Air-Flow Meter (AFM)

" Air-flow measurement

The air quantity inducted by the engine is an exact measurement of its operating load. The sensor flap in the air-flow sensor measures the entire air quantity inducted by the engine, thereby serving as the main control quantity for determining the load signal and basic injection quantity. On the basis the measured air quantity and the engine speed input, the microcomputer calculates the optim ignition angle and corresponding injection time. Like the ignition angle, injection time is adjuste specific operating conditions. Air-flow measurement takes into account a variety of changes that could occur in an engine during its service life, such as wear, combustion chamber deposits and changes in valve clearances. Because the inducted air first has to pass through the air-flow ser before reaching the engine, the resulting signal from the air-flow sensor can be taken into acco before the cylinder is actually filled; this makes for optimum mixtures at all operating points during load changes.

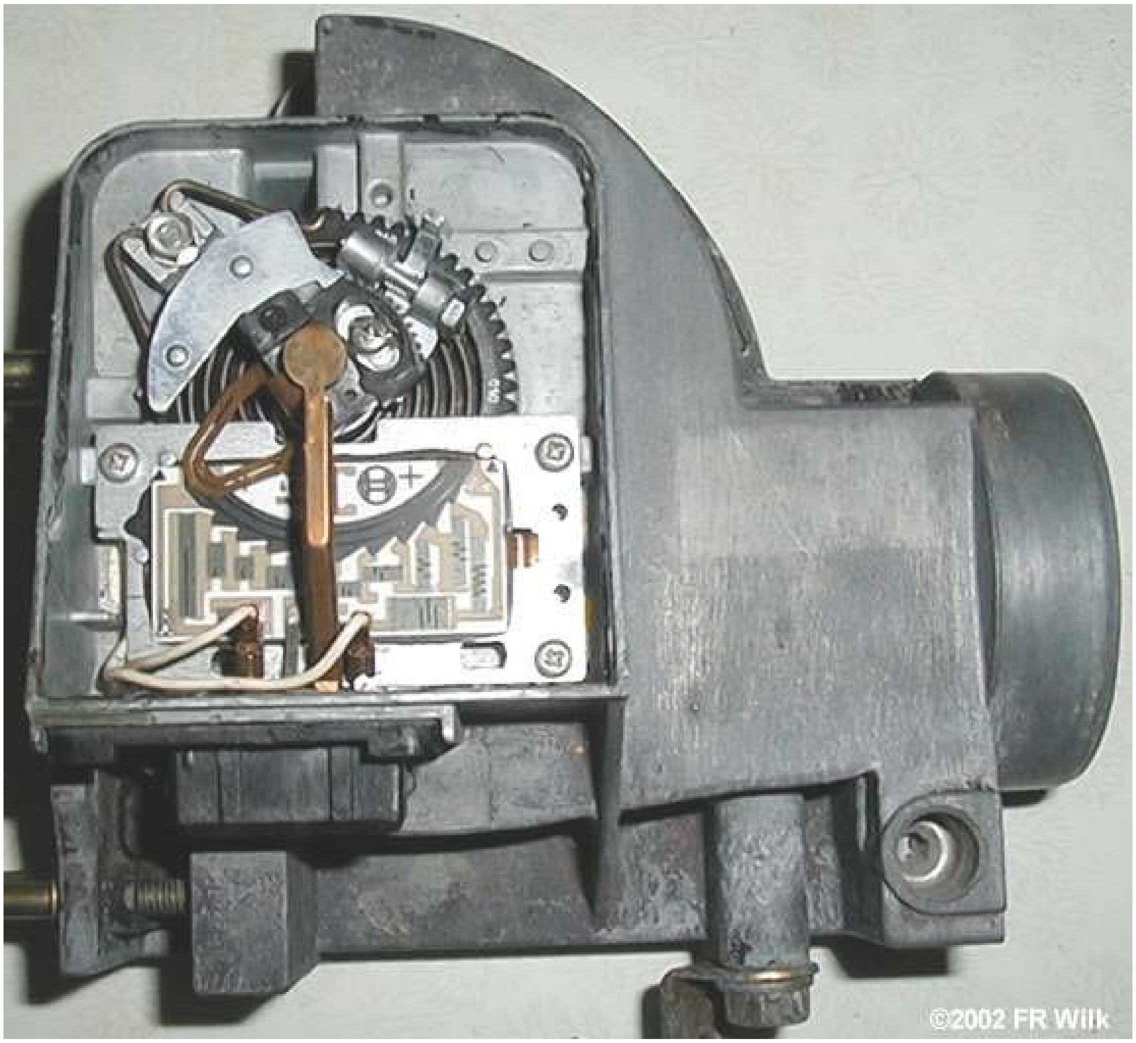
Air-flow sensor

The air-flow sensor works on the flap principle, measuring air throughput very precisely and delivering the signal for air quantity per unit of time to the control unit. The principle used here in the air-flow sensor is the measurement of force exerted on the sensor flap by the inducted air pas through it. A helical spring exerts counter force on the flap. For a certain flow value, the flap assumes a certain deflection angle; along with an increase in this angle, the effective cross sectional flow area also increases. To minimize the influence on the flap of fluctuations in the intake sys caused by the individual cylinder intake strokes, a compensation flap is connected rigidly with th actual sensor measuring flap. The result is that these fluctuations affect the compensation flap equally but in the opposite direction, so that they cancel out and have no effect on the measurements. When deflected by the inducted air, the air-flow sensor flap moves the sli potentiometer, which translates the flap angle α into a corresponding voltage signal U_P and transmits it to the electronic control unit. The potentiometer's wiper track is composed o high-resistance segments, for each of which there is a parallel connected low resistance resistor wiper track and resistors are calibrated so that the voltage U_P increases with increasing flap angle.

The potentiometer of the air-flow sensor is of the thick-film type, with a ceramic plate ba high-resistance wiper track as well as the two contact rivets on the wiper itself are of an wear-resistant material. The resistance are connected to the wiper track by very narrow cor segments, the so-called data points. These data points terminate under the wiper track and thu define the specified voltage steps. In the Motronic, the wiper-type potentiometer is constructed so as to ensure that there is a linear relationship between inducted air quantity and slider output voltage The high temperatures and abrupt temperature changes that always prevail in the vehicle compartment have no negative effects on the behavior of the thick-film resistors. In addition, in order that potentiometer aging and temperature fluctuations do not affect the accuracy of th measurements, the control unit evaluates only resistance ratios. An adjustable bypass diverts a small quantity of air past the air-flow sensor flap. Variations in this bypass air quantity, whi independent of the sensor-flap position, are applied as the basis for correction of the air-fuel mixtur for idle adjustment. In the Motronic system, the control unit switches on the fuel pump by way external pump relay; for reasons of safety, no fuel is pumped if the ignition is on and the en stationary. "

from 'Automotive Electric/Electronic Systems ©Robert BOSCH GmbH, 1988'

The Air-Flow Meter (AFM), also know as Air-Flow Sensor (AFS), measures the volume of air flowi into the engine. The AFM is two sensors in one, air-flow and air temperature. AFM measures volume in units of cubic meters per hour (m^3/h). The DME requires air mass. The difference being air density. Within the AFM is a sensor that measures air temperature. Air density and then air mass is calculated by the DME and the proper level of fuel is metered.



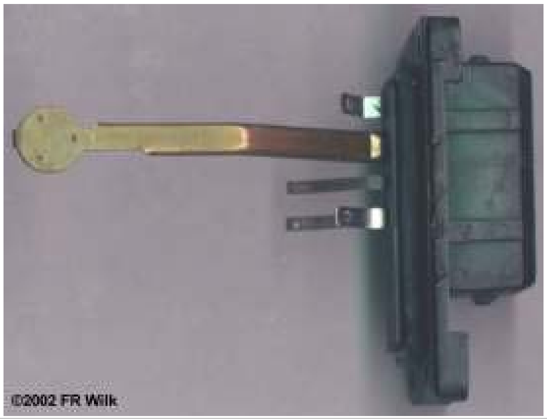
Inside the AFM

1. Wiper track 2. Wiper 3. Spring 4. Ring gear 5. Ring gear retainer 6. Temperature sensor 7. Wiper assembly retainer 8. Electrical connector 9. Bridge to wiper

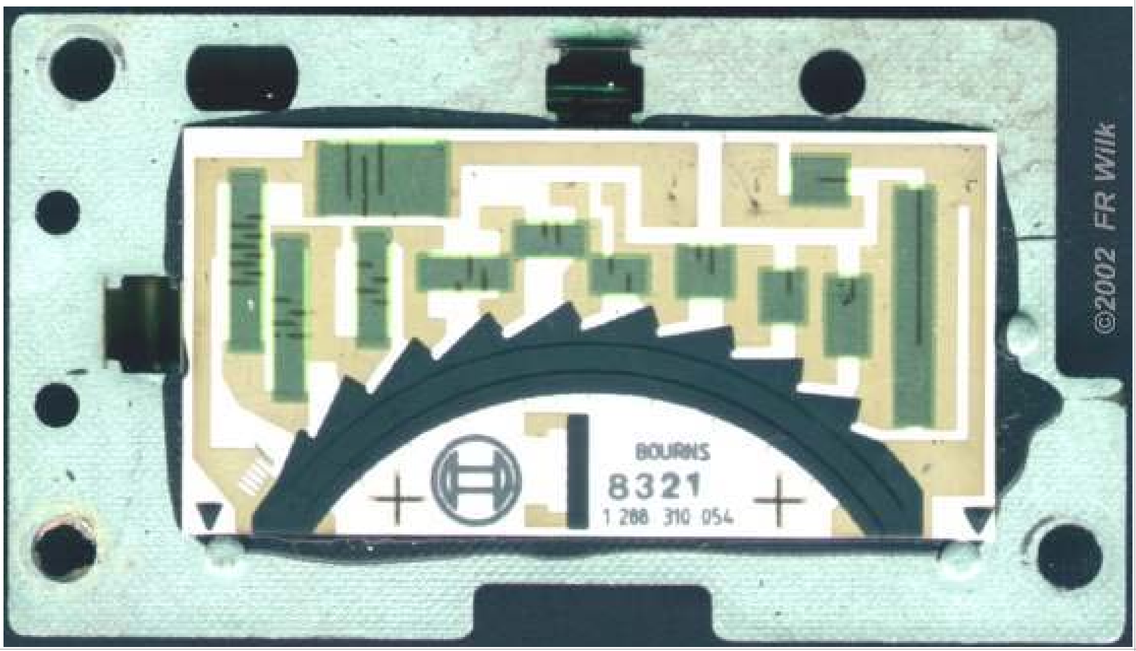
Left........ With the substrate mounting plate and the wiper assembly removed, we have a better view of the clock spring. Note the flat side on the shaft for accurate keying of the wiper assembly. In the lower right is a yellow plastic device which is the air temperature sensor.

Diagonal......... is the connector top view.

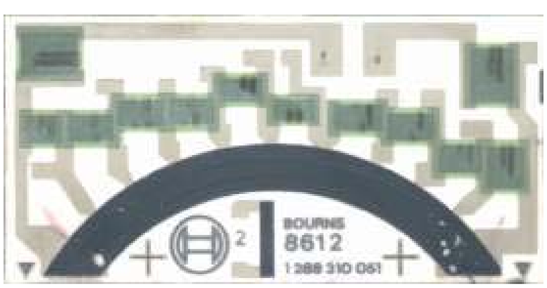
Below.......... is the side view of the AFM connector showing pin numbers.



AFM Connector, note the missing pin

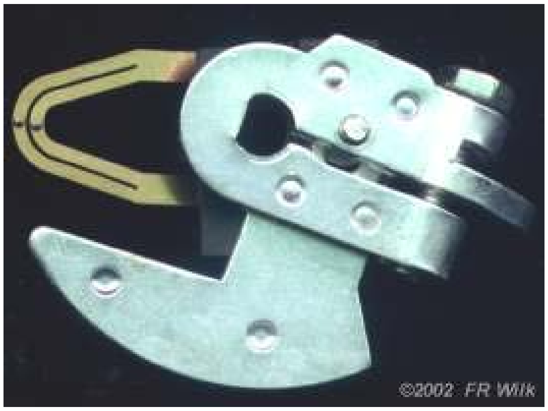


Above......... A 1984 thick-film ceramic substrate glued to its metal mounting plate. The black 1/3 circle area is the wiper track made of a resistive material. The white is the bare ceramic, the gold is a conductive metal, and the green are thick-film resistors. Black laser cuts can be seen in the green resistor material. The laser trimming is done after the AFM is assembled with the ceramic substrate in place. The dark grooves in the wiper track are clearly visible. This is damage from the wear of the wiper contacts showing its age .



Left.......... A 1986 AFM has a different layout of the ceramic substrate than the 84 AFM above. Note the holes in the wiper track area and the fuzzy look of the laser cuts in the resistors. This AFM was full of moisture when the plastic cover was removed. The moisture damage is evident.

Wiper Assembly, top view

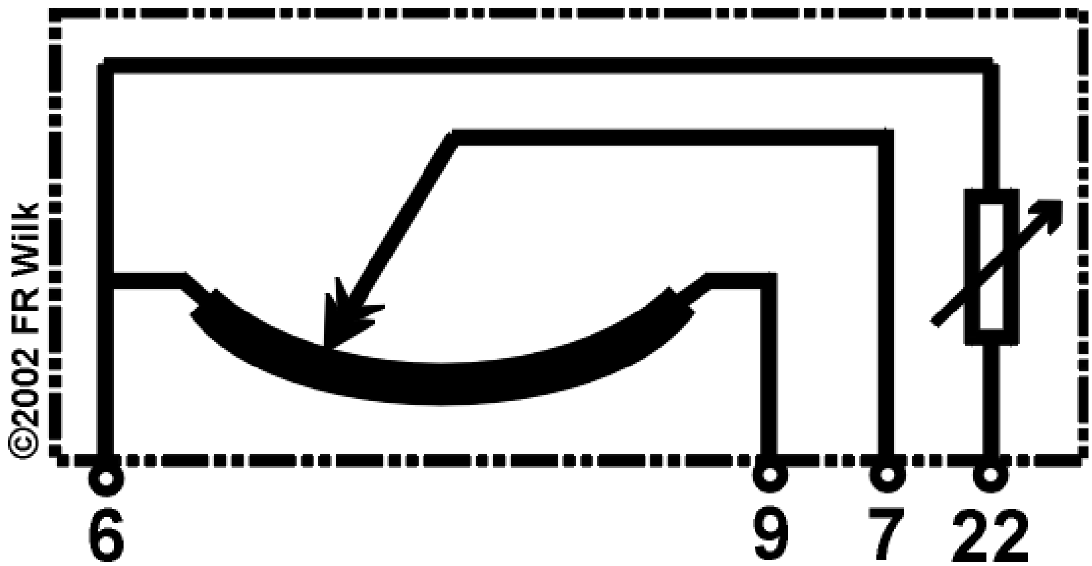


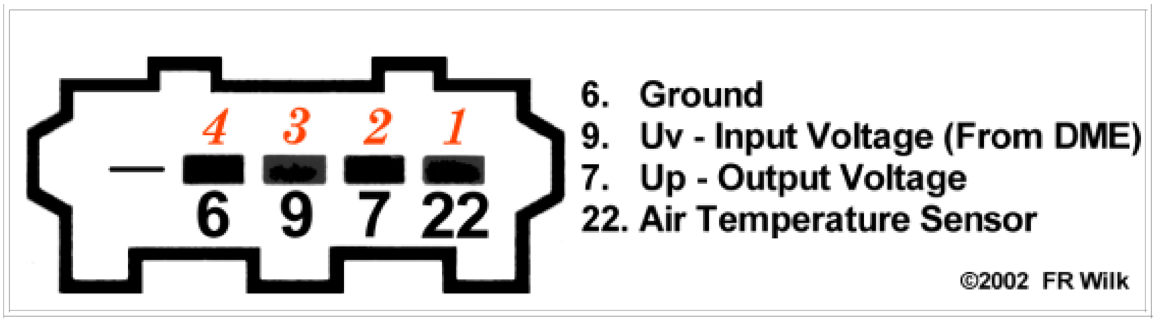
Wiper Assembly, bottom view

Left.......... Bottom view of the wiper. The split wiper unit makes redundant contact with the wiper track area for higher reliability. The ball shaped wiper contacts are clearly visible. After 100,000 miles, the ball contacts make two nice deep grooves in the wiper track's resistive surface.

See "**Refurbish your AFM**" section to get longer life out of your AFM.

AFM Schematic

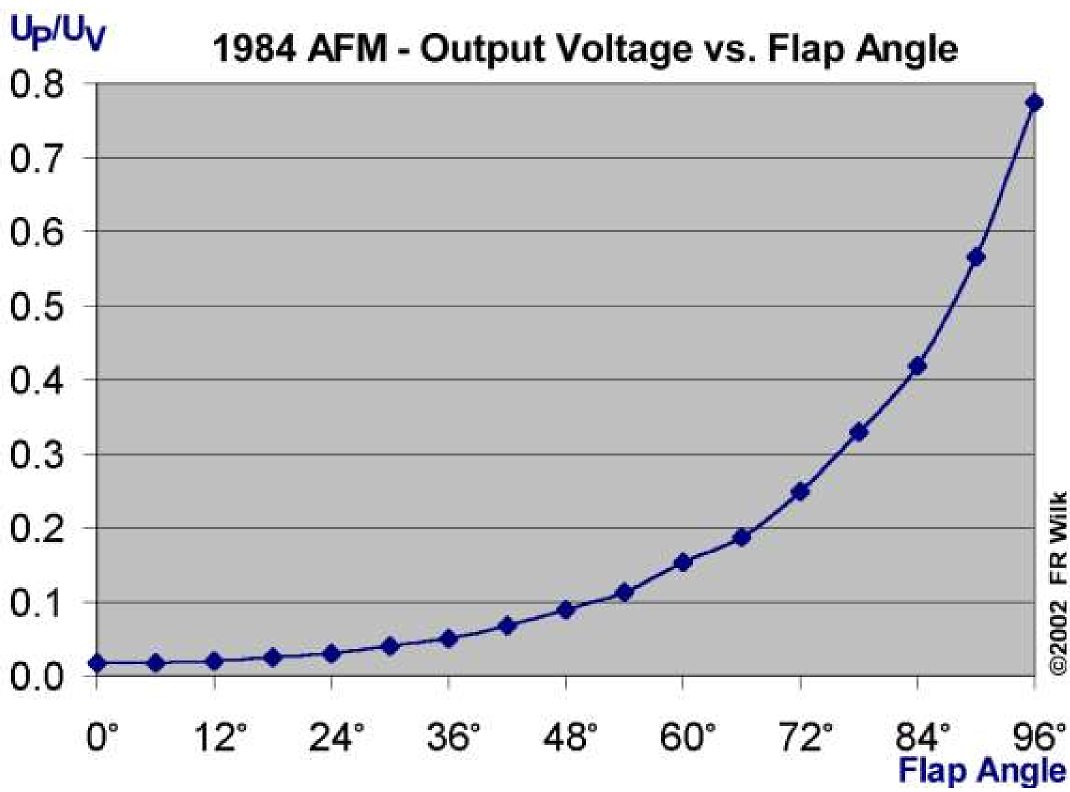




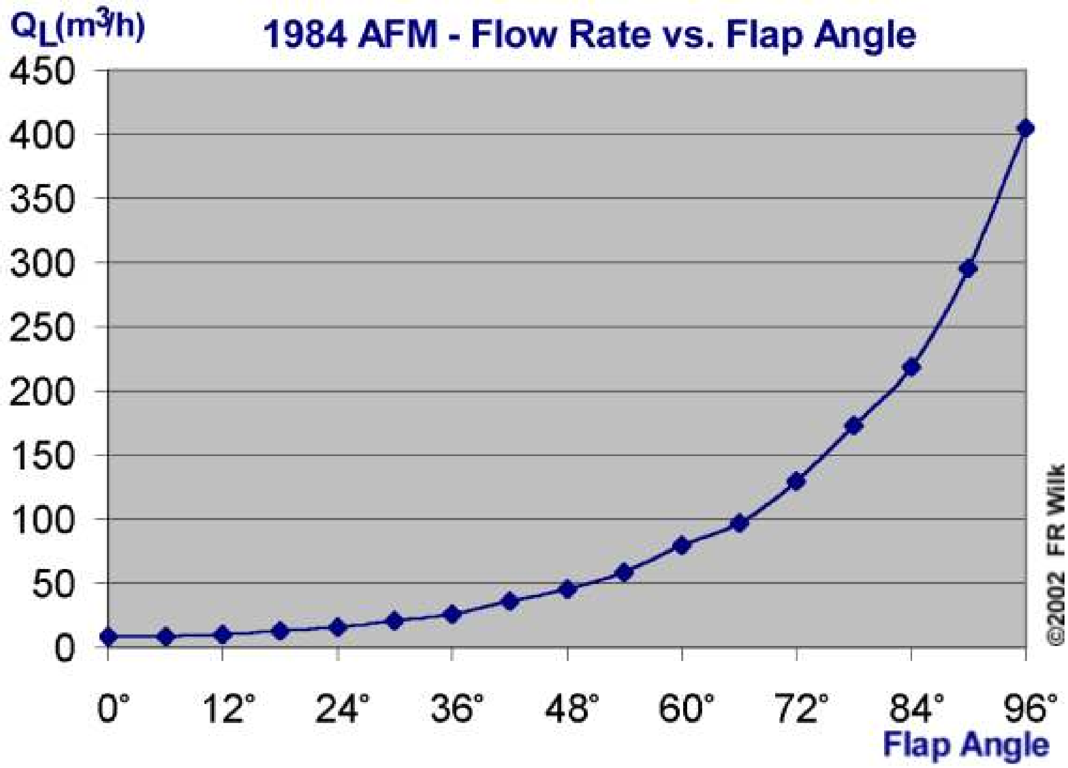
The Early 944 AFM

DME supplied voltage $\mathbf{U_V}$ and the AFM output $\mathbf{U_P}$**.** The ratio of $\mathbf{U_V/U_P}$ is used by the DME. The early DME voltage was typically 12V unregulated (8V minimum). Both voltages $\mathbf{U_V}$ and $\mathbf{U_P}$ are constantly being measured by the DME.

The output is non linear with respect to flap angle. The output is linear with respect to air-flow rate This complex function is designed into the ceramic substrate and its resistor array.



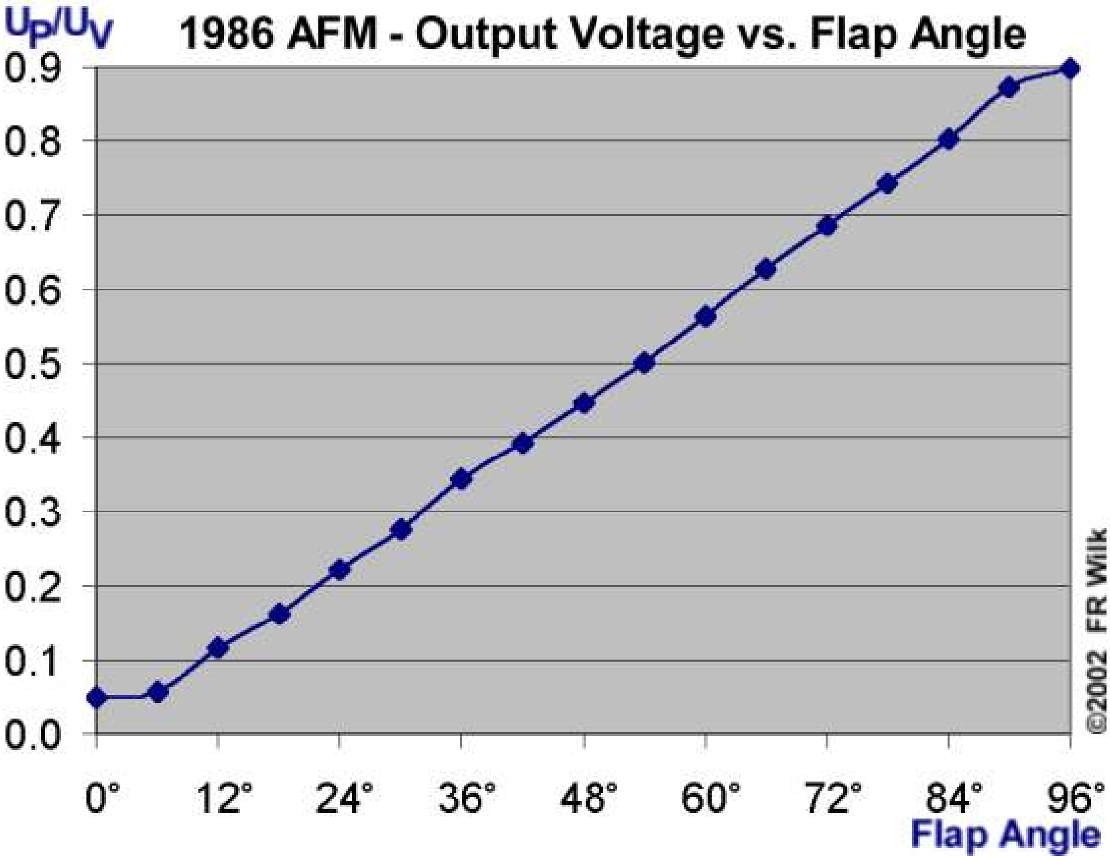
When filling in the appropriate air-flow rate, we have:



The Late 944 AFM

The design of AFMs changed with the late 944 AFMs. There is no longer any intelligence to its output. This makes it much easier to design and cuts the cost. On the down side, it uses mc resources of the CPU. The output is linear with the angle of door opening. If the door open full has a U_P=4.5V, then the door half open will have a U_P=2.25V. A quarter open, U_P=1.13V, etc.

In the late AFM, the voltage being supplied by the DME U_V has changed to a regulated 5V ±0.5V. This voltage is now very stable. The early DME voltage was typically 12V unregulated (8V minimum).



Testing the AFM's Potentiometer

You can not use an ohmmeter to test an AFM's potentiometer. It will jump about meaninglessly. ` must test it as it is being used. You have to force a voltage **U_V** and measure the output voltage **U_P**. This can be done with the AFM in the car and the ignition on. Here is a simple bench test setup.

Bench testing an AFM. Sophisticated test equipment consisting of a 9 Volt battery, battery connector, and two 0.1 inch female blade connectors (hard to find). Cost, under $2. The outpu voltage **$U_P$** must rise smoothly as the door is opened. **U_P** must never decrease as the door is opening not even for a moment. This is called non-monotonicity and can drive your DME i oscillations.

Testing the AFM's Air Temperature Sensor

An ohmmeter is used to measure the resistance of the temperature sensor. This is a roon temperature measurement and the values are in the tables below. With an ohmmeter, measu between pins 6 and 22 (AKA 1 & 4). If the resistance is out of tolerance, you will have to get ano AFM. Spare parts are not available. The temperature sensor can be moved from another AFM but it is easier to just buy a good used AFM.

1984 Air Temperature Sensor

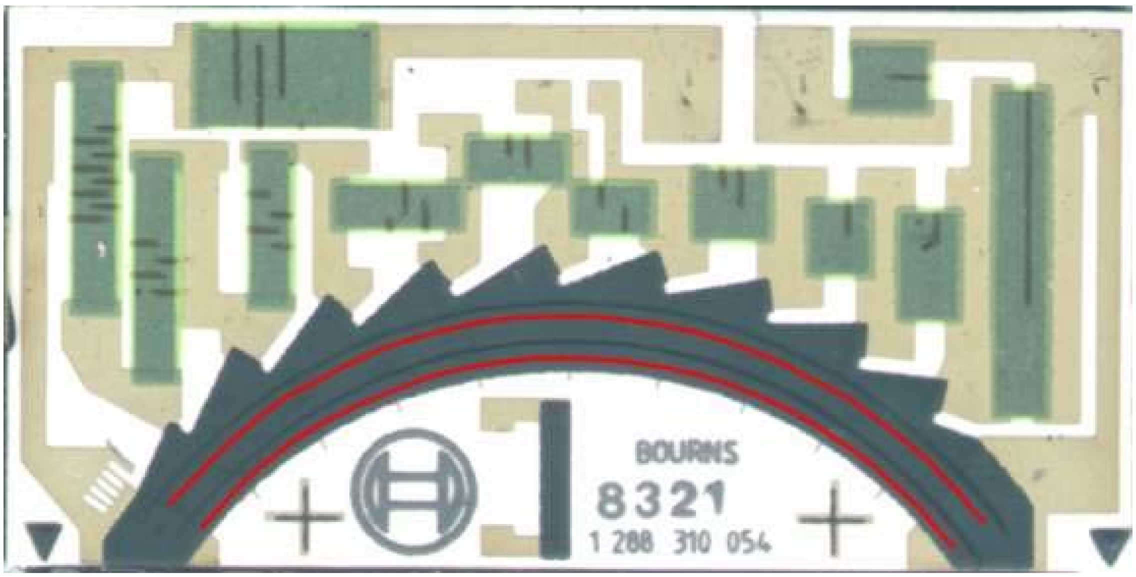
Air Temperature		Minimum Resistance	Maximum Resistance	Tolerance
0°C	32°F	5.0kΩ	6.2kΩ	10%
20°C	68°F	2.2kΩ	2.8kΩ	10%
30°C	86°F	1.5kΩ	1.9kΩ	10%

The early and late AFM sensors appear to be the same part but are specified in different ways.

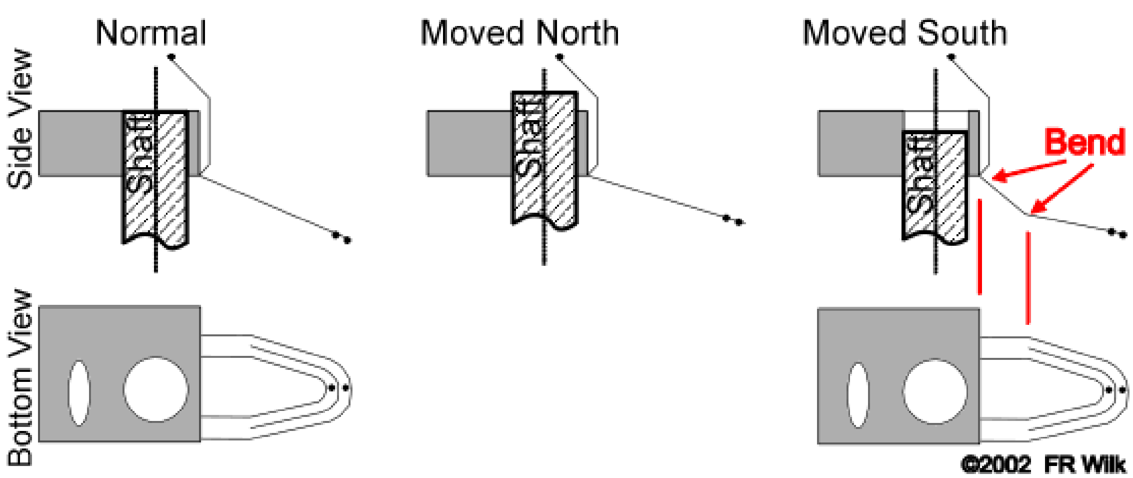
1986 &1986Turbo Air Temperature Sensor

Air Temperature		Minimum Resistance	Maximum Resistance
0°C	32°F	4.4kΩ	6.8kΩ
15°C - 30°C	59°F - 86°F	1.4kΩ	3.6kΩ
40°C	104°F	1.0kΩ	1.3kΩ

Refurbishing your AFM



The deep black grooves in the wiper track is from normal wear. The red groves are drawn demonstrate the new track over virgin material.



The goal is to repair the damaged potentiometer. The potentiometer is made up of the wiper running along a resistive wiper track on the ceramic substrate. Moving the wiper assembly so that it runs along a fresh unused material on the wiper track. Observe the relationship of the top of the shaft and the top of the wiper assembly. They are usually about the same height. You will need a 7mm wrench to loosen the bolt on the wiper assembly retainer. Never touch the Phillips screw holding the wiper in place as this will move your angular set point.

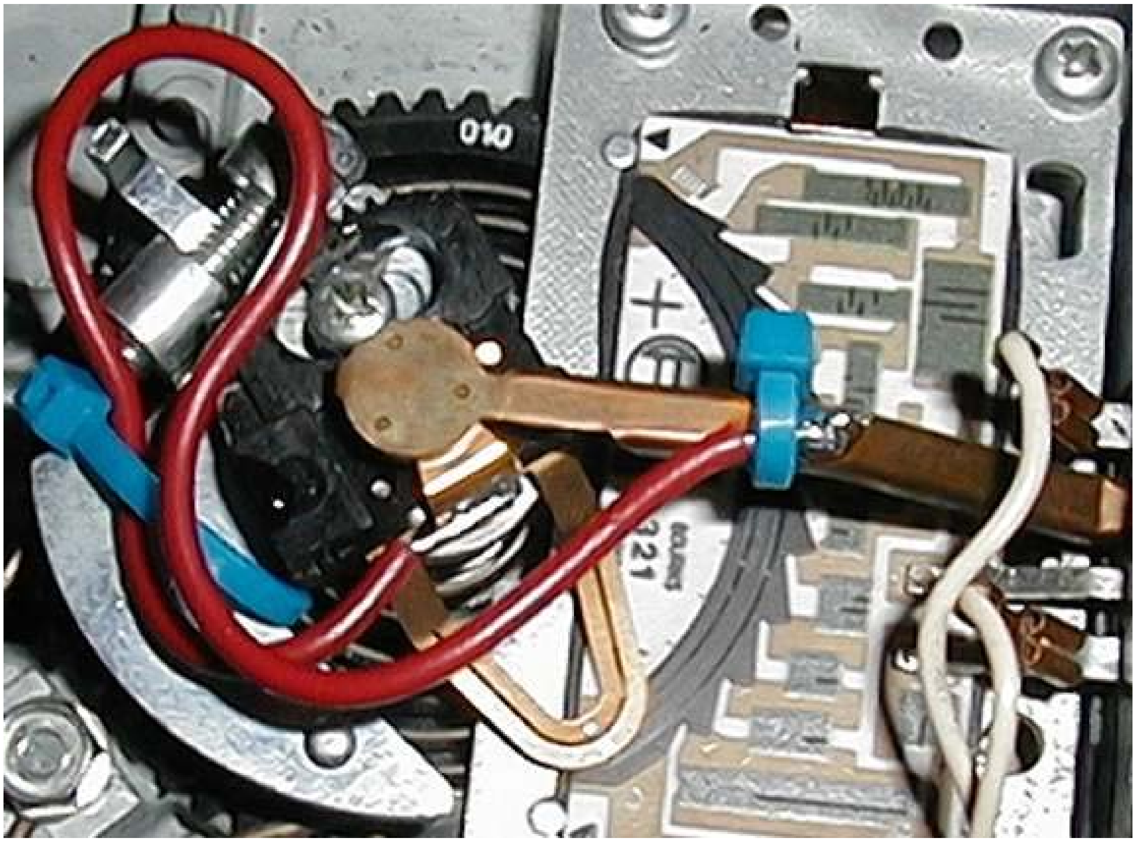
North:

Moving the wiper assembly down on the shaft will move the wiper contacts north of the previous wear grooves. This is the simplest to do.

South:

Moving the wiper assembly up on the shaft will move the wiper contacts south of the previous grooves. This is a little more work. First, remove the 4 screws holding the connector in place. remove the connector. Loosen the bolt on the wiper assembly retainer. The entire wiper assembly will pull off of the shaft. Do not worry about the alignment, the shaft is slotted so that it will go back to the exact same shaft angle. Bend the wiper as shown. Replace the wiper assembly on the sha leaving it higher on the shaft. This will move the wiper contacts south of the damaged area. Replac the connector.

Update Your 1984 AFM



In the late 1980s, BOSCH started using a redundant wire from the connectors bridge to the wiper and the wiper. Probably to reduce noise and contact resistance at the pivot point. On a few that tested, the voltage drop was unusually high. The red wire, above, simulates the BOSCH installation . The blue ties are to take pressure off of the solder joints. I recommend making this modification if ever you have the black plastic cover off of the AFM.

Changing the Spring Tension of an AFM

Dont do it! Never change the tension of the spring on your AFM. You will destroy the calibration of your AFM. The AFM is laser trimmed to a fine tolerance by BOSCH.