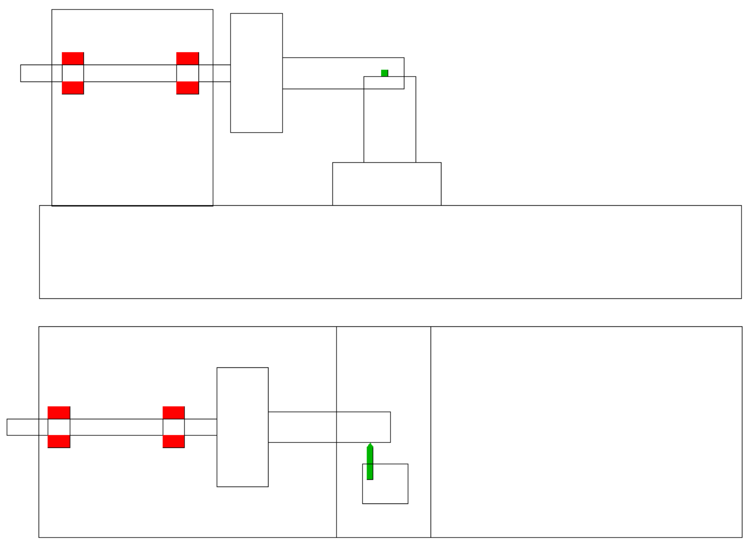
The Problem that is Solved by The Ultra Low Resistance Electronic Edge Finder, version 1

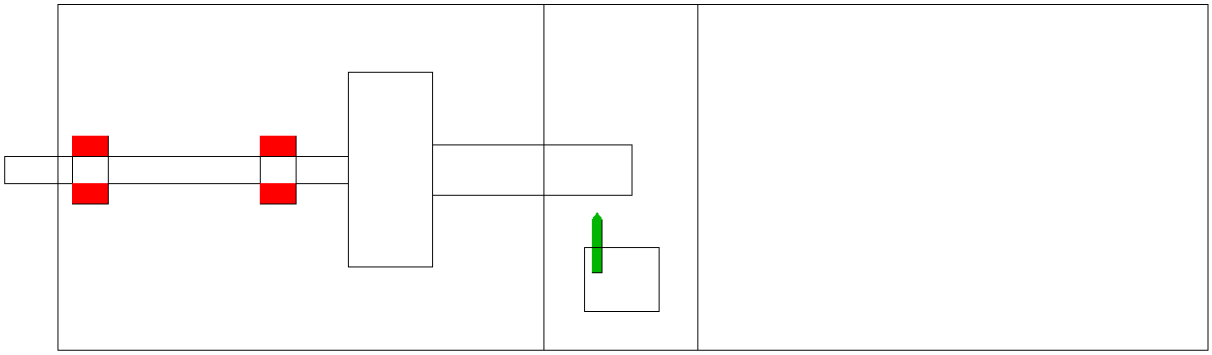
By R. G. Sparber



Here you see a simplified drawing of a lathe. The spindle bearings are in red and the cutter is in green. The bearings are held in the headstock which is firmly attached to the ways. The cutter is firmly attached to the tool post which in turn is firmly attached to the apron.

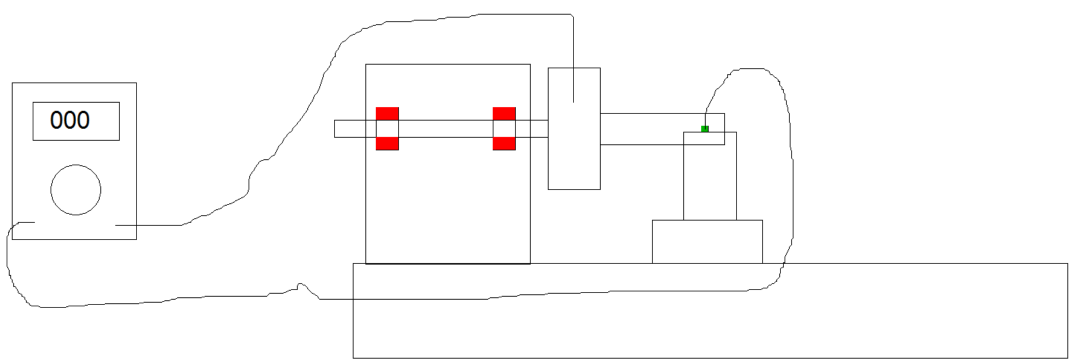
The apron rests on the lathe ways.

The above description is a mechanical description of a lathe. I will now suggest an electrical description.



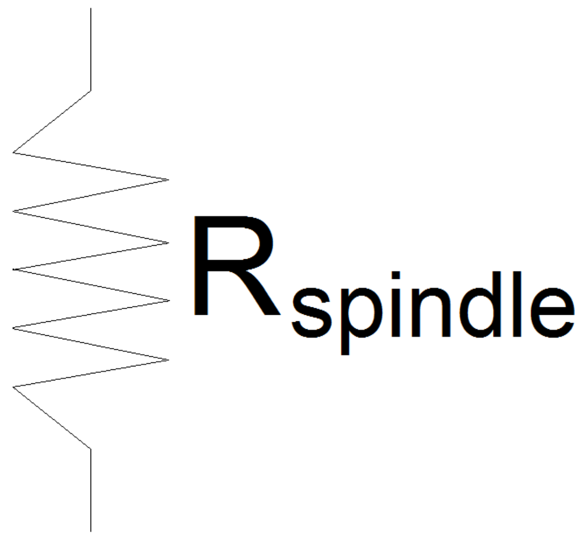
With all of this steel, there is very little electrical resistance between the cutter and the bottom surface of the apron. Even though there is oil on the ways, I have measured very little resistance between apron and ways. There is essentially no resistance from the ways to the headstock. Most of the electrical resistance is within the spindle bearings.

If the lathe is running (without the tool contacting the work piece), this resistance between cutter and spindle can be many thousands of ohms because the spindle is suspended on a thin coating of oil. But when the lathe coasts to a stop, I see the resistance fall dramatically. On my lathe I measure 40 ohms between spindle and cutter. On commercial grade lathes and those with sleeve or babbit bearings, the resistance is more like 0.01 ohms.

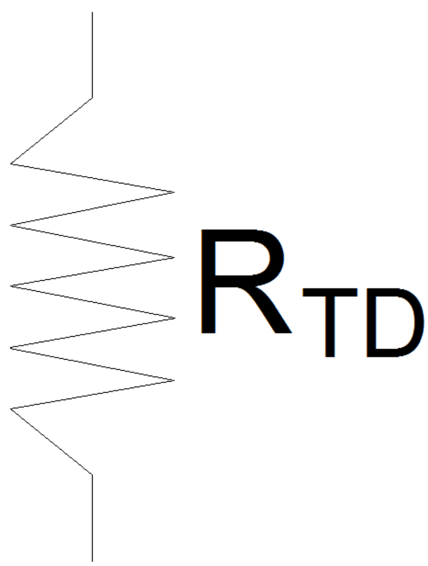


If you connect a common digital ohm meter between the chuck and the cutter, you might read zero ohms. It really isn't zero ohms, just too small for this meter to read. By using a much larger test current and reading the resulting voltage, it is possible to read the tiny resistance.

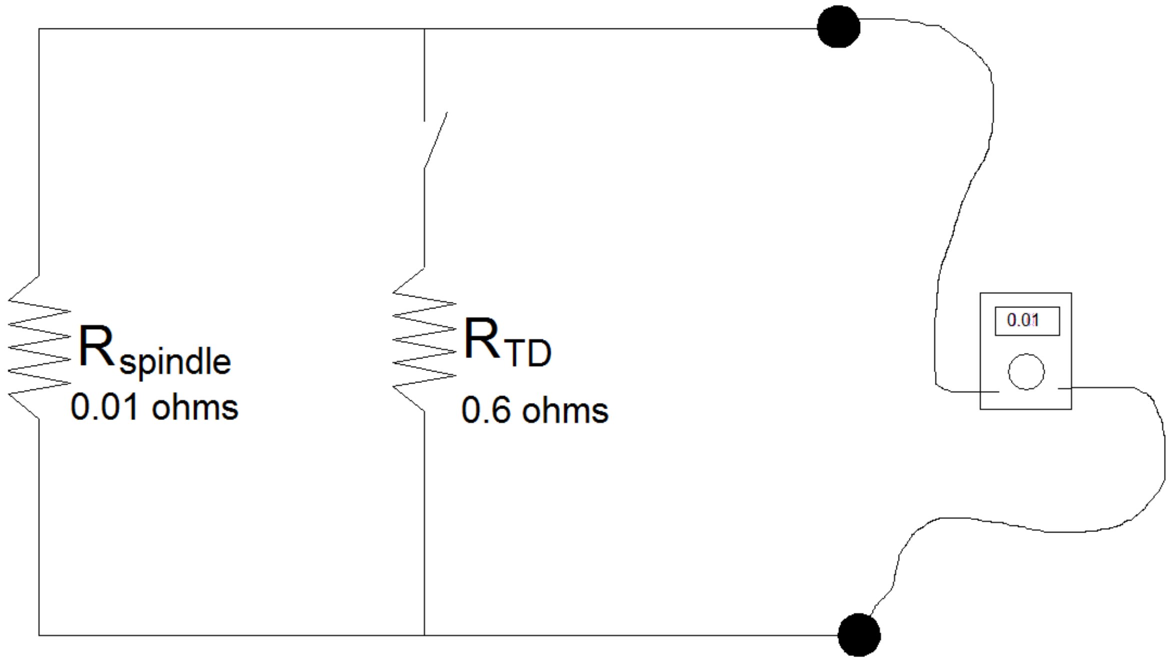
A second reading of interest is the resistance created when the cutter just kisses the work piece. To measure this value, I used a layer of paper around the cutter holder to electrically isolate it from the tool holder. I again used a large test current and determined that this resistance is no larger than 0.6 ohms.



Let me represent the measured electrical resistance between spindle and tool post by this resistor labeled $R_{spindle}$.



I also have the resistance measured between my spindle (or work piece) and the cutter when the cutter has been insulated from the rest of the machine.



This is how the two resistors are arranged to represent the problem. Before touch-down, the resistance measured between cutter and work piece is essentially the spindle resistance of 0.01 ohms. When the cutter touches the work piece, it is the same as closing the switch. The spindle resistance is placed in parallel with the touch-down resistance. The result is that the total measured resistance is reduced by a small amount. An ultra sensitive ohm meter would read 0.0100 ohms before touch-down and 0.00984 ohms after touch-down[2]. This is a change in measured resistance of only 0.00016 ohms or 0.16 milli ohms.

Recall that volts = ohms times current. So if you have a 1 ohm resistor and passed 1 amp through it, you would get 1 volts.

Most ohm meters work by passing a known current through the unknown resister and reading the resulting voltage. So if the meter puts out 0.001 amps and it is measuring a 1,000 ohm resistor, you would get (0.001 amps x 1,000 ohms =) 1 volt. That is easy to measure with a meter. But when you get to resistances around 1 ohm, you are at the limit of what the meter can handle. The resulting voltage would only be (0.001 amps x 1 ohm =) 0.001 volts or 1 milli volt. That is close to the limit for most meters.

[2] To calculate the total resistance of two resistors in parallel, multiply them together and divide by their sum: $\frac{A \times B}{A+B}$

Now, consider the challenge of trying to measure 0.01 ohms with a standard ohm meter. You apply 0.001 amps and the resulting voltage is only 0.00001 volts or 10 micro volts. It doesn't take much electrical noise to exceed this value.

The voltage you get off of a radio antenna is on the order of micro volts. When I tried to amplify my test voltage using a multiplier of about 300,000, I picked up noise that was probably from a local radio transmitter. With more circuitry, I can probably filter out most of this unwanted signal.

A far simpler means of dealing with these tiny resistances is to boost the test current. Commercial milli ohm and micro ohm meters apply up to 10 amps of current.

In my case, I have found that a test current of 1 amp is enough to detect the shift in resistance caused by touch-down. Since I am passing this current through 0.01 ohms, the maximum voltage generated will be (0.01 ohms x 1 amp=) 0.01 volts. By design, my circuit limits the voltage it put across the spindle bearings to 0.01 volts for all resistance values. This takes a bit of fancy electronics but I do have that part working reliably.

Detecting the resistance takes more electronics but I have found that it is not that hard to see this 0.16 milli ohm change caused by touch-down as long as I can apply a large enough test current.

The big show stopper has to do with potential damage to the bearings caused by passing 1 amp through them. Limiting the voltage to 0.01 volts means that the maximum power applied to the spindles is (1 amp x 0.01 volts=) 0.01 watts. That is a far cry from EDM where you might use at least 40 volts at 0.5 amps to apply 20 watts of power to the surface of the work piece. We are talking about a 2000:1 difference here. Yet, the last thing I want to do is offer a device that could damage bearings. So, at the very least, more study is needed and maybe a few tests that can tell me how much current at 0.01 volts is needed to darken the surface of a ball bearing.

As an aside, I would like to address those suggestions about using high frequency test currents. Given that the current is flowing through a massive amount of steel, the inductance of this path is about as close to zero as possible. When the lathe is running, there would be a measurable capacitance across the bearings. But when stopped, this capacitance is replaced by a very low resistance.

Hopefully, version 2 will have some solid answers. I welcome your comments and questions.

Acknowledgements

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