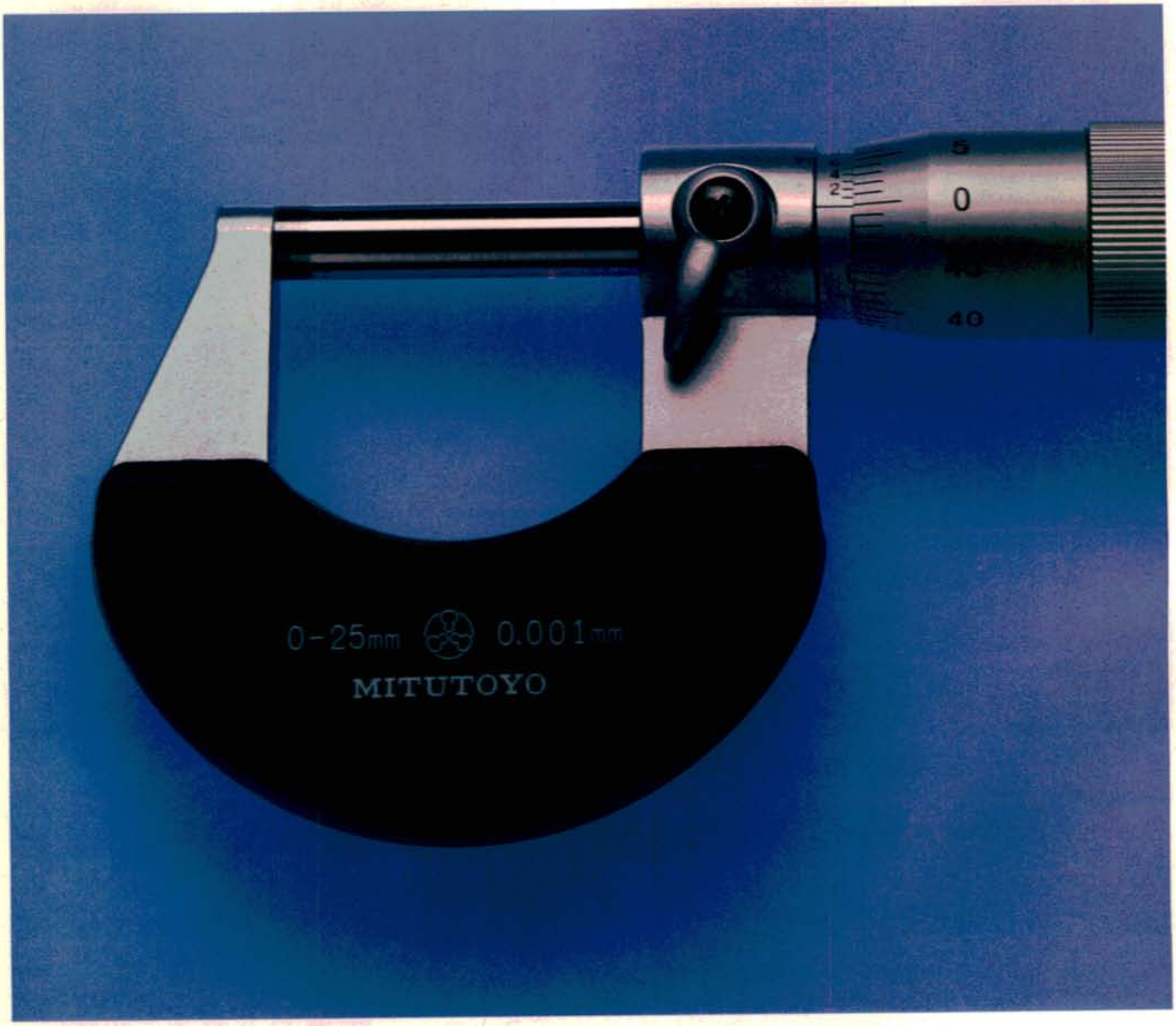
Metrics, Mechani



If you were born and raised in this good old U.S. of A., the metric system can seem strange and foreign. Those of us raised using the North American system of weights and measures quite naturally think in terms of buying gallons of gasoline, not liters. We travel at speeds measured in miles-per-hour, not kilometers-per-hour. And perhaps most importantly, play football on a field 100 yards long. We're not quite ready for a first down and 9.14 meters to go.

Since we're accustomed to using it in our everyday lives, we generally find the North American system to be easier and simpler. The truth is, it's actually a lot more complicated than the metric system, with its confusing array of unit measurements, and its unit conversion complexities.

For the sake of argument, let's assume that someone came to you with a new system of weights and measures. Using length measurement as an example, he begins building a thing called an *inch* out of smaller divisions he calls halves, quarters, eighths, six-

cs & Micrometers

teenths, thirty-seconds, and so on. He uses 12 of these inches to make a foot, 36 to make a yard. Five and one half yards make a rod; 40 rods make a furlong; and eight furlongs make a mile. We can also travel that mile by going 5280 feet. I don't know about you, but I'd have the guy thrown out.

The next guy shows up and starts his presentation with a base unit of length measurement called a *meter*. It's about as long as the first guy's yard (39.37 inches to be exact). If we want to measure something a lot longer or shorter than a meter, we simply multiply or divide that meter by a factor of 10 and add a short prefix to indicate what we've done.

The following chart gives the most common prefixes and their multiples:

Kilo	× 1000
Hecto	× 100
Deka	× 10
Base unit meters, liters, grams etc.	
Deci	× 0.1
Centi	× 0.01
Milli	× 0.001

Let's take a real example. Since an inch is 2.54 centimers long, it will also be 25.4 millimeters long. Another way to think of it is that 2.54 hundredths of a meter would be equal to 25.4 thousandths of a meter.

If we go from a larger metric base unit to a smaller metric base unit we move the decimal point one space to the right for each consecutive unit change.

If we go from a smaller metric base unit to a larger metric base unit we move the decimal point one space to the left for each subdivision change.

Conversions between base units become a matter of sliding the decimal point back and forth. Here's another quick chart:

.000254 Kilometers	=	1 inch
.00254 Hectometers	=	1 inch
.0254 Dekameters	=	1 inch
.254 Decimeters	=	1 inch
2.54 Centimeters	=	1 inch
25.4 Millimeters	=	1 inch

There are other prefixes and their corresponding multiples available, but they're used more often by the boys at NASA to measure the distance between stars. For our purposes in the shop, the chart above should suffice.

Inch Sizes and Metric Sizes

Since we can't possibly cover every aspect of the metric system in one article, we've chosen to concentrate on length measurement and the proper use of tools needed to make precision measurements. Length was a logical place to start since you'll begin using it the next time you reach for a wrench or socket.

Those of you who have both inch and metric sized wrenches have realized that some of the wrenches of each type are very close to being the same. Some sockets are actually marked as both 3/4 and 19 mm. Here's another small chart to show you the metric dimensions of common inch sized wrenches as a reference.

Inch Size	Metric Dimension
5/16	7.9 mm
3/8	9.5 mm
7/16	11.1 mm
1/2	12.7 mm
9/16	14.2 mm
5/8	15.8 mm
11/16	17.4 mm
3/4	19.0 mm
13/16	20.6 mm
7/8	22.2 mm

You'll note that the cross-overs aren't always exact. It will give you some reference point for comparison, however.

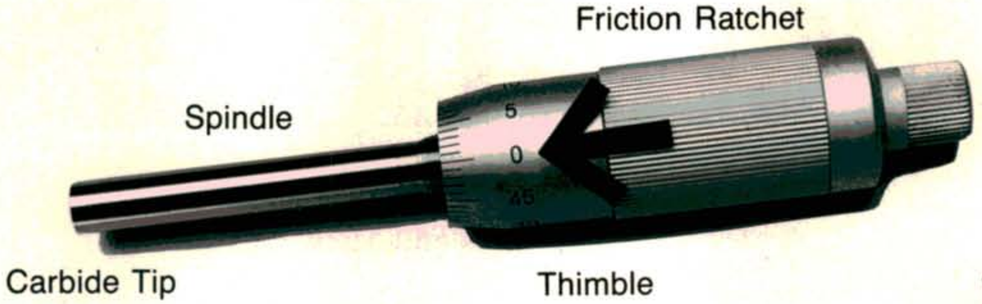
Precision Measurement

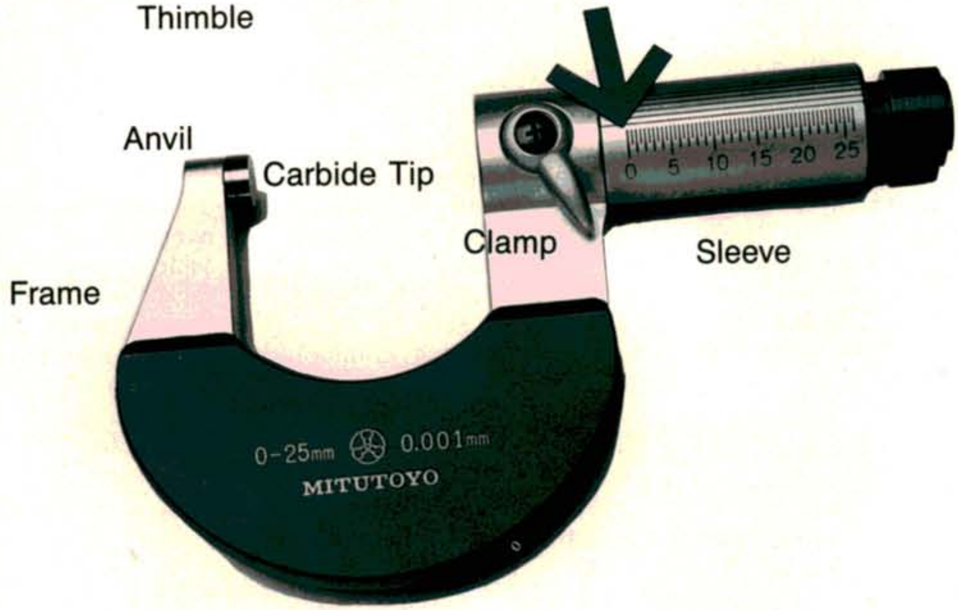
Your use of precision measuring equipment will depend on the type of repair you normally do. If you do a lot of engine repair, you'll live with a micrometer, vernier, or other precision measuring tool in your hands. And even if you do general repairs, you'll still want to mic those brake rotors before and after you machine them.

A good quality micrometer doesn't cost a fortune. The traditional vernier style micrometer is the least expensive, although digital mics are available. They are more expensive, however, than the old style without being any more accurate.

Being the cheapskates that we are, we chose the base model micrometer, the one that makes you squint a bit and scratch your head. No ups, add ons or extras.

Our first two photos show the mic disassembled so we could label the major components.

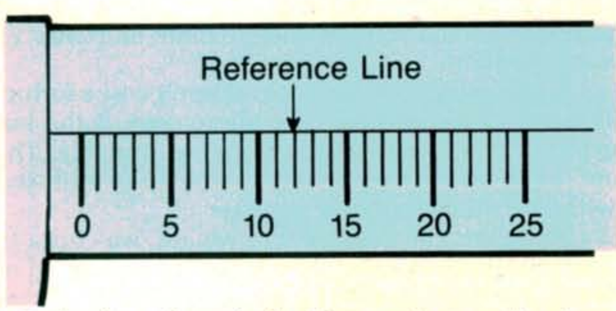




In our first photo, you'll note the calibrations around the thimble of the mic. They are numbered from zero to 50, with each division representing one one-hundredth of a millimeter. One complete turn of the thimble changes the opening of the mic fifty one-hundredths or one half of a millimeter. Two full turns changes the opening one full millimeter.

Our second photo shows the frame of the mic with its calibrated sleeve. This particular mic has a measurement range from zero to 25 mm (which roughly corresponds to the range of a zero to one inch mic).

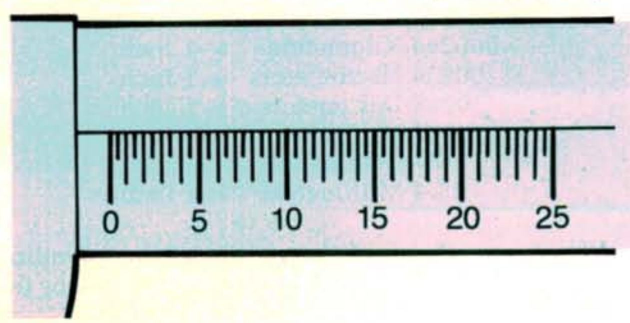
This mic is calibrated only for whole millimeters.



Let's take a closer look at the numbers on the sleeve of the micrometer. This simplified illustration shows the calibrations in whole millimeters, with each fifth increment emphasized. (Zero, 5 mm, 10 mm, 15 mm, 20 mm, and 25 mm.)

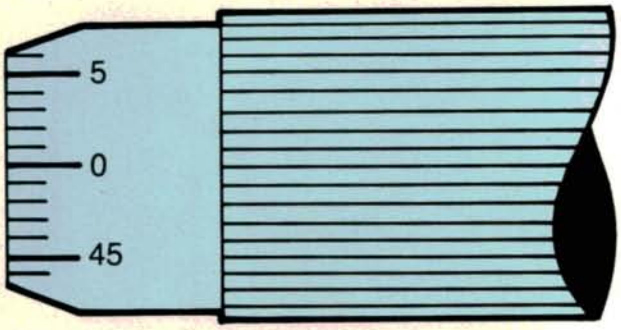
Unfortunately, this particular micrometer would be of little use to us unless we were always measuring things that came out in whole millimeter sizes. Since we need two complete turns of the thimble to open or close the mic one full millimeter, we ought to add more lines to our calibrated scale for half millimeter sizes.

Half millimeter lines added. (Short lines)



This illustration shows half millimeter lines added to the scale. Things are a bit more crowded now. It doesn't have to be confusing, however, if we remember that we have a 25 mm micrometer. We have 25 bigger lines representing whole millimeters. The remaining, or short lines, are half millimeters.

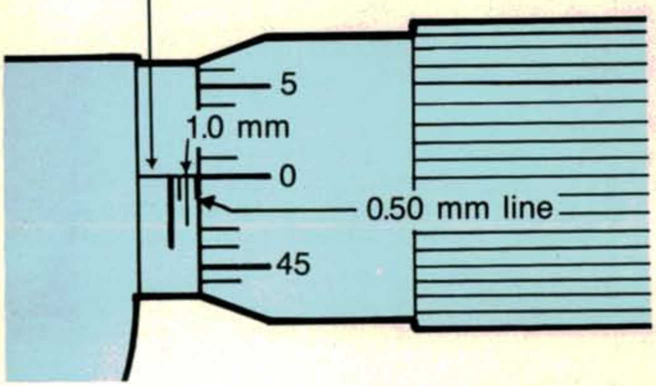
One complete turn of thimble equals $^{50}/_{100}$ths mm.



Here's our thimble again. Remember that there are a total of 50 calibrations around the thimble. As a result, any time the zero on the thimble lines up with the reference line on the sleeve, the reading will end in an even millimeter or $^{50}/_{100}$ths (exactly one half of a millimeter).

If you have a metric micrometer of your own, why not get it out. Turn the mic until it just closes. Unless one of your helpers has used it as a c-clamp, the zero line on the thimble should line up with the reference line on the sleeve.

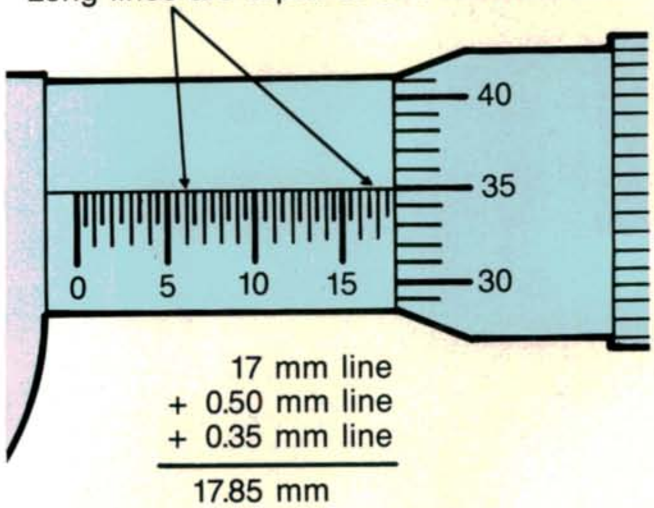
Reading is taken at reference line.



Turn the thimble counter-clockwise to open the micrometer. When the zero on the thimble comes around for the second time, the micrometer will be open one full millimeter. Now turn the thimble one more complete turn, another $^{50}/_{100}$ths, until the mic looks like our illustration.

Our micrometer is now open 1.5 mm. Pretty easy, huh?

Long lines are equal to one full millimeter.



Okay, before anyone gets swell-headed, let's do something a little tougher. Let's take a dime and measure it. Whenever measuring something round like this, be careful to measure at the widest point to get an accurate reading. Also, never overtighten the mic on the piece or you may damage the delicate calibrations of the micrometer, making this and all future readings false. Good mics will have a friction collar on the thimble that slips if you turn the mic too tight. This prevents damaging the mic by overtightening.

Let's start measuring the dime. If we count the large black lines exposed on the sleeves we see we're somewhere between the 15 and 20 mm lines. We also count two more whole millimeter lines past the 15 mm mark. We have a total of 17 whole millimeters exposed and part of another.

We also have a half millimeter line exposed (the shorter line to the right of the last whole millimeter mark.

So far we have 15 mm + 2 mm + 0.50 mm = 17.50 mm.

We still have some exposed sleeve to the right of the 0.50 mm mark. This space represents a distance, in 100ths of a millimeter between the last half millimeter mark and the next whole millimeter.

If we look at the thimble now, we see the number 35 on the thimble aligned with the reference line on the sleeve. Let's add that to our total so far:

15 mm + 2 mm + 0.50 mm + 0.35 = 17.85 mm

That's it. Our dime is 17.85 mm in diameter. Due to wear and tear, your dime may vary. Some micrometers (this one included) allow you to use an additional vernier scale to read as close as thousandths of a millimeter. For most shop use, however, readings in hundredths of a millimeter will be accurate enough.

Worth the Money

Once you begin using precision measuring equipment, you'll find that it can be a great help in diagnosing the cause of a mechanical problem. It can also help to sell that repair when the customer sees the cause of his problem in black and white.

Finally, it gives you the peace of mind that comes from knowing the job was done right the first time.

We'll continue this article later with a look at vernier calipers and dial indicators; what they'll do for you and how to use them.

—By Ralph Birnbaum