediately with soap and water.

### Battery

Always disconnect the battery ground (-) cable at the battery before working on any part of the fuel or electrical system.

### Fire extinguisher

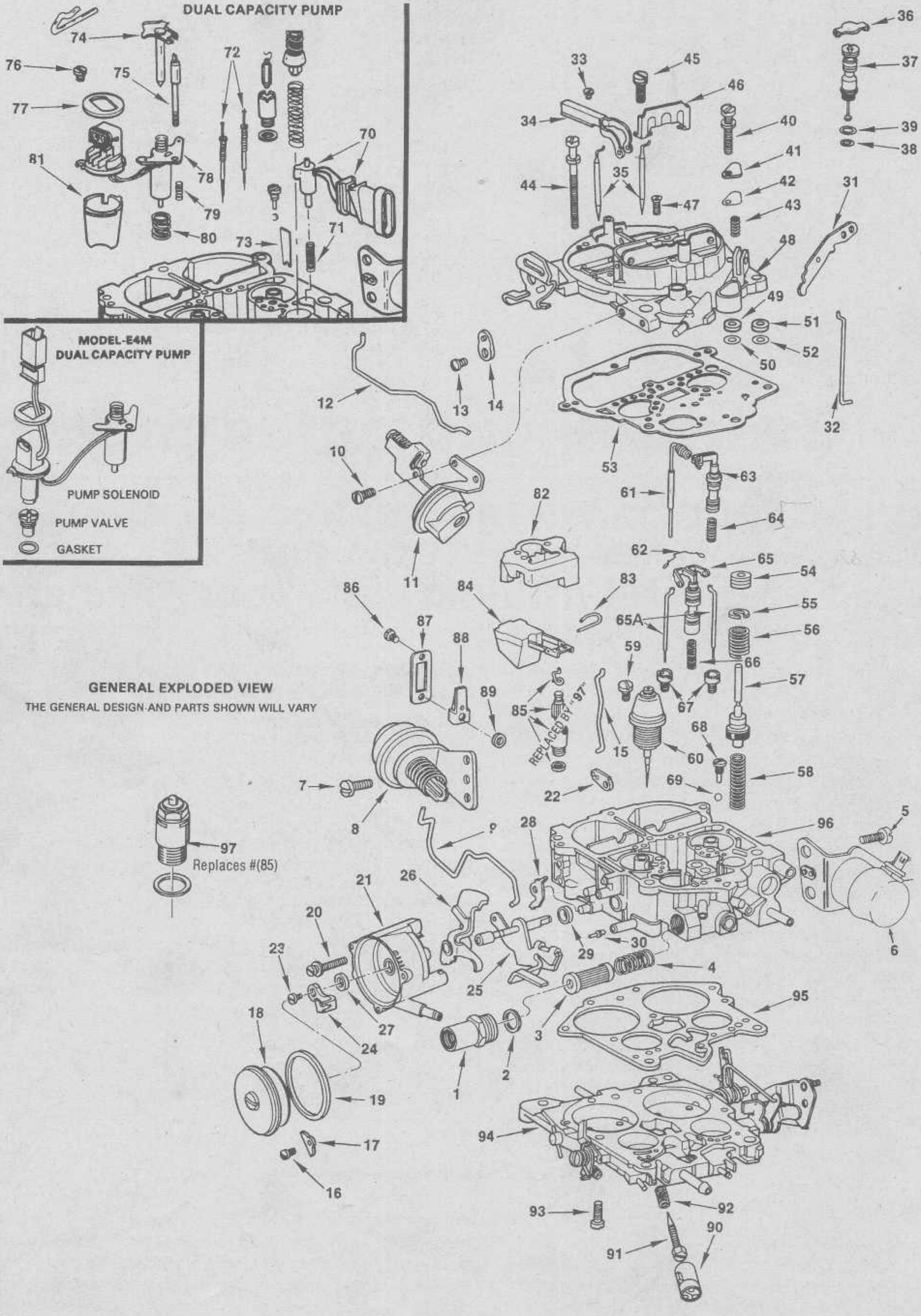
We strongly recommend that a fire extinguisher suitable for use on fuel and electrical fires be kept handy in the garage or workshop at all times. Never try to extinguish a fuel or electrical fire with water. Post the phone number for the nearest fire department in a conspicuous location near the phone.

### Compressed air

When cleaning carburetor parts, especially when using compressed air, be very careful to spray away from yourself. Eye protection should be worn to avoid the possibility of getting any chemicals or debris into your eyes.

### Lead poisoning

Avoid the possibility of lead poisoning. Never use your mouth to blow directly into any carburetor component. Small amounts of Tetraethyl lead (a lead compound) become deposited on the carburetor over a period of time and could lead to serious lead poisoning. Check passages with compressed air and a fine-tipped blow gun or place a small-diameter tube to the component and blow through the tube to be sure all necessary passages are open.



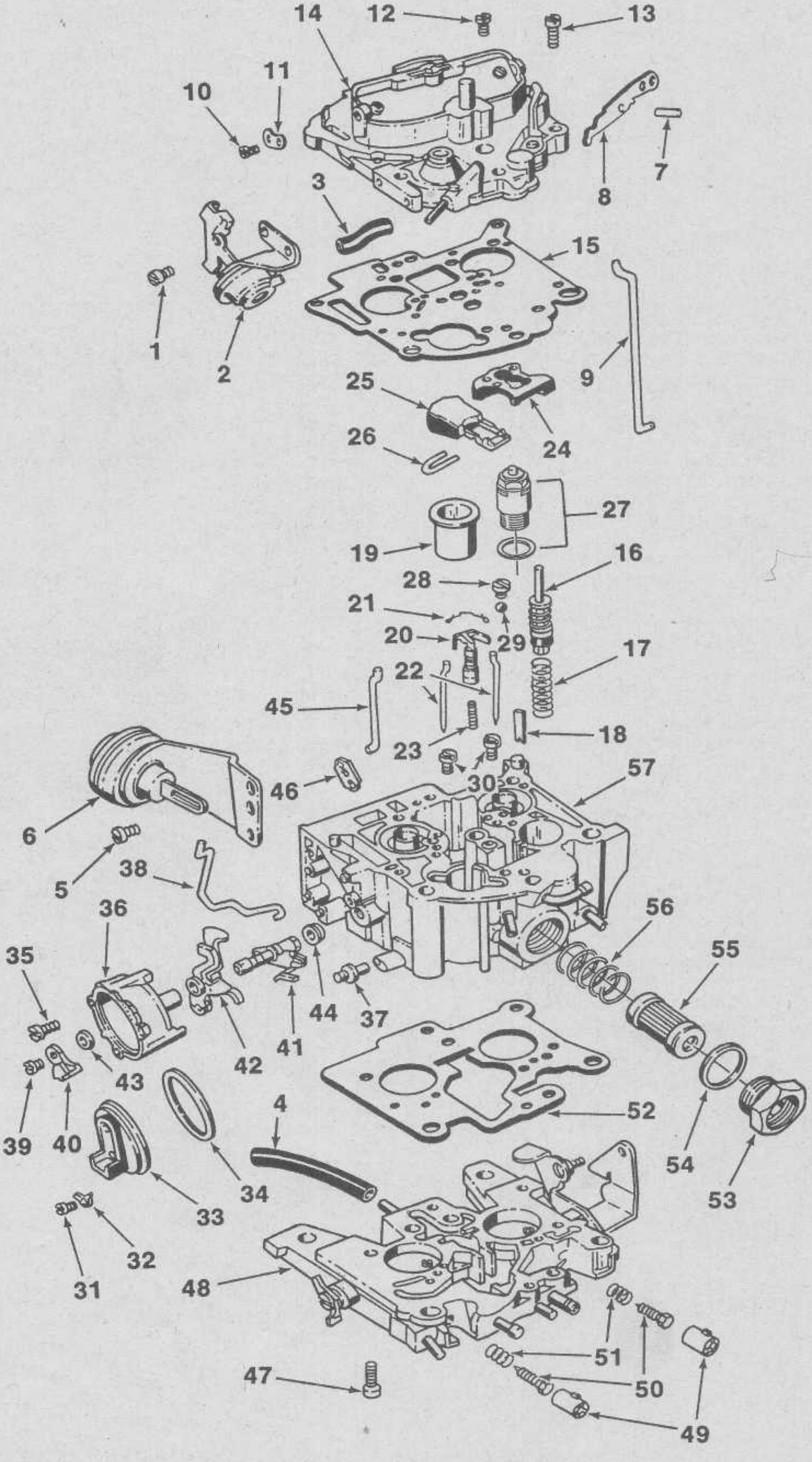
7D.1a An exploded view for a typical 4M series (Quadrajet) carburetor

1. Fuel Filter Nut
2. Fuel Filter Nut Gasket
3. Fuel Filter
4. Fuel Filter Spring
5. Solenoid Screw
6. Idle Speed Solenoid
7. Rear Vac. Break Screw
8. Rear Vac. Break Assembly
9. Rear Vac. Break Rod
10. Front Vac. Break Screw
11. Front Vac. Break Assy.
12. Front Vac. Break Rod
13. Choke Lever Screw
14. Choke Lever
15. Choke Rod
16. Choke Cover Retainer Rivet
17. Choke Cover Retainer
18. Choke Cover Assembly
19. Choke Cover Gasket
20. Choke Housing Screw
21. Choke Housing Assy.
22. Intermediate Choke Lever
23. Choke Coil Lever Screw
24. Choke Coil Lever
25. Intermediate Choke Shaft
26. Fast Idle Cam
27. Choke Housing Seal
28. Sec. Lockout Cam
29. Inter. Choke Shaft Seal
30. Vacuum Passage Tube
31. Pump Lever
32. Pump Rod
33. Sec. Metering Rod Holder Screw
34. Sec. Metering Rod Holder
35. Sec. Metering Rods
36. Air Bleed Valve Cover
37. Idle Air Bleed Valve
38. Lower Bleed Valve O-Ring
39. Upper Bleed Valve O-Ring
40. Vent Cover Screw
41. Vent Cover
42. Vent Cover Gasket
43. Vent Valve Spring
44. Airhorn Screw-Long
45. Airhorn Screw-Short
46. Air Baffle
47. Airhorn Screw-Special
48. Airhorn Assy.
49. Pump Stem Seal
50. Pump Stem Seal Retainer
51. T.P.S. Plunger Seal
52. T.P.S. Plunger Seal Retainer
53. Airhorn Gasket
54. Pump Stem Spacer
55. Pump Spring Retainer
56. Pump Spring
57. Pump Stem Assy.
58. Pump Return Spring
59. Aneroid Assy. Screw
60. Aneroid Assy.
61. Auxiliary Metering Rod
62. Metering Rod Spring
63. Auxiliary Power Piston
64. Auxiliary Power Piston Spring
65. Power Piston Assy.

65A. Main Metering Rods

66. Power Piston Assy. Spring
67. Main Jets
68. Pump Discharge Ball Screw
69. Pump Discharge Ball
70. Throttle Position Sensor Assy.
71. T.P.S. Spring
72. Main Metering Rod & Spring
73. Pump Well Baffle
74. Solenoid Plunger
75. Sol. Lean Mixture Adj. Screw, See Special Instruction.
76. ECM Connector Screw
77. ECM Connector Gasket
78. ECM Connector & Solenoid Assy.
79. Lean Mixture Screw
80. Solenoid Spring
81. Well Insert
82. Fuel Bowl Insert
83. Float Hinge Pin
84. Float & Lever Assy.
85. Needle & Seat Assy.
86. Hot Idle Compensator Cover Screw
87. Hot Idle Compensator Cover
88. Hot Idle Compensator Assy.
89. Hot Idle Compensator Gasket
90. Idle Limiter Cap (2)
91. Idle Needle (2)
92. Idle Needle Spring (2)
93. Throttle Body Screw
94. Throttle Body
95. Throttle Body Gasket
96. Main Body
97. Rotory Inlet Valve

**7D.1b Parts list for a typical 4M series (Quadrajet) carburetor**

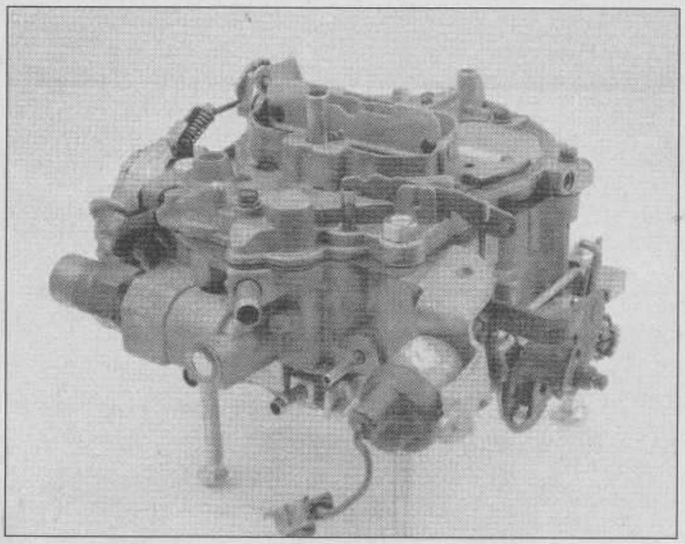


7D.2a An exploded view for a typical 2M series (Dualjet) carburetor

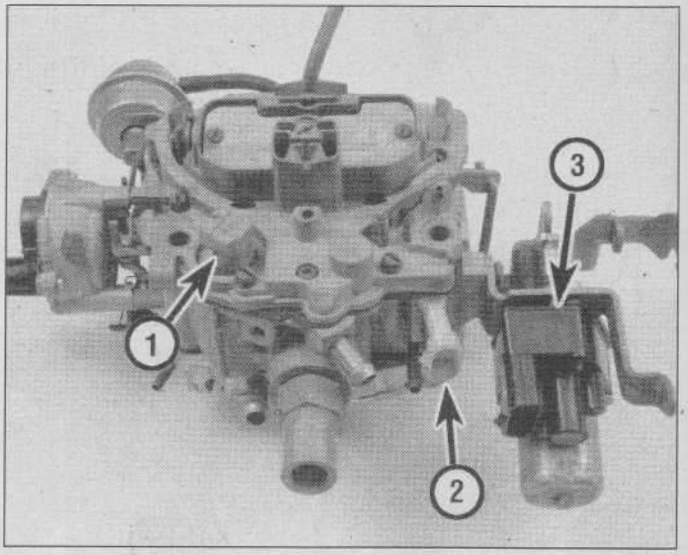
1. SCREW (2) - FRONT VACUUM BREAK
2. FRONT VACUUM BREAK ASSEMBLY
3. HOSE - FRONT VACUUM BREAK
4. HOSE - REAR VACUUM BREAK
5. SCREW (2) - REAR VACUUM BREAK
6. REAR VACUUM BREAK ASSEMBLY
7. PIN - PUMP LEVER
8. LEVER - PUMP
9. ROD - PUMP
10. SCREW - CHOKE LEVER
11. LEVER - CHOKE SHAFT
12. SCREW (2) - BOWL COVER (TAPERED HEAD)
13. SCREW & LKWSHR. (5) - BOWL COVER
14. BOWL COVER ASSEMBLY
15. GASKET - BOWL COVER
16. PUMP ASSEMBLY
17. SPRING - PUMP
18. BAFFLE - PUMP WELL
19. INSERT - ANEROID CAVITY
20. POWER PISTON ASSEMBLY
21. SPRING - METERING ROD
22. METERING ROD (2)
23. SPRING - POWER PISTON
24. INSERT - FLOAT BOWL
25. FLOAT & LEVER ASSEMBLY
26. HINGE PIN - FLOAT
27. ROTORY VALVE & GASKET
28. PLUG - PUMP DISC BALL
29. BALL - PUMP DISC
30. JET (2) - MAIN METERING
31. SCREW (3) - CHOKE COVER RETAINER
32. RETAINER (3) - CHOKE COVER
33. CHOKE COVER ASSEMBLY
34. GASKET - CHOKE COVER (NONE ELECTRIC MODELS)
35. SCREW & LKWSHR - CHOKE HOUSING
36. CHOKE HOUSING ASSEMBLY
37. TUBE - VACUUM PASSAGE
38. LINK - REAR VACUUM BREAK
39. SCREW - CHOKE COIL LEVER
40. LEVER - CHOKE COIL
41. SHAFT ASSY. - INTERMEDIATE CHOKE
42. CAM - FAST IDLE
43. SEAL - CHOKE HOUSING SHAFT HOLE
44. SEAL - INTERMEDIATE CHOKE SHAFT
45. ROD - CHOKE
46. LEVER - INTERMEDIATE CHOKE
47. SCREW & LKWSHR. (4) - THROTTLE BODY
48. THROTTLE BODY ASSEMBLY
49. CAP (2) - IDLE LIMITER
50. NEEDLE - IDLE ADJUSTING
51. SPRING - IDLE ADJUSTING NEEDLE
52. GASKET - THROTTLE BODY
53. FILTER NUT - FUEL INLET
54. GASKET - FILTER NUT
55. FILTER - FUEL
56. SPRING - FILTER
57. FLOAT BOWL ASSEMBLY

**7D.2b Parts lists for a typical 2M series (Dualjet) carburetor**

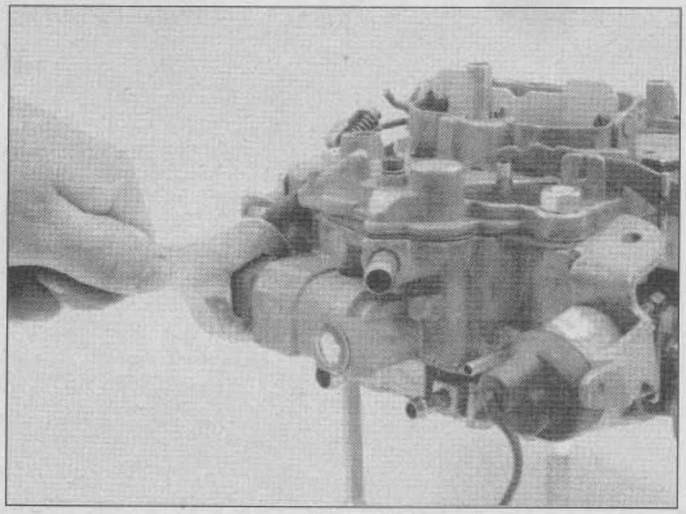
## *Disassembly*



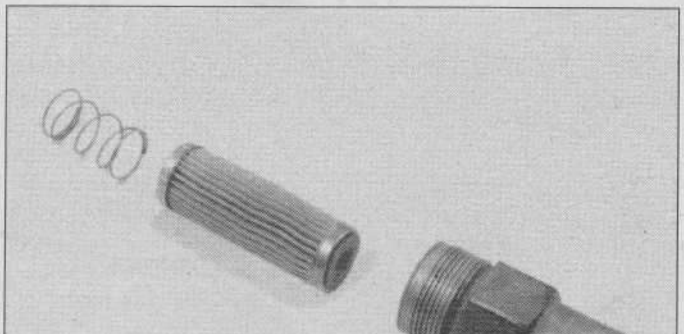
**7D.3 After removing the carburetor and mounting it on a stand (see Chapters 6 and 7A), make notes or diagrams of levers, slots or holes that linkage connects to or anything that could be difficult to remember during reassembly. Note:** *Remember that, on extremely dirty carburetors, overnight cleaning may be required and reassembly may not be possible until the next day.* **Before removing any components, always empty the gasoline from the carburetor into an approved gasoline container for proper disposal.**



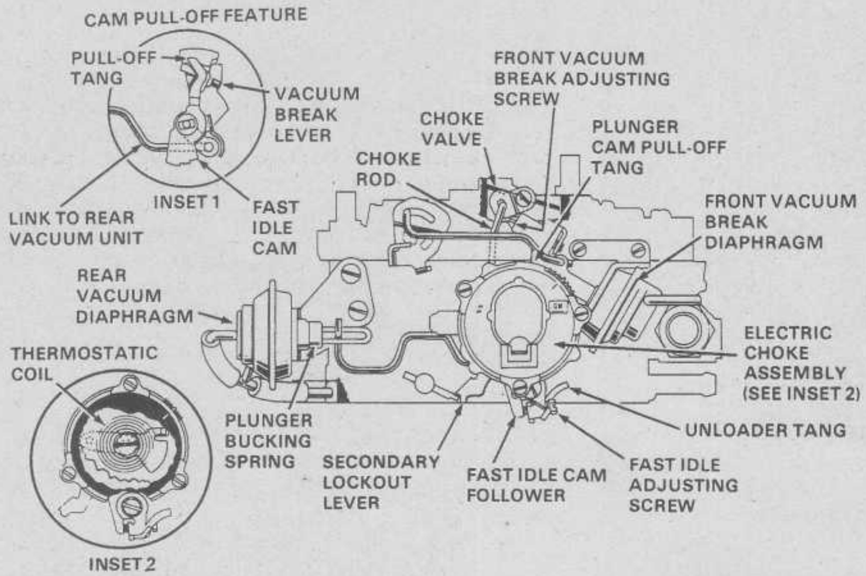
**7D.4 This is a Dualjet carburetor with mixture control solenoid (1) and throttle position sensor (2) connectors (Quadrajet connectors are identical). Carburetors with these connectors are controlled by the vehicle's computer and referred to as "feedback" carburetors. Also note the Idle Speed Control (ISC) motor (3), which the computer uses to control the curb idle speed. The ISC motor should not require adjustment in normal service, but if it's malfunctioning, it should be replaced.**



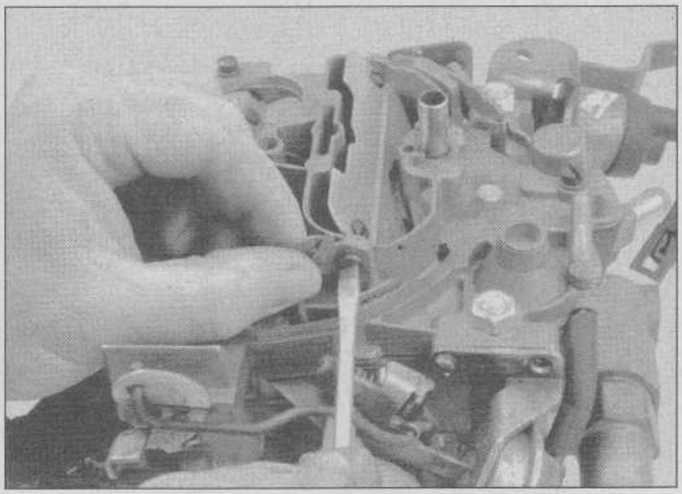
**7D.5 Using a 1-inch wrench, as shown, remove the fuel inlet nut from the main body of the carburetor. Note:** *Other models may have nuts that look different or aren't in exactly the location shown here.*



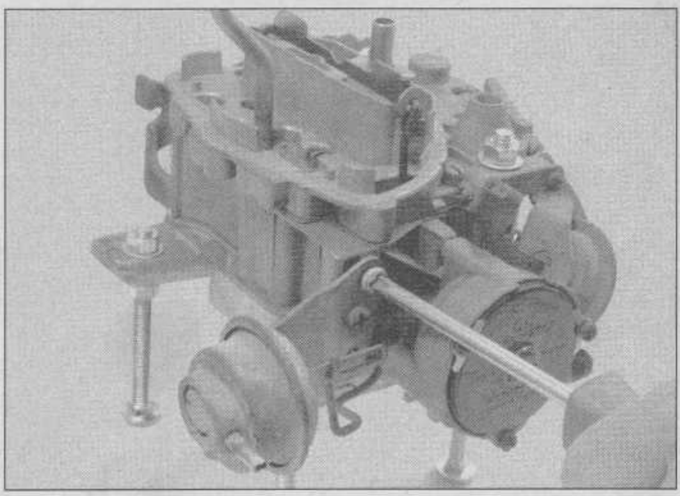
**7D.6 Remove the filter and the spring from the carburetor. Always replace the filter at overhaul time.**



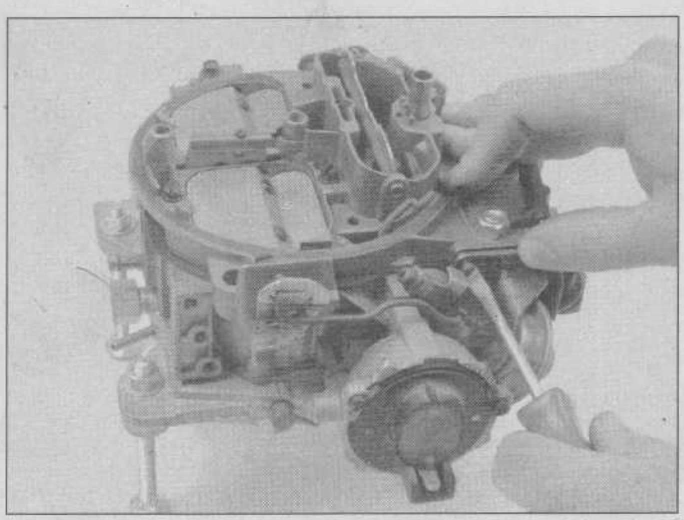
**7D.7 Here's a chart that identifies automatic (electric, in this case) choke system components. The model shown is an M4ME Quadrajet, but other models are similar. Use this drawing as an aid in identifying choke components in the following photographs.**



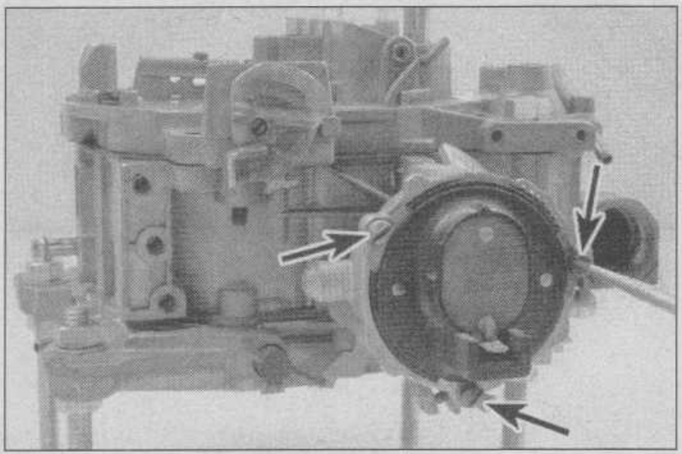
**7D.8 Remove the choke lever screw and lever. Leave the linkage rod that the lever is connected to in place for now.**



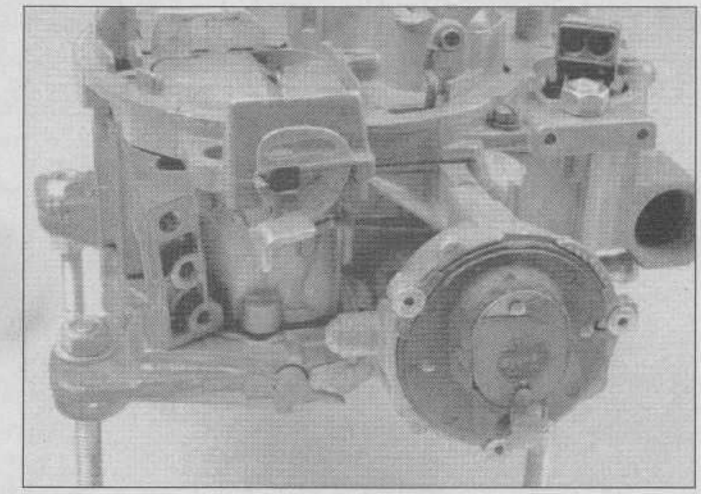
**7D.9 Remove the two screws, then remove the auxiliary (rear) vacuum break diaphragm**



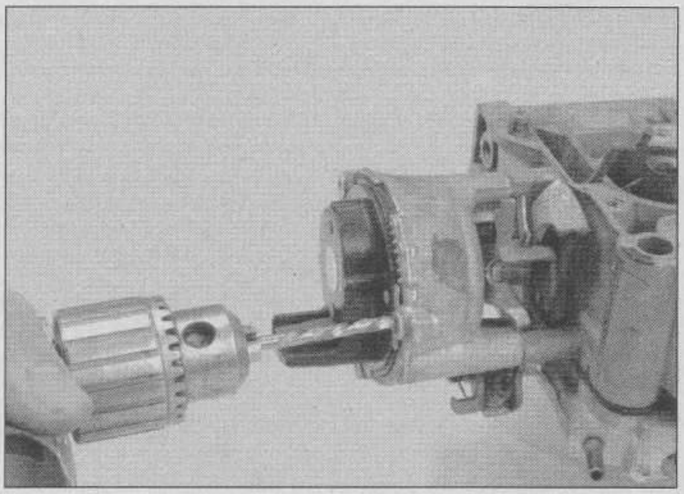
**7D.10 Remove the two screws and the front vacuum break diaphragm**



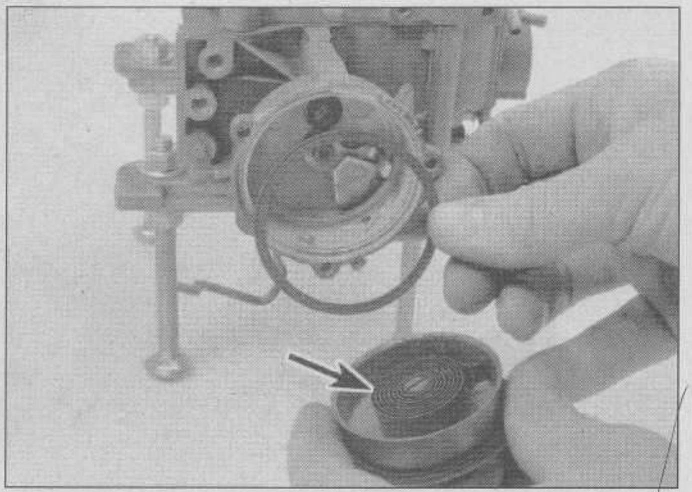
**7D.11 If your vehicle has an on-carburetor choke housing with a cover that's retained with screws, remove the three screws (arrows) and the choke cover retainers beneath the screws. Be careful not to lose the retainers!**



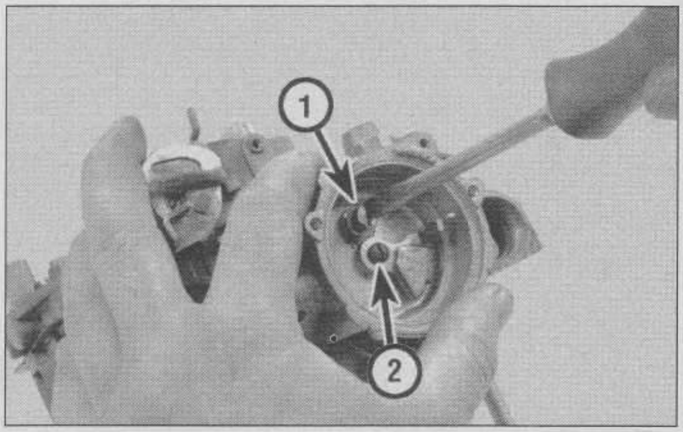
**7D.12a Due to emission regulations, the choke cover on many later models is riveted to the choke housing. The choke cover must be removed to check the choke coil and clean the housing at overhaul time, so . . .**



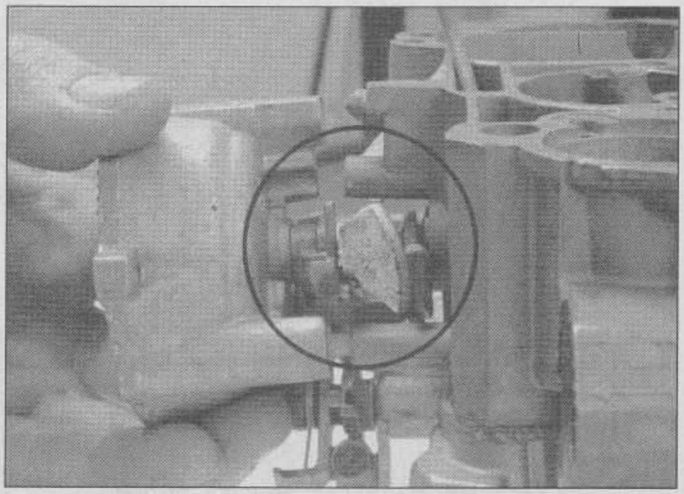
**7D.12b . . . drill the heads off the three rivets. Note:** *The overhaul kit normally comes with self-tapping screws to replace the rivets during reassembly.*



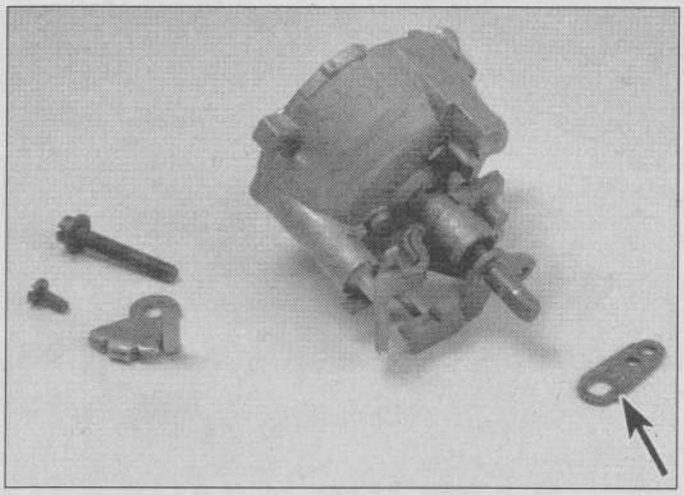
**7D.13 After removing the screws or drilling out the rivets, remove the choke cover and gasket. If the choke coil (arrow) is broken, bent, distorted or corroded, it should be replaced. This coil is in OK condition and can be reused.**



**7D.14a Remove the choke housing screw (1) as shown and remove the screw attaching the lever to the shaft (2) . . .**

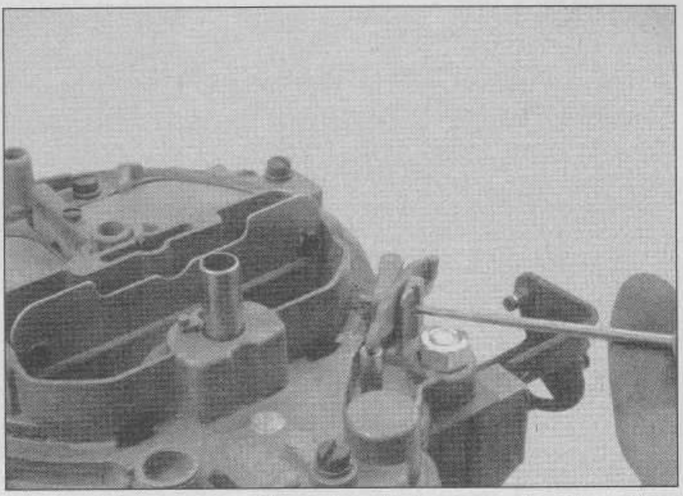


**7D.14b . . . then remove the choke housing assembly from the carburetor main body. Note:** *Carefully observe how the linkage (circled area) is assembled so you can put it back together correctly on reassembly.*

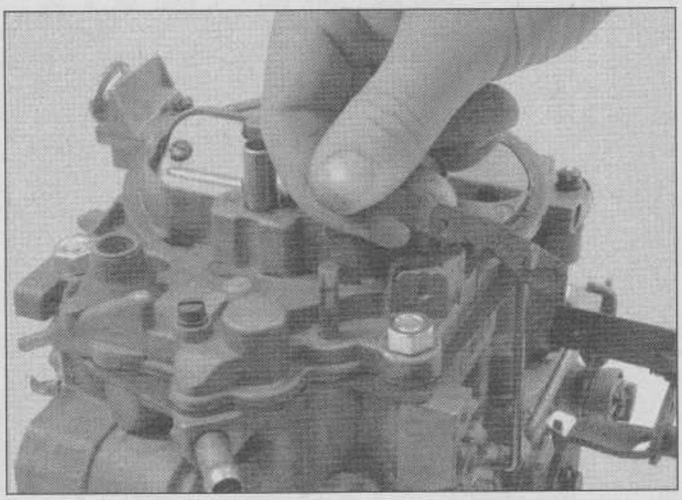


**7D.14c Once the assembly is off the carburetor, reassemble the parts, as shown here, to avoid confusion during reassembly. The lever (arrow) is located inside the main body attached to a linkage rod. Lift it out with the linkage rod (see illustration 7D.8). If the lever falls off the rod, wait until the main body is completely disassembled, then invert the main body on the bench so the lever falls out.**

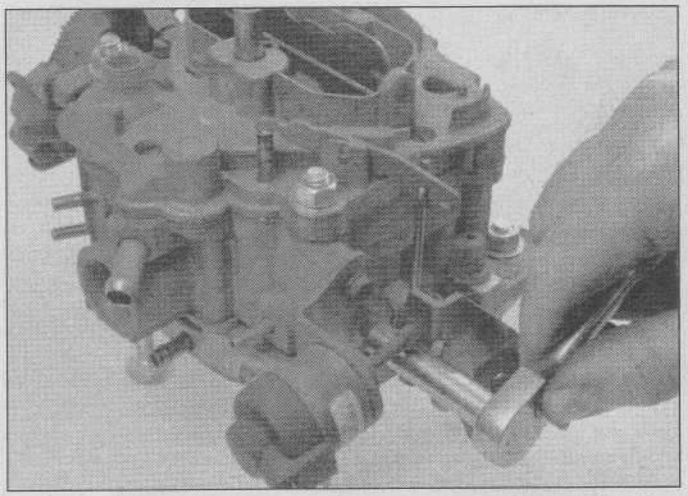
7D.15 Once the housing has been removed, carefully lift out and discard the choke shaft seal (arrow). Replace it with a new seal during reassembly.



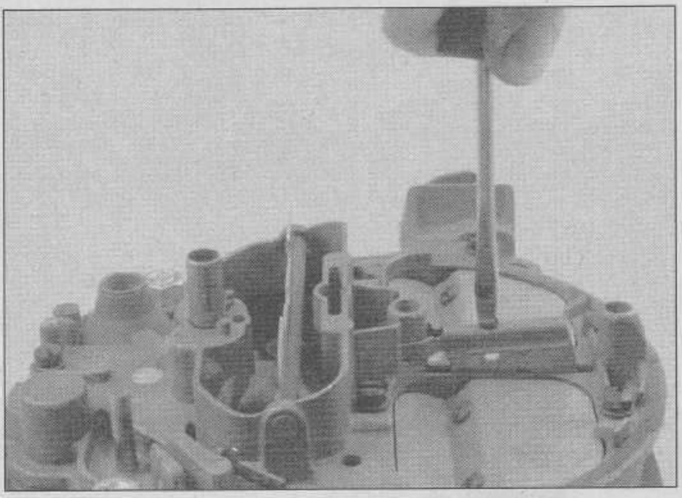
7D.16a Using a very small punch and a hammer, drive the roll pin through the lever . . .



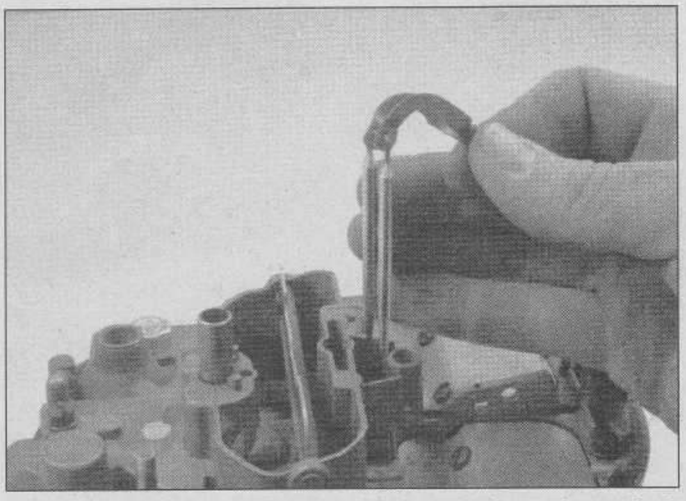
7D.16b . . . just far enough to lift the lever from the air horn and disconnect it from the rod.



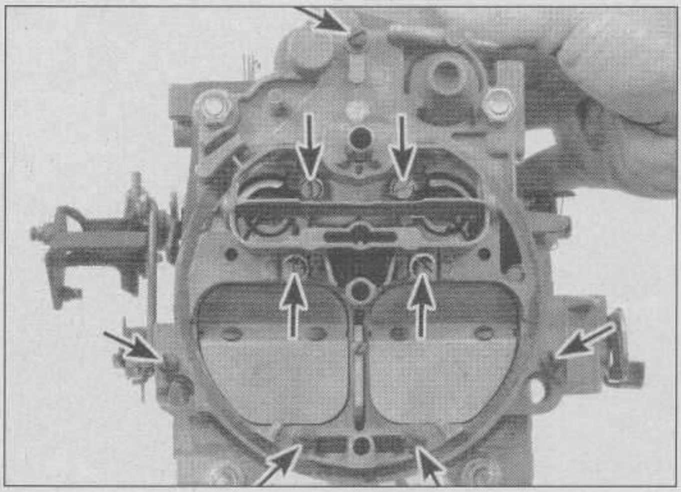
7D.17 If your carburetor is equipped with an idle-stop solenoid or an Idle Speed Control (ISC) motor, remove the two screws and lift it off (idle-stop solenoid shown)



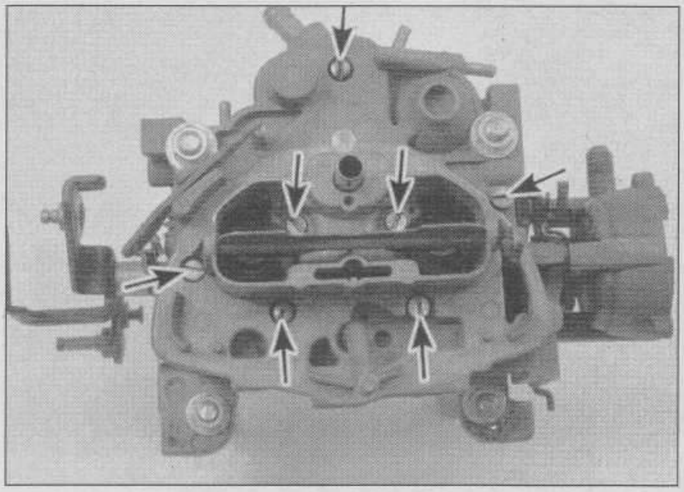
7D.18a On Quadrajet models, remove the secondary metering rod holder screw (arrow) . . .



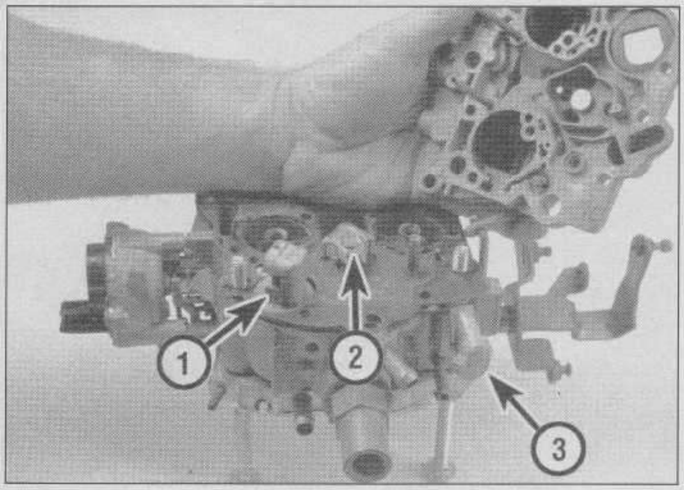
7D.18b . . . and lift out the holder with the metering rods attached



**7D.19 On Quadrajet models, remove the nine screws that hold the air horn assembly to the main carburetor body. If you are using a bolt-type carburetor stand, you'll also have to remove the two upper front nuts at this time.**

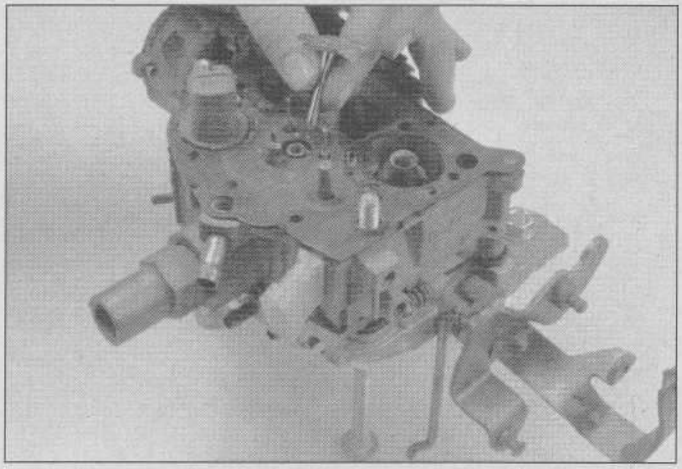


**7D.20 On Dualjet models, there are only seven screws to remove. Again, if you're using a bolt-type carburetor stand, be sure to remove the upper front nuts also.**

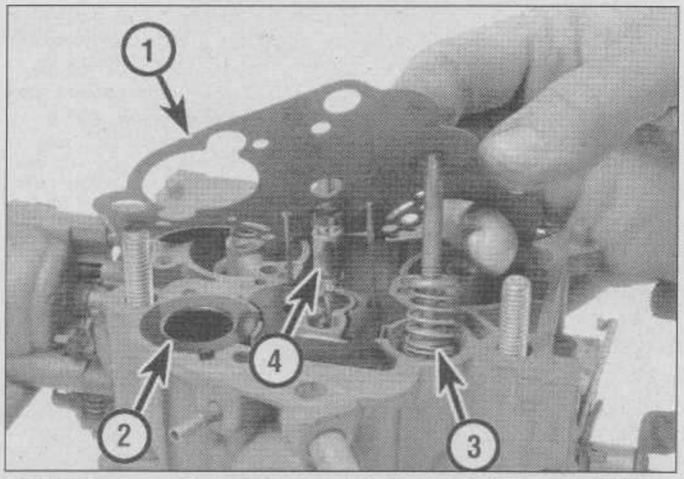


**7D.21 When removing the air horn on a feedback version of either a Dualjet or Quadrajet, there are additional components to be removed and cleaned by hand. DO NOT place these in any solvent tanks; they can be damaged by strong solvents.**

1. *Mixture control solenoid connector*
2. *Mixture control solenoid plunger (the solenoid itself is beneath the gasket)*
3. *Throttle Position Sensor (TPS) connector.*



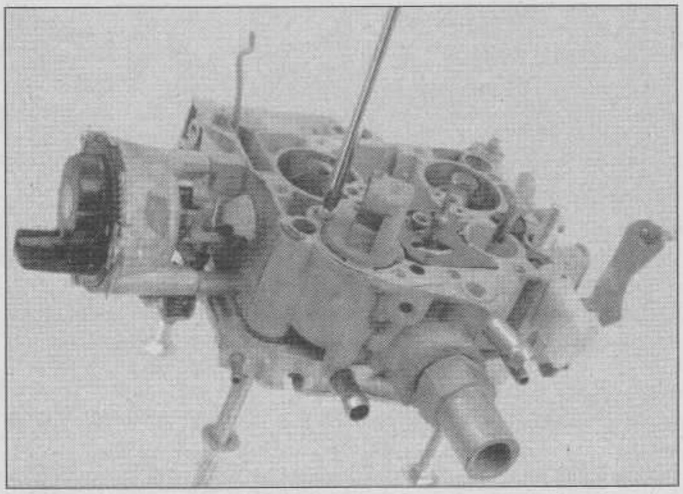
**7D.22 If your carburetor is a feedback version, first remove the mixture control solenoid plunger**



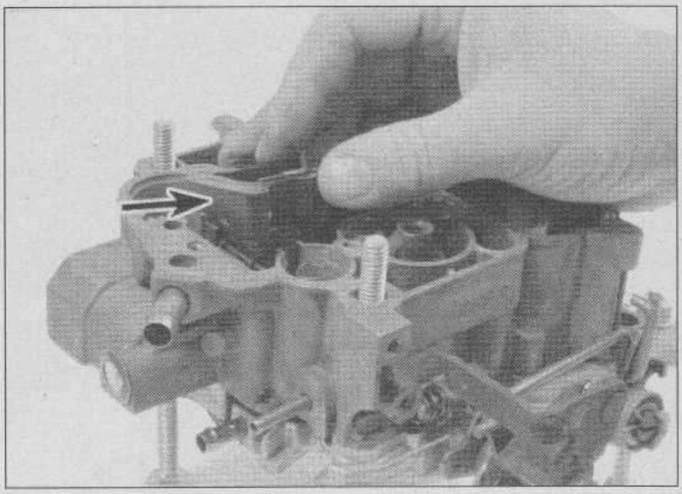
**7D.23 Next, on all models, carefully remove the gasket (1), the plastic cup (2) (if equipped) and the accelerator pump assembly (3). On non-feedback models, the power piston (4) and metering rods can be removed with the gasket. The power piston usually doesn't pull out easily, since it's secured by a plastic retainer, so push the piston down and release it. Caution:** *On reassembly, be sure to position the tab in the new gasket under the power piston arms, as shown here, Otherwise, richening action will not occur.*

### Tip:

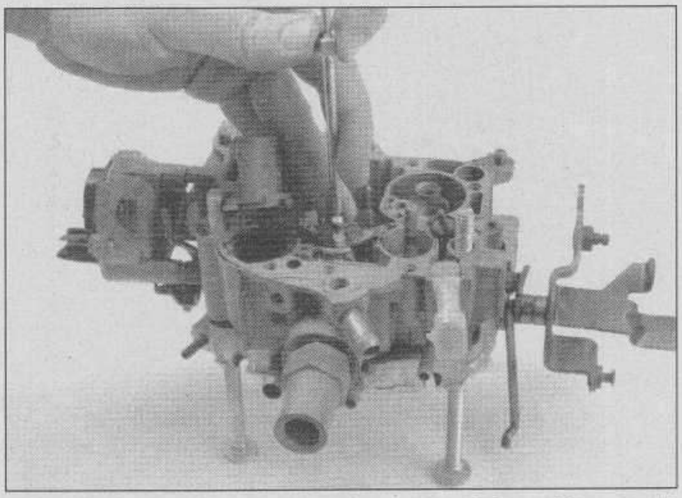
Be careful not to damage the air horn gasket when removing it. Overhaul kits frequently include several gaskets, and you can use the old gasket as an aid in selecting the new gasket (it should have the same holes in the same places, etc.).



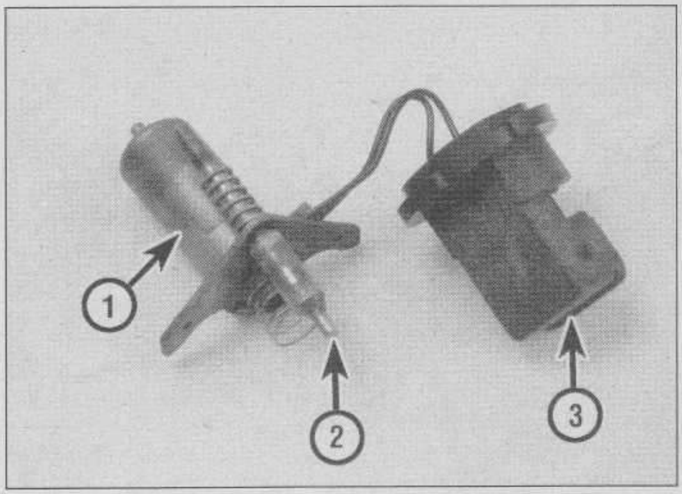
7D.24a On feedback models, remove the screw securing the mixture-control solenoid connector



7D.24b On all models, lift out the float bowl insert

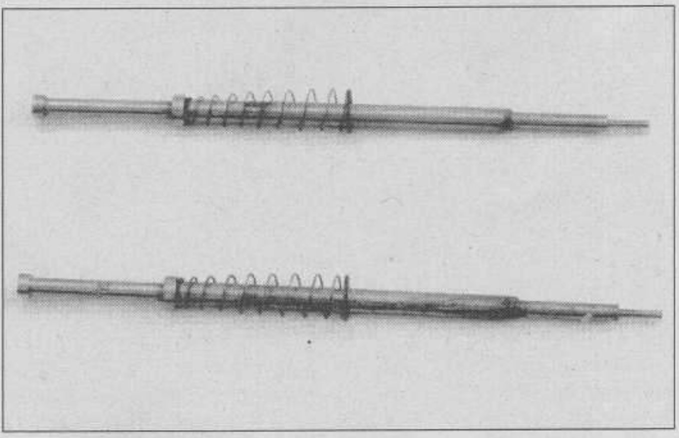


7D.24c On feedback versions, using a screwdriver with a special D-shaped head (available at auto parts stores and from automotive tool suppliers), turn the solenoid adjusting screw clockwise until it bottoms, counting the number of turns. Write this number down, since it will be used to provide an initial setting on reassembly. Now unscrew and remove the solenoid adjusting screw and lift out the mixture control solenoid, wiring and connector.

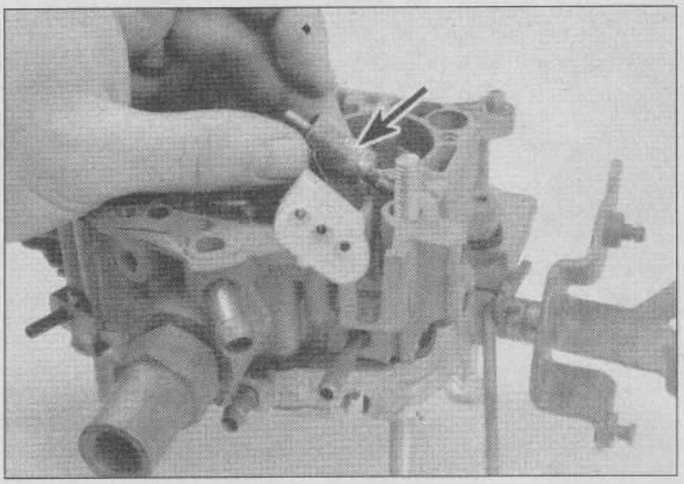


7D.24d On feedback versions, the mixture control solenoid assembly consists of:

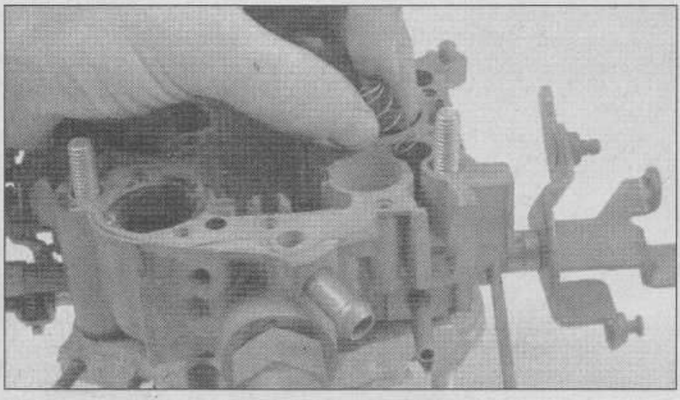
1 *The mixture control solenoid*
2 *The adjustment screw*
3 *The electrical connector*



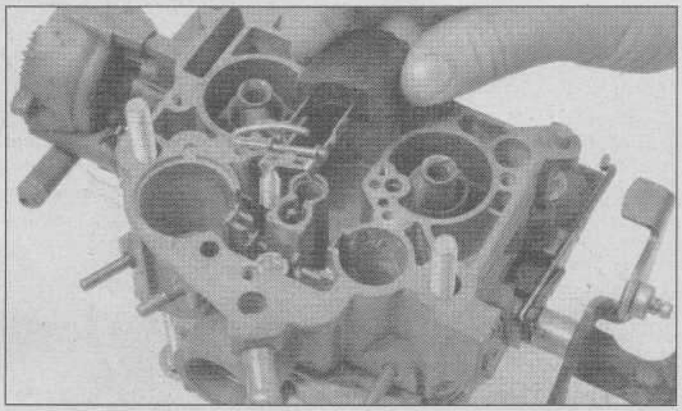
7D.25 On feedback models, remove the primary metering rods - note how the springs are installed



7D.26a On feedback models, lift the Throttle Position Sensor (TPS) and connector from the carburetor main body . . .



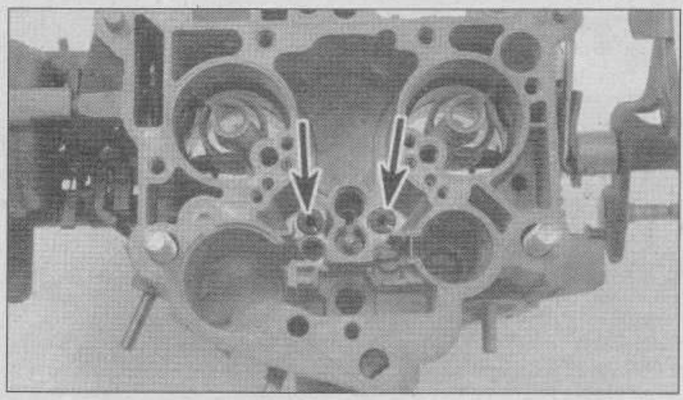
7D.26b . . . and remove the sensor adjusting spring from the well



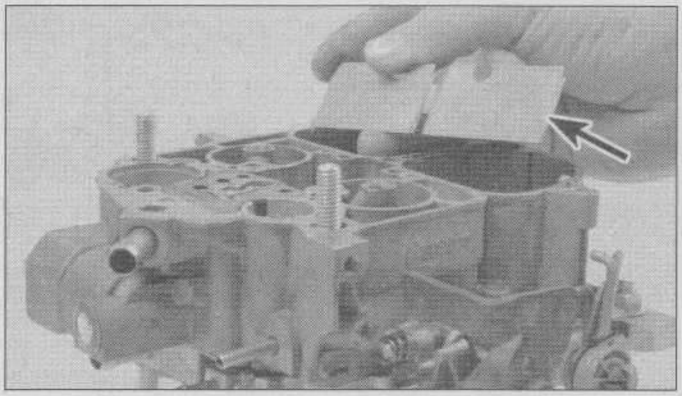
7D.28 Lift the float and needle up and out of the main body and set them aside

**Tip:**

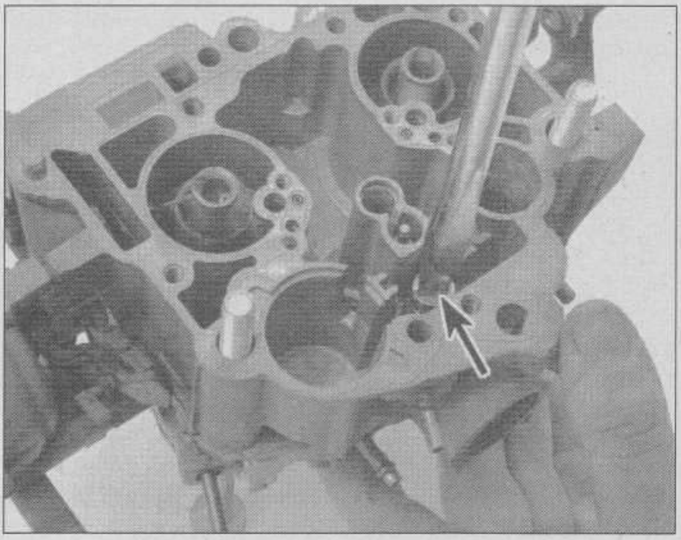
The needle and seat will be replaced on reassembly, but inspecting them will sometimes reveal the cause of carburetor failure. If the needle and/or seat are dirty, damaged or sticking together, they could easily have been the cause of fuel overflow/flooding (fuel leaking past the needle when seated) or fuel starvation/engine dying out (needle and seat sticking together).



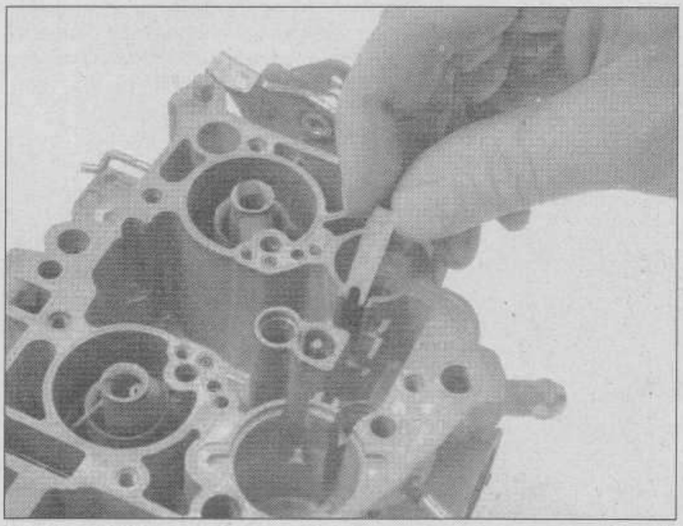
7D.30 Using a large screwdriver, unscrew and remove the two main metering jets (arrows)



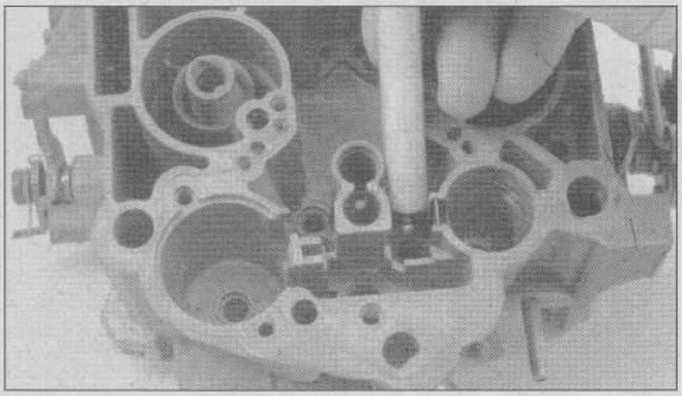
7D.27 On Quadrajet models, remove the baffle on the secondary side of the casting. It just lifts out; there are no attachments



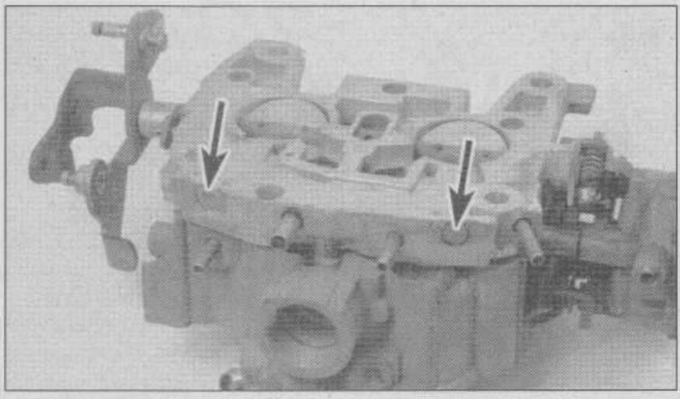
7D.29 Using a large screwdriver, unscrew the seat from the carburetor



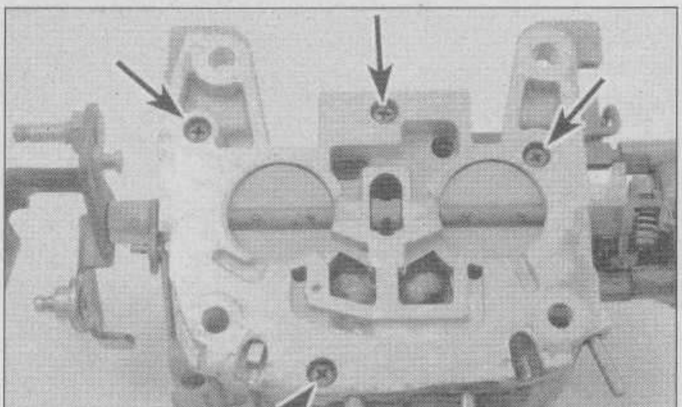
7D.31a Slide out the accelerator pump fuel well baffle (if equipped)



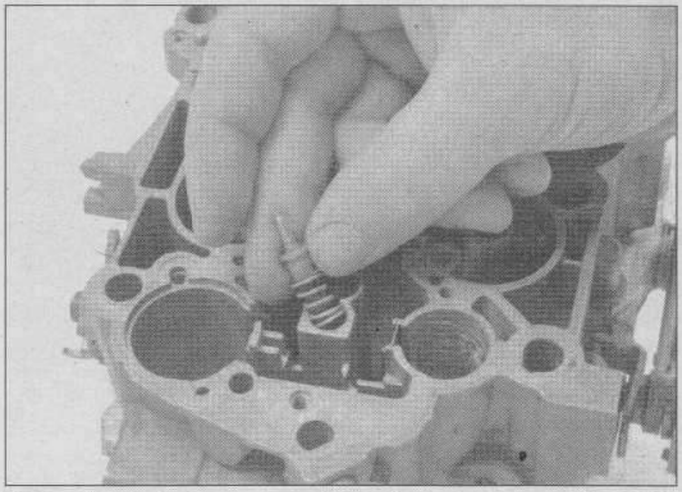
**7D.31b Remove the accelerator pump discharge screw (plug) and remove the check ball. Either use a magnet or turn the carburetor over, catching the ball as it falls out. Caution:** *Be certain all other springs and loose components are already removed from the carburetor so no parts are accidentally lost when the carburetor is turned over.*



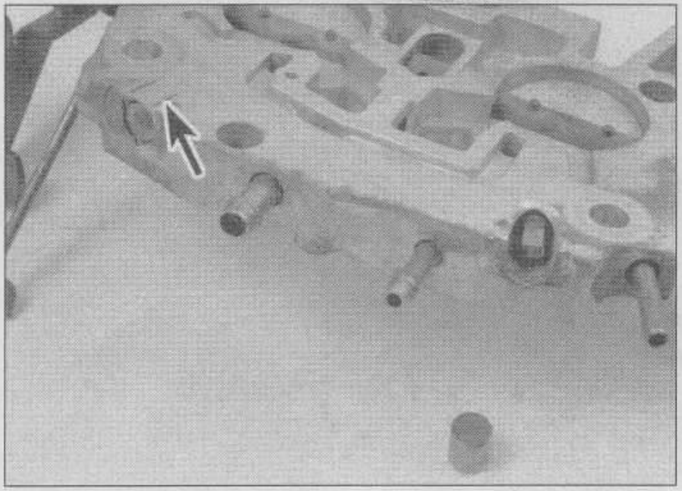
**7D.33 Remove the idle mixture screws from the locations shown by the arrows. This is a later model with plugs installed over the mixture screws to prevent tampering with the factory-set mixture; proceed to 7D.34 to remove these plugs. On early models, the screws are exposed and can be removed with a screwdriver, although some screws have plastic limiter caps that must be broken off with pliers before the screws can be removed. The limiter caps were designed to limit the amount of mixture adjustment available to the mechanic when the vehicle was new, and they don't need to be replaced on reassembly.**



**7D.35 Remove the screws (arrows) attaching the throttle body to the main body (Dualjet shown, Quadrajet similar)**



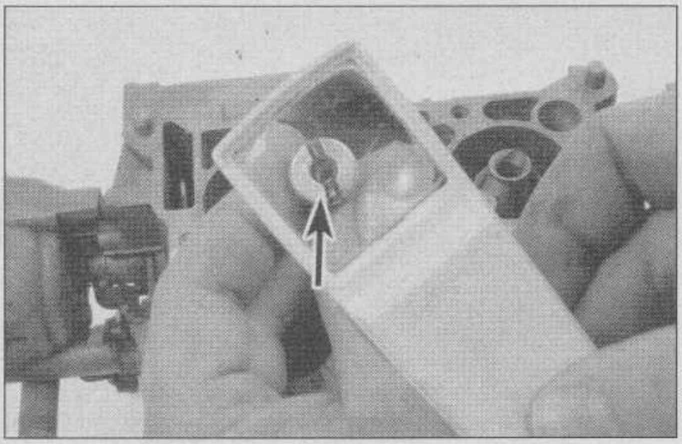
**7D.32 This is the factory metering adjustment screw. We DON'T recommend removing it during the overhaul. But if you feel it's been tampered with or is so dirty that it must be removed to be properly cleaned, unscrew and remove it. Caution:** *Before removing the metering screw, turn it clockwise, counting the number of turns, to a lightly seated position. Then, on reassembly, reinstall the screw to its original setting. If you have no point of reference for this setting, or if the setting has been tampered with, set it at about 3 1/2 turns from its seated position.*



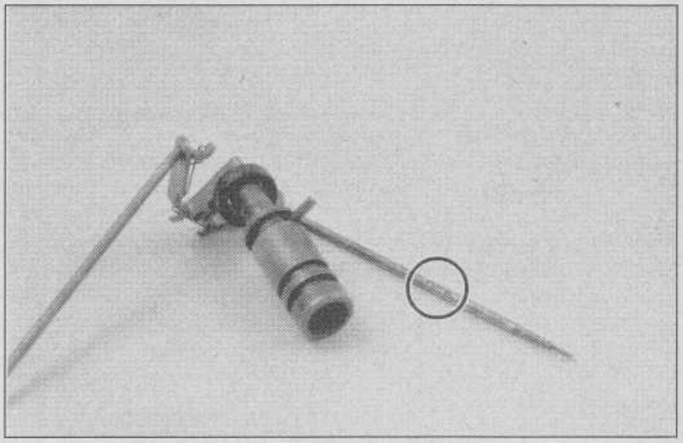
**7D.34 To remove the idle-mixture-screw plugs on later models, you'll need to cut with a hacksaw at the locations shown by the marked lines (arrow). Caution:** *Cut away absolutely no more material than necessary to remove the plugs.* **After making the cuts, use a chisel to break away the material between the cuts. Using a punch and hammer, drive out the cap from behind, then unscrew the idle-mixture screws. Note:** *A special screwdriver with a D-shaped head (available at most auto parts stores) is usually necessary to remove the screws.*

## Tip:

Be very careful when removing the old gasket between the throttle body and the main body. Gaskets vary among models, and you'll want to keep your old gasket intact so you can use it to select the correct new gasket from the overhaul kit (several new gaskets are often included, and you'll want to make sure the new gasket has all holes in the same places, etc.).



**7D.36 A magnifying glass will make it easier to inspect the main jets, which should have smooth, unobstructed holes in them. If either jet is damaged, replace the two as a set. Be sure to write down the number (arrow) so you can order the correct jets**



**7D.37 Also inspect the metering rods for bends, breaks, scratching or wear at the tips. Again, if a rod is damaged, replace the two as a set. Write down the numbers stamped on the rods (circled) so you'll be able to order the correct type (primary metering rods shown, secondary rods similar).**

## *Cleaning and inspection*

Refer to Chapter 7A for information on inspecting parts and information on "dips" and solvents you can use to clean parts. DO NOT immerse the following parts or use harsh solvents to clean them, since they will harden, swell, distort or be otherwise damaged:

*Idle-stop solenoid (some non-feedback models)*
*Electric choke coil*
*Accelerator pump plunger*
*Choke diaphragms*
*Throttle Position Sensor (TPS) (feedback models)*
*Mixture-control solenoid (feedback models)*
*Idle Speed Control (ISC) motor (feedback models)*
*All other electrical, rubber and plastic parts*

Make sure all fuel passages, jets and other metering components are free of burrs and dirt. After cleaning, blow out all passages with compressed air. If an air compressor is not available, aerosol cans of compressed gas designed for cleaning computer keyboards will work as well. Do not use a piece of wire for cleaning the jets and passages.

Inspect the upper and lower surfaces of the air horn, float bowl and throttle body for damage. Be sure all material has been removed. Inspect all lever holes and plastic bushings for excessive wear and out-of-round conditions and replace them, if necessary.

Check the choke valve and linkage for excessive wear, binding and distortion and correct or replace as necessary.

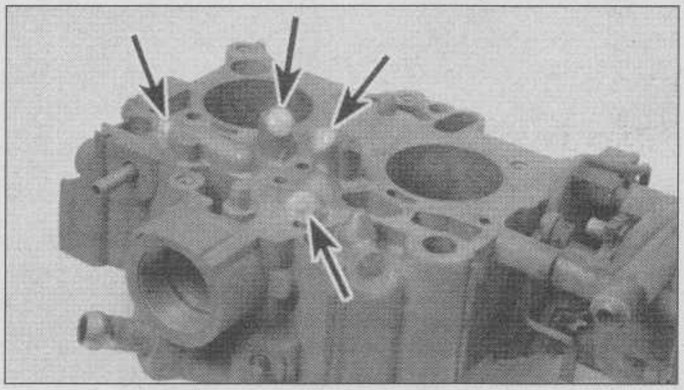
### Mixture-control solenoid check

On feedback models, install the plunger in the mixture-control solenoid, making sure the solenoid is upright and the spring is still in place on the solenoid. Check the mixture-control solenoid in the following manner:

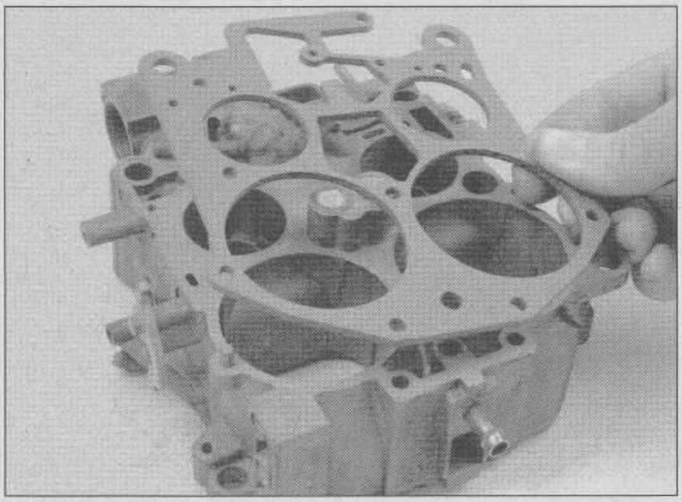
a) Connect one end of a fused jumper wire to either solenoid-wire terminal at the solenoid connector. Connect the other end to the positive terminal of the vehicle's battery (12-volt automotive battery).
b) Connect another jumper wire between the other terminal of the solenoid connector and the negative terminal of the battery. **Caution:** *Do not hook up the solenoid in this manner for more than about a second or the solenoid could be damaged from overheating.*
c) When the solenoid is connected to the battery in this manner, the solenoid plunger should be drawn into the solenoid and the plunger should seat completely (you shouldn't be able to press the plunger any further into the solenoid). **Note:** *Some solenoids are polarity sensitive, so, if the plunger is not drawn into the solenoid, try switching the wires at the battery.* If the plunger is not drawn down quickly and completely, the solenoid is probably faulty. Replace it.
d) Disconnect the wires from the solenoid connector and remove the plunger from the solenoid. Carefully check the plunger tip to be sure it has an even taper and isn't pitted or otherwise damaged. Also, use a flashlight to check the plunger seat inside the bottom of the solenoid for pitting, blockage or other damage. If these inspections reveal any undesirable conditions, replace the solenoid and/or plunger.

## *Reassembly*

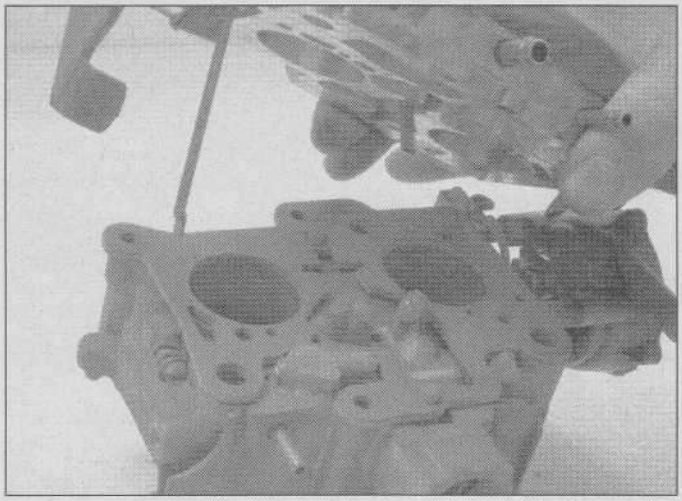
**Note:** *Unless discussed specifically in the following series of photographs, reassembly of components is in the reverse order of disassembly.*



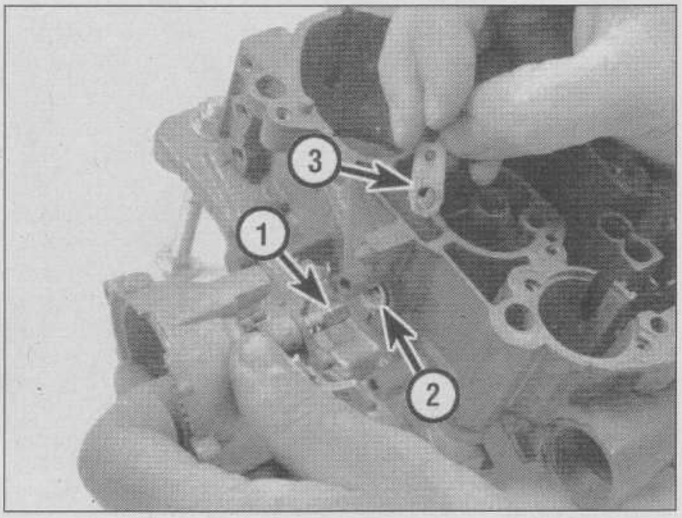
**7D.38 The underside of the fuel well has steel plugs installed in factory machining holes. They are prone to leakage and often cause driveability problems when they leak. Before beginning reassembly, to make sure your plugs are sealed, we recommend applying an epoxy compound, such as JB Weld, to the plugs, as shown here (arrows). Epoxy compounds are available at auto parts stores. Follow the label directions.**



7D.39a Whether it's on a Quadrajet, or . . .



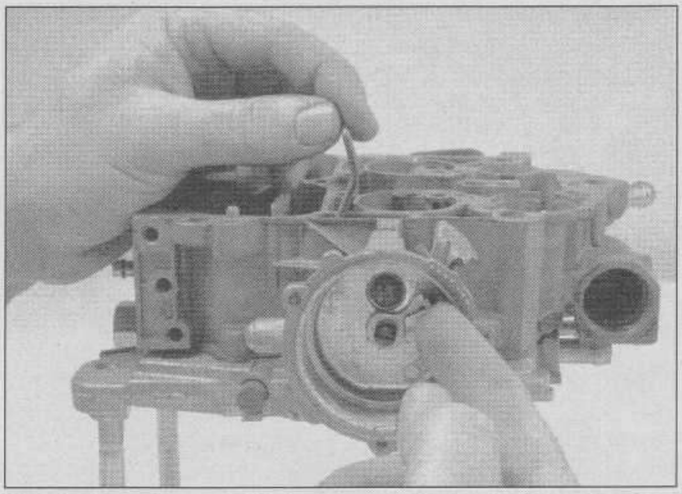
7D.39b . . . a Dualjet, use the old throttle-body gasket to select the correct new one from the overhaul kit, then assemble the throttle body to the main body, tightening the screws securely



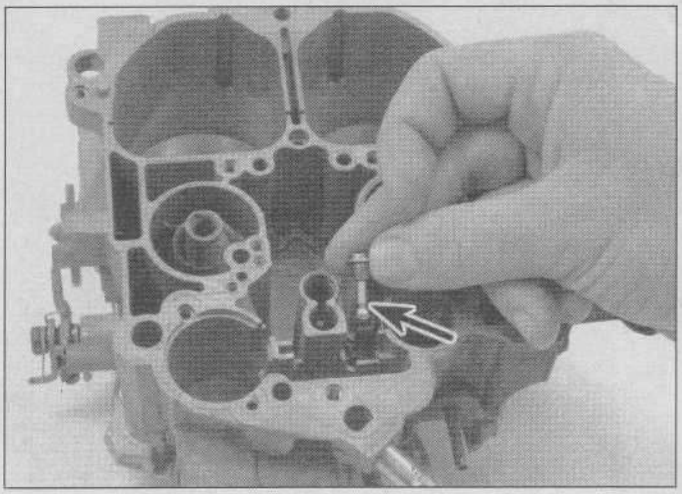
### Tip:

It's possible for throttle-body screws to vibrate loose and fall into the engine, causing severe engine damage. To prevent this possibility, it's a good idea to apply removable-type thread-locking compound to the screws before installing them.

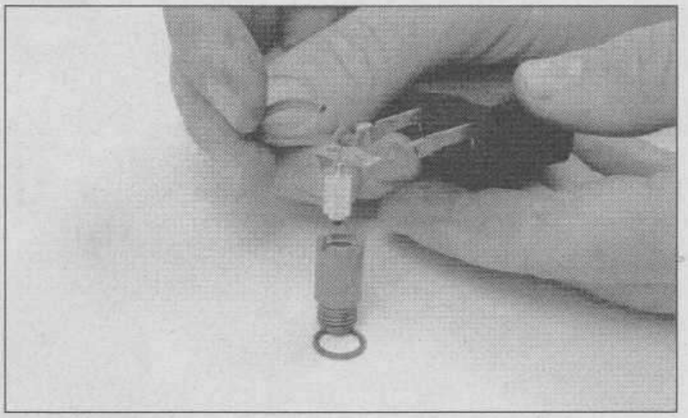
7D.40a Before installing the air horn, reassemble the automatic choke linkage/housing (on-carburetor coil housing shown, divorced-coil linkage is similar). The shaft (1) goes through the hole (2) (be sure a new seal is installed at the hole) and through the lever (3) inside the main body housing. **Note:** *It's usually easiest to hook the linkage rod (not shown) to the lever and lower the lever into the hole using the linkage rod. Otherwise, you'll have to try to connect the rod with the lever already inside the carburetor.*



7D.40b Once the assembly has been reattached to the carburetor, verify the lever is on in the correct direction. Push down on the linkage rod and the lever inside the choke housing should be in the up position, as shown.



7D.41 Be sure to reinstall the check ball and screw (arrow) for the accelerator pump circuit



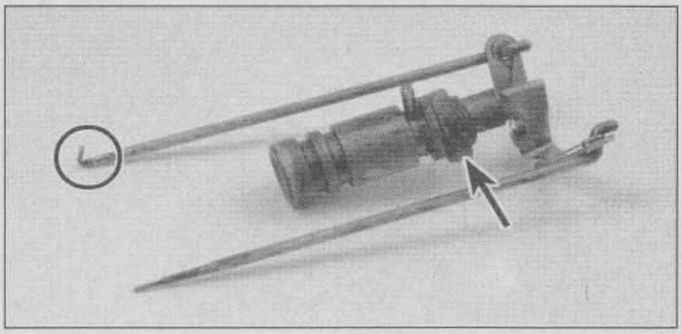
**7D.42 Reinstall the float and the new needle and seat with a new gasket. Note how the needle is suspended from the float arm by its clip - this is usually the easiest way to lower the two parts into the carburetor after the seat is screwed into place. Caution:** *Be sure to inspect the float, as described in Chapter 7A. Floats frequently need replacement at overhaul time.*

## Bench adjustments

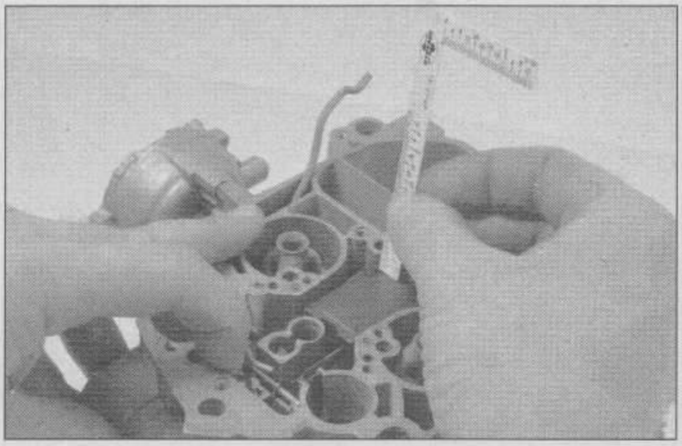
The following adjustments should be made during reassembly, before installing the carburetor on the vehicle. If not performing an overhaul, however, many of these adjustments can be made with the carburetor still installed on the vehicle.

Several choke-related adjustments require the use of an angle gauge to achieve optimum accuracy for emissions regulations. However, the following chart can be used to approximate the settings if an angle gauge is not available. Use a drill bit of the correct diameter (right column) positioned at the rear of the airhorn and close the choke plate against it to achieve the correct measurement.

| *Required adjustment angle at choke plate (degrees) (from overhaul kit instructions)* | *Choke plate-to-airhorn opening dimension (inches)* |
|---|---|
| 14 to 18 | 1/8 |
| 18 to 22 | 5/32 |
| 22 to 26 | 3/16 |
| 26 to 30 | 7/32 |
| 30 to 34 | 1/4 |
| 34 to 38 | 9/32 |
| 38 to 42 | 5/16 |
| 42 to 46 | 11/32 |

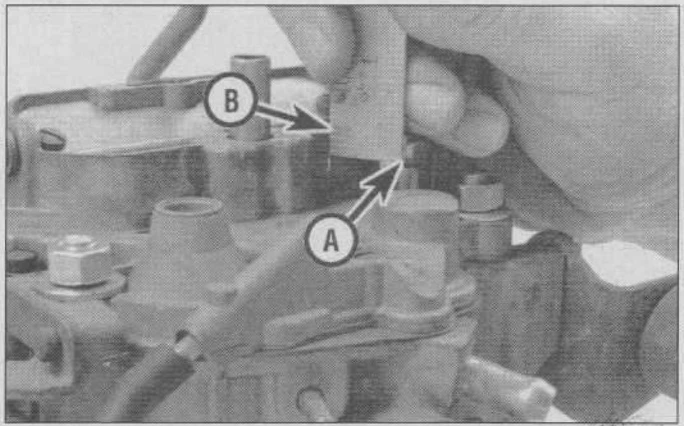


**7D.43 When reinstalling the power valve and metering rods on non-feedback models, be sure to carefully guide the metering rods into the main jets; otherwise, you might bend the fragile tips of the rods, as shown in the circle. Also, be sure to press the retainer (arrow) into the main body to secure the power valve against spring tension. After the retainer is in place, press the power valve down slightly against spring tension and release it - the retainer should keep the power piston from popping out of the main body. Note:** *New airhorn gaskets for non-feedback models are usually perforated in the area of the power valve/metering rods so you can install the valve and rods first. When installing the air horn gasket, press down the perforated center section and carefully guide it under the power valve arms/metering rods.*

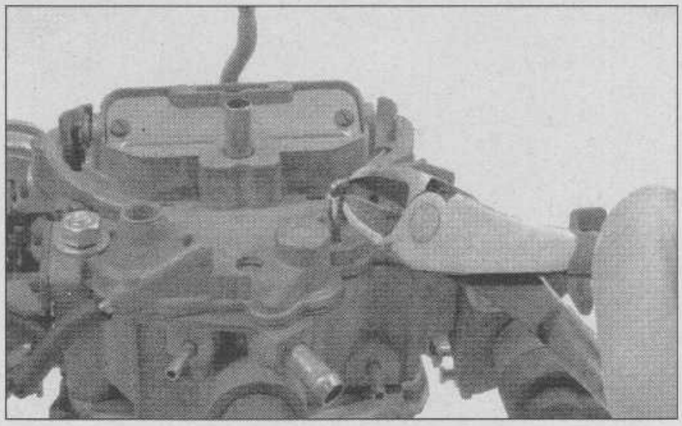


**7D.44 Float level adjustment details (all models)**

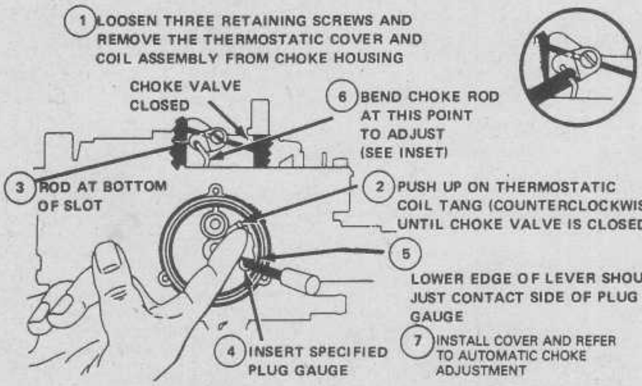
1 *Hold the float hinge pin/retainer firmly in place*
2 *Lightly push down on the front end of the float arm to seat the needle*
3 *Measure the distance from the top of the casting, with the gasket removed, to the top of the float at the point shown. Compare your measurement to the specification listed in the overhaul kit instructions.*
4 *If adjustment is necessary, remove the float and bend the float*



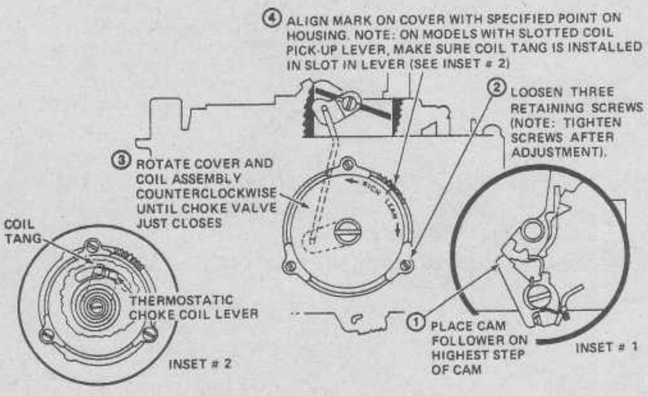
**7D.45 With the throttle valve completely closed and the linkage rod in the correct hole in the accelerator pump lever (see the overhaul kit specifications), use a ruler, as shown, to measure the height of the accelerator pump rod (point A to point B) and compare it to the specifications for your model . . .**



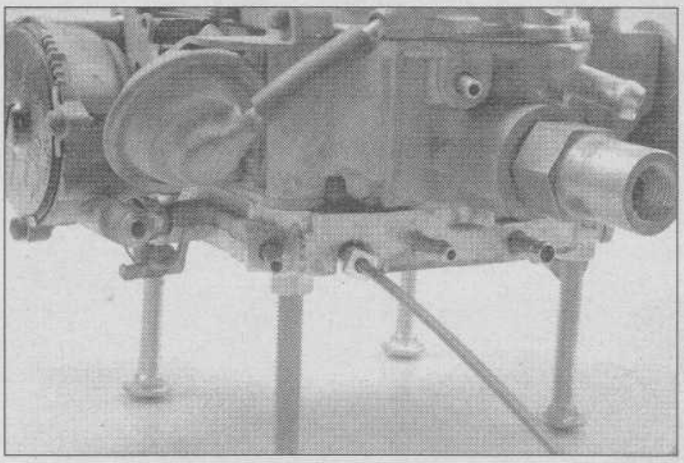
**7D.46 . . . and, if adjustment is needed, CAREFULLY bend the accelerator pump lever at the point shown in this illustration to get the correct height**



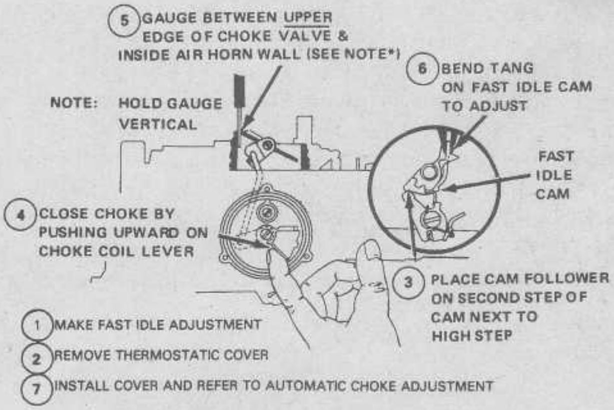
**7D.48 Rochester M4MC/M4MCA carburetor automatic choke coil lever adjustment details**



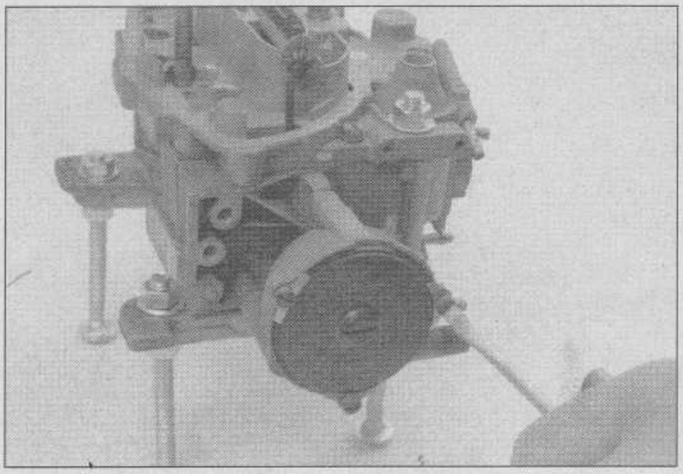
**7D.50 You set the automatic choke coil the same way on all models with an integral choke housing (attached to the carburetor). Follow the numbered sequence shown before installing the carburetor on the engine. Since choke coils lose their tension over time, you may find, on older coils, that lining up the marks does not provide enough choke. Readjust the coil by rotating the cover counterclockwise until the choke plate closes completely, then rotate it clockwise until the plate just moves away from the fully closed position (about 1/16-inch, measured at the rear of the air horn), and . . .**



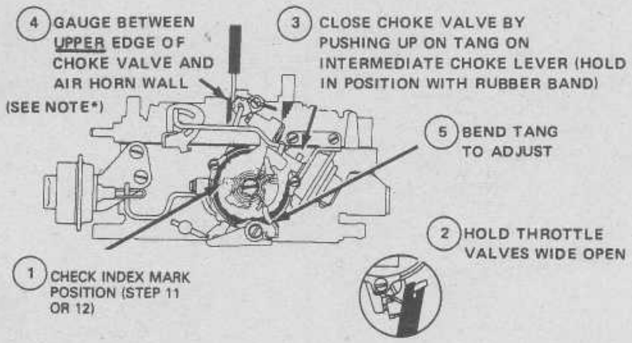
**7D.47 Reinstall the idle mixture screws and turn them clockwise until they're lightly seated, then turn them counterclockwise about 2 1/2 to 3 turns. This will provide a preliminary idle mixture adjustment. Final idle mixture adjustment must be made on the vehicle. Note:** *On models originally equipped with anti-tampering plugs, the screws have a D-shaped head and require a special screwdriver, like the one shown, for proper adjustment. Such screwdrivers are available at most auto parts stores.*



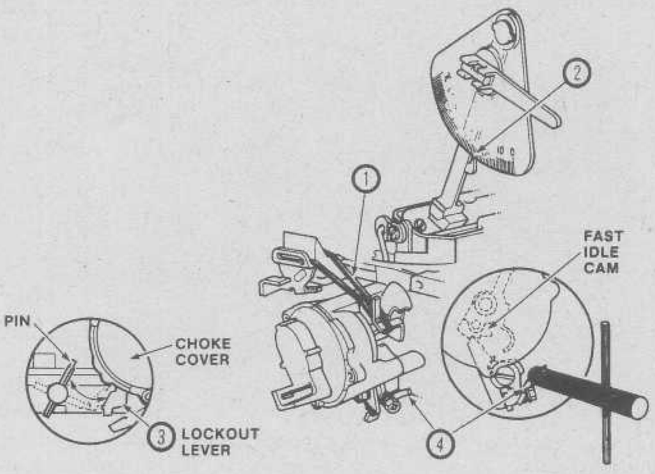
**7D.49 Rochester M4MC/M4MCA carburetor choke rod (fast idle cam) adjustment details**



**7D.51. . . re-tighten the three cover screws. Note that the metal clips beneath the screws must be positioned so they exert their maximum spring force against the cover. If they're installed backwards, the choke cover will have a tendency to rotate, changing the choke setting (manifold-heated choke housing shown).**

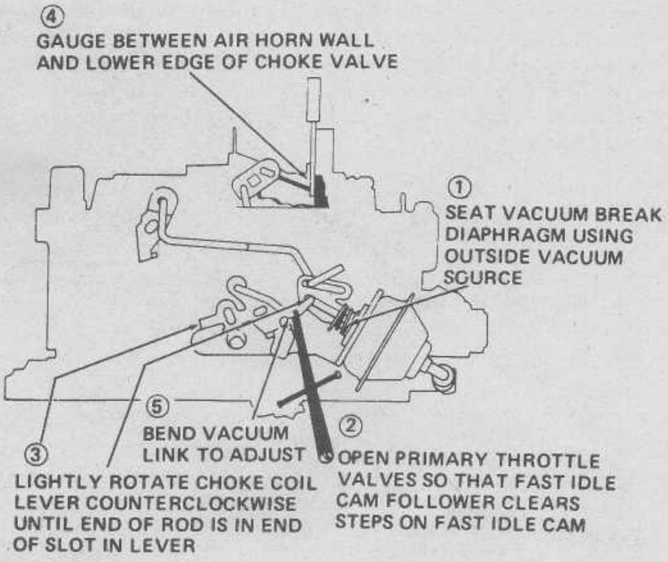


7D.52 Rochester M4MC/M4MCA carburetor choke unloader adjustment details

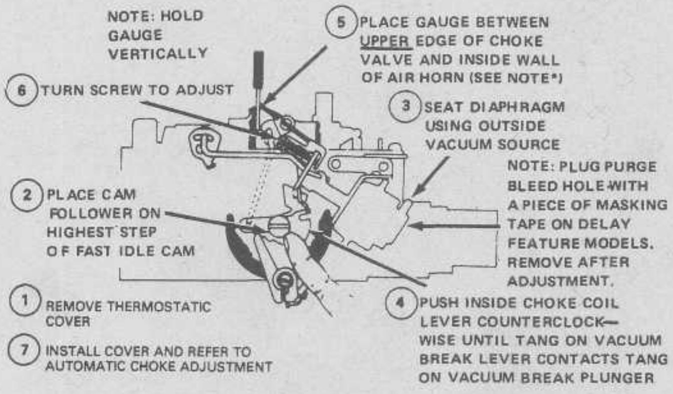


7D.53 Rochester E4ME/E4MC carburetor choke unloader adjustment

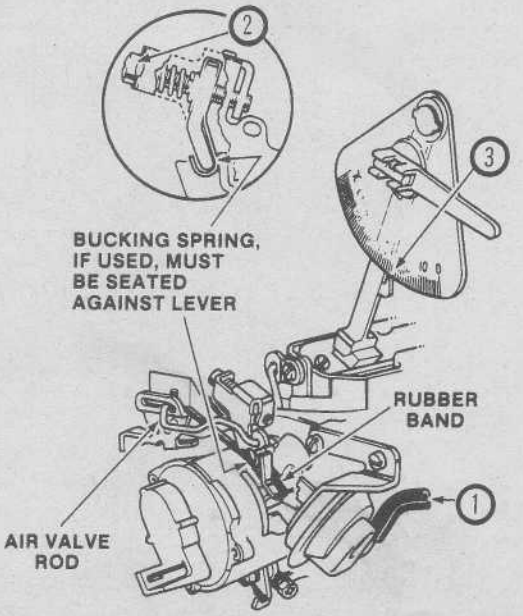
1 *Attach a rubber band to the intermediate choke shaft green tang*
2 *Set the angle gauge to the specified angle (see the overhaul kit specifications)*
3 *On Quadrajet models, make sure the secondary lockout lever is in the position shown*
4 *Adjust by bending the fast-idle lever tang*



7D.54 Rochester 4MV carburetor vacuum break adjustment (typical)

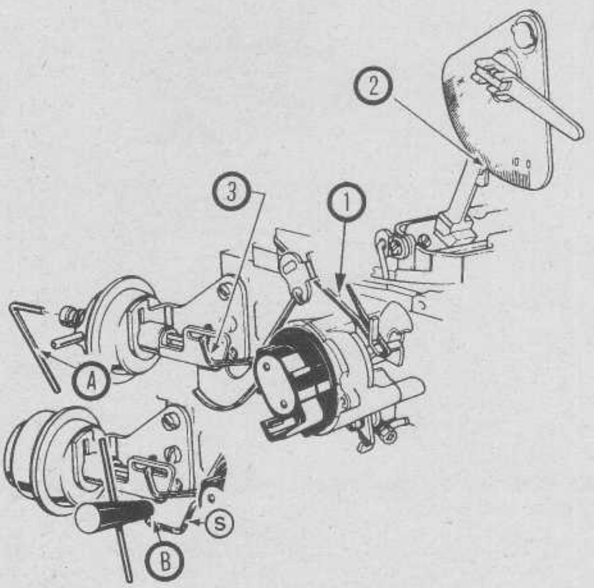


7D.55 Rochester M4MC/M4MCA carburetor vacuum break adjustment details



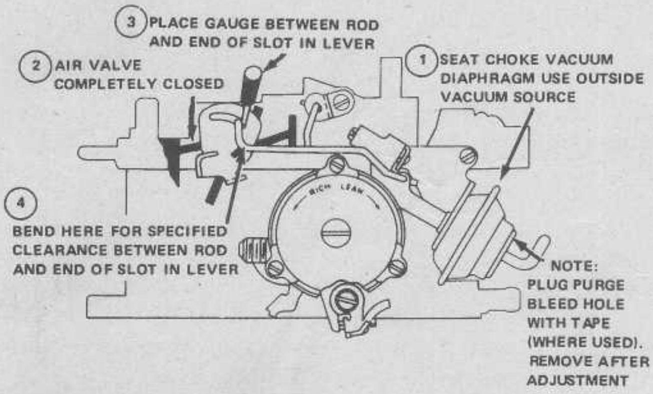
7D.56 Rochester E4ME/E4MC carburetor front vacuum break adjustment details. Before adjustment, install a rubber band to the intermediate choke shaft tang. Also install an angle gauge, as shown

1 *Apply vacuum to the vacuum-hose port with a hand-vacuum pump until the diaphragm is completely seated*
2 *Turn the adjustment screw . . .*
3 *. . . until the angle gauge (or drill bit - see page 7D-16) indicates the correct angle (see the overhaul kit specifications)*

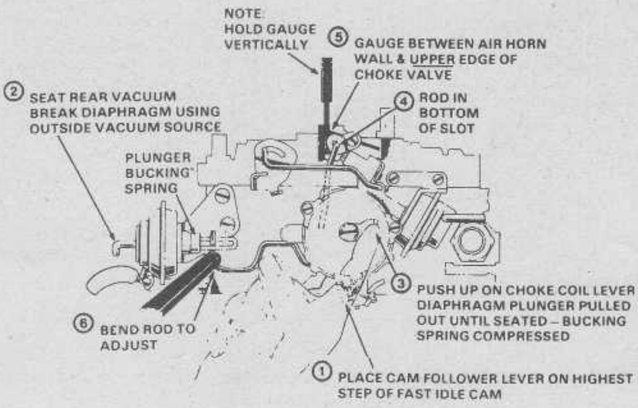


7D.57 Rochester E4ME/E4MC carburetor rear vacuum break adjustment details

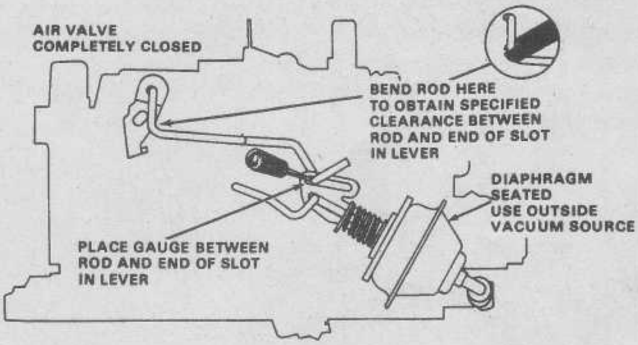
1 *Attach a rubber band to the intermediate choke shaft green tang*
2 *Set the angle gauge to the specified angle (or use a drill bit - see page 7D-16)*
3 *Air valve rod*
A *Adjust here - use a 1/8-inch Allen wrench*
B *Adjust here by bending the vacuum break rod while supporting it at Point S*



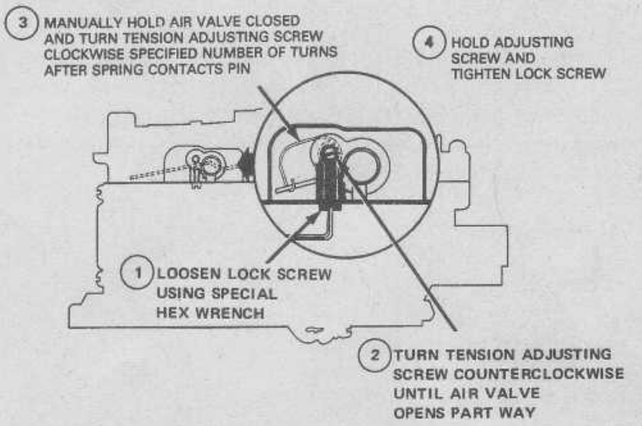
7D.60 Rochester M4MC/M4MCA carburetor air valve rod adjustment details



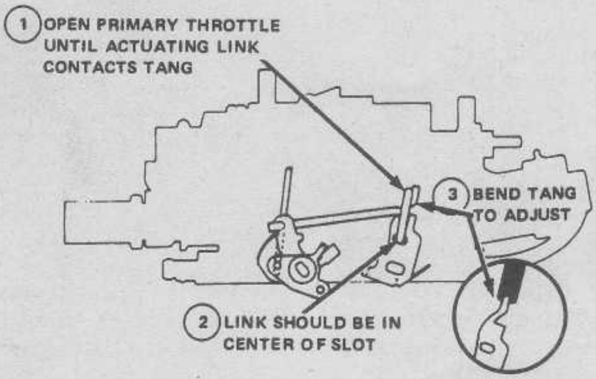
7D.58 Rochester M4ME carburetor rear vacuum break adjustment details



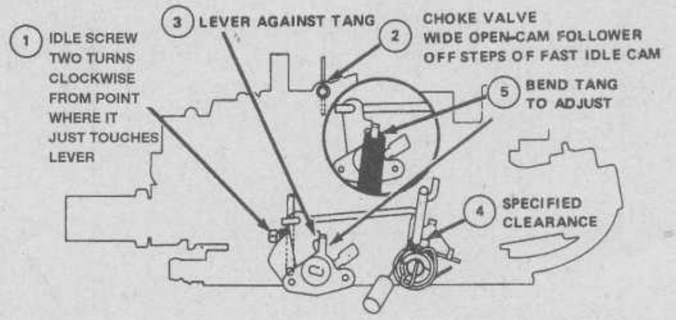
7D.59 Rochester 4MV carburetor air valve dashpot adjustment (typical)



7D.61 Rochester M4MC/M4MCA carburetor air valve spring adjustment details



7D.62 Rochester M4MC/M4MCA carburetor secondary opening adjustment details



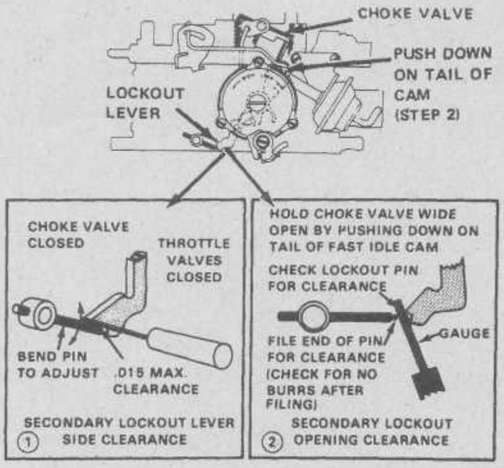
**7D.63 Rochester M4MC/M4MCA carburetor secondary closing adjustment details**

## *Mixture control solenoid plunger adjustment (feedback models only)*

### Measuring plunger travel

**Note:** *If you're reassembling the carburetor after overhaul, just set the air horn in place when measuring the plunger travel (there's no need to install the gasket or screws, and you may need to remove the air horn again to adjust the travel).*

1) Insert a special carburetor float gauge tool (available from auto parts stores and tool manufacturers) into the vertical "D"-shaped vent hole in the air horn casting next to the idle air bleed valve cover **(see illustration)**. It may be necessary to file material off the side of the gauge to make clearance for the tool to enter without binding.
2) First, press down on the gauge and make sure the gauge moves up and down freely without any binding.
3) With the gauge resting against the plunger (no pressure applied), sight across the air horn and record the mark on the gauge that lines up with the top of the air horn casting (upper edge).
4) Lightly press DOWN on gauge until the plunger bottoms. Record this measurement **(see illustration)**.
5) Now, subtract the first measurement from the second measurement and record the difference. This reading is the total plunger travel.



**7D.64 Rochester M4MC/M4MCA carburetor secondary lockout adjustment details**

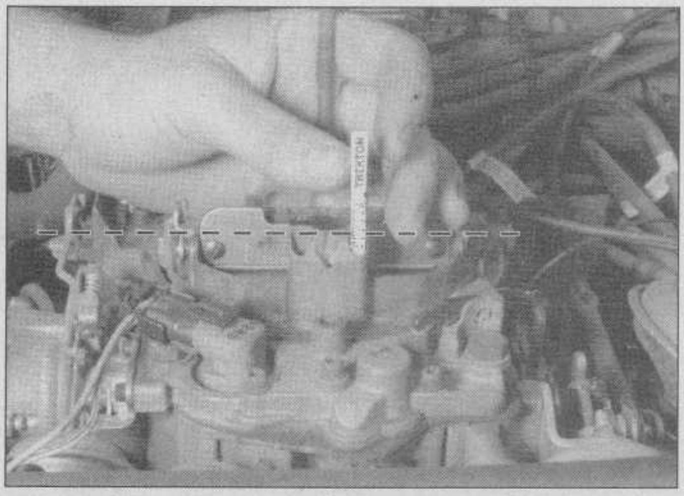
6) If the difference in travel is between 3/32 and 5/32-inch, no adjustment is necessary. If the difference is less than 3/32-inch (not enough travel) or greater than 5/32-inch (too much travel), adjust the plunger travel, as follows.

### Adjusting plunger travel

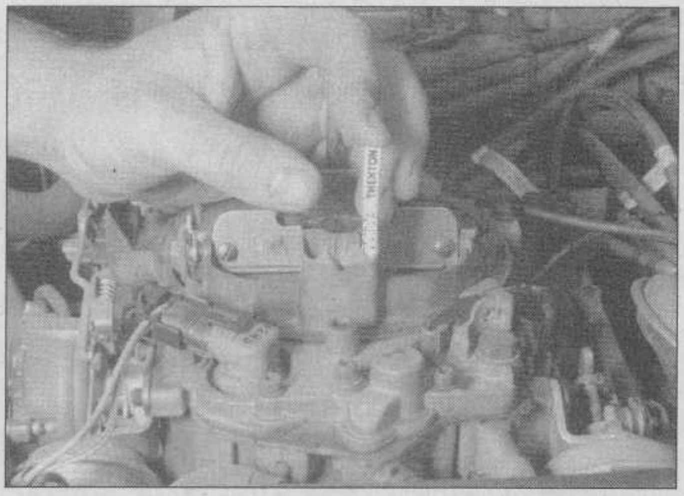
**Note 1:** *This adjustment usually is not required after overhaul if you kept the adjustment at its original setting. It is only necessary if the travel is not correct or the duty cycle (percent "on time") is incorrect as determined by the* System performance test *detailed in Chapter 5.*

**Note 2:** *The air horn must be removed from the carburetor during this procedure; however, the procedure can be performed with the carburetor on or off the vehicle.*

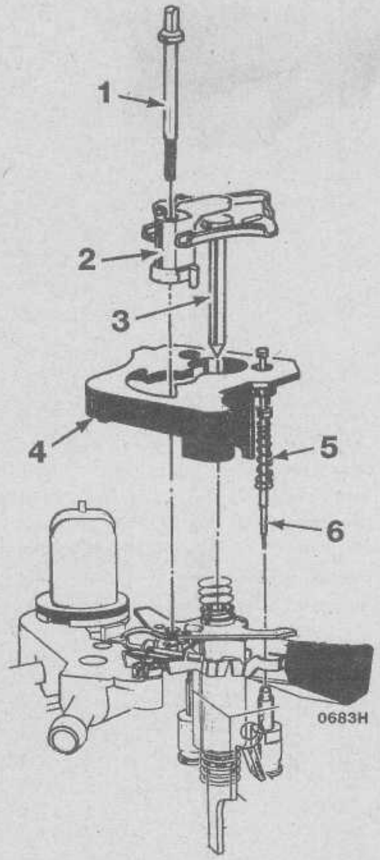
**Note 3:** *These carburetors are equipped with either a* ***four-point*** *mixture control solenoid adjustment system (earlier feedback systems) or a* ***two-point*** *mixture control solenoid adjustment system (mainly on 1985 and 1986 models). The four-point system is equipped with separate lean-stop and rich-stop adjustments that correctly adjust the travel of the solenoid plunger from rich to lean. The* ***two-point*** *system uses an inte-*



**7D.65 To measure plunger travel, first measure the plunger height with no pressure applied to the gauging tool, then . . .**



**7D.66 . . . press lightly on the gauge until it bottoms the plunger and measure again. The difference between the two measurements is the travel.**



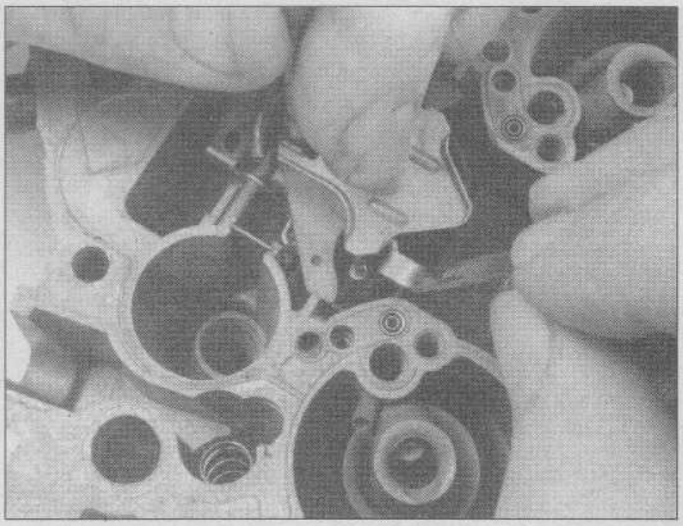
7D.67 Mixture-control solenoid and related components - exploded view (two-point adjustment system shown, four-point system similar)

1 *Adjusting screw*
2 *Limit stop (two-point type shown) - note arm on top that provides the rich stop*
3 *Solenoid plunger*
4 *Float-bowl insert*
5 *Metering rod spring*
6 *Metering rod (two per carburetor)*

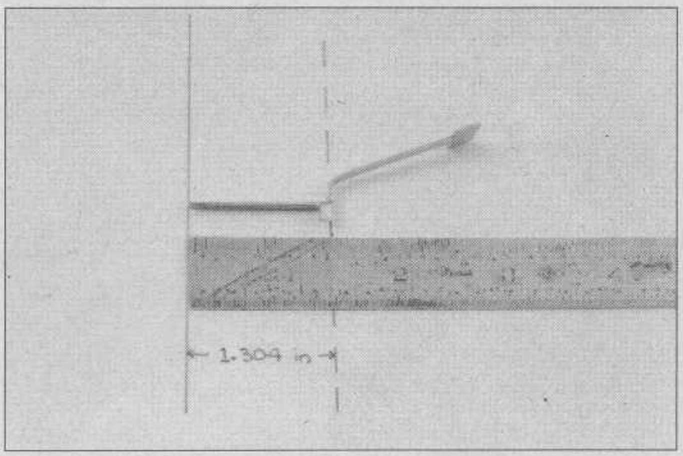
*gral rich limit stop bracket that essentially limits the travel of the plunger going up (rich) as well as the plunger going down (lean). Therefore, only one adjustment is required.*

**All models**

1) Remove the air horn from the carburetor. Also remove the solenoid plunger and the plastic float-bowl insert, then reinstall the plunger (removing the insert will allow access to the float-bowl area). **Note:** *On two-point systems* **(see illustration)**, *it will be necessary to remove the solenoid adjusting screw and rich-stop before the solenoid plunger and insert can be removed. Prior to removing the screw, turn it clockwise until the plunger bottoms, counting the number of turns. After the insert is removed, reassemble the plunger and stop, setting the adjusting screw the same number of turns from the lightly-bottomed position.*
2) Now install a special gauging tool (available from auto parts stores and automotive tool suppliers) onto the base of the metering jet and directly under the solenoid plunger **(see illustration)**. This tool is made specifically to measure the solenoid plunger travel **(see illustration)**, which should be 1.304 inches.



7D.68 To adjust the lean-stop, place the gauging tool (being held at right) on the metering jet and under the solenoid plunger, as shown, then depress the plunger and turn the adjusting screw until the plunger bottoms against the lean stop and touches the top of the gauging tool simultaneously

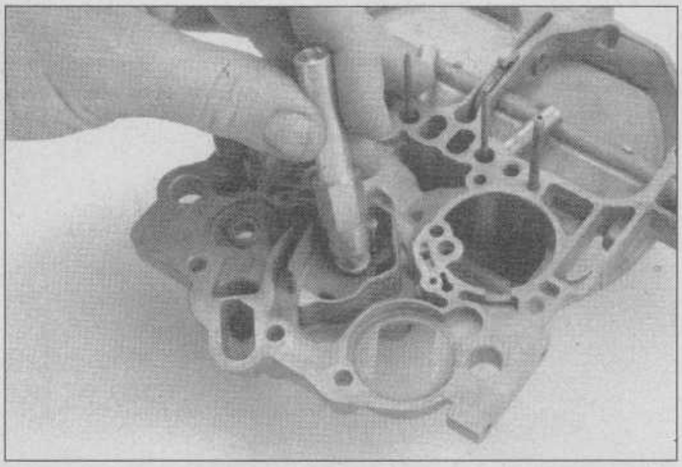


7D.69 The gauging tool, shown here, allows you to precisely set the lean-stop at 1.304 inches.

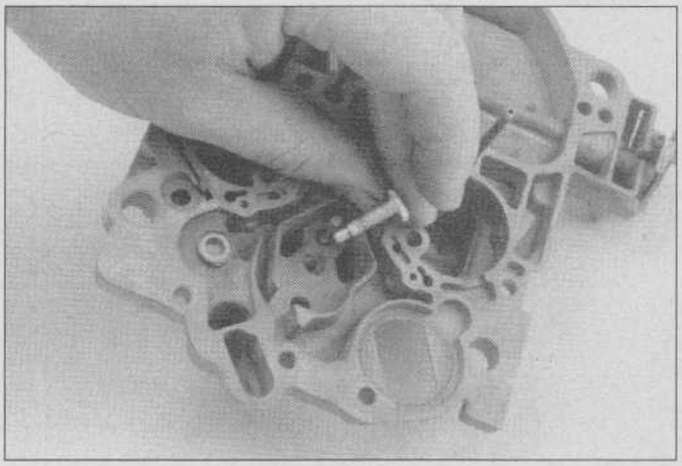
3) Apply very slight pressure to the solenoid plunger with the tip of your finger to bottom it. Slowly turn the lean-stop screw with the special adjustment tool until it (the solenoid plunger) just touches the gauging tool when it's bottomed against the lean stop. This is the factory-specified distance for the lean-stop adjustment.
4) If you have a four-point system, proceed to Step 5. If you have a two-point system, the adjustment is complete. Turn the adjusting screw clockwise to the lightly-bottomed position, counting the number of turns, then unscrew and remove the screw, rich stop and plunger. Install the insert and reassemble the parts, turning the adjusting screw in the same number of turns. Install the air horn and proceed to Step 9.

**Models with four-point adjustment systems only**

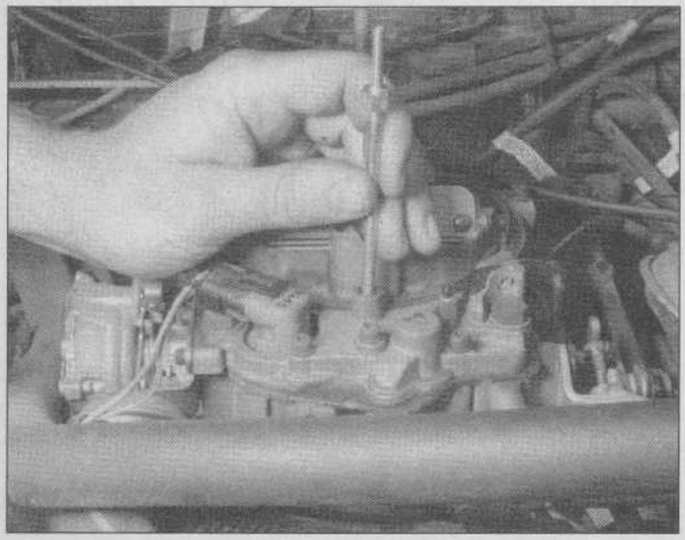
5) Reinstall the air horn, along with a new gasket, onto the carburetor main body, but attach it temporarily with two screws only. Recheck the solenoid plunger travel, as described earlier in this procedure. If the travel is correct, completely assemble the air horn and proceed to Step 9 to finish the job.



7D.70 On four-point systems, if the travel is not correct after setting the lean-stop, unscrew . . .



7D.71 . . . and remove the rich-stop screw from the carburetor air horn



7D.72 Using a special tool to adjust the rich-stop screw on four-point systems

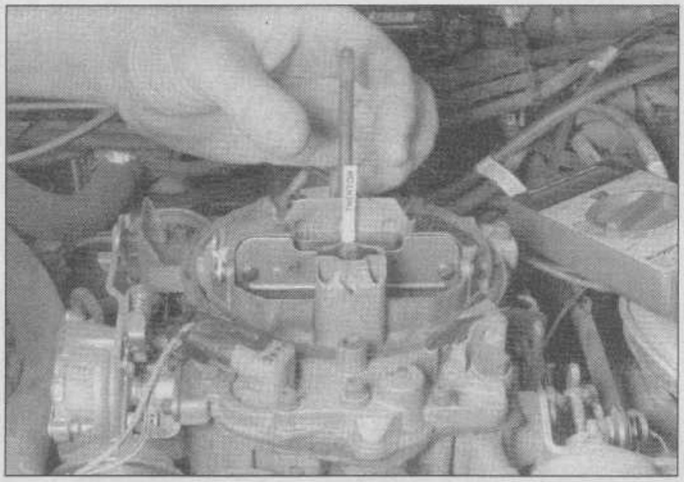
6) If the plunger travel is still not correct, remove the air horn, invert it and remove the rich-stop screw **(see illustrations)**.
7) With the rich-stop screw removed, drive the plug out of the air horn using a punch and a hammer. Reinstall the rich-stop screw.
8) Reinstall the carburetor air horn. Insert the special float gauge into the "D"-shaped vent hole (see *Measuring plunger travel* earlier in this procedure) and, using the special carburetor tool, turn the rich-stop screw **(see illustration)** until the total solenoid plunger travel is 1/8-inch.

### All models

9) With the plunger travel correctly set and the air horn reinstalled, install the replacement plugs into the carburetor body. Be sure to install the hollow end down.

## On-vehicle adjustments

After the carburetor is reinstalled on the engine (see Chapter 6), several on-vehicle adjustments are necessary to fine-tune engine performance. Also, make these adjustments any time engine performance is poor and you suspect carburetor problems.



7D.73 Using a gauge, the "wet" float level can be checked on the vehicle, without removing the air horn

### Float level check

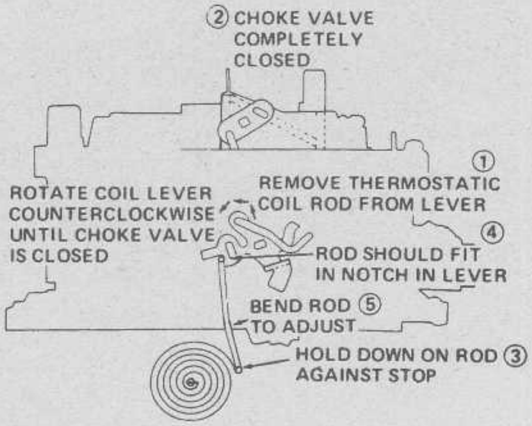
**Note:** *This procedure is normally not necessary after overhaul if the float level was carefully set during reassembly.*

These carburetors are equipped with a slotted access hole to insert a special float level tool for quick-checking the float level adjustment. These tools are available from auto parts stores and tool manufacturers. This procedure will allow the home mechanic to find out if the float level is incorrect and the cause of any driveability problems such as hard starting, flooding or a rich-running condition.

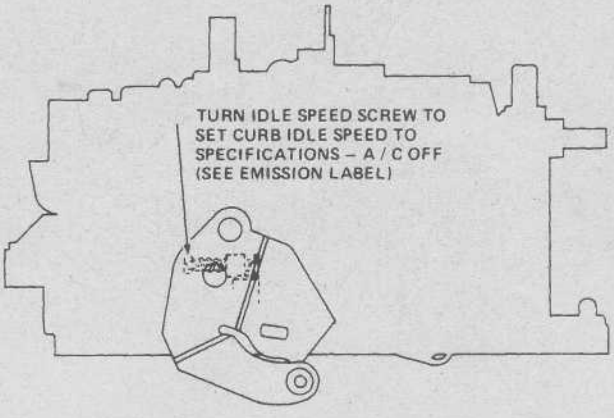
First, with the engine running at idle and the choke wide open, carefully insert the gauge into the vent slot (next to the air cleaner mounting stud) in the air horn and allow it to rest against the float inside the carburetor (do not press down on the gauge) **(see illustration)**.

Sight across the top of the air horn and observe the mark on the gauge directly at eye level as it lines up with the top of the casting at the vent slot. The setting should be within 1/16 inch of the specified float level setting. Refer to your carburetor specification sheet included in the overhaul kit for the correct float setting.

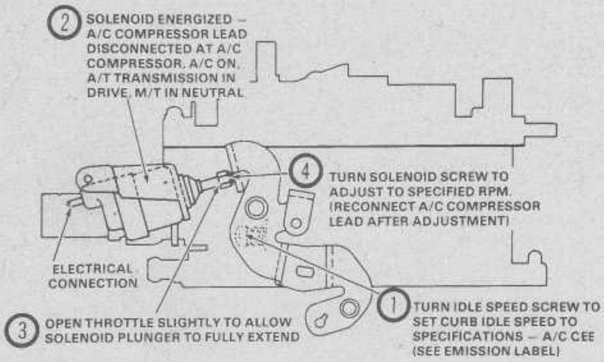
If the setting varies more than 1/16-inch, remove the air horn and adjust the float level according to the procedure described in illustration 7D.44.



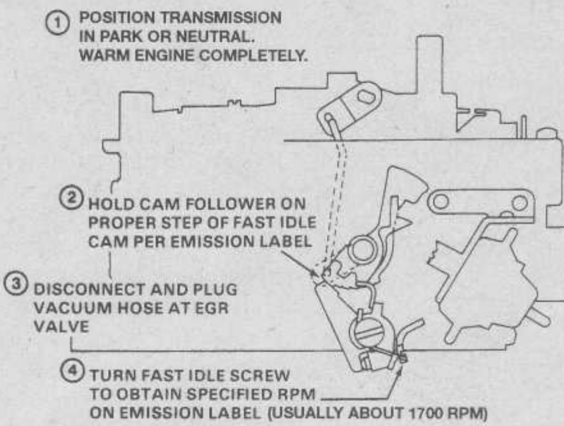
**7D.74** On models with a "divorced" choke coil (mounted in the intake manifold), follow these steps to set the choke coil. When the engine is at room temperature (about 70-degrees F), open the throttle and make sure the coil holds the choke valve almost (but not quite) completely closed. If not, the coil is faulty or the linkage is binding.



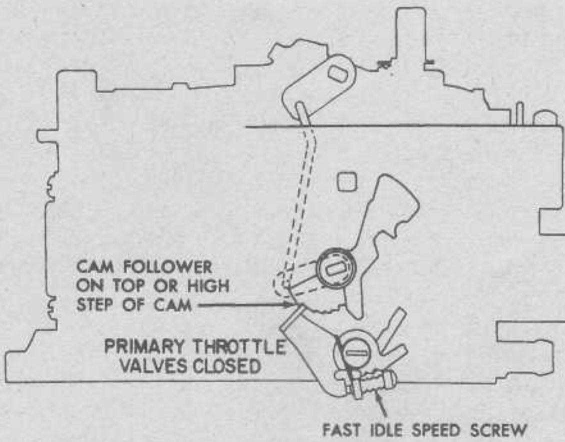
**7D.75** On non-feedback models without an idle-stop solenoid, after the engine is warmed to normal operating temperature and the idle mixture is adjusted, turn the idle speed screw, as necessary, to adjust the idle speed to the specification listed on the VECI label under the hood (normally, the speed should be approximately 750 rpm with the transmission in PARK [automatic] or NEUTRAL [manual]).



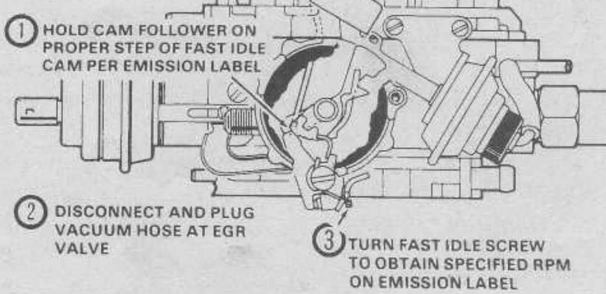
**7D.76** If your non-feedback carburetor is equipped with an idle-stop solenoid, as shown, set the curb idle speed, as discussed in illustration 7D.75. Then follow the Steps shown in this illustration to adjust the solenoid-idle speed to the specification listed on the VECI label under the hood.



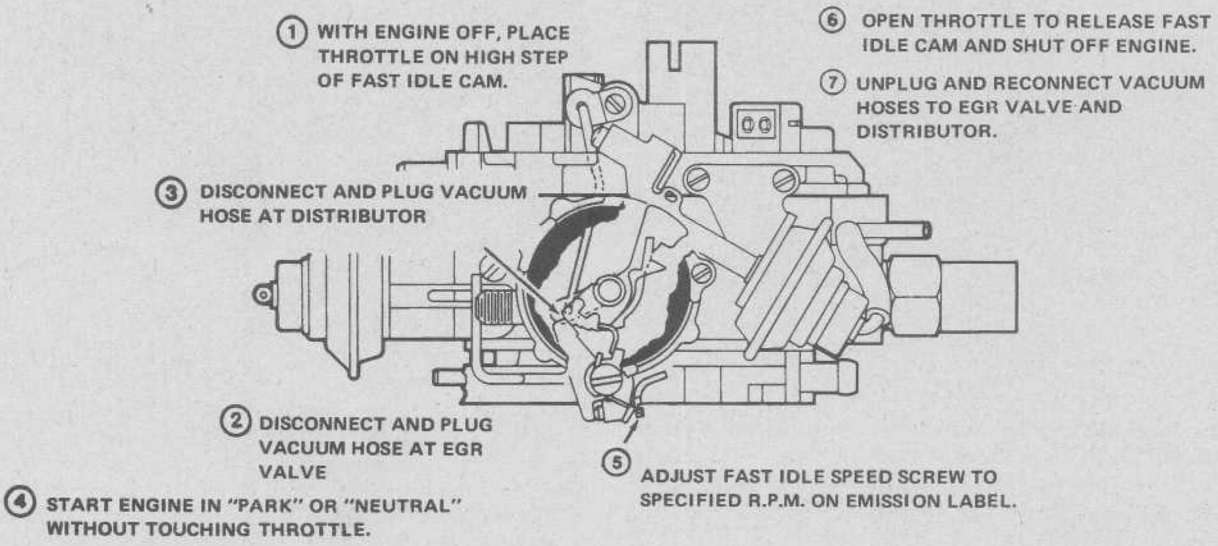
**7D.77** Fast-idle speed adjustment details (M4M/M2M models)



**7D.78** The fast-idle speed screw is in a slightly different location on 4MV models, but the procedure is essentially the same as shown in the previous illustration.



**7D.79** Fast-idle adjustment details (E4ME/E4MC models)



7D.80 Fast-idle adjustment details (M2ME models)

### Idle mixture adjustment

**Note:** *On some later models with D-shaped mixture screw heads, a special screwdriver, available at most auto parts stores, will be necessary to make this adjustment.*

With the engine idling at the proper speed, turn each idle mixture screw clockwise **(see illustration 7D.34)** until the idle speed drops a noticeable amount. Now slowly turn the mixture screw counterclockwise until the maximum rpm is achieved, but no further. Work from one mixture screw to the other, making sure both screws are about the same number of turns out from the lightly-bottomed position; this assures there's a mixture balance. After the idle mixture adjustment is correct, check the idle speed again to make sure it's still correct.

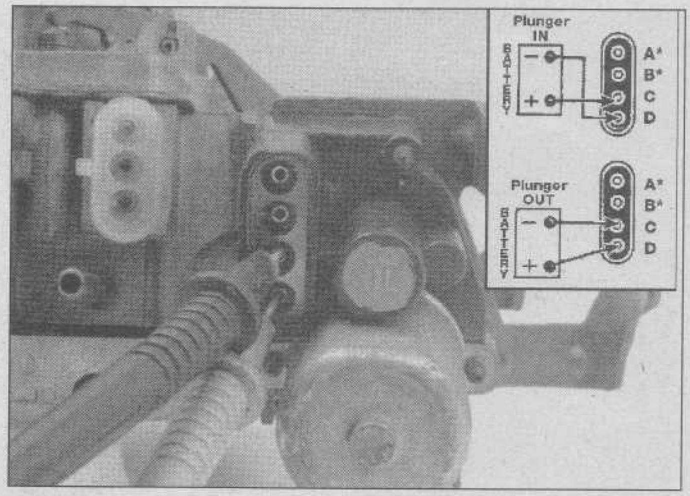
### Feedback carburetor adjustments

Depending upon the engine size and year of the vehicle, feedback carburetor systems require several on-vehicle adjustments to fine-tune engine performance.

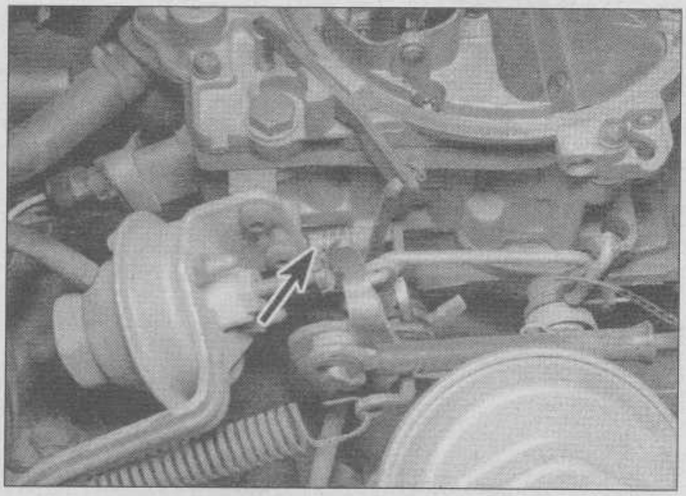
### Idle speed control (ISC) system

If the carburetor has just been overhauled, the ISC solenoid has just been replaced with a new one or the vehicle is having a fluctuating idle problem, it is necessary to check the ISC system adjustments.

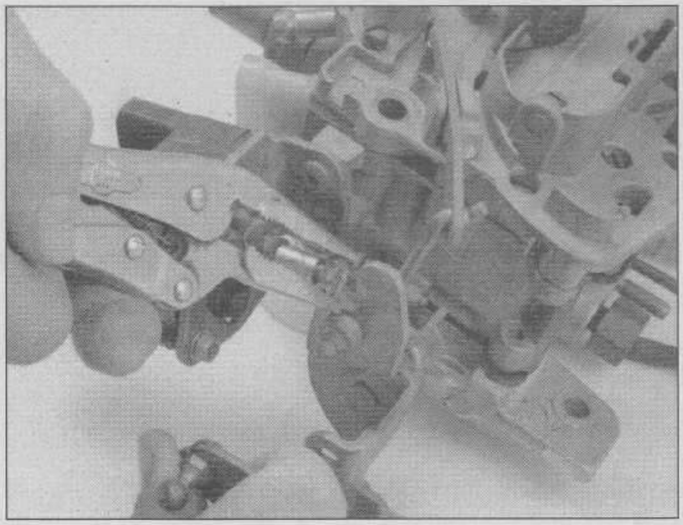
1) First, place the transmission in Neutral, set the parking brake and block the drive wheels. Connect a tachometer according to the manufacturer's instructions.
2) With the A/C off (if equipped), start the engine and warm it up to normal operating conditions (closed loop).
3) Turn the ignition OFF and unplug the connector from the ISC motor.
4) Fully retract the ISC plunger by applying 12 volts to terminal C (run a fused jumper wire from the battery's positive terminal) of the ISC motor connector and grounding terminal D **(see illustration)**. **Note 1**: *Do not allow the battery voltage (12V) to contact terminal C any longer than necessary to retract the ISC plunger. Prolonged contact will*



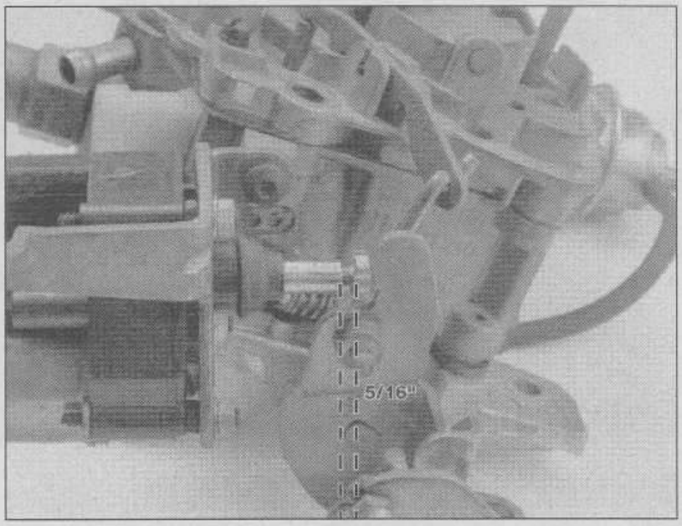
7D.81 Using jumper wires, apply battery voltage to terminals C and D to extend or retract the ISC solenoid plunger



7D.82 Location of the idle-stop screw (arrow) on feedback carburetors (on non-feedback carburetors, this is the curb-idle speed screw)



**7D.83 Adjust the ISC plunger by turning the plunger end with pliers (carburetor removed from engine for clarity), but . . .**



**7D.84 . . . do not unscrew the plunger end more than 5/16-inch from its all-the-way-in setting**

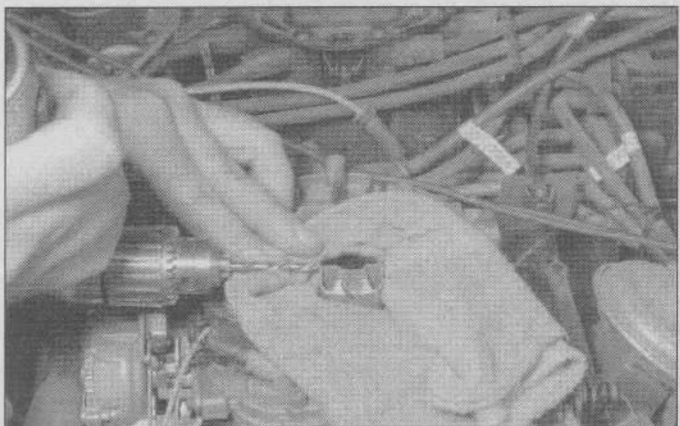
*cause damage to the motor. Also, it is very important to never connect a voltage source across terminals A and B, as it may damage the internal throttle contact switch.* **Note 2:** *If the ISC solenoid does not respond when battery voltage is applied to the C and D terminals, it is faulty and should be replaced.*

5) Start the engine and allow it to return to normal operation (closed loop). Have an assistant place his foot firmly on the brake and place the transmission in DRIVE (automatic) or Neutral (manual).
6) With the plunger completely retracted (from Step 5), turn the idle stop screw **(see illustration)** to attain the minimum idle speed. The minimum base idle speed is usually about 450 rpm in DRIVE. Consult your VECI label under the hood of the engine compartment to verify the idle specifications.
7) Now, with the transmission In DRIVE or Neutral and an assistant holding his foot firmly on the brake pedal, fully extend the plunger by applying battery positive voltage (12V) to terminal D of the ISC connector and grounding terminal C **(see illustration 7D.81). Note**: *Do not allow the battery voltage (12V) to contact terminal D any longer than necessary to retract the ISC plunger. Prolonged contact will cause damage to the motor. Also, it is very important to never connect a voltage source across terminals A and B as it may damage the internal throttle contact switch.*
8) With the ISC plunger fully extended, check the idle speed, which should be approximately 900 rpm in DRIVE or NEUTRAL. If necessary, adjust the plunger length **(see illustrations)**. Consult your VECI label under the hood of the engine compartment to verify the idle specifications. **Note**: *When the ISC plunger is in the fully extended position, the plunger must also be in contact with the throttle lever (on carburetor) to prevent possible internal damage to the ISC solenoid.*
9) If the ISC motor was removed and the plunger length changed, double-check the maximum allowable speed (see Step 8). If necessary, readjust the plunger until the correct speed is obtained.
10) Reconnect the harness connector to the ISC motor.

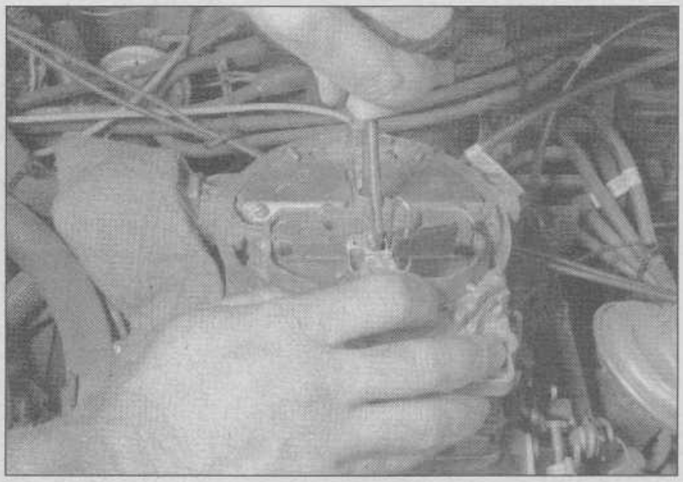
### Idle air bleed valve (E2ME and E4ME)

To gain access to the idle air bleed valve, it is necessary to first remove the idle air bleed valve cover. Often, if the carburetor has been overhauled before, the cover has already been removed. If it has not been removed before, the air bleed is probably still at its factory setting and should not be tampered with unless it's known to be incorrect.

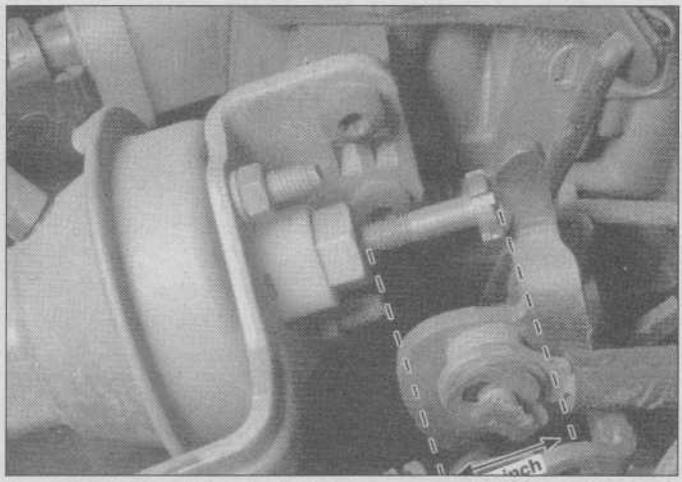
1) With the engine off, cover all the bowl vents, air inlets and air intakes with masking tape to prevent any metal chips from falling into the carburetor.
2) Carefully align a Number 35 drill bit (0.110 inches) on one end of the steel rivet heads and drill only enough to remove the rivet head from the carburetor. Use a drift and hammer to remove the remaining rivet from the assembly **(see illustration)**.
3) Lift off the cover and remove any pieces of metal, rivets or debris from the carburetor body. Discard the idle air bleed valve cover.
4) Using compressed air (if available) blow out any remaining pieces of metal from the carburetor area.
   **Warning:** *Be sure to wear safety goggles whenever using compressed air.*



**7D.85 Be sure to protect the carburetor when drilling out the air-bleed cover rivets (otherwise, metal chips could fall into the carburetor!)**



**7D.86 The special gauging tool shown is necessary to check the idle air bleed valve adjustment. Use a large screwdriver, as shown here, to adjust the valve.**



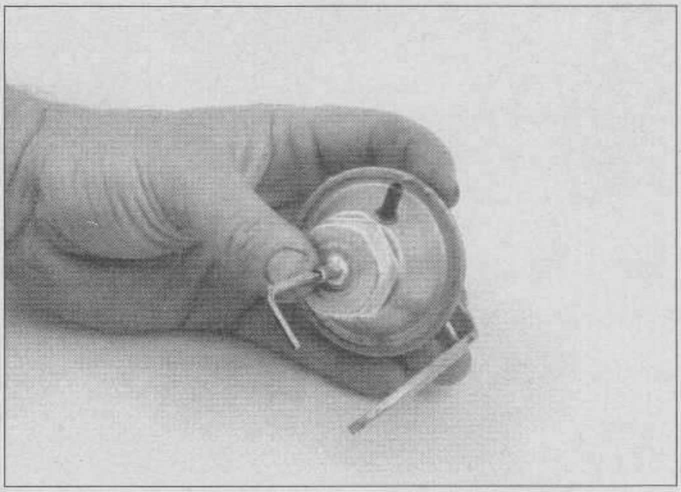
**7D.87 DO NOT adjust the ILC plunger to a point where the screw is extending more than 1-inch**

5) Install a special gauging tool (available from auto parts stores and automotive tool suppliers) into the "D"-shaped vent hole **(see illustration)**. The upper end of the tool should be positioned over the open cavity next to the idle air bleed valve.
6) While holding the gauging tool down lightly, engage the solenoid plunger against the solenoid stop. Adjust the idle air bleed valve so that the gauging tool will pivot over and just contact the top of the valve **(see illustration 7D.86)**.
7) Remove the gauging tool. Next, it will be necessary to check the duty cycle ***(on-time)*** of the mixture control solenoid to verify that the air bleed is adjusted properly or if the idle mixture must be adjusted (see the *System performance check* in Chapter 5).
8) Disconnect the canister purge hose and plug the end (canister side). Start the engine and allow it to reach normal operating temperature (closed loop). Follow the procedure for checking the M/C solenoid duty cycle in Chapter 5 *System performance check*. If the dwell average is not within 25 to 35 degrees, then it will be necessary to adjust the idle mixture (refer to the procedure in this chapter).

### Idle load compensator (ILC) (some later 5.0L engines)

The idle load compensator (ILC) is used instead of an ISC solenoid on some later 5.0L engines to control curb idle speed. The ILC uses manifold vacuum to sense changes in engine load and compensates by changing the idle speed. The idle load compensator is adjusted at the factory. It is not necessary to make any adjustments unless the curb idle speed is out of adjustment or the ILC solenoid was faulty and had to be replaced. Before adjusting the ILC, make sure the vacuum lines to the anti-diesel solenoid, vacuum regulator, ILC solenoid and all the components that require vacuum are in order and not leaking. Check the vacuum schematic on the VECI label under the hood for the correct vacuum routing.

1) Connect a tachometer according to the manufacturer's instructions. Remove the air cleaner and plug the hose to the thermal vacuum valve (TVV). Disconnect and plug the vacuum hose to the EGR valve. Disconnect and plug the vacuum hose to the canister purge port. Disconnect and plug the vacuum hose to the ILC.
2) Back out the idle-stop screw on the carburetor three turns **(see illustration 7D.82)**.
3) Turn the A/C system OFF (if equipped). Place the transmission in PARK (automatic) or NEUTRAL (manual), apply the emergency brake and place a block under each of the drive wheels.
4) Start the engine and allow it to reach normal operating temperature. On automatic transmission models, have an assistant place his foot firmly on the brake pedal and place the transmission in DRIVE. The ILC plunger should be fully extended with no vacuum applied. Using back-up wrenches, adjust the ILC plunger to obtain 750 rpm, plus or minus 50 rpm.
5) Next, measure the distance from the jam nut to the tip of the plunger **(see illustration)**. It should not exceed 1 inch. If the plunger measures more than 1 inch, check for other carburetor problems.
6) Remove the plug from the vacuum hose and reconnect it to the ILC and observe the idle speed. Idle speed should be 450 rpm (vehicle in NEUTRAL (manual) or DRIVE with the brake applied). If the idle speed is correct, proceed to Step 9).
7) If the idle speed is not correct, it will be necessary to adjust the ILC diaphragm. Stop the engine and remove the ILC. Remove the center cap from the center outlet tube. Using a 3/32 inch hex key wrench, insert it through the open center tube to engage the idle speed adjusting screw inside **(see illustration)**. If the idle speed was low, turn the adjusting screw counterclockwise ONE turn to increase the idle speed approximately 75 rpm. Conversely, turn the screw clockwise ONE turn to lower the idle speed about 75 rpm. **Note***: Turn the adjusting screw TWO full turns to raise or lower the idle speed approximately 150 rpm and consequently use the same ratio to calculate the necessary rpm change desired for the situation.*
8) Re-install the ILC onto the carburetor and attach the springs and other related parts. Recheck the idle speed. Make sure the engine is completely warmed up (closed loop). If it is not correct, repeat the ILC adjustment procedure.
9) The last adjustment must be performed on the engine after the TPS value has been reset by the ECM. This can be accomplished by turning off the ignition for 10 seconds or more. Using a hand-held vacuum pump, apply vacuum to the ILC vacuum tube inlet to fully retract the plunger.



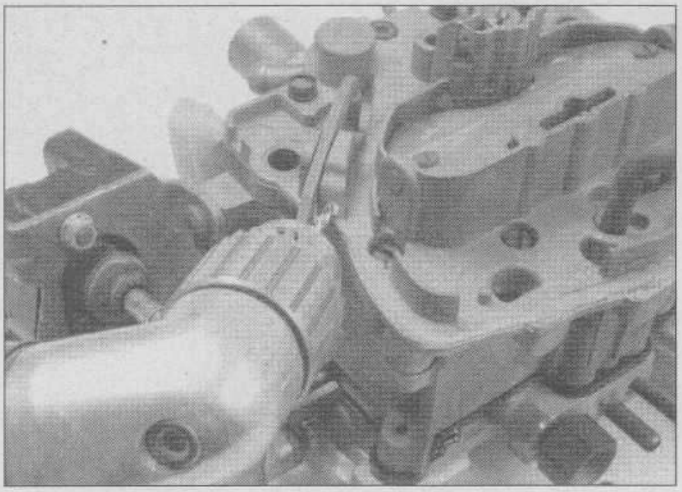
**7D.88 Use a 3/32-inch hex wrench to adjust the ILC solenoid (removed from vehicle for clarity)**

10) Adjust the idle stop screw on the carburetor to obtain 450 rpm with the vehicle in NEUTRAL (manual) or DRIVE with the brake applied.
11) Place the vehicle in PARK and stop the engine. Remove the plug from the ILC vacuum hose and install the hose onto the ILC. Reconnect all the vacuum hoses, install the air cleaner and gaskets.

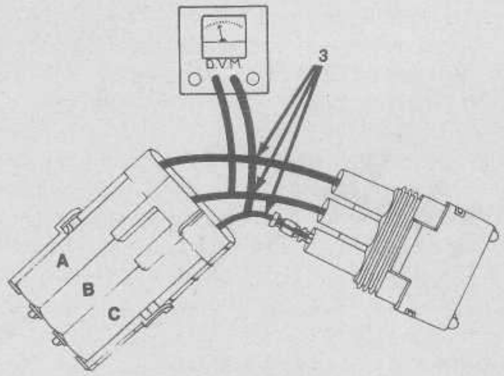
**Throttle position sensor (TPS)**

The throttle position sensor is equipped with an adjustment screw that is covered over with a factory-installed plug. Do not remove the plug unless it has been determined with careful testing that the TPS is out of adjustment. Refer to Chapter 5 for complete diagnostic procedures for checking the TPS. This is a critical adjustment that must be performed correctly.

1) Using a 0.076-inch drill bit, carefully drill a hole in the aluminum plug covering the TPS adjustment screw **(see illustration)**. Drill only enough metal to start a self-tapping screw.
2) Start a number 8 X 1/2-inch long self-tapping screw into the drilled hole in the plug, turning the screw just enough to ensure good thread engagement in the hole.
3) Place a wide blade section of screwdriver between the screw head and the air horn casting. Carefully pry against the screw head to remove the plug. It is also possible to use a slide hammer.
4) Disconnect the TPS electrical connector, install jumper wires, as shown **(see illustration)**, then connect a digital voltmeter between the wires connected to the B (center) and C (bottom) terminals of the TPS connector on the carburetor.
5) With the engine off and ignition on and the throttle closed, turn the screw until the voltage reading is approximately 0.48 volts **(see illustration)**.
6) Make sure the voltage is correct. Then install a new plug into the air horn. Drive the plug into place until it is flush with the raised boss on the casting.



**7D.89 To adjust the TPS, drill out and remove the access plug (carburetor shown removed from vehicle for clarity) . . .**



**7D.90 . . . disconnect the TPS connector and hook up a digital voltmeter, as shown . . .**

**7D.91 . . . then use a small screwdriver to turn the adjusting screw until the voltage readings are correct**

# Notes

# 8 Selection and modification

## Finding the right carburetor

### *Carburetor selection*

Matching the carburetor to the engine and application is critical for performance and/or economy. Many hot rodders like the look of a huge carburetor, or carburetors, on their engine. They fall into the trap of "bigger is better" or "if a little is good, more is better." This might hold true for cubic inches, but it almost never should apply to carburetion.

If an engine is over-carbureted, it will have poor throttle response and bog and hesitate at low speeds and won't start to run well until very high rpm. Fuel economy and emissions will be poor.

Larger displacement engines and engines that run at high rpm need larger capacity carburetors than smaller engines running at lower speeds. The most important factors in carburetor size selection are engine displacement, maximum rpm and volumetric efficiency.

### *Volumetric efficiency*

Volumetric efficiency is a measure of the engine's ability to fill the cylinder completely, and is given as a percentage. For example, a 100 cubic inch engine that gets 80 cubic inches of air/fuel mix into the combustion chamber on each intake stroke has a volumetric efficiency of 80-percent.

Testing has shown that a volumetric efficiency of about 80 to 85-percent is reached, which is generally what an average, well built, four-barrel equipped high-performance street engine will provide. You must decide at what rpm range you want your engine to run best.

When selecting a carburetor, use the following formula or chart to estimate the required cfm rating **(see illustration)**. Round off all results to the nearest carburetor size. Be realistic, you're only hurting the end result of all your hard work by overestimating.

Put in your specific numbers for cubic inches and RPM range of the engine. The remaining number in the equation are predetermined except for the volumetric efficiency percentage

| | Engine RPM | | | | | |
|---|---|---|---|---|---|---|
| Engine displacement (cu. in.) | 4000 | 4500 | 5000 | 5500 | 6000 | 6500 |
| 250 | 245 | 260 | 290 | 320 | 350 | 380 |
| 275 | 255 | 290 | 320 | 350 | 380 | 420 |
| 300 | 280 | 315 | 350 | 380 | 420 | 450 |
| 325 | 300 | 340 | 380 | 415 | 450 | 490 |
| 350 | 325 | 365 | 405 | 445 | 490 | 525 |
| 375 | 350 | 390 | 435 | 480 | 520 | 565 |
| 400 | 370 | 420 | 465 | 510 | 555 | 600 |
| 425 | 400 | 450 | 500 | 550 | 600 | 650 |
| 450 | 420 | 470 | 520 | 580 | 625 | 700 |

**8.1 As a general rule, high performance small-block engines will need 400 to 600 cfm carburetors, and big-block engines will need 600 to 800 cfm carburetors, exact size will depend upon the actual engine modifications that have been made. Note:** *The table shown here is for stock street engines. For high performance models increase the cfm rating about ten percent.*

(VE). For the chart shown, a figure of 80-percent VE is used, but for an engine that is more highly modified, a figure of 85-percent will be closer to your actual cfm needs.

**The formula to use in figuring your own requirement (cfm) is:**

(cubic inches ÷ 2) x (maximum rpm ÷ 1728) x VE = cfm

**Example:**

You have a 350 cubic inch engine that will reach a maximum of 7000 rpm. Let's also say you've built an engine that's well thought out with the right combination of parts, so you're VE is roughly 85-percent, compared to the 80-percent used for milder engines. Plug these numbers into the formula:

(350 ÷ 2) x (7000 rpm ÷ 1728) x 85% = 602 cfm

So you would need approximately a 600 cfm carburetor to handle the needs of the engine.

**Note:** *As a general rule, high-performance small-block engines will need 400 to 600 cfm carburetors and big-block engines will need between 600 to 800 cfm, depending on actual displacement and level of modification. Smaller carburetors generally give better throttle response but fall off slightly in power at top end.*

The following chart lists the various Rochester carburetors and their flow ratings:

### *Rochester Carburetor Flow Ratings*

| Carburetor model | cfm |
|---|---|
| **Monojet (1M series)** | |
| 1-7/16 inch throttle bore, 1-7/32 inch venturi | 160 |
| 1-11 /16 inch throttle bore, 1-5/16 inch venturi | 210 |
| 1-11/16 inch throttle bore and 1-1/2 inch venturi | 250 |
| **DualJet (2M series)** | |
| 1-3/32 inch venturi | 230 |
| 1-7/32 inch venturi | 285 |
| **Varajet (2S series)** | |
| 28 mm primary | 375 |
| 30 mm primary | 395 |
| **Model 2G** (1-7/16 inch throttle bore, 1-1/4 inch flange, 1-3/32 inch venturi) | 280 |
| **Model 2G** (1-11/16 inch throttle bore, 1-1/2 inch flange) | |
| 1-3/16 inch venturi | 350 |
| 1-1/4 inch venturi | 380 |
| 1-5/16 inch venturi | 425 |
| 1- 3/8 inch venturi | 435 |
| **Model 4G** | |
| 1-7/16 to 1-1/8 inch primary and 1-7/16 to 1-1/4 inch secondary | 485 |
| 1-7/16 to 1-1/8 inch primary and 1-11/16 to 1-15/32 inch secondary | 550 |
| 1-9/16 to 1-1/8 inch primary and 1-11/16 to 1-15/32 inch secondary | 690 |
| **Quadrajet: (4M series)** | |
| 1-3/32 inch venturi (primary) | 750 |
| 1-7/32 inch venturi (primary) | 800 |

## Carburetor modifications

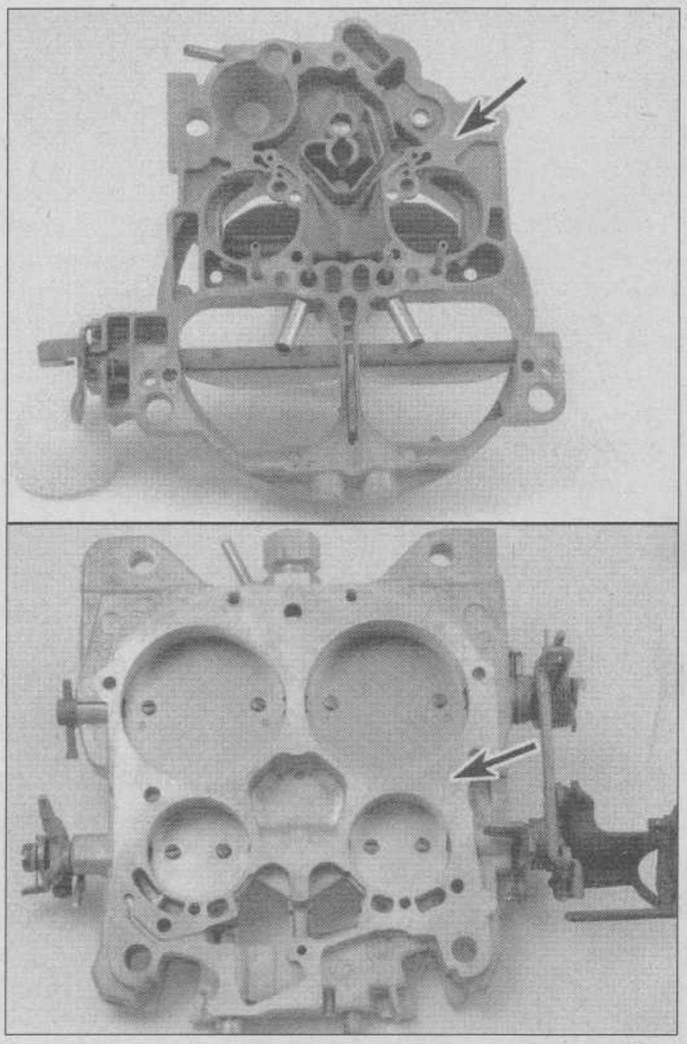
### *Most carburetors use seven basic operating systems:*

*Fuel inlet/float circuit*
*Idle circuit*
*Transfer/off idle circuit*
*Main metering circuit*
*Power enrichment circuit*
*Accelerator pump circuit*
*Choke circuit*

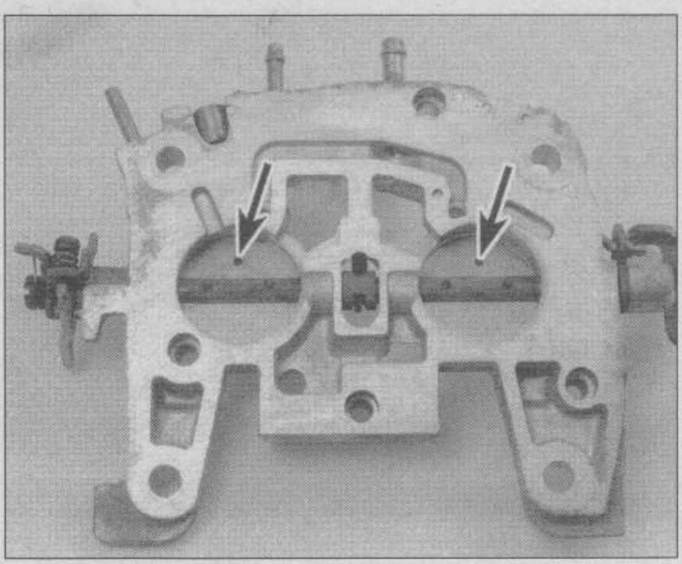
The main purpose for modification of one or more of these systems is to increase engine performance.

When engine and other vehicle modifications for performance applications are performed, some carburetor operating characteristics change. These changes necessitate "dialing-in" the carburetor to achieve peak engine performance.

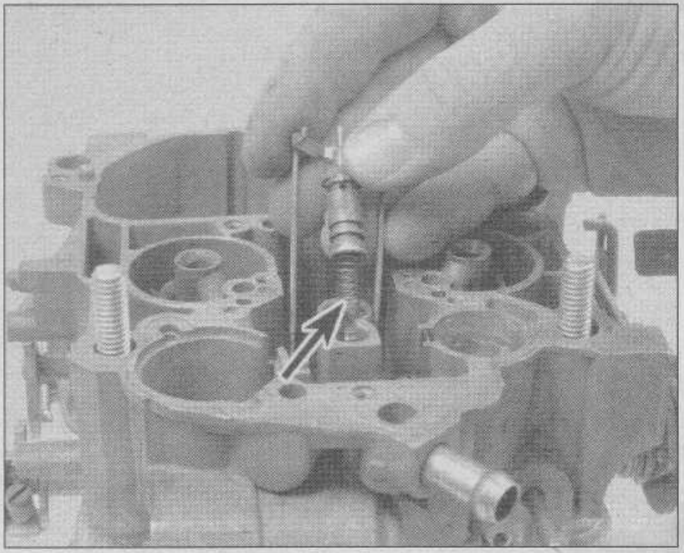
Anyone having a good basic working knowledge of carburetor systems can "dial-in" or modify a carburetor. The purpose of this guide is to explain and illustrate some of the available parts and methods for modifying carburetor operating characteristics to achieve the best possible performance.



**8.2 Check both sides of the throttle plate and the underside of the air horn for flatness**



**8.3 The holes drilled in the throttle plates will allow you to back the curb idle screw out to a normal position and you'll regain control of the idle mixture**



**8.4 If engine modifications have caused a low vacuum condition at idle, the spring under the power piston may have to be shortened to prevent the power enrichment circuit from operating when it shouldn't**

Complete system operations are covered in Chapter 3. Disassembly, reassembly, and adjustment specifications are covered in Chapter 7 of this book.

All carburetor tuning begins with the disassembly and inspection of the carburetor. This serves to familiarize yourself with the systems and components of the unit.

## Main body

If the carburetor has been in service for any length of time, you should inspect the flat surfaces for warpage. Anything in excess of 0.010-inch warpage in the areas indicated **(see illustration)** will require resurfacing to insure a proper gasket seal. We recommend draw filing using a medium-fine flat file to true the surface. Except in extreme cases, it is usually not necessary to have the surface machined. **Caution:** *Don't attempt to file any surface that has a raised sealing bead on it, such as the top and underside of the main body.*

## Throttle body

Many engines that have been modified for higher performance seem to have a problem maintaining a low, smooth idle. The main reason for the condition is the selection of the camshaft. The more "extreme" the camshaft profile, the larger the lift and duration, the harder it is for the engine to produce vacuum. This makes it necessary to raise the idle speed to compensate. Sometimes you'll find the curb idle screw turned in as far as it can go and still the car has a hard time idling.

Because the vacuum is lower and the idle rpm requirement is higher, the throttle plates must be opened for additional airflow. Unfortunately, since transfer slot exposure is increased, fuel flow is also increased, which usually makes the engine run too rich and makes adjustment difficult. The idle mixture screws are no longer useful, because the throttle plates are opened too far and you lose vacuum at the idle ports. The ability of the idle mixture screws to meter fuel is lost. One way to close the throttle plates back down to partially cover the slots and still provide the additional airflow that is required, is to drill a 3/32-inch hole in each primary throttle plate **(see illustration)**. **Note:** *If the engine is radically modified, it may be necessary to drill the holes in the secondary throttle plates as well.*

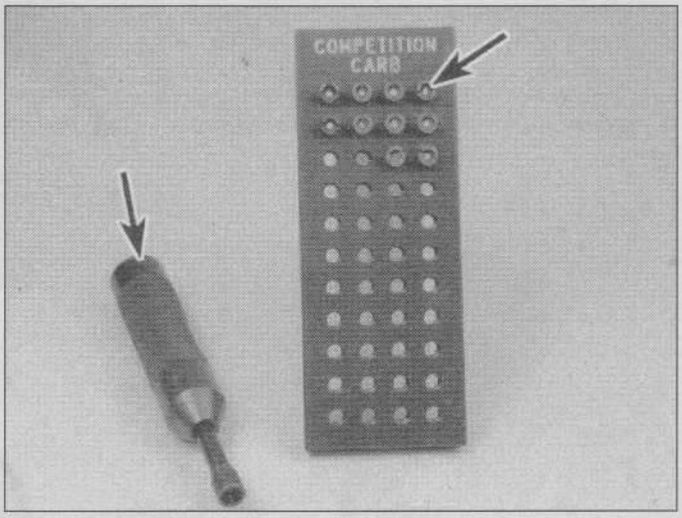
## Main body and air horn

The power valve or power piston/metering rod assembly is designed to supplement the fuel flow through the main jets. During acceleration, low manifold vacuum allows the power valve to open. Fuel flow through the power valve or past the raised metering rods effectively increases fuel discharge in the main well approximately 6 to 10 jet numbers during the time it's operating. In the case of the power piston/metering rod(s), all of the enrichment takes place in the main circuit, as the metering rod(s) is/are lifted up in the main jet(s).

If the intake manifold vacuum is extremely low at idle, the spring tension in the power valve or under the power piston may overcome the force of vacuum pulling the piston down (or holding the power valve shut). In an instance such as this, the power valve would open or the power piston would raise up, pulling the metering rods higher up in the main jets. This condition would cause the mixture to be way too rich during idle, off idle and even while cruising. A problem like this would not clear up until wide open throttle had been reached and the spark plug fouling from the over-rich mixture had been blown out. To overcome this problem, the power valve or power piston spring will have to be weakened or shortened. This can be done by clipping coils from the spring **(see illustration)**. Remove only 1/2 coil at a time so as not to take off too much.

The main jets that come with the carburetors are generally in the ballpark for most applications. Of course, this varies with the extent of engine modification. At any rate, the first changes that should be made to the air/fuel ratio in the main system should be made with the jets **(see illustration)**, or on models that have metering rods, the jets *and* metering rods **(see illustration)**.

To provide a better response as the secondary throttle plates open up, drill a series of four 0.030-inch holes, starting



**8.5 There is a wide range of main metering jets available for all models. One of the easiest ways to keep all of them organized and undamaged is to get a pre-drilled and threaded holder from your local auto parts store or speed shop. The tool on the left is a special driver just for jet removal and installation. It captures the jet in the end of the tool so there's no chance of damaging it.**

at 1/4-inch from the bottom and about 3/32-inch apart, through the secondary fuel feed tubes **(see illustration).** Also, carefully drive the air bleed tubes into the air horn approximately 3/16 of an inch, so they protrude one-inch from the surface of the air horn. This will reduce the restriction in the secondary fuel passages. **Caution:** *Be careful not to distort the orifices at the ends of these tubes.*

## Float bowl

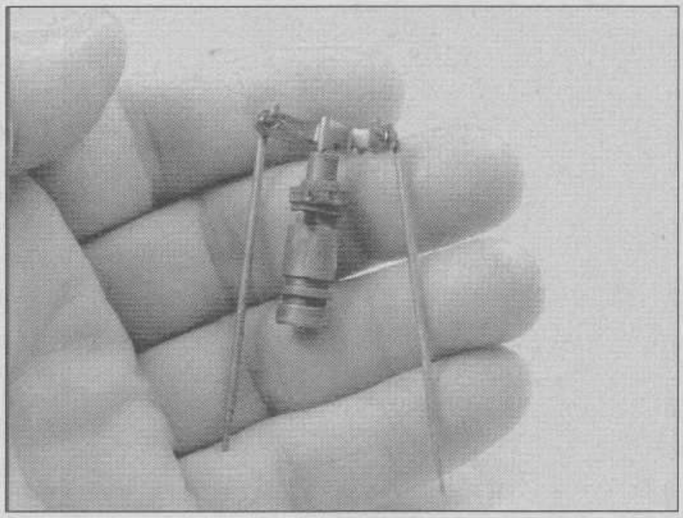
A controlled fuel pressure is very important. The inlet pressure should be between 7 and 8 psi at idle. Anything in excess of that might have a tendency to create flooding problems by overpowering the needle-and-seat assembly. It's recommend that you use Viton needle unless the type of fuel being used is one of the modern racing fuels where octane levels are increased considerably or when octane boosters are used in proportions in excess of the manufacturer's suggested levels. In some cases, the use of these fuels will create problems by attacking the Viton on the needle.

## Accelerator pump

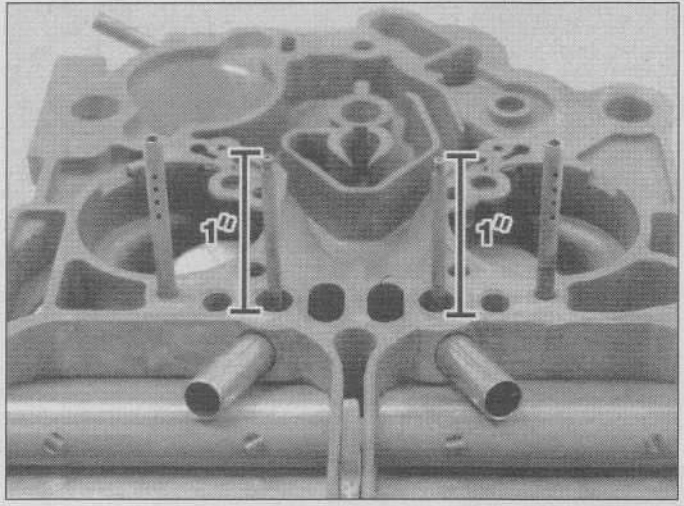
The accelerator pump shooter size has a direct affect on the initial off-line or "launch" performance. If the initial acceleration produces a hesitation and then picks up, the pump shooter size should be increased. On the other hand, if the pump shooter is too large, it may cause a bog or sluggish response from too much fuel. Another indication that the shooters are too large is a puff of black smoke on acceleration.

To alter the shooter size, you'll have to obtain a set of very small drills (approximately 0.0135 to 0.040-inch) and a pin vise. Make changes only 0.002-inch at a time. When you have a clean, instant throttle response when the throttle is opened up under a no-load condition, you'll know you have the right diameter shooter orifices.

The duration of the pump squirt can be changed by altering the duration spring tension. A weaker spring gives a longer duration, but a weaker shot of fuel. Increasing the tension on the duration spring will give a shorter but harder injection of fuel.



**8.6 Metering rods are available in different profiles to provide the correct amount of fuel enrichment at the desired point in the power curve**



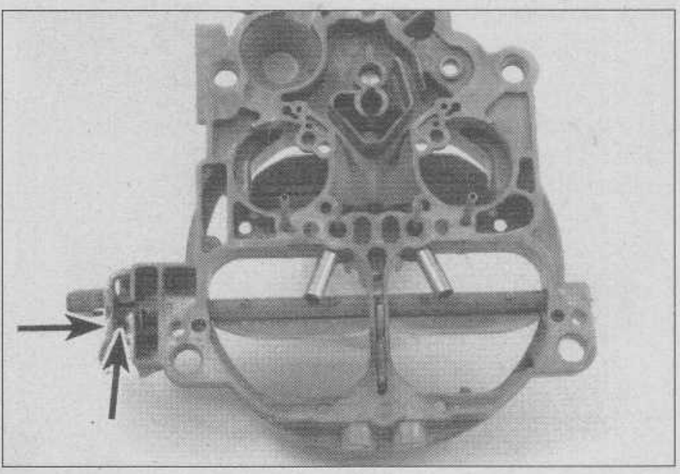
**8.7 To reduce restrictions in the secondary fuel passages, *carefully* drive the air bleed tubes in to a height of one-inch. The 0.030-inch holes in the fuel feed tubes help to provide a better transition as the secondary throttles are actuated.**

The capacity of the pump can be changed by boring out the pump well and using a larger diameter pump cup, but this modification must be performed by a machinist specializing in carburetor modification.

## Secondary circuit

To modify the secondary circuit on a Quadrajet, you're pretty much limited to changing the secondary metering rods and the opening point of the air valve. Jet sizes can't be experimented with, since the secondary circuit uses fixed orifices instead of removable jets.

Before installing different secondary metering rods, try adjusting the opening point of the air valve. For high-performance applications, you'll want to adjust the air valve to open sooner, so the secondaries are actually effective in metering fuel sooner. There is an adjusting screw on the right side of the air valve shaft which controls the tension on the air valve spring **(see illustration)**. By reducing the tension on this spring, the



8.8 This Allen screw (right arrow) locks the adjusting screw (left arrow) that controls the tension on the air valve spring. Reducing the tension on this spring (loosening the adjusting screw) will allow the air valve to open sooner, which in many cases will be enough to improve throttle response and secondary operation without changing the secondary metering rods. The Allen screw must be loosened before the adjusting screw can be turned (also, it must be tightened before you let go of the adjusting screw)

air valve will open sooner and secondary fuel metering begins. When making this adjustment, turn the adjusting screw out about 1/8th turn at a time, until a slight bog appears as the throttle is opened, then turn the screw back in 1/8th of a turn, or enough to make the bog disappear. The bog results from a too-lean condition, caused by too much airflow through the secondaries.

There are over 90 different secondary metering rod sizes/tip profiles which will enable you to fine-tune the operating characteristics of the secondary system. Tuning the secondary side will take time and patience. You'll have to experiment with the size and shape of the tips on the rods to achieve the desired fuel metering as the secondary throttle plates begin to open and at wide-open throttle.

## Heat

While heat isn't considered a modification, if it gets out of control it will certainly modify the way the carburetor performs. The ability to cool the fuel mixture has a direct impact on the way the vehicle will run. The cooler the fuel mixture, the more power that can be made from that mixture, since it will be more dense.

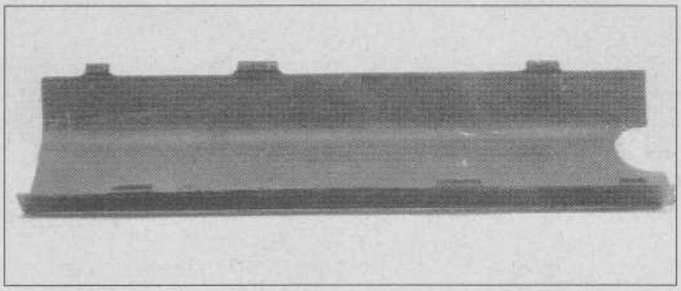
There are several ways to keep the carburetor and fuel isolated or insulated from the heat of the engine.

First, if you had the intake manifold off, before reinstalling the intake manifold check to see if the manifold design will allow the installation of a windage tray between the heads **(see illustration)** to keep hot oil from splashing against the bottom of the manifold. This will keep the air/fuel mixture cooler just before it enters the combustion chambers.

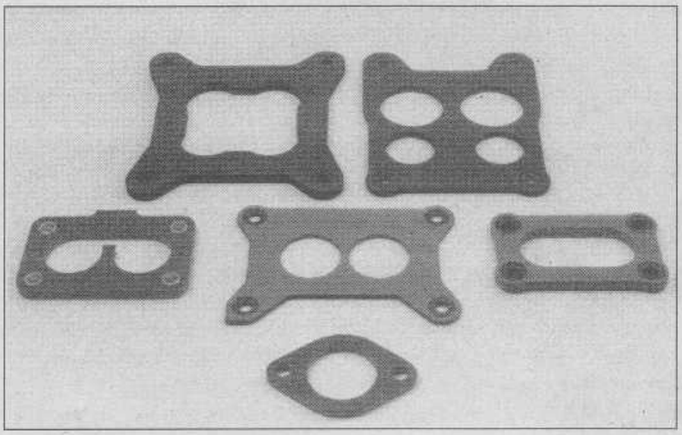
Second, there are a number of different carburetor base gaskets and spacers available to be used when installing the carburetor on the intake manifold **(see illustration)**. These are made of different types of heat insulating materials. everything from paper to a phenolic composite. If space allows the installation of any of these, by all means use them to keep the carburetor (and ultimately the fuel mixture) cooler.

Third, there are heat shields available from the manufacturer or from many aftermarket sources that are installed between the manifold and carburetor **(see illustration)** that are made of aluminum and act as a heat sink. The heat from the manifold enters the shield before it reaches the carburetor and, because of the large surface area, dissipates the heat quickly.

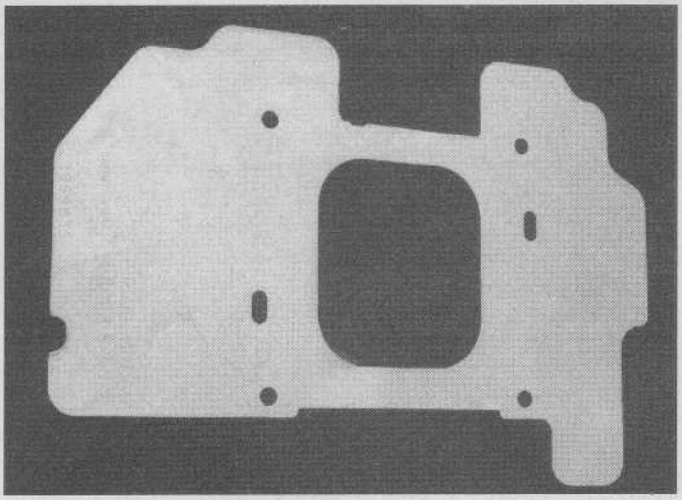
Last, but one of the most over looked causes of unnecessarily preheating the fuel is the routing of the fuel lines and fil-



8.9 Some types of manifolds don't allow the use of a windage tray, but most do. The advantage to these is that they keep hot oil from contacting the bottom of the manifold. The cooler you can keep the fuel mixture, the more power your engine will make.



8.10 These are a few of the different types of insulator gaskets found in a typical overhaul kit



8.11 This type of insulator acts more like a cooling "fin" rather than an insulator. It's made from aluminum so it absorbs heat quickly and spreads it over the large surface area, where the air passing over it can dissipate the heat before it can all get up to the carburetor.

ters. Many people go to great lengths to buy all the right parts, and do all the "trick" stuff to their engines and overlook the detail work. Running fuel lines too close to headers or touching the engine block at some point creates a "hot spot," which if severe enough can even cause vapor lock.

Remember, nothing is so small or simple that it should be overlooked or taken for granted. The details are everything - they distinguish a professional approach to doing a job versus the backyard "hack" repair that always seems to have to be done over and over again because of impatience and/or poor planning. Do it right and do it once.

# Engine modifications

In these times of ever-increasing fuel costs, the beleaguered enthusiast is constantly reminded of the trade-offs required to drive a performance vehicle. It takes fuel to produce horsepower, and the faster you go, the more you need.

But performance and economy don't have to be mutually exclusive. By properly matching components and careful tuning, you can improve the power and efficiency of the drivetrain to obtain the best of both worlds.

Automotive designs are, by necessity, fraught with compromises. Factory engineers must allow for wide variations in production line tolerances, driving techniques, low octane fuel, carbon build-up, wear, emissions certification, neglect and lack of maintenance while keeping costs down.

Stock production passenger cars and light trucks are designed for a balance between everyday stop-and-go driving around town and cruising on the highway. The engines and drivelines are optimized for low and mid-range power rather than high rpm peak horsepower.

Engines are basically air pumps that mix fuel and air and produce power from the combustion. Anything you can do to increase the flow of air (assuming the fuel system is capable of delivering sufficient fuel in the correct proportions) through the engine will increase power. Other ways to increase power and/or economy are to reduce weight, friction and drag.

Every engine is designed to operate most efficiently in a certain speed range (measured in revolutions per minute [rpm]). The length and diameter of the intake and exhaust ports and the intake and exhaust manifolds (or headers) help determine the power band of the engine. Long, small-diameter intake and exhaust runners improve low-rpm torque and decrease high-rpm power. Conversely, short, large cross-section passages favor high rpm power.

The type and rating of intake and exhaust systems, the camshaft, valve springs and lifters, ignition, cylinder heads, valve diameters and bore/stroke relationship are matched at the factory to ensure a good combination of economy, power, driveability and low emissions. Additionally, the transmission characteristics, differential gear ratio and tire diameter must all work in harmony with the engine.

For street driving, low and mid-range torque is much more useful (and economical) than theoretical ultimate horsepower at extremely high rpm. A street-driven engine that produces high torque over a wide range of rpm will deliver more average horsepower during acceleration through the gears than an engine that delivers higher peak power in a narrow range of rpm.

Heavy vehicles with relatively small engines should have lower gearing (higher numerically) than light vehicles with relatively large engines. Also, the engine in a heavy vehicle should be optimized for maximum torque in the low and middle rpm range, since it takes more torque to get a heavy vehicle moving and to accelerate it.

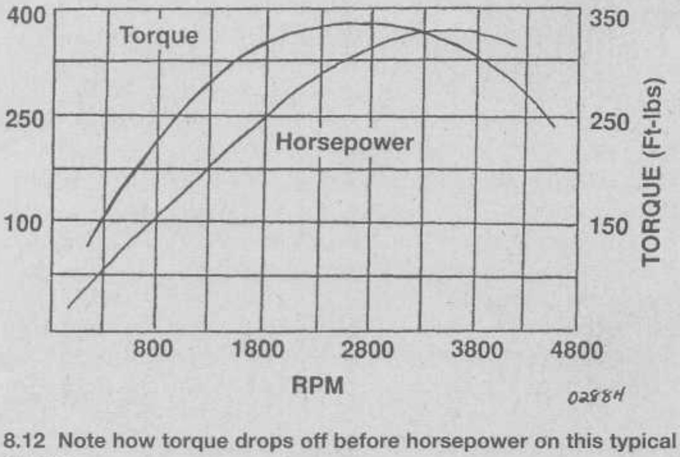
New cars and trucks have low numerical axle ratios, lock-up torque converters, overdrives and more ratios in the transmissions to get good mileage and acceleration. One of the best ways to improve performance and economy at the same time on an older vehicle is to install a transmission with more forward gears and a differential with better ratios than stock. Frequently, these parts are available from late-model vehicles at wrecking yards for reasonable prices.

Most racing engines run in a narrow range at high rpm and don't need the flexibility low-speed torque provides. Many hot rodders succumb to the temptation of putting a radical racing camshaft or a huge carburetor on an otherwise stock engine. This increases the theoretical airflow capacity in one part of the engine without changing the flow characteristics of other components. Since the components aren't matched, intake air charge velocity slows down and fuel doesn't mix properly with the air. The engine no longer has an optimum rpm band. This results in a gas-guzzling slug that isn't as fast as stock.

Torque, usually measured in foot-pounds (ft-lbs) in the USA, is a measure of the twisting force produced by the engine. Horsepower is a measure of work done by the engine. Torque (in ft-lbs) multiplied by engine speed (rpm) divided by 5,250 equals horsepower.

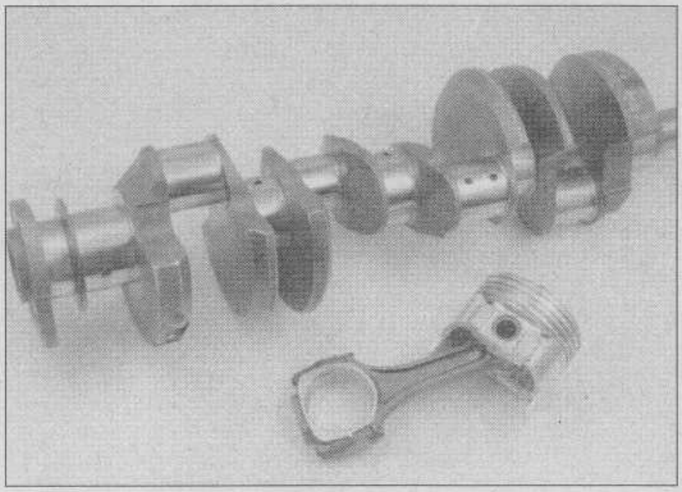
Engines produce the most power from a given amount of fuel at their peak torque. This is the rpm the factory engine design is optimized for. Peak horsepower is achieved by spinning the engine faster than this most- efficient speed. The torque peak always occurs at a lower rpm than the peak horsepower **(see illustration)**. Horsepower peaks when the gains made by running faster are balanced by the losses caused by running above the optimum speed the engine components are tuned for.

You can tell a lot about an engine from its power specifications. On a high-performance engine, maximum horsepower will usually be higher than maximum torque, and peak power will occur at a relatively high rpm. Also, as a general rule, high-performance street engines put out approximately one horsepower per cubic inch or better. For example, a hypothetical standard engine might have 300 cubic inches of displacement, maximum torque of 275 ft-lbs @ 3,000 rpm and 200 hp @



**8.12 Note how torque drops off before horsepower on this typical engine**

**8.13 Special chips are available for computer-equipped vehicles**



**8.14 Long-stroke crankshafts and oversize pistons can boost torque and horsepower by increasing displacement**

4,200 rpm. The high-performance version with the same displacement might have 245 ft-lbs @ 3,800 rpm and 325 hp @ 5,600 rpm. **Note:** *Late-model (about 1972 and later) engine horsepower ratings are net (with accessories connected) whereas earlier models are rated for gross or brake horsepower (without accessories). Net ratings tend to be lower, but more realistic than the gross ratings.*

Before you select components to modify your vehicle, you should plan out realistically what you want it to do. Your engine must be in excellent condition to start with, otherwise it will quickly self-destruct. Check the condition of the engine thoroughly. If necessary, rebuild it now; you can include modifications during the overhaul and it will cost less than if you did the work separately.

Find out what the factory rated horsepower and torque are, and at what rpm the peaks occur. Then determine what rpm the engine is turning at your usual highway cruising speed and what the gearing is. If your vehicle isn't equipped with a tachometer, temporarily connect a test meter with long wires run into the interior. To determine the axle ratio, check the tag on the differential.

Once you know these things, you can decide which way to go. Generally, if you modify the vehicle so it has to run at higher rpms and/or you want a large increase in power, expect to sacrifice a considerable amount of fuel economy and reliability.

Some of the more popular ways to dramatically raise power output are supercharging, turbocharging, nitrous oxide injection or by swapping a much larger displacement engine into the vehicle. There are many books devoted to each of these methods, and these subjects are beyond the scope of this Chapter.

Depending on the year and model of your vehicle, you may be able to make substantial improvements in mileage through careful tuning, by changing axle ratios, tires, intake and exhaust modifications, camshaft replacement and ignition improvements. Vehicles from the 1950s through the 1970s are most responsive to these changes, which must be carefully planned and coordinated.

Newer computer-controlled models have many of these changes incorporated in them already and get better mileage than their predecessors. They are so sensitive to modifications that even a change in tire diameter can affect the driveability of the vehicle.

There are very few modifications that can be done to computer-controlled vehicles without making them violate emission laws. Several aftermarket manufacturers produce intake manifolds, camshafts, exhaust systems and computer chips **(see illustration)** that can increase the performance of late-model vehicles. Shop carefully and read the fine print to determine computer compatibility before you purchase any components.

If you are planning to rebuild your engine, you may want to make many modifications during the overhaul. While the engine is apart, you can easily change the cylinder heads, pistons, connecting rods, crankshaft and camshaft. Modified cylinder heads can provide substantial gains in high rpm power. For a mild street engine, a good three-angle valve job and matching the intake ports to the intake manifold will make it run better without sacrificing driveability. Older engines can benefit from the addition of hardened valve seats and special valves to enable them to run on low-lead or unleaded gasoline.

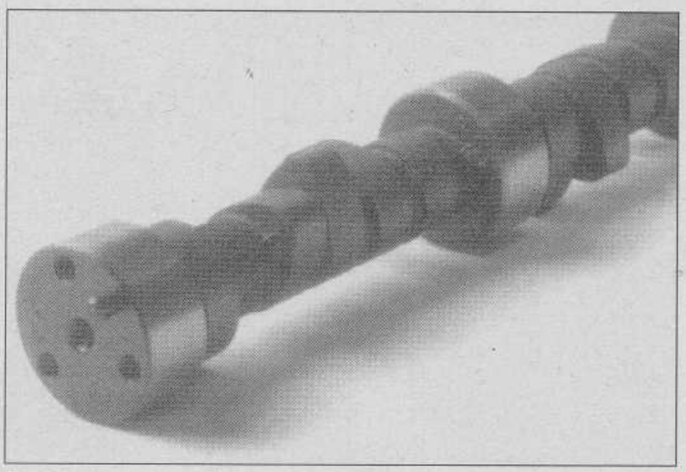
High-compression pistons improve power and efficiency at all speeds, but if you exceed about 9:1, premium fuel is necessary. Flat-top pistons produce a better flame front in the combustion chamber than dished (concave) ones. Forged pistons are stronger than cast pistons; however, cast pistons work fine on the street.

Longer stroke crankshafts with matching connecting rods and large-bore pistons **(see illustration)** can increase horsepower without sacrificing driveability or low-end torque. However, if you intend to build a high rpm engine, don't get carried away with this: long-stroke engines can limit high-rpm potential.

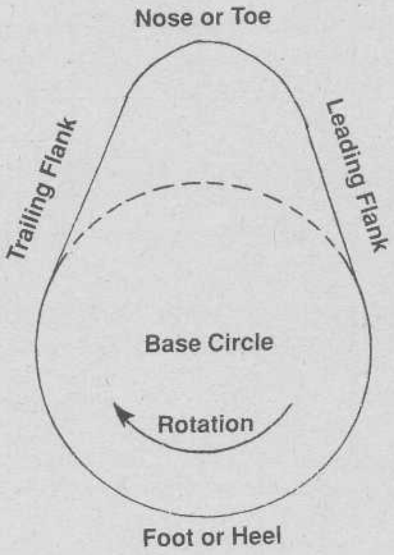
Before you assemble the engine, have an automotive machine shop blueprint and balance the parts; it's a way of finding extra horsepower that doesn't require more fuel.

In this Section we will discuss the pros and cons of various component changes and how they affect other parts of the vehicle. Usually, if you change one part, you'll have to modify or replace others that work in conjunction with it. Check the fuel mileage of your vehicle and measure performance carefully with a stop watch before and after each modification to determine its effect. Test before and after under the same conditions on the same roads to ensure accuracy.

Many books and articles have been written on how to turn your street vehicle into a race car by spending a fortune. Of



8.15 As the camshaft turns, the lobes push the valve lifters up



8.16 Each portion of the camshaft profile has a specific name and function

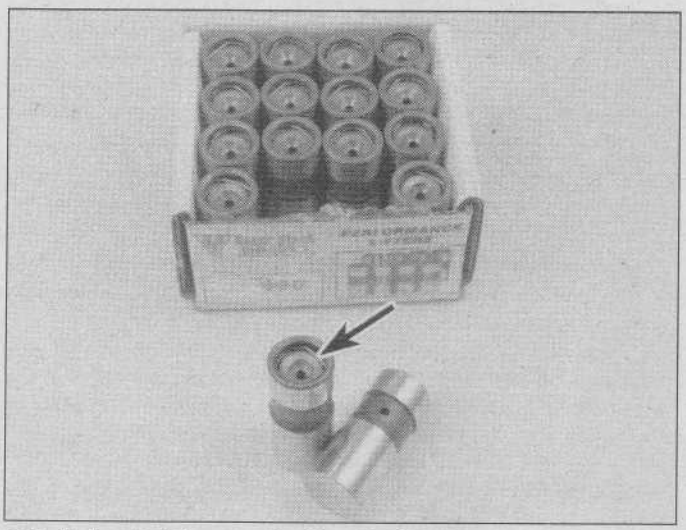
course, that leaves you back at square one, because you don't have a vehicle to drive to work anymore. We will attempt to limit the discussion to modifications that can be done at home for a reasonable cost and that will not prevent the vehicle from being used as daily transportation.

Make sure any modifications are legal according to the latest federal, state and local laws. Many states conduct "smog" inspections for street-driven vehicles. Removing or modifying emission control systems is often illegal, and usually results in little or no improvements in power or economy. Besides, we all have to breathe the air. Many jurisdictions forbid loud exhausts, too. Be sure to check with your state department of motor vehicles and state or local police regarding current regulations.

## *Camshaft selection*

The camshaft is the mechanical "brain" of the engine **(see illustration)**. It determines when and how fast the valves will open and close, and how long they stay open by pushing up valve lifters with elliptical (egg-shaped) lobes as it turns **(see illustration)**.

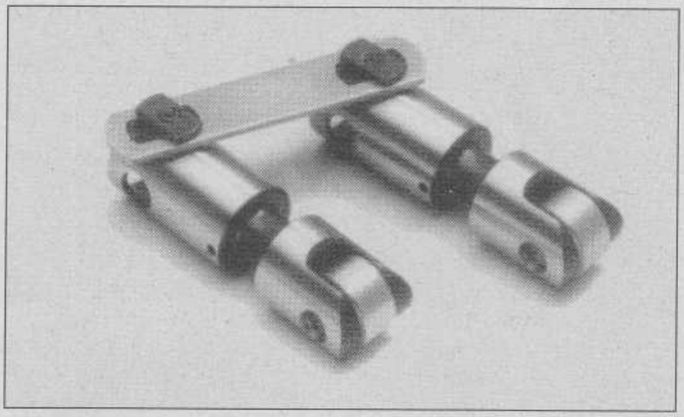
The camshaft, more than any other single part, determines the running characteristics (or "personality") of the engine. A single camshaft design cannot provide maximum power from idle to redline. Like everything else in a motor vehicle, camshaft design is a compromise. If a camshaft is designed to produce gobs of low-end torque, good driveability and fuel economy, it must give up some peak horsepower at high rpm. Conversely, camshafts designed for high rpm run poorly at idle and lower engine speeds.



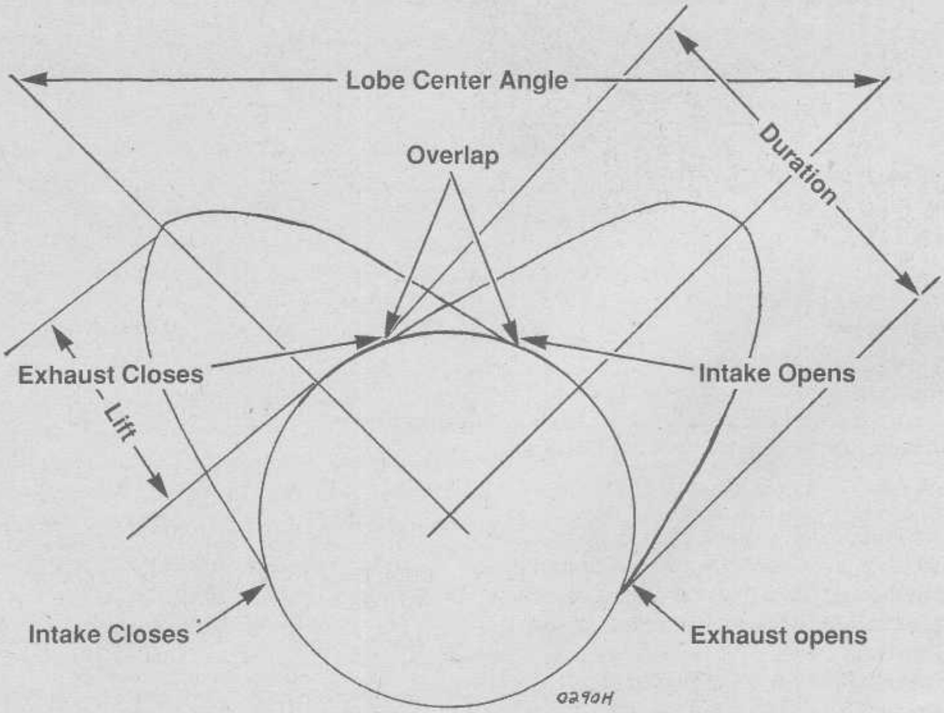
8.17 Hydraulic lifters can be identified by the retainer clips in the top (arrow)

Before you can make an informed choice on camshaft selection, you need to know some basic design parameters and terminology. Camshafts must be designed to work with a certain type of valve lifter and must not be used with any other type. There are three basic types of valve lifters: mechanical, hydraulic and roller. Mechanical lifters, also known as solid or flat tappets, are the oldest, simplest and least expensive type. Because of their light weight, mechanical lifters allow an engine to rev slightly higher before the valves float. The main disadvantages of mechanical lifters are the necessity of frequent valve adjustments and the noise they produce.

Hydraulic lifters **(see illustration)** are the most common type used in V8 engines. They have a small internal chamber where engine oil collects and a check valve to prevent backflow. This feature allows the lifter to automatically compensate



8.18 Aftermarket roller lifters



8.19 This end view of a typical camshaft profile shows the lift, duration, overlap and lobe center angle

for differences in valve lash, or clearance. Standard hydraulic lifters are relatively inexpensive and are maintenance-free; however, at high rpm, they tend to pump up and float the valves. Special high-performance lifters are available which extend the rpm range high enough for virtually any street machine. Hydraulic lifters are the most popular type of lifter used in performance street engines, and work well in most applications.

Roller valve lifters **(see illustration)** are the best and most expensive type available. They increase horsepower and improve fuel economy by reducing friction. Roller lifters are available in both solid and hydraulic versions. If you can afford it, buy a roller camshaft and lifters. Hydraulics are next best and mechanical are least desirable for a street engine.

Every engine has a certain speed it runs best at, which is a result of the "tuning" of components to achieve an optimum flow velocity of air/fuel mixture.

The main reason engines don't run at maximum efficiency throughout the power band is because air has mass, and therefore inertia. As engine speed increases, the amount of time available for the gases to enter and exit the combustion chamber becomes less. Camshaft designers compensate for this by opening the valves earlier and holding them open longer. But the valve timing that works well at low speed is inefficient at high speed.

Several quantifiable factors determine camshaft characteristics. The most important and widely advertised items are LIFT, DURATION and OVERLAP **(see illustration)**.

Lift is simply the amount of movement imparted by the camshaft lobe. Lift specifications can be confusing because the rocker arms multiply the actual lift at the camshaft lobe by a ratio of approximately 1:1.5 to 1:1.7. Most camshaft manufacturers provide "net" lift specifications which is the maximum amount of lift (or movement) that occurs at the valve. Actual lobe lift measured at the camshaft is considerably less than net lift. Up to about 0.50 inch net lift, more lift produces more power. Beyond this point, there are diminishing returns. High lifts also result in greater wear rates and premature failure of valve train components.

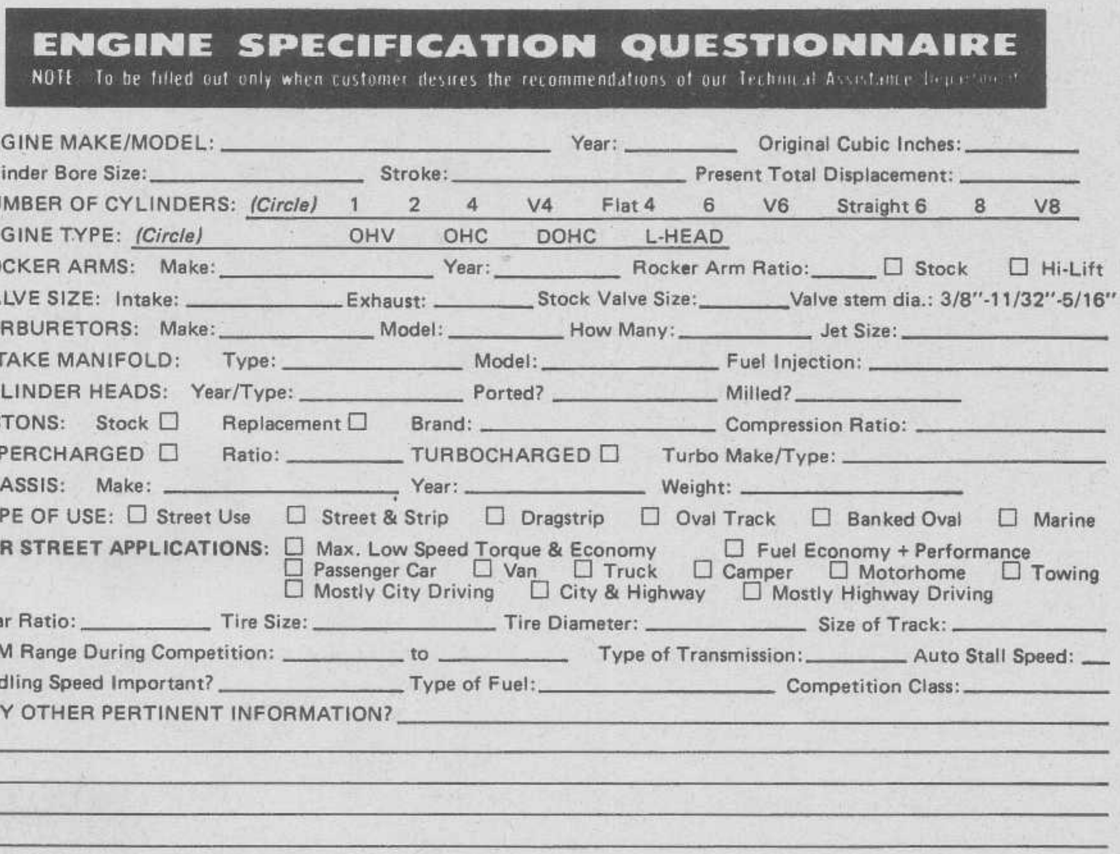
Duration indicates how long a valve stays open and is measured in degrees of crankshaft rotation (remember that camshafts turn at one half of crankshaft speed). Long duration increases high rpm power at the expense of economy, exhaust emissions and low-end power.

Comparing duration of different camshafts is difficult because not all manufacturers use the same method of measuring. Some companies measure duration from the exact point where the valve lifts off the seat. This produces a higher number, but in practice, the fuel/air mixture does not begin to flow significantly until the valve has lifted a certain amount.

Most camshaft experts have agreed to measure duration starting and ending at 0.050 inch lift. This method produces a smaller number that is more representative of flow characteristics. For street use, cams having about 230-degrees of duration (measured at 0.050 inch lift) work well. Be sure you know which method of measurement is being used when you compare camshafts from different manufacturers.

Overlap is a measurement of crankshaft rotation in degrees during which both the intake and exhaust valves are open. Like duration, long overlap also increases high rpm power at the expense of economy, exhaust emissions and low-end power.

Two factors influence valve overlap specifications. First and easiest to understand is the amount of valve duration. Second is the lobe centerline angle or lobe displacement of the camshaft.



**ENGINE SPECIFICATION QUESTIONNAIRE**

NOTE To be filled out only when customer desires the recommendations of our Technical Assistance Department

ENGINE MAKE/MODEL: ____ Year: ____ Original Cubic Inches: ____
Cylinder Bore Size: ____ Stroke: ____ Present Total Displacement: ____
NUMBER OF CYLINDERS: *(Circle)* 1 2 4 V4 Flat 4 6 V6 Straight 6 8 V8
ENGINE TYPE: *(Circle)* OHV OHC DOHC L-HEAD
ROCKER ARMS: Make: ____ Year: ____ Rocker Arm Ratio: ____ ☐ Stock ☐ Hi-Lift
VALVE SIZE: Intake: ____ Exhaust: ____ Stock Valve Size: ____ Valve stem dia.: 3/8"-11/32"-5/16"
CARBURETORS: Make: ____ Model: ____ How Many: ____ Jet Size: ____
INTAKE MANIFOLD: Type: ____ Model: ____ Fuel Injection: ____
CYLINDER HEADS: Year/Type: ____ Ported? ____ Milled? ____
PISTONS: Stock ☐ Replacement ☐ Brand: ____ Compression Ratio: ____
SUPERCHARGED ☐ Ratio: ____ TURBOCHARGED ☐ Turbo Make/Type: ____
CHASSIS: Make: ____ Year: ____ Weight: ____
TYPE OF USE: ☐ Street Use ☐ Street & Strip ☐ Dragstrip ☐ Oval Track ☐ Banked Oval ☐ Marine
FOR STREET APPLICATIONS: ☐ Max. Low Speed Torque & Economy ☐ Fuel Economy + Performance
☐ Passenger Car ☐ Van ☐ Truck ☐ Camper ☐ Motorhome ☐ Towing
☐ Mostly City Driving ☐ City & Highway ☐ Mostly Highway Driving
Gear Ratio: ____ Tire Size: ____ Tire Diameter: ____ Size of Track: ____
RPM Range During Competition: ____ to ____ Type of Transmission: ____ Auto Stall Speed: ____
Is Idling Speed Important? ____ Type of Fuel: ____ Competition Class: ____
ANY OTHER PERTINENT INFORMATION? ____

8.20 **This questionnaire is typical of the information camshaft manufacturers need to choose the right camshaft for a specific application**

The lobe center angle varies indirectly with the overlap. That is, when overlap increases, lobe center angle decreases, and vice versa. Increasing the angle generally increases low-end torque and reducing the angle improves high-rpm horsepower.

Another area of design that affects camshaft characteristics is the lobe profile. The rate of lift, acceleration and rate of valve closing are determined by the shape of the lobes and affect the way the engine runs. By opening and closing the valves more quickly, cam designers can get more flow from a given amount of duration.

Camshafts and valve train components must be matched to work together properly. In addition, you must carefully match the camshaft/valve train to the other components used on the engine and vehicle, especially the intake and exhaust, gearing and transmission.

Most camshaft manufacturers have technical departments that help customers determine the best camshaft and components for their specific application. In order make accurate recommendations, they need complete information on the vehicle **(see illustration)**. If you have a heavy vehicle with a relatively small engine, you must be conservative with the camshaft and other components. Follow the recommendations of the camshaft manufacturers; they have done a lot of testing and research.

Modified camshaft timing can result in valve-to-piston interference and severe engine damage. Be sure to check the following when you install a camshaft with different specifications than the original one:

## Valve spring coil bind

Whenever a camshaft with higher lift than stock is installed, the springs should be checked for coil bind. Due to the increased travel, the valve spring coils may hit together (bind), causing considerable damage.

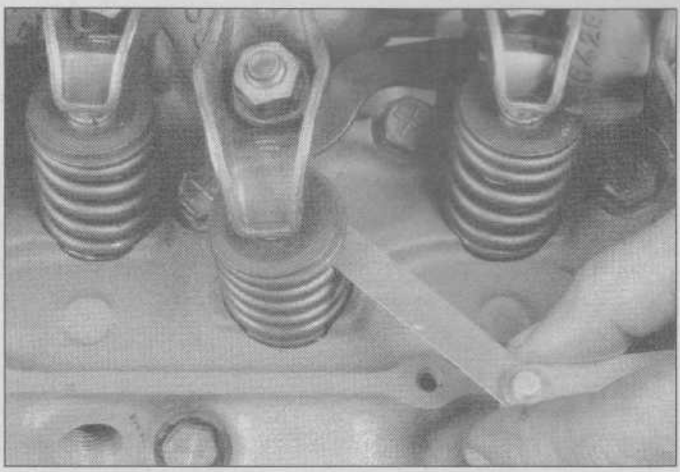
Perform this check with the new camshaft and lifters in place and the valve covers off. The cylinder heads, rocker arms and push rods must be in place and adjusted. Using a socket and breaker bar on the front crankshaft bolt inside the lower pulley, carefully turn the crankshaft through at least two complete revolutions (720-degrees). When the valve is completely open (spring compressed), try to slip a 0.010 inch feeler gauge between each of the coils **(see illustration)**. It should slip through at least two or three of the coils. If any spring binds, stop immediately and back up slightly. Then correct the problem before continuing. Usually, the valve springs must be replaced with special ones compatible with the camshaft.

## Spring retainer-to-valve guide clearance

Sometimes high-lift camshafts will cause the valve spring retainers to hit the valve guide. To check for this, rotate the crankshaft as described above and check for guide-to-retainer interference **(see illustration)**. There should be at least 1/16 inch clearance.

## Piston-to-valve clearance

Remove a cylinder head and press modeling clay onto the top of a piston **(see illustration)**. Temporarily reinstall the cylinder head with the old gasket and tighten the bolts. Install and adjust the rocker arms and pushrods for that cylinder. Ro-



8.21 Use a feeler gauge to check for coil bind

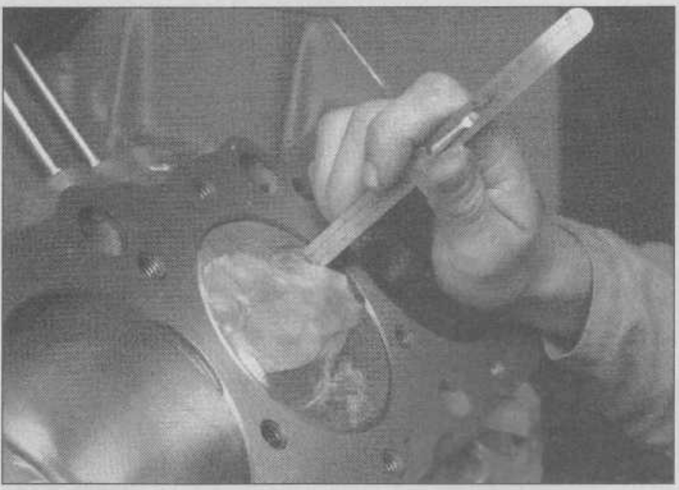
tate the crankshaft through at least two complete revolutions (720-degrees). Remove the cylinder head and slice through the clay at the thinnest point **(see illustration)**. Measure the thickness of the clay at that point. It should be at least 0.080 inch thick on the intake side and 0.10 inch thick on the exhaust side. If clearance is close to the minimum, check each cylinder to be sure a variation in tolerances doesn't cause valve-to-piston contact.

## Degreeing the camshaft

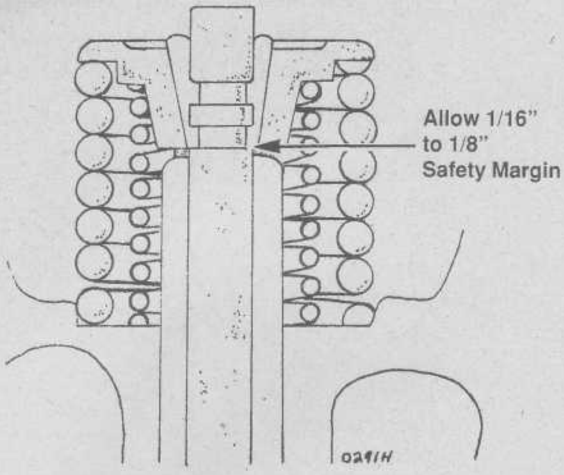
Every manufactured part has a design tolerance, and when several parts are put together, these tolerances can combine to create a significant error, called tolerance stacking. A lot of power can be lost by assembling an engine without checking and, if necessary, correcting the camshaft timing.

The first step is to find true Top Dead Center (TDC); original factory marks can be off by several degrees. Remove the number one spark plug. Using a socket and breaker bar, rotate the crankshaft slowly in a clockwise direction until air starts to blow out of the spark plug hole. Stop rotating the crankshaft at this point.

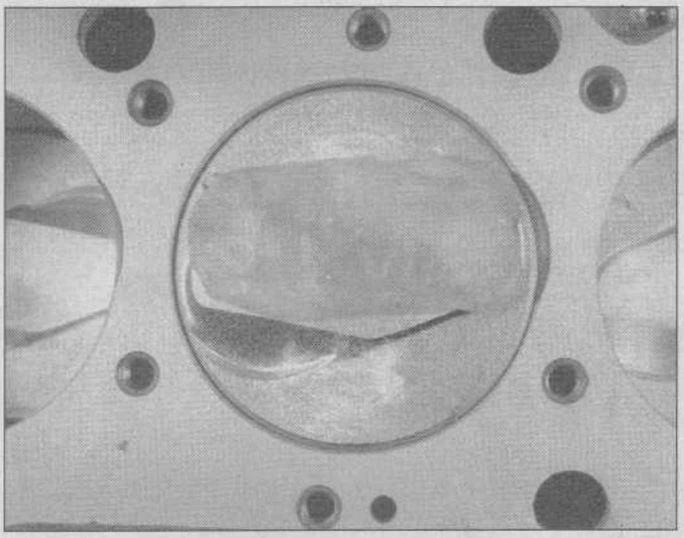
Obtain a positive stop tool **(see illustration)**. Screw it into the number one cylinder spark plug hole; it prevents the piston from going all the way to the top of the bore during this procedure.



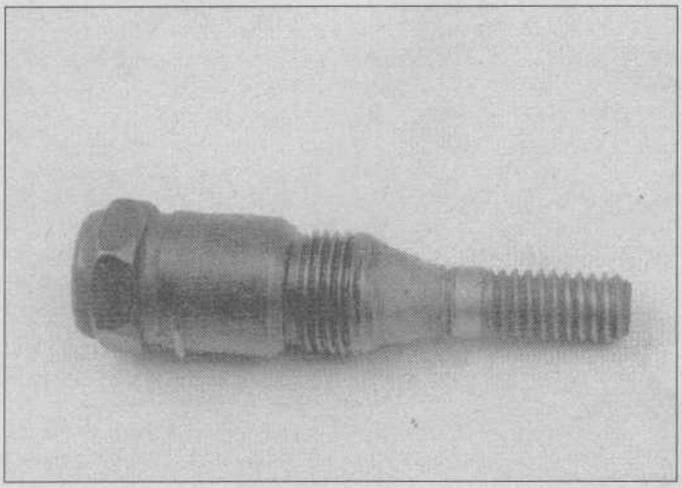
8.24 After the clay is compressed, cut through it at the thinnest point and measure it's thickness at that part



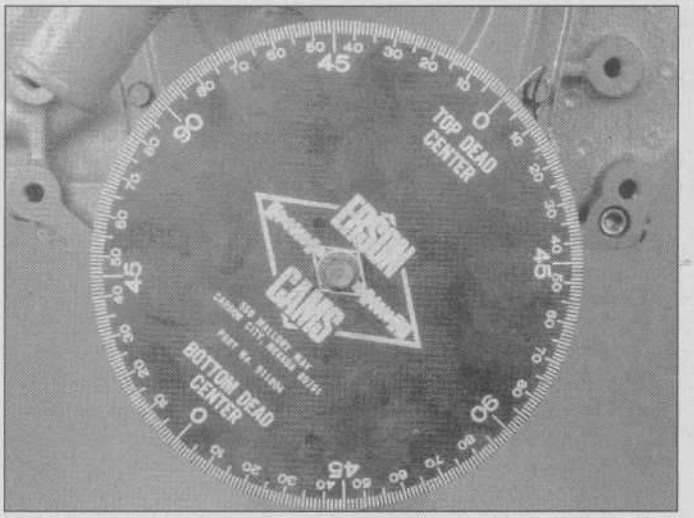
8.22 Check for interference between the valve guide and the spring retainer



8.23 Press the modeling clay onto a piston where the valves come close to the piston crown

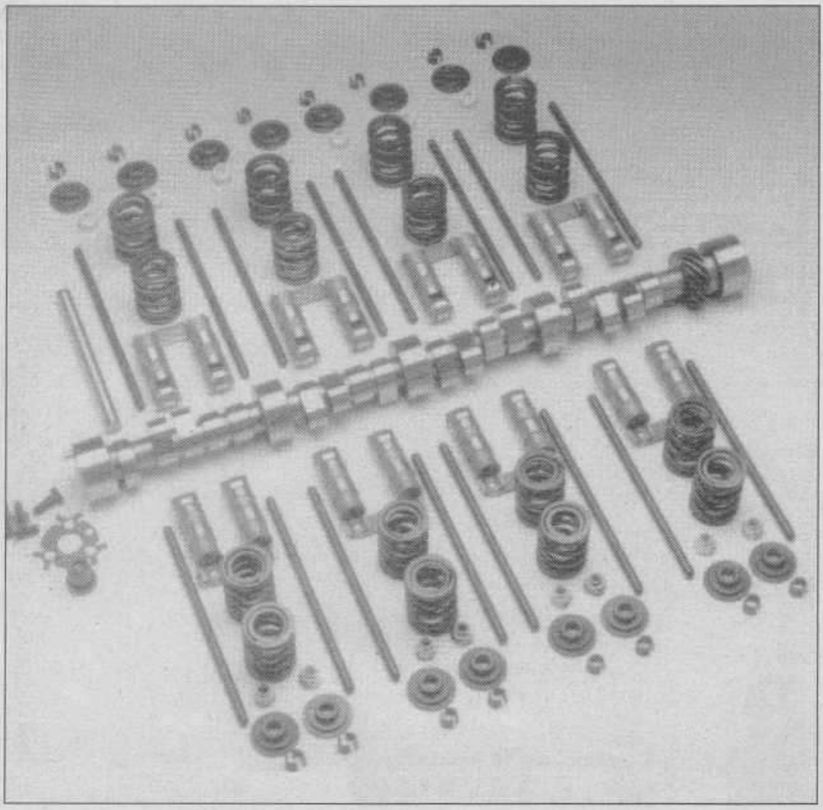


8.25 You can buy a positive stop from a speed shop or fabricate one yourself

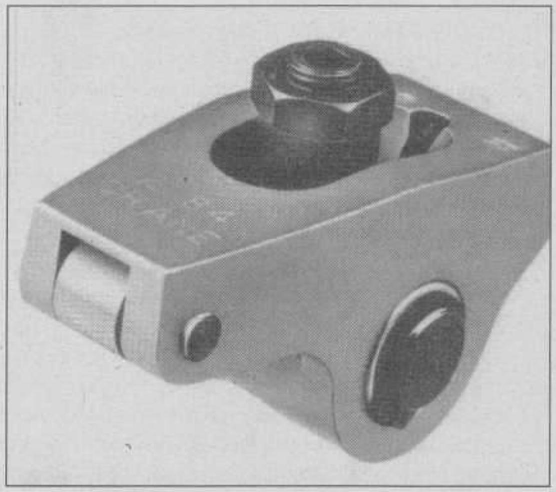


8.26 Mount a degree wheel on the front of the crankshaft and install a pointer as shown

8.27 Mount a dial indicator in line with the pushrod, as shown



8.28 Buying a complete camshaft kit ensures compatibility of components



8.29 Roller rocker arms reduce friction, add horsepower and ensure more stable valve lash

Mount a degree wheel securely to the front of the crankshaft and fabricate a pointer out of coat hanger wire **(see illustration)**. Rotate the crankshaft very slowly in the same direction (clockwise when viewed from the front) until the piston touches the stop. **Note:** *Use a large screwdriver on the teeth of the flywheel/driveplate to turn the crankshaft; otherwise you may disturb the degree wheel.* Note what number the pointer aligns with and mark the degree wheel with a pencil.

Now rotate the crankshaft slowly in the opposite direction until it touches the stop. Again note what number the pointer aligns with and mark the degree wheel with a pencil. True TDC is exactly between the two marks you made.

Double-check your work, remove the piston stop, then rotate the crankshaft to true TDC and check the factory mark. If it is off by a degree or more, correct the factory timing marks.

Now that you've found true TDC, you can check camshaft timing in relation to your crankshaft. Advancing the camshaft in relation to the crankshaft improves low-end performance and retarding the camshaft benefits high-rpm performance at the expense of low-end performance. Whenever cam timing is changed, ignition timing must be reset, and valve-to-piston clearance should be checked if a large change is made.

Read the specification tag included with the camshaft, it should have the opening and closing points (in degrees) of the intake and exhaust valves at 0.050 inch lift. **Note:** *This is the industry standard; if the cam manufacturer uses a different lift,* *follow their recommendations.*

Begin this check with the engine on true TDC and the degree wheel set at zero. Mount a 0-to-1 inch dial indicator on the intake pushrod of the number one cylinder as shown **(see illustration)**. The dial indicator shaft must be in exact alignment with the centerline of the pushrod. Preload the indicator stem about 0.100 inch and then reset the dial to zero. **Note:** *If the cylinder heads are not installed, mount the indicator so it presses against the lifter.*

Rotate the crankshaft clockwise until 0.050 inch movement occurs at the dial indicator. Note the position of the pointer in relation to the degree wheel. Record your reading and continue rotating the crankshaft until the lifter again returns to 0.050 inch lift. Record this reading.

Repeat the above procedure on the adjacent exhaust valve lifter and record the results. Compare the readings to the camshaft timing specification tag. If you want to be really thorough, check every cylinder - camshaft machining can be imperfect in some cases.

The readings you have taken may be two to four crankshaft degrees off of the timing tag figures. If this is the case, there are probably slight errors in the dowel pin hole location on the camshaft sprocket. These variations can be corrected by using an offset cam sprocket bushing. These are readily available in speed shops and from camshaft manufacturers. Follow the instructions provided with the kits. **Note:** *Some cam manufacturers build in one or two degrees of advance to compensate for timing chain wear.*

### Matching valve train components

Most camshaft manufacturers sell camshaft kits **(see illustration)** that include the matching lifters, valve springs, pushrods, retainers and sometimes even the rocker arms. Purchasing all of the components from the same source, ensures compatibility of the parts. Also, if you have a problem, it's easier to deal with only one manufacturer.

#### Precautions

On hydraulic and mechanical lifter camshafts, don't install used lifters on a new camshaft. Used roller lifters may be installed on a new camshaft designed for roller lifters if the lifters are in good condition; however, it's always best to replace all components at the same time.

Apply a generous coating of assembly lube to all components prior to installation. Follow the manufacturer's instructions and don't take any short cuts. Let the cam and lifters break in, then change the oil frequently.

## *Rocker arms*

Installing roller rocker arms **(see illustration)** is an easy way to gain a few horsepower and improve mileage by reducing friction. Roller rockers are available from many manufacturers and are compatible with all types of lifters. Buy a known quality brand and use quality hardware and pushrods to complete the installation.

## *Exhaust modifications*

### Stock manifolds

The original stock cast iron exhaust manifolds are quiet, sturdy, compact and you probably already have them. If you intend to modify your vehicle only slightly, they'll probably work fine.

Smog regulations in some areas prohibit the use of aftermarket tubular headers with catalytic converters. If these regulations apply to your vehicle, you can still pick up some additional power by adding dual exhaust while still retaining the original type manifolds.

Several good cast iron manifolds were used on high-performance and police models, especially in the 1960s. On small-block engines, the "ram's horn" design used in the 50's and 60's flows very well. Manifolds designed for Corvette are usually better than others. These may still be available from your dealer or a salvage yard. If you intend to use these on a different body style than they were originally designed for, be sure there is enough clearance and the outlet is in the right place.

### Aftermarket headers

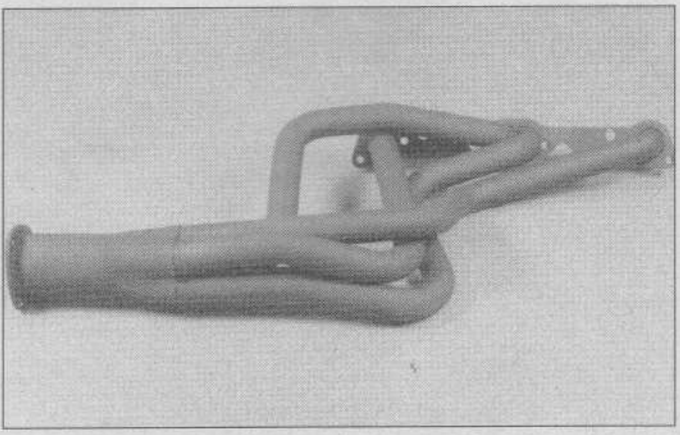
Tubular steel exhaust headers generally provide increases in power without significant changes in fuel economy. They do this by allowing the exhaust gases to flow out of the engine more easily, thereby reducing pumping losses. Headers also "tune" or optimize the engine to run most efficiently in a certain rpm range. They do this by using the inertia of exhaust gases to produce a low-pressure area at the exhaust port just as the valve is opening. This phenomenon, known as scavenging, can be exploited by choosing headers of the correct type, length and diameter to match your engine type, driving style and vehicle.

Header manufacturers produce a large variety of headers designed for different purposes. Most of them provide detailed information, recommendations and specifications on their products to assist you in selecting the right headers for your application. Some companies also have technical hotlines to answer customer questions.

### Types

Most headers come in a conventional four-into-one design **(see illustration)**. This means that all four pipes on one side of the engine come together inside a large diameter collector pipe. These four-into-one designs tend to produce more peak power at high rpm at the expense of low and mid-range torque.

Another, less common approach to header design is commonly known as "Tri-Y" because of their appearance. The initial four pipes are paired into two pipes and then these are paired again into one pipe at the collector. This design provides more low and mid-range power, but sacrifices a slight amount of horsepower over about 6,000 rpm compared to the four-into-one design.



**8.30 Four-into-one headers are the most common type**

One of the more recent developments in exhaust system technology is the Anti-reversion (or AR) header. They have a small cone inside the pipe near the cylinder head that prevents reflected pressure waves from creating extra backpressure. The AR design also allows the use of larger diameter tubing without sacrificing a lot of low-end torque. Anti-reversion headers broaden and extend the torque curve and improve throttle response.

### Length and diameter

Selection is not an exact science, but rather a series of compromises. Generally, long tubing and collector lengths favor low-end torque and shorter lengths produce their power in the higher rpm range. Larger diameter tubing should be used on large displacement engines and smaller cross-section tubing should be used on smaller displacement models.

Most street headers have primary tubes that are 30 to 40 inches long. Primary tube diameter should be about the same as exhaust port diameter. For small block engines this is about 1 5/8 in.. On big block engines, 1 7/8-inch is typical. The collectors are usually about 10 to 20 inches long and three to four inches in diameter.

### Component matching

It's also important to match the characteristics of the intake and exhaust systems. Keep in mind that heavier vehicles with relatively small engines need more low-end torque and higher numerical gearing to launch them than lighter vehicles with larger engines. Follow the manufacturer's recommendations to ensure that you obtain the correct model for the application.

Open-plenum, single-plane intake manifolds with large, high-CFM carburetors should only be used with four-into-one headers designed for high rpm. This combination should also include a high-performance camshaft matched to the other components and a fairly high numerical gear ratio.

If you want a more tractable street engine, you may want to go for a 180-degree dual-plane manifold with a somewhat smaller carburetor and Tri-Y" type headers or four-into-one headers with relatively long tubes. A mid-range camshaft would help complete the package.

### Buying tips

Be sure to check the manufacturer's literature carefully to determine if the headers will fit your vehicle and allow you to retain accessories such as power steering, air conditioning, power brakes, smog pumps, etc. Note if there is sufficient clearance around the mounting bolts for a wrench. Also, some headers interfere with the clutch linkage on manual transmission models, so check for this, if applicable.

Some applications require the engine to be lifted slightly or even removed to allow header installation. Find out how the mufflers and tailpipes connect to the headers, also. Most installations require some cutting and modifications to the existing exhaust system, which may require a trip to the muffler shop. Check the instructions, ask questions and know what you are getting into before you purchase any components. Don't let poor planning get you stuck with a ticket for driving to the muffler shop with open headers!

Most headers don't come with heat shields like stock manifolds do and tend to melt original spark plug wires and boots. Plan on purchasing a set of heat-resistant silicone spark plug wires and boots, along with the necessary wire holders or looms to keep them away from the headers.

Also, look for header kits that have adapters for heat riser valves and automatic choke heat tubes. Some models with air pumps need threaded fittings in the headers to mount the air injection rails. If your vehicle has an exhaust gas oxygen sensor, be sure the replacement headers have a provision for mounting the sensor.

After the headers are installed, the fuel mixture may be too lean. Carbureted models usually require rejetting, and some fuel-injected engines may need fuel system adjustments. Test the vehicle on an engine analyzer after installation and tune the engine as necessary; failure to do so may result in driveability problems and/or burned valves.

### Disadvantages

Headers have several disadvantages which should be considered before you run out and buy a set. Because of their thin tubing construction, headers emit more noise than cast-iron exhaust manifolds. Most headers produce a "tinny" sound in and around the engine compartment and some also produce a resonance inside the vehicle at certain engine speeds.

Tubular headers also have more surface area than cast-iron manifolds, so they give off more heat to the engine compartment. Engines with stock manifolds transmit this heat into the exhaust system instead.

Another drawback is port flange warpage. Some lower-quality headers have thin cylinder head port flanges which are more prone to warpage and exhaust leaks. Compare the thickness of the flanges on various brands and also check the gaskets and hardware supplied with the kits. The gaskets should be fairly thick and well made and the hardware should be of a high grade and fit your application. Look for the best design and quality control. Before you install headers, check the flanges for warpage with a straightedge, and if warpage is excessive, return them before they are used.

If you live in the "Rust Belt," be prepared for corrosion. Regular paint will quickly burn off and rusting will begin. Before installation, thoroughly coat the headers with heat-resistant paint, porcelainizing or aluminizing spray.

Aftermarket tubular exhaust headers are not approved for use on catalytic converter-equipped vehicles in California and some other jurisdictions (engines equipped with tubular headers from the factory are approved). Additionally, vehicles originally equipped with air injection tubes in the manifolds must retain this system. Check the regulations in your area before you remove the original manifolds.

## *Exhaust systems*

Substantial gains in both performance and economy throughout the rpm range can be obtained by properly modifying the stock exhaust system. The less restriction, the more efficient the engine will be. By increasing the flow capacity, you can unleash the potential horsepower in your engine.

The original mufflers, pipes and catalytic converters on most vehicles have small passages and tight bends. Perhaps the most difficult task when choosing exhaust components for a performance street vehicle is to make the system reasonably quiet while still having low restriction. Also, vehicles originally equipped with catalytic converters won't pass emissions inspections if the catalysts are removed.

Before you purchase a new exhaust system or individual components, you need to know what is available and the pros and cons of various items. Determine what you want your vehicle to be like, what your budget is, then design a balanced system that meets your requirements.

Many special parts and even complete high-performance systems are available for some popular models. If you have a less-common vehicle, you may have to devise a system composed of "universal" parts or use items originally designed for other vehicles.

If you intend to do the modifications on your vehicle yourself, find a level concrete area to work. Raise the vehicle with a floor jack and support it securely with sturdy jackstands. **Warning:** *Never work under a vehicle supported solely by a jack!*

Most exhaust system work requires only a small number of common hand tools. Sometimes, special equipment such as an acetylene torch, a pipe expander or pipe bender will be necessary. Muffler shops usually have this equipment and can modify, fabricate and install custom exhaust systems. But remember, the more work you do yourself, the more money you can save.

One of the easiest ways to reduce backpressure and increase flow capability is by adding dual exhaust. This effectively doubles the capacity of the exhaust without making the vehicle appreciably louder. Sometimes you can reuse most of the original parts on one side and install new parts on the other. If your vehicle is required to have a catalytic converter, you can install one on each side of the system to stay within the law.

As a general rule, mufflers and pipes with large inlet and outlet openings can handle more flow volume than smaller ones, all other factors being equal. Also, shorter mufflers are usually louder and have less restriction than longer ones. So keep this in mind when choosing mufflers.

### Conventional or original equipment mufflers

This is the type your vehicle came with from the factory. They are usually of reverse flow construction, and are quite heavy and restrictive. The only time you should consider using these is if you are adding dual exhaust and want to match the original muffler to save money.

### Glasspack mufflers

Glasspack mufflers **(see illustration)** are usually less expensive than conventional or "turbo" mufflers, and have less restriction than original equipment types. Unfortunately, they're also too loud to meet most noise regulations and they vary greatly in quality and performance.

### Turbo mufflers

Originally, factory engineers designed a large, high flow muffler for use on the turbocharged Chevrolet Corvair. Hot rodders found out and started using them for all sorts of vehicles. The name "turbo muffler" was first applied to these Corvair parts and gradually became generic, covering all high-flow oval shaped mufflers.

Turbo mufflers **(see illustration)** offer the best features of stock and glasspack mufflers. They are simply high-capacity mufflers that have low restriction without making much more noise than the original units. Today, virtually every muffler manufacturer sells a "turbo" muffler. They have expanded coverage to include many models; there should be one to fit your application.

### Exhaust crossover pipes

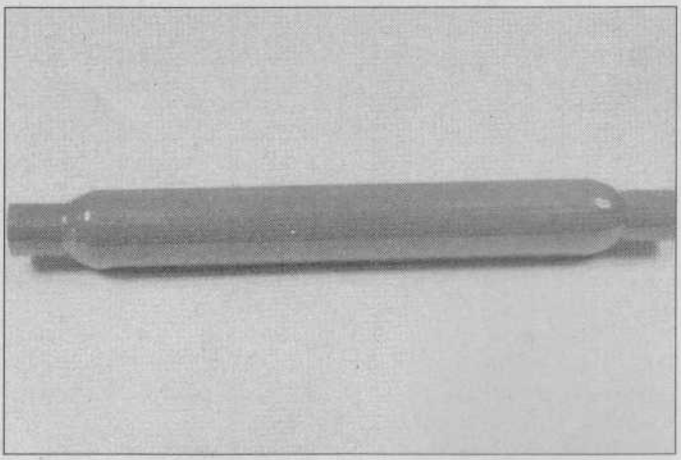
Every dual exhaust system should have an exhaust crossover pipe located upstream of the mufflers. This tube balances the pulses between the two sides of the engine and allows excess pressure from one side to bleed off into the opposite muffler. This reduces noise and increases capacity. Be sure that any system you purchase incorporates this design, which improves power throughout the rpm range.

### Stainless steel

Stainless steel mufflers and pipes are preferable to regular steel ones if you plan to keep your vehicle for a long time and/or do a lot of short-trip driving. Several specialty manufacturers produce ready-made and custom-built exhaust components from stainless steel. These parts are extremely resistant to corrosion and most are warranteed for the life of the vehicle. They usually cost several times more than standard components, so consider that when you make a purchase decision.

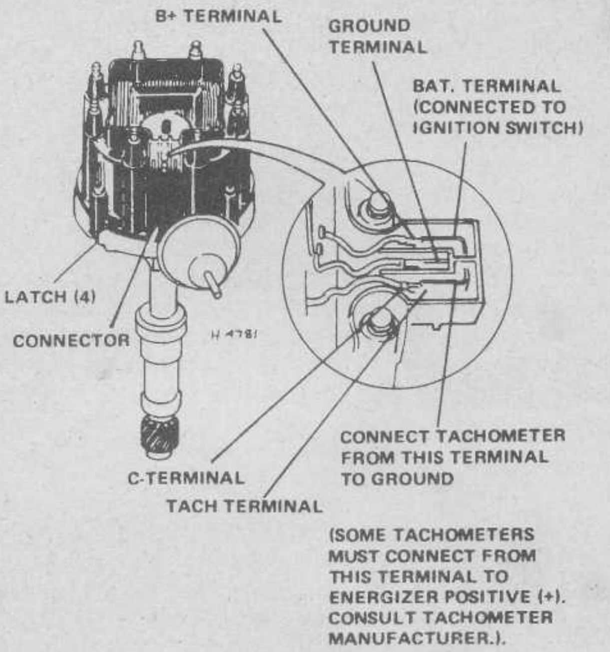
### Pipe diameter

Exhaust pipe diameter is measured inside the pipe. Small increases in diameter result in large increases in flow capacity. As a general rule, small block engines displacing 5.0 to 5.8 liters run well with 1-7/8 to 2-inch diameter exhaust pipes, with the more powerful ones using 2-1/4 inch. Engines over 6.5 liters almost always use 2-1/4 to 2 1/2-inch pipes.

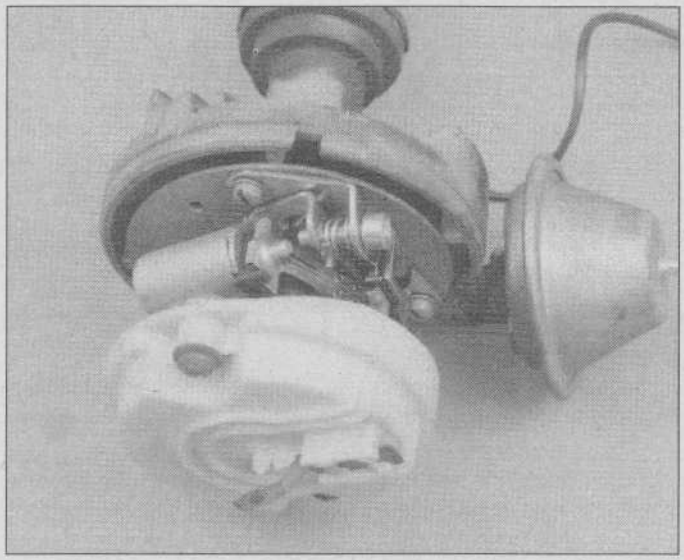


**8.31 Glasspack mufflers use a " straight through" design - the larger diameter portion is packed with fiberglass or a similar material to help deaden noise**

**8.32 Turbo mufflers have large passages and high flow capacity**



**8.33 A typical Chevrolet electronic ignition distributor**



**8.34 A typical points-type ignition distributor**

## *Ignition systems*

Pre-1975 model engines were equipped with point-type distributors. Standard models came with single-point distributors, while high-performance models often have dual-point versions. If your engine has a single-point distributor, it will probably benefit from an aftermarket performance-oriented replacement unit.

Breakerless electronic ignitions available in the aftermarket and those installed by the factory since 1975 **(see illustration)** make conventional point-type distributors outmoded **(see illustration)**. However, all non-computer controlled ignitions can benefit from being checked and the advance curve prepped by an ignition shop on a distributor tester. If your engine has a high-performance dual-point distributor, you may want to retain it to keep the engine original. Stock distributors use an advance curve that is a compromise between economy, low-octane fuel and emissions. For most applications, total spark advance should not exceed 38-degrees. So if the centrifugal advance in the distributor produces 28-degrees advance at the crankshaft, initial timing should be about 10-degrees BTDC.

Be very careful when you vary significantly from original specifications. Too little advance results in lost power, overheating and reduced fuel economy. Too much advance can cause internal damage to the engine and high exhaust emissions. Be sure the timing is not advanced to the point where the engine pings continuously under load. A slight rattle when you accelerate is normal, but continued pinging will damage pistons, rods and bearings.

If you have a late-model vehicle with computer-controlled electronic ignition, about the only thing you can do is install an aftermarket control module. Some of these will cause a vehicle to fail an emissions test; check with the manufacturer of the product before you buy.

Some of the more recent model vehicles have knock sensors mounted in the block that detect any pinging and signal the ignition control module to retard the spark timing until the noise goes away. This feature also allows the ignition timing to advance for higher octane fuel and to retard if pinging is detected due to lower octane. Don't tamper with this system; it works well as it is.

Every ignition upgrade should include a new, high-quality distributor cap, rotor, spark plugs and ignition wires (and new points and condenser, if equipped). For street machines, use radio interference suppression wires (TVRS); the solid non-suppression wires will wipe out radio reception (for you and cars and houses near you) and won't provide a measurable gain in performance. Use clips to keep the wires apart. Long parallel runs can cause induced crossfire.

A quality high-performance ignition coil is a nice extra. Be sure to get one that is compatible with the rest of the ignition system.

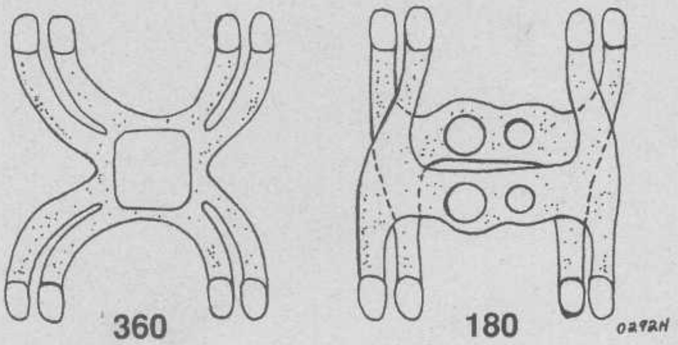
## *Intake manifolds*

A new intake manifold can unlock a considerable amount of power and improve economy at the same time if it is selected properly. Another benefit of using a high-performance manifold is the low weight of aluminum compared to the original cast-iron units.

Although exotic multi-carburetor high-rise and cross-ram manifolds look great, for street use, simple is better. Almost all current high-performance street manifolds are topped off with a single four-barrel carburetor. These provide power with economy and reliability at relatively low cost. Multiple carburetor setups are expensive to buy and difficult to tune and maintain. A single, properly selected carburetor will provide all the flow necessary for a street engine.

Intake manifolds, like many other parts of the engine, are "tuned" to perform best in a certain rpm range. Generally, manifolds with long runners produce more low rpm torque and manifolds with relatively short runners increase high rpm horsepower.

There are two basic intake manifold designs available for street machines, single plane and dual plane, also known as



**8.35 On 360-degree designs, all of the runners feed from a single chamber (or plenum) - on 180-degree designs, half the runners connect to one plenum and half to the other**

360-degree and 180-degree designs **(see illustration)**.

Virtually all stock V8 intake manifolds use the dual-plane design because they enhance low and mid-range power, economy, driveability and produce low emissions. Dual plane-manifolds **(see illustration)** are divided so every other cylinder in the firing order is fed from one side of the carburetor and the remaining cylinders are fed from the other side. This effectively improves intake velocity and throttle response at low and mid-range rpm at the expense of some top-end power.

On single-plane (360-degree) intake manifolds **(see illustration)**, all of the intake runners are on the same level and approximately the same length. This helps improve mixture distribution, which is a problem with some dual-plane manifolds. Recently, single-plane manifolds have been designed with better low and mid-range performance. If you want increased mid and top-end power instead of low and mid-range torque, a single-plane manifold may be the way to go. Keep in mind, though, that the most usable power produced by an engine is in the low and mid rpm range.

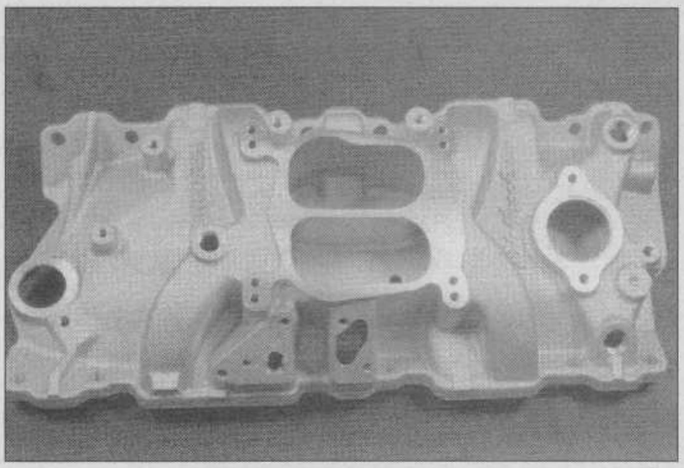
Intake manifolds are available in low, mid and high-rise versions. The low-rise type is designed to fit under low hood lines and generally sacrifices some power relative to the higher rise type. For most applications, if there is enough hood clearance, go with the high-rise type.

There are two other common designs that you should know about, which are used primarily for racing. Unfortunately, these manifolds, decrease low-end performance, driveability and fuel economy and increase exhaust emissions.

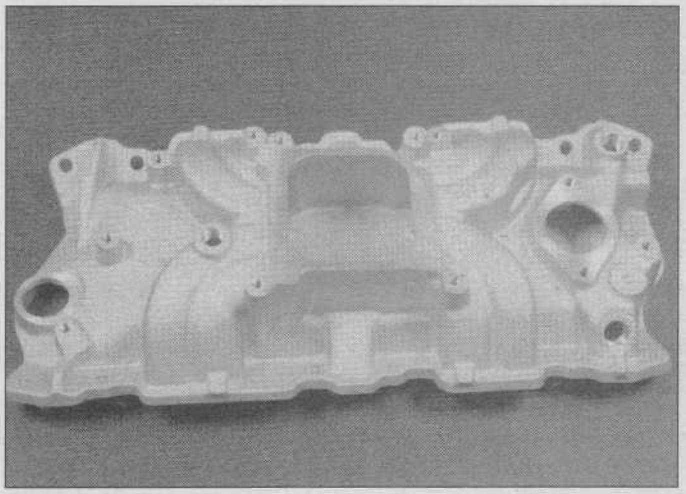
The cross-ram manifold mounts two four-barrel carburetors side-by-side, instead of one in front of the other. Each carburetor feeds the cylinders on the opposite bank and provides a "ram-tuning" effect.

Tunnel-ram manifolds also mount two four-barrel carburetors, but they are installed in-line instead of side-by-side. They look wild on "Pro-street" cars with the carburetors sticking through the hood, but don't work well on street-driven vehicles.

There are a bewildering number of high-performance factory and aftermarket intake manifolds available for carbureted engines. Manufacturers provide a wealth of information in their catalogs to assist the buyer in making an informed purchase. However, the engines must be identical to the engines listed in the tests to produce the same amount of power. All of the components must work together for best results.



**8.36 A typical dual-plane manifold**



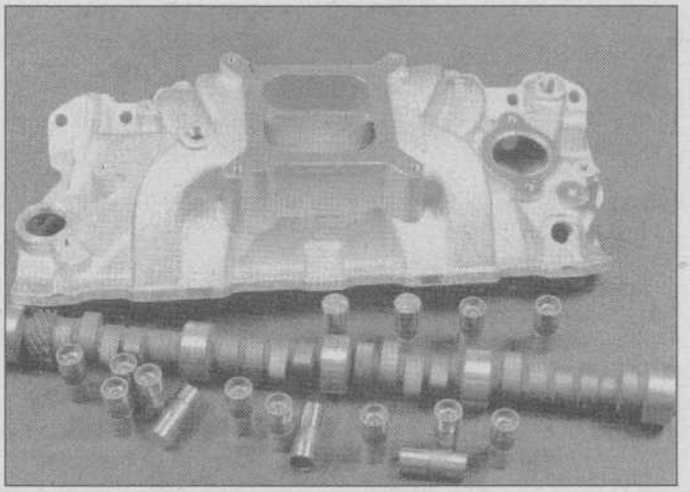
**8.37 A typical single-plane manifold**

Once you decide on the basic type (single-plane or dual-plane) and rpm range, you must get the right manifold to fit your engine and carburetor. If the carburetor currently on the engine is in good condition and meets your needs, you can retain it and save money. If the carburetor is defective or doesn't suit the application, now is the time to change it.

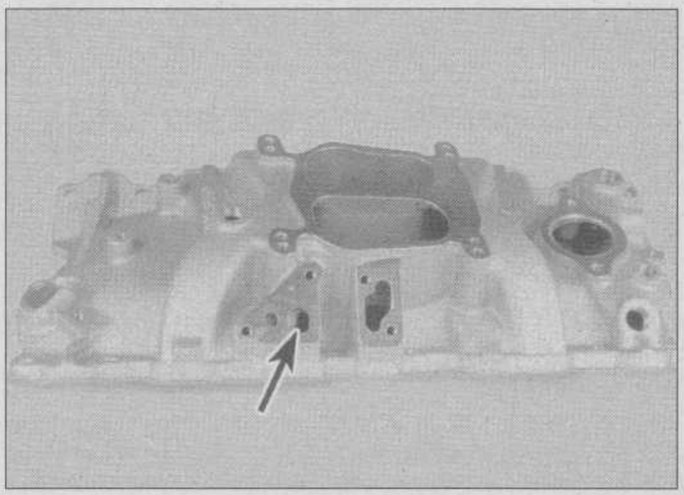
The intake manifold mounting flanges for various carburetors are different, so you must decide what carburetor to use before you buy a manifold. For example, spread bore and regular bore carburetors have different bore sizes and bolt pattern spacing.

Many performance enthusiasts over-carburate their engines, which hurts throttle response, economy and emissions. The carburetor must be matched to the manifold and the engine for best results.

Be sure to match the manifold characteristics with the overall theme and purpose of your vehicle. Carburetor manufacturers spend countless hours testing their products on dynomometers testing flow (CFM) and performance variations with every modification and adjustment change. Some compa-



8.38 Some companies make kits with compatible camshafts and intake manifold combinations



8.39 If your vehicle is equipped with EGR, make sure the certified aftermarket intake manifold you select has a mounting point for the EGR valve (arrow)

nies sell matched camshaft and manifold kits **(see illustration)**. Before you plunk down your hard-earned cash, find out from the manufacturer what the manifold is designed to do and what it will be like on your engine.

Emission-controlled models may be required to have a functional Exhaust Gas Recirculation (EGR) valve. Some aftermarket manifolds don't have a provision for EGR; this could cause you to fail an emissions test. Also, many engines ping under load when the EGR is disconnected.

Make sure the manifold has exhaust crossover passages to improve warm-up driveability. Without these, the engine will hesitate and stumble until it is fully warmed up.

Sometimes replacement manifolds require different throttle linkage and mounting hardware. Some engines have a choke stove and many have numerous vacuum fittings. Be sure the parts are readily available in kit form or separately before you purchase a manifold.

A few aftermarket intake manifolds are available for throttle body and port-injected engines. Most of these are designed to improve power and economy while still remaining "smog" legal. Check local regulations before modifying any emission-controlled vehicle.

### Installation tips

Always use new gaskets and seals during installation. Follow the instructions provided with the gasket set and the intake manifold and use quality, name-brand products.

If the cylinder heads have been resurfaced, be sure to have the machine shop mill the manifold surfaces to prevent leaks.

Aluminum manifolds are slightly more prone to warpage than their cast-iron counterparts. Follow the recommended tightening procedure, which is usually an alternating sequence from the center toward the ends, working from side-to-side. Use a torque wrench to tighten the fasteners to the torque specified by the manifold manufacturer

Install a new thermostat and gasket whenever you replace the intake manifold. Use the correct heat range thermostat for the vehicle. Most emission-controlled models use a 195-degree F. thermostat. Earlier models generally use a 180-degree unit.

After the installation is complete, carefully adjust the accelerator linkage to allow full throttle opening and check for binding and sticking before starting the engine.

Be sure there is sufficient fresh oil and coolant in the engine. Run the engine, set the ignition timing, adjust the carburetor and check for oil, fuel and coolant leaks.

# Emission considerations

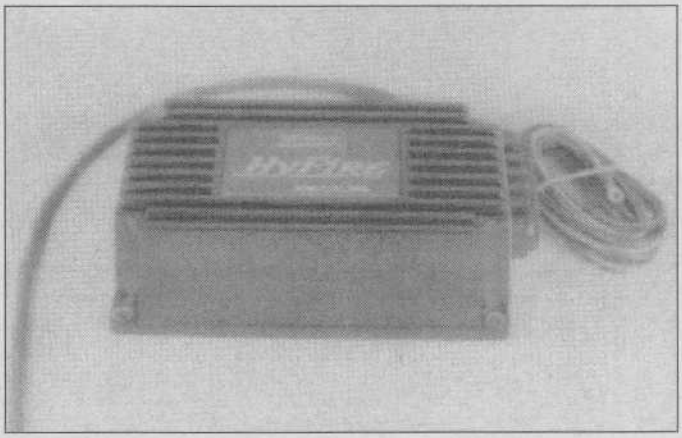
## *Can you modify an emissions-controlled vehicle?*

Basically, yes!, so long as you leave all emissions systems intact and the EPA (or, if you live in California, the California Air Resources Board [CARB]) has certified all the components you're planning to install. **Note:** *The components must be certified for use on your particular vehicle. Although, anything you do on the vehicle can be considered "tampering".*

### What is tampering?

EPA regulations and many state laws prohibit tampering with the emissions components originally installed on the vehicle. They also prohibit replacing an emissions-related component with a non-original component, unless that component has been specifically certified for use on the vehicle. "Emissions-related" components are any components that have an effect on emissions. Although their primary function is not emissions control, authorities consider many engine, fuel and exhaust system components to be emissions related. These include camshafts, intake and exhaust manifolds, air cleaners and carburetors or fuel-injection systems. Even aftermarket replacement computer chips must be certified for use in the vehicle.

Tampering with emissions system components (for example, removing an air pump, disconnecting an EGR vacuum hose or even replacing an air cleaner with an aftermarket unit that doesn't have the original emissions provisions) is not only illegal, it can decrease your engine's performance. Vehicles designed for operation with emissions control devices often run better when the systems are hooked up and working properly. This is particularly the case with newer, computer-con-



**8.40 Computer-controlled ignition systems like this one can give a slight increase in performance and fuel economy to vehicles that don't already have a computer - check to be sure they're certified for use on your vehicle**

trolled vehicles in which the computer uses information from the emissions systems to control the engine's operation.

Since most smog inspections involve a visual inspection as well as exhaust gas analysis, you'll be caught if you tamper with your emissions systems or emissions-related components. And there's usually no limit on how much you have to spend to correct components that have been tampered with; you'll have to put everything back the way it was, regardless of cost, or you won't get registered.

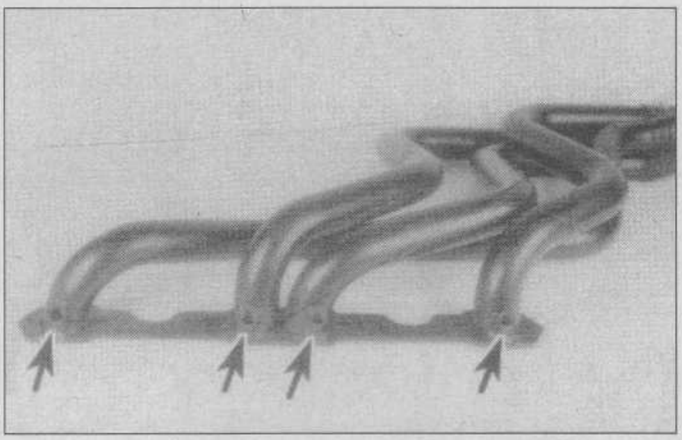
And don't figure you can fool the inspectors. They have on-line information or books that tell what equipment must be installed on the vehicle, and inspectors are usually pretty good at spotting non-original equipment, such as a non-certified high-performance carburetor.

Don't fall into the trap of figuring you can change a camshaft without worry, since it's inside the engine and won't be found on a visual inspection. Many long-duration camshafts cause the engine to emit excessive pollutants at idle. You may pass the visual inspection, but you might fail the exhaust analysis. Considering the amount of work and expense involved in replacing a camshaft, it pays to make sure it is certified for use in your vehicle.

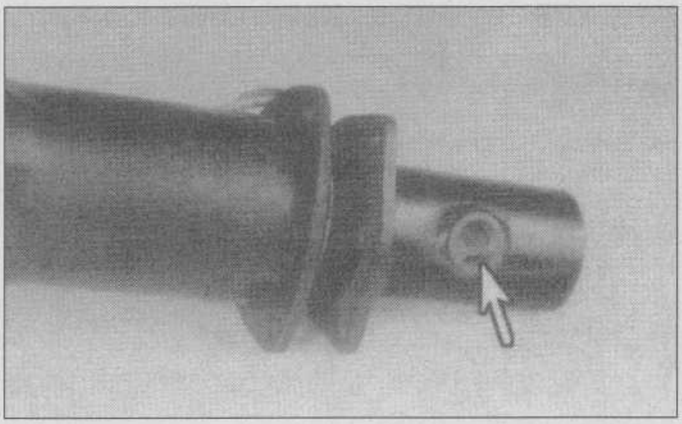
## What modifications can you make?

### Aftermarket equipment

Many aftermarket manufacturers offer equipment that is designed for use on emission-controlled vehicles. These components include carburetors, intake manifolds, electronic ignition systems, exhaust headers and camshafts **(see illustrations)**. Avoid components that are for racing use only. These often say "for off-highway use only" or "not for use in pollution-controlled vehicles" in their product literature. If you doubt any piece of equipment, check with the manufacturer to see if the component is EPA or CARB certified.



**8.41 If you have an air injection system on your vehicle and the injection tubes are threaded into the exhaust manifold, make sure the certified exhaust headers you select have provisions for mounting the tubes in the same place (arrows), and . . .**



**8.42 . . . if your vehicle is equipped with an oxygen sensor, be sure to use the collector on the end of the header that has a mounting hole for the sensor (arrow)**

# Conversion factors

*Length (distance)*

| | | | | |
|---|---|---|---|---|
| Inches (in) | X 25.4 | = Millimetres (mm) | X 0.0394 | = Inches (in) |
| Feet (ft) | X 0.305 | = Metres (m) | X 3.281 | = Feet (ft) |
| Miles | X 1.609 | = Kilometres (km) | X 0.621 | = Miles |

*Volume (capacity)*

| | | | | |
|---|---|---|---|---|
| Cubic inches (cu in; in$^{3}$) | X 16.387 | = Cubic centimetres (cc; cm$^{3}$) | X 0.061 | = Cubic inches (cu in; in$^{3}$) |
| Imperial pints (Imp pt) | X 0.568 | = Litres (l) | X 1.76 | = Imperial pints (Imp pt) |
| Imperial quarts (Imp qt) | X 1.137 | = Litres (l) | X 0.88 | = Imperial quarts (Imp qt) |
| Imperial quarts (Imp qt) | X 1.201 | = US quarts (US qt) | X 0.833 | = Imperial quarts (Imp qt) |
| US quarts (US qt) | X 0.946 | = Litres (l) | X 1.057 | = US quarts (US qt) |
| Imperial gallons (Imp gal) | X 4.546 | = Litres (l) | X 0.22 | = Imperial gallons (Imp gal) |
| Imperial gallons (Imp gal) | X 1.201 | = US gallons (US gal) | X 0.833 | = Imperial gallons (Imp gal) |
| US gallons (US gal) | X 3.785 | = Litres (l) | X 0.264 | = US gallons (US gal) |

*Mass (weight)*

| | | | | |
|---|---|---|---|---|
| Ounces (oz) | X 28.35 | = Grams (g) | X 0.035 | Ounces (oz) |
| Pounds (lb) | X 0.454 | = Kilograms (kg) | X 2.205 | = Pounds (lb) |

*Force*

| | | | | |
|---|---|---|---|---|
| Ounces-force (ozf; oz) | X 0.278 | = Newtons (N) | X 3.6 | = Ounces-force (ozf; oz) |
| Pounds-force (lbf; lb) | X 4.448 | = Newtons (N) | X 0.225 | = Pounds-force (lbf; lb) |
| Newtons (N) | X 0.1 | = Kilograms-force (kgf; kg) | X 9.81 | = Newtons (N) |

*Pressure*

| | | | | |
|---|---|---|---|---|
| Pounds-force per square inch (psi; lbf/in$^{2}$; lb/in$^{2}$) | X 0.070 | = Kilograms-force per square centimetre (kgf/cm$^{2}$; kg/cm$^{2}$) | X 14.223 | = Pounds-force per square inch (psi; lbf/in$^{2}$; lb/in$^{2}$) |
| Pounds-force per square inch (psi; lbf/in$^{2}$; lb/in$^{2}$) | X 0.068 | = Atmospheres (atm) | X 14.696 | = Pounds-force per square inch (psi; lbf/in$^{2}$; lb/in$^{2}$) |
| Pounds-force per square inch (psi; lbf/in$^{2}$; lb/in$^{2}$) | X 0.069 | = Bars | X 14.5 | = Pounds-force per square inch (psi; lbf/in$^{2}$; lb/in$^{2}$) |
| Pounds-force per square inch (psi; lbf/in$^{2}$; lb/in$^{2}$) | X 6.895 | = Kilopascals (kPa) | X 0.145 | = Pounds-force per square inch (psi; lbf/in$^{2}$; lb/in$^{2}$) |
| Kilopascals (kPa) | X 0.01 | = Kilograms-force per square centimetre (kgf/cm$^{2}$; kg/cm$^{2}$) | X 98.1 | = Kilopascals (kPa) |

*Torque (moment of force)*

| | | | | |
|---|---|---|---|---|
| Pounds-force inches (lbf in; lb in) | X 1.152 | = Kilograms-force centimetre (kgf cm; kg cm) | X 0.868 | = Pounds-force inches (lbf in; lb in) |
| Pounds-force inches (lbf in; lb in) | X 0.113 | = Newton metres (Nm) | X 8.85 | = Pounds-force inches (lbf in; lb in) |
| Pounds-force inches (lbf in; lb in) | X 0.083 | = Pounds-force feet (lbf ft; lb ft) | X 12 | = Pounds-force inches (lbf in; lb in) |
| Pounds-force feet (lbf ft; lb ft) | X 0.138 | = Kilograms-force metres (kgf m; kg m) | X 7.233 | = Pounds-force feet (lbf ft; lb ft) |
| Pounds-force feet (lbf ft; lb ft) | X 1.356 | = Newton metres (Nm) | X 0.738 | = Pounds-force feet (lbf ft; lb ft) |
| Newton metres (Nm) | X 0.102 | = Kilograms-force metres (kgf m; kg m) | X 9.804 | = Newton metres (Nm) |

*Power*

| | | | | |
|---|---|---|---|---|
| Horsepower (hp) | X 745.7 | = Watts (W) | X 0.0013 | = Horsepower (hp) |

*Velocity (speed)*

| | | | | |
|---|---|---|---|---|
| Miles per hour (miles/hr; mph) | X 1.609 | = Kilometres per hour (km/hr; kph) | X 0.621 | = Miles per hour (miles/hr; mph) |

*Fuel consumption**

| | | | | |
|---|---|---|---|---|
| Miles per gallon, Imperial (mpg) | X 0.354 | = Kilometres per litre (km/l) | X 2.825 | = Miles per gallon, Imperial (mpg) |
| Miles per gallon, US (mpg) | X 0.425 | = Kilometres per litre (km/l) | X 2.352 | = Miles per gallon, US (mpg) |

*Temperature*

Degrees Fahrenheit = (°C x 1.8) + 32

Degrees Celsius (Degrees Centigrade; °C) = (°F - 32) x 0.56

**It is common practice to convert from miles per gallon (mpg) to litres/100 kilometres (l/100km), where mpg (Imperial) x l/100 km = 282 and mpg (US) x l/100 km = 235*

# Glossary

## A

**Accelerating-well ports** - These ports prevent momentary leanness during the period that occurs between the opening of the air valve and the actual discharge of fuel from the secondary nozzles.

**Accelerator pump** - A pump - usually some sort of piston - located in its own pump well in the carburetor float bowl, that adds a small amount of extra fuel under high pressure into the throttle bore to make up for the momentary shortage of fuel caused by the loss of vacuum that occurs when the throttle plates are suddenly opened.

**Adjustable off-idle air bleed** - Some emissions-era Rochesters have a separate air passage to bleed air past an adjustment screw into the idle system. This screw is preset by the factory to produce precise off-idle air/fuel mixture ratios to meet emission-control requirements.

**Adjustable part throttle (APT)** - A supplementary circuit on some carburetors that can be adjusted to control part-throttle mixtures more accurately than a fixed orifice. The APT detours around the main jet, going directly from the float bowl to the discharge nozzle feed well.

**A/F** - Air/fuel.

**AIR** - Air Injection Reactor.

**Air bleed** - A calibrated (precisely-drilled) hole in the carburetor body which allows air to enter a metering circuit.

**Air density** - The amount of air per unit measure, such as length, area or volume. The mass per unit volume of air under specified or standard conditions of pressure and temperature. Air density varies directly with pressure and temperature: The lower the pressure, or the higher the temperature, the less dense the air.

**Air-fuel mixture** - The air and fuel traveling to the combustion chamber after being mixed by the carburetor.

**Air-fuel ratio** - The proportions of air and fuel (by weight) supplied for combustion. See *stoichiometric*.

**Air horn** - The part of the carburetor body that the air enters first.

**Air horn baffle** - Used on some Q-jets to prevent incoming air from forcing fuel into the secondary wells through the bleed tubes. Prevents secondary-nozzle lag during heavy acceleration.

**Air Injection Reactor (AIR)** - Airflow from pump is directed by CCC system controlled solenoids to reduce exhaust emissions.

**Air pressure** - Atmospheric pressure (14.7 psi).

**Air valve** - A large plate mounted above the venturis on the secondary side of Quadrajets. Once the primaries are open about 35-degrees, the secondaries begin opening, but no air flows through the secondaries until the vacuum under the air valve is strong enough to pull it open.

**Aneroid altitude compensator** - A bellows device, installed integrally with the APT system on some post-1975 Q-jets, that automatically compensated for changes in altitude by raising or lower the primary metering rods, richening or leaning out the air/fuel mixture in accordance with changes in air pressure.

**Anti-dieseling solenoid** - Also referred to as an *idle-stop solenoid*. An electrically-operated two-position plunger used to provide a predetermined throttle setting. When activated, the idle stop solenoid allows the throttle plate(s) to close only so far; when deactivated, it allows the throttle(s) to close all the way, blocking the entry of any more air/fuel mixture into the engine to prevent dieseling (engine run-on) after the ignition key is switched off.

**Anti-siphon bleeds** - Small holes drilled into the cluster to prevent main-system fuel from continuing to flow when the throttle is closed, stopping airflow through the carburetor.

**Anti-stall dashpot** - A diaphragm unit mounted on the carburetor that allows air to escape slowly from its vacuum chamber to prevent throttle plate(s) in the carburetor from closing too suddenly - and stalling the engine - during deceleration.

**Aspirator channel** - This passage is plumbed from the point of lowest vacuum in the booster venturi on an upward angle to the vertical fuel pickup channel.

**Atmospheric pressure** - The weight of the atmosphere per unit area. Atmospheric pressure at sea level is 14.7 pounds per square inch (psi). Atmospheric pressure decreases as the altitude increases.

**Atomization** - The joining of fuel and air molecules into a mist of fine droplets.

**Automatic choke** - A device that positions the choke valve automatically in accordance with engine temperature, or in accordance with time.

**Auxiliary air bleeds** - Used on some idle systems; usually add air to idle system downstream from the regular idle air bleed; act in parallel with idle air bleed.

# B

**Bakelite** - A synthetic resin used for insulating the automatic choke heating element and the carburetor spacer plate.

**Barometric pressure sensor (BARO)** - Reads atmospheric pressure. May be called BARO, or barometric absolute pressure sensor.

**Bimetal** - Two types of metal bonded into a strip and formed into a coil. Each type of metal has different thermal expansion characteristics, so the coil straightens when heated and coils up when cold. Bimetals are used to open and close choke plates.

**Booster venturi** - A small venturi located immediately above and concentric with the main venturi. Boosters are designed to amplify the weak venturi vacuum signal that occurs during low airflow conditions.

**Bowl vent** - Connects the float bowl to the carburetor's air inlet. Depressurizes the fuel being pumped into the float bowl by the fuel pump and acts as a vapor separator by allowing vapors in the float bowl to escape into the carburetor air inlet. Bowl vents are cut at a 45-degree angle and face incoming air so that reference pressure remains the same regardless of airflow.

# C

**Carbon monoxide (CO)** - One of the pollutants found in engine exhaust.

**Catalytic converter, three-way** - Exhaust converter containing platinum and palladium to speed up conversions of HC and CO, and rhodium to accelerate conversion of NOx.

**CCC** - See *Computer Command Control*.

**Center-hung float** - This type of float pivots on an axis that's parallel with the vehicle axles. It's a better float design than a side-hung float during high-speed cornering because the float isn't affected by centrifugal force, so it won't pull the inlet valve open in the middle of a corner.

**cfm** - Cubic feet per minute; a measurement of the air capacity through the carburetor venturi(s) determined by the cylinder displacement and engine rpm.

**Charge density** - Another term for *mass flow*. A dense charge has more air mass, so higher compression and burning pressures can be developed for higher power output. Least charge density is available at idle; highest density is at wide open throttle. See *air density*.

**Choke** - See *choke plate*.

**Choke index** - Automatic chokes have index marks. The factory setting closes the choke when the bimetal is about 70-degrees F. If you want less or more choke at this temperature, move the choke index one mark in the direction indicated by the arrows designating a leaner or richer mixture (you will seldom need to move the choke more than one mark).

**Choke kick** - A preset position for the choke valve set by manifold vacuum that is routed through a carburetor body passage to the choke diaphragm.

**Choke plate** - Or simply *choke*. A device installed in the air horn of the carburetor, used when starting a cold engine. When closed, the choke plate(s) chokes off airflow through the air horn, creating a pressure differential (partial vacuum) below it in the venturi area, which pulls fuel from the main-metering circuit, adding to and enrichening the air/fuel mixture provided by the idle circuit during warm-up.

**Closed loop fuel control** - The normal operating mode for a *feedback carburetor* system. Once the engine is warmed up, the computer can interpret an analog voltage signal from an exhaust gas oxygen sensor and alter the air/fuel ratio accordingly with a *duty-cycle solenoid* or *solenoid-controlled valve*.

**Condensation** - Change of state during which a gas turns to liquid, usually because of temperature or pressure changes.

**Controlled canister purge (CCP)** - ECM-controlled solenoid valve that permits manifold vacuum to purge the evaporative emissions from the charcoal canister.

**Closed loop** - Used to describe oxygen sensor to ECM to M/C solenoid circuit operation.

**Computer Command Control (CCC)** - An electronically-controlled fuel metering system used on GM vehicles. Utilizes an oxygen sensor, a throttle position sensor and other information sensors to provide a computer with the data it needs to alter the air/fuel ratio via a mixture control solenoid in the carburetor.

**Coolant temperature sensor** - Device that senses the engine coolant temperature, and passes that information to the electronic control module through a coaxial connector.

**Cross-jetting** - Re-jetting the carburetor jets from left-to-right to compensate for a left-to-right variation in performance. These tests are usually conducted using an engine dynamometer.

**Cruising circuit** - See *main metering system*.

**Curb-idle stop screw** - A screw which provides an adjustable stop for the throttle lever.

**Curb-idle port** - See *idle discharge hole*.

## D

**Dead-head pressure** - A fuel pressure reading taken directly at the fuel pump outlet. Many systems use a fuel pressure regulator; dead-head pressure is an unregulated measurement.

**Dashpot** - A device consisting of a piston and cylinder with a restricted opening, used to slow down or delay the operation of some moving part. On carburetors, dashpots are used to prevent the throttle plates from slamming closed when the accelerator pedal is lifted suddenly.

**Diagnostic code** - Pair of numbers obtained from flashing "Check Engine" light. This code can be used determine area in CCC system where a malfunction may be located.

**Diaphragm** - A thin dividing sheet or partition which separates a housing into two chambers, one of which is usually vented to vacuum while the other is not; used in vacuum-controlled secondaries, anti-stall dashpots and other carburetor control devices.

**Directional baffle plate** - Installed in Quadrajet secondary bores to help direct the airflow for improved distribution in the intake manifold.

**Discharge check ball** - A small check ball that lifts off its seat when the pump well is pressurized by the accelerator pump, which allows fuel to be discharged into the venturi through the shooter nozzle.

**Discharge nozzle** - The end of the main delivery tube that discharges fuel into the venturi area.

**Divorced choke** - Also known as a *remote* choke. Vacuum diaphragm is mounted on the carburetor, but the bimetal spring is mounted either on a pad on the intake manifold or in a heat well in the exhaust manifold. Choke lever is operated by a mechanical linkage rod from the bimetal spring.

**Dry setting** - The adjustment of the float with a graduated rule or drill bit while the carburetor is disassembled on the bench. Usually consists of setting a prescribed clearance between the top of the float and the air horn.

**Duty-cycle solenoid** - Also known as a *mixture control solenoid*. The duty-cycle solenoid is a computer-controlled device in a feedback carburetor that alters the mixture adjustment.

**Dwell** - The amount of time (recorded on a dwell meter in degrees) that voltage passes through a closed switch, as in a mixture control solenoid, for example.

## E

**Early fuel evaporation (EFE)** - Method of warming the intake manifold during cold engine operation. Provides efficient air/fuel mixing.

**Electric choke** - Chokes can be operated by a bimetal spring heated by a solid-state heating unit or by a nichrome-wire resistor. Both types increase temperature just like a coolant-controlled choke as engine warms up.

**Electronic Control Module (ECM)** - A box containing electronic circuitry which operates the CCC system. The ECM also turns on the "Check Engine" light when a malfunction occurs in the system.

**Electronic Spark Timing (EST)** - ECM-controlled timing of ignition spark.

**Emulsification** - The process of making an emulsion.

**Emulsion** - Air/fuel mixture in one of the carburetor's circuits, before it is discharged and fully atomized.

**Emulsion tube** - A small tube with holes in it; protrudes down into the main or mixing well, introduces air from a bleed into the well to emulsify the fuel.

**Energize/de-energize** - When voltage is passed through the M/C solenoid, the metering control armature is pulled into the solenoid (energized). When the voltage to the solenoid is turned off, a spring raises the metering control armature (de-energized).

**Engine calibration unit** - Also known as a *Programmable Read-Only Memory (PROM)*. An electronic component which can be specifically programmed to the design of each car model to control the M/C solenoid. Plugs into the Electronic Control Module (ECM).

**Exhaust gas recirculation (EGR)** - Method of reducing NOx emissions levels.

**Exhaust oxygen sensor** - Also known as an *oxygen sensor* or an *$0_2$ sensor*. Device that detects the amount of oxygen in the exhaust stream, and sends that information to the ECM.

## F

**Fast idle cam** - A cam or eccentric, attached to the choke plate by a linkage rod, that prevents a cold engine from stalling by holding the throttle plate partially open, which allows the engine to run at a faster-than-normal speed as long as the choke is applied.

**Feedback carburetor** - A modern emissions-era carb which responds not only to the amount of air moving through it, but also the demands of the engine operating conditions. Feedback carbs are just one part of a *closed-loop system* (an oxygen sensor, various other sensors, a computer, a duty-cycle solenoid or solenoid-controlled valve and a catalytic converter) which uses a microprocessor to monitor and adjust the air/fuel mixture.

**Fixed idle-air bypass** - Some Quadrajets have idle air passages from the air horn to a point just below the throttle plates. Extra air through these passages allows the throttle plates to be more closed at idle, reducing the signal applied to the discharge nozzles for the main metering circuit and eliminating nozzle drip at idle.

**Flame arrester** - A device installed in the air filter housing; prevents flames from escaping into the engine compartment during a backfire.

**Float** - A chamber which floats in the fuel in the float bowl. The float is attached to and controls the inlet fuel valve (needle and seat). When the fuel level goes down, the float sinks and opens the inlet valve; when the fuel level rises to the "full" level, the float rises with it and closes the inlet valve. Floats are made of brass, nitrophyl or molded plastic.

**Float bowl** - The carburetor's reservoir for storing the fuel needed to supply all metering circuits.

**Float bumper spring** - A small spring installed under the float tang to minimize float bounce and vibration

**Floating cup** - Fills the accelerator pump well through the center of the pump piston cup. The type of accelerator pump inlet valve used on all current Rochesters. Designed to fit on the plunger with a small amount of vertical clearance. During delivery stroke, cup is forced up against piston face, sealing off a fill hole in the face. As plunger and piston travel upward on return stroke, cup drops a few thousandths of an inch from piston face and fuel enters through hole in the face.

**Float level** - The float position at which the float needle closes against its seat, shutting off the fuel inlet valve to prevent further delivery of fuel.

**Float system** - The circuit that controls the entry of fuel into - and the level of fuel in - the float bowl.

**Flooding** - A condition that occurs when the fuel level in the float bowl is too high. Flooding occurs when the float level is incorrectly adjusted, the float is rubbing on the side of the fuel bowl or the fuel inlet needle is held off the seat by some foreign matter or by a worn out seat. A flooded float bowl causes the idle and main circuits to deliver an air/fuel mixture that's too rich to burn.

**Four-barrel carburetor** - A carburetor with four throttle bores, four throttle plates, etc. A four-barrel is really a pair of two-barrel carbs in a single assembly.

## H

**High impedance voltmeter** - A voltmeter with high opposition to the flow of electrical current. Good for reading circuits with low current flow, such as found in the CCC system.

**High-speed bleeds** - Another name for the main air bleeds; located in the air horn.

**High-speed circuit** - See *main metering system*.

**Hot idle compensator** - A small air valve that allows fresh air to enter the manifold and lean the mixture when the engine is hot.

**Hot soak** - Occurs when the engine is stopped during hot weather or after it has been run long enough to be fully warmed up; also the period during which the phenomenon known as *percolation* occurs (see *Percolation*).

**Hydrocarbons (HC)** - One of the pollutants found in engine exhaust.

## I

**Ideal mixture** - The air/fuel ratio which provides the best performance while maintaining maximum conversion of exhaust emissions, typically 14.7:1.

**Idle air bleed** - A tube that allows air into the idle circuit to *emulsify* the fuel.

**Idle air bleed valve** - An adjustable idle air bleed used on feedback carburetors. Controls the amount of air bled into the idle fuel mixture prior to the mixture entering the idle system, when the M/C solenoid is energized.

**Idle-air bypass** - Used on some Rochester two and four-barrel carburetors. Air above the venturi bypasses the almost-closed throttle plates at idle, re-entering the carburetor below the plates, ensuring a consistent idle even with dirty throttle plates and reducing signal at discharge nozzles for main metering circuit, which eliminates *nozzle drip* at idle.

**Idle air compensator** - Used on some Rochester two-barrel carburetors to offset the enriching effects of excessive fuel vapors caused by fuel percolation during extremely hot operating conditions.

**Idle channel restriction** - Does the same thing as the *idle feed restriction* but is located in the idle passage just below the idle air bleed instead of the bottom of the idle tube. In the primary idle channel, the amount of fuel emitted by the idle discharge port is adjustable because there's a screw with a tapered tip extending into the port. On the secondary side, the idle discharge port uses a fixed idle channel restriction with no adjustment.

**Idle discharge hole** - Also known as the *curb-idle port*. The hole through which the idle mixture enters the airstream flowing past the throttle plate.

**Idle feed restriction** - Also known as an *idle orifice* or *idle jet*. A metering orifice that controls the amount of fuel that can enter the idle tube.

**Idle limiter** - Any device that limits the maximum richness of the idle air/fuel mixture in the carburetor; also aids in preventing overly rich idle adjustments. Limiters take either of the two following forms: An external plastic cap (see *idle limiter cap*) or an internal-needle type located in the idle passages of the carburetor.

**Idle limiter cap** - An external plastic cap on the head of the idle mixture adjustment screw on emissions era Rochesters; limits the idle mixture screw adjustment to about 1/2-turn.

**Idle mixture** - The air/fuel mixture supplied to the engine during idling.

**Idle mixture screw** - The adjustment screw that can be turned in or out to lean out or enrich the idle mixture.

**Idle orifice** - See *idle restriction tube or idle jet.*

**Idle solenoid** - An electric solenoid designed to raise the curb-idle speed to compensate for an additional load, such as the air conditioner, on the engine.

**Idle Speed Control (ISC) motor** - An ECM controlled motor that extends or retracts a plunger that contacts the throttle lever, which regulates the position of the throttle valve to compensate for an additional load, such as the air conditioner, power steering pump, etc. on the engine. Although it regulates idle speed, it is not used to adjust the curb idle speed.

**Idle system** - The circuit through which fuel is fed when the engine is idling.

**Idle-transfer hole** - See *idle transfer port.*

**Idle transfer port/slot** - A port drilled into the carburetor body slightly above the idle port to allow extra fuel/air emulsion into the airstream during the transition period when the throttle plate is opening from its idle (closed) position to a larger (cruising) opening angle.

**Idle tube** - A tube in the carburetor from the main well that allows fuel to pass through during idle.

**Inlet valve assembly** - The needle and seat that control the admission of fuel into the float bowl. When the float sinks, the float lever arm pulls the needle off its seat and allows fuel to enter the float bowl; when the float rises, the arm pushes the needle against its seat and fuel flow into the float bowl is blocked.

**Inputs** - Information from sources (coolant temperature sensor, exhaust oxygen sensor, etc.) that tells the ECM how the engine is performing.

**Integral choke** - A one-piece choke assembly that mounts both the bimetal assembly and the vacuum piston housing on the carburetor.

**Intermittent** - Occurs now and then; not continuously. In electrical circuits, refers to occasional open, short or ground.

**Internal bowl vent** - A tube designed to vent excess fuel vapors from the fuel bowl back into the carburetor during acceleration and cruising conditions.

## J

**Jet** - A calibrated passage through which fuel flows. Jets are usually machined out of solid brass and threaded so they can be replaced. However, some jets are actually drilled right into the carburetor body.

**J-type vent tubes** - Special tubes located on the top of marine carburetors that direct any overflow from the carburetor bowl(s) back into the throttle bores. USCG-approved method of preventing fire in the engine compartment if the inlet valve sticks in an open position.

## K

**Kickdown linkage** - On vehicles with an automatic transmission, the linkage on the carburetor that produces a downshift when the accelerator pedal is pushed down to the floorboard.

## L

**Lean surge** - A change in engine rpm caused by an extremely lean setting.

**List number** - The part number stamped onto the body of the carburetor, used for identification; can be cross-referenced to obtain the model number.

## M

**Main air bleed** - Reduces the signal from the discharge nozzle, which lowers pressure difference causing fuel flow and leans out the mixture. Decreasing bleed size increases pressure drop at main jet and gives a richer mixture. Main air bleed also acts as an anti-siphon, so fuel doesn't continue to dribble into venturi after airflow is reduced or stopped.

**Main body** - The center section of the carburetor through which air passes and is mixed with fuel. The main body always houses the choke plate(s) and the venturi(s).

**Main delivery tube** - Also known as the *main nozzle*. The tube that delivers fuel from the main mixing well to the venturi.

**Main jet** - The removable orifice positioned at the bottom of the float bowl that allows fuel into the main well. Main jets are available in various sizes to alter the characteristics of the main metering circuit.

**Main metering circuit** - See *main metering system.*

**Main metering system** - Also known as the *main metering circuit*, the *cruising circuit* or the *high-speed circuit*. Supplies the correct air/fuel mixture to the engine during cruising and high-speed conditions.

**Main mixing well** - See *main well.*

**Main nozzle** - See *main delivery tube.*

**Main venturi(s)** - The large venturi(s) cast into the carburetor main body.

**Main well** - The reservoir in which fuel for the main system is stored. The main well is located in the main body casting. It's connected to the venturi area by the discharge nozzle.

**Main-well tube** - Also known as the *emulsion tube*. A perforated tube which extends from an air bleed in the top of the air horn down into the main well. Admits air from the air bleed into the main well to emulsify the fuel in the main well. Improves idle response and stability when the engine is hot and prevents fuel percolation and general hot-starting problems. Also improves response in the main metering circuit during part-throttle conditions.

**Malfunction** - A condition that causes the CCC system to operate incorrectly. Typical malfunctions are: wiring harness opens or shorts, failed sensors or M/C solenoid or ECM failure.

**Manifold Absolute Pressure (MAP) sensor** - Also known as a *manifold pressure sensor* or *pressure differential sensor*. Reads pressure changes in intake manifold.

**Manifold vacuum** - The difference in air pressure, or *pressure drop*, between atmospheric pressure and air pressure in the intake manifold, that occurs just below the throttle plate(s); usually expressed in inches of Mercury (in-Hg). Manifold vacuum is proportional to the angle of the throttle plate(s): When the plates are closed or nearly closed, manifold vacuum is high; as they open farther, manifold vacuum decreases; by the time they're fully open, there's virtually no manifold vacuum.

**Manifold vacuum (VAC) sensor** - Also known as *manifold pressure sensor*, *pressure differential sensor* or *vacuum sensor*. Reads pressure changes in intake manifold in relation to barometric pressure.

**Mass flow** - In physics, mass is the measure of a body's resistance to acceleration. The mass of a body is different from, but proportional to, its weight. In automotive circles, mass flow refers to the amount of air that can be pumped into each cylinder. Mass flow is proportional to air density. The greater the density, the greater the mass.

**Mechanical secondary** - A secondary system controlled by linkage connected to the primary system.

**Metering restriction** - Precisely-machined orifice in an air bleed, jet or metering circuit; regulates amount of air, fuel or air/fuel mixture that can get through.

**Metering signal** - A (relative) vacuum signal generated by the pressure differential that occurs at the venturi. The strength of the metering signal determines how much fuel is pulled from the main circuit into the venturi: The smaller the venturi, the greater the pressure drop and the stronger the metering signal; the larger the venturi, the smaller the pressure drop and the weaker the metering signal.

**Mixture adjusting screw** - A tapered screw used to regulate the amount of air/fuel mixture through the curb-idle discharge port into the airstream. Usually located near the discharge hole.

**Mixture control (M/C) solenoid** - Device, installed in carburetor, which regulates the air/fuel ratio by oscillating the metering rods.

## N

**Needle-and-seat** - The components of the inlet valve assembly.The needle is attached to the float lever arm; when the float rises, the lever arm closes the needle against its seat, preventing fuel from entering the float bowl. When the float level drops, the lever arm pulls the needle off its seat, allowing more fuel to enter the float bowl.

**Nitrophyl** - A closed cell material that's impervious to gasoline and fuel additives; used as a float material.

**Non-staged carburetor** - A four-barrel carburetor that has secondary throttle plates which open at the same time as the primary throttle plates, or a two-barrel carburetor with only one throttle shaft (both throttle valves open simultaneously).

**Nozzle drip** - Air rushing by the venturi at idle can cause fuel to drip from the discharge nozzle for the main metering circuit.

## O

**Off-idle discharge ports** - Also known as *transfer ports*. The holes that deliver fuel from the idle circuit during the transition from curb-idle to the main metering circuit. Located just above the throttle plates. At curb idle, off-idle ports function as an extra air bleed for further emulsification of the idle mixture; but as vacuum moves up the carb bore when the throttle plates are opened, they become fuel discharge ports. Either one or more holes, or a single slot (slots are usually used because they're cheaper to manufacture).

**Open-loop fuel control** - A non-feedback mode of operation which a feedback system resorts to when the engine is started while it's still cold. During this period, the oxygen sensor isn't yet able to supply reliable data to the computer for controlling the air/fuel mixture ratio because the engine isn't yet warmed up. So mixture control is handled by a program stored in computer memory.

**Outputs** - Functions, typically solenoids, that are controlled by the ECM.

**Oxidation catalyst (OC)** - Type of bead material in catalytic converter which aids in oxidation of CO and HC.

**Oxides of nitrogen ($NO_x$)** - One of the pollutants found in engine exhaust.

## P

**Part-throttle mixture** - As the primary throttle plate opens, vacuum below the plate is reduced. Some of the fuel flow is from the idle port and some is from the idle transfer port or slot. Proportionally, more air is bypassed around the throttle plates, so the mixture gradually leans out. This transition phase is known as "part throttle mixture."

**Percolation** - Phenomenon that occurs during a *hot soak* period: Fuel in the main system between the float bowl and the main discharge nozzle boils over, vapor bubbles push liquid fuel out of main system into venturi, fuel falls onto throttle plate and trickles into manifold. Excess vapors from fuel bowl and from bubbles escaping down the main well are heavier than air and drift down into manifold. This makes engine hard to start.

**Phenolic spacer -** A carburetor base gasket made from a thermosetting resin used specifically for heat insulation between the carburetor and the intake manifold.

**Ported vacuum** - A slot-type port located right at the throttle plates, used for controlling various devices that must work in proportion to throttle plate opening, such as the EGR valve. When the throttle plates are closed at idle, there's virtually no vacuum signal at this slot. But as the throttle plates open during acceleration, they expose the slot to a progressively increasing amount of intake manifold vacuum (see *manifold vacuum*).

**Power circuit** - See *power system*.

**Power piston** - The spring-loaded, manifold-vacuum-controlled piston that lowers and raises the tapered metering rod(s) which lean out or richen, respectively, the mixture. The power piston also controls the power circuit (see next definition).

**Power system** - Or *power circuit*. The circuit that supplies a richer mixture when the engine needs to produce extra power for acceleration or passing. The power circuit consists of a vacuum passage in the carburetor that supplies manifold vacuum to a spring-loaded power piston; when manifold vacuum drops below a certain level, spring pressure opens the power valve and extra fuel is admitted to the main well.

**Power valve** - A spring loaded piston assembly that works like a "switch" operated by manifold vacuum. At a given load, the amount of manifold vacuum is no longer sufficient to overcome spring pressure, so the power valve is opened by the spring, which allows extra fuel from the power circuit to enter the venturi.

**Pressure differential** - Also known as *pressure drop*. The drop in air pressure that occurs when air flowing through a tube meets a restriction such as a choke, venturi or throttle plate, causing a relative vacuum toward which air or fuel flows when acted upon by atmospheric pressure.

**Pressure drop**- -See *pressure differential*.

**Primary bore(s) -** The throttle bore(s) and venturi(s) for the primary system.

**Primary inlet system** - The float circuit for the primary side of the carburetor.

**Primary pull-off diaphragm** - Device that partially opens the choke when vacuum develops (i.e. when the engine starts), allowing more air to pass through the carburetor, thinning out the excessively rich idle mixture.

**Primary side** - The choke and throttle plates, venturis and metering circuits associated with the *primary system*.

**Primary system** - The part of a staged carburetor that operates all the time.

**Primary throttle** - Linkage and throttle levers associated with the primary side of the carburetor.

**PROM** - Programmable Read-Only Memory. An electronic term used to describe the engine calibration unit.

**Pull-off diaphragm** - See *vacuum break diaphragm*.

**Pump inlet check ball** - A steel ball located in the plunger head or in the bottom of the accelerator pump well. The pump inlet check ball prevents fuel from escaping from the well when the throttle is opened and pressure is exerted on the fuel in the pump well by the accelerator pump piston.

**Pump sag** - A hesitation in carburetor performance between the time the accelerator pump squirts fuel into the venturi and the point at which the main fuel circuit is activated.

## Q

**Qualifying diaphragm** - See *vacuum-break diaphragm*.

## R

**Radial discharge nozzle** - This unusual booster venturi has four "spokes" or arms which carry fuel to the outer circumference of the booster before discharging it from tiny holes in the ends of the spokes. Used only on the Corvair Model H carburetor.

**RAM tuning** - A resonance phenomenon gained by changing the length of the intake passage from the carburetor to the intake valve thereby improving torque at one point on the rpm band depending upon the tuned length.

**Reference pressure** - The fuel bowl is vented to the outside air to maintain a constant (atmospheric) pressure on the fuel, thus maintaining a constant fuel level as a point of reference for the other systems in the carburetor.

## S

**Secondary side** - The choke and throttle plates, venturis and metering circuits associated with the *secondary system*.

**Secondary system** - The part of a staged carburetor that's only used to supply extra fuel and air for increased power. The secondary system doesn't open until the primary system has already opened a certain amount.

**Secondary throttle** - The linkage and throttle levers associated with the secondary system on staged carburetors.

**Secondary venturi(s)** - The venturi(s) associated with the secondary system.

**Self-diagnostic code** - The ECM can detect malfunctions in the CCC system. If a malfunction occurs, the ECM turns on the "Check Engine" light. A diagnostic code can be obtained from the ECM through the "Check Engine" light. This code will indicate the area of the malfunction.

**Shooter** - The accelerator pump discharge nozzle; squirts extra fuel into the throttle bore when the accelerator pump circuit is pressurized by the pump piston.

**Shooters** - Small pump-discharge restrictions in the cluster assembly. These small cavities prevent accelerator pump pullover feeding from the pump system at high airflows.

**Side-hung float** - This float design has a pivot axis that's perpendicular to the vehicle axles. It has slightly better float control and fuel handling during acceleration and braking than its center-pivoted counterpart.

**Signal** - Another name for *vacuum* transmitted from one location in the carburetor to another. For example, a vacuum signal from the low-pressure venturi area to the float bowl, which is referenced to atmospheric pressure, initiates main circuit fuel flow.

**Signal amplifier** - Any device, such as the booster venturi, that amplifies a vacuum signal.

**Solenoid-controlled valve** - See *duty-cycle solenoid*.

**Spillover point** - Also known as the *pullover point*. The location of the main circuit discharge in the venturi, which is always higher than the fuel level in the bowl so fuel won't run into the venturi when it shouldn't. When spillover begins is determined by the size of the venturi and by the displacement of the engine pulling air through the carburetor.

**Square jetting** - Same size jetting in all four holes or same size in primary barrels with a different "same size" in the secondaries.

**Staged carburetors** - Carburetors equipped with a secondary system. Staged carbs are activated either mechanically or by a vacuum diaphragm. Think of staged four-barrels as two two-barrels in parallel.

**Stagger jetting** - See *cross-jetting.*

**Stoichiometric** - Stoichiometry is the methodology and technology by which the quantities of reactants and products in chemical reactions are determined. In automotive science, the ideal, or stoichiometric, air/fuel ratio has been determined to be 14.7 parts air to 1 part fuel, or 14.7:1.

## T

**Throat** - The narrowest diameter of the venturi.

**Throttle body** - On carburetors, the casting which houses the throttle plate(s) and shaft(s) and the throttle linkage for the primary and, if equipped, the secondary bores. The throttle body is a separate component that's bolted to the underside of the carburetor main body.

**Throttle bore** - Each barrel shaped opening cast into the carburetor main body that directs air through the carburetor; each throttle bore contains a venturi, a booster venturi, a discharge nozzle for the main circuit, an accelerator pump shooter, a curb-idle discharge port, a transfer slot, etc.

**Throttle plate** - Also known as a *throttle valve*. Round disc-shaped valve positioned at the bottom of the throttle bore to control airflow. The throttle plate does not control the volume of air/fuel mixture pumped through the engine; the displacement never changes, so the volume of air pulled into the engine is constant for a given speed. The throttle controls the *density* or *mass flow* of air pumped in to the engine by the pistons. Least charge density is available at idle; highest density is available at wide open throttle. A dense charge has more air mass, so higher compression and burning pressures can be developed for higher power output. See *air density and mass flow.*

**Throttle Position Sensor (TPS)** - Device that tells the ECM the angle of the throttle plate.

**Throttle shaft** - The shaft to which the throttle plate is affixed and on which it rotates. The throttle shaft is slightly offset (about 0.020-inch on primaries and about 0.060-inch on secondaries), so one side of the throttle plate has a larger area to induce self-closing.

**Throttle stop screw** - This screw sets the angle of the throttle plate opening.

**Throttle valve** - See *throttle plate*.

**Transfer port or slot** - See *off-idle discharge ports*.

## U

**Unloader** - If the engine doesn't start quickly, the extra fuel pulled into the carburetor by the choke plate creates an excessively rich mixture that floods the engine. To purge this excess fuel from the manifold, you push the accelerator pedal to the floor while cranking the engine. When the gas pedal is floored, a tang on the throttle lever contacts the fast idle cam, opening the choke enough to allow additional air through the carburetor and clear excess fuel from the manifold during engine start-up. This tang is known as the unloader.

## V

**Vacuum** - In science, the absence of air. In automotive circles, any pressure that is lower than atmospheric pressure (14.7 psi). Vacuum is used extensively for controlling fuel flow within various metering circuits in a carburetor. Generally measured in inches of Mercury (in-Hg). There are three types of vacuum: manifold, ported and venturi. The strength of these vacuums depends on the throttle opening, engine speed and load. See *manifold vacuum, ported vacuum* and *venturi vacuum*.

**Vacuum break diaphragms** - Also known as a *pull-off diaphragm* or *qualifying diaphragm*. A choke mechanism on automatic chokes that partially opens the choke plate to a preset opening when vacuum develops (i.e. when the engine starts) to prevent an excessively-rich idle (though it's still about 20 to 50-percent richer than normal).

**Vaporization** - A change of state from liquid to vapor or gas, by evaporation or boiling; a general term including both evaporation and boiling.

**Vapor lock** - The formation of gasoline vapor in the fuel lines; bubbles of gasoline vapor usually restrict or prevent fuel flow to the carburetor.

**Vehicle Speed Sensor (VSS)** - Sensor in speedometer cluster which sends vehicle speed information to the electronic control module.

**Velocity valve** - Also known as an *auxiliary valve*. Located above the secondary throttle plates and below the venturi area on 4GC carburetors with mechanically-linked secondaries. Once primaries have opened about 45-degrees, secondaries begin opening. Little airflow passes the secondaries until vacuum under velocity valves is strong enough. The velocity valves delay secondary airflow for a smooth transition during secondary throttle plate opening. If engine rpm is high enough, air velocity forces spring-loaded velocity valves open. When full throttle is applied at low engine speeds, velocity valves begin opening but close quickly because insufficient air is flowing to force them open. Their spring tension limits opening until engine vacuum increases.

**Vena contracta** - The point of lowest-pressure and highest velocity that's located 0.030-inch below the venturi's throat (minimum diameter). The center of the discharge nozzle or the trailing edge of the booster venturi is placed at the vena contracta.

**Vent** - An opening through which air can leave an enclosed chamber.

**Venturi** - The part of the carburetor bore that necks down into a smooth-surface, bottleneck-shaped restriction.

**Venturi effect** - In an internal combustion engine, a relative vacuum is created in the cylinders by the downward strokes of the pistons. Because atmospheric pressure is higher than the low-pressure area in each cylinder, it rushes through the carburetor to equalize the low-pressure area in the cylinders. On its way to the cylinders, however, air must pass through the venturi. The venturi constricts the inrushing air column, then allows it to widen back out to the throttle bore diameter. This incoming air has a certain pressure. To get through the venturi, it must speed up, which lowers its pressure as it passes through the venturi. This change in pressure is known as the venturi effect.

**Venturi vacuum** - The low pressure area that occurs in the carburetor venturi area. Venturi vacuum is proportional to the speed of the air moving through the carburetor, which in turn is dependent on engine speed.

**Viton-tipped needle** - Special inlet valve needle with a hardened-rubber tip. Viton-tipped needles are resistant to dirt and conform to the seat even at low sealing pressures.

**Volumetric efficiency** - The ratio of the actual mass (weight) of air taken into the engine, to the mass of air the engine displacement would theoretically consume if there were no losses. The measure of how well an engine "breathes."

## W

**Wet setting** - The adjustment of the float with the carburetor mounted on engine and the float bowl full of fuel.

**WOT (wide open throttle)** - The largest possible opening angle of the throttle plate(s).

# Index

# Common spark plug conditions

## NORMAL

***Symptoms:*** Brown to grayish-tan color and slight electrode wear. Correct heat range for engine and operating conditions.
***Recommendation:*** When new spark plugs are installed, replace with plugs of the same heat range.

### WORN

***Symptoms:*** Rounded electrodes with a small amount of deposits on the firing end. Normal color. Causes hard starting in damp or cold weather and poor fuel economy.
***Recommendation:*** Plugs have been left in the engine too long. Replace with new plugs of the same heat range. Follow the recommended maintenance schedule.

### CARBON DEPOSITS

***Symptoms:*** Dry sooty deposits indicate a rich mixture or weak ignition. Causes misfiring, hard starting and hesitation.
***Recommendation:*** Make sure the plug has the correct heat range. Check for a clogged air filter or problem in the fuel system or engine management system. Also check for ignition system problems.

### ASH DEPOSITS

***Symptoms:*** Light brown deposits encrusted on the side or center electrodes or both. Derived from oil and/or fuel additives. Excessive amounts may mask the spark, causing misfiring and hesitation during acceleration.
***Recommendation:*** If excessive deposits accumulate over a short time or low mileage, install new valve guide seals to prevent seepage of oil into the combustion chambers. Also try changing gasoline brands.

### OIL DEPOSITS

***Symptoms:*** Oily coating caused by poor oil control. Oil is leaking past worn valve guides or piston rings into the combustion chamber. Causes hard starting, misfiring and hesitation.
***Recommendation:*** Correct the mechanical condition with necessary repairs and install new plugs.

### GAP BRIDGING

***Symptoms:*** Combustion deposits lodge between the electrodes. Heavy deposits accumulate and bridge the electrode gap. The plug ceases to fire, resulting in a dead cylinder.
***Recommendation:*** Locate the faulty plug and remove the deposits from between the electrodes.

### TOO HOT

***Symptoms:*** Blistered, white insulator, eroded electrode and absence of deposits. Results in shortened plug life.
***Recommendation:*** Check for the correct plug heat range, over-advanced ignition timing, lean fuel mixture, intake manifold vacuum leaks, sticking valves and insufficient engine cooling.

### PREIGNITION

***Symptoms:*** Melted electrodes. Insulators are white, but may be dirty due to misfiring or flying debris in the combustion chamber. Can lead to engine damage.
***Recommendation:*** Check for the correct plug heat range, over-advanced ignition timing, lean fuel mixture, insufficient engine cooling and lack of lubrication.

### HIGH SPEED GLAZING

***Symptoms:*** Insulator has yellowish, glazed appearance. Indicates that combustion chamber temperatures have risen suddenly during hard acceleration. Normal deposits melt to form a conductive coating. Causes misfiring at high speeds.
***Recommendation:*** Install new plugs. Consider using a colder plug if driving habits warrant.

### DETONATION

***Symptoms:*** Insulators may be cracked or chipped. Improper gap setting techniques can also result in a fractured insulator tip. Can lead to piston damage.
***Recommendation:*** Make sure the fuel anti-knock values meet engine requirements. Use care when setting the gaps on new plugs. Avoid lugging the engine.

### MECHANICAL DAMAGE

***Symptoms:*** May be caused by a foreign object in the combustion chamber or the piston striking an incorrect reach (too long) plug. Causes a dead cylinder and could result in piston damage.
***Recommendation:*** Repair the mechanical damage. Remove the foreign object from the engine and/or install the correct reach plug.

# ROCHESTER
# Carburetor Manual

Part C: Models 2G, 2GC and 2GV

Chapter 3 Carburetor fundamentals

7D-12 Chapter ... Overhaul and adjustments

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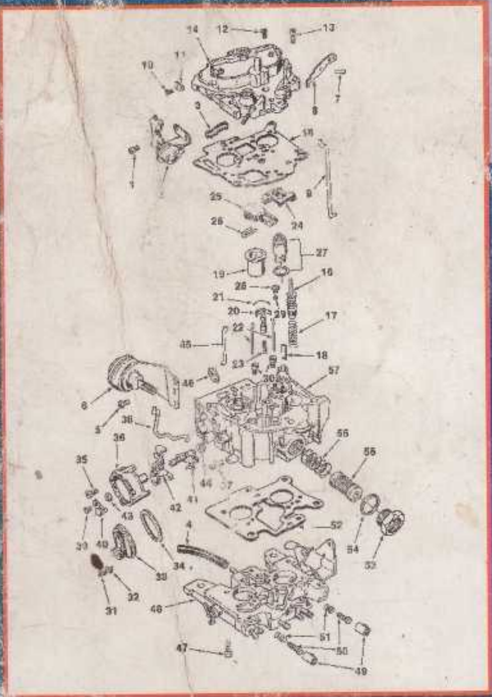

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