# Smiths Tachometer Calibration and Repair

I got interested in calibrating the Smiths electronic tachometer some time ago when I realized that my tach was completely out of calibration. I used a technique similar to the one described in Tom Ballous 1975 Tech Tip to calibrate my tach at about 1200RPM using my dwell/tach meter. I began to wonder, however, how well calibrated my dwell/tach meter was and how well my Smiths tach was at high RPM. This curiosity led me to analyze how the Smiths tach works and to design a personal computer based tach calibration tool. This paper is intended to explain how the tachometer works, to explain how my tach calibrator works, and to update Tom Ballous Tech Tip with my opinions and advice.

Tachometer background information:

I know of two types of electronic tachometers in cars, inductively coupled and direct coupled.

Direct connect electronic tachs have a direct electrical connection to the ignition circuit. These tachs use voltage signals in the ignition circuit to drive the tach.

The inductively coupled type of tach such as the Smiths electronic tachs of the 1960s uses a one turn loop of the ignition wire as the primary side of a transformer that couples the current pulses caused by the cars ignition circuit into the inside of the tach. The timing of those current pulses are used to drive the tach. These tachometers were used in Sunbeam Tigers and Alpines as well as in Shelby Cobras and other British cars of the period. Since this is the tach Ive had the most experience with, this is the tach I will describe in detail.

The Smiths tach must be disassembled in order to calibrate or repair it. Carefully rotate the chrome bezel until the tabs on the bezel line up with the slots on the case. This can be a very difficult job if the seals have aged badly and stuck. Whatever you do, DON'T pry up the tabs on the bezel or youll ruin it. If you need to, you can CAREFULLY pry a tiny bit around the bezel in an attempt to break it loose. Don't tap the edge as the meter is very fragile.

Once you get the chrome bezel off the tach, the face glass and inside bezel must come out, if they didn't come out with the chrome bezel. Carefully pry the inner bezel from the case. It is not necessary to separate the glass from either bezel if it is stuck to one of them. Be careful prying on anything, especially if the glass is still in place, as it is very easy to damage it or the bezels. I have not been able to locate a source for the seals, so I just try to be very careful, and reuse what I can with whats left of the seals. I always use a lint free cloth and glass cleaner to clean the glass while the tach is apart.

Once the meter face is exposed, be very careful not to mar or get finger prints on the face or break the needle. The next step is to remove the tach innards from the case.

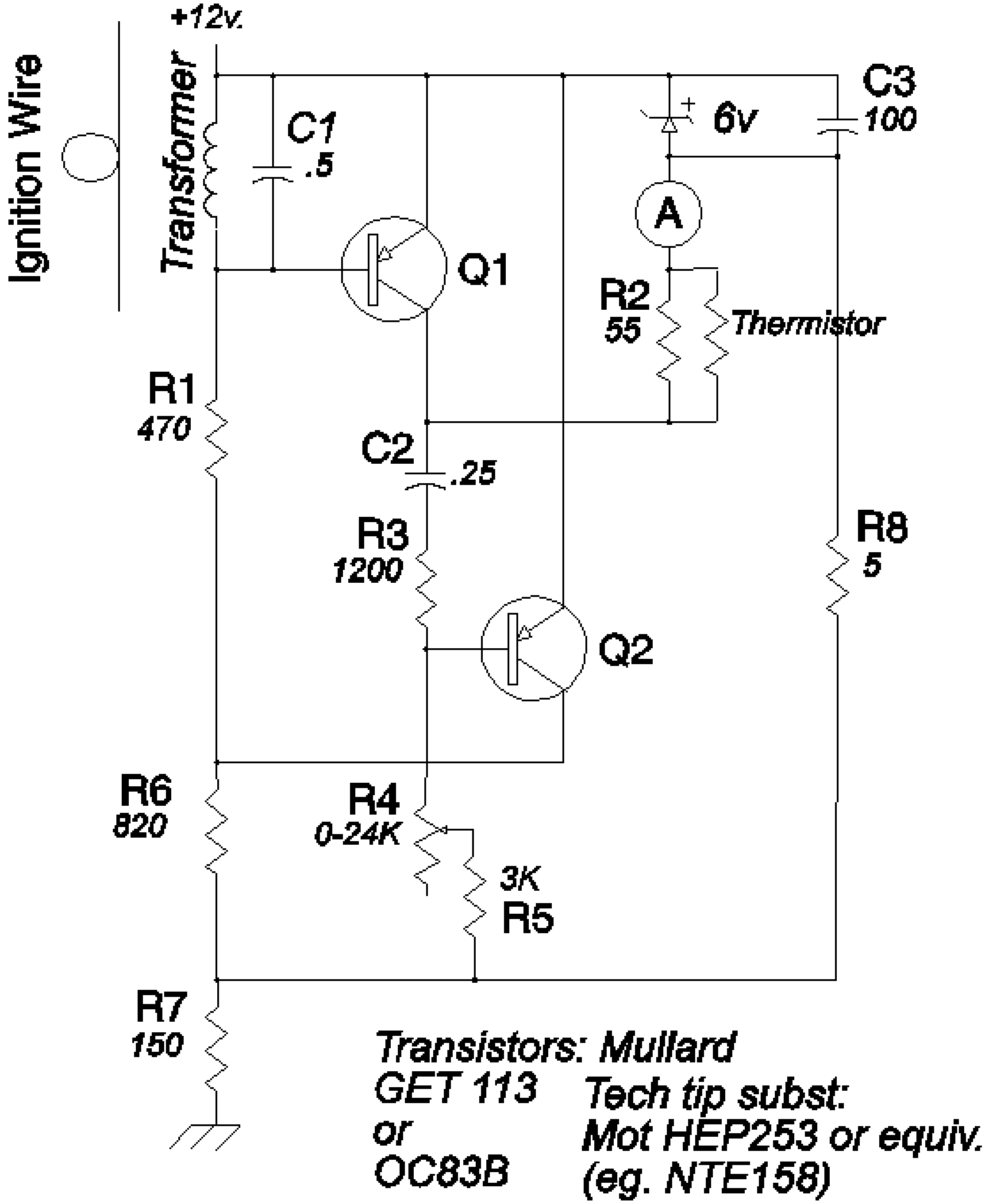
There are four screws on the back of the case, two of which are recessed in holes in the case and two of which are not. The two in the recessed holes hold the innards of the tach together so don't take them out. Put the tach case face down on the bench. While pinching the U bracket stud with one finger and the power spade lug with another to hold up the tach innards, remove both of the non-recessed screws. The tach innards are now being held in the case by your two fingers. Pick up the case and cup your other hand under the face of the case. Carefully let the stud and spade lug slide out of your fingers and catch the face of the tach by the edges in the cup of your hand. You can then pull the case off of the tach innards and turn it over. You are now ready to calibrate or debug the tach.

This is a good time to slide a shield under the needle to shield the face and repaint the needle if you can find appropriate paint. (My artistic talents arent very good, so I never try that step myself.)

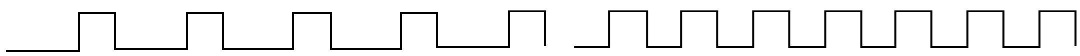
Reassembly is the reverse of this process.

Electronically, the Smiths tach is a relatively simple two Germanium transistor inductively coupled electronic tach. The following diagram shows the schematic of the tach: (I think I may have the Zener symbol upside down, BTW.)

## Smiths Tachometer




The two transistors together form a monostable multivibrator, or one-shot. Normally, the collector of Q1 is at 6V. An ignition pulse couples through the transformer to trigger a one-shot voltage pulse to 12V on the collector of Q1 for a set amount of time. Every time an ignition pulse is detected through the transformer, the collector of Q1 will pulse from 6V to 12V for a fixed amount of time. While the collector of Q1 is at 12V, the top of the meter is held at 6V by the Zener diode, so current will flow through the meter, causing the needle to deflect. The width of the voltage pulse is determined by the combination of the 0.25uF capacitor C2 and the combination of resistors R3, R4 and pot. R5. The one-shot is triggered by every ignition pulse, so the voltage waveform looks like a series of pulses when the engine is running. Since the pulses are fixed in width and the frequency of the pulses is determined by the engine speed, the ratio of the time the waveform is at 12V vs. 6V goes up with increases in engine speed and down with decreases in engine speed. The way the meter works, the more time the waveform is at 12V, the more the needle is deflected and the less time the waveform is at 12V, the less the needle is deflected.



Low RPM, Little Needle Deflection    High RPM, Lots of Needle Deflection

As the meter movements wear, lose their lubrication or get dirty, they require more energy to deflect the meter.  On many older tachs, I have found that widening the one shot pulse width works to add the required energy.  However, the one shot pulse will be terminated early if the ignition pulse gets shorter than the one shot pulse.  I have found that many older tachs can't be adjusted enough to compensate for the required extra energy.  The symptom of this problem is a tach that will not register above a certain RPM.  I have tried sewing machine oil to improve the meter movement as recommended by my jeweler, but to no avail.  Untill I am able to identify a lubricant or a cleaner/lubricant combination that works, I add energy by cutting down on the resistance of the 55 ohm resistor/thermistor combination.

To calibrate the meter, you want to drive the tach with a very accurate, known signal at the correct frequency for the RPM reading that you want on the meter. Once you are driving the tach with the accurate frequency, you can adjust the needle deflection to the proper place by turning the calibration pot. R5. The tach can only be calibrated at one RPM. After that, all you can do is check to see how close you are at other RPMs.

It is possible to recalibrate the 7,000RPM Alpine 4 cylinder tachs to work in V8 Tigers using this method.

These tachometers contain electronic parts that are about 30 years old. The characteristics of all the internal components are likely to slowly change as they age, and I have found a number of tachs that have become uncalibrated, and many fail.

The most common failure modes I have seen are failure of the main timing capacitor C2. Failure of this cap. has caused tachs to be erratic, temperature sensitive or just plain dead. If you suspect your tach to have this problem, locate the capacitor, carefully unsolder the capacitor, and replace it with a new one. I have been occasionally able to locate a supply of 0.25uF capacitors, but available 0.22uF to 0.27uF capacitors work fine. I also come across numeraous tachs with a failed transistor input transistor.  The symptom of that failure is that the tach will not work in cars with lower ignition current. One way to diagnose this problem is to temporarily pull the plastic block off tha back of the tach, move the wire a bit and put two or three loops of wire through the metal "U" bracket that goes over the plastic block and put that on the back of the tach.  If the added magnetic flux gives you enough signal to trigger the tach, then the input transistor is failing. This could also be an indication of problem with your coil circuit as well, however. The other major failure mechanism I have seen is a broken meter spring. The meter needs to be replaced in this case. Replacement meters must be gotten from a parts tach. As a matter of course, the tach will have to be recalibrated if any of the parts are replaced. I use a cheap Radio Shack ohm meter set to the 10 ohm scale to test for meter continuity. I find that the ohm meter provides enough current to deflect the meter a bit if it is functional. All of the broken meters I have seen exhibit an open circuit.

All of the Smiths tachs of this era use the same electronic and mechanical design, regardless of number of cylinders, positive or negative ground or the make of the car. The power and ground wires are reversed between tachs for positive or negative ground cars. The only other thing that changes is the face used on the meters. So don't throw away any vintage Smiths tachs or tach parts, even if they are dead. They can be used to resurrect any other one.

Calibration:

After learning how the Smiths tach works, I set about to develop a highly accurate personal computer based calibration tool, as I didnt trust any other dwell/tach meter any more than I did my Smiths. The calibration tool I designed is conceptually quite simple. I designed a unit that plugs into the serial port of an Intel compatible personal computer and will generate a current pulse through the ignition wire that simulates the current pulse that happens when a spark plug is fired. I then wrote a program that causes the current pulses to occur at very precise times based on the RPM desired by the user. The timing is based on the highly accurate crystal used for timing on the computers serial port. This crystal controlled circuit must be highly accurate, or computers would not be able to communicate with one another. This device and software will convert your personal computer into a highly accurate tach calibrator that works from 500 to 10,000RPM, in the car or on the bench.

For the curious, I found that my 1200RPM dwell/tach meter was over 100 RPM off at 1200 RPM and my tach was off about 1000RPM at 5000RPM even after my dwell/tach calibration effort.

Opinions on Tom Ballous Article:

In general, Toms article has aged well. There are, however, a few things that you should be aware of.

Spray-Kleen type evaporative electronics solvents are loaded with CFCs and are extremely bad for the environment. Contact Cleaner 2000 is an environmentally safe alternative that I recommend.

A Positive Earth Alpine tach can easily be converted to negative earth by using a soldering iron to switch the power connections, so any Smiths tach is worth hanging on to.

I especially wouldn't calibrate my tach at high RPM using Tom's method, since the risk to the engine is not necessary anymore.

It is not often obvious by external inspection if the 0.25uF cap has failed. If the tach is not functional or temperature sensitive, it is the first thing I would replace to see if that is the problem.

The germanium transistors used in the Smiths design have a very low threshold voltage. Silicon transistors have a much higher threshold voltage. It is likely that replacing the germanium transistors with silicon transistors could really change the characteristics of the tach. However, I would stick with the germanium transistors. The HEP 253 number is still a good number for finding a germanium replacement, although they are hard to find. You sure can't get them from Radio Shack any more. There are some small electronics distributors who still do carry them. Another good part number is NTE158.

You can live with more turns of the ignition wire through the metal loop, which will give you a higher flux density for coupling the ignition signal to the tach. However, I wouldn't do it unless absolutely necessary, as removal of the nylon block on the ignition wire makes me worry about chafing the insulation off the ignition wire, shorting 12V to the tach and stalling the car, if not causing an electrical fire. I'd replace the input transistor if you have this situation.

To Obtain a Tach Calibrator:

In order to allow Sunbeam enthusiasts to accurately calibrate their tachs, I have started manufacturing the PC peripheral calibration units plus software for sale.

The calibrator consists of a unit that amplifies a signal coming out of the computer's serial port so it will emulate the ignition current pulses of your car. There is also PC software that drives the serial port to produce highly accurate timing pulses. This, in conjunction with an external power supply (such as your car's battery) allows you to debug tach problems and calibrate funtional tachs.

Please contact me at 1-408-398-2804 or email me at mwolson at pacbell.net if you are interested in purchasing a unit.

I have also developed software to drive the calibrator from a Palm Pilot. That software will be available as soon a