A GENTLEMAN'S GUIDE TO CLASSIC SMITHS AUTOMOTIVE GAUGES

Part I – Gauges.

Electrical senders are dealt with in Part II.

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CONTENTS:

1. NOTES RE CONVENTIONS USED WITHIN THE TEXT:

Throughout the text the letter “n”, or “N”, has been used to denote any number. Where the gauge number is significant it has been provided in full. Otherwise irrelevant numbers have been replaced.e.g. TC 43nn/nn.

Similarly, a lower case “x” has been used to replace any letter, in gauge prefixes such as “Bx” for any bimetal gauge.

An upper case “X.” refers to a literal gauge prefix for older gauges such as “X.80540/2” which is an electric (early bimetal) temperature gauge.

Usually only the four numbers after the type prefix are shown. Often these will be followed by a slash and two more numbers possibly followed by one or two letters. These later numbers and letters are generally ignored as they are not relevant to the discussion. These numbers usually denote scale options such as scale and pointer colour and scale marking. Letters indicate a hardware change that does not affect operation of the basic “xx nnnn” gauge.

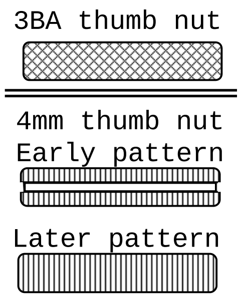
“Short-scale” gauge refers to a gauge with a pointer sweep of less than 270 degrees. These are also referred to as “arc” gauges. All classic gauges other than “PG”, “TG” and “VG” gauges are “short-scale”. The “xG” Bourdon tube gauges can be either full-scale or short-scale.

SCREW THREADS USED IN SMITHS GAUGES:

Smiths instruments, up to at least the mid 1970s, used “British Association” (BA) threads for screw threads for gauges. Though in less common use now, they are still used in model engineering and can be frequently found at hobbyist/model engineering suppliers.

BA threads are a metric thread but dimensions are frequently given in imperial (inch) units. Sizes range from 0BA (6mm/0.2360 inch dia.) to 16BA (0.79mm/0.0310 inch dia.) Some sources list sizes down to 25BA (0.25mm/0.010 inch dia.). Sizes commonly used by Smiths in these instruments are 3, 4, 5, and 6 BA. Later gauges – air cored and Caerbont manufactured “Classic” gauges – use metric threads.

Case clamp fixing thumb nuts varied between years and instruments. For the gauges of interest here, 3BA threads are used. A cross-hatch knurling pattern is used on thumb nuts for these. Use 4mm shakeproof washers to secure thumb nuts.



For Gen-4, 3BA threads continued to be used but on later instruments, 4mm threads are used and these thumb nuts have a shallow groove in the centre of the knurling and a ribbed pattern. The 4mm studs affixed to the case have bright plating. Later (Caerbont) metric gauge nuts have ribbed knurling but no groove.

Common thread sizes used externally on gauges are set out below:

Threa	Application	Notes
3 BA	Case mount/ Early quadrant gauge fixing/ Bx range terminals	Alloy Thumb nut/ Steel screw/steel nut/ Brass sleeve nut
4 BA	FG, TC terminals	Brass: nut/sleeve nut
5 BA	FG, TC pole adjustment/ Bourdon tube side fixing	Steel nut/ Steel screw – countersunk
6 BA	Later quadrant gauge fixing	Steel screw
3mm	Case mount	Alloy Thumb nut
3.5m	Late bimetal terminals	Brass sleeve nut
4mm	Case mount	Alloy Thumb nut

2. INTRODUCTION:

Smiths gauges are found in numerous vehicle makes and models. They are everywhere. If you have an English classic car, chances are it uses Smiths gauges. This document looks at these gauges, how they work and how they may be kept operating. "Jaeger" instruments that have "Made in England" or "Made in U.K." marked on the dial are also Smiths manufactured gauges.

Some of the information presented is from Smiths documentation and is applicable for gauges manufactured prior to about 1970. Other information was derived by testing several of the gauges themselves.

2.1. Types of gauge:

TABLE A:- GAUGES COVERED IN THIS DOCUMENT		
Parameter	**Mechanical prefixes**	**Electrical prefixes**
Fuel level		FG, BF, ACF
Temperature	TD, TL, TG	TE, TC, BT, ACT
Pressure	PD, PL, PG	BP, ACP
Vacuum	VD, VL, VG	
Voltage		BV, ACV
Current		AM
Dual gauge	GD, GDR	DBR, DEA

Over the years that gauges have been fitted to cars, several "technologies" have been employed in gauge construction. These include mechanical gauges, e.g. Bourdon tube, and electrical gauges. Electrical gauges comprise moving iron ("FG" and "TC"), bimetal ("TE", "PE" amd "Bx") and the air cored ("ACx") gauges. The "Bx" bimetal gauges are the most common found in cars manufactured in the mid-1960s and later.

2.2. GAUGE NUMBERING SYSTEM:

Early Smiths gauge numbers were prefixed "Z." for speedometers and tachometers and "X." for everything else. Later gauges had "UC-" (clock), "UF-" (fuel), "UP-" (pressure), "US-" (speedometer) or "UT-" (temperature), prefixes. Others had part numbers comprising several groups of digits separated with dashes. In the early 1960s, Smiths rationalised their instrument numbering system using the prefixes set out in Table A above. Smiths also manufactured in Australia and this is printed on the dial but no part number is usually present. A label on the side of the gauge case prefixed "M" is followed by a six digit number identifies these gauges.

It has changed again with gauges from Caerbont. The modern BF2242-00C gauge is identified as such only on a label on the side of the gauge. The dial on one to hand is marked "41-822-101-87" which doesn't tell you a lot.

If working with gauges with an "X." prefix, you will need to determine the gauge type. For these gauges the number tells you nothing useful. e.g. an X.80587 is equivalent to a PL 6202/00 Bourdon tube pressure gauge but an X.80588, the next number in sequence, is equivalent to a TE 6201/00 bimetal temperature gauge. The "X." prefix is marked on the gauge but parts listings may only provide the number.

The numbering system used by Smiths during the 1960s and on into the 1970s (or later) provided some information about the gauge itself. The gauge prefix (see table A) identified the type of gauge and was followed by a four digit number – Nnnn – the upper case number "N" has the following significance;

1 – an accessory, as opposed to an OEM, gauge.
2 – two inch diameter round cased gauge
4 – a rectangular cased gauge – two inches wide, 1 3/4 inches high.
5 – 2 1/2 inch square gauge usually found in larger commercial vehicles
6 – a quadrant gauge, to fit an instrument panel (cluster) or a speedometer case as in early Minis and Triumph Herald cars, or to fit a rectangular instrument panel.
8 – a caseless gauge.

The significance of the other digits in this group and those following the "/" has not been decoded.

The exception to the above numbering system was the "TC" type temperature gauge where the two inch diameter gauge was numbered "TC **43**nn/nn". The "TC" type quadrant gauges used the "TC **6**nnn/nn" part number format as for every other quadrant gauge.

"GD" ("Gauge Dual") type gauges are all 2 inch diameter Bourdon tube gauges and usually comprise an oil pressure gauge and a temperature gauge although dual air pressure gauges (for commercial vehicles) are also found as are dual temperature (oil, water). These gauges were fitted to some English sports cars.

"GDR", or "Gauge Dual Ribbon" gauges were fitted to the early 1960s Volvo P1800 cars and were dual temperature (oil, water) Bourdon tube type mechanical gauges. Instead of a pointer, these gauges moved a coloured ribbon in a viewing window. The only other ribbon gauge from Smiths, that I am aware of, was the range of ribbon speedometers ("SR" prefix) fitted to a number of BMC vehicles also about this time.

Dual electric gauges (DBR2300/00 – Fuel and Temperature, DEA2300/00 – Amps and oil pressure) were fitted to the Rover P6B 3500S. These are the only dual electrical gauges known to the author.

2.3. Miscellaneous notes:

A number of different mounting methods were used for these gauges. By far the most common are the "U" shaped bracket that clamps the gauge to a panel and the formed "legs" used with clusters and larger gauges. The bracket may have one or two nuts securing it and may be shaped to avoid a lamp or pipe fitting. For the style of gauge shown in *fig 1* below, a clamping ring plate, which may also be in the form of a sub-panel retaining several instruments, slips over the gauge and is attached to the instrument panel to clamp the gauge in place.

Other methods of fitting gauges were a bayonet type fitting where three small nubs protrude from the edge of the case and enter slots cut in the panel and the gauge is turned to fix it in place, tensioned with a spring either under the bezel flange or a retaining ring. One other method that is often found is a pair of brackets fixed to the case to take mounting screws that screw into the dashboard or panel. This last is most often found within quadrant and caseless type gauges (see *fig. 5* later in this document) in a gauge cluster or speedometer case but is also found on some individual gauges.

Some earlier cases were die-cast, later cases were pressed steel. The case dimensions, however, did not change.

2.4. Gauge lighting:

A number of lighting methods are used. The most common is a light fitting on the rear of the gauge. Quadrant gauges have no light fitting and relied on light spill from a bulb at the centre of the cluster to provide illumination.

Figure 1: Dual gauge with ring style fixing and using external illumination

Usually only found as original equipment in vehicles, come gauges are illuminated by an externally mounted lamp which often provided lighting to more than one gauge. The gauge shown in *fig. 1* is of this type. Slots were formed around the front of the case and a plastic window provided to keep dust out. This window could also colour the illumination (blue here).

2.5. INSTRUMENT PANELS AND CASELESS GAUGES:

Smiths produced a large number of instrument panels, commonly known as "gauge clusters". These can be found with both "X." and "IP" prefixes. Individual gauges used within the panel had their own part number. In most cases these panels were round and used the quadrant gauges (see *figs 2 & 5*) that have been mentioned previously. There could be one to four gauges in a round panel though three is the most common configuration. These are found in 3 inch, 4 and 5 inch nominal diameter assemblies. Three inch panels would contain one or two gauges where four inch panels would hold three. 5 inch clusters usually contained four gauges.

Gauges in Instrument Panels could be of almost any type. Fuel gauges can be moving iron, bimetal or air cored. Temperature gauges can be Bourdon tube, thermal (TE prefix), semiconductor (TC prefix), bimetal (BT prefix) or air cored (AC prefix). Oil pressure gauges are usually Bourdon tube type, though late model clusters are likely to contain air cored gauges. Ammeters (moving iron; prefixed "AM" or marked "Lucas") are also found as are Volt gauges (BV or AC prefixes). In most cases the part number of the gauge cannot be read without removing the gauge from the panel.

Later quadrant type gauges are secured with screws and are interchangeable between clusters. Mounting holes in early clamped quadrant gauges have a larger diameter mounting hole, designed to fit over a locating pin forming part of the panel, so replacing an early style clamped gauge with a later gauge could be an issue. Mounting hole spacing was the same in each case.

A few instrument panels were rectangular which used a different gauge mounting system with two mounting lugs, top and bottom diagonally opposed, formed as part of the case. The two quadrant gauge styles are shown on the left in *fig. 2*, along with a disassembled Instrument Panel/ gauge cluster from a Triumph 2000 showing the individual gauges on the right.

FIGURE 2: Photos showing the two styles of "quadrant" gauge on the left and to the right an instrument panel from a Triumph 2000 Mk II. The parts listing for this Triumph instrument panel are:

Instrument Panel (complete)	IP 3232/06
Fuel gauge	BF 6106/08
Temperature gauge	BT 6106/09
Voltmeter	BV 6100/01

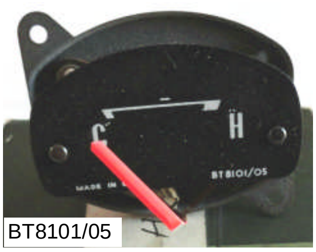
The gauges could be replaced as individual items.

<u>CASELESS GAUGES</u> were also produced and these are differentiated by having the gauge mechanism fully or partly exposed. (See *fig. 13* for an example of such a gauge.) Earlier types were fitted to speedometer cases as for some Hillman Avenger and Hillman Imp models. There are quite a range of fitting styles for these gauges.

In later instrument panel assemblies a flexible "printed-circuit" is used to connect instruments and dashboard indicator lamps, the terminals often also acted as the mounting points for the gauge. These gauge assemblies always used "Caseless" gauges. The gauge part number is often obscured when installed. Typical of this style of dashboard are those fitted to the Morris Marina (refer *fig. 28*), Rover 3500S (refer *fig.13*) and Triumph TR7/TR8 cars.

Some examples of Smiths caseless gauges.

Examples of caseless bimetal gauges to fit into a speedometer case. Example at right from a Hillman Hunter, Avenger or Imp.



BT8101/05

BT8105/00

Below: Some examples of bimetal gauges for fitting to an instrument panel with "printed circuit" wiring as in fig. 28.

BT8114/01

BT8115/00


BT8120/00

Right: A caseless air cored gauge for a Triumph TR7.

ACT8102/02

3. MECHANICAL TEMPERATURE, PRESSURE AND VACUUM GAUGES:

3.1. BOURDON TUBE GAUGES

The majority of Smiths mechanical pressure gauges are of the Bourdon tube type. The main element, the Bourdon tube, is essentially a partially flattened thin-walled tube bent into a circular shape. One end is sealed and pressure is introduced at the other.

For oil pressure and engine vacuum (sometimes called "Fuel Consumption" or "Performance) gauges, a tube connects between the gauge and the relevant part of the engine. As pressure is applied, the Bourdon tube tends to straighten out, or contract in vacuum gauges, and this movement is indicated by an attached pointer.

Some temperature gauges also use a bourdon tube, using the pressure generated when a volatile liquid is heated within a closed system. A metal bulb, usually brass, filled with a suitable liquid (di-ethyl ether) is connected to a Bourdon-tube gauge by a length of capillary tube. As the bulb is heated, the pressure in the system increases and deflects the gauge's pointer. The gauge dial is calibrated in degrees or marked "C-N-H", rather than pressure.

Diagrams of Smiths Bourdon tube gauges are shown in *fig. 1* below which shows different types of linking methods used to connect the Bourdon tube to the pointer assembly and the manner in which these gauges are adjusted in order to calibrate them.

Do not over-pressurise these gauges. An over-pressured Bourdon tube will distort and will be inaccurate at least, if not completely unserviceable.

Not all Bourdon tubes are equal. Smiths have a range of Bourdon tubes to fit different pressure ranges and/or degrees of pointer movement.

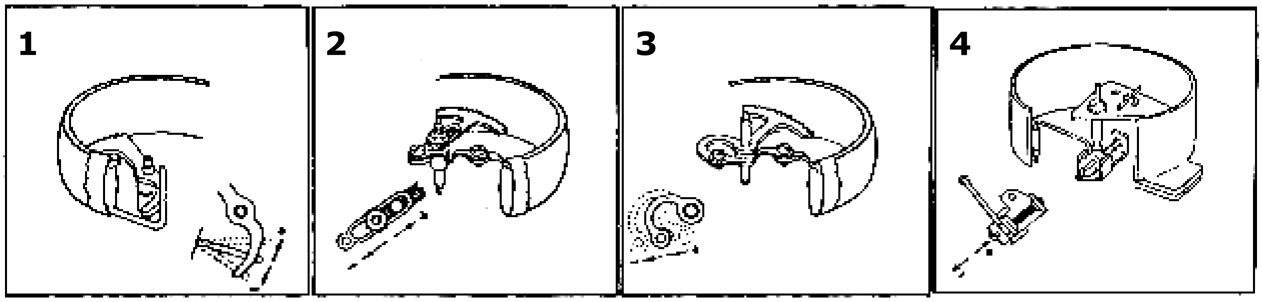


***FIGURE 3*: showing Bourdon tube to pointer assembly link styles used in Smiths gauges.**

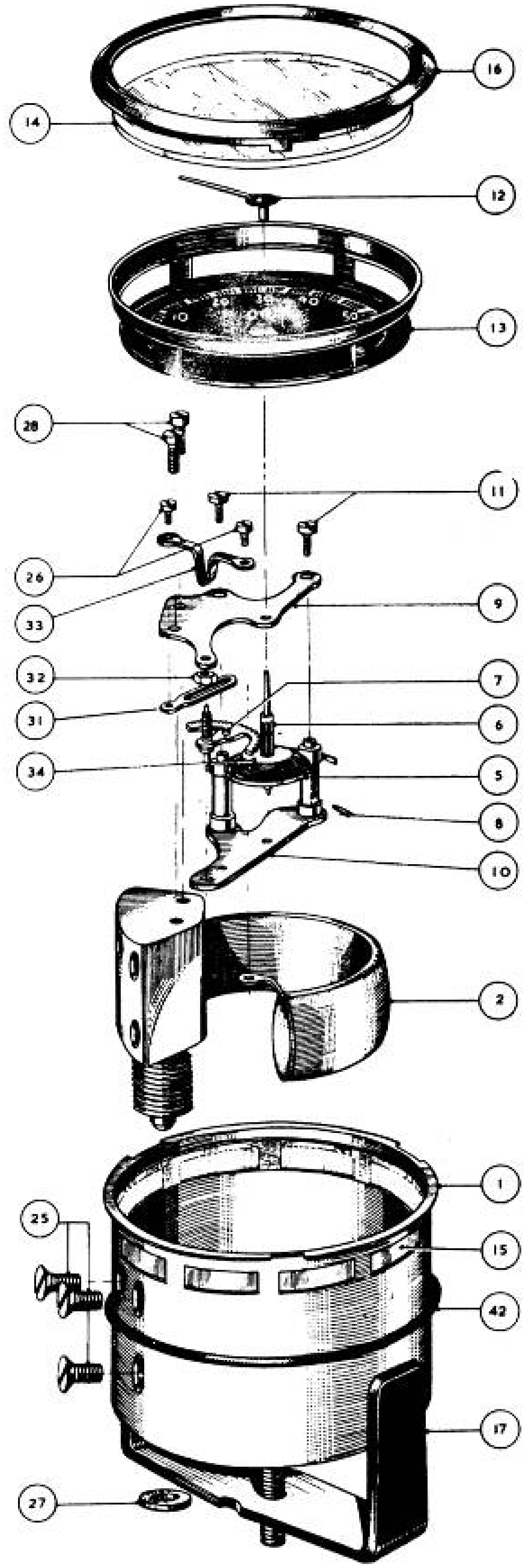
1: PL/TL/VL type gauge with fixed link between Bourdon tube and pointer assembly

2: PG/TG/VG type gauge with early style link

3: PG/TG/VG type gauge later style link

4: PL/TL/VL type gauge with alternative (earlier) style link

Fig. 4 on the next page is an exploded view of a typical Bourdon tube gauge. This particular illustration is of a "PG" type gauge.



1 Case
2 Bracket and Bourdon Tube Assembly
5 Hairspring
6 Pinion
7 Quadrant and Spindle
8 Hairspring Taper Pin
9 Movement Plate (Top)
10 Movement Plate (Bottom)
11 Movement Plate Fixing Screw
12 Pointer
13 Dial
14 Glass
15 Celastoid Window
16 Bezel
17 Fixing Strap
25 Fixing Screw (for Type 'A' Movement)
26 Linkage Connecting Screw
27 Leather Sealing Washer
28 Movement Fixing Screw
31 Adjusting Arm
32 Adjusting Arm Lock-Nut
33 Connecting Link
34 Hairspring Shield
42 Rubber Ring (External)

***FIGURE 4*: ** Showing construction of Bourdon tube oil pressure (shown) and temperature gauges. (Diagram from Smiths Motor Accessories service data.)

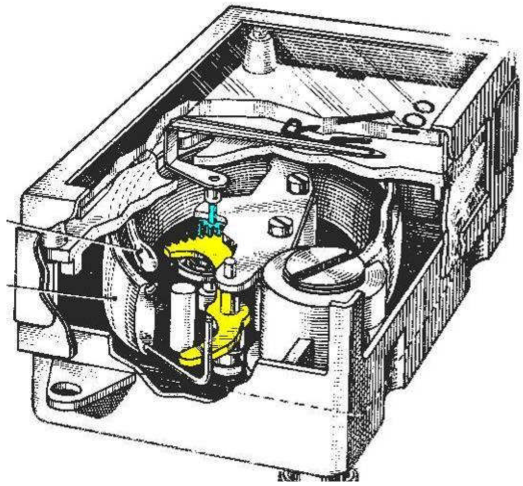
3.1.1. Difference between “xG” and “xL” mechanical gauges:

(*Refer also to fig. 3 above*.)

Bourdon tube pressure, temperature and vacuum gauges are prefixed PG/TG/VG or PL/TL/VL. (Diaphragm gauges, “xD” prefix are described later in this document.)

The difference is internal: “G” indicates a gear driven gauge pointer and “L” a link controlled pointer mechanism. All gauges with 270 degree (or gauges that require more than a 90 degree swing of the pointer) are xG type gauges. The link type gauge is only capable of moving a pointer through 90 degrees of arc.

The “xG’ mechanism can be seen in *fig. 4* on the previous page and in *fig. 4a* at right.



A gear (yellow) is linked to the Bourdon tube and engages with a pinion (blue) on the pointer spindle. A very small movement of this gear turns the pinion over a much larger arc. As can be seen in *fig. 4a*, this mechanism is also used where a smaller degree of movement of the Bourdon tube is required.

(Note: *fig.4* identifies the gear assembly (7) as “quadrant and spindle”. This use is unrelated to “quadrant” used within this document to describe a type of gauge case.)

The “xL” type mechanism is cheaper to produce and has fewer moving parts. An exploded view of the “PL” mechanism is shown in *fig. 4b below*. Quadrant type gauges and short-scale mechanical gauges can be of this type.

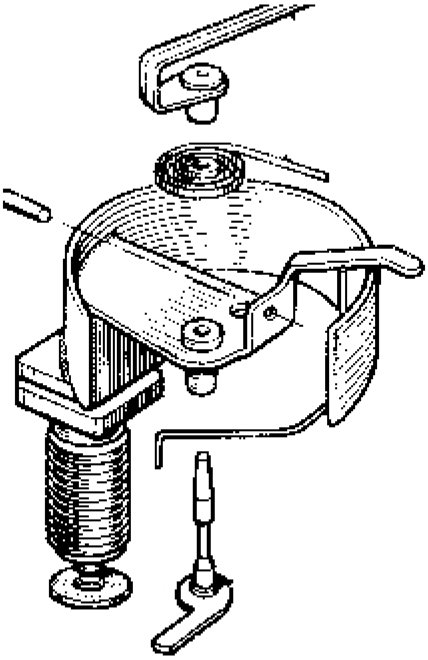


FIGURE 4b: Exploded view of a “PL” type gauge mechanism.

Bourdon tube gauges are found in 2” diameter cases, in square or rectangular cases and as “quadrant” style gauges included in a gauge cluster. A quadrant type Bourdon tube gauge is shown in *fig. 5* at right. The quadrant style gauge may use a more compact design but these can still be re-calibrated if required. Mechanical quadrant gauges, both oil pressure and water temperature, are always of the Bourdon tube type.

FIGURE 5: Quadrant style oil pressure gauge.

3.2. DIAPHRAGM GAUGES:

You may occasionally come across diaphragm type pressure, vacuum and temperature gauges though these seem to be fairly scarce and only found on older vehicles. Diaphragm gauges can be identified by the location of the pressure connection – in the centre of the gauge rather than offset as bourdon tube gauges are. (*fig. 6* below.)

Rear view of Smiths diaphragm pressure gauge

Rear view of Smiths Bourdon tube pressure gauge

FIGURE 6: Identifying Smiths mechanical oil pressure gauge type. Refer to text.

Diaphragm gauges rely on the resistance provided by the stiffness of the diaphragm to resist pressure and limit movement (*fig. 7*), though a spring may also be fitted to increase this resistance.

To the best of my knowledge, Smiths have not manufactured diaphragm automotive gauges for many years but this construction is still used in electrical oil pressure senders.

Diaphragm gauges are all short-scale gauges.

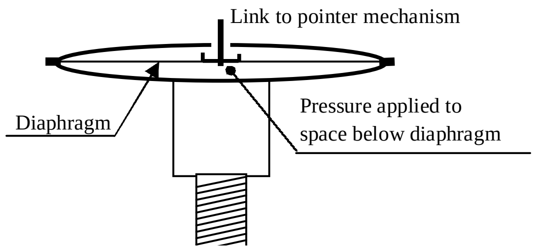


***FIGURE 7*: **Sketch showing construction of a diaphragm gauge

3.3. TROUBLESHOOTING MECHANICAL GAUGES:

There is not much that can go wrong with these gauges. They work or they don't. If a mechanical temperature gauge fails to work it's almost certain that the gauge has lost the filling liquid and will need refilling.

Oil gauges will not return to zero if they have been over-pressurised but may also indicate beyond full scale if the Bourdon tube has distorted. If a newly-fitted gauge fails to read at all, then check that the connection is correct and not to a blind or blocked drilling in the block.

In the case of vacuum gauges, simply remove the tube or pipe from the back of the gauge with the engine running. You should hear air being sucked into the vacuum line. A damaged vacuum gauge will behave very much like an oil pressure gauge as described above.

For all gauges that have a pointer attached to a spindle (including speedometers and tachometers), the pointer is held in place by friction between two matching tapered surfaces. If these have not been properly (re-)assembled, loosening of the pointer can occur.

For an oil pressure or vacuum gauge, the pointer will remain at zero or minimum indication point or, in the case of a dual gauge, the lower gauge pointer will hang vertically.

If such a gauge fails to indicate, remove from the dashboard and rotate it observing whether the pointer moves as you do this. If the pointer is loose and rotates, remove the bezel and glass (which may not be that easy – refer Appendix B) clean the spindle and pointer with a cloth or tissue and, holding the dial horizontal, place the pointer on the zero mark and tap the pointer boss with the handle of a moderately-sized screwdriver to fix it in place. ***Do not use adhesives, such as threadlocking compounds. They are not necessary***. If you can't see a zero mark – usually a dot just below the pointer stop – then set the pointer against the "wrong" side of the stop pin. Tap in place (as above) and carefully lift the end of the pointer and move to the "correct" side of the stop pin. Be gentle here. Lift the pointer just enough to clear the pin. In some cases the stop pin may be retractable removing any risk of bending the pointer. Ideally you would apply a known pressure to the gauge and set the pointer to indicate the applied pressure.

If the calibration of a pressure gauge is suspect, the gauge can be checked and re-calibrated as necessary. For pressure gauges an accurate pressure source will be required. A deadweight tester is the ideal tool for recalibrating pressure gauges but comparison with a known good gauge is a reasonable option.

Vacuum gauges are commonly calibrated against another gauge of known accuracy. The gauges are connected to a vacuum pump or even the inlet manifold of a running engine.

For Bourdon tube temperature gauges, failure of a soldered joint or breakage of the capillary tube are the most common reasons for failure. But for 2 inch gauges, including dual gauges, also check the pointer hasn't loosened on the spindle. These gauges can be repaired but need to be refilled with (diethyl) ether which may be difficult to obtain.

Smiths Classic dual gauges using Bourdon tubes are still manufactured.

4. ELECTRICAL GAUGES:

Smiths produced a number of electric measuring systems. And they are all different!

4.1. IDENTIFYING AN ELECTRICAL GAUGE:

To determine what type of gauge you are dealing with, look at the ID marking on the gauge. Unfortunately, this is easier said than done – particularly if the gauge is still mounted in the dashboard. The photos below will help in identifying gauges.

FIGURE 8: Showing early "X" type bimetal gauge.

Fig. 8 at right shows the faceplate from an older gauge and the ID code is plain to see. This is an electrical gauge of the "TE" type which is the only type of electrical temperature gauge using the "X.nnnnn" ID. This particular gauge has bullet type terminals on the rear. "TE" gauge pointers sit at the Hot end of the scale when the ignition switch is off.

Any fuel gauge marked "X. nnnnn" is an "FG" type gauge.

FIGURE 9: FG or TC gauge

Fig. 9 shows the rear view of an "FG" or "TC" "moving-iron" gauge. Each of these gauges has nuts (arrowed) in slotted holes which are the means of calibrating these gauges. Both these gauges require a good earth connection to work. These types of gauge were produced as 2" diameter, rectangular and quadrant style gauges. "TC" gauges are all 12V gauges. "FG" gauges were available for 6V, 12V and 24V electrical systems. The pointer in these gauges is free to move as can be seen if the gauge is rotated. These gauges have small stop pins to limit pointer travel which are not present on other gauge types.

FIGURE 10: Bimetal gauge

Fig. 10 shows the rear of a bimetal gauge. The two arrows show where calibration adjustments are made. As-new, the access holes are covered by a pressed-in cork disk. Normally these remain in place and if missing may indicate the gauges have been re-calibrated. Fuel and temperature gauges of this type must be supplied with a constant voltage to be accurate. Bimetal oil pressure gauges do not use the voltage regulator unless used with a resistive, rather than bimetal, sender.

FIGURE11: Rear view of an Air Cored gauge.

Fig. 11 shows the rear of an air cored gauge which has no provision for calibrating the gauge. These gauges are non-repairable. Calibration is effected by means of a calibration resistor and is done during manufacture. These gauges also are 12V gauges and do not use a voltage regulator. Like the "FG" and "TC" type gauges, they are require a good earth connection to the case .

24 Volt air cored gauges do exist. They are no different to the 12 Volt gauge except for an internal 270 Ohm resistor to drop the voltage. Removal of this resistor permits operation on 12 Volt systems (and vice-versa).

Fig. 12 at right shows portions of gauge dials showing the gauge type; A quadrant type "TC" temperature gauge at top (TC 6210/01) and an air cored gauge (ACP 2203/03) below. The type can be readily seen here, but is normally hidden by the mask (or dress plate) that sits in front of the dial.

FIGURE 12: Gauge ID.

For a quadrant gauge sitting in the cluster assembly it may not be possible to read the type ID at all without removing the gauge from the cluster.

You will need to know the type of gauge you are dealing with in order to check it out properly. Troubleshooting information is provided later in this document.

As a general rule, electrical gauges were single units. Those in clusters were still individual gauges that could be removed, repaired or replaced on a "per-gauge" basis. The only dual electric gauges I have seen are those fitted to the Rover P6B 3500 saloons. These are the caseless DEA2003/00 (ammeter and oil) and the DBR 2003/00 (fuel and temperature) complete with piggy-backed voltage regulator. Except for the ammeter, these were bimetal gauges and the DBR 2003/00 is shown here in *fig. 13*.

The dashed outline on the right-hand image shows approximately where the voltage regulator plugs in to the gauge itself.

FIGURE 13: Front and rear views of the DBR 2003/00 (top) and DEA.2003/00 (bottom) dual electric gauges fitted to some Rover cars.

TROUBLESHOOTING ELECTRICAL GAUGES:

When trying to determine why an electrical gauge isn't working, there are some basic tests that apply to all gauges.

Firstly, and obviously, an electrical gauge of any type must have a supply from the battery to operate. So this is the first thing to check. A vehicle wiring diagram, if available, can be particularly useful for identifying fuses and wiring paths.

Loss of power supply to gauges is commonly due to blown fuses, which will almost certainly supply, and affect, other equipment in the vehicle, and to dislodged connectors which is easily done for some types. Some gauges require a good earth connection to the case of the gauge as this forms a third terminal for the gauge.

If power is not available at the gauge, find and fix the cause then, as required, follow the steps in the tables below for the type of gauge that is fitted to the vehicle. (Refer to "IDENTIFYING AN ELECTRICAL GAUGE" section earlier in this document.) If bimetal fuel and temperature gauges are fitted but do not work then check the voltage regulator. If one gauge only does not work, remove the sender wire from the other gauge and connect in lieu of the sender wire to the failed gauge. If the gauge then operates there is a sender/wiring fault.

Gauges can be checked for operation by either removing the sender connection or shorting to earth. ***When checking "TE" or "PE" bimetal gauges, do not short to earth but use a low power (dashboard) bulb in place of the sender***.Later "Bx" gauges can tolerate a short circuit to earth for a short period though using a low resistance (bulb as above) is to be preferred. Do not short out the sender for longer than necessary. A minute or two will not harm the gauge but avoid doing this for significantly longer periods.

Sender or wiring can be short-circuit, open-circuit, or be connected wrongly. Wrong connections are not likely unless wires have been removed from a gauge such as when refurbishing a dashboard and gauges or re-wiring/making changes to a vehicle's electrics. Short- and open-circuits may result from damage to wiring looms far from the gauge.

In the following texts, earth connection to the gauge is only mentioned if the gauge type requires an earth for successful operation. In the majority of cases, gauge lighting also requires an earth at the gauge.

For most English vehicles, Ford being the notable exception (Ford used Smiths gauges in some of their vehicles), the following wire colours are used for the different gauges:

Fuel sender – green wire with black stripe

Temperature sender – Green wire with blue stripe

Oil pressure sender – white wire with brown stripe (same as oil warning light)

Regulator output (to gauge) – Light green with green stripe

Battery supply to regulator – green

WIRING DIAGRAMS FOR ELECTRIC GAUGES:

Fig. 14 below sets out wiring diagrams for all electric gauges other than Voltmeter and ammeter, wiring for which are set out in *figs 15 and 16*.

All "BF" and "BT" gauges and some pressure gauges, require an instrument voltage regulator. Other gauge types do not. The fuse may, or may not, be present.

Most Smiths gauges discussed in this document will work in both positive- and negative-earth vehicles. Air-cored gauges are the exception and will not work in positive-earth cars.

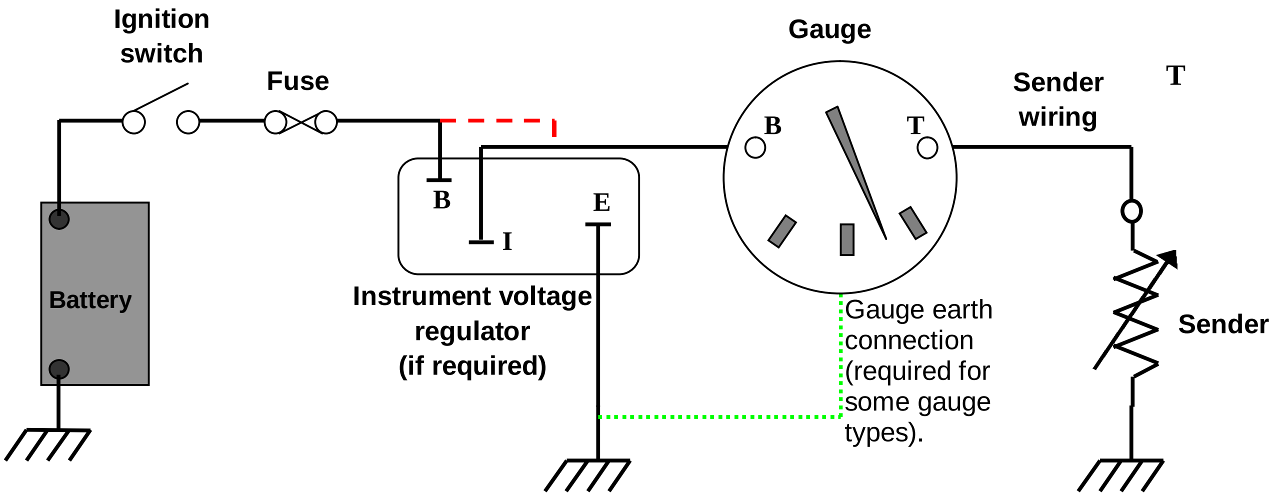


FIGURE 14: Wiring diagram for all electric gauges except: volt gauge and ammeter.
Dashed red line shows connection if no instrument voltage regulator is used.
Dotted green line shows required earth connection for FG, TC and ACx gauges
The voltage regulator is only used with "BF" and "BT" type bimetal gauges. "BP" gauges may, or may not, require a voltage regulator depending on the type of pressure sender – Resistance or Bimetal.

When checking for voltage in bimetal gauge circuits, first check at the "B" terminal of regulator then at the gauge. The original regulators switched voltage at the "I" terminal on and off once they had warmed up, so when testing make sure to wait a few seconds to determine whether the regulator is working – the voltage should start switching off and on within 30 seconds. An LED and resistor or LED test lamp is the best tester to use for this test. The LED does not have the thermal inertia of an incandescent bulb and will blink once or twice per second if the voltage regulator is working and likely to be good. Dimming of an incandescent test lamp may be hard to determine.

In the case of a "solid-state" regulator, the output voltage will be a constant 10V and can be checked with a standard volt- or multi-meter.

To test the earth circuit, measure voltage between instrument cases and vehicle body with the dashboard lights on. Earths usually loop from instrument case to instrument case so it may only be one gauge that is causing grief. Note that the instrument voltage regulator is often mounted on and earthed via the speedometer case. If a voltage can be measured between any case and earth when the ignition or lights are ON, then that earth connection is suspect. You may get a few millivolts here testing a good system but any more and the earthing should be checked.

BATTERY CONDITION GAUGE:

The voltmeter, or battery condition gauge wiring, is much simpler and is set out in *fig. 15*. Again, the fuse may not be present.

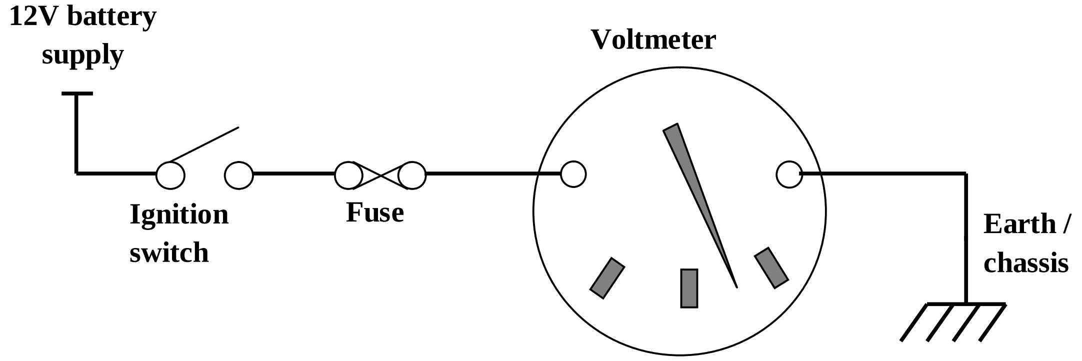


FIGURE 15: Wiring diagram for voltage (aka "Battery condition") gauge.

AMMETER:

Ammeters are completely different beasts and are wired in series with the main feed from the battery with larger diameter wires. The only load not originally measured by an ammeter is the starter motor. If heavy loads, such as driving lights or electric radiator fans have been added to a vehicle and wired either directly, or through a relay, to the battery terminal, then these loads will not pass through the ammeter and provide a misleading reading. Ammeters do not require a connection to earth for their operation.

If fitting an ammeter, wire it in as shown in *fig. 16* below and turn something on, e.g. headlights. The pointer should show "discharge" or "-". If it is indicating a charge then simply swap the connections at the rear of this gauge. (You will need to do this if converting a positive earth vehicle, fitted with an ammeter, to negative earth.) Note that each terminal on an ammeter will be permanently live so insulate all connectors. "Classic" Smiths and Lucas ammeters will not be damaged if connected back-to-front. Ammeters can really only fail if they have burnt out, usually as a result of a short circuit or being connected between 12V and earth, in which case nothing else, apart from the starter motor should work. Replace a faulty ammeter.

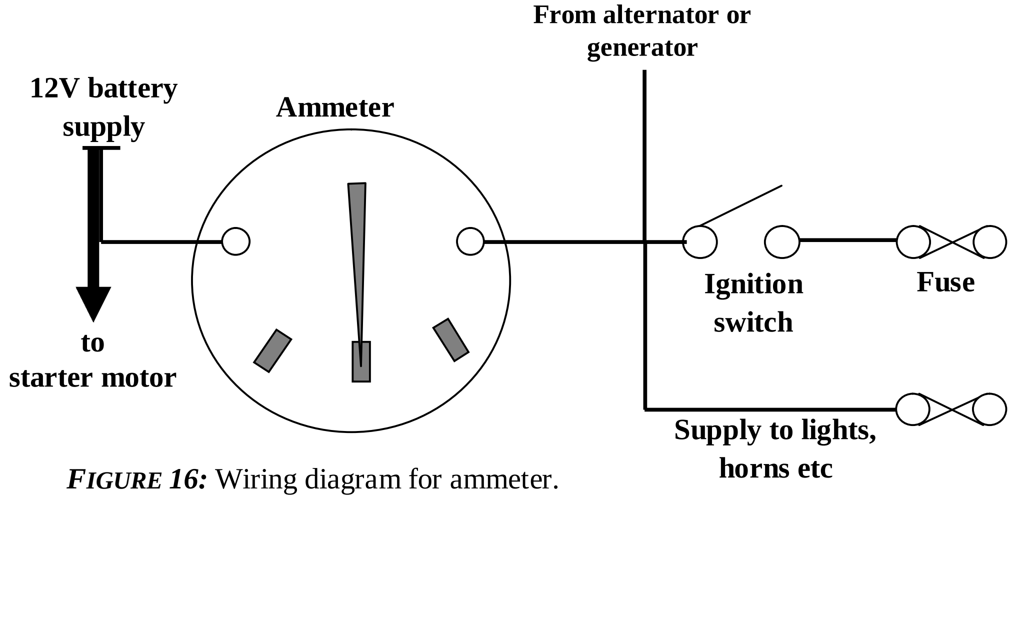


FIGURE 16: Wiring diagram for ammeter.

OPERATIONAL CHECK OF SMITHS ELECTRICAL GAUGES:

Whether the sender is a resistive element, such as a tank unit or temperature sender, or an interrupter, such as the TT1200 and many pressure senders, a resistor can be substituted for the sender to check the gauge's operation.

The resistors set out in the columns for "Nearest preferred value" in the following table approximate the value in Ohms (Ω) to check the operation of the respective type of gauge which should read at, or near, low-scale mark and high-scale mark when that resistor is substituted for the sender.

All resistors should have a power rating of 1 Watt or more.

Nominal resistance values are those used in Smiths SR/D380 tester. (*Data sourced from Mark Olson, who reverse-engineered one of these devices*.)

<table>
<tr><th colspan="6">Table B: Resistor values to check operation of different 12V gauges</th></tr>
<tr><th rowspan="2">SWITCH POSITION</th><th rowspan="2">GAUGE PREFIX</th><th rowspan="2">GAUGE INDICATION</th><th rowspan="2">NOMINAL RESISTANCE (OHMS)</th><th colspan="2">NEAREST PREFERRED VALUE (OHMS)</th></tr>
<tr><th>E12</th><th>E24</th></tr>
<tr><td>1: Fuel Gauge E:</td><td>FG</td><td>Empty</td><td>3.3</td><td>3.3</td><td>3.3</td></tr>
<tr><td>2: Fuel Gauge F:</td><td>FG</td><td>Full</td><td>75</td><td>68</td><td>75</td></tr>
<tr><td>3:Thermal C:</td><td>TE/PE/BP</td><td>Cold</td><td>63.3</td><td>68</td><td>62</td></tr>
<tr><td>4:Thermal H:</td><td>TE/PE/BP</td><td>Hot</td><td>310</td><td>330</td><td>300</td></tr>
<tr><td>5:Semi-Cond C:</td><td>TC</td><td>Cold</td><td>550</td><td>560</td><td>560</td></tr>
<tr><td>6:Semi-Cond H:</td><td>TC</td><td>Hot</td><td>10</td><td>10</td><td>10</td></tr>
<tr><td>7: BiMeta| 10V CE:</td><td>BF/BT</td><td>Cold/Empty</td><td>256.8</td><td>270</td><td>270</td></tr>
<tr><td>8: BiMeta| 10V N ½:</td><td>BF/BT</td><td>Normal/Half</td><td>68</td><td>68</td><td>68</td></tr>
<tr><td>9: BiMetal 10V HF:</td><td>BF/BT</td><td>Hot/Full</td><td>18.9</td><td>18</td><td>18</td></tr>
<tr><td>10: BiMeta| 5V CE:</td><td></td><td>Cold/Empty</td><td>72.7</td><td>68</td><td>75</td></tr>
<tr><td>11: BiMeta| 5V N ½::</td><td></td><td>Normal/Half</td><td>22.8</td><td>22</td><td>22</td></tr>
<tr><td>12: BiMeta| 5V HF:</td><td></td><td>Hot/Full</td><td>10</td><td>10</td><td>10</td></tr>
</table>

CAUTION: THESE RESISTORS CAN GET VERY HOT!!

For all bimetal gauges ("TE", "PE", "BF", "BT", "BP", "BV"), it can take several tens of seconds for the gauge pointer to reach its final position. Allow two minutes for these gauges to stabilise when checking.

For voltmeters (BV and ACV) and ammeters, calibration is checked against a suitable Volt meter or Ammeter.

The SR/D 366 (10 & 12V), SR/D 380 (5, 10, 12 & 24V) and SR/D 409 testers (5V, 10V, 12V, 24V and Air Cored), (there may be other testers) are field test devices that give an indication of a gauge's operation. Gauge calibration is a different matter. All gauges of a particular type are calibrated to sender resistance values for the particular type. Calibration is done against datum points marked on the dial as can be seen in the following *fig. 17*. Note how the scale alignment differs between these two gauges. Bimetal temperature gauges are shown here but the same calibration values also apply to "BF" type fuel and "BP" type pressure gauges.

GAUGE CALIBRATION:

Actual calibration of a gauge is performed using calibration points marked on the dial which may, or may not correspond with the minimum and maximum values printed on the dial of the gauge.

All gauges of a particular type are calibrated to the same resistance values at each calibration point. In the case of bimetal gauges, types “BF”, “BP” and “BT” are all calibrated identically. There may be differences between the calibration points and the scale markings between gauges but these differences permit only a “fine-tuning” of the parameter being displayed, such as a gauge/sender combination with a gauge marked in degrees F vs a gauge marked in degrees C.

Calibration values are presented in *Table B* below. (Bold numbers are from Smiths service data and correspond to calibration marks on dial. Non-bold values are derived values from other than service data records.)

Many of these are non-standard values for the range of resistors usually stocked by retail electronic parts outlets. Non-standard resistor values in *Table B* are displayed in *italic text* and give those values that should cause the pointer to move to the lower, mid (where applicable) and upper scale calibration points.

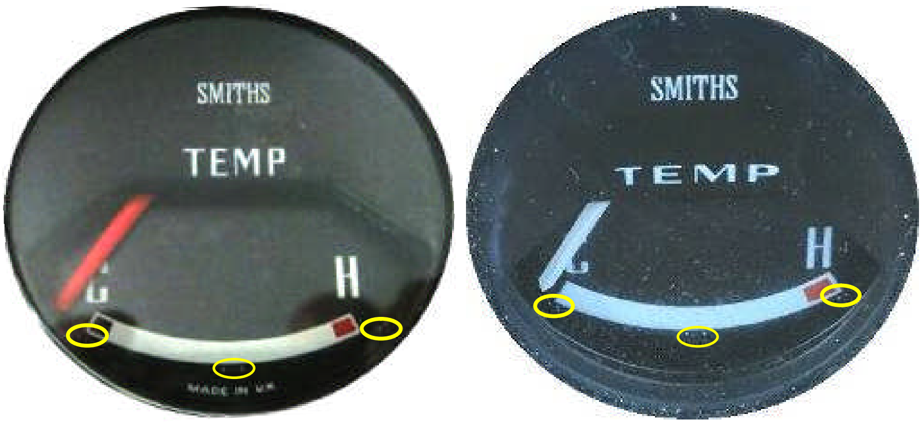
TABLE B: GAUGE CALIBRATION

Gauge type	**Low-scale**	**Mid-scale (Ohms)**	**High-scale**
Bimetal (early) TE prefix	68		*310*
Bimetal (early) PE prefix	*310*		68
Moving iron FG prefix	***4***	***45***	**75**
Moving Iron TC prefix	***550***	***26.4***	***8.8***
Bimetal (late) Bx prefix	240	68	20
Air cored ACx prefix (Gauges fitted to some European cars use different values)	240 (same as bimetal)	68 (May not have mid-scale calibration marks.)	20

This “fine-tuning” between gauge scale and calibration points can be seen when comparing the scale markings as shown in *fig. 17* below. In this case the difference arises from the vehicle manufacturers’ requirements. Any significant change in range must be accommodated by the sender itself.

It is worth noting here that the lower and upper calibration points define only how the gauge is calibrated and have no bearing on the associated sender. Maximum and minimum resistance values of a sender are not necessarily the same as the calibration values.

FIGURE 17: BT2204/07 on left. BT2204/24 on right. Yellow ovals mark calibration points. Note Hot calibration point relative to the printed scales.



FG (FUEL) AND TC (TEMPERATURE) MOVING IRON GAUGES:

"FG" fuel gauges have been around for a long time. Inside the gauge, two coils generate a magnetic field that causes the pointer, attached to a bow-tie shaped piece of iron, to take up a position that is a function of the combined magnetic field produced by the coils. This piece of iron is mounted on a spindle to which is attached the gauge's pointer. As the current through the coils changes in response to changes in the resistance of the sender, the resultant magnetic field also changes causing the pointer to move. The gauge connects to a tank level sender which comprises a variable resistor which varies the current through the coils and thus the position of the pointer. "FG" gauges were produced in 6V, 12V and 24V forms.

The TC range (a.k.a. "semiconductor") gauges are Smiths "second generation" electrical temperature gauge. They operated in a similar manner to the "FG" fuel gauge. "TC" gauges employed a Negative Temperature Coefficient (NTC) thermistor as the temperature sensor. (A thermistor is a material, the resistance value of which depends on its temperature. "Negative Coefficient means that the resistance reduces as the temperature increases. Positive Temperature Coefficient (PTC) thermistors do exist and are used as sensors on some modern cars.)

Fig.18 at right is a diagrammatic representation of this type of gauge. "A" and "B" are the magnetic pole pieces on which the coils are wound. These attract the iron "bow-tie" to which to the pointer is attached. As the relative currents in the coils change, the pointer moves between cold and hot (or empty and full) positions indicated by dashed pointer outlines.

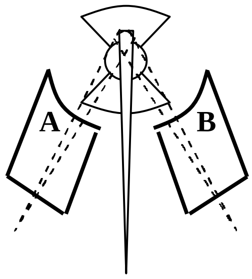


FIGURE 18: Moving iron fuel and temperature gauge construction.

With most other gauges, the worst that can happen if there is no, or a bad, earth connection to the gauge case is that the light won't work. With these gauges, lack of a good earth will cause the gauge to sit at one end of the scale, usually "zero", all the time.

The diagram in *fig. 19 below* is an electrical circuit diagram of moving-iron gauges. (The fuel gauge has an internal resistor (shunt) connected between the B and T terminals.) Note that in each of these gauges, one end of one coil is connected to earth (circled in green) via the metal case of the gauge itself.

Hint: If you have either or both of these gauges fitted to your vehicle and the readings change when you turn the lights on then check the earth connection to the dashboard/gauges!

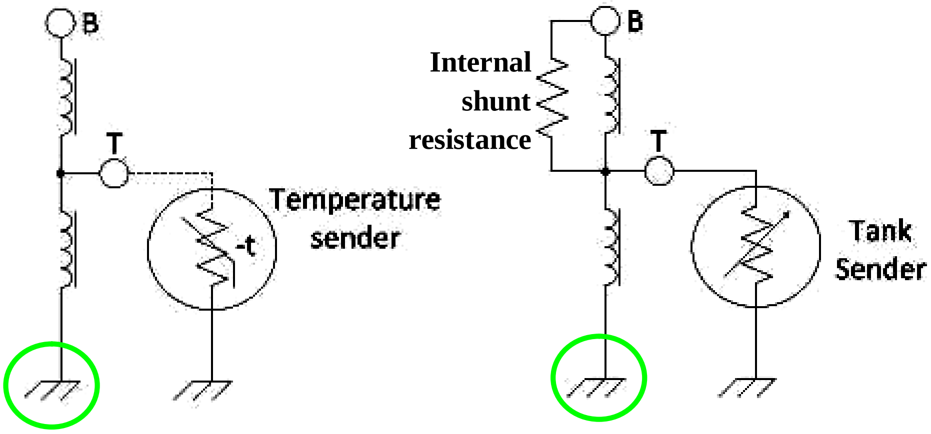


FIGURE19: Internal wiring diagrams for TC temperature and FG fuel gauges

Unlike bimetal gauges, these gauges must be connected to the car wiring in a specific way with the "B" terminal to the battery supply and the "T" terminal to the sender for them to work correctly. The letters "B" and "T" are marked adjacent to the terminals on the rear of the instrument.

Hint: In many cases the "B" terminal is fitted with a dual-blade connector where the "T" terminal has a single blade. This is to allow daisy-chaining of the supply for other instruments but can be a handy way of identifying the terminals when the back of the gauge is obscured. **According to Smiths, these gauges can be damaged if the battery supply is connected to the "T" terminal.**

Table C	**Identifying FG gauge terminals**	
Terminals	Resistance – 12V gauge	Resistance – 6V gauge
B to case	152.5 to 168 Ohms	39 to 46 Ohms
B to T	57.5 to 63 Ohms	17 to 20 Ohms
T to case	95 to 105 Ohms	22 to 26 Ohms

When installing, or re-installing, these gauges take extra care to get the "B" and 'T" connections right. If uncertain, measure resistance between each of these terminals and case. According to early Smiths data for "FG" gauges, measured resistance should be within the limits given in Table C below:
No comparable published data for "TC" gauges is to hand. Two versions of this gauge have been identified. The first simply has the gauge part number printed on the dial. The second has the gauge part number followed by "MMI", as shown in fig. 20 below, and these two variants have significant differences in resistance for B–T and B-case values. The following table should provide sufficient data to enable the "B" and "T" terminals to be identified. "TC" gauges were never produced in 6V versions.

Table D	**Identifying TC gauge terminals:**	
Terminals	Resistance – MMI gauge	Resistance – non-MMI gauge
B to case	247 to 262 Ohms	226 to 233 Ohms
B to T	96 to 108 Ohms	71 to 77 Ohms
T to case	152 to 165 Ohms	152 to 165 Ohms

The above values were determined by measuring 4 of each type of gauge so are representative only. If you wish to check the calibration of a "TC" temperature gauge then the resistor values that should have the pointer aligning with the calibration marks (arrows in *fig. 20* below) are:

C – 550 Ohms (560)
N – 26.4 Ohms (27)
H – 8.8 Ohms (10)

Resistor values in brackets are the nearest standard E12 values and will have the pointer very close to the calibration marks.

FIGURE 20: TC temperature gauge – non-MMI on left, MMI (circled) on right

There is no difference in calibration between these two types of temperature gauge. Note that the examples in *fig. 20* are both are marked "TC 6210/01.

FG GAUGES TROUBLESHOOTING:

TABLE E	FG FUEL GAUGE	
Fault	Cause	Remedy
Gauge pointer doesn't move from EMPTY	No voltage supply to gauge	Check wiring and fuse. Check earth connection to case of gauge.
	Sender or wiring short-circuit	Remove wire from sender terminal. Sender fault if pointer moves to FULL. Else check wiring.
	Gauge faulty	Remove wire from sender terminal. Gauge faulty if pointer remains at EMPTY. Repair or replace gauge
Gauge pointer moves to FULL and remains there.	Sender open-circuit	Connect gauge "T" terminal to earth through a small bulb or resistor. Wiring or sender fault if pointer moves to EMPTY.
	Open-circuit in wiring	Disconnect at sender and briefly connect sender wire to earth. Sender faulty if pointer moves to EMPTY. Replace sender else check gauge and sender wiring.
	"B" and "T" terminals swapped	Check wiring and remedy. (Unlikely unless re-wiring of gauges has been done.)
Gauge inaccurate	Gauge out of calibration	Check gauge with test unit or resistance values provided later in document. Re-calibrate or replace gauge if out of calibration.
	Sender out of calibration	If gauge satisfactory, replace sender.

FG gauges need a good earth at the gauge in order to work and are supplied with 12V directly from the switched ignition supply. Do not use an instrument voltage regulator with these gauges. The sender for the FG type gauge has a low resistance when the tank is empty (< 4Ω) and a higher resistance with a full tank (> 75Ω). BF type gauges use a different sender - > 240Ω empty and < 20Ω at full. If you wish to replace one of these gauge types with the other, then both gauge and sender must be replaced.

Note: Due to internal changes made to these gauges, some older "FG" type gauges may read EMPTY when "B" and "T" terminals have been wired wrongly. This behaviour has only been seen in gauges marked "X.nnnnn".

TC GAUGES TROUBLESHOOTING:

TC temperature gauges are similar but act opposite to the fuel gauge in operation.

TABLE F	TC TEMPERATURE GAUGE	
Fault	Cause	Remedy
Gauge pointer doesn't move from COLD	No voltage supply to gauge	Check wiring and fuse. Check earth connection to case of gauge.
	"B" and "T" connections swapped.	If gauge has just been installed or re-installed check these connections. Connect correctly if required.
	Open-circuit in wiring	Connect gauge "T" terminal to earth through a small bulb or resistor. Wiring or sender fault if pointer moves to HOT. Else gauge faulty.
	Sender faulty	Disconnect wire at sender and briefly connect to earth. Sender faulty if pointer moves to HOT. Replace sender else check wiring.
	Gauge faulty	Repair or replace gauge.
Gauge pointer moves to HOT and remains there.	Poor or no earth at gauge	With ignition on, check voltage between case of gauge and a good earth. Should be 0V. Make sure gauge is earthed.
	Sender short-circuit	Disconnect wire at sender. Sender faulty if pointer moves to COLD.
	Short-circuit in wiring	Check wiring, ensuring connections are correct.
	Gauge faulty	Repair or replace gauge
Gauge inaccurate	Sender out of calibration Gauge out of calibration	Check gauge with test unit or resistance values provided later in document. Re-calibrate or replace gauge if out of calibration. If gauge satisfactory, replace sender.

AIR-CORED GAUGES:

Later 1970s cars may be fitted with air-cored gauges, prefixed "ACx" where "x" can be "T" (temperature), "F: (fuel), "P" (pressure) or "V" (voltage). Air-cored, "ACx", gauges are an updated version of the earlier "FG" and "TC" moving iron gauges.

As with the "FG" and "TC" gauges, these are also a "three-terminal" gauge requiring a good earth to operate. Unlike the earlier moving-iron gauges, these are not repairable, neither are they adjustable.

Fig. 21 below (*copied from Smiths service bulletin #150, dated July 1974*) shows the circuit diagram of one possible configuration of the Air Cored gauges (*sender connected across the "C" winding*). There is also an "ACV" voltage gauge but the internal connections have the calibration resistor replaced by a Zener diode.

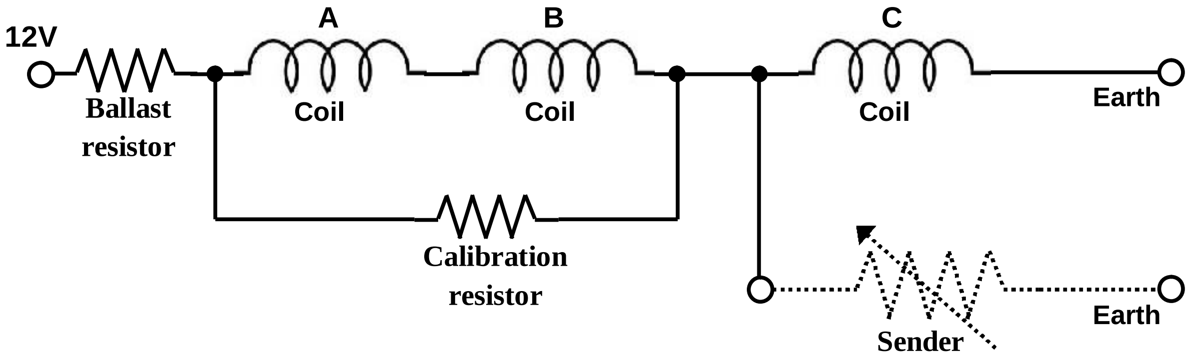


FIGURE 21: Circuit diagram of Smiths Air Core gauge

In operation these gauges work in a similar manner to the moving-iron "FG" and "TC" gauges. A magnetic field is generated that causes a pointer to move depending on the sender resistance and hence the resultant field. The significant differences between these gauges and moving iron gauges are that these have a magnetised armature driving the pointer, thus they are polarity conscious.

Two air-core gauges to hand are both pressure gauges and terminals are marked differently. Each has a male ("B") and female ("T") spade terminal on the back, in one case they are marked "B" (battery) and "T" (transmitter /sender) and in the other markings are "1" and "2". These also have only two calibration points marked on the dial. Calibration resistances are 240 Ohms (Cold/Empty/ zero end of scale) and 20 Ohms at the top end (Hot/Full/full scale).

Smiths air cored gauges are produced calibrated to two different standards; Smiths Instrument and Euro. These are referred to as "A Winding" (Smiths) and "B Winding (Euro) gauges. Those calibrated to Euro standard will not be accurate with classic Smiths senders, and vice versa.

Air cored gauges calibrated to Smiths standard can replace most Smiths bimetal gauges when connected to the switched ignition supply, not to the instrument voltage regulator, and a good earth is provided (which is normally required for gauge lighting). The pointer of air cored pressure gauges will continuously swing from zero to full scale if connected to a bimetal type (PTnnnn) sender, **so an air cored pressure gauge cannot be directly substituted for a bimetal pressure gauge unless a suitable sender (PTRnnnn) is also fitted**.

AIR-CORE GAUGES TROUBLESHOOTING:

Note: Air cored gauges are non repairable and cannot be recalibrated. They are also heavily damped and take a little time to fully react to a change. They are polarity conscious and can only work on negative earth vehicles. These gauges, with the exception of the voltmeter, will survive reversed polarity.

To check a 12 Volt gauge, other than voltage, measure resistance between “B” and “T” terminals which should be close to 250 Ohms. Resistance between “T” terminal and earth should be about 300 Ohms.

For a 24 Volt gauge, resistance between B and T terminals should be about 520 Ohms. Resistance between “T” terminal and earth should be about 300 Ohms as for the 12 Volt gauge.

	AIR CORED GAUGE	
Fault	Cause	Remedy
Gauge pointer doesn’t move from EMPTY/COLD/ZERO	No voltage supply to gauge	Check wiring and fuse.
	“B” and “T” terminals swapped	Check wiring. Some gauges have a “T” terminal with female spade fitting and the “B” terminal has a male spade which should make a wrong connection impossible.
	Open-circuit in wiring	Connect gauge “T” terminal to earth through a small bulb or resistor. Wiring or sender fault if pointer moves upscale. Else gauge faulty.
	Sender faulty	Disconnect wire at sender and briefly connect to earth. Sender faulty if pointer moves upscale. Replace sender else check wiring.
	Gauge faulty	Replace gauge.
Gauge pointer moves to FULL/HOT/FULL-SCALE	No earth connection	Check earth connection to case of gauge.
	Sender short-circuit	Disconnect wire at sender. Sender fault if pointer moves to EMPTY/COLD/ZERO. Else check wiring
	Short-circuit in wiring	Check wiring ensuring connections are correct.
Gauge inaccurate	Sender out of calibration	Check gauge with test unit or resistance values provided later in document.
	Gauge out of calibration	Replace gauge if out of calibration. If gauge satisfactory, replace sender.

ACx gauges should read at the low end of the scale with no voltage present. If the gauge indicates above zero with no voltage applied, gauge is faulty. These gauges have a small magnet inside to return the gauge to zero when power is removed.

BIMETAL GAUGES:

Bimetal elements are comprised of two pieces of dissimilar metals bonded together. All things expand with heat and metals are no exception. Some metals expand a little bit and some expand a lot.

Bimetal devices are found everywhere. Commonly used in thermostats in domestic appliances. In cars they are found in temperature switches, automatic choke mechanisms and (older) flasher units for direction indicators/hazard warning lights as well as gauges and instrument voltage regulators. Their operation is as follows:

As the name suggests, bimetal elements comprise two different metals bonded together. Each of the metals has a different thermal coefficient of expansion and so changes in temperature cause the bimetal element to distort or change shape.

Fig. 22 shows a bimetal bar, at low temperature (top) and its reaction to heat (bottom). In this example the metals are copper (orange) and steel (black), When this bar is heated, the copper expands more than the steel and the bar bends as shown.

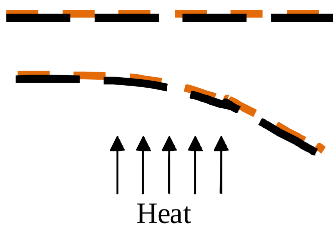


FIGURE 22: Bimetal element construction and operation

The degree of bending depends on both the materials used and the change in temperature. This change in shape can be used to drive a pointer or operate an electrical switch.

It is worth bearing in mind that bimetal elements have a "thermal mass" and will not respond quickly to changes. Typically a change in temperature will not be fully responded to for a period of several tens of seconds. Compare this with the action of moving iron gauges which respond immediately to any change.

Bimetal gauges are the most common Smiths electrical gauge. The first bimetal gauges were the "TE" type gauges introduced in the mid-1950s. By the mid 1960s, the bimetal "BF" gauge had replaced the earlier moving-iron FG gauge and the "BT" temperature gauge had replaced the "TC" gauge which itself had replaced the earlier "TE" type. These "new" (BF and BT) gauges were supplied with a lower (average) voltage from the instrument voltage regulator described above.

The sketch in *fig. 23* on the next page shows the basic construction of a bimetal gauge. Operation is straightforward. The heating coil heats in response to the current flowing through the resistance wire wound around it. As the bimetal bar moves, it moves the pointer across the scale. Only two connections to the gauge are required and it doesn't matter which terminal is connected to supply or sender. The terminals are labelled "T1" and "T2" here but there are no markings on the gauge itself. Unlike the instrument voltage regulator, there really is little to go wrong.

THE DIFFERENCE BETWEEN BIMETAL/THERMAL/BITHERMAL" GAUGES:

"Bimetal" describes those gauges that employ a bimetal element to move the pointer and require an instrument voltage regulator for correct operation. "Thermal" and "Bithermal" are used interchangeably to describe those gauges that do not require the regulator but are driven by bimetal-type senders – "TE", "PE" and "BP" gauges. The "BV" voltage gauge is also included in this group. Within this document "bimetal" refers to all these gauges with differences noted as required.

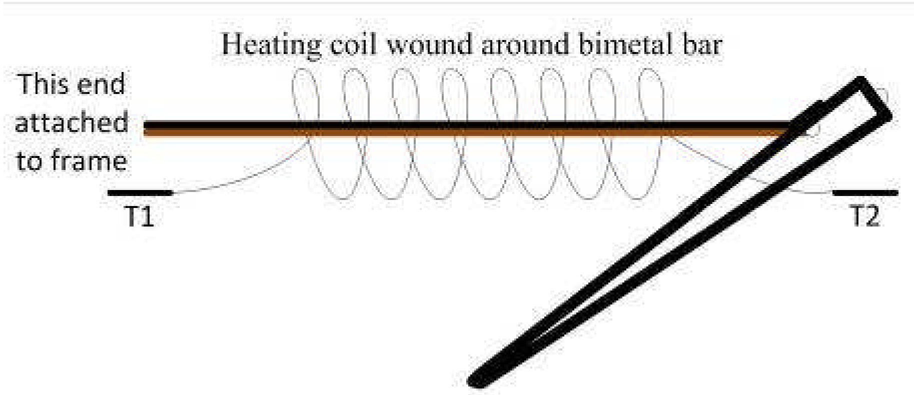


FIGURE 23: Smiths bimetal gauge schematic diagram.

Fig. 24 below shows the internal construction of Smiths bimetal gauge, an early gauge on the left and the later gauge on the right. The significant difference between them was the metal plate covering the adjusting plates in the earlier gauge. With the resulting large metal-to-metal contact area, it did not need much corrosion to effectively lock everything together. The later gauge did away with this cover plate and the means of adjustment can be readily seen.

Slotted holes allowing adjustment of support plates.

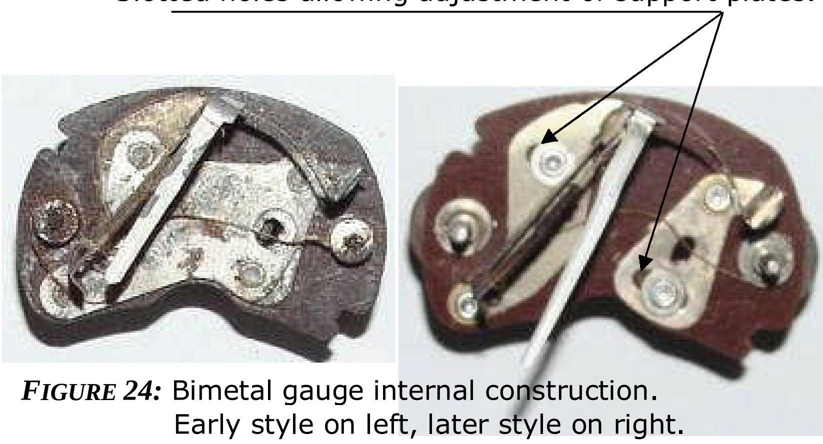


FIGURE 24: Bimetal gauge internal construction.
Early style on left, later style on right.

"TE" TEMPERATURE AND "PE" PRESSURE GAUGES:

Early electric temperature gauges were marked "X.{number}" and "TE {number}". The TE gauges were bimetal gauges that operated directly from the car's 12V system – the associated sender unit functioning as a temperature controlled voltage regulator. The sender itself is a bimetal unit in which a contact (switch) within the sender opens and closes the circuit generating an average electrical current resulting from the switching duty cycle. For testing purposes, this switching cycle can be simulated by a fixed resistance, for which values are given in Table B (page 12).

"TE" gauges can be identified by the fact that the pointer of the "TE" gauge sits at the upper (hot) end of the scale with no voltage present, rather than at the lower end as the later gauges do.

Bimetal gauges (all) give very little trouble, provided they have not been overheated, which can happen if a sender is short circuited or the regulator has failed for a significant length of time.

Note that "TE/PE" and "BT/BP" gauges are not electrically interchangeable. The "TE/PE" gauges have a heating coil resistance of about 25 Ohms. The corresponding value for the "Bx" gauges is about 62 Ohms. The sender has a low (effective) resistance when cold and high when hot. (i.e. a positive temperature coefficient or "PTC") More usually, temperature senders work the other way with a high resistance corresponding to a low measured value and a low resistance corresponding with a high value (Hot/Full/max pressure).

“TE”/”PE” GAUGE TROUBLESHOOTING:

Check for voltage between each gauge terminal and earth with the engine cold. One terminal should measure 12 - 14V and the other about half this figure. Note that, like the voltage regulator the sender interrupts the circuit so the sender terminal voltage will alternate between 12V and 0V. This will produce an erratic reading on a voltmeter but this is normal.

FIGURE 25: Bullet style terminals on TE gauge.

“TE” gauges may have bullet style terminals and these can be readily dislodged. *Fig. 25* shows these connectors on such a gauge. If you have done some work behind the dashboard and the gauge stops working then these connections are first thing to check.

“TE” GAUGE:

TABLE H	**TE TEMPERATURE GAUGE**	
Fault	Cause	Remedy
Gauge pointer doesn’t move from HOT	No voltage supply to gauge	Check wiring and fuse
	Sender or wiring open-circuit	Remove wire from sender terminal and connect wire briefly to earth through a low value resistance (e.g. small dashboard lamp) . Sender fault if gauge moves toward COLD. Else check wiring.
	Gauge faulty	Remove wire from sender terminal of gauge and connect to earth through a gauge bulb or similar**. Sender or wiring fault if pointer moves to COLD. Repair or replace gauge
Gauge pointer moves to COLD and remains there.	Sender short-circuit	Remove wire from sender terminal. Wiring or sender fault if pointer moves to HOT.
	Short circuit in wiring	Reconnect sender wire to gauge and disconnect at sender. Sender faulty if pointer moves to HOT. Replace sender else check wiring.
Gauge inaccurate	Sender out of calibration	Check gauge with test unit or resistance values provided within this document.
	Gauge out of calibration	Re-calibrate or replace gauge if out of calibration. If gauge satisfactory, replace sender.

****** A direct short to earth can damage these gauges!!

"PE" GAUGES:

TABLE I	PE PRESSURE GAUGES	
Fault	Cause	Remedy
Gauge pointer doesn't move from ZERO	No voltage supply to gauge	Check wiring and fuse
	Sender or wiring open-circuit	Remove wire from sender and connect to earth through a gauge bulb or similar**. Sender fault if pointer moves to FULL-SCALE. Else check wiring
	Gauge fault	Remove wire from sender terminal of gauge and connect to earth through a gauge bulb or similar**. Sender or wiring fault if pointer moves to COLD. Repair or replace gauge
Gauge pointer moves to FULL-SCALE and remains there.	Sender short-circuit	Remove wire from gauge sender terminal. Wiring or sender fault if pointer moves to ZERO.
	Short circuit in wiring	Reconnect sender wire to gauge and disconnect sender. Sender faulty if pointer moves to ZERO. Replace sender else check wiring.
Gauge inaccurate	Sender out of calibration	Check gauge with test unit or resistance values provided later in document.
	Gauge out of calibration	Re-calibrate or replace gauge if out of calibration. If gauge satisfactory, replace sender.

The PE gauge is the same as the TE gauge apart from the fact that the pointer sits at the lowest point on the scale when power is removed.

** A direct short to earth can damage these gauges!!

BIMETAL GAUGES (EXCEPT "BP" AND "BV" GAUGES):

There is little to go wrong. Provide voltage and a sender and they should work.

Note that these gauges react slowly to changes. Allow several seconds after making a change to the sender input to allow the gauge to move to its new position.

If a single gauge is simply indicating a wrong value and responds to changes normally then either the sender or gauge is out of calibration. Replace sender or have gauge calibrated. When both BF and BT gauges are fitted and both gauges are reading wrongly, the instrument voltage regulator is the most probable cause.

TABLE J	**BIMETAL GAUGE**	
Fault	Cause	Remedy
Gauge pointer doesn't move from EMPTY/COLD	No voltage supply to gauge Open-circuit in wiring Sender faulty Gauge faulty	Check wiring and fuse. Check earth connection to case of gauge. Connect gauge "T" terminal to earth through a small bulb or resistor. Wiring or sender fault if pointer moves to FULL/HOT Else gauge faulty. Remove wire from sender terminal on gauge and connnect to earth through a small bulb or resistor. Sender faulty if pointer moves to FULL/HOT. Replace sender else check wiring. Repair or replace gauge.
Gauge pointer moves to FULL/HOT.	Sender short-circuit Short-circuit in wiring	Disconnect wire at sender. Sender faulty if pointer moves to EMPTY/COLD. Check wiring ensuring connections are correct.
Gauge inaccurate	Sender out of calibration Gauge out of calibration	Check gauge with test unit or resistance values provided later in document. Re-calibrate or replace gauge if out of calibration. If gauge satisfactory, replace sender.

"BP" GAUGES:

Internally these gauges are identical to the BF/BT gauges. The difference is in the way they are wired in a vehicle. The original pressure transmitters used with these gauges were bimetal devices that are essentially a pressure-sensitive voltage regulator and the gauges are supplied with unregulated 12 Volts. It is also possible that some of these were provided with variable-resistor type senders in which case these would need to be supplied from the instrument voltage regulator. This should be shown on the vehicle's wiring diagram. Later pressure senders used with air cored gauges are variable resistance type senders.

"BP" BIMETAL GAUGES TROUBLESHOOTING:

TABLE K	**BP PRESSURE GAUGES**	
Fault	Cause	Remedy
Gauge pointer doesn't move from ZERO	No voltage supply to gauge Sender or wiring open-circuit Gauge faulty	Check wiring and fuse Connect gauge to earth through a small bulb or resistor. Sender faulty if gauge reads FULL-SCALE. Else check wiring Remove wire from sender terminal on gauge and connect to earth through a small bulb or resistor. Gauge fault if no change. Repair or replace gauge
Gauge pointer moves to FULL-SCALE and remains there.	Sender short-circuit Short circuit in wiring	Remove wire from sender terminal on gauge. Sender faulty if pointer moves to ZERO. Check wiring.
Gauge inaccurate	Sender out of calibration, Gauge out of calibration	Check gauge with test unit or resistance values provided later in document. Re-calibrate or replace gauge if out of calibration. If gauge satisfactory, replace sender.

Testing "BP" gauges is exactly the same as testing the "PE" gauge but the senders and calibration resistance values differ.

VOLTMETERS AND AMMETERS:

Voltmeters connect between switched 12V supply and earth. Provided connections are good they should work unless a fuse (when fitted) is blown or the gauge is damaged. The resistance of the heating element in the "BV" gauge is 122 Ohms rather than the 62 Ohms of other bimetal gauges. Replace a faulty gauge. "ACV" gauges are wired the same way. Replace if faulty.

For ammeters, see ammeter wiring section. These go or they don't. Replace a faulty ammeter.

THE BIMETAL INSTRUMENT VOLTAGE REGULATOR:

The diagram in *fig. 26* shows how this regulator reduces the effective voltage to the gauges. The ratio of on time to off time will be 5:1 at 12V. As the voltage increases, this ratio will change due to the more rapid heating of the bimetal strip and the on time will reduce. Similarly a reduction in voltage will cause an increase in on time.

***FIGURE 26:* BIMETAL INSTRUMENT VOLTAGE REGULATOR**

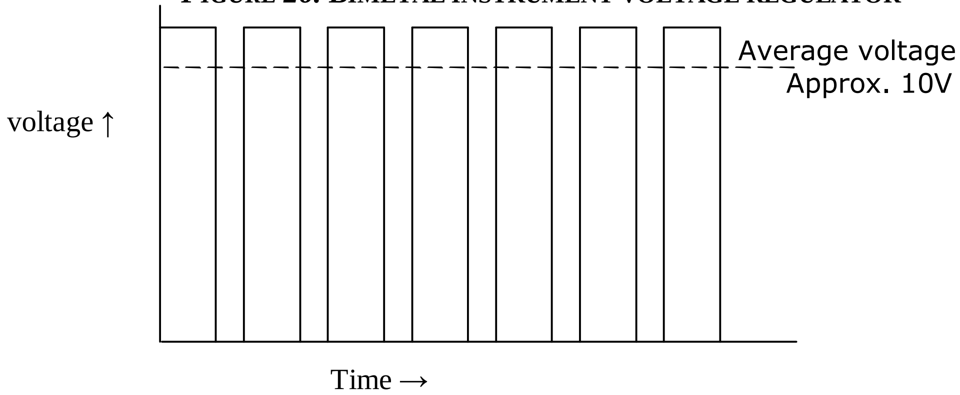


Fig. 27a shows the Smiths instrument voltage regulator looking from above. As shown, the bimetal element is not a simple bar but is a square "U" shape. The bimetal element itself is made as a single piece of metal. It is anchored to the base plate (not shown) at the end of one of the arms and this is the "I" terminal of the device. One end of the heating coil is connected to this terminal through the bimetal element itself. The contact to make or break the supply to the gauges is on the end of the opposite arm which also carries the heating coil. The black line at the base of the U at the left of the diagram represents a bent up section of metal to resist bending as can be seen in *fig. 27b*, which shows a side view of the works of this voltage regulator.

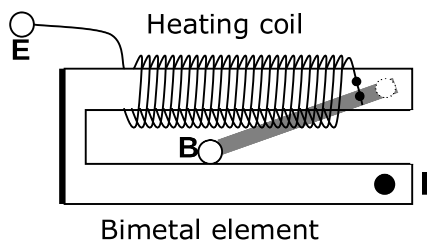


FIG. 27A: Instrument voltage regulator plan view

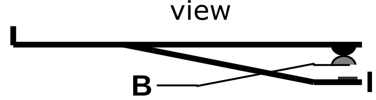


***FIG. 27B*:** Instrument voltage regulator elevation

Bimetal devices respond to temperature from any source including changes in ambient temperature. And that is the reason for the U shaped element. The lower arm, the arm without the heating coil, will bend due to changes in ambient temperature and so compensate for any change in the other arm that performs the switching (regulating) function. This same construction is found in all bimetal gauges and in oil pressure senders but not in bimetal temperature senders such as the TT 1200/00, which respond to changes in "ambient" temperature – "ambient" temperature in the case of a temperature sender is the temperature of the water in the car's cooling system. In the case of the gauge itself, the "ambient" temperature of the gauge can increase markedly on a hot day and when the dashboard lights are turned on. An incandescent bulb is an effective heater and it is operating within an enclosed space for those gauges with the lamp fitted inside the gauge case.

Things to note about this regulator are:

- it needs a good earth connection in order to work

  and

- unlike the senders for "TE/PE/BP" type gauges, the switching off and on is constant.

FIGURE 28: Voltage regulator mounted at rear of a Morris Marina instrument panel.

It is also very important to connect to the correct terminals. Some regulators such as the BR 1307/00 had dual male spade terminals for battery connection and dual female spade terminals for instrument connection. This made it hard to get wrong. The BR 1300/00 was similar but with male connectors only. A mounting plate was fixed to the case of most regulators. These were designed to mount on the rear of a speedometer or on a metal panel. Those regulators without a mounting flange, such as the BR 1303/20, are intended to plug in to connectors on the rear of an instrument panel as can be seen in the photo of part of a Morris Marina instrument panel in *fig. 28* and in *fig. 14* earlier in this document.

If replacing one of these regulators, there are a few points to keep in mind. Quite apart from the connector/mounting styles the regulator must have the correct regulated output voltage: 10 Volts for Smiths instruments, 7 Volts for AC Delco instruments (from memory) and 5 Volts for Ford and VDO instruments.

For those regulators fitted with male spade terminals only, make sure when refitting that the correct wires go to the correct terminals. If the "B" and "I" terminal connections are swapped, the supplied gauges may read briefly then not at all. The bimetal bar can "overheat" and may develop a "set" that will prevent it making contact with the "B" terminal and the regulator will need replacing (again).

The following is from a British Leyland – Triumph service note. This applies only to the bimetal regulator:

> “The first step should be to check the correct output of the voltage stabilizer which, in the case of the models previously mentioned, should be 10 volts. To do this accurately, the use of an ordinary Triumph TR-4 or Spitfire (***bimetal***) temperature gauge taken from stock will be most useful. Connect a 12 volt 2.2 watt bulb (dash illumination bulb) in series with the test gauge. This will introduce sufficient resistance in the circuit to allow the gauge to just read full scale when 12 volts is applied.
>
> Next, connect the gauge to a 10 volt source. For example, to the "l" terminal of a known properly functioning stabilizer on a new car. Allow at least 2 minutes for the gauge to register and stabilize, then mark the front of the dial opposite the pointer. The gauge has now been calibrated to read 10 volts.
>
> If you have a suspected stabilizer to test, disconnect the lead from the "I" terminal on the stabilizer. Connect one end of your test gauge to the "I" terminal on the stabilizer, the other to ground, and after 2 minutes note the readings on the test gauge. This should read 10 volts if the stabilizer is in proper working order.
>
> Incidentally, the bulb which is in series with the gauge will also serve as an indicator; and if the circuit is functioning properly, this bulb should glow for approximately 30 seconds and then commence flashing.”

Another method of testing these regulators is provided on the next page.

BIMETAL VOLTAGE REGULATORS TROUBLESHOOTING:

Generally these regulators supply more than one gauge so if the regulator fails, multiple gauges can be affected. Usually, fuel and temperature gauges. If only one of several gauges is affected, the regulator is not the problem.

A quick test can be done to check the bimetal-type instrument voltage regulator output but the calibration dots printed on the scale of the gauge used must be visible. Connect a 68 Ohm, 1 Watt resistor in place of either the fuel or temperature sender and turn the ignition on. (Disconnect the coil if you are not running the engine.) Allow the gauge reading to stabilise for a minute or two then observe the location of the pointer relative to the two centre calibration dots. Refer to *fig. 20* which shows these. The pointer should sit mid way between them. (In some gauges the dots may be replaced by a short bar as in *fig. 29* below.) If the pointer is well outside the dots then the regulator must be suspect. (This assumes that the gauge calibration itself is good.)

TABLE L	**BIMETAL INSTRUMENT VOLTAGE REGULATOR**	
Fault	Cause	Remedy
Gauges reading high	Bad or no earth connection at regulator Regulator out of adjustment or faulty	Check earth wiring Briefly short out the 'B" and "I" terminals of the regulator. If' no increase in the gauge reading, the regulator is faulty. Adjust or replace regulator.
Gauges reading low	Regulator out of adjustment.	Adjust or replace regulator
Gauges not reading	no voltage supply to regulator Regulator connected wrongly Dirty contacts in regulator	Check fuses and regulator connections. Check wiring Replace regulator

There are now a number of "solid-state" regulators on the market and should be much more reliable than the bimetal type. These are polarity sensitive, and are available in positive and negative-earth versions. Be careful testing these regulators. Too much current draw may destroy them. These also require a good earth connection. Test these regulators with a voltmeter. If the output voltage measured is not very close to 10 Volts then the regulator or earth connection is faulty.

FIGURE 29: Gauge scale showing mid-point calibration "bar" in lieu of the more usual dots.

MECHANICAL SPEEDOMETERS:

I'm not going to examine these in detail. A document readily available on the internet, "Repairing-Jaeger-and-Smiths-Speedometers" by Anthony Rhodes is worth reading if you want to know more about these instruments. He has it pretty well right.

There is no real difference between mechanical speedometers and tachometers. Essentially a mechanical tachometer is a mechanical speedometer without the odometer bits.

In the event you want to change a speedometer, either because the old one is shot or you want one that reads in km/h or for any other reason then there are a number of things to take into consideration.

Physical size is pretty obvious but then you may be creating a custom dash in which case that will not be an issue.

The presence, or absence, of warning lights may be a consideration. Warning lights are readily installed elsewhere.

The cable fitting on the back of the speedometer may differ, in which case a new cable will be required. Chances are a suitable cable exists for another vehicle that will do the job though it is a straightforward exercise to have a custom cable made up depending on the inner cable diameter. This can be of 3 mm or "4mm" (actually 3.5mm) diameter. There are, or were standard cable fittings that would get around this little problem. You will almost certainly need to change the fittings if swapping for a "metric" instrument.

Standard 3mm and 4mm fittings can be seen on a Spitfire (and other vehicles) with a 3mm cable driving the mechanical tachometer, whereas the speedometer uses a 4mm cable. The drive cable fitting on the rear of each instrument is very different.

A most important parameter is the turns per mile or turns per kilometre, which will be marked on the dial of a Smiths speedometer. To change from an imperial (miles/h) to a metric speedometer then you will need a speedometer of (tpm x 0.625) tpk. For example, a speedometer of 1184 tpm can be changed for a metric speedo @ 740 tpk. As long as this number remains the same or equivalent and provided no changes have been made to transmissions/differential ratio/tyre sizes then you should be good to go.

There are two parts to speedometer calibration; Odometer and Speed indication. Both are quite separate and repairing/re-calibrating a speedometer involves both. Smiths used a gear and pawl and ratchet combination to drive the odometer and a magnet and hairspring to calibrate for speed. For the odometer part, the gears available had a pitch of 20, 25 or 32 teeth (per inch) and ratchet wheels were available from 20 teeth to about 60 teeth. Later on, a twin-start 25 pitch gear was produced giving a fourth pitch of 12.5. (Metric speedometers fitted to late model Triumphs, such as the 2500S and Stag, are 512.5 turns per kilometre which obviously requires the 12.5 pitch gear.) The odometer calibration was <u>pitch x number of ratchet teeth</u> and this is the tpm/tpk figure on the dial. The degree of magnetisation of the rotor magnet, could be adjusted within fairly wide limits to give the correct speed reading. If you drive the speedometer at the same number of revolutions per minute as the tpm/tpk number printed on the dial then the speedometer should indicate 60 – mph or km/h as appropriate. So with a bit of old cable to fit the speedometer, an electric drill to drive it and a calculator you can quickly check the speed calibration. The revolutions per minute to indicated speed ratio is linear for magnetic instruments – half the rpm should indicate half the speed etc. The calculation to do this is: (drill rpm / tpm) x 60 and this calculated value is what the speedometer should indicate. With a two-speed drill you can check at each drill speed to estimate the linearity of the speedometer. It should be good unless someone has fiddled with it. Similar comments apply to chronometric instruments as fitted to many British motorcycles but the earlier governor type instruments (pre mid 1930s mainly) were not at all linear across the indicated range.

As mentioned above, if you have made changes to the transmission etc then you may need to re-calibrate the speedometer. This is not really the sort of thing you can do in the home workshop though the equipment required is not unduly complex but is most definitely specialised. (*See Appendix D for a method to quickly check odometer gearing*.)

It is possible to check your odometer's accuracy on the road. Somewhere, hopefully not too far away, is a speedometer check area on the road. These usually cover about 3 km but sometimes more and are marked with small signs beside the road. Using an odometer and calculator (they are almost all in metric measurement (km) these days) then rocking up to one of these and using a tripmeter (or odometer if it has a tenths of a mile/km indication) to check distance recorded will give you a measure of the odometer's accuracy and the likely calibration it should have. (Ideally you would have a counter on the cable that accurately counts the number of turns.) It is an unfortunate fact that the majority of these speedometer check areas are in 100km/h zones and often in the middle of nowhere. There may also be a measured mile or kilometre in some cities if you know where to look.

So if you have changed something significantly in your car's drive train then it may be a good investment to have the speedometer (of your choice) recalibrated to suit your car's gearing. It might also help to protect your wallet from plunder resulting from driving too fast.

Check the speedometer drive gear oil seal when an opportunity arises, such as when working on the clutch or driveshaft. This should be done as a matter of course when overhauling/re-conditioning a gearbox. Oil in a speedometer is not something you want to happen as repairs are usually very expensive – particularly in older speedometers as hypoid oils and some brasses do not go well together. Plastic gears etc are unaffected but any particulate matter in the oil will act like grinding paste!

APPENDIX A:- TWO INCH GAUGE MASK STYLES:

The gauge mask, as its name suggests, masks something and in the case of these gauges it is the pointer pivot that is concealed. Smiths have used several mask styles in their round, two inch gauges. Early gauges had no mask. Almost all later gauges have had masks fitted but these are made in different styles as shown below.

The mask has no effect on the gauge, it is purely cosmetic. If replacing a gauge in a "classic" car, then there is a good chance of acquiring one from another vehicle of the same model which will have the "correct" mask.

The photos below show three different masks from Smiths gauges. The two pictures at left show masks from "bottom-scale" gauges, the third from a "top-scale" gauge. All these mask forms are used in both "top-" and "bottom-scale" gauge types.

The portion of the dial covered by the mask also varies but masks will be of a similar form to those shown here.

On the other hand, if you are creating a custom dashboard for a vehicle, then the mask, style will be another point to consider.

If customising a dashboard, the following need to be considered:

Mask style

Pointer style

Pointer colour

Dial/scale - style and colour

Gauge – top or bottom scale

If customising a gauge cluster, where gauges originally have the zero point at the left or bottom (*see fig. 2*), gauges from the same location in a cluster must be used to maintain this pattern. The calibration of FG, TC and amps gauges may be adversely affected if placed in the "wrong" location within the cluster.

Appendix B: Tabbed bezel removal:

For many gauges the bezel is retained against the rim of the case by three tabs. To remove a bezel, rotate the bezel relative to the case until the tabs align with "slots" in the case's rim and pull off. Often this is not easy to do. Various methods can be employed to remove "difficult" bezels and some are listed below.

Note that bending the tabs up will permanently distort, and possibly crack, the bezel adjacent to the tabs. Don't do it if it can be avoided.

If it is not possible to turn the bezel by hand, the following tips may help.

With a small screwdriver, or similar tool, placed between a bezel tab and the case, carefully lever the tab away from the case just enough to cause the tab to move. Repeat for all tabs. Run a thin blade between the bezel and the rim of the case in between the tabs. This will break any bond that may have formed between the bezel and the case rim. In some cases this may be all that is required to free the bezel sufficiently for it to be removed.

Grip the bezel and case firmly in your hands and try turning the bezel. If it still doesn't move try turning the bezel one way then the other. This may be sufficient to move the bezel and once it has started moving, keep going until it turns sufficiently to line the tabs with the slots in the case and you're done.

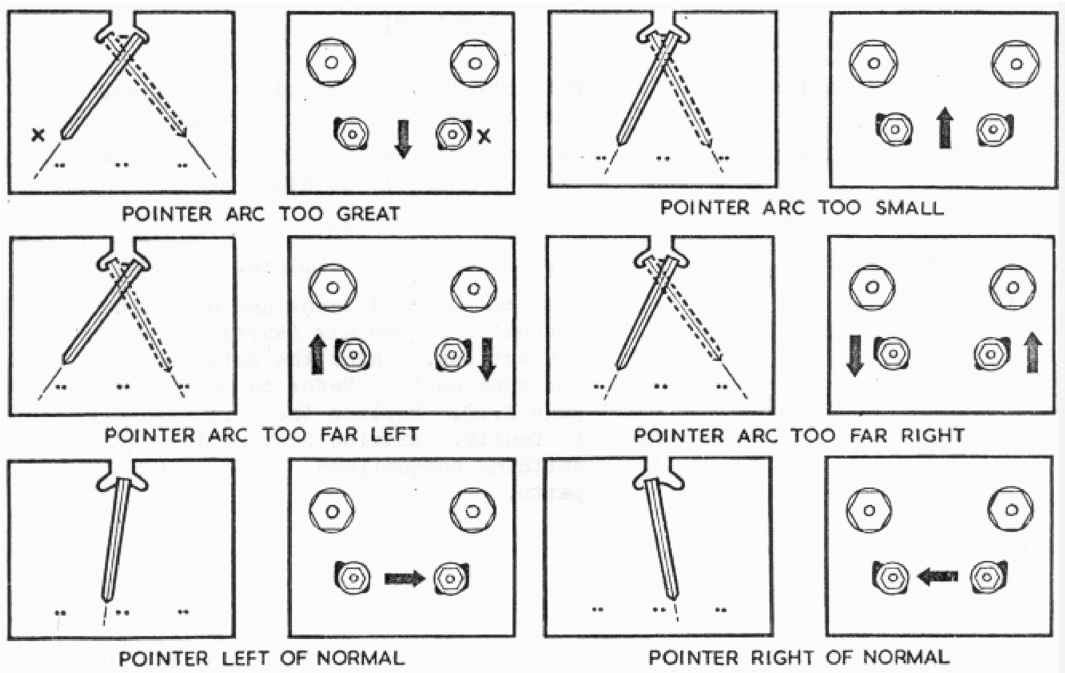
Tom Hayden, from Ohio, advises that he has used a shallow pan of hot water to free stuck bezels. Water temperature should be between 50˚C and 60 ˚C or the temperature from a tempered hot water system tap (nominally 55 ˚C). Depth of water needs to be just sufficient to cover the bezel and case rim when the instrument is placed in the water face-down. 3/8 inch or 9mm is plenty for a flat-bottomed pan. Allow to soak for a few minutes then remove the bezel.

If necessary soaking in hot water could be repeated. Tom also notes that hot water is good for removing hardened seal material from the bezel itself.

Note: Do not use boiling water if using this "hot water" method! There is a risk that hot water contacting a cold glass could cause the glass to crack. In order to reduce the risk, ensure that the instrument (glass) itself is as warm as possible which will be achieved if the instrument has been sitting in a reasonably warm room for a while.

Appendix C: Calibration details for Smiths gauges

Calibration Adjustments for "TC" and "FG" Gauges



Method of adjusting pointer position during calibration of FG and TC gauges.

The above adjustment method is taken from a Smiths service manual. This is the method of calibrating a TC temperature gauge and is similar to that for the FG fuel gauge. Temperature gauges usually had a steel plate sitting between the case and the gauge's coils, whereas the fuel gauge usually has the coils sitting on the case itself.

The adjustments shown above were for calibrating a gauge but have a limited range for accommodating manufacturing tolerances of the various parameters. It cannot be used to match a sender to a gauge as it does not have the range of adjustment required to accomplish this.

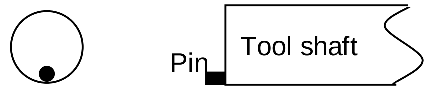
Even if you were to have a sender that was close enough to be matched by this method, it's not advisable as you end up with a "non-standard" gauge and the whole process will need to be repeated should that gauge need replacement at some future time. If it was that close, the same result could have been achieved with external resistors.

Similar comments regarding adjusting gauges to match senders apply to the bimetal gauges described in the next section. The bimetal gauges have a wider adjustment range than the FG and TC gauges.

If altering the calibration of these gauges note that the pole pieces, and hence the treaded studs used are very soft and easily stripped if too much force is applied! Use only the light-section spring washers originally supplied with the gauge and tighten nuts only enough to compress this spring washer.

Appendix C: continued

Calibration Adjustments for TE, PE and Bx Bimetal Gauges:

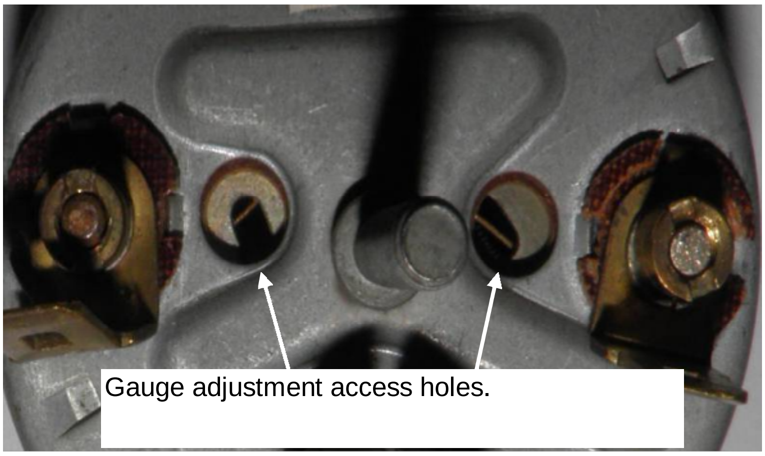


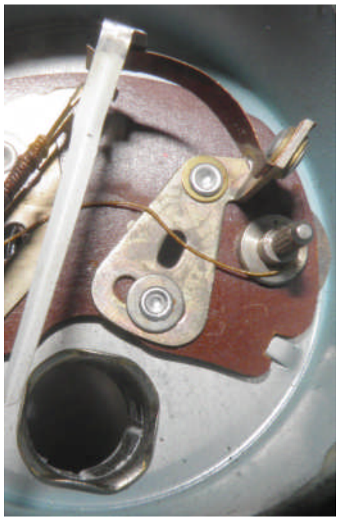
Sketch of tool for adjusting bimetal gauges.
Diameter of shaft = 5mm
Diameter of pin = 1.5 – 2mm

To adjust calibration of a bimetal gauge a special tool is required, as shown in the sketch at right. A screwdriver is not suitable for this job as the motion required is to slide the adjusting arm to one side, not to turn as for a screw. The adjusting plates themselves are quite thin and easily distorted.

Use the tool shown above to check the movement of the adjusting arms in the gauge. Normally these holes are sealed with a small cork disc. Remove this with a sewing pin or needle (replace when finished – they are simply pressed into place. The adjusting arms should only require a small force to move. If the adjusting arms are reluctant to move, remove the bezel, glass, slip ring if fitted and dial. Any sign of corrosion around the adjusting arms is a problem. If corrosion is evident place a few drops of penetrating oil on the sliding faces and pivot point and set aside to soak for an hour or so. Use of penetrating oil is pretty much required for the earlier style of gauge fitted with a cover plate (see figure 24 earlier in this document) covering the adjustment arms.

ACx gauges are not adjustable. It may be possible to improve accuracy by using external trimming resistors but no internal means of adjustment is provided.





The left-hand photo shows calibration access points of bimetal gauge with cork seals removed. Right-hand photo shows internal construction. Note the slot at the bottom of the support plate showing how calibration is achieved. The support plate needs to be moved sideways and not rotated as for a screw. It is difficult to calibrate these gauges without a tool like that shown above. Friction between the support plate and the base of the movement makes adjustment with a screwdriver, or similar tool, difficult.

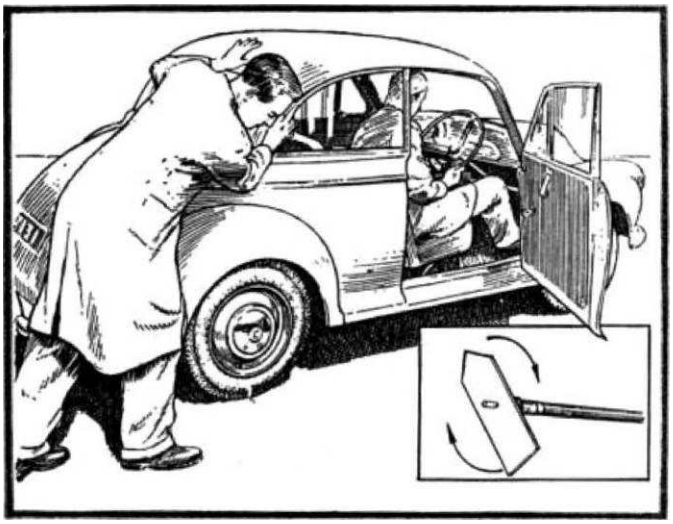
APPENDIX D:- ODOMETER CALIBRATION CHECK

Adapted from Smiths publication (S.1347)

If a non-standard rear axle or gearbox has been fitted to a vehicle, a quick, simple but approximate check is obtained as described below.

GEARING TEST

Disconnect flexible drive from speedometer. With gears in neutral, count number of turns of inner shaft for six turns of the rear wheels when vehicle is moved forward in a straight line. Measure rolling radius of the rear wheels. With tyres at correct pressure, measure from centre of the hub to ground. Apply figures in formula below.



FORMULA (MPH)

(1600 x N)/R = TPM No.

Where N = Number of turns made by the inner shaft for 6 turns of rear wheel and R = Radius of rear wheel in inches measured from centre of hub to ground.

EXAMPLE (MPH)

Cardboard pointer on inner shaft rotates 12½ times as vehicle is pushed forward 6 turns of rear wheel. Rear wheel radius = 13". Flex turns per mile

(1600 x 12.3)/13 = 1616 TPM

FORMULA (KPH)

(2653 x N)/R = TPK No.

Where N = Nurnber of turns made by the inner shaft for 6 turns of rear wheel and R = Radius of rear wheel in centimetres measured from centre of hub to ground.

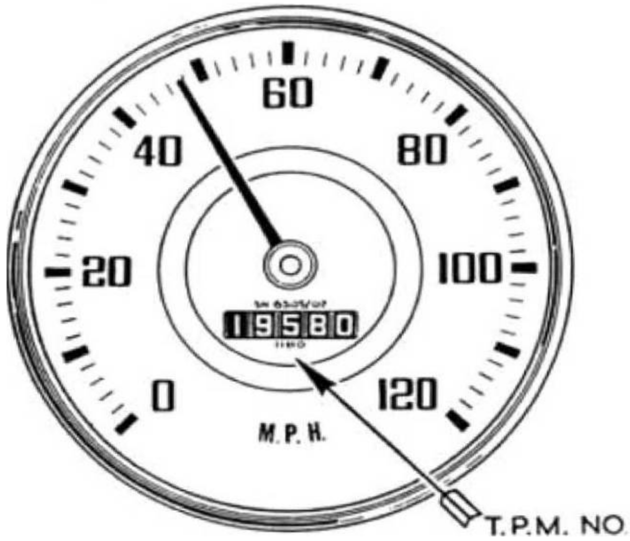
EXAMPLE (KPH)

Cardboard pointer on inner shaft rotates 12½ times as vehicle is pushed forward 6 turns of rear wheel. Rear wheel radius 33 cm. Flex turns per kilometre

(2653 x 12.5)/33 = 1005 TPK

CORRECT SPEEDOMETER

The number displayed on the speedometer dial should correspond within 32 either way with the number obtained from the above exercise. If it does not, the speedometer will need to be recalibrated.



Change log

Date	Version	Change list
Aug 2020	1.0	Initial release
Oct 2020	1.1	Minor updates and clarifications
Nov 2020	1.2	Added in section on clusters and minor rewrites.
March 2021	1.3	Minor re-writing of some sections. Corrected typos and references
July 2021	1.4	Added section on adjusting gauges. Minor edits.
November 2022	2V0	Minor revision. Add Appendix C.
July 2024	2V0	General editing. Add section on screw sizes.