All About Suspension-Damper Rods & Fork Kits

# POPULAR CYCLING

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**SUPER TESTS!**

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- Yamaha IT 400

**HOW TO:**

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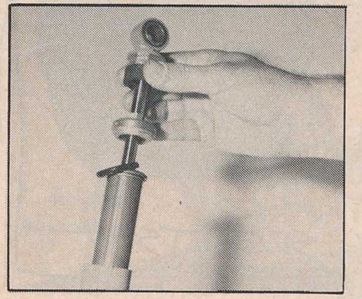

Cover:
Marty Tripes puts the new Bultaco 370 Pursang into the outer hemisphere for Steve Reyes' trusty Pentax.

Centerspread:
Tony D., Roger, and other heroes, under the lights, earning a living.

# POPULAR CYCLING

VOLUME 9, NUMBER 6

## FEATURES



## DEPARTMENTS



## TECHNICAL



## ROAD TESTS



## STAFF



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By Brad Zimmerman

# ALL ABOUT SUSPENSION

## Part 2-Damper Rods

### THEIR COMPONENTS, FUNCTIONS AND PROBLEMS

*Editor's Note—This is the second installment in our series about suspension. If you read Part 1, which dealt with fork springs and oil weights in the March issue, you're ready to move on to the second segment, which explains damper rods and their functions.*

*We at Popular Cycling feel that it's about time the general public, and not just the "inside people" find out how and why suspension works. There are too many riders, amateurs and pros alike, that don't really understand what is going on inside the forks and shocks, and how they're supposed to work. Many people make the wrong choices because many times they (and their dealer) don't really know what is required in particular instances to cure the problems.*

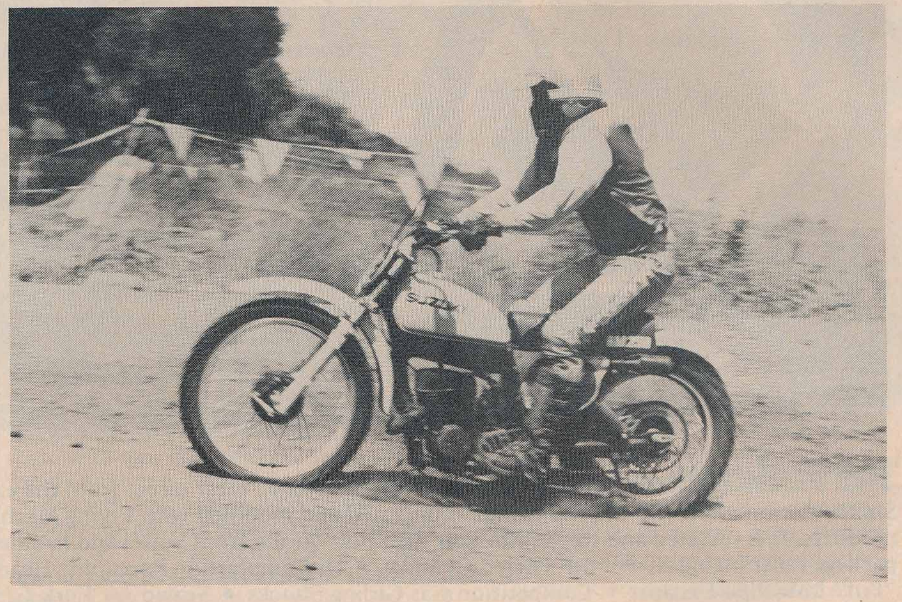
*With this in mind, we have set out to explain suspension to you in detail, showing you what each part does, how it's supposed to function, and how to determine for yourself what suspension qualities you are really looking for.*

*We contacted Al Baker Racing and Development, and S&W Shocks, for assistance in this portion of the article. Both Al Baker, and the folks at S&W are well versed in suspension, and can help the private individual find out a little more about his own machine.*

*We're not going to tell you, in any of these installments, to use a particular brand of fork kit, spring, shock and so on. We have used the S&W damper rod kit in this section, simply because the S&W people are obviously familiar with the unit, and because it is a good example of a properly constructed fork kit. There are others of high quality around the motorcycle world, and there are other really dangerous units for sale.*

*Read Part 2 slowly, carefully, and read it at least twice. If you get stuck and don't understand something, backtrack a few paragraphs and go through it again. It's a very involved series, possibly the most technical piece you've ever read in Popular Cycling, but we feel that it's important enough to run in our magazine. We're sure that if you go slowly, read the article thoroughly, you too will become somewhat of an expert in the field of suspension.*

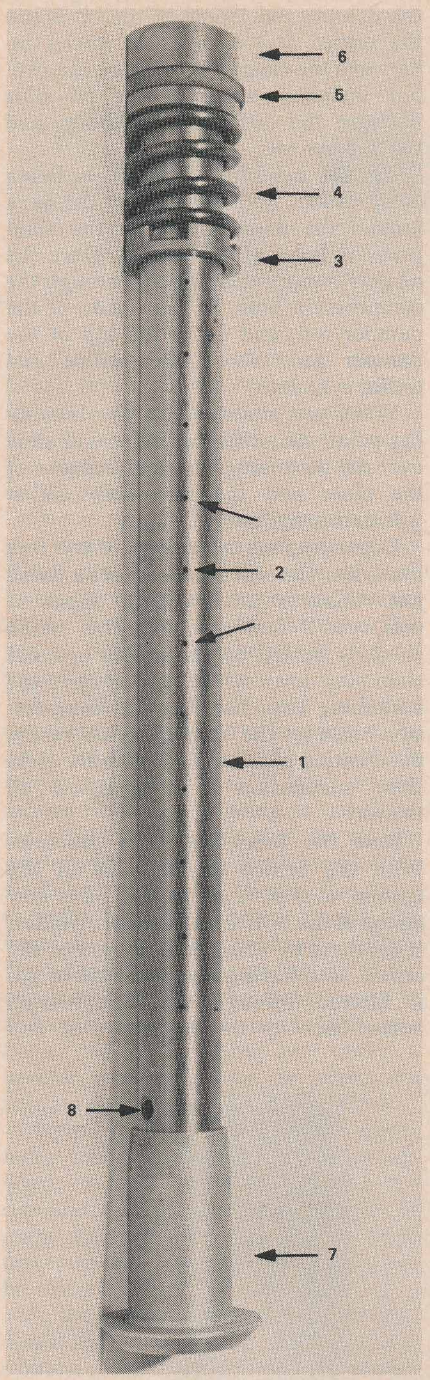
*If something totally baffles you, drop us a line, and write the word "Suspension" on the outside of the envelope. We'll do our best to clear up your problems. Again, read the article carefully: it's very involved, very intricate, and very interesting.*



For most riders, the only time they are familiar with a damper rod or its related parts, is when the old forks are coming apart. Usually the stock units are thrown away and an accessory fork kit is installed. The directions are followed, and most of us are aware of a definite improvement in the handling and suspension of the front end. It feels better, works better and was usually worth the money.

The problem is that many people get themselves into trouble with fork kits, even with the stock damper units, because they don't understand the principles behind the units, their function, and what to look for in the way of problems. With the assistance of Al Baker Racing and Development, and S&W, the suspension people, we're going to try and clear up the problems so you know what's down there, what it's doing, and if it should be changed.

Before we go into any of the technical aspects of damper rods, we would like to point out one thing. After reading this article, don't attempt to modify

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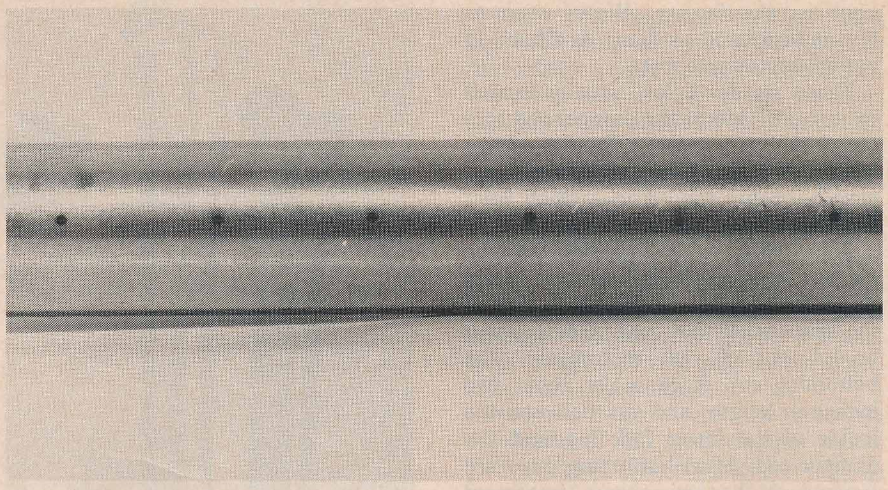

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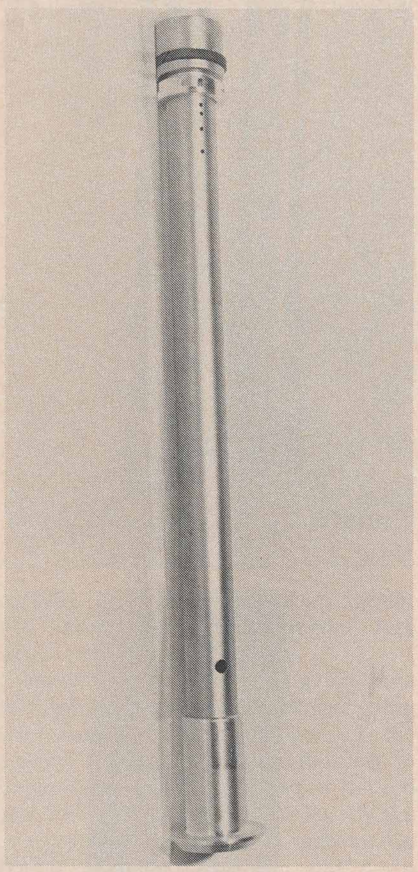

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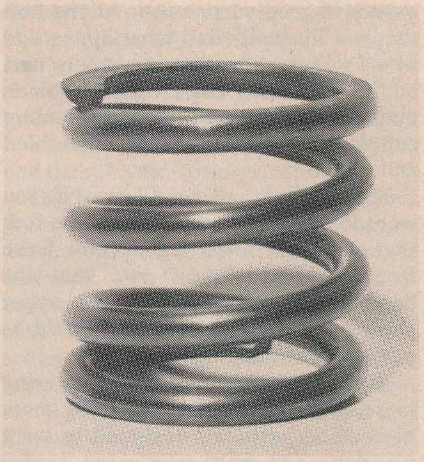

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1. This is the stock Honda Elsinore damper rod and associated parts. The damper rod (#1) has rebound holes (#2) drilled almost the entire length of the rod. The compression holes (#8) are close to being right. The taper on the bottoming cup (#7) is way off, the orifice (#3) is wrong, and the rebound spring (#4) should be discarded. The damper stop (#6) and its cork O-ring (#5) are duplicated in most fork kits.

2. There are too many rebound holes on the Honda damper rod. They are also spaced evenly, and have the same size openings, which mystifies just about everyone who knows anything about suspension and the proper placement of rebound holes. A secret? Probably not—just a mistake.

3. The rebound spring in the stock Honda unit is designed to stop the forks from topping out too quickly and to slow down the orifice and orifice cylinder. Honda should have gone to a better rebound hole design and a ground taper on the damper rod instead.

4. You'll notice that the S&W replacement damper rod for the Elsinore is quite different. There is no rebound spring, the rebound holes are smaller in number and different in location, and the compression hole is slightly larger.

your existing damper rods in an effort to avoid buying a fork kit. It's not worth the hassle, it's very complicated, and you *will* run into problems. Leave the manufacturing of fork kits to the pros—they've been doing it for years and know how to sort out the kinks and get things properly operating.

For simplicity, we'll first explain the stock parts and their supposed functions of the Japanese rod. The reason we're going with the Japanese model is because it's the most popular, it has the biggest, but simplest problems, and with the exception of Husky and Betor, most damper rods are identical in their operation and working parts.

The first, and largest part, is the damper rod itself. Most damper rods are about a foot in length, even in the stock machines. In the rod you'll find a variety of holes and openings, put there for a specific purpose.

Starting at the bottom, you'll find that the damper rod itself is hollow, and has a threaded section, that allows it to be connected firmly to the lower leg of your forks. About three inches up you'll find some slightly larger holes. Most bikes have two holes in the bottom, 180 degrees from each other. These holes are called the *compression holes.* Some machines, like the new RM Suzukis, have four holes in the bottom.

Moving further up on the damper rod, you'll find some other, smaller holes. The number of holes is decided upon by the factory. We've seen as few as three and as many as fifteen in various motorcycle forks.

These smaller holes, usually located on just one side of the damper rod, are the *rebound holes.* They're large enough to slip a pin through, and are usually evenly spaced in a stock front damper rod.

Back down on the bottom of the damper rod, you'll find what is called the *bottoming cup.* This cup is part of the suspension unit, and should never be left out of your motorcycle. The bottoming cup is generally about two inches in length, and sits between the inside of the lower fork leg and the damper rod. Most bottoming cups are tapered at the top, a very important aspect of good suspension. At the bottom you'll usually find what appears to be a large washer, that is actually part of the bottoming cup. This section is merely there to center that bottoming cup while the bike is being assembled and ridden.

That's about all you'll see if you were to remove the screw from the fork that allows the lower leg to come loose from the bike. You'll note that the damper rod goes up into the upper chrome slider, and usually is held in place with a snap ring.

If you were to pop that snap ring loose, you would find quite a few more pieces and parts, all designed to work together. The first component to fall out would be the *orifice cylinder.* This is a large, two-inch (approximately) high cylinder that is very similar in looks to the bottoming cup.

Inside the orifice cylinder will be a small spacer type of unit. These vary in design and style. Some look like small preload spacers. Others are bridged and cut out, looking like small cylindrical castles. This component is called the *orifice.*

Above the orifice you'll find a topping out or *rebound spring.* This spring butts up against the top of the damper rod, where the metal is larger in diameter. The top section is called the *damper stop.* In the middle of the stop you'll find a cork or rubber O-ring, that is designed to insure a good fit between the damper rod and the upper fork tube. When assembled, your spring sits right on top of the damper stop section.

Now that you've got all the parts, you can understand how everything works. First let's take a compression stroke, the action that the forks take when you hit a bump and they attempt to soak up the shock.

Inside your forks you've got fork oil, which is slightly above the level of the damper rod stop. The oil is inside the hollow section of the rod, outside the rod, and between the damper rod and the lower leg. You've got a damper rod

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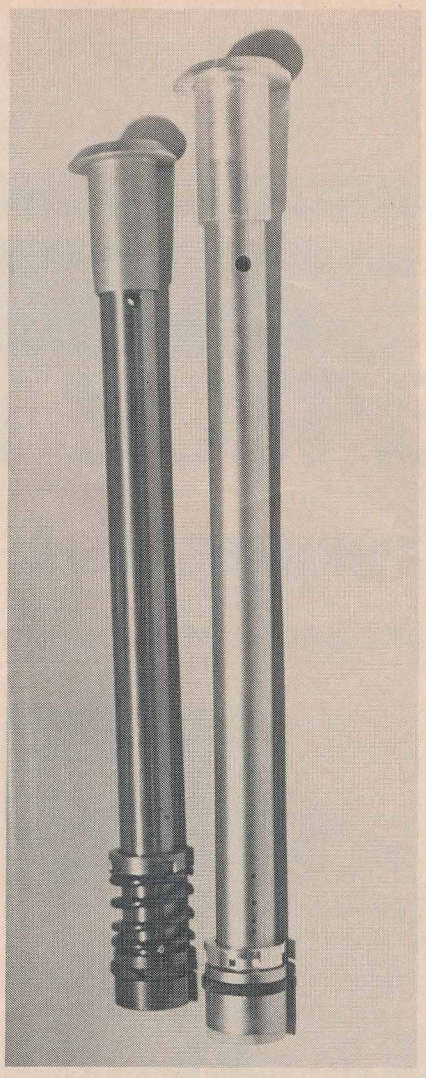

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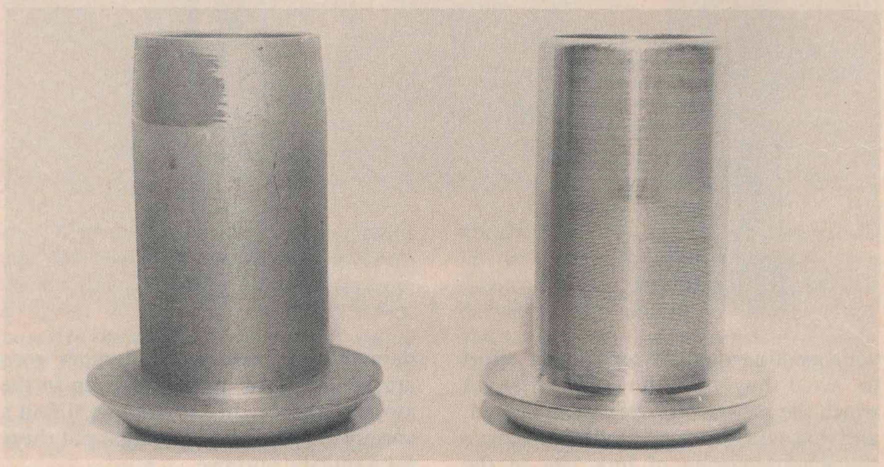


that is completely surrounded with oil.

On a compression stroke, the first thing that happens is the lower leg moving upward, compressing the spring, and raising the pressure inside the damper rod area, putting more of a psi (pounds per square inch of oil) demand on the fork oil.

First the damper rod is moved up into the chrome slider because it is attached to the lower leg by way of a screw in the bottom. The orifice, inside its collar, is stationary, but for all intents and purposes, it is going down the damper rod. Some of the oil below the orifice and cylinder is forced in-between the clearance between the two. For instance, some of the oil slips between the orifice, its cylinder, and the damper rod.

But the majority of the oil is being compressed, and fed out of the area around the damper rod by the compression holes at the bottom. Once the oil gets compressed, it goes through the compression hole, to the inside of the damper rod, and up to the top of the damper rod, above the orifice and orifice cylinder.

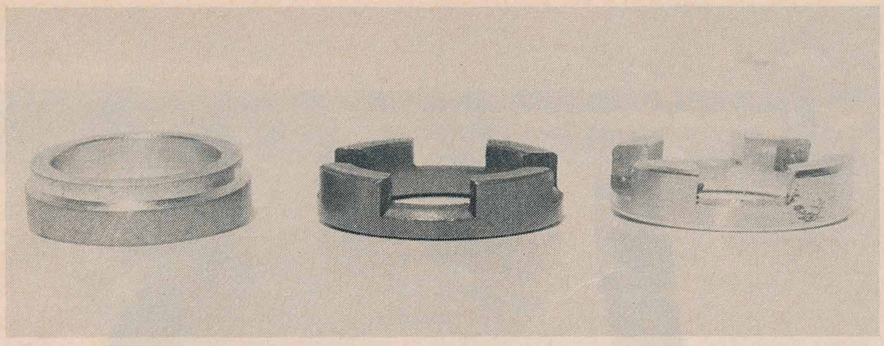
When you almost reach the bottoming point, the orifice cylinder will slide over the bottoming cup, and because of the taper and the remaining oil, it will start to hydraulic lock.

Depending on the quality of the fork internals, you will or won't feel a harsh jolt. Chances are, with a Japanese unit, you'll feel the jolt. This harsh shock is caused by the orifice cylinder slamming down on the bottom lip of the bottoming cup, because the compression holes let the oil escape too easily, not creating a cushion of hydraulic lock. Your suspension is compressed all the way.

Now the forks begin to rebound. With the orifice all the way at the bottom, over 90% of the fork oil is now on top of the orifice and orifice cylinder. It got there by being compressed by the orifice, and having nowhere else to go, it filtered through the compression holes, back up through the rod, and then back down on top of the orifice cylinder.

So the orifice is now at the bottom, trying to get back up towards the top in its normal location. The fork springs are trying to push the legs apart, forcing that orifice back up where it belongs by pushing down on the damper rod (connected to the lower leg).

The fork oil is again compressed, by the action of the orifice coming back upward on the damper rod. This is where the rebound holes come in.



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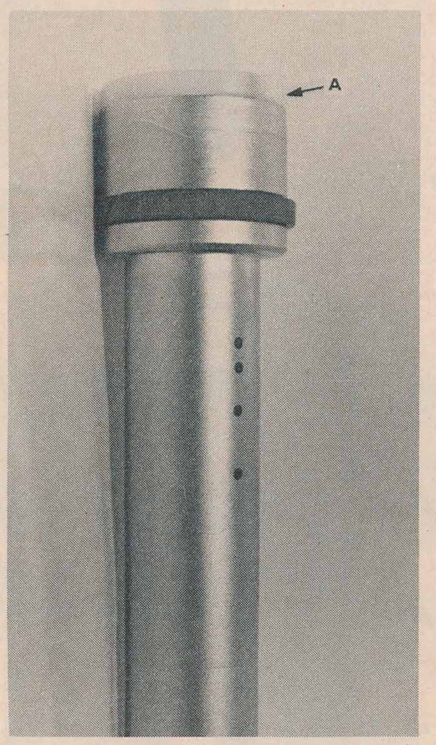
Let's assume that you've got six rebound holes. As the orifice is working its way back up, some of the oil that is now on top of it is seeping back through the orifice, the damper rod and the orifice cylinder.

The majority of it is once again being put under pressure, and having nowhere else to go, it is metered back inside the hollow section of the damper rod by the rebound holes. As the orifice comes back up the damper rod, it passes over these holes.

Assuming that you've got six holes, the rebound of the forks is going to be quick for the first half of the orifice's return trip. But once it gets to the rebound holes, it is going to cut down the available passages that the oil can go through. It passes the bottom of the six holes, leaving the oil only five holes to meter through. Then it passes the next, and so forth, gradually cutting down the possible escape routes of the oil. It is here that the forks begin to reduce their rebound speed. With less holes, the oil is being put under a greater pressure, thus in turn, it's slowing down the speed of fork travel.

As the orifice continually eliminates more rebound holes by traveling upward, it will eventually get to the rebound spring. This spring is put in many units to keep the orifice from traveling to the damper stop, and breaking it off with forward force.

So the spring is incorporated to slow down the orifice and its retaining cylinder. When the forks are almost topped out, the spring is encountered, the orifice pushes on it, and in the

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process of compressing that spring, the orifice, and subsequential fork speed travel, is slowed down.

While the oil was being metered through the rebound holes, it was going back into the hollow section of the damper rod, and was being fed back to the outside of the rod, between the rod and the inner wall of the fork leg, by the compression holes at the bottom. So during one continuous up and down stroke, you've got fork oil moving upward and downward, keeping the orifice and cylinder surrounded.

That's what happens when you hit a big, bottoming out type of obstacle. In the smaller ripply sections, the orifice will move only slightly. It will move up and down only about an inch while the forks are just barely hitting the normal small obstacles.

In instances like this, the rebound holes aren't really effective. There is enough clearance between the orifice, the damper rod, and the orifice cylinder to allow enough metering oil to seep through. The majority of the rebound holes aren't put into play until larger bumps are experienced.

Now we'll show you the common drawbacks of the stock damper units. The rebound holes are spaced evenly up one side of the damper rod. If you were to take the orifice and rebound spring, and put them at the top of the damper rod, you'll notice that the rebound holes don't continue up past the bottom of the orifice—the manufacturer stops drilling holes below the point where the orifice and the rebound spring meet.

This is where much of the topping out problems come from in the common damper rod. The holes are no longer metering the flow of oil. Instead a mechanical device, the spring, is used to slow down the speed and travel of the orifice and cylinder. But what usually happens is that the orifice will bottom out the spring, between itself and the damper stop on top, and for all practical purposes, creates coil bind.

Even when the orifice compresses the rebound spring completely, it usually is still trying to travel upward due to its momentum and the demands of the motorcycle. So there is a shock wave sent up when the force is transmitted from the orifice, through the rebound spring, and into the entire fork assembly. That's the terrible knocking feeling you get when the forks are topped out. That's what makes your wrists hurt. The spring is too short, not strong enough, and isn't consistent.

In a stock damper rod, the sizes of the rebound holes, and their respective spacing, is usually way off. The compression holes can be either too large or too small. So you know that if the forks are topping out, sending a "klunking" up to the handlebars when you're riding, then the rebound spring is being bottomed out.

You also might find that the forks are compressing too quickly. That's usually the fault of the compression holes. They're too large, allowing the oil to be filtered through them too quickly. Your front end easily bottoms out, and you usually compensate by a heavier spring rate, while in reality, you need smaller compression holes.

If the opposite occurs, the situation where the forks don't go down quickly enough, then the compression holes are

5. Looking at the two damper rods up close, you can see that the spring is taking up about three-quarters of an inch. S&W, with the elimination of the spring and some additional length in the damper rod, has given you more travel in a safe manner.

6. A close-up of the bottoming cups. On the left is the stock Honda unit, which has too much of a drastic taper, allowing the forks to bottom easily. The S&W unit on the right has a better taper, and aids in a hydraulic lock to slow the travel down drastically, reducing bottoming out and saving your arms, forks and wheels.

7. There is a variety of different orifices on the market. Starting from the left, you've got the Suzuki RM unit made of aluminum, the Honda unit made of cast iron (very destructive inside forks) and the S&W unit, made of aluminum.

8. The rebound holes in the S&W unit number only four. Notice the different spacing. Behind these holes, the plastic insert (A) feeds small reeds from the inside of the damper rod, cutting off the available oil flow through the rebound holes until it's really needed.

probably too small. The oil cannot escape through the compression holes quickly enough, thus it backs up, creates a hydraulic lock between the bottom of the damper rod and the orifice, and stops the downward motion of the forks.

Many people compensate for this problem by going to a lighter spring rate. Again, it can work in some instances, but that's not really the problem here. It's the compression holes.

In between these two positions, you'll find many times that the forks are either too mushy or too soft. If they're too mushy, the rebound holes are too large, allowing an abnormally high amount of oil to escape through them, not giving you good fork action. If they're too stiff, then the rebound holes, and the small space between the orifice, damper rod and orifice cylinder, are too small, not letting the oil get out, causing great pressure, and quite often, hydraulic lock.

The orifice, damper rod, and orifice cylinder also help to determine whether the forks are going to bottom or top out. Both the bottoming cup and topping out spring are used as last resorts by your suspension, because the rebound holes, and the clearances between the orifice, damper rod and orifice cylinder, are supposed to perform the majority of the work.

Now you should know how the stock units work, why they work that way, and what's wrong. You can usually tell, by concentrating very hard on what's going on up there, what function and component of the damper rod assembly isn't right.

To see how the damper rods are supposed to work properly, let's dissect a damper rod kit. The unit we're going to work with is the S&W unit.

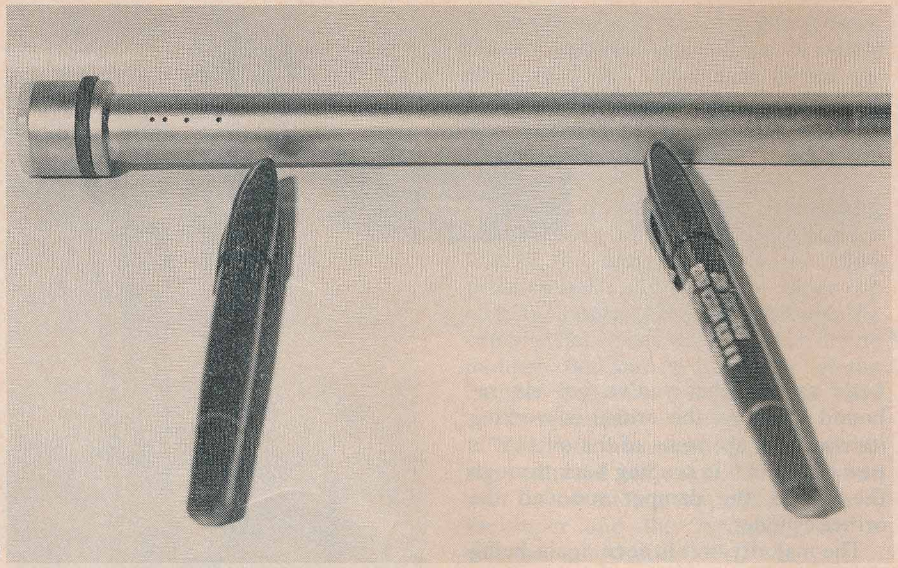
The stock damper rod photos are of a stock Honda damper unit, and the modified unit is for the same machine, manufactured by S&W. You'll notice first off that the S&W kit doesn't use the rebound spring at the top. The orifice is also designed differently, and seems to slide up and down the new damper rod a little easier.

In the bottom of the rod, you'll see that although the compression holes are almost identical, the S&W holes are slightly larger. Obviously, they found the Honda wasn't metering the oil out through the compression holes quickly enough, thus the need for larger holes, placed in a slightly higher location.

Up at the top, inside the damper rod, you'll see that there is a little plastic piece that sits above the damper stop, and goes into the inside of the damper rod. Incorporated into this plastic piece are tiny little reeds, that back up to the rebound holes. The rebound holes themselves are smaller in number. The stock Honda unit has 11 rebound holes, evenly spaced down the damper rod. The S&W rod has only four holes, two of them being very close together.

The S&W bottoming cup is also different. It isn't as tapered as the stock Honda unit, being thicker in outer diameter. It's the same height though, and still retains the bottom flat section.

In overall length, the S&W unit is less than half an inch taller than the stock Honda unit. But, with the elimination of that rebound spring, you've gained almost three quarters of an inch, thus you've got an additional inch of safe travel. We'll get back to "safe travel" later.



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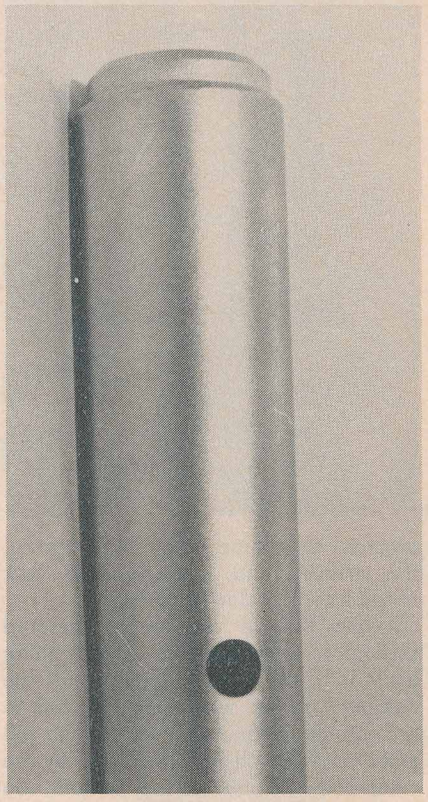

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To the naked eye, the diameters of the damper rods appear to be the same. If you were to measure the outer thickness of the S&W rod with Vernier calipers or a micrometer, you'd find that there is a *ground taper* in the rod.

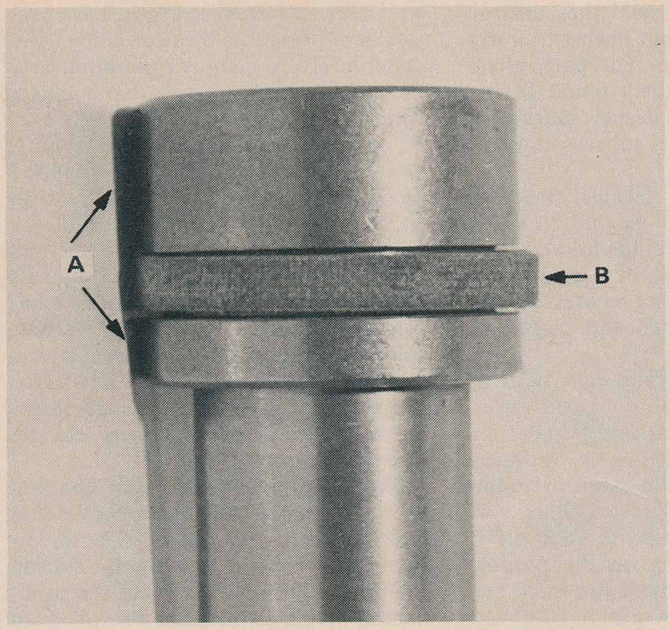
The ground taper starts about an inch and a half below the bottom rebound hole. From there the rod itself is turned down, giving you a taper somewhere in the neighborhood of 10 thousandths. Once the taper reaches its limit of ten thousandths, it gradually slopes back upward to the stock diameter. You've got a concave section in the middle of the damper rod, while at both the top and bottom, the stock outer diameter thickness remains the same.

All these little changes add up to an entirely different damper rod assembly. First let's take the absence of the rebound spring. It would seem that the orifice and cylinder would easily top out the front works without the aid (although there is minimal aid, it does make a difference) of the rebound spring.

The rod taper and the different rebound holes compensate for the lack of a rebound spring. The return action of the orifice is slowed down by the rebound holes, due to the fact that they are the right size, and in the proper positions. Also, a little hydraulic lock, experienced when the orifice is within half an inch of the damper stop, aids in eliminating the topping out problem.

Going to the other extreme, you also have the additional help of hydraulic lock, due to the different taper in the bottoming cup. You'll remember that on the stock unit, the taper was very visible, and allowed the orifice cylinder to clonk down the first half inch of the bottoming cup before the taper disappeared.

On the S&W unit, the taper on the rod is still there. It's longer by about three-quarters of an inch, but the taper



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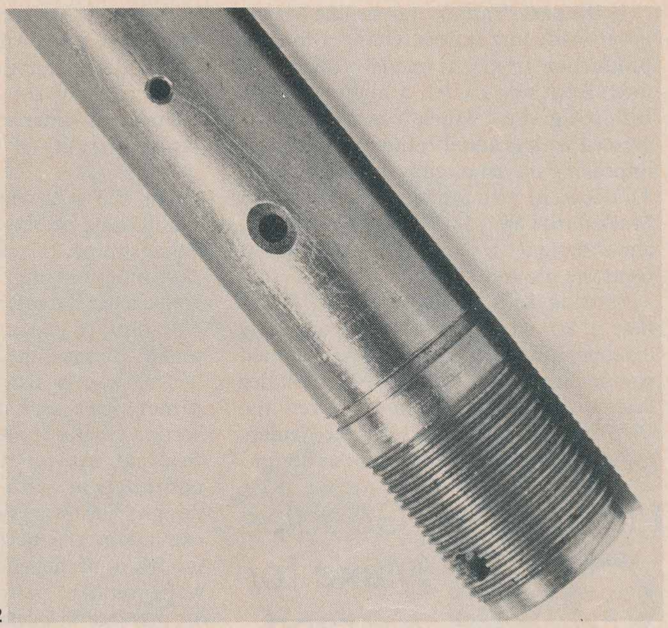
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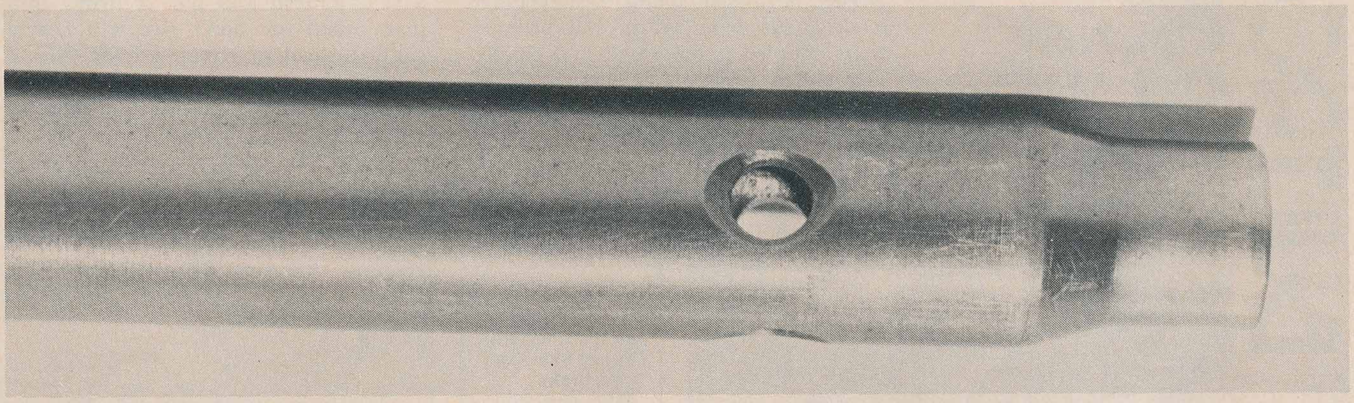
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isn't as distinct, and not as drastic as stock. Less oil can go between the bottoming cup and the orifice cylinder when the bottom point is near. Thus the bottoming out problem is softened by hydraulic lock, supplied by the different taper design.

Getting back to the damper rod itself, we'll explain the taper in the middle of the rod. You'll recall that a lot of oil passes between the orifice, damper rod, and the orifice cylinder. With the taper in the rod, there is a larger opening between these three components, thus more oil can get through this area, increasing the dampening qualities.

The reeds in the rear of the damper rod, that meter the amount of work the rebound holes perform, don't come into play unless radical demands are made by the bike for suspension. On regular bumps, the taper on the damper rod, and the clearance between the three components (rod, orifice and cylinder) is sufficient in supplying enough rebound and compression dampening for normal riding. It isn't until the suspension is taxed, the orifice is working, and the psi rating of the oil is raised drastically, that the reeds behind the rebound holes open up and function.

If we haven't already lost you in a confusing swarm of technical information, and you understand the functions and the differences up to this point, you've got a pretty good grasp of fork kits and suspension differences that damper rods make. Once you know what each part does, you can carefully shop for a good fork kit, knowing what you want.

But this isn't the end. There are a few more things that you should check out on a fork kit before buying. This is one problem that many consumers have. They figure that ten or fifteen bucks isn't too much to spend on a fork kit, even if it doesn't work out. Unfortunately, they don't realize that they're putting their life on the line, relying on someone else's know-how to keep their bike running. As far as we're concerned, we'd rather check out a fork kit thoroughly before we put it in any bike *we* ride!

The first thing to find out is the

**Continued on page 70**

9. The ground taper in the S&W unit is between the two pens stolen from a motel. The taper is slight, but makes for a big improvement in suspension qualities.

10. The compression holes in the S&W unit (there is one more on the other side of the rod) are just slightly larger than those found in the stock Honda rods.

11. The O-ring (B) is situated in the damper stop (A) and is designed to cut down on oil seepage. When inspecting your forks, make sure that the O-ring hasn't deteriorated or ripped. Replace if necessary.

12. In the Suzuki RM damper rod (which is in drastic need of help) there are two rebound holes. The total volume of these two different size holes is more than that of the regular four holes on the S&W. It looks trick, but doesn't do much.

13. Another mystical design on the RM damper rods. It has four compression holes instead of the usual two. It's a nice idea, but it doesn't work, and forces the fork spring to do all of the work in the compression department, instead of helping along by metering the oil flow through the bottom of the damper rod.

## DAMPER RODS

recommended oil weights that the fork kit will work in harmony with. Since you realize the importance of the compression and rebound holes, you can easily see that a heavy fork oil will tend to aerate while passing through these holes.

Also the fact that the heavier oil is going to go through the holes slower will tell you that your forks are not going to travel as quickly. Some fork kits have larger holes drilled in the damper rod, and larger tolerances between the orifice, cylinder and damper rod, to use the heavier oils. But if you read the first part of the *suspension* series, you'll know that heavier oils are more susceptible to aeration (which is foaming and pumping up), and temperature changes. It's very possible that if you started out riding with a 30 weight oil in the morning it would be stiff. By the end of the day the oil would have thinned out due to the change in temperature. You could start the day with stiff forks, and end up riding a bike that now tops out and bottoms out, has pumped up a few times, doesn't work properly, and generally beats you to death.

A proper fork kit should work with an oil no heavier than 15 weight. If the manufacturer says that the kit will work just fine with a 20 or 30 weight oil only, we suggest that you go to another kit that is set up to run the lighter oils.

The ideal kit would be one that is designed to run with a three or five weight oil (three weight is extremely hard to find). An acceptable kit should be able to run with a 10 weight oil, and not much higher.

Another difference to keep your eye out for is the problem of extremely long damper rods. Some fork kit manufacturers will simply lengthen the damper rod, giving you your two or two-and-a-half inches of additional travel. If you'll remember, the S&W kit was only slightly longer than stock. The majority of the additional travel was in the design of the damper rod, which allowed the elimination of the rebound spring. With the spring out, they could put the rebound holes higher up on the rod, adding to the travel.

But many manufacturers of fork kits don't do that. Instead they lengthen the damper rod. Here's where the problems start. First of all, your fork overlap, the amount of depth that the slider goes into the lower leg, is reduced by the added length of the damper rod.

The rod is what basically holds the two halves of your forks together. The rod is secured to the lower leg by way of a bolt, and connects to the upper slider by a circlip that holds the orifice cylinder in place.

With a longer damper rod, you are actually pulling the two halves farther apart, so where you might have normally had the slider going four inches into the lower leg when the bike was stationary, you now have it overlapping a mere inch and a half. Three and a half inches should be the minimum overlap.

With such a small amount of overlap, you are running the risk of not only destroying your suspension, but also your body. The lack of proper overlap between the two components will allow the chrome slider to bend right below where it's attached to the triple clamps. Even worse, you are running the chances of breaking the forks in half, right where the slider and lower leg come together, because the overlap wasn't there and the two parted company, due to flex and back and forth stress.

The final problem of radically extended damper rods is the springs inside the bike. Even with the S&W kit, which has just a small and safe extension, you should run longer springs. With many kits that are an inch and a half or two inches longer, you're going to run into problems if you use the stock springs.

Let's say that you bottom out the suspension with your two-inch extended damper rods and your stock springs. The springs are going to coil-bind before the damper rod bottoms out. That damper rod can bend, or break, or stop functioning altogether. All of the stress is put on the damper rod by the spring in a coil-bind situation, instead of being transmitted to the lower leg like it normally is.

By now you should understand all the problems and solution to damper rods. They're complex little devils, and will fool you with their simple looks. It's now a matter of riding your bike, determining what is wrong, if anything, and looking around for the proper kit.

If you do have any problems, drop us a line care of the magazine, with the word "Suspension" put on the front. We'll do our best to help you out. If it pertains in particular to Hondas and Suzukis, Al Baker Racing and Development, 15174 Raymer St., Van Nuys, CA 91405 can help you out with an S&W kit, the proper springs, and technical information you need.

Picking the proper fork kit, or deciding that you don't need one, should be in your grasp now. We hope that you take into consideration the theories and functional operations that we've shown you here and make a wise choice.

In the next installment we're going to go onto the rear end of the motorcycle, showing you how the shocks and springs work. We'll even show you how to match up that rear suspension to your, by now, plush front end.