The BMW 2002 tii Fuel Injection System

BMW of North America, Inc.

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BMW Service Training

Description of System

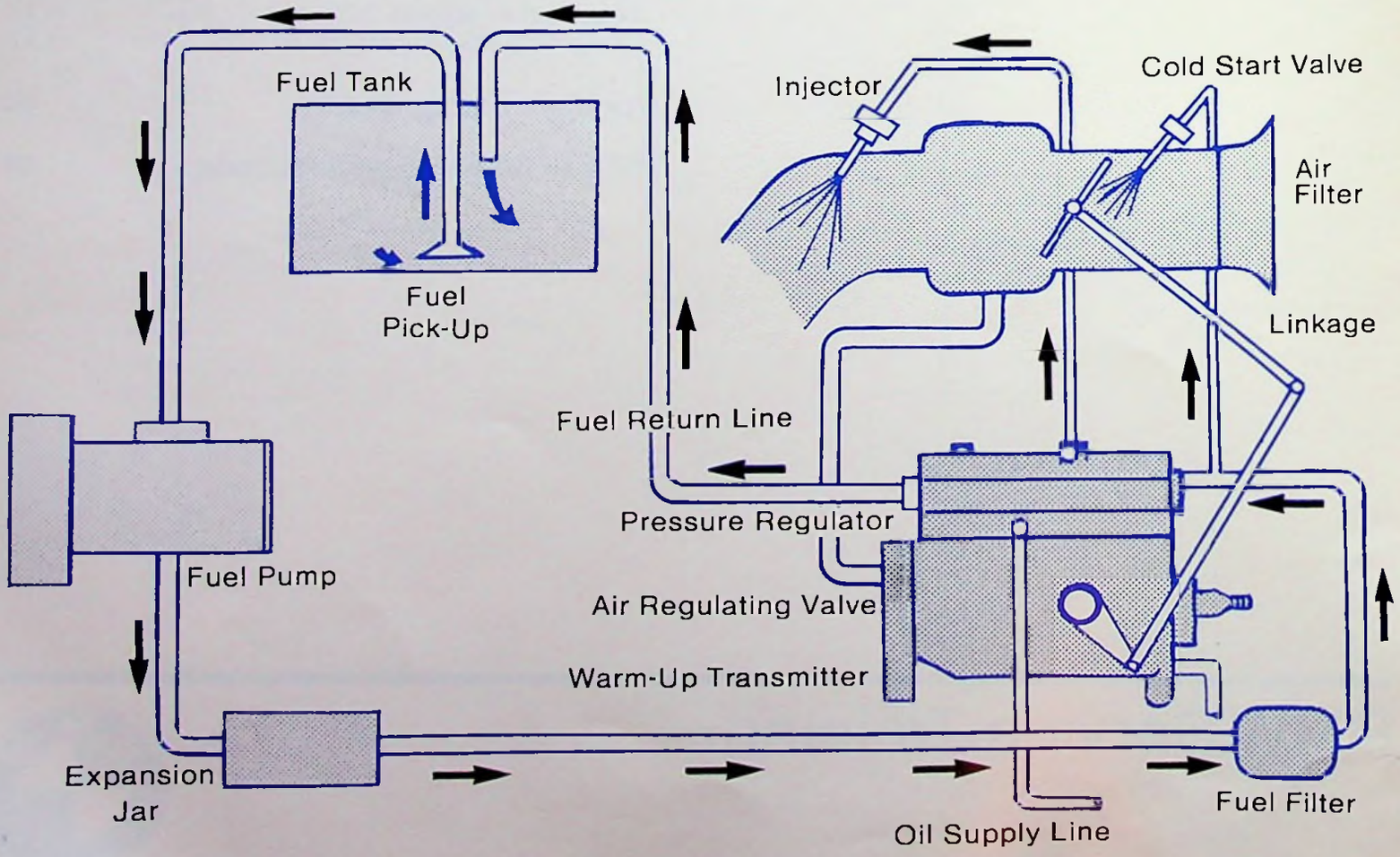
The BMW 2002 tii was introduced into the US Market in 1971. It is simply a further modification of the 2002 carbureted model, employing fuel injection as a means of getting gas to the engine.

It is basically just the same as other 2002's: the engine has a slightly higher compression ratio, the suspension system is somewhat stiffer, and the brakes are larger. The major difference is the fuel system.

This was the first year BMW featured fuel injection. The system incorporated a Kugelfischer Mechanical Fuel Injection Pump. A list of components and their operation will be found in the next section, along with a wiring diagram and schematic of the system.

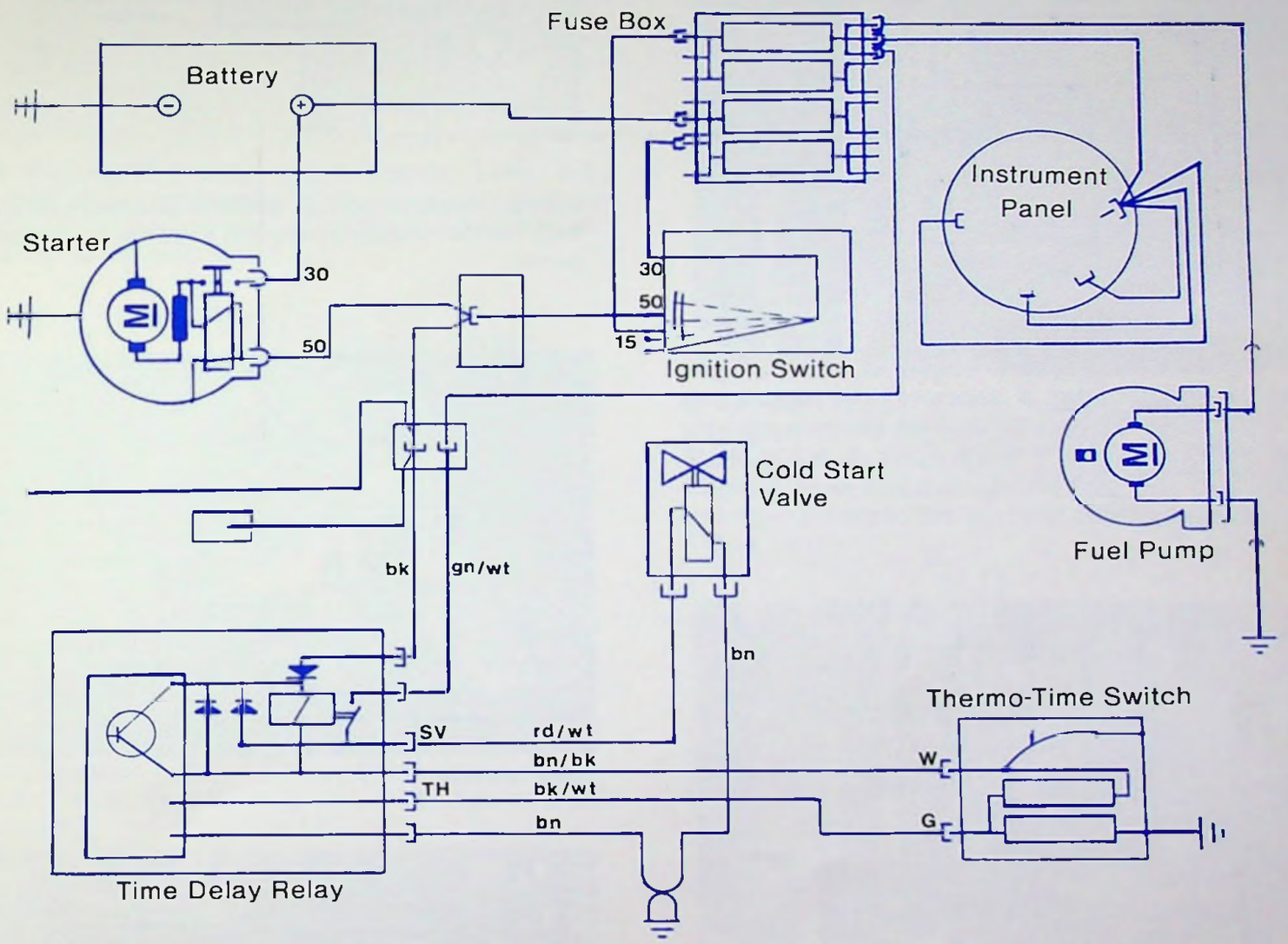
Components

The components are: The fuel tank with a filter screen in the pick-up; a high-pressure fuel pump; an expansion jar; a fuel filter; the injection pump with a Warm-Up Transmitter and Auxilliary Air Valve; fuel delivery and return lines; the injectors; and a Cold-Start System.



The electrical components are the battery, starter fuse box, instrument panel components, fuel pump, ignition switch, and the Cold-Start System Components: the Cold-Start Valve, the Time Delay Relay, and the Thermo-Time Switch.

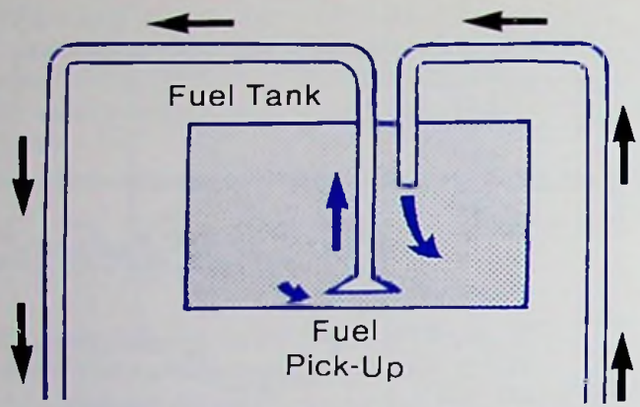
The following diagram is a schematic of the electrical system of the 2002 tii with all components labeled.



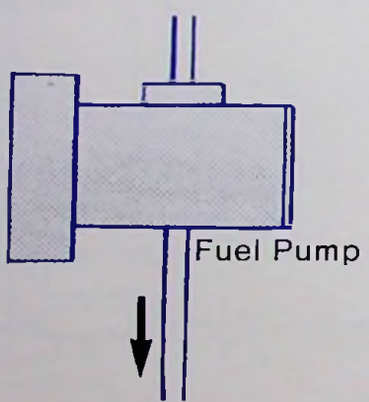
COLOR	CODE
White	wt
Green	gn
Brown	bn
Yellow	yl
Gray	gy
Blue	bu
Red	rd
Black	bk
Violet	vi

Operation

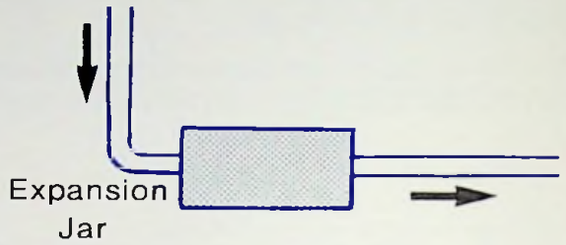
Fuel Supply System



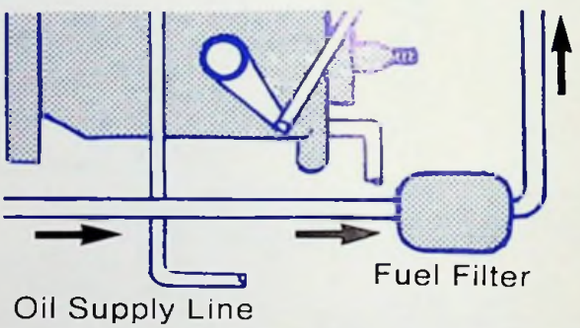
The fuel supply system begins in the fuel tank, which incorporates a separate fuel pickup and gauge float. Since fuel injection systems are very sensitive to contamination, there is a fine mesh screen in the pick-up.



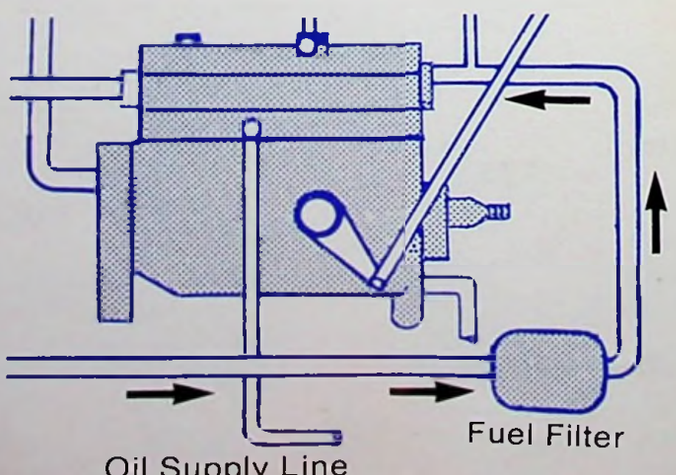
Next is the fuel pump. It is a high-pressure, 'Roller Cell' type similar to those pumps on current fuel-injected models. As soon as the ignition is turned on, the pump puts the system under full pressure - approximately 2 bar. There is also a fine mesh screen in the pump's inlet.



Next is the expansion jar, which is mounted together with the fuel pump. It acts like a muffler to dampen noise.

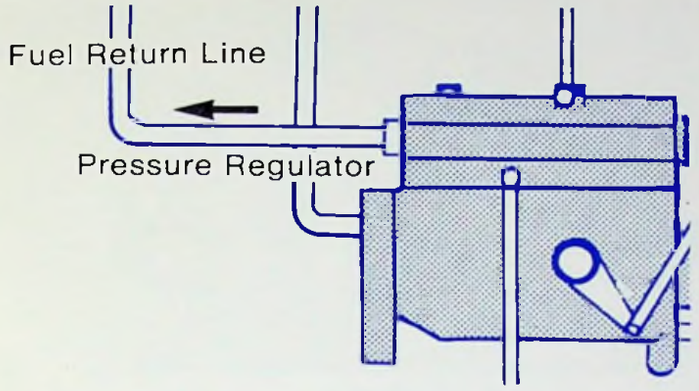


The fuel filter is mounted in the engine compartment on the left side of the radiator. It contains a paper element and a lint trap. If you have to remove this filter, make sure you put it back in the same way you took it out. It's adviseable to change it during every major service.



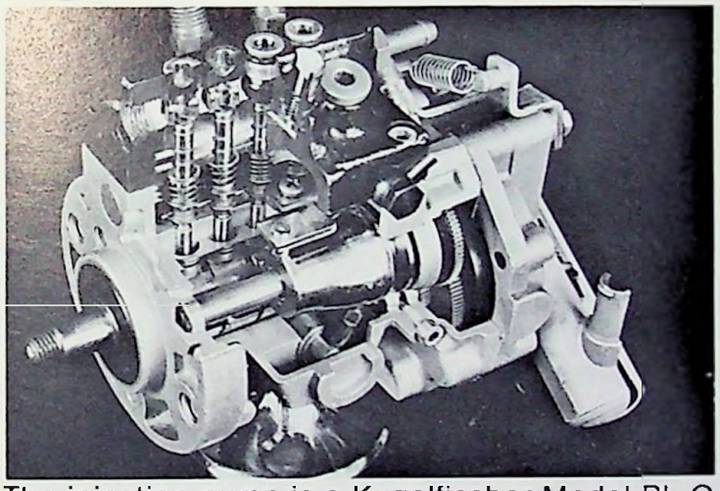
From the fuel filter, gas flows directly into the inlet of the injection pump. There is also a fine mesh screen

in this inlet. This screen, plus the screens in the fuel pick-up and fuel pump, should be serviced every 40,000 miles.

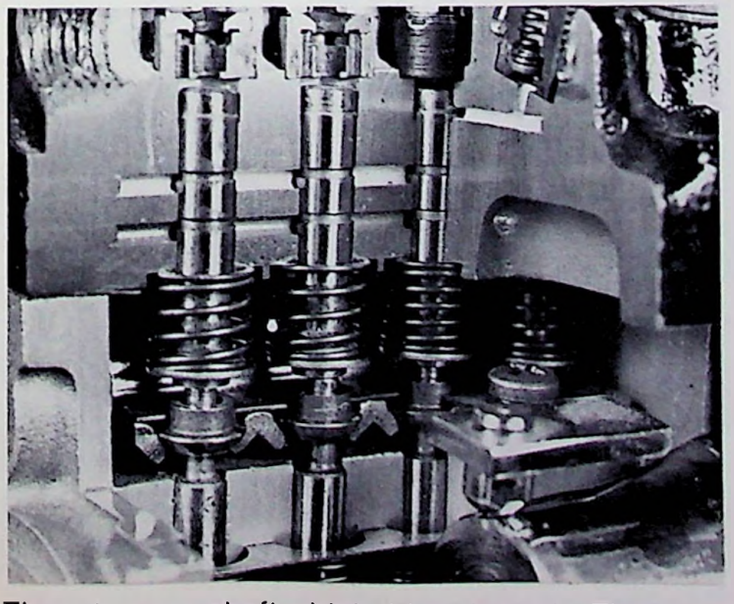


At the rear of the top of the injection pump is a pressure regulating valve. It maintains fuel pressure at approximately 2 bar, and allows excess fuel to return to the tank.

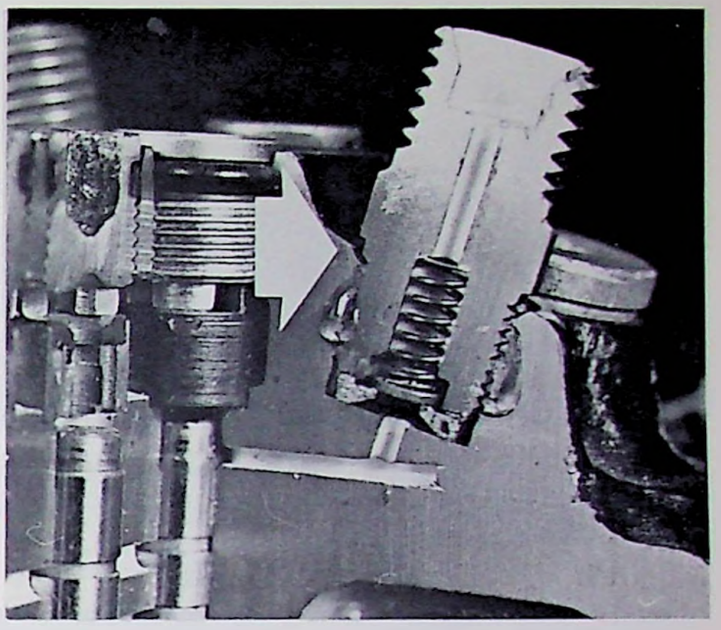
Injection System



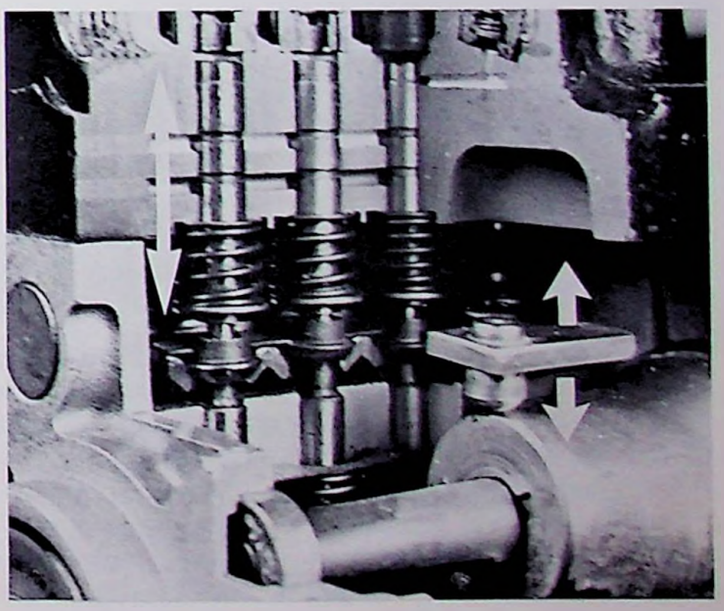
The injection pump is a Kugelfischer Model PL O Mini Pump. It's interior is very much like a small engine.



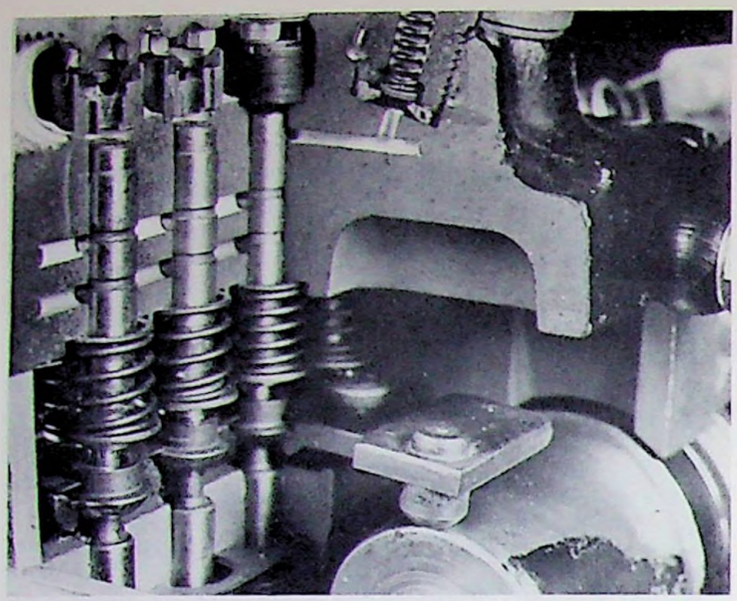
There is a camshaft which drives tappets. These, in turn, drive plungers which are pushed back down by springs. When these plungers move down, suction valves are pulled open and gas is sucked into the cylinders of the pump.



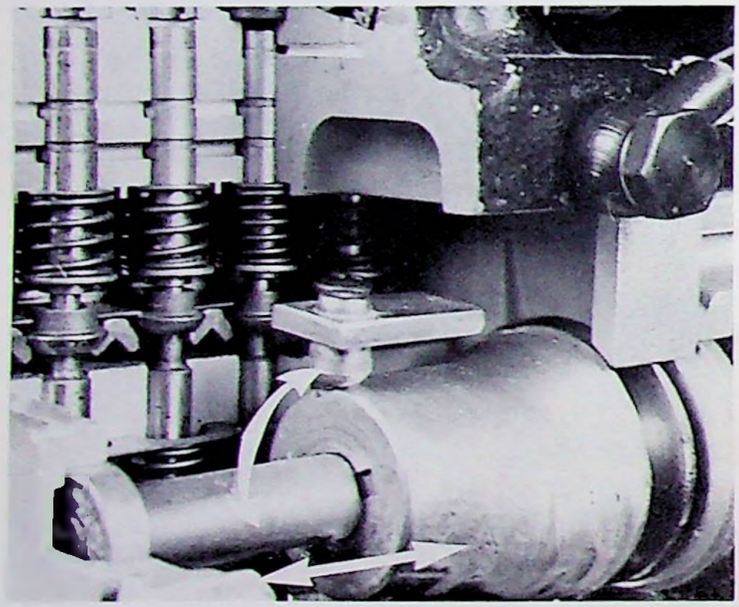
Pressure created by the upward stroke of the plungers forces the suction valves closed and the delivery valves open. Fuel is pushed out into the delivery lines and through the injectors. The pressure generated by the injection pump is quite high - 35 to 38 bar.



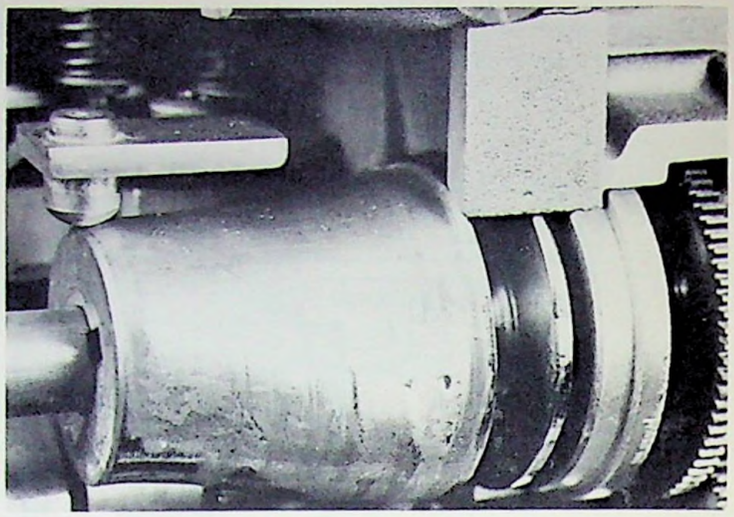
The amount of fuel injected into the engine is controlled by the stroke of the plungers. Their travel is limited by a regulating lever inside the pump. The position of this lever is controlled two ways.



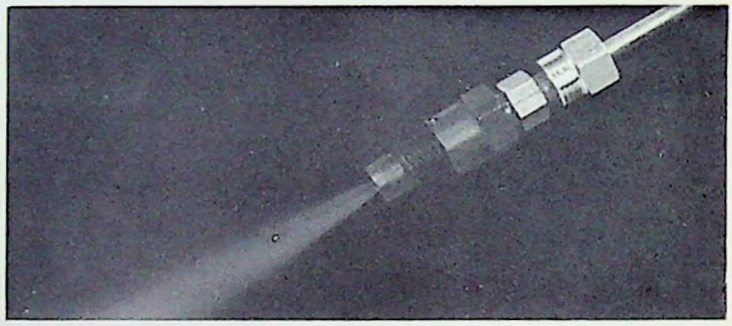
One side rides on an irregular cone; the other is mounted on an eccentric hinge which is controlled by the warm-up transmitter.



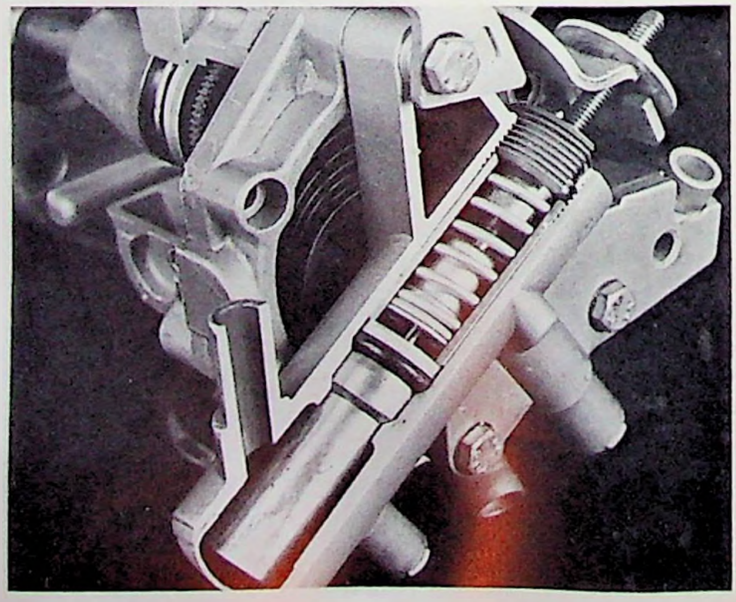
The irregular cone controls lever movement two ways: backward and forward movement of the cone is directly connected to the throttle linkage; rotation of the cone is related to engine speed.



A magnetic pick-up inside the pump's camshaft transmits engine speed, through a set of gears, to the cone. The cone then rotates, much like a speedometer, in time with varying camshaft speeds. These movements raise or lower the regulating lever, varying the amount of fuel injected into the engine.

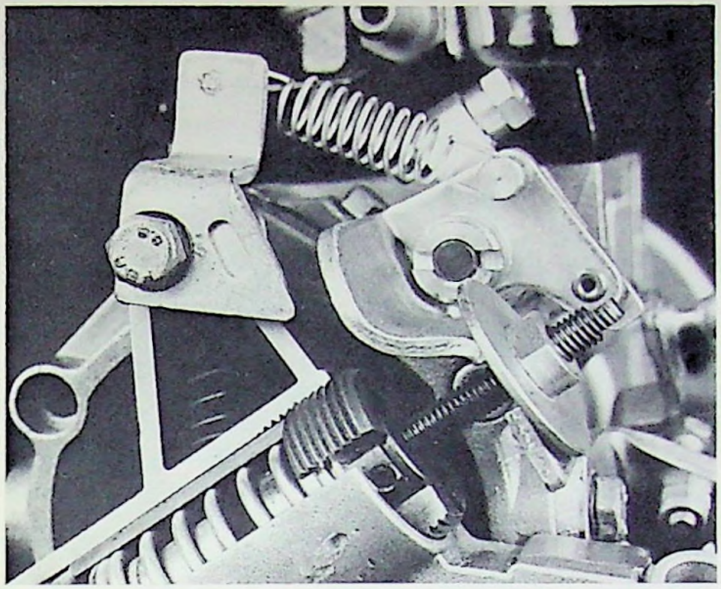


Fuel delivery lines run from the delivery, or pressure, valves on the pump to the injectors. Inside each injector is a spring-loaded valve in a tapered seat. When pressure from the injection pump reaches 35 to 38 bar, the springs are overpowered and the valves are forced open, spraying fuel into the intake.

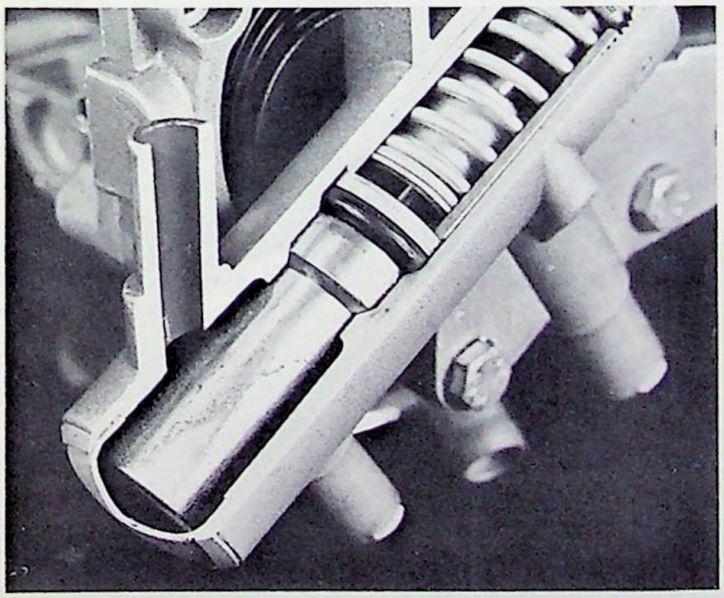


The final part of the injection system is the Warm-Up

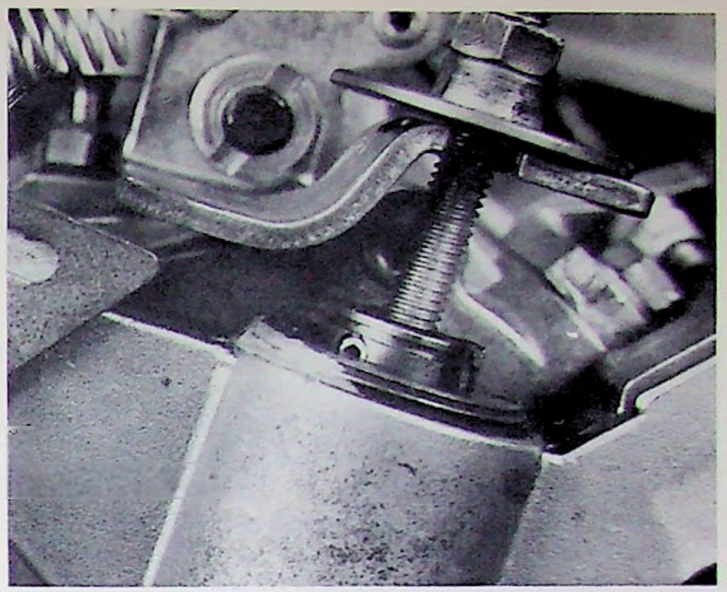
Transmitter, which incorporates an Auxilliary Air Valve. The Warm-Up Transmitter is located on the back of the pump and provides a richer mixer for warm-up.



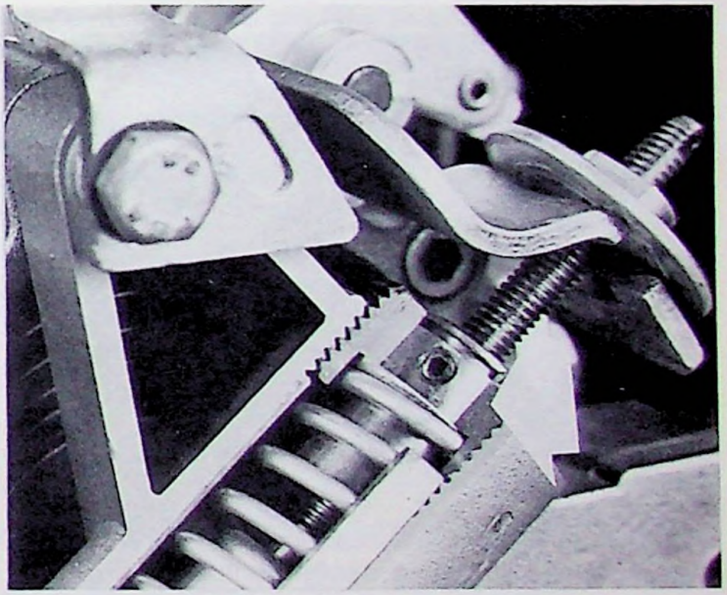
It is connected, via linkage, to the eccentric hinge on the back of the pump's regulating lever. When the engine and warm-up transmitter are cold, the hinge is rotated to its lowest position. This lowers the rear of the regulating lever and increases the amount of fuel injected.



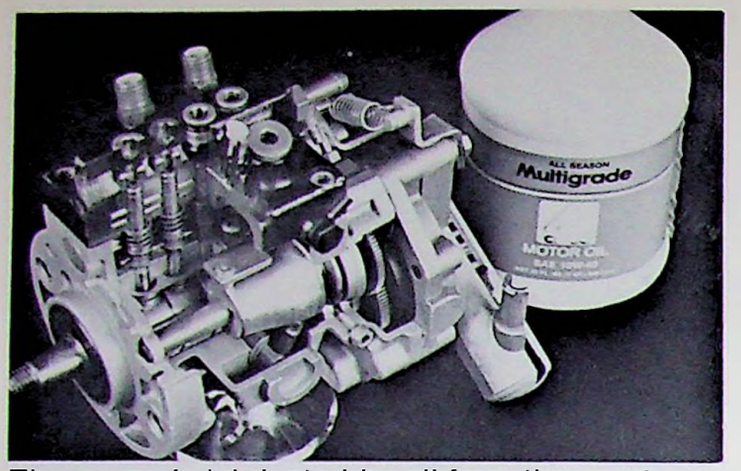
As coolant temperature increases, a heat-sensing element in the warm-up transmitter expands, pushing a rod out of the unit's housing.



As the rod extends, the eccentric hinge for the regulating lever rotates upward, gradually returning the lever to its warm-operating position and leaning off the mixture.



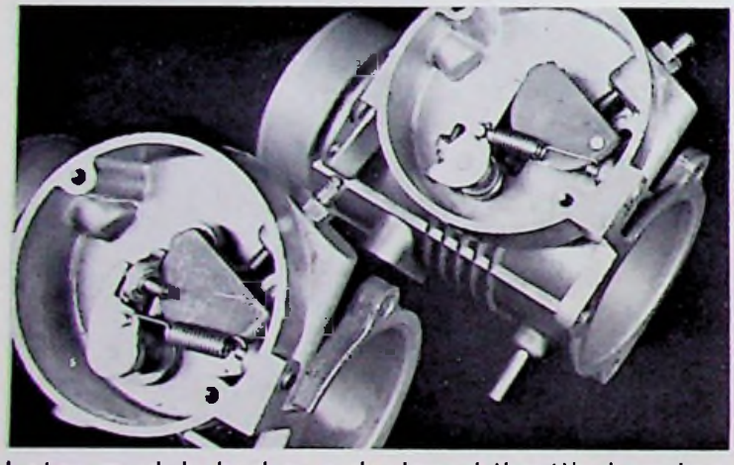
Additional air is necessary to maintain a stable idle, so an Auxilliary Air Valve is incorporated in the Warm-Up Transmitter. It is simply a valve on the upper end of the warm-up transmitter rod. A rubber hose connects this valve with the air collector on the intake manifold. As the rod extends, the valve is gradually closed, shutting off the extra supply of air to the intake.



The pump is lubricated by oil from the crankcase under pressure. Excess oil is returned through a line near the dip-stick.

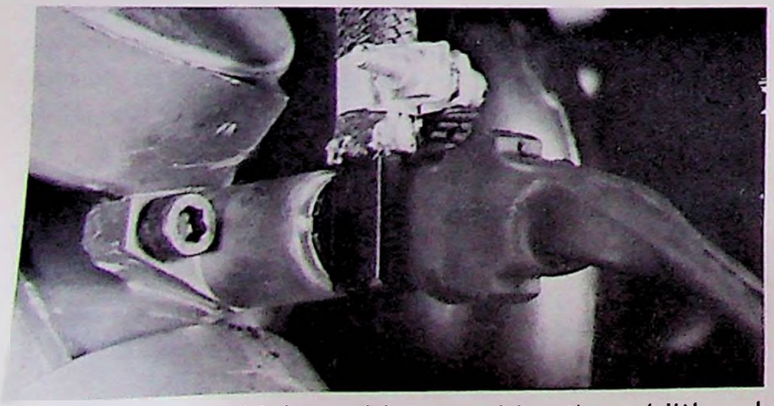
The pump comes from the factory dry, so oil must be added before the engine is started. A warning tag is attached to new or rebuilt pumps as a reminder.

Some changes were made to the pumps between the first models in 1971 and the later years up to 1974. Do NOT interchange pumps from different model years. Be sure to check the part number for the model year you're working on. Additionally, in 1974, a vacuum limiter was added to the system for deceleration control.

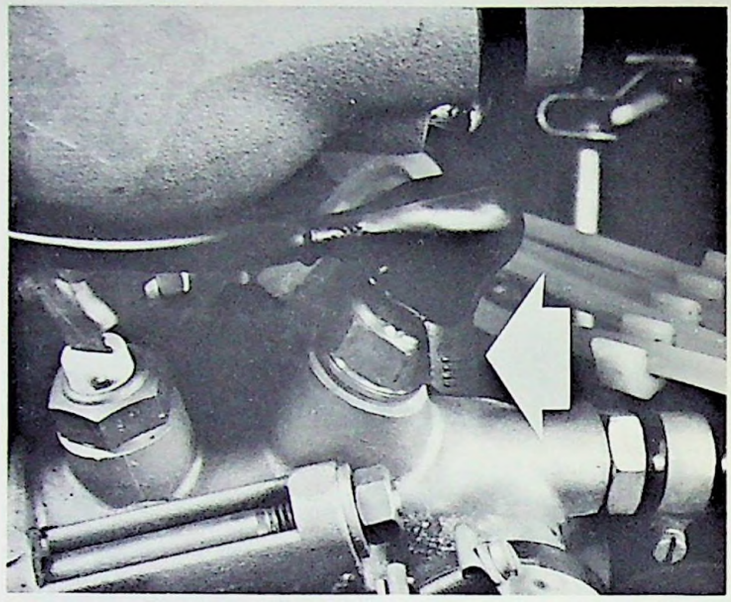


Later models had a re-designed throttle housing, which made CO adjustments much less sensitive.

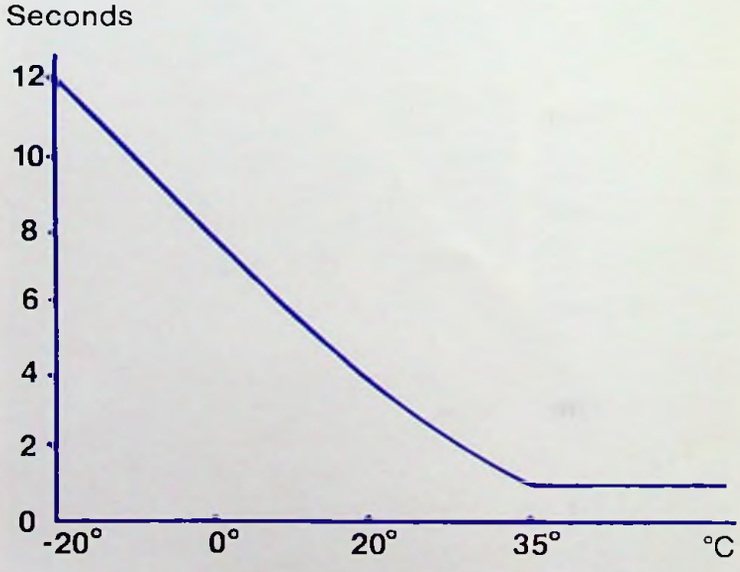
Cold-Start System



The Cold-Start Valve, which provides the additional amount of fuel necessary for cold starting, is controlled by two electrical devices: the Cold-Start Relay and Thermo-Time Switch. When the engine is cranked, current flows through the Relay to both the valve and the Thermo-Time Switch. On a warm engine, the contacts in the switch are open, and the relay provides power to operate the valve for only one second.



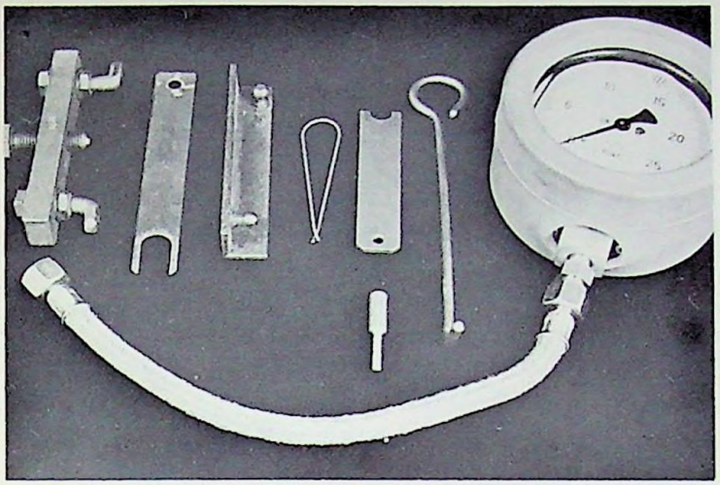
On a cold engine, the bi-metallic strip in the Thermo-Time Switch causes the valve to remain powered for a longer duration, causing more injection.



For example, injection duration is 8 seconds at 0° C, 4 seconds at 20° C, and one second at 35° C. Above 35° C, the bi-metallic strip in the Thermo-Time Switch has been heated enough to interrupt current flow; the points open and the cold-start relay loses its ground, which interrupts current flow to the valve and ends injection. But the valve will *always* inject one second of extra fuel, no matter what the coolant temperature of the engine is.

Special Tools

The following is a list of BMW Special Tools necessary for adjustment and repair of the 2002 tii:

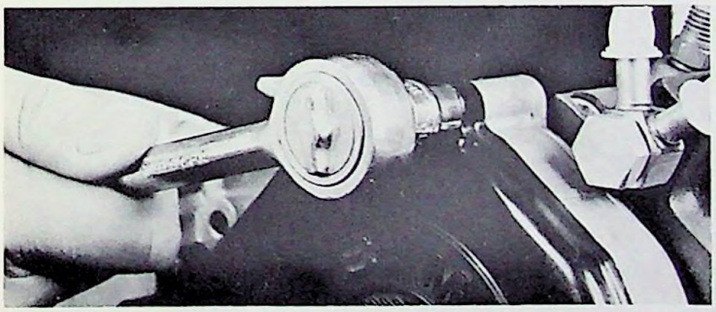


Fuel Pressure Gauge,	No. 88886133060
85mm Linkage Gauge,	No. 88886135040
5mm Hook,	No. 88886135050
4mm Throttle Adjustment Pin,	No. 88886135080
Air Regulating Cone Retainer Plate	No. 88886135140
Inlet Valve Tweezers,	No. 88886135150
Pump Pulley Puller,	No. 88886135240
Warm-Up Transmitter Feeler Gauge,	No. 88886243040

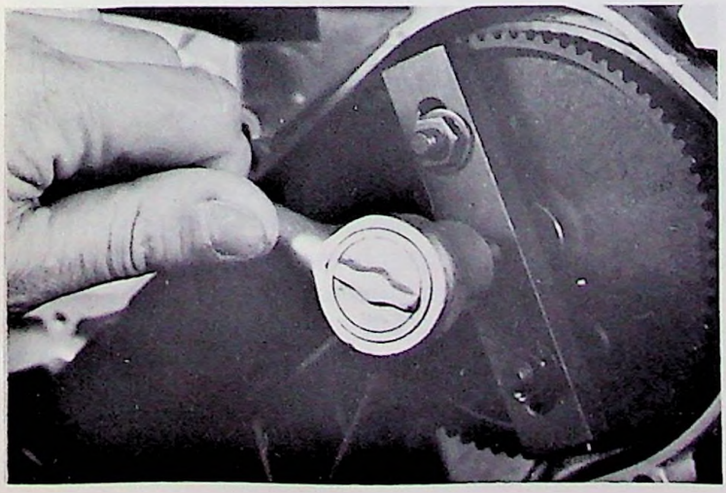
All the above parts can be ordered through your parts department.

Repair Procedures

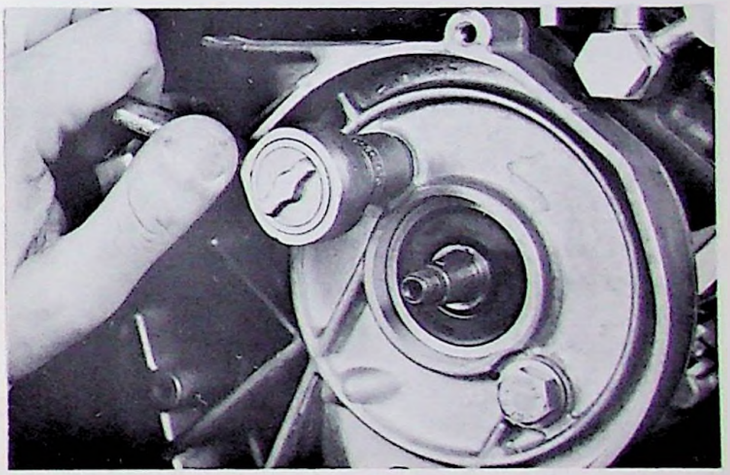
There are no actual repairs that can be made to the injection pump except for replacement of the suction and delivery valves or the warm-up transmitter. Should the pump itself be defective, it must be replaced.



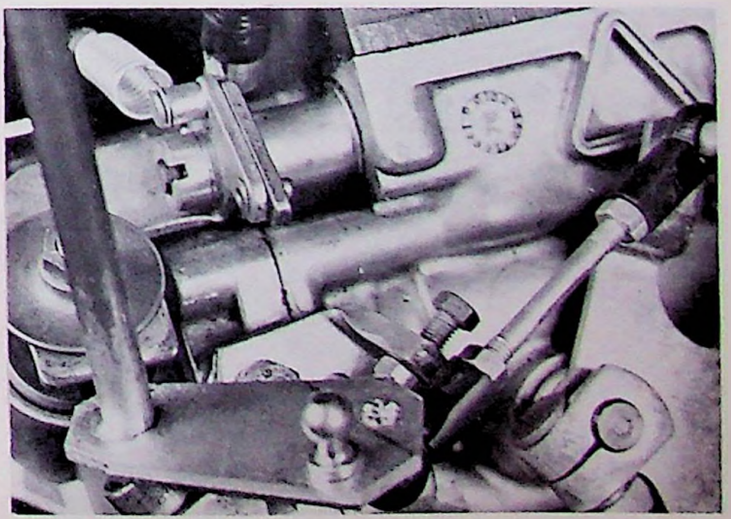
Remove the top plastic drive belt cover.



With the pulley puller remove the pulley from the pump. *Do not force it.* You can bend the camshaft inside the pump.

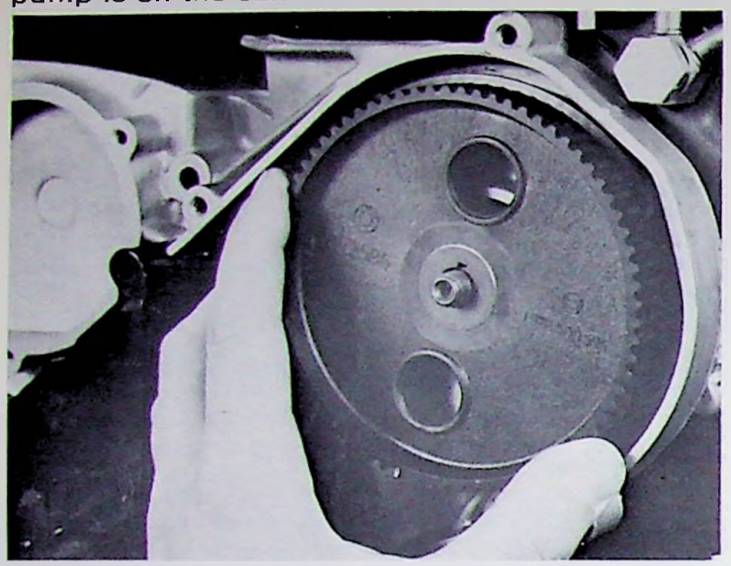


Disconnect the linkage and fuel and oil lines, and remove the pump.

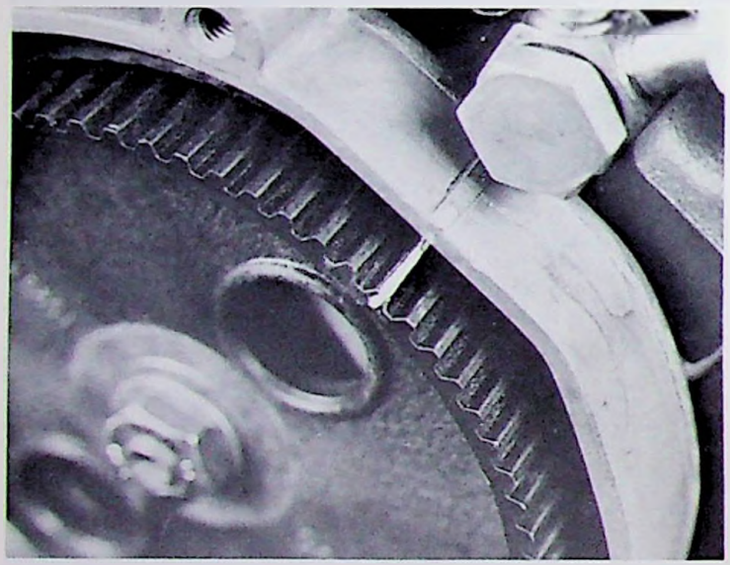


Before installing the replacement pump, check the

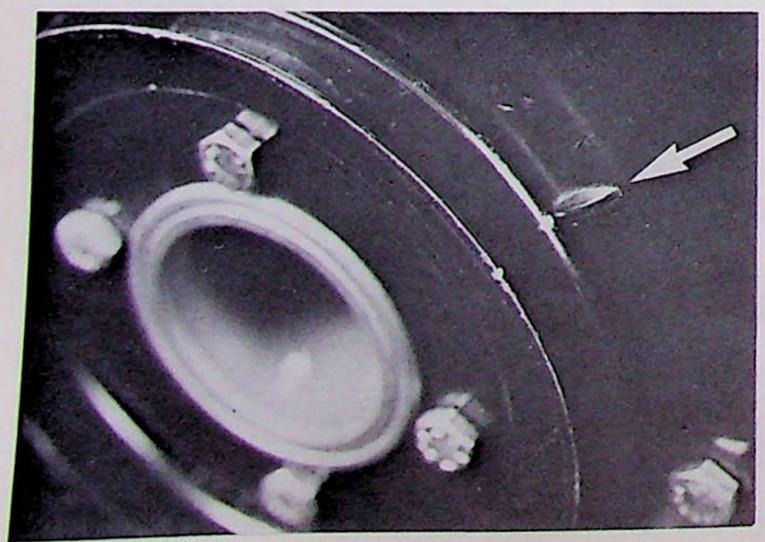
full-throttle stop screw. It's much easier when the pump is off the car.



After the replacement pump is mounted on the engine, install the keyed pulley on the pump's camshaft.

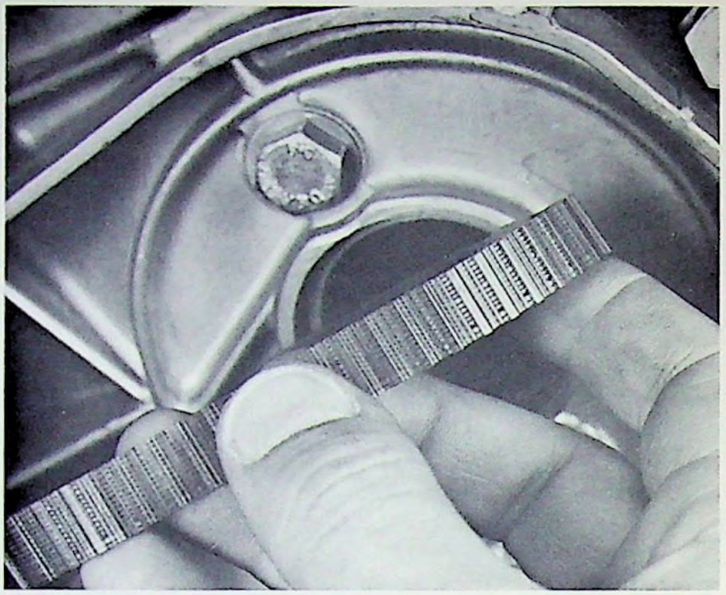


Now, line up the TDC mark on the pulley with the mark on the top front drive belt cover.



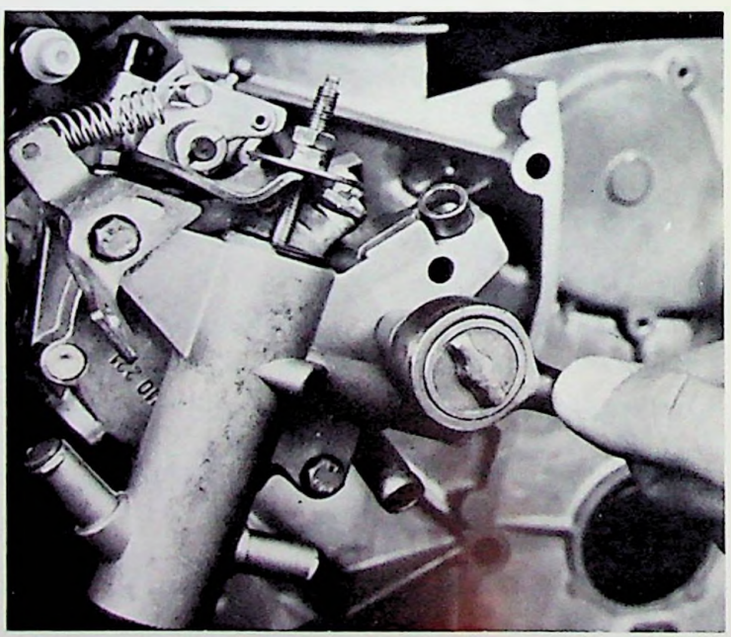
Set the engine to the number one TDC firing position.

Now, replace the drive belt.

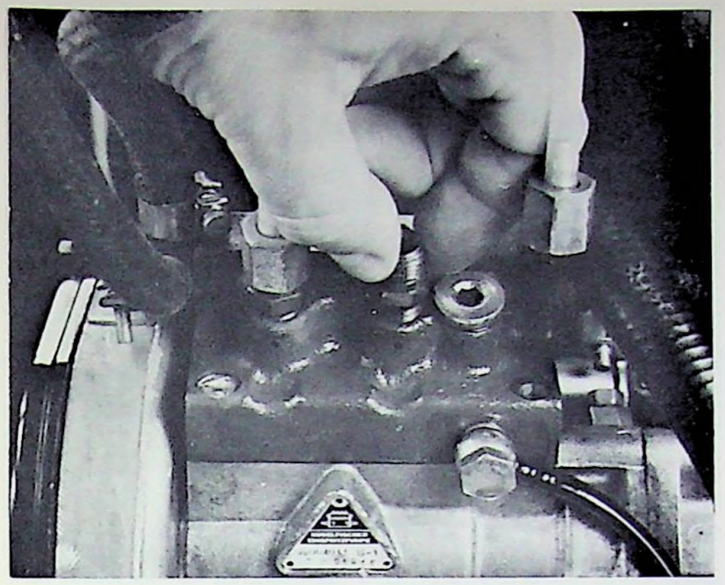


Check the condition of the belt before installation, and replace it if necessary. Now, reconnect the oil and fuel lines.

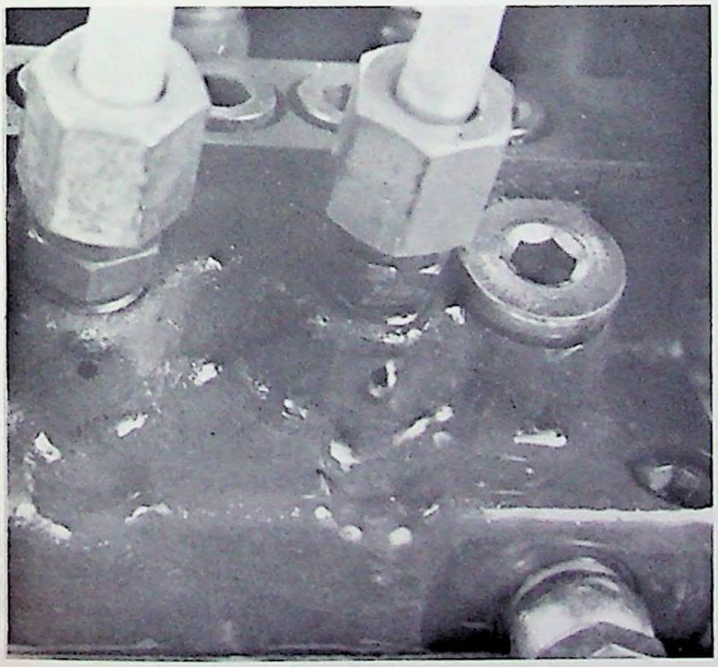
The warm-up transmitter, the suction and delivery valves, and the pressure relief valve are the only items that can be replaced on the pump.



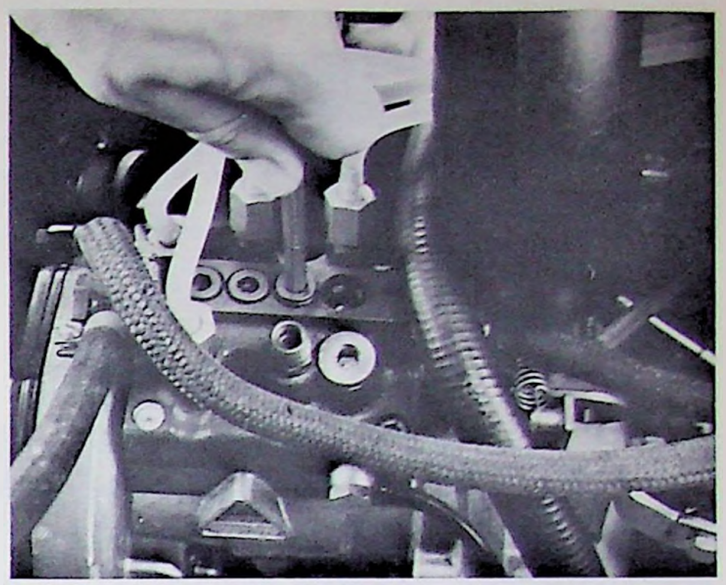
The warm-up transmitter is mounted on the rear of the pump with three screws. Disconnect the water and air hoses, remove the screws, and replace the unit. The rod will have to be adjusted after the new unit is installed.



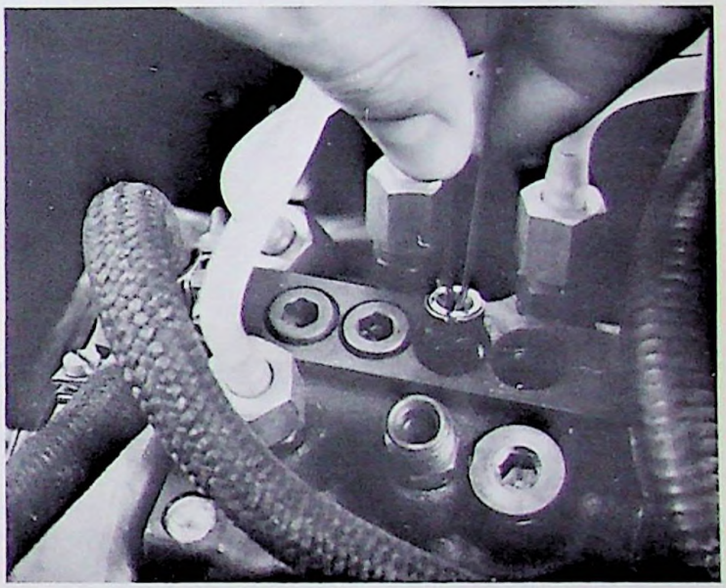
The fuel delivery valves are removed by unscrewing them with a 12mm wrench. Be careful when you replace these valves. There is a thin metal seal under each one. These seals must be properly seated to insure a proper pressure seal.



If, after the valve has been replaced, gasoline leaks out of the small hole below the valve, the metal seal hasn't seated properly or the fitting isn't tight enough.



To replace the suction valves, unscrew the retaining screw with a 6mm Allen Wrench.



Now use the brass tweezers to lift out the valves. *Do not* use a magnet to remove these valves.

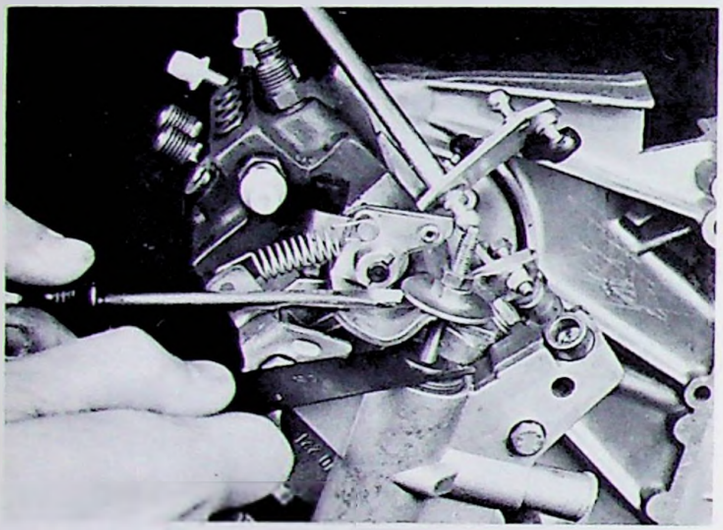
The pressure relief valve on the rear of the pump is simply unscrewed with a 19mm wrench and replaced.

Adjustments

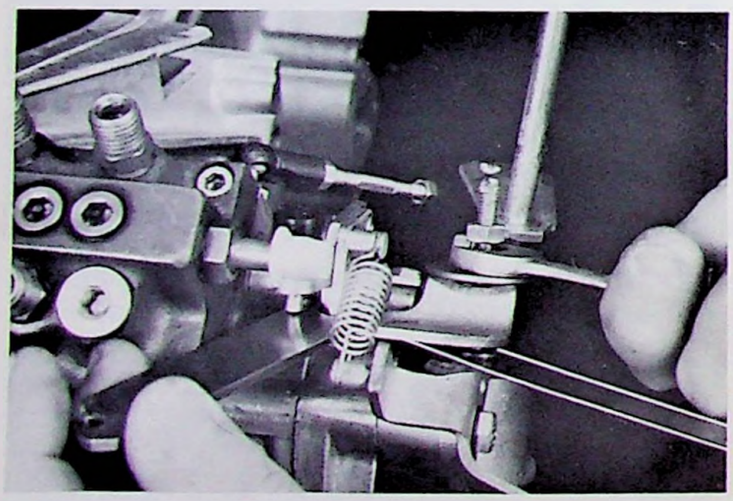
It is not always necessary to perform adjustments to the linkage of the tii fuel injection system. They are only necessary if a major component has been replaced or the engine will not readily meet tune-up specifications.

Warm-Up Transmitter

This adjustment *must* be done on a *cold* engine.



Lever out the Air Regulating Cone with a screwdriver and insert the Retaining Plate.

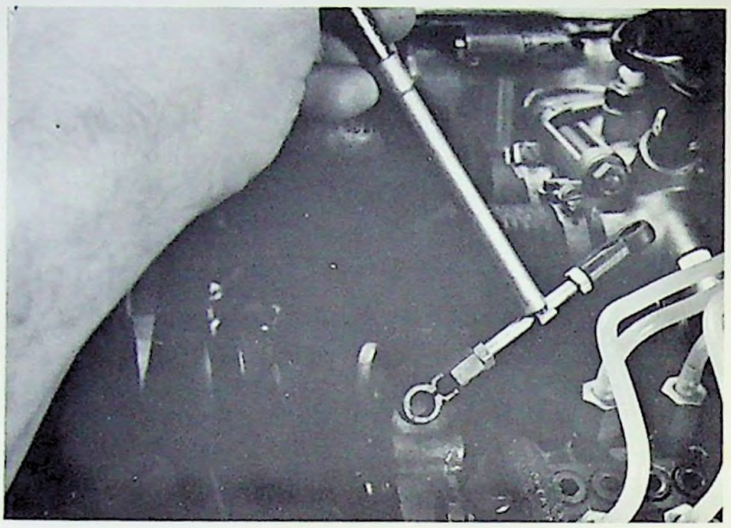


Check the distance between the screw on the enrichment lever and its stop with the Feeler Gauge. It should be 2.6mm. If it is not, loosen the lock nut on the end of the rod, and adjust the plate nut until the correct distance is obtained. Tighten the lock nut.

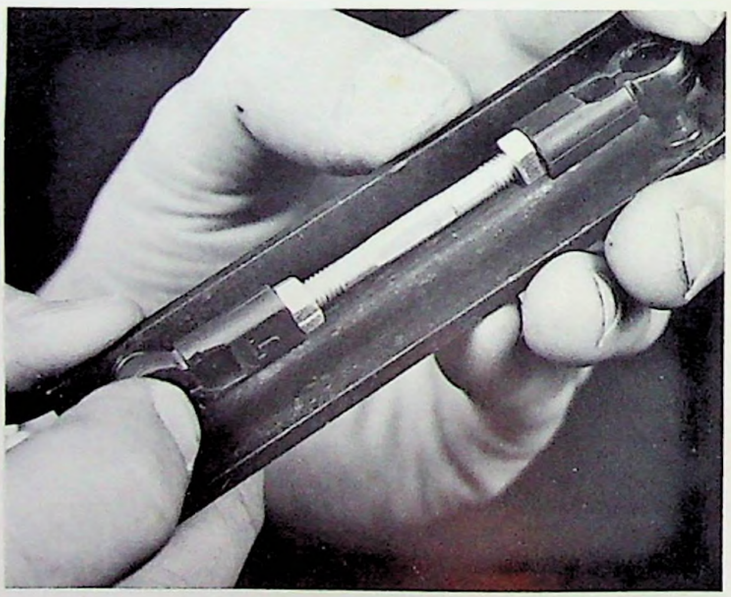
Never use the screw on the enrichment lever to set this gap. It has been set at the factory and re-adjustment will result in improper warm-up operation.

Pump/Throttle Linkage

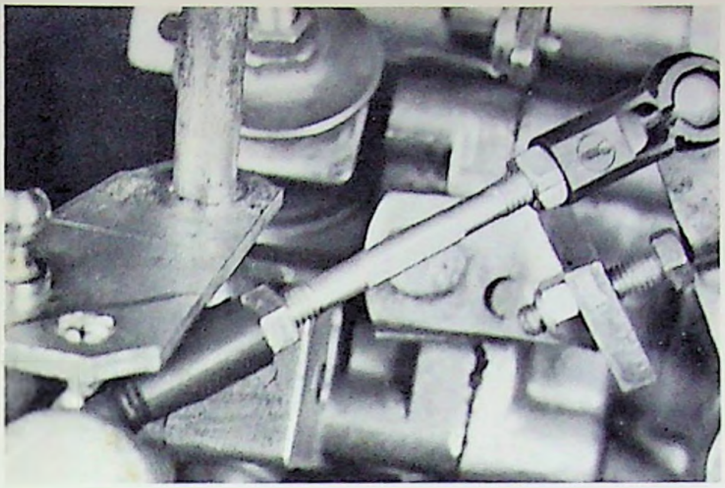
There are two parts to this linkage: one section is on the back of the pump itself, from the regulating lever to the bell crank; the other section is from the bell crank to the throttle butterfly.



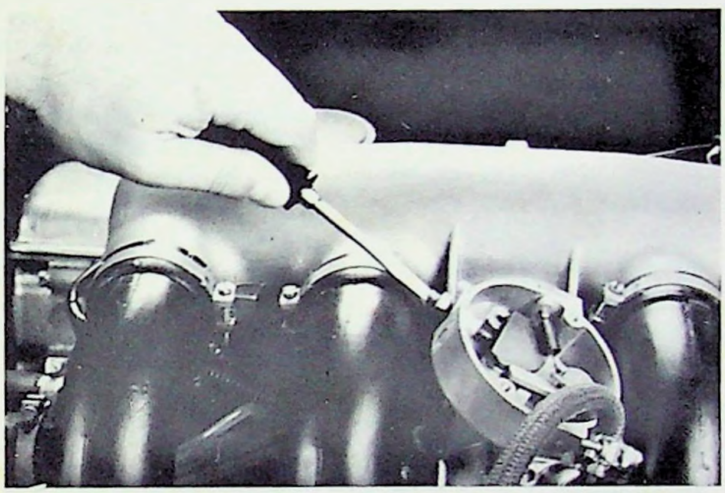
First, attach mechanical fingers to the short linkage on the back of the pump. It can easily fall down into the engine compartment and is difficult to retrieve.



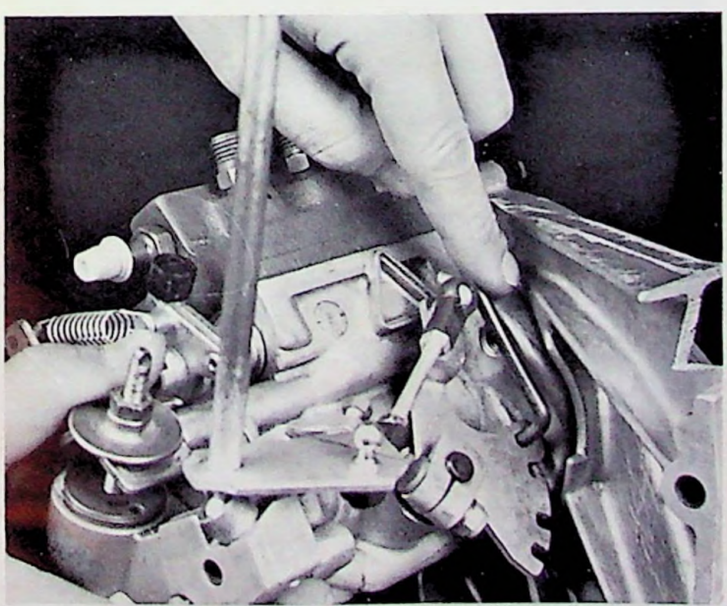
Adjust the length of this linkage until it can be easily pressed onto the 85mm gauge. Once the length is set, tighten the lock nuts and reinstall the rod.



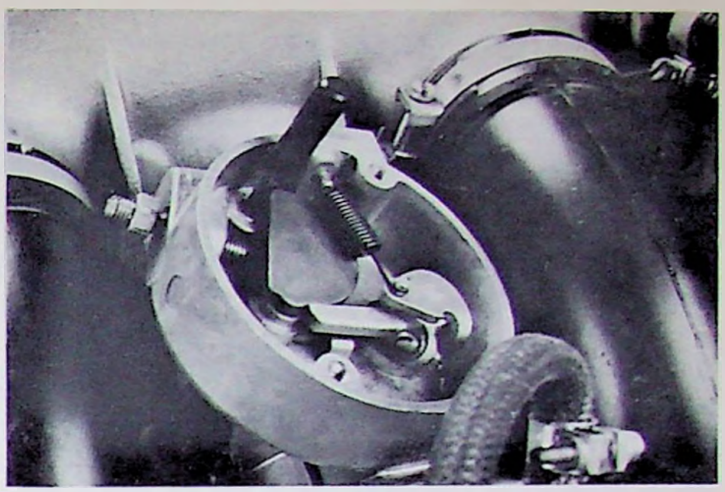
Be careful of the ends of this rod. They are plastic and can be easily damaged.



Next, remove the throttle housing cover and the air cleaner. Back off the idle adjustment screw.



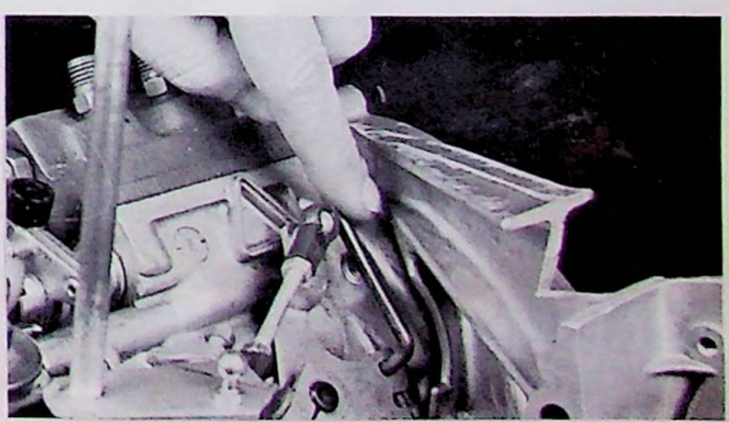
Insert the 5mm hook into the first slot on the pump's regulating lever and the hole in the pump housing. This is the correct idle position for the cone inside the pump.



Now, insert the 4mm pin into the hole in the throttle housing. Check to see that the eccentric cam just touches the pin.

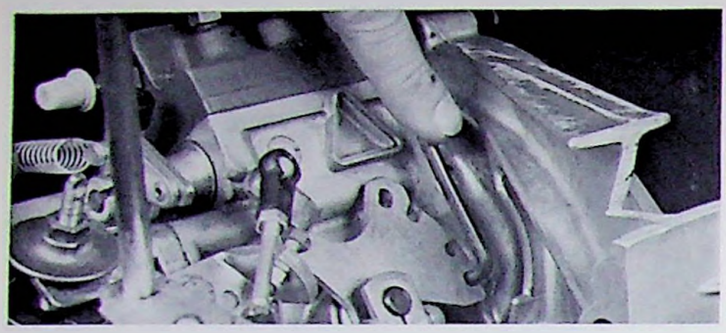
If it does not touch the pin, loosen the two screws on the linkage clamp.

With light finger pressure, push the eccentric cam against the pin, and tighten the screws on the linkage clamp.



Remove the 5mm hook, and open and close the throttle two or three times. With the eccentric cam against the pin, it should be easy to re-insert the 5mm hook without forcing. If it cannot be easily inserted, repeat the adjustment.

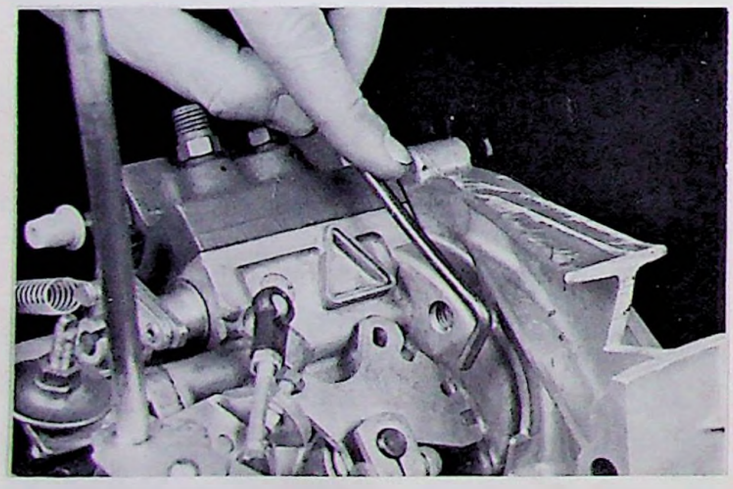
Full Throttle Stop



Insert the 5mm hook in the last slot on the pump regulating lever and the hole in the housing. If the lever just touches the stop screw, it is properly adjusted. If not, loosen the lock nut and adjust the stop screw. Tighten the lock nut.

Accelerator Linkage

Measure the distance between the ends of the connecting rod between the bell crank on the firewall and the throttle. It must be 289mm, center to center. If it is not, loosen the lock nuts and adjust the rod correctly.



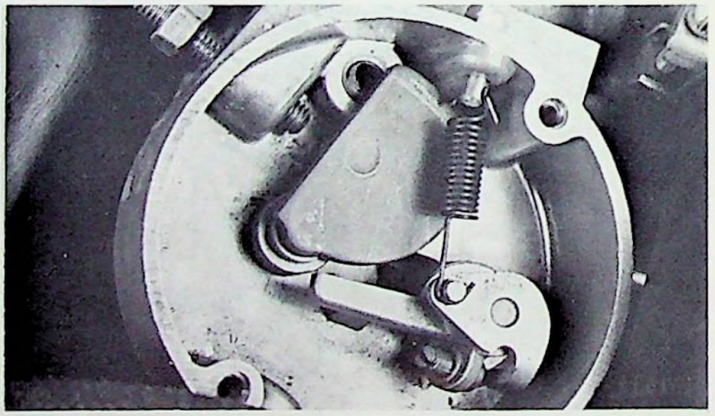
Now, push the pedal to its stop. Make sure it is resting on the stop and not on the carpet. Try to insert the 5mm hook into the last slot on the regulating lever. It should go in easily. If not, disconnect the safety clip on the firewall bell crank and remove the pin. Push the gas pedal to its stop, and insert the 5mm hook into the full-throttle cut-out on the pump.

Screw the pin up or down until it fits readily into the hole in the bell crank. Replace the safety clip.

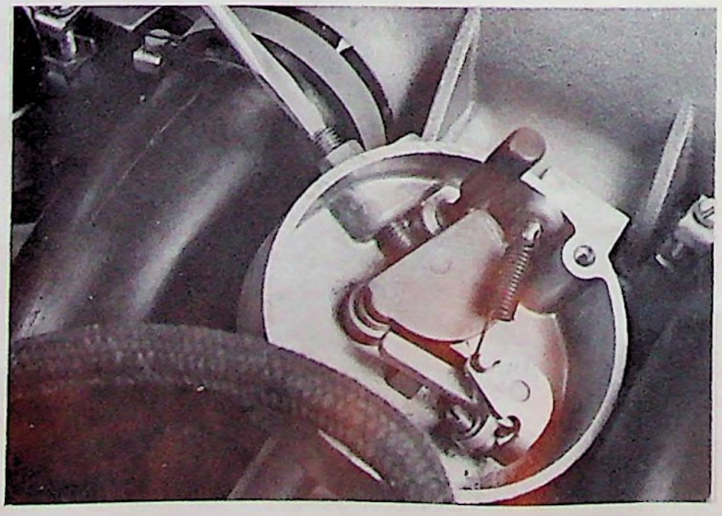
If your adjustments are correct, the gas pedal will hit its stop before the regulating lever on the injection pump reaches *its* stop screw.

Throttle

These adjustments are part of the normal tune-up procedure. Normally, minor adjustments to the idle or mixture screws will bring the engine within specifications. However, if major components have been replaced or the linkage has been completely re-adjusted, the basic throttle adjustment must be done before the engine can be fine tuned.

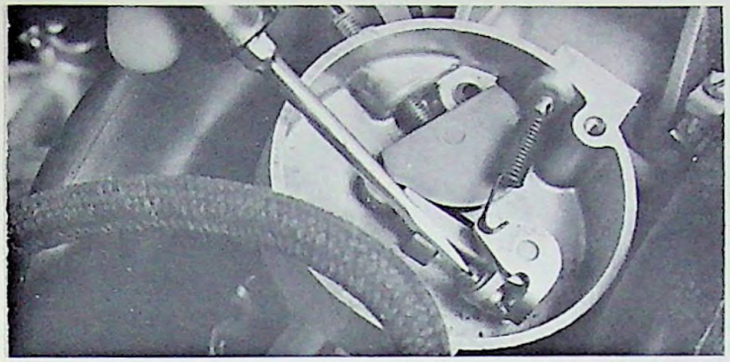


Back off both the idle adjustment screw *and* the mixture adjustment screw.

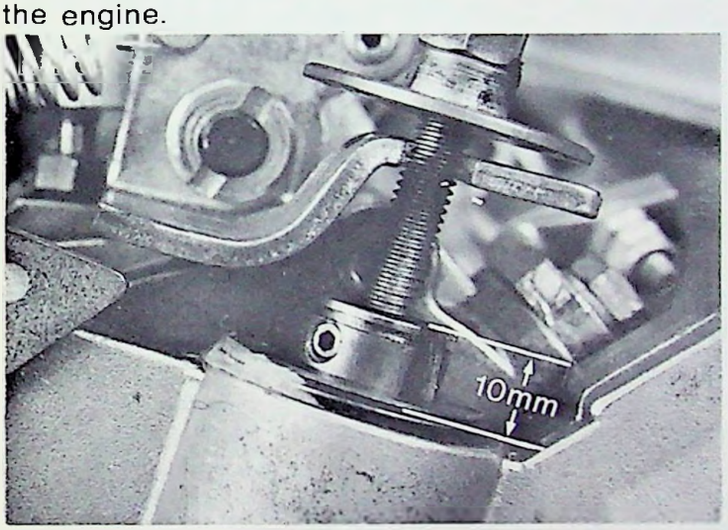


Insert the 4mm pin into the hole in the throttle

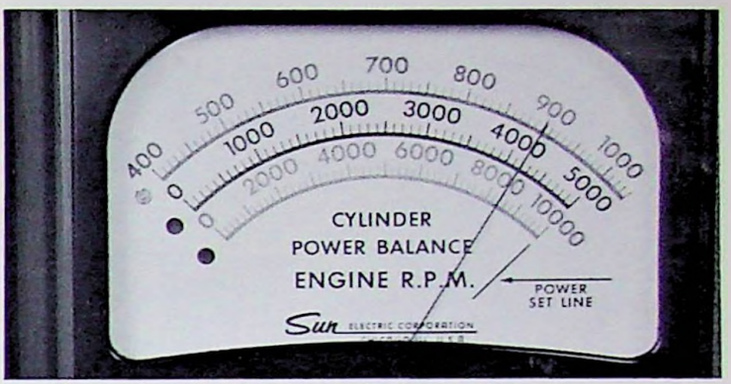
housing, and with light finger pressure, push the eccentric lever against the pin. Turn the idle adjusting screw in until it just touches the eccentric lever, and tighten the lock nut.



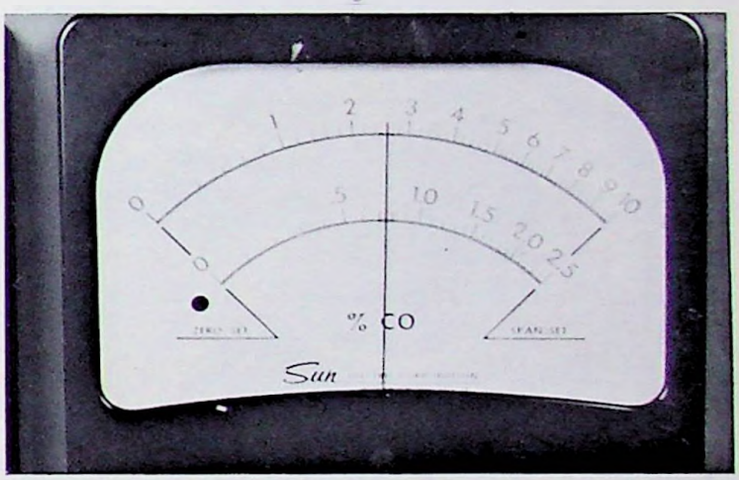
Now turn the mixture screw in until it touches the trailing lever and the trailing lever, in turn, is just touching the back of the eccentric. There will be a slight amount of play between the two lever until the screw is correctly adjusted. Once it is set, give the screw another half turn in. This will allow you to start the engine.



Let the engine warm up. To correctly set idle and CO, the engine must be completely warmed up and the Air Regulating Cone must be extended to its full 10mm. If it is not, the Warm-Up Transmitter is out of adjustment or defective.



Once the engine is warm, set the idle to 850 to 1000 RPM's by turning the idle adjustment screw *in*.

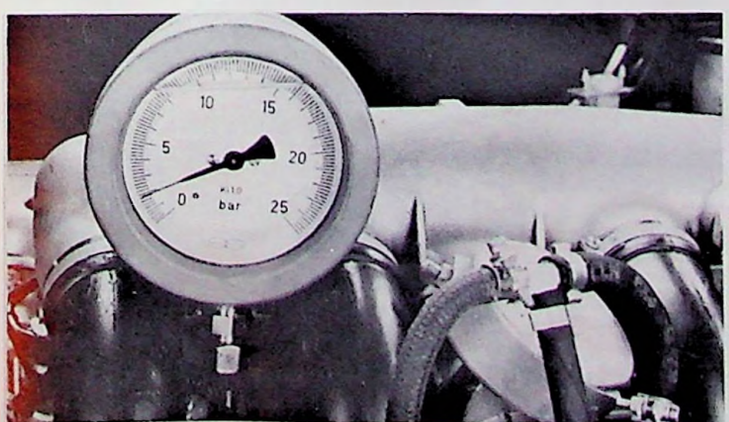


Adjust CO by turning the mixture screw *in* to raise CO, or *out* to lower it.

The correct setting is 2- to 3 percent.

Troubleshooting Hints

Before troubleshooting the injection system, make sure that the ignition system is functioning correctly, that there is an adequate fuel supply, and that the injection pump is correctly timed.

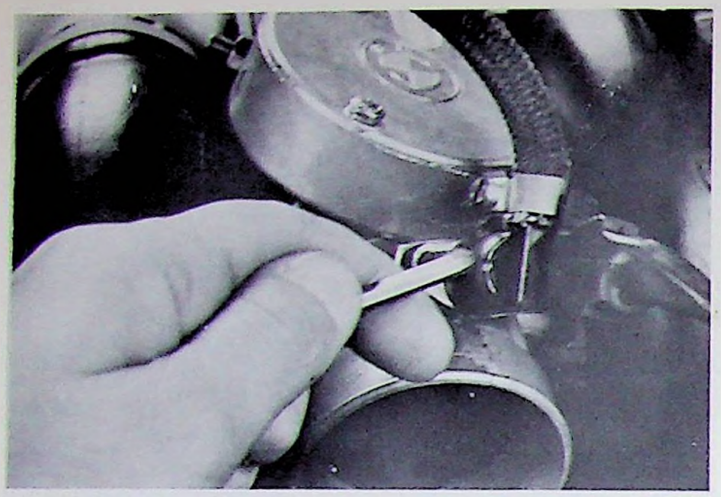


Inadequate fuel supply can cause problems in all three areas of engine operation: starting, warming up, and running. Use the BMW Special Tool, the Fuel Pressure Gauge, to make sure there is an adequate supply of fuel to the pump.

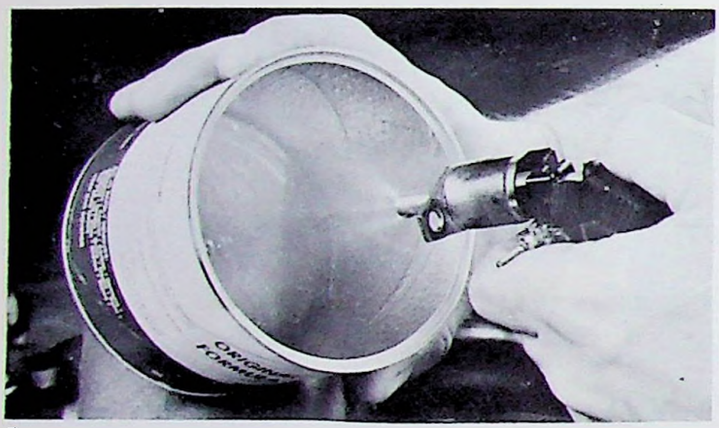
If the pump is not correctly timed, the same problems can occur. You should suspect timing problems if the operating problems began occuring after the car had been worked on.

Cold-Starting Problems

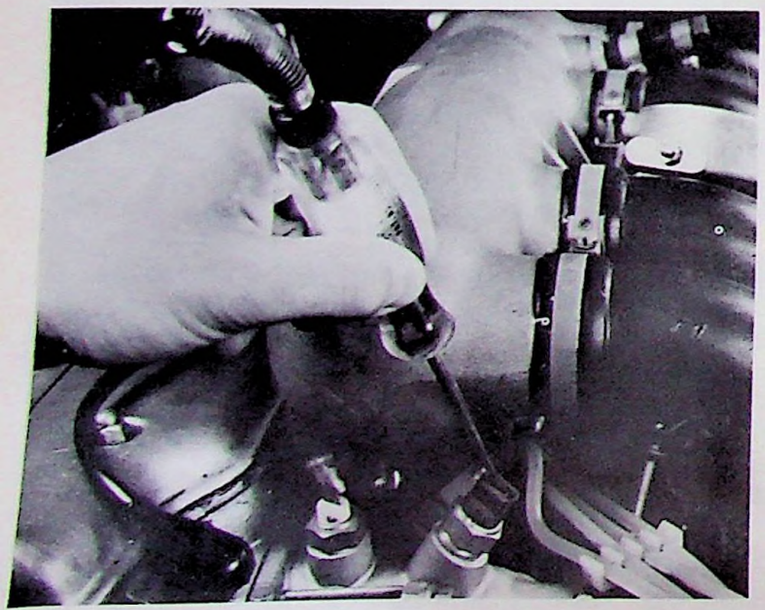
Occasionally, cold-starting problems are caused by improper starting procedures. Make sure your customer stays on the starter long enough.



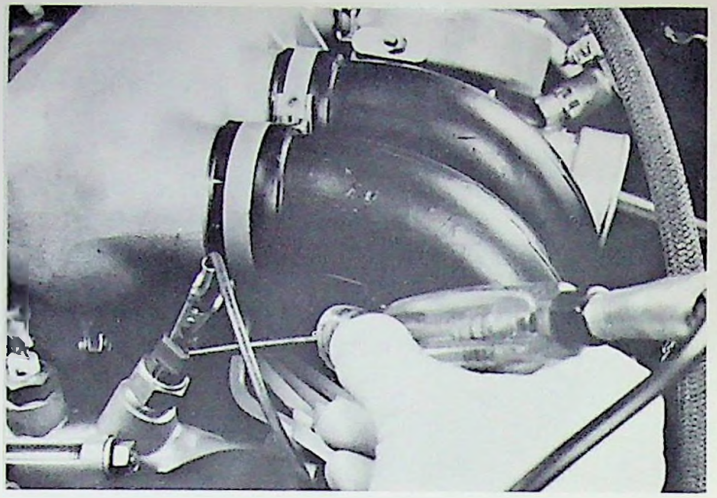
To check the Cold-Start Valve, first remove it from the intake. Place a container under the valve to catch injected fuel.



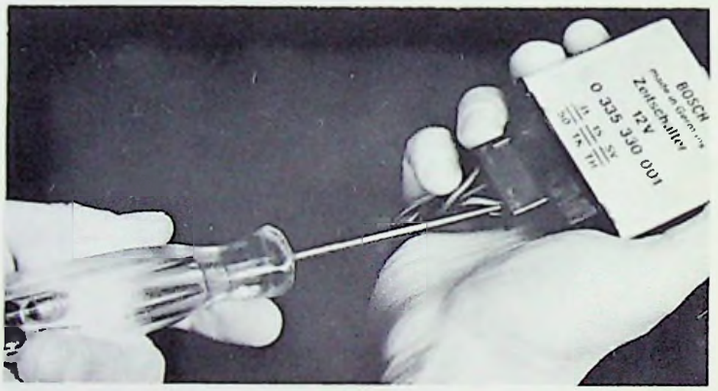
Connect a jumper wire from the positive terminal of the battery to terminal 'SV' on the Cold-Start Relay. If the valve is functioning properly, it should inject continuously.



To check the Thermo-Time Switch, first remove the *connector. Connect a test light between the positive battery terminal and connection 'W' on the switch. The light should come on if the switch is cold.*



Leave the light attached, and connect a jumper wire between the positive terminal on the battery and terminal 'G'. This will heat the bi-metallic strip in the switch. The test light should go out after a few seconds.



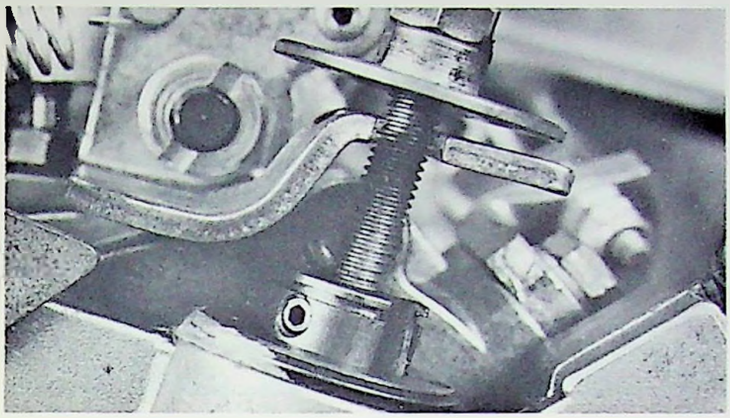
To test the Cold-Start Relay, connect the test light between ground and terminal 'SV'. Pull the coil wire and crank the engine. The test light should come on as soon as the engine begins to turn over and go out after a few seconds.

Now disconnect the connector on the Thermo-Time Switch. The light should now go out after one second.

Finally, connect the test light between terminal 'TH'

and ground. The light should come on as soon as the starter is engaged, and remain on as long as the starter is powered.

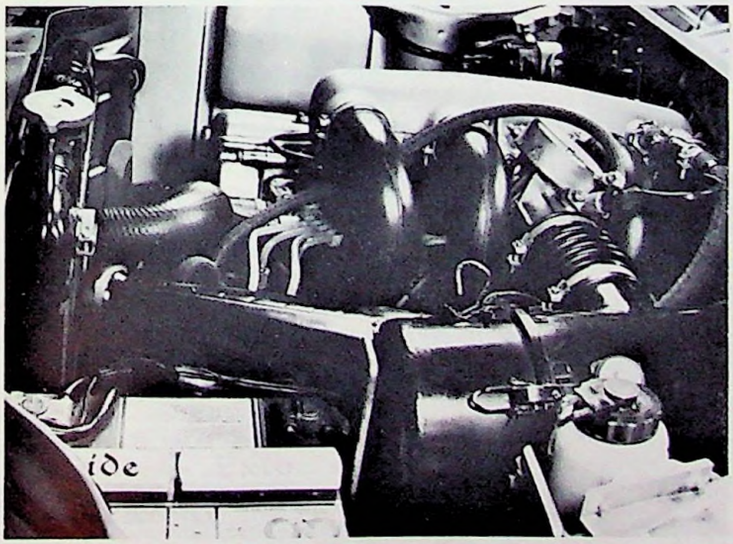
Warm-Up Problems



Most warm-up problems are related to the Warm-Up Transmitter. Check the adjustment. If that seems all right, make sure the cone is extended the full 10mm. When the engine has completely warmed up. If not, it will have to be replaced.

Warm-Running Problems

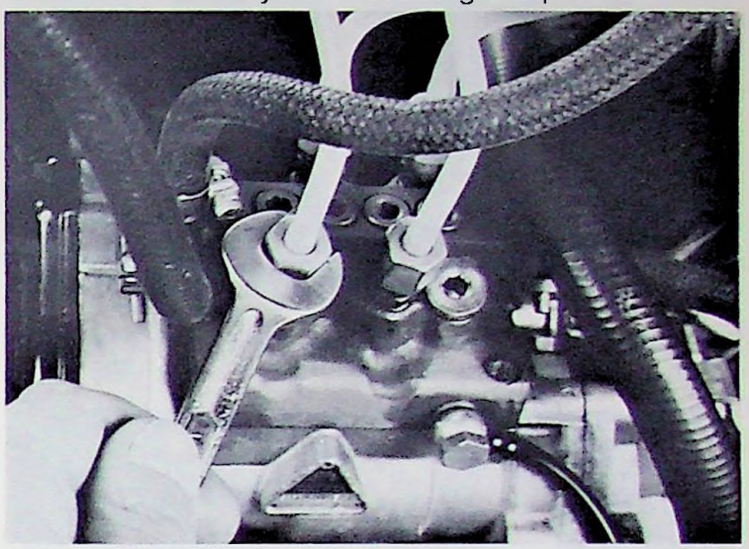
Most warm-running complaints are either surging or misfiring. Surging is generally caused by the improper adjustment of the injection system's components, or by worn linkages. If all the adjustments are correct, and linkages are not worn or damaged, the pump itself may be defective and will have to be replaced.



Sometimes the problem cylinder can be determined with an oscilloscope. But there's another way.

Misfiring can be caused by either ignition problems or by the injection components. Remember that this car has a conventional ignition system which should be checked with a suitable engine analyzer before working on the injection system.

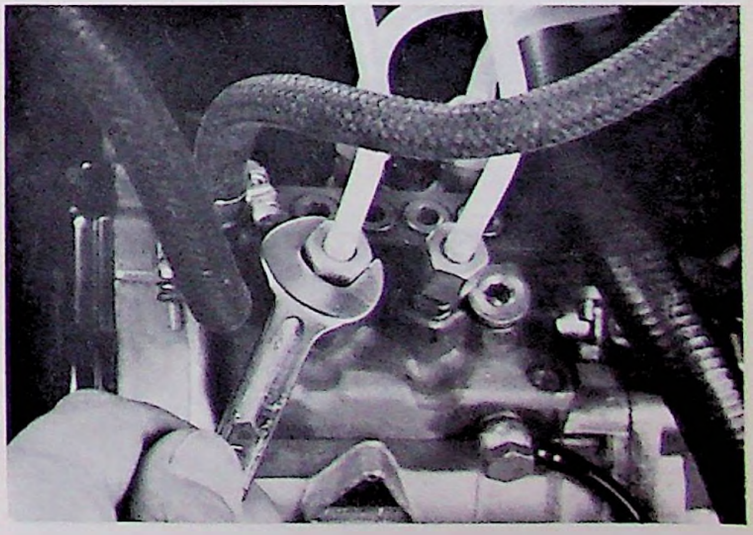
An Infrared Tester can help you determine whether the problem is in the ignition or injection system. Excessively high HC readings generally indicate problems in the ignition system; low readings tend to indicate a problem in the injection system. If the problem is in the injection system, the first thing to do is isolate the cylinder causing the problem.



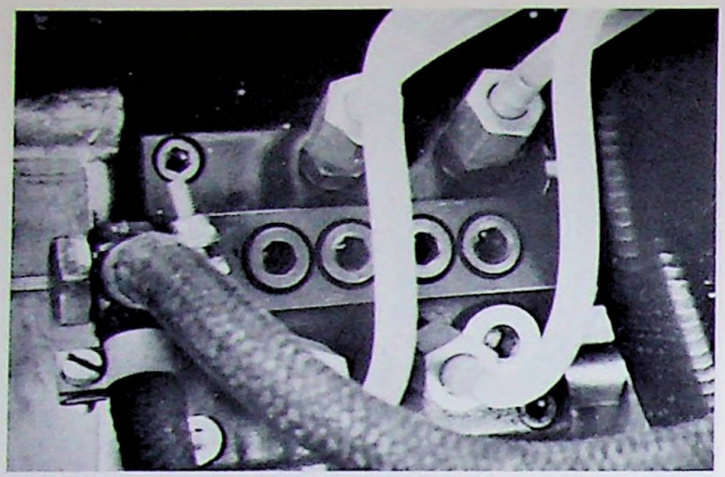
With the engine running, slightly loosen the fuel line fitting above the delivery valve for cylinder one. Don't take the fitting off, just slightly loosen it. The high pressure inside the pump will force fuel out through the loosened threads, and you should hear a noticeable difference in engine sound and speed. There will be little or no difference on the problem cylinder.

Once the cylinder with the bad fuel supply system has been located, the next thing to isolate is whether the problem is in the pump, the injector, or the suction or delivery valves.

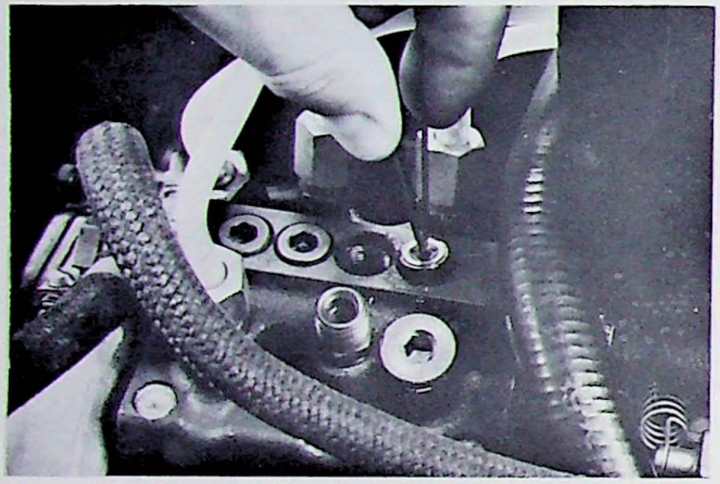
If no gas leaked out when the fitting was loosened, the problem is probably the suction valve or the pump. If fuel did leak out, the problem is a defective delivery valve or injector.



Assuming fuel did leak out, determine whether it is the valve or the injector. Switch the delivery valve with one from another cylinder.

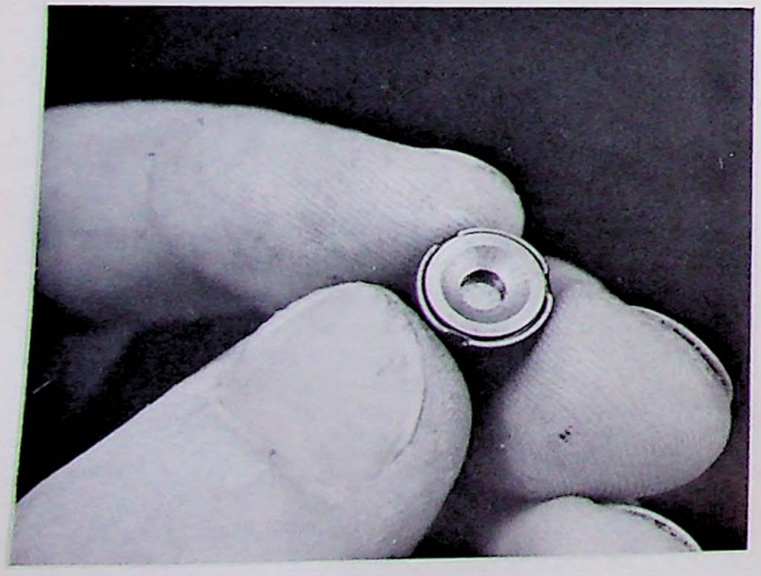


But, if fuel did *not* leak out, the problem could be the suction valve or the pump.

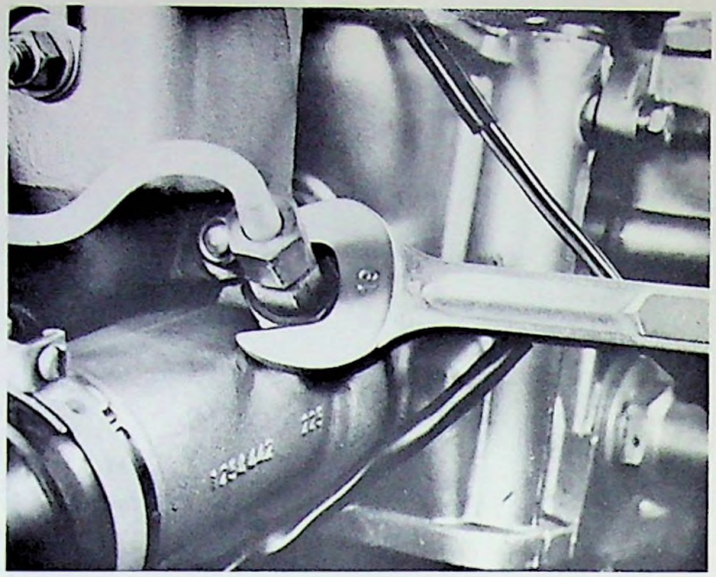


Again, exchange valves first. Remove the Allen screws on the problem cylinder and one of the remaining cylinders. With the BMW Special Tool, the *brass* tweezers, lift out both valves.

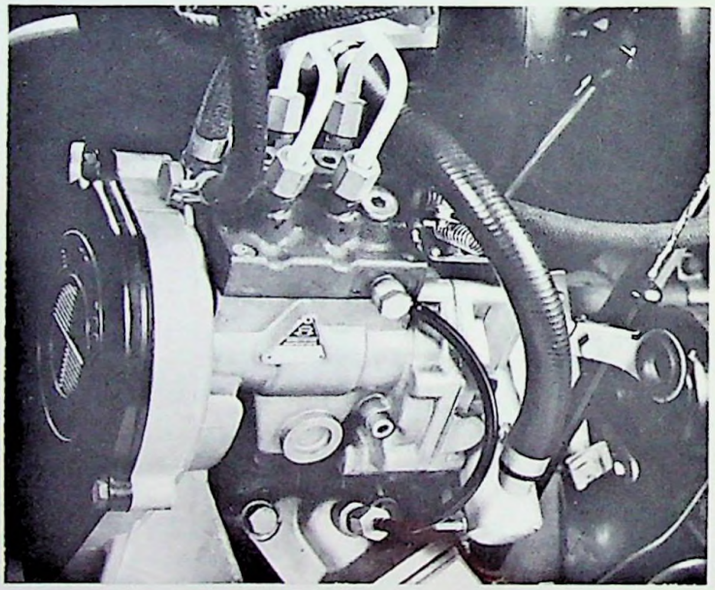
Do Not use a magnet. It can ruin the pump!



If the problem moves to the 'new' cylinder, the problem is the valve. If it does not, the problem is the injector.



So check the injectors. If your dealership services diesel products, you should have an injector tester on hand. If not, you'll have to repeat the same procedure: switch injectors.



If the problem is still not corrected, the problem is in the pump. Since there is nothing you can do to repair the pump, it must be replaced with a new one or rebuilt.

Notes:

Diagnosis

Condition	Cause	Correction
Idle speed too low, engine at operating temperature.	1. Idle adjustment incorrect.	1. Adjust idle with infrared CO tester.
	2. Ignition timing incorrect. (Too Late.)	2. Adjust ignition timing.
	3. Throttle valve adjustment not matched to injection pump.	3. Synchronize throttle valve to injection pump.
	4. Warming up device jammed.	4. Check hose clamp on damper valve.
	5. Injection pump not adjusted properly.	5. Replace injection pump.
Engine cutting out, misfiring.	1. Throttle valve adjustment not matched to injection pump.	1. Adjust throttle valve linkage.
	2. Defective injection valve.	2. Replace injection valve.
	3. Piston in injection pump stuck	3. Replace injection pump.
	4. Delivery valve leaks.	4. Replace delivery valve.
	5. Suction valve defective.	5. Replace suction valve.
	6. Fuel pump pressure not steady.	6. Check all electrical connections and ground connection, or replace fuel pump.
Engine backfiring on deceleration.	1. Throttle valve adjustment not matched to injection pump.	1. Adjust throttle valve linkage.
	2. Throttle does not return to idle position.	2. Replace throttle housing.
	3. Idle adjustment incorrect.	3. Adjust idle with Infrared CO Tester.
Insufficient engine/power output.	1. Fuel pump pressure too low.	1. Check all electrical connections to fuel pump, or replace fuel pump.
	2. Defective injection valve.	2. Replace injection valve.
	3. Throttle valve adjustment not matched to injection pump.	3. Adjust throttle valve linkage.
	4. Throttle does not go to full throttle position.	4. Adjust linkage.

Diagnosis

Condition	Cause	Correction
Too high fuel consumption.	1. Warm-up regulator does not cut out.	1. Remove hose clamp and bleed cooling system. Replace warm-up transmitter.
	2. Cold Start valve leaking.	2. Replace Cold Start valve.
	3. Throttle valve adjustment not matched to injection pump.	3. Adjust throttle valve linkage.
	4. Injection pump not adjusted properly.	4. Replace injection pump.

2002 tii Engine Specifications

COLD START: Turn on ignition and start engine with very light throttle.
Keep the starter engaged until the engine runs.

IMPORTANT! Before ever turning on the ignition, make sure that all fuel lines are secured in place with the hose clamp tightened on every single connection. At the moment the ignition is switched on, the fuel pump immediately puts the fuel system under full pressure.

Idle Speed 850-1000 RPM CO Volume 2-3%

Compression Ratio 9.0:1

Dwell Angle 60° ± 1°

Timing Setting at 2700 RPM

Centrifugal Advance: Begin at approximately 800 RPM.
End at approximately 3500 RPM. Maximum range 32° ± 2°. } **Not on '74's**

Spark Plug: Bosch W 7 D (W 175 T 30)

Gap: 0.6-0.7 mm (0.024" - 0.028")

Injectors - nozzle pressure: 30-38 kp/cm^2 (425-540 PSI)

Fuel Pump pressure: 2 kp/cm^2 (28 PSI)