9

SWITCHES, RELAYS, AND SOLENOIDS

SWITCH FUNCTIONS

Switches are to electricity what faucets are to water. Just as a faucet controls the flow of water, switches control the flow of electricity. There are, however, some significant differences in the functions of the two items.

1. We open a faucet to allow water to flow, and close it to stop the flow of water. Electrical switches operate just the opposite: we close a switch to allow electricity to flow, and open it to stop the flow.

2. Faucets can be adjusted to regulate the water flow, from a mere trickle to full flow. Switches, in general, are all or nothing; closed, they allow full flow, and open, there is no flow at all

3). The typical faucets we are accustomed to in our homes are simple on-off devices, controlling the flow of water from one source to one outlet. Electrical switches can be used in the same manner, but they can also perform more complicated switching functions. For example, the hazard switch in a later model TR6 disconnects the turn signal flasher, bypasses the turn signal indicator lamp, turns on the hazard flasher and the hazard flasher indicating lamp, and connects together the turn signal lamps on both sides of the car. Quite a bit for one simple switch, and all without the use of a relay.

SWITCH TYPES

The most basic type of switch found in a Triumph is a simple on-off switch, such as the switch that operates the brake lights. This type of switch is illustrated in the upper left of **figure 1A**, below.

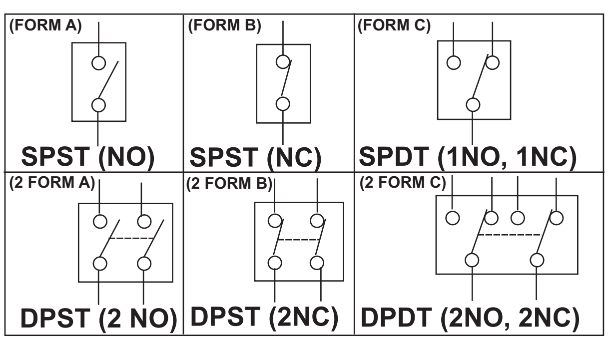

FIGURE 1A

This switch is commonly referred to as a "normally open, single pole, single throw" switch. The phrase "single pole, single throw" is usually abbreviated SPST, and "normally open" is abbreviated NO.

The switches shown in **figure 1A** can be either "maintained" or "momentary" switches. A maintained switch stays in the last position it was placed in, whereas a momentary switch will return to its "shelf" position as soon as the operator releases it. Generally, maintained switches are depicted as shown in **figure 1A**, while momentary switches are usually depicted as shown in **figure 1B** below. Note that the symbols for the SPDT and the DPDT switches are the same for either maintained or momentary types. For these switches, you will have to read the description to determine the operation for a given switch.

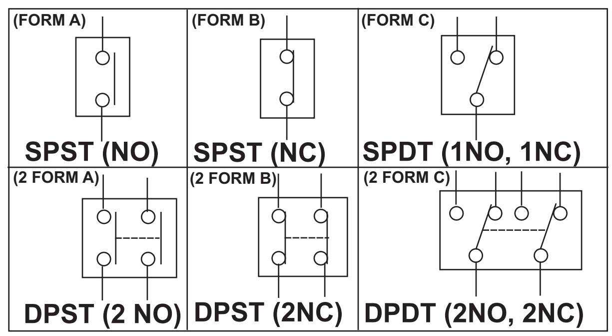

FIGURE 1B

When describing a manual, maintained position, switch, the term "SPST" is generally adequate, without the use of a "normally open" or "normally closed (NC)" modifier, as there is usually no "normal" position. When describing the operation of a momentary switch, such as the brake light switch, though, this modifier is very important. In fact, the brake light switch is a SPST, normally CLOSED, momentary switch. That is, when the switch is laying on the bench, the contacts are closed. In operation, when the brake pedal is released, the switch is operated, and the contacts are then OPEN (this peculiar method of operation is explained in chapter 11, Brake and Back Up Lights).

A SPST, normally closed switch is depicted in the upper middle of **figures 1A** and **1B**. In most engineering departments, these switches are not usually referred to as SPST; rather they are described as "form a" or form b," as shown. The term "form a" simply means a SPST, (NO) switch, and "form b" means a SPST (NC) switch. This terminology is much more concise and definitive than the SPST designations, but, unfortunately, will not be understood by most folks outside of electrical engineering, so you will need to use the SPST terms for the most part.

In the upper right of **figures 1A** and **1B** is a SPDT (single pole, double throw) switch, with one NC and one NO contact, also referred to as a "form c" switch. This type of switch is typically used as a "selector" switch - operating, for example, the high beams in one position, and the low beams in the other. Just to confuse matters even further, this switch is available in two configurations. In one configuration, the switch has three positions, with the center position being off, and in the other configuration, the switch has only two positions. Two types of "center-off" switches are depicted in **figure 2**, below, and are shown in the "off" position.

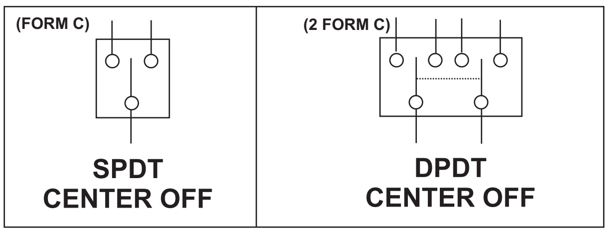

FIGURE 2

At the bottom of **figures 1A** and **1B** are three other examples of switches, and the diagrams should be self explanatory. The dashed line indicates that the two poles of each switch are operated simultaneously, with only one handle or knob.

The switches shown in the above figures cover most of the types you will normally encounter when working on a Triumph, and about the only types readily available in the typical auto parts stores. Other types of switches used will be described as they are encountered in the various chapters of this book.

RELAYS

Relays are nothing more than electro-mechanical switches, replacing the manual operation with electrical operation. The components that make up a relay are:

1. A coil of wire wrapped around an iron core,
2. A metal armature with one or more electrical contacts attached,
3. A spring to return the armature to its rest position when the relay is de-energized,
4. One or more fixed brackets with contacts attached,
5. Terminals for attaching wires for connecting external wires to the internal components described above, and
6. A protective housing, with mounting fixtures.

A typical relay is shown in **photo 1**, top right.

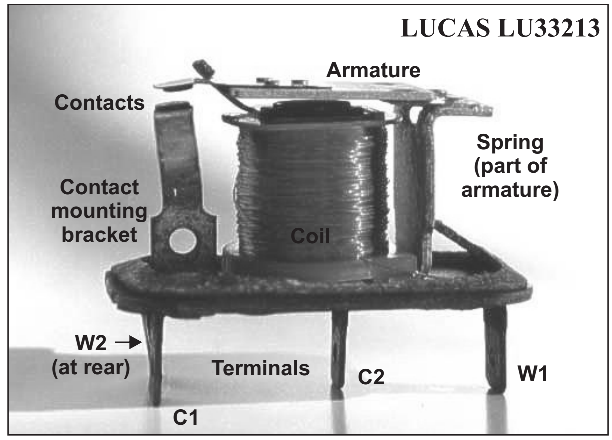

PHOTO 1

In operation, current through the coil of wire (1) creates a magnetic field, which magnetizes the iron core. The magnetized core than attracts the armature (2), pulling it toward the core, causing the contact on the armature to make contact with the contact on the fixed bracket (3), allowing current to flow through the contacts

When current flow through the coil of wire is interrupted, the iron core is no longer magnetized, and the spring (3) pulls the armature away from the core, and the contacts are separated, interrupting the flow of current.

The left hand side of **figure 3**, below, shows the physical details of the external connections and the schematic diagram for this relay. On the right are representations of a DPST relay, which is also shown in **photo 2**, next page.

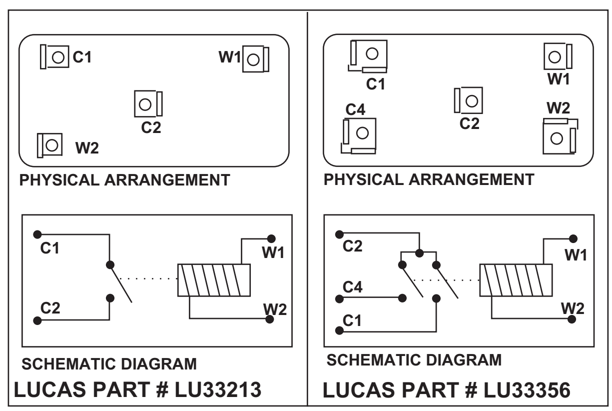

FIGURE 3

There are a couple of items worth noting with this particular DPST relay. First of all, notice that, unlike the DPST switch shown in **figures 1A** and **1B**, the two poles are not isolated from one another. One side of each pole is connected to the other pole, making this switch a three terminal device. In other words, this relay has one input and two outputs. When the relay is operated, power from the input terminal is fed to both output terminals. Secondly, notice the absence of a contact pad on the C1 bracket! This relay, removed from a '75 TR6, is very definitely bad.

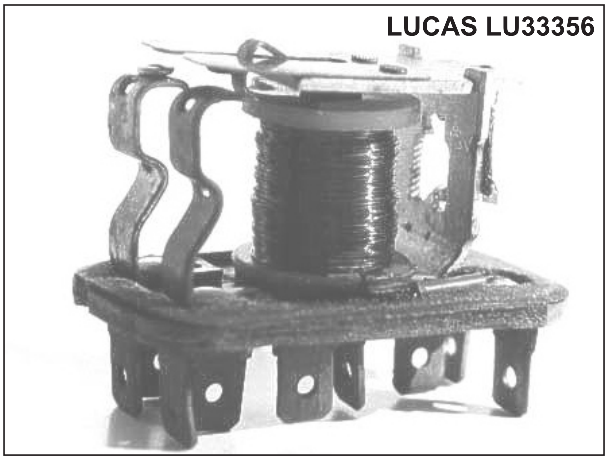

PHOTO 2

WHY USE RELAYS

If a relay is nothing more than an electrically operated switch, why bother using one. Why not just use a switch and be done with it - using a relay in addition to a switch has to cost more. There are a few good reasons:

1. CURRENT CAPACITY: often, for esthetics or space concerns, it is desirable to use small switches to operate high current loads. When these small switches lack the capacity for switching heavy loads without damage, a relay can be used as a go-between, allowing a small current through the switch to operate a relay coil, and using the relay contacts to operate the heavy load. In this situation, a relay is often referred to as an “interposing” relay, i.e., it is interposed between the load and the switch.

2. EASE OF REPLACEMENT: It can be quite difficult sometimes to get to a dash mounted switch to replace it, and it can be extremely difficult to get to some of the mechanically operated switches, such as the reverse switch in the transmission, for replacement. Relays, on the other hand, can be conveniently mounted so as to make replacement easy. In a TR250 or a TR6, in fact, they are mounted on a small bracket under the hood, where they can be removed and replaced with very little difficulty. Even if the primary switch can handle the load, they still fail after time, and so will a relay, so ease of replacement is a very important consideration.

3. CONTACT MULTIPLICATION: not as often a factor in automotive usage as in industrial applications, using a multiple pole relay can allow a simple on-off switch to operate several devices at once. In my workshop, for example, I have a 12 pole, double throw relay, left over from some long forgotten project. Using this relay and a SPST switch, I could operate up to 24 independent devices at once - turning 12 off, while turning another 12 on.

More appropriate to automotive usage would be the use of one switch to control two relays, one for each of a pair of high powered driving lights. One set of contacts in the switch controls two relay contacts. Of course, you could always buy a switch with ample capacity to operate both lamps, or a double pole switch, but it may be that the switch you prefer for esthetic reason has only one set of low current contacts.

4. COMPLEX FUNCTIONS: prior to about 1972, Triumph used a simple DPDT (one NO and one NC contact) switch, operating a relay, to control the hazard flasher. In ‘72, the relay was eliminated, resulting in the need for a more complex switch. The pre ‘72 switch can be replaced with an off the shelf switch, but not the later models.

You may also want to “interlock”certain functions, such as allowing your driving lights to be on if and only if you have both the driving light switch on and the headlights on high, or allowing the starter to operate only if the transmission is in neutral. Again, it may be possible to do all of this with only switches, but the use of relays often greatly simplifies things.

RELAY SUBSTITUTES

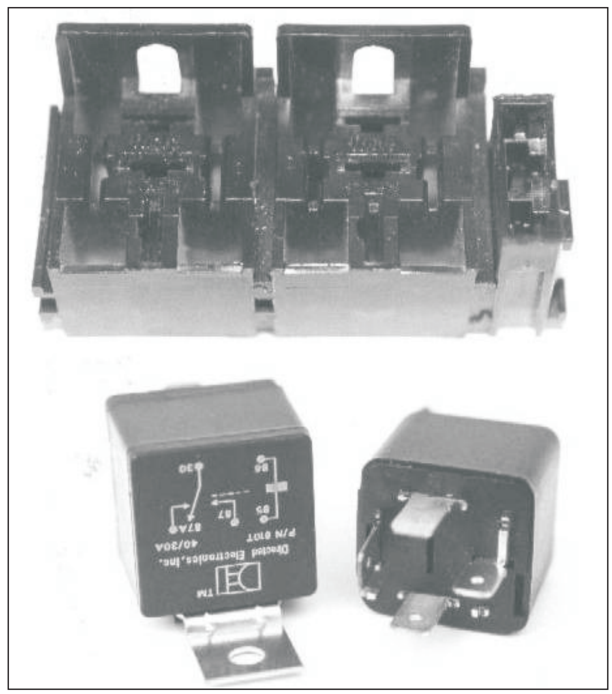

PHOTO 3

As this book is written, genuine Lucas relays are still readily available for the TR250/TR6, although they are a bit pricey. Luckily, aftermarket relay are available to substitute for all applications, and are quite a bit cheaper. Prices range from around $5 for a simple SPST relay, with a 30 amp rating, to around $12 for a SPDT, 30 amp relay. Too make life a bit simpler, relay sockets are also available at a very reasonable price. **Photo 3** above shows typical aftermarket relays, along with the matching interlocking sockets and a fuse holder that also interlocks with the sockets. You'll notice that one of the relays has a mounting tab on it, which may eliminate the need for sockets.

Figure 4, below shows two types of replacement SPST relays that are available in most auto parts stores. In this figure, I have labeled the terminal with both the industry standard for automotive relays, and, in parentheses, the equivalent Lucas identifiers.

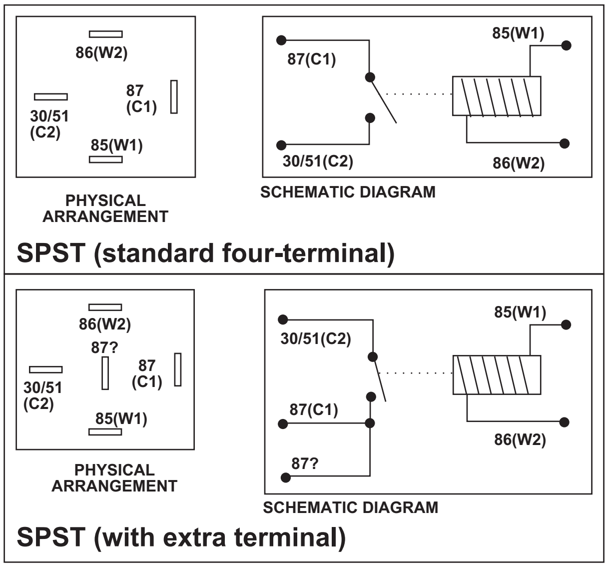

FIGURE 4

If you want to operate two loads from the same relay, such as a pair of driving lights, using the five terminal relay may simplify things, as you can connect each of the lamps to a separate terminal, eliminating the need to terminate two wires into one terminal. On the other hand, if all you have is the standard four terminal relay, there is nothing wrong with connecting two or more wires to the same terminal- automakers do it often.

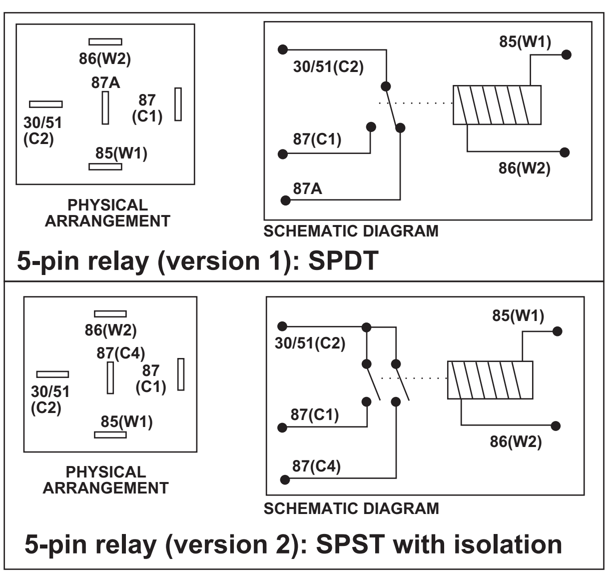

FIGURE 5

In **figure 5**, below left, are two other versions of a 5-pin relay. Externally, they are similar, but their operation is quite different. Version 1 is a "selector" type - i.e., ***either*** 87 ***or*** 87a will have power, but not both. With the relay energized, power is applied to terminal 87. With the relay de-energized, power is applied to terminal 87a.

With version 2, power is applied to both output terminals, both labeled 87, when the relay is energized. This configuration allows the loads to be isolated from each other when the relay is de-energized. The starter relay used on the later models is an example of an application of this type relay. In this application, it is important that the ballast resistor bypass ***not*** be connected to the starter solenoid when the relay is off, yet they both must be connected to power when the relay is on.

POLARITY

The coils and contacts in all of these relays are non-polarity sensitive, meaning is doesn't matter which way you wire them. You can make the W1(85) terminal negative, and the W2(86) positive, for example, or the other way around, and the relay will work just fine. The same is true of the C Terminals. On the DPST relays, the C1(87), the C2(30/51), and the C4(87A) terminals are all isolated from one another when the relay is de-energized, and they are all three connected together when the relay is energized. Therefore, as long as you don't mix up the wire connections ***AT*** the terminal, it doesn't matter ***WHICH*** terminal you use.

To clarify that a little bit: if you now have one black wire on terminal W1, and two purple wires on terminal W2, you can place the black wire on terminal W2, and BOTH purple wires on terminal W1. It is NOT OK to move just one of the purple wires to terminal W1.

CAVEAT!

When you receive your relays, but before you use them, check the diagram printed or stamped on the side of the case. These relays all look alike, and it is not at all uncommon for them to get mixed up in the bins at the warehouse. When the stock picker reaches into a bin for a relay, he or she usually assumes the relays are as marked on the bin, and doesn't check them to be sure. It is very rare when I order several relays at a time that they are all what I asked for.

SOLENOIDS

A solenoid consists of the following components

1. A coil of wire wrapped around a hollow core,
2. A movable iron rod inside the wire coil,
3. A spring to return the iron rod to its rest position when the solenoid is de-energized,
5. Terminals for connecting external wires to the solenoid

coil, and
6. A protective housing, with mounting fixtures.

When a current is passed through the wire coil, the movable iron rod moves, either into or out of the hollow core, depending on which end of the rod you are referring to.

And that's all there is to a solenoid! And this simple operation is what makes solenoids so versatile. Through mechanical coupling, the movement of the rod can be made to do many things. By coupling it to a diaphragm, as an example, it can be used as a horn; couple it through a lever to the drive gear, and it becomes a starter solenoid; attach a set of electrical contacts to it, and it serves as a relay, usually, a high power relay, capable of switching many amps.

Photo 4, below, shows the internals (well worn) of a starter solenoid from a TR3 (and typical of those used in a TR250). Notice the size of the electrical contact area as compared to the relay shown in **photos 1** and **2**.

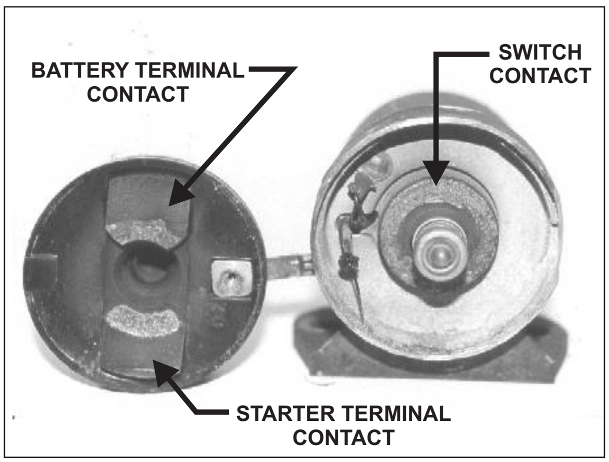

PHOTO 4

Theoretically, there is no reason a relay can't be made big enough to handle high current, but in practice, solenoids are made much more powerful than relays. Being more powerful, they also draw a lot more current than a relay, and they close the electrical contacts with much more force, making a much better contact. Because of the high power aspects of a solenoid, they can operate much larger contacts than a relay, which aids greatly in producing the higher current handling capacity.

The only solenoids used in a TR250 or a TR6 are those used in the horns, and the starter solenoids. The horn solenoids are described in the chapter 18, Horns, while the starter solenoids are described in chapter 25, Starters. Suffice it to say at this point that the starter solenoid schematics are identical to the schematics for the relays previously described. The solenoids used in the TR250 and early TR6 models are the equivalent to a SPST relay, while the later TR6 models, with a ballast resister bypass connection, are equivalent to a DPST relay.

SWITCH REPAIR

Even though new switches are readily available for most applications, sometimes it is more desirable to repair the one you have. To repair a rocker type switch, it will have to be taken apart and cleaned. Disassembly is quite easy, and how to do it is clear from an examination of the switch, as shown in **photos 5** and **6**, below.

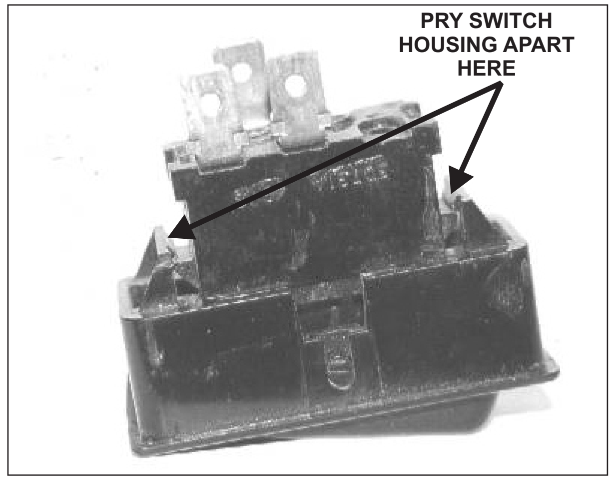

PHOTO 5

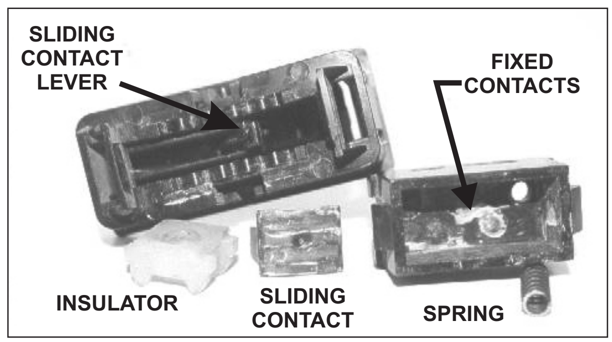

PHOTO 6

Basically, it involves slightly spreading tabs on the switch housing and removing the internals. Once you have the switch apart (watch for the spring so that it doesn't jump out and roll under the workbench where you can't get to it), clean the old grease out, and with a pencil eraser, or similar abrasive, lightly wipe the contacts until they are shiny. If you can locate it, replace the grease with a suitable grease for electrical contacts, available from Radio Shack or other electrical supply house, and reassemble. As they say, reassembly is the reverse of disassembly. If you can't find the proper grease, go ahead and reassemble dry, and you shouldn't have any problems.

There are two types of momentary door switches used, as shown in **photos 7** and **8** below. The first type, **photo 7**, has open contacts. To repair these type switches, all that is necessary is to carefully clean the contact with a mild abrasive, such as a fine grit sandpaper.

The other type, shown in **photo 8**, has the contacts enclosed in the plastic housing. To repair this type, use a fine toothed hobby saw to saw the plastic housing in two, being very careful not to cut into the internal mechanism. Use a mild abrasive, such as a pencil eraser or fine grit sandpaper, to clean the contacts, and use super glue to glue the two halves back together. I have two switches on one my cars that were repaired this way ten years ago, and they are both still working just fine. Economically, it's not really worth the trouble, but if you have the time, it can be a satisfying thing to do - restoration vs replacement!

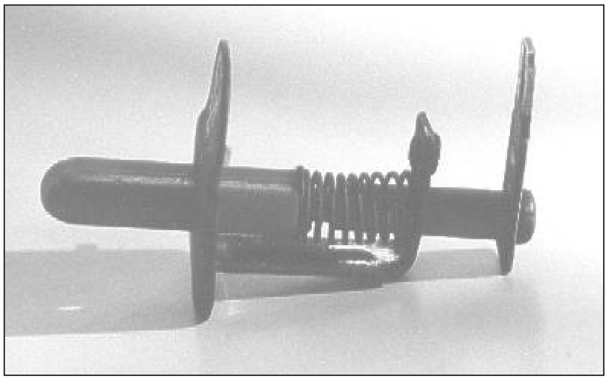

PHOTO 7

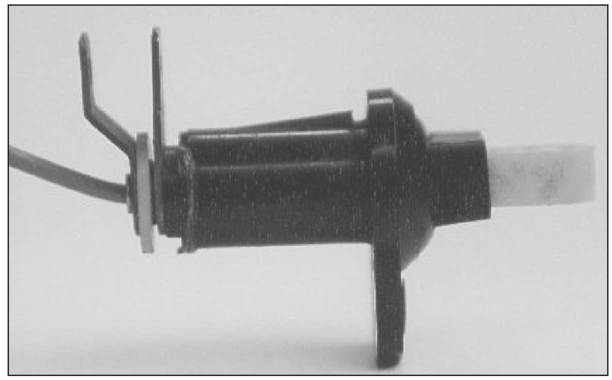

PHOTO 8