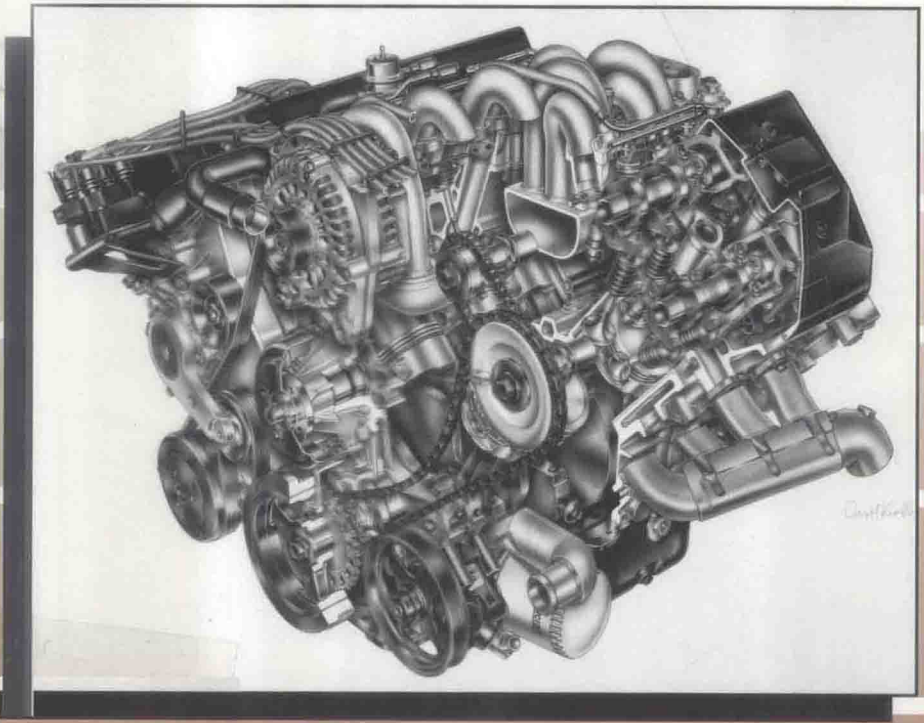
CHEK-CHART

FUEL SYSTEMS AND EMISSION CONTROLS 3RD EDITION



SHOP MANUAL

Fuel Systems and Emission Controls

Third Edition

By Chek-Chart

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Acknowledgments

In producing this series of textbooks for automobile technicians, Chek-Chart has drawn extensively on the technical and editorial knowledge of the nation's carmakers and suppliers. Automotive design is a technical, fast-changing field, and we gratefully acknowledge the help of the following companies and organizations in allowing us to present the most up-to-date information and illustrations possible. These companies and organizations are not responsible for any errors or omissions in the instructions or illustrations, or for changes in procedures or specifications made by the carmakers or suppliers, contained in this book or in any other Chek-Chart product:

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At Chek-Chart, Ramona Torres managed the production of this book. Type was set by Maria Glidden and Diane Maurice. Original art and photographs were produced by Dave Douglass, Gerald A. McEwan and Karen von Felten.

With respect, this work is dedicated to **Kalton C. Lahue:** 1934-1993. He wrote all the books.

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Introduction to Fuel Systems and Emission Controls

Fuel Systems and Emission Controls is part of the Chek-Chart Automotive Series. The package for each course has two volumes, a *Classroom Manual* and a *Shop Manual.*

Other titles in this series include:

- Automatic Transmissions and Transaxles
- Automotive Brake Systems
- Automotive Heating, Ventilation, and Air Conditioning Systems
- Automotive Steering, Suspension, and Wheel Alignment
- Automotive Engine Repair and Rebuilding
- Engine Performance Diagnosis and Tune-Up
- Automotive Electrical and Electronic Systems.

Each book is written to help the instructor teach students how to become competent and knowledgeable professional automotive technicians. The two-manual texts are the core of a complete learning system that leads a student from basic theories to actual hands-on experience.

The entire series is job-oriented, especially designed for students who intend to work in the car service profession. A student will be able to use the knowledge gained from these books and from the instructor to get and keep a job. Learning the material and techniques in these volumes is a giant leap toward a satisfying, rewarding career.

The books are divided into *Classroom Manuals* and *Shop Manuals* for an improved presentation of the descriptive information and study lessons, along with the representative testing, repair, and overhaul procedures. The manuals are designed to be used together: the descriptive material in the *Classroom Manual* corresponds to the application material in the *Shop Manual.*

Each book is divided into several parts, and each of these parts is complete by itself. Instructors will find the chapters to be complete, readable, and well thought-out. Students will benefit from the many learning aids included, as well as from the thoroughness of the presentation.

The series was researched, written, and produced by the editorial and production staffs of Chek-Chart. For over 65 years, Chek-Chart has provided car and equipment manufacturers' service specifications to the automotive service field. Chek-Chart's complete, up-to-date automotive data bank was used extensively in preparing this textbook series.

Because of the comprehensive material, the hundreds of high-quality illustrations, and the inclusion of the latest automotive technology, instructors and students alike will find that these books keep their value over the years. In fact, they will form the core of the master technician's professional library.

How To Use This Book

Why Are There Two Manuals?

Unless you are familiar with the other books in this series, *Fuel Systems and Emission Controls* will not be like any other textbook you've used before. It is actually two books, the *Classroom Manual* and the *Shop Manual*. They have different purposes, and should be used together.

The *Classroom Manual* teaches you what you need to know about fuel delivery systems and components and also about emission control systems. The *Classroom Manual* will be valuable in class and at home, for study and for reference. You can use the text and illustrations for years to refresh your memory — not only about the basics of fuel systems and emission controls, but also about related topics in automotive history, physics, and technology.

In the *Shop Manual*, you learn test procedures, troubleshooting, and how to repair the systems and parts you read about in the *Classroom Manual*. The *Shop Manual* provides the practical hands-on information you need to work on fuel systems and emission controls. Use the two manuals together to fully understand how these systems work, and how to fix them when they don't work.

What Is In These Manuals?

The key features of the *Classroom Manual* make it easier for you to learn, and to remember what you learn:

- Each chapter is divided into self-contained sections for easier understanding and review. The organization shows you clearly which parts make up which systems that perform the same task differently or the same.
- Most parts and processes are fully illustrated with drawings or photographs. Important topics appear in several different ways, to make sure you can see other aspects of them.
- Important words in the *Classroom Manual* text are printed in **boldface type** and are defined on the same page and in a glossary at the end of the manual. Use these words to build the vocabulary you need to understand the text.
- Review questions are included for each chapter. Use them to test your knowledge.
- Every chapter has a brief summary at the end to help you to review for exams.
- Every few pages you will find sidebars — short blocks of "nice to know" information — in addition to the main text.

The *Shop Manual* has detailed instructions on overhaul, test, and service procedures for modern components and current fuel systems. These are easy to understand, and usually have step-by-step explanations to guide you through the procedures. The *Shop Manual* contains:

- Helpful information that tells you how to use and maintain shop tools and test equipment
- Safety precautions
- Clear illustrations and diagrams to help you locate trouble spots while you learn to read service literature
- Test procedures and troubleshooting hints that will help you work better and faster
- Tips the professionals use that are presented clearly and accurately
- A sample test at the back of the manual that is similar to those given for Automotive Service Excellence (ASE) certification; use this test to help study and prepare yourself when you are ready to be certified as a fuel system and emission control expert.

Where Should I Begin?

If you already know something about automotive fuel systems and emission controls and know how to repair them, you will find that this book is a helpful review. If you are just starting in car repair, then the book will give you a solid foundation on which to develop professional-level skills.

Your instructor will design a course to take advantage of what you already know, and what facilities and equipment are available to work with. You may be asked to read certain chapters of these manuals out of order. That is fine. The important thing is to really understand each subject before you move on to the next.

Study the vocabulary words in boldface type. Use the review questions to help you understand the material. When you read the *Classroom Manual*, be sure to refer to your *Shop Manual* to relate the descriptive text to the service procedures. And when you are working on actual car systems and components, look back to the *Classroom Manual* to keep basic information fresh in your mind. Working on such a complicated piece of equipment as a modern car isn't always easy. Use the information in the *Classroom Manual*, the procedures in the *Shop Manual*, and the knowledge of your instructor to help you.

When you perform test procedures and overhaul equipment, you will need a complete and accurate source of manufacturers' specifications, and the techniques for pulling computer trouble codes. Most shops have either carmakers' annual shop service manuals, which lists these specifications, or an independent book such as the Chek-Chart *Car Care Guide*. This unique book is updated each year to give you service instructions, capacities, and troubleshooting tips that you need to work on specific cars.

Safety Summary

Most professional technicians work for years without ever suffering a serious injury. By following a few common sense rules of safety, you can follow in their footsteps and avoid injury to yourself or to others in the vicinity.

Shop Service Safety

The following precautions should be observed whenever you perform any shop activity:

- Know the location of shop first-aid supplies and the number to call for emergency medical assistance.
- Never use gasoline as a cleaning solvent unless it is specifically recommended. If gasoline is used, have a fire extinguisher handy and exercise extreme caution.
- All auto repair shops have flammable liquids and combustible materials. You can minimize fire hazards by not smoking within the shop area at any time.
- Keep flames and sparks away from a charging battery. Highly explosive hydrogen gas forms during the charging process.
- Do not arc the terminals of a battery to see if it is charged. The sparks can ignite the explosive hydrogen gas as easily as an open flame.
- Always wear safety goggles in any area or during any job where an eye hazard could exist.
- Remove all jewelry such as rings and watches before starting work. Remove sweaters, tuck in loose clothing, and tie back long hair.
- If you are not sure how to use any tool, machine, or test equipment, ask your instructor about its safe operation before using it.
- Make sure your hands, the floor, and your entire work space are dry before touching any electrical switches or plugs, or using any electrical equipment.
- Keep floors, aisles, and your work area clear of all tools, parts, and materials. Mop up any spilled liquids immediately.
- Do not carry sharp tools such as screwdrivers, awls, or scrapers in your pockets. Carry them in your hand with the cutting edge facing downward.
- Make sure that any component you clamp in a vise is properly secured before you work on it.
- Do not splash cleaning solvents when putting parts into, or removing them from, a cleaning tank.
- If an air nozzle is used to dry the cleaned parts, make sure the airstream is directed

away from yourself and anyone else in the immediate area.
- Before starting an engine, be sure the parking brake is set, the drive wheels are blocked, and the transmission or transaxle is placed in neutral (manual) or Park (automatic).
- Do not run the engine in a closed area or room. Connect the vehicle exhaust pipe to shop exhaust ducts or make sure there is sufficient ventilation to prevent the accumulation of poisonous exhaust gases.
- Keep your hands and other body parts away from hot exhaust components. Catalytic converters heat up rapidly and retain their heat for a long time after the engine is shut off. If you must work around such objects when they are hot, wear safety gloves.
- Do not drive a vehicle faster than five miles per hour in, or when entering or leaving, the shop area.

Fire Prevention Safety

You should be aware of two major subjects concerning fire prevention safety. They are:

- Proper handling and storage of combustible and flammable materials.
- Availability and use of fire extinguishers.

Flammable Materials

Automobile shops use many flammable materials, including gasoline, diesel fuel, grease and oil, as well as solvents and thinners. Under certain conditions, these present extreme fire hazards.

Other combustible materials are commonly found in automotive shops. These include various wood, plastic, and paper materials. Their hazardous nature increases when they are covered with oil or grease.

It is important that you observe certain basic precautions when using and storing these materials around a shop:

- Keep combustible and flammable materials away from sparks, open flame, hot metal, or cutting torches. Do not smoke in or around such areas.
- All fuels, lubricants, solvents, and other flammable materials should be stored in approved containers and locations. These containers should be kept closed when not in use.
- If any flammable material is spilled, it should be cleaned up immediately, and the cleaning materials disposed in an appropriate manner.
- Do not allow any accumulation of oily rags or papers. Keep these combustible materials in metal containers designed for their storage and properly dispose them every day.
- Containers should be bonded together and electrically grounded whenever you transfer a flammable liquid from one to another. This will prevent any possible sparking from static electricity.

Fire Extinguishers

The shop should be properly equipped with the various types of fire extinguishers used with different types of fires. However, fire extinguishers are useless unless they are properly maintained and ready to go at all times. In addition, everyone in the shop should know the location of all extinguishers, and be familiar with their use.

There are four classes of fire extinguishers. Each class should be used with specific fires:

- *Class A* is designed for use on general combustibles such as cloth, paper, and wood. It should not be used on electrical fires or fires containing flammable liquids.
- *Class B* is designed for use on flammable liquids and greases, including gasoline, oil, thinners, and solvents.
- *Class C* is used only on electrical fires.
- *Class D* is effective only on combustible metals such as powdered aluminum, sodium, or magnesium.

The extinguishing agent inside the fire extinguisher determines its use. Plain water or bicarbonate of soda is satisfactory for use on Class A fires, but neither should be used on electrical fires or flammable liquids. Carbon dioxide (CO_2) extinguishers can be used on flammable liquids and electrical fires, but are not satisfactory to extinguish burning wood or paper.

The class rating is clearly marked on the side of every fire extinguisher. Some units are multipurpose and can be used with more than one type of fire. This type of fire extinguisher often is used in automotive shops.

Cleaning with Solvents and Parts Washing

Automotive shops deal with common chemicals daily. These include fuels, cleaning solvents, lubricants, and adhesives. All these chemicals are necessary, but many are toxic and can be harmful to you, the equipment,

and the vehicles on which you are working if they are not handled properly. Observe the following precautions whenever you are working with or near such chemicals:

- Do not use gasoline as a cleaning agent or solvent unless it is specifically recommended. It presents an extreme hazard.
- Do not use gasoline, cleaning solvent, or paint thinner to clean your hands. If you must clean parts in such solutions, always wear rubber gloves and arm protection to prevent the solvent from touching your skin. Such chemicals affect the natural oil in your skin and their use can result in a rash, nausea, or other health problems.
- Always read the instructions before using any cleaning material. Some cleaning solutions are very caustic; and while they will work with some metals, they will harm others. If in doubt, ask your instructor.
- Always wash your hands before eating, drinking, or smoking when you have been handling caustic or toxic chemicals.
- Avoid breathing gasoline vapors when possible and keep the chemical away from your mouth. Gasoline is highly toxic when swallowed or when large quantities are inhaled.
- Paint thinner, antifreeze, and gasoline are among the shop chemicals that will damage painted surfaces and rubber or plastic components. Immediately wash any spills with a mild soap and water solution and rinse thoroughly.
- Always wear safety glasses whenever you are working with solvents or steam cleaners.
- When parts are to be washed, immerse them carefully in the cleaning tank to avoid splashing solvent.
- Solvents and many chemicals used in a shop should always be used in a well-ventilated area. Their toxic fumes often have no odor and your nose cannot warn you of their danger.
- Dispose of all used chemicals properly. They should be packaged in suitable containers and disposed of according to local health and safety regulations. They should *not* be poured into lavatories, toilets, or waste water drains.

Parts washing tanks usually contain a general-purpose solvent that will remove oil, grease, and dirt from most components. This general-purpose solvent should not be replaced with gasoline or other flammable solvents. The parts washing tank should have a safety cover held open by a chain and fusible link. If a fire occurs in or near the tank, the link will melt and allow the cover to drop closed. Do not prop the cover open and override this valuable safety feature.

To clean parts in the washer, you can submerge them and wait for the solvent to dissolve the oil, grease, or dirt. Dunking the parts in the solvent and then brushing them with a soft-bristle brush will accelerate the process. This often is all that's required to clean a part. Many parts washers used to clean carburetor parts have an agitator to circulate the solvent. This speeds the process of dissolving the contamination. General parts washers usually have a nozzle that sprays a stream of solvent on the parts. This solvent is constantly being filtered and recirculated. Washing the parts under the nozzle with the soft-bristle brush is the recommended procedure for a rapid, thorough cleaning.

Engine Fuel System Safety

Everything we have covered to this point applies to working on the fuel system. In addition, there are other general practices you should observe:

- Keep your hands, clothing, hair, and tools away from any moving components when you are working under the hood with the engine running.
- Exercise extreme caution around electric cooling fans, because some designs will start whenever engine coolant temperature reaches a certain level, whether or not the engine is running.
- Keep your clothes away from hot exhaust system components. Manifolds and catalytic converters remain very hot long after the engine is shut off.
- Keep all flammable liquids and oily cloths away from running engines or any other source of heat that might cause them to ignite.
- Plug or cap all fuel lines that are disconnected for service. This will prevent messy and possibly dangerous leaks.
- Do not use a torch or other form of heat or flame producing device near nylon fuel lines used with fuel injection systems.
- Leave the engine air cleaner in place whenever possible. This prevents the possibility of a backfire or dropping contamination or small tools into the engine. If the air cleaner must be removed, cover the carburetor or intake manifold openings with clean shop cloths for the same reasons.

When servicing any electric engine control system:

- Do not short circuit or ground any solid-state electronic components or electrical terminals, or apply battery voltage directly to electronic components, unless a test procedure specifies otherwise.
- Refer to the manufacturer's instructions when connecting older test equipment to breakerless ignition systems. Some older test equipment will not work properly and may even damage the system.
- Make sure the ignition is off before disconnecting or connecting the wiring harness connector to the control unit.
- Do not remove the grease used to prevent corrosion from the connectors.

When servicing any Chrysler electronic ignition or engine control system:

- Do not touch the switching transistor on the control unit with the engine running. The high voltage present will produce a severe electric shock.
- Do not file the sharp edges of the reluctor teeth.

When servicing any Ford electronic ignition or engine control system:

- Do not let a straight pin used to pierce wires for voltage checks touch a ground.
- Do not disconnect the spark plug wires directly above the pick-up coil. An arc from the wire may damage the pick-up coil.

Contents

On the Cover:
Front — The 4.6-liter DOHC V8 engine used in the Lincoln Mark VIII, courtesy of Ford Motor Company.
Rear — A cutaway of a General Motors Multec fuel injector, courtesy of the General Motors Corporation.

PART ONE

Introduction to Fuel and Emission System Service

1

Vacuum Control Diagnosis

ENGINE VACUUM

Whenever an automotive engine is running, it produces vacuum. As each piston moves down on its intake stroke, pressure is reduced in the cylinder and in the intake manifold. The total vacuum produced depends upon two factors: engine design and engine condition.

Engine Design

The number of cylinders, displacement, compression ratio, valve overlap and lift — all these help govern the amount of vacuum produced by an engine. Different designs produce different amounts of vacuum. For example, a V-type engine generally produces less vacuum than an inline engine. Engines with emission controls often have high lift cams and greater valve overlap. These engines produce a lower level of vacuum with a less steady reading than those without emission controls.

Engine Condition

How much vacuum an engine will produce depends on how efficiently it does its job. A badly worn engine cannot produce as much vacuum as one in good condition. Piston rings, valves, carburetion, ignition timing, and exhaust all affect engine vacuum. Each has a predictable effect on engine vacuum. This makes it possible to diagnose engine condition and performance by measuring the amount of vacuum.

VACUUM SOURCES

Vacuum drawn directly from a tap at the intake manifold, figure 1-1, is called manifold vacuum. Manifold vacuum is used to diagnose engine condition. Manifold vacuum is greatest at idle and decreases as the throttle is opened. At wide-open throttle, there is very little vacuum in the intake manifold.

Vacuum drawn from an opening just above the throttle valve is called ported vacuum. When the throttle valve is closed during idle or deceleration, there is no significant vacuum at the port, figure 1-2. As the throttle is opened, it uncovers the port and allows vacuum to pass, figure 1-3. Ported vacuum usually operates carburetor assist devices, distributor vacuum advance units, and emission control systems. Ported vacuum cannot exceed manifold vacuum.

TESTING ENGINE VACUUM

Most vacuum readings are taken at engine idle speed. A vacuum gauge, figure 1-4, is used to measure the difference between atmospheric

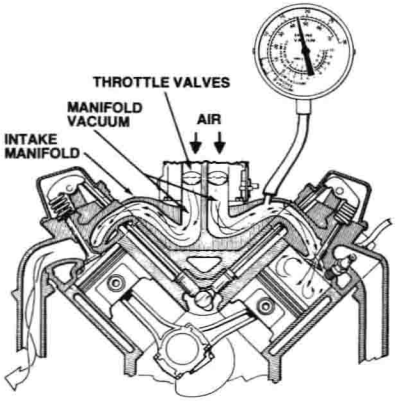

Figure 1-1. The vacuum gauge is connected to a tap on the intake manifold to measure manifold vacuum.

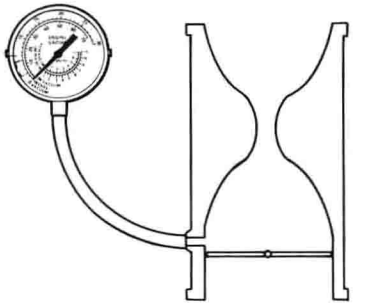

Figure 1-2. Throttle closed, vacuum port covered.

pressure and intake manifold pressure, or vacuum. The gauge can be graduated in inches of mercury (in. Hg) or millimeters of mercury (mm Hg). The normal vacuum reading usually varies between 18 and 22 inches or 460 and 560 millimeters of mercury at sea level. Vacuum readings will drop about one inch or 25 millimeters for every 1,000 feet (305 meters) increase in elevation above sea level, figure 1-5.

It is important to know the basic specifications for the engine to be tested. These generally are provided in the automaker's factory shop manual or in an independent specification manual. You must know what a normal vac-

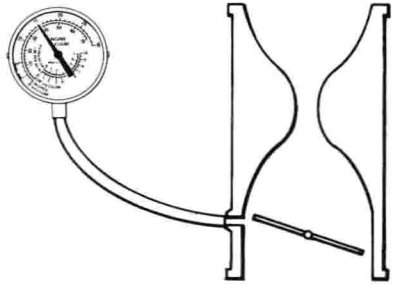

Figure 1-3. Throttle open, vacuum port uncovered.

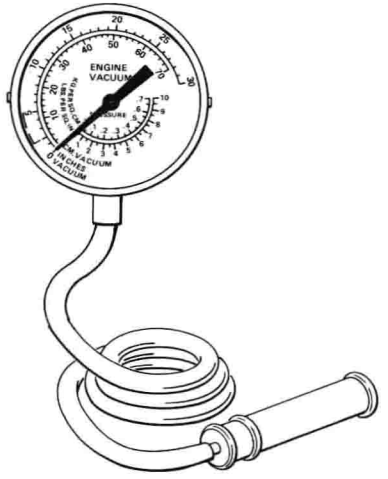

Figure 1-4. A typical vacuum gauge.

ALTITUDE	INCHES OF VACUUM
Sea Level to 1,000 Ft.	18 to 22
1,000 Ft. to 2,000 Ft.	17 to 21
2,000 Ft. to 3,000 Ft.	16 to 20
3,000 Ft. to 4,000 Ft.	15 to 19
4,000 Ft. to 5,000 Ft.	14 to 18
5,000 Ft. to 6,000 Ft.	13 to 17

Figure 1-5. A normal engine produces approximately these vacuum readings at the altitudes shown.

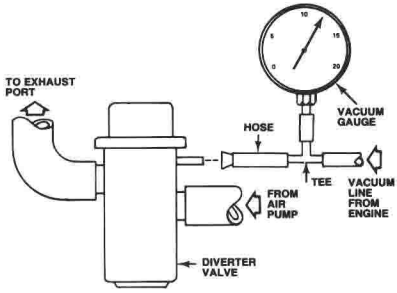

Figure 1-6. The tee inserted in this vacuum line to the diverter valve allows valve operation to be checked with a vacuum gauge without interrupting system operation. (Ford)

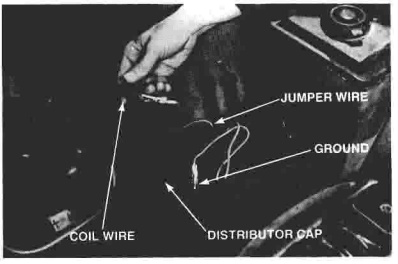

Figure 1-7. Use a jumper wire to ground the coil secondary wire to the engine block to disable the ignition.

uum reading should be in order to determine abnormal conditions.

Using A Vacuum Gauge

To test engine vacuum, connect the vacuum gauge to a source of manifold vacuum. Some engines have a plug in the intake manifold; remove it and replace it with an adapter fitting. Connect the vacuum gauge to the adapter fitting by a rubber hose. If the engine has no manifold plug, connect the vacuum gauge to the vacuum source of a system using manifold vacuum, such as the exhaust gas recirculation (EGR), transmission-controlled spark (TCS), or air injection systems. Using a special adapter T-fitting, you can connect a vacuum gauge into the vacuum line to the power brake booster on many cars.

Connect the vacuum gauge to the EGR or TCS system by installing a tee in the system

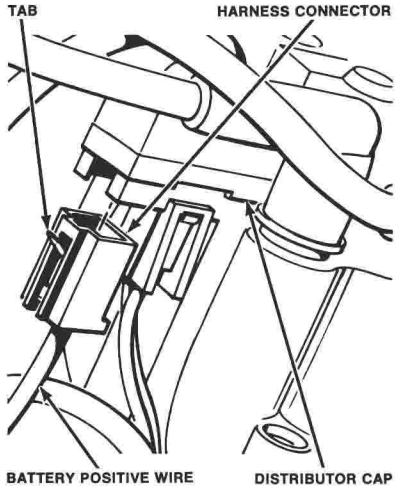

Figure 1-8. Disable the GM HEI breakerless ignition by disconnecting the battery feed wire from the ignition module.

line, figure 1-6. Connect the vacuum gauge line to the tee so the gauge can monitor manifold vacuum without disturbing the system. All connections must be tight and free of leaks. Engine vacuum should be tested with the engine at normal operating temperature.

Other Special Equipment

You will need hand tools and a vacuum gauge with a length of rubber tubing as well as the following test supplies for some vacuum tests. You should obtain:

- A tachometer to measure engine speed when vacuum tests are specified at certain speeds
- A remote starter switch (pushbutton) to crank the engine during vacuum tests made at cranking speed
- A jumper wire to ground the ignition system when required
- Cleaning solvent or engine tune-up solvent in a small dispenser can or oil can to check for vacuum leaks at gaskets
- Small plugs to close any vacuum hoses disconnected during testing; wooden or plastic golf tees work well for this.