

Smiths FG-Series Fuel Gauge

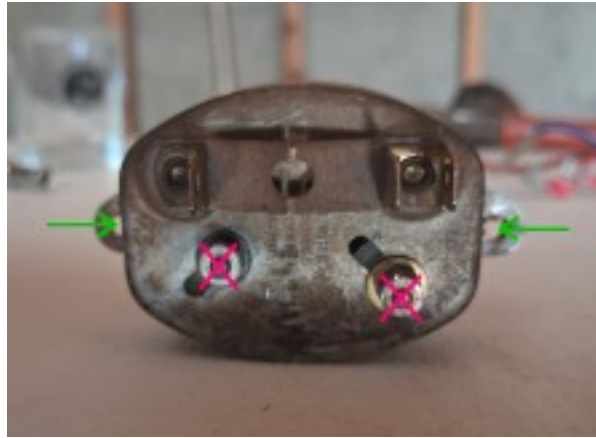
as fitted in early Triumph Herald

Repair and Calibration

I relied heavily on Alex Miller's *A Gentleman's Guide to Classic Smiths Automotive Gauges*. This guide is published in 2 volumes. Volume I covers the gauges themselves and Volume II the various senders. Both volumes are available on the internet.

Mechanical Considerations - Things Not To Screw Up

The early Herald fuel gauge can be removed from the instrument cluster without removing the cluster from the dash. It's held in by a pair of small nuts. Not *those* small nuts – the two on the back of the gauge body hold the electromagnets in place inside the gauge. Loosening them **will** affect the calibration. Removing them **will** allow the electromagnets to flop about inside the case, which might damage the incredibly thin wires they're wound with. The mounting nuts thread onto posts in the gauge cluster that go through the holes in the ears, off to the sides of the gauge body. The nuts on my car fit snugly in a 7/32" socket.



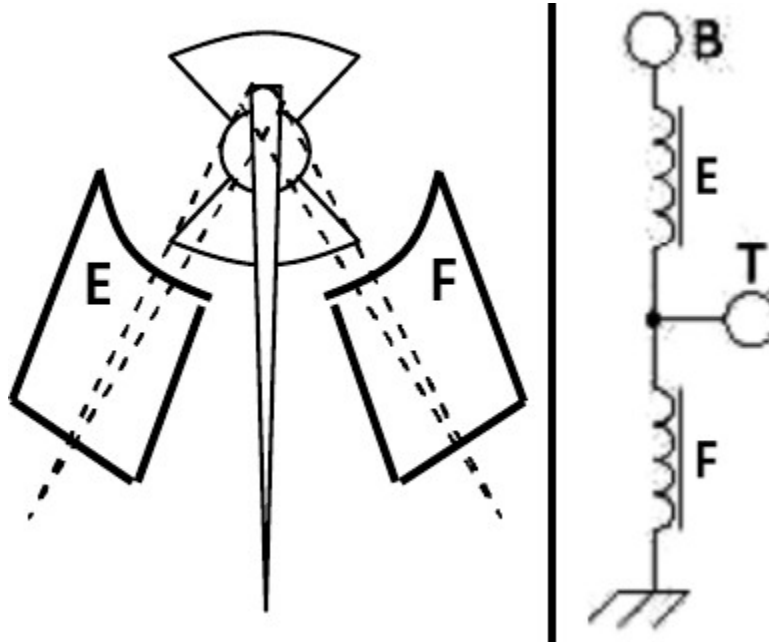
If you need to open the gauge (to demagnetize the iron “bow tie”, or if the unit is more severely non-operational than mine was), the face is held onto the body at the mounting holes. The sheet metal of the face that's directly over the holes is cut into 4 tabs, each about 1/32" long, and bent over the inner edges of the holes in the sheet metal case. You *might* be able to pry the tabs up, but you might hurt yourself trying. I drilled one of them out using a 1/8" bit. This weakened the tabs enough without obliterating them. It's not necessary to do both sides! You can rotate the face out of the way around the intact side.



The indicator needle is made of an extremely flimsy piece of metal, cut and bent to shape. It's very easily deformed, so be careful handling the gauge at all times while it's exposed!

How the Whole Thing Works

The unit consists of a pair of electromagnets, and an indicator needle mounted to a piece of iron shaped like a bow tie. One magnet pulls the bow tie towards the “E” position on the gauge face, the other pulls it towards the “F”. The “B” (for Battery) terminal is connected internally to one end of the E-side magnet. The “T” (for Tank) terminal is connected to the other end of the E-side magnet, and to one end of the F-side magnet. The other end of the F-side magnet is grounded to the case by way of the magnet’s mounting screw and nut. If this nut is not snug, the electrical connection will not be solid, and gauge operation will be intermittent or worse.



Both sketches are copied from Miller's "Gentleman's guide"

When there's battery voltage at the B terminal and the T terminal is open (not connected externally), the current path runs through both coils to the grounded case. The F coil has about 2x the number of windings as the E coil (119 ohms of wire measured between the T terminal and the case of my unit vs 59 ohms measured between terminals B and T), so it produces a much stronger magnetic field with the same current, and the needle shoots past the F mark on the gauge face. The tank unit is a variable resistor connected in parallel with the F coil, one side connected by a wire to the T terminal and the other grounded through the body of the car. The sender resistance is essentially zero when the tank is empty, which effectively shorts out the F coil, allowing the E coil to win by default. When the tank is full it still steals some of the F coil's current, but the F coil still dominates the magnetic pull felt by the bow tie. In between, the resistance of the tank unit determines the relative strengths of the 2 electromagnets, and thus the position of the needle.

The electromagnets are mounted in slots which run out at angles from the pivot point of the iron bow tie. Calibration is accomplished by sliding them nearer or farther from the bow tie – the closer each one is, the more strongly it will pull on the bow tie at a given current level. The slots are a few degrees outside of the E and F marks on the gauge face. The pointer needle is angled a few degrees towards the

F side of the bow tie to compensate, so it points directly at the E position on the dial when the E magnet is activated alone. The F magnet alone pulls it well above the F mark.

Calibration

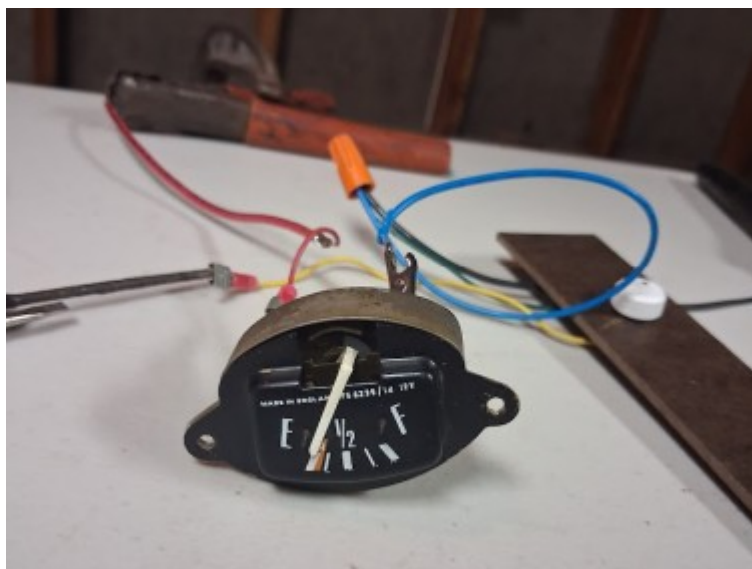
I built a calibration bench using a 100 Ω 1W potentiometer in place of the gas tank sender, with a couple of crimp terminals that fit over the terminals of the gauge, an alligator clip, a wire nut and some wire. It's powered from the car via a jumper cable, the ends of which are firmly clamped to the table I'm working on because it's dangerous to have them flopping around. A red wire, stripped on one end with a crimp-on attached to the other, is connected from the car's battery by way of the jumper cable, to the B terminal of the gauge. 3 green wires are joined together by the wire nut. One connects via the jumper cable to a solid ground point on the car, one is soldered to the alligator clip which will be used to ground the gauge case, and the third is soldered to one terminal of the potentiometer. The last wire is soldered to the wiper terminal of the potentiometer at one end, and has the other crimp-on at the other end for connection to the T terminal. The third terminal of the potentiometer is left open.



To get the calibration data I needed, I drove the car until it ran out of gas on the main fuel feed. I measured the resistance of the sender unit. It was about 13 Ω . Then I flipped the tank to the reserve feed, drove to a gas station and filled it up all the way into the filler neck, to make sure the float was pinned to the roof of the tank. The sender measured about 83 Ω . Those are the calibration values I'm using – I want it to point to F when the tank is full, and I want an accurate reading when it's getting close to needing me to flip to the reserve feed, which I prefer not to have to do. I mounted the potentiometer in a piece of fiberboard and scratched lines at the 13 Ω and 83 Ω positions.

Before trying to calibrate the gauge, it's important to make sure the indicator needle aligns as intended with the magnetic field. When the E electromagnet is energized and the F is completely not, the needle should point perfectly at the E line on the gauge. The test bench can do this as-is if the potentiometer goes all the way to 0 Ω , otherwise you can temporarily connect the grounded alligator clip to the T

terminal, rather than the gauge case. Turns out my needle had gotten bent a bit towards the F end when I accidentally placed the gauge face-down. I carefully bent it back.



The calibration procedure: First, set the external resistance to the reserve feed transition value (13Ω in my case) and adjust the position of the E magnet so the needle points to the boundary of the “reserve tank” area. Snug the nut (do not over-tighten). Next, set the resistance to the full-tank value, and adjust the position of the F magnet so the needle points to the F mark. This could take a few tries, since you have to snug the nut each time you move the magnet to get an accurate reading, and loosen it again if it’s still off the mark. Once the F position is set, go back and check the reserve setting. If it has moved due to repositioning the F magnet, repeat the procedure.

Residual Magnetism

The polarity of the car’s electrical system determines the polarity of the magnetic field generated by the gauge’s electromagnets. Early Heralds were shipped with the + side of the battery grounded. Modern accessories such as sound systems require the – side grounded. It’s quite easy to change the polarity, just disconnect the battery, rotate it 180° and hook it back up. The only thing that doesn’t work perfectly after the swap is the fuel gauge! This is due to residual magnetism that builds up in the iron bow tie from years of exposure to the fixed-polarity magnetic field. If the coils produced a North magnetic field, the bow tie will develop a slight South polarity. When the car’s electrical polarity is reversed, the magnetic polarity generated by the electromagnet coils will be as well, and the residual magnetism in the bow tie will resist the pull of the magnets (South repels South), causing the gauge to read low. This will correct itself over hundreds to thousands of miles of exposure to the new coil polarity. I checked mine on the test bench. After thousands of miles it has adapted, and the gauge now reads lower when I reverse the jumper cable leads exposing it to the original + ground. There are procedures to quickly neutralize the residual magnetism by applying a very strong magnetic field. These are beyond the scope of this document except for a warning: do NOT apply excessive voltage to the gauge, as there is a risk of fusing the coils!