A GENTLEMAN'S GUIDE TO CLASSIC SMITHS AUTOMOTIVE GAUGES

Part II – Electrical senders (transmitters)

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Contents:

NOTES RE CONVENTIONS USED WITHIN THE TEXT:

Throughout the text the letter "n" has been used to denote any number. Where the number is significant it has been provided in full. Otherwise irrelevant numbers have been replaced.e.g. TT nn00.

INTRODUCTION:

This document investigates the operation of senders, or transmitters, used to drive the electrical fuel, temperature and oil pressure gauges produced by Smiths during the 1960s and 1970s. As noted in part 1, there were several different types of electrical gauge produced, each of which has different electrical characteristics.

Where possible, information presented in this document has been sourced from Smiths service data otherwise from results of bench-testing senders. In the case of fuel and pressure senders, the number of items to hand was limited and, in the case of pressure senders some assumptions have been made which, while probably are correct, may not be "right on the nail".

Table A below sets out the types of Smiths electrical gauge, and the order, in which senders are discussed here.

TABLE A: GAUGES AND SENDERS REFERRED IN THIS DOCUMENT		
Parameter	**Gauge prefixes**	**Sender prefixes**
Fuel level	FG, BF, ACF	FT, TK, TFS, others?
Temperature	TC, TE, BT, ACT	TT
Pressure	BP, ACP	PT, PTR

Within this document I have used the term "characteristic" when referring to the response of a sender to changes in the measured parameter. Notably when dealing with temperature senders. Gauges may have the same resistance range values for a specific type of gauge but the actual value of the measured parameter, as indicated by the gauge, is dependent on the sender's characteristic or behaviour. Looking at fig.16, the curve for a temperature sender shows its behaviour, or characteristic, in response to temperature change.

Note that where I have provided charts showing temperature sender characteristics within this document, the method used to compile the data at that time was limited to a maximum temperature of 100 deg. C. The upper operating range of temperature gauges/senders can be well above 100 deg. C and resistance values of the sender continue to reduce as the temperature increases.

Information supplied within this document is assumed to be reasonably accurate. Due to limited numbers of temperature senders available to test and possible "aging" of these (older) senders, data presented may be at variance with the original specification for these devices. Cross-reference data is taken from manufacturers publications and is assumed to be accurate.

How information supplied here is used is the end user's responsibility.

A CLOSER LOOK AT GAUGE CALIBRATION:

In part 1, a list of resistors to enable a quick check of the calibration of electrical gauges in which common resistor values, approximating those for the maximum and minimum scale points, were presented. More comprehensive calibration values are presented in table B below. (Bold numbers from Smiths service data and corresponding to calibration marks on dial. Non-bold values are test values and correspond to scale marks and not necessarily calibration marks.)
Many of these are non-standard values for the range of resistors usually stocked by retail electronic parts outlets. The values provided in table B give those values that should cause the pointer to move to the upper, mid (where applicable) and lower scale graduations.

TABLE B:	**GAUGE CALIBRATION**		
Gauge type ▼	Low-scale (Ohms)	Mid-scale (Ohms)	High-scale (Ohms)
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

Fig. 1 shows a bimetal fuel gauge for different resistance values. Due to the gauges inherent non-linear characteristic, a relatively small change in resistance (20 > 33Ω) can make a significant difference to the indicated value at the upper end of the scale. A similar change in sender resistance at the low end of the scale would barely be noticeable. Thus a "USA standard" (Table C page 6) sender would never show a full tank but would read correctly at "Empty".

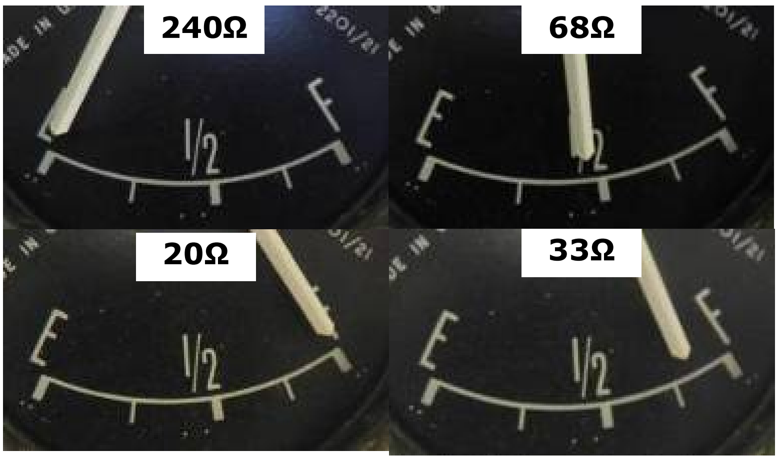


Figure 1: Bimetal gauge calibration and pointer position at 33Ω. 240 - 33Ω is a common fuel sender range.

FUEL TANK UNITS:

Fuel tank level senders were produced in a variety of forms having different terminals, mounting position (top, side), arm lengths, angle through which the arm moves, floats and fixings. Some (later) units have low-level switches fitted for driving warning lamps. For the senders/gauge combinations dealt with here, there are only two resistance ranges applicable to the various gauges: 3Ω to 80Ω (e.g. FT5300-73 @ 3.3Ω to 80Ω) for the FG gauge and ≥240Ω to ≤20Ω for the BF and ACF gauges. (Note that resistance values given here are for the full range of the resistance element but the useful range may be less than this.)

Fig. 2 at right shows the internal construction of the FT3331/56 fuel tank level sender. This is from an early Triumph Herald and works with the "FG" type of gauge. The resistance range of this unit is 0–85 Ohms empty to full.

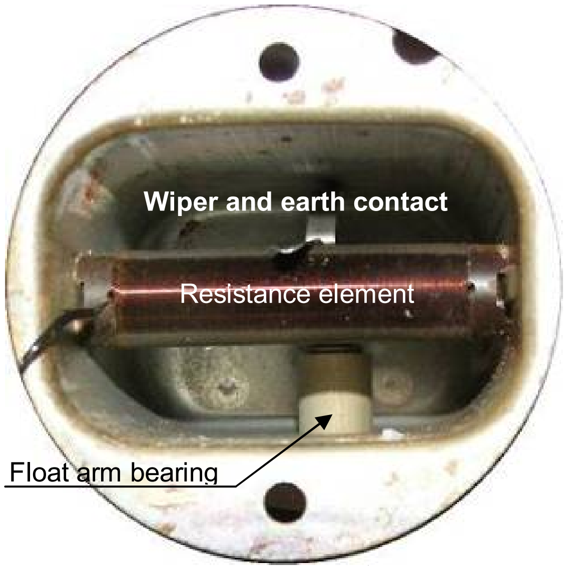


Figure 2: FT 3331/56 fuel tank level sender

Fig. 3 below shows the internal construction of a later TF1002/008, fuel tank level sender. This has a measured resistance range of 245 – 15 Ohms and is used with a bimetal, "BF" type gauge. The resistance element is wound on a shaped former to match the response of the gauge. (The wiper arm here is shown towards the "Full" position.)

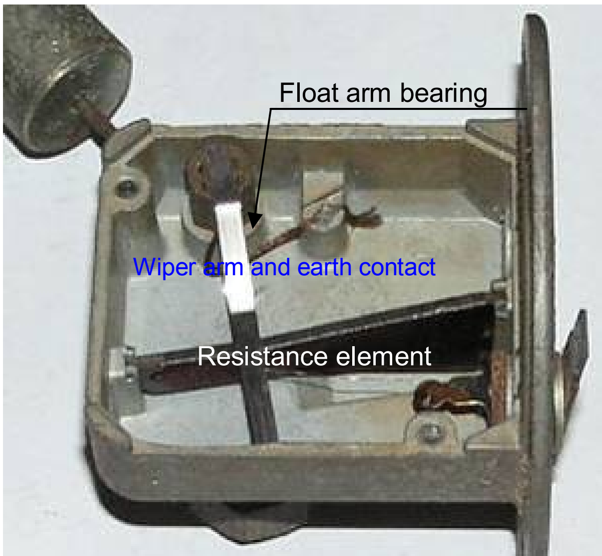


Figure 3: TF 1002/008 tank level sender.

As noted in table A, there are a number of prefixes used for these senders. These are set out in a table on the following page. Those senders prefixed "TFS" include a low fuel level warning light switch and have an extra terminal for this. The fuel gauge terminal is marked "T" and the switch terminal "W". There may also be a third terminal on the sender which may be marked "E" (for "earth") or, for those senders with a sheet-metal mounting flange/plate, rather than diecast, may be unmarked and spot welded directly to the mounting flange.

Fuel tank level sender ranges are available from Caerbont/Smiths, as set out in table C below, of which only two (magenta text) are of interest here.

For an "FG" type fuel gauge, only senders with a range of 0-80 Ohms or 3-80 Ohms (Empty > Full) are suitable (bold underlined text in table). For "BF" bimetal gauges, a sender having a resistance range of 240 > 20 Ohms (Empty > Full) is required. Note that the 240-33 Ohm items listed are very close but will never indicate "FULL" as demonstrated in fig.1 in the section "A CLOSER LOOK AT GAUGE CALIBRATION" earlier in this document.

Table C: Fuel tank level sender resistances		
Fuel Sender	**Ohmic Values**	
Sender type	**Empty**	**Full**
Euro	10	180
Smiths early (FG gauges)	**3**	**80**
Classic (Smiths bimetal gauges)	**240**	**20**
Dip Pipe	68	3
Smiths Euro	275	27
USA	240	33

Resistance range and characteristic (these terms are not equivalent) are the most critical parameters as far as operation with a particular gauge is concerned. Further options for mounting abound and for any application these will need to be determined. If trying to find a sender for an older vehicle you may have to resort to a sender with adjustable arm length and suitable range of movement (specified in degrees).

With a bit of fiddling, a sender with a slightly wider resistance range than that expected by a gauge may be pressed into service so that only a part of the resistive element is used. By way of example, Caerbont's website has several senders listed with values in the 0 – 83 Ohms range any of which could be expected to work with an "FG" type gauge. By adjusting the length of the float arm and/or bending the float arm (official Smiths procedure for servicing earlier tank level senders), matching of the characteristics should be readily achieved.

Resistance ranges provided by manufacturers denote the resistance values at minimum and maximum scale values in that order.

FUEL TANK LEVEL SENDER IDENTIFICATION:	
Sender code	**Matching gauge type**
FT, TM, TMS	FG - Moving Iron gauge
TF, TFS, TB, TBS	BF - Bimetal

It may be possible to find a suitable sender with low-level switch if you wish to add this feature.

If the only suitable sender has an "insulated return" this is not a problem as a wire from the return terminal to earth is all the extra work required. Similarly, different terminal(s) on a sender are readily accommodated either by fitting a new terminal to the connecting wire or using an adapter cable (which you may need to construct).

TEMPERATURE SENDERS:

Of the Smiths senders dealt with here, temperature senders are those that have caused the most grief. Ideally you will replace a temperature sender with that specified for the vehicle of interest. But for older vehicles this may not be easily done or even not possible, as the original sender is no longer manufactured.

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 of some gauges but these differences permit only a "fine-tuning" of the parameter being measured, such as a gauge/sender combination with a gauge marked in deg. F vs a gauge marked in deg. C.

This "fine-tuning" between gauge scale and calibration points can be seen when comparing the scale markings on a BT2204/07 (Triumph GT6) temperature gauge with those for a BT2204/24 (Jensen-Healey) gauge as shown in fig. 4 below. In this case the difference arises from the vehicle manufacturers' requirements. Any significant change in range must be accommodated by the sender itself.

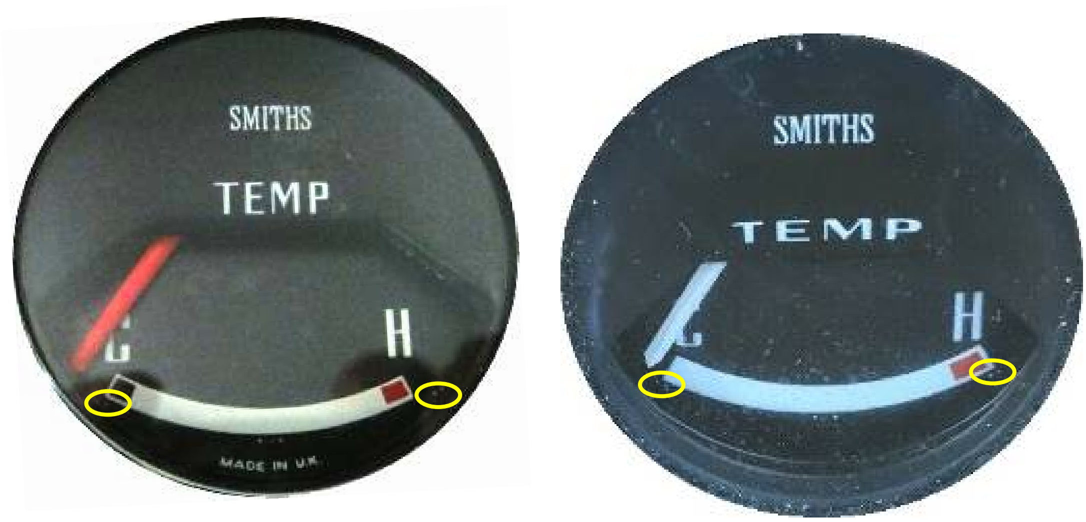


Figure 4: BT2204/07 on left. BT2204/24 on right. Yellow ovals mark calibration points. Note Hot calibration point relative to the printed scales.

If you have re-powered a vehicle with an engine from another manufacturer then you may require a sender with a different thread to Smiths "standard" 5/8 UNF. It may be possible to find a suitable sender but the better idea may be to purchase gauge and sender as a set. http://danr.mhartman.net/wp-content/uploads/Senders-Report.pdf can provide some useful tips (for Smiths bimetal gauges). Some of the current range of senders from Caerbont/Smiths may also be suitable. (These have not been used or tested at this time.)

BIMETAL SENDER:

The temperature sender used with "TE" type gauges, fig. 5 at right, also uses a bimetal element and functions as a temperature-sensitive variable voltage regulator . Physically it looks very much like a Bourdon tube temperature gauge bulb and was held in place by a separate nut or collar. These senders are designated TT1200/00 or TT1200/01. There is also a 24V variant marked TT1300/01 which has a heating coil resistance of c100 Ohms, where the 12V sender has a resistance of c25 Ohms.

Figure 5: Smiths TT 1200/01 bimetal temperature sender.

Fig.6 shows a sketch of the temperature transmitter element and fig. 7 below is a photograph of an aftermarket device. Unlike the later "BT" gauges, these transmitters and gauges are not used with a separate instrument voltage regulator.

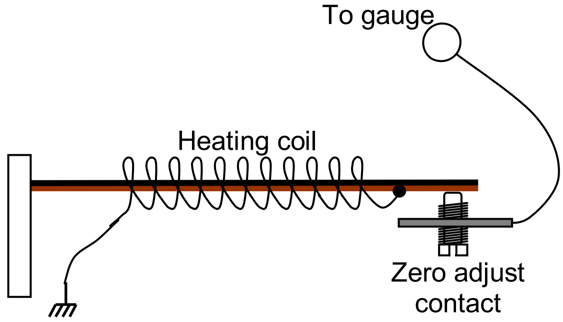
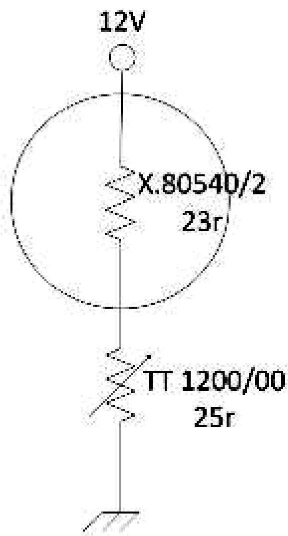


Figure 6: Bimetal temperature transmitter circuit (TT1200 type) as used with "TE" type gauge.

Figure 7: Bimetal temperature sensing element (Aftermarket unit but similar to Smiths sender.)

In the following description, the nominal battery voltage of 12 Volts has been used. In real life, the fully charged voltage of a lead-acid cell is about 2.4 Volts to give an actual voltage of about 13.6V. Using the "real" value will change only the numbers and not the method of operation. For the purposes of this description I will treat each resistance as equal and of 25r (25 Ohms).



At right is a circuit diagram of the TE style gauge and sender. The resistances shown are as-measured for the heating coils in a gauge and sender to hand. Normal manufacturing tolerances may produce different values but they should be close to those shown here.
When voltage is first applied, a current of 0.24 Amps (12V/50r) will flow through the circuit. Each resistor consists of a length of nichrome wire wound around a bimetal bar and each will dissipate about 1.5 Watts, heating and causing the bimetal elements to bend. In the case of the gauge, the

pointer will move from its "rest" position at HOT towards the COLD position.
The bimetal element within the TT 1200 sender will also be heated and bend until such time as it breaks the circuit, the bimetal strip inside the sender will open the circuit and begin cooling. The bimetal strip will "unbend" fairly quickly and the sequence will repeat. As the temperature of the sender increases the rate of cooling of the bimetal strip reduces and the contacts remain open for a longer period. The effect of this is to vary the current as shown in figs 8, 9 and 10 below. (The on time, when the contacts are closed is shown as constant here and the off time varies according to the temperature of the sender. This is simply due to the fact that the rate of cooling of the bimetal bar will be a function of the temperature of the sender's body – the cooler the sender is, the quicker heat will be removed.)

FIG. 8: SENDER "OUTPUT" WHEN COLD

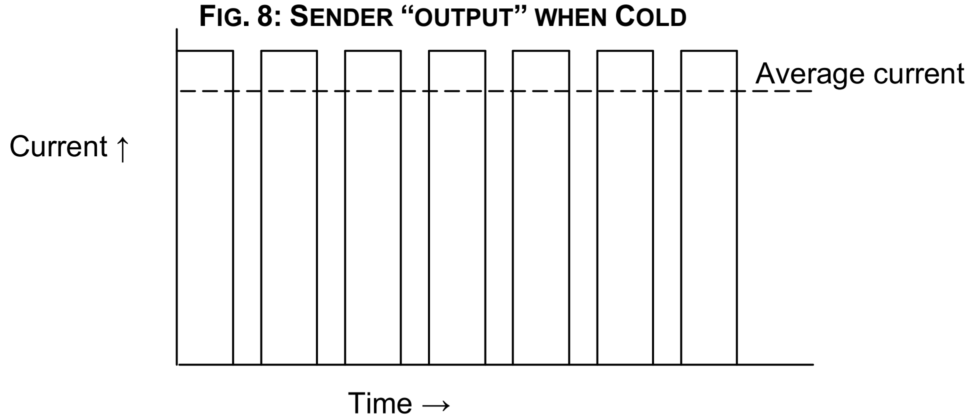


FIG. 9: SENDER "OUTPUT" WHEN NORMAL

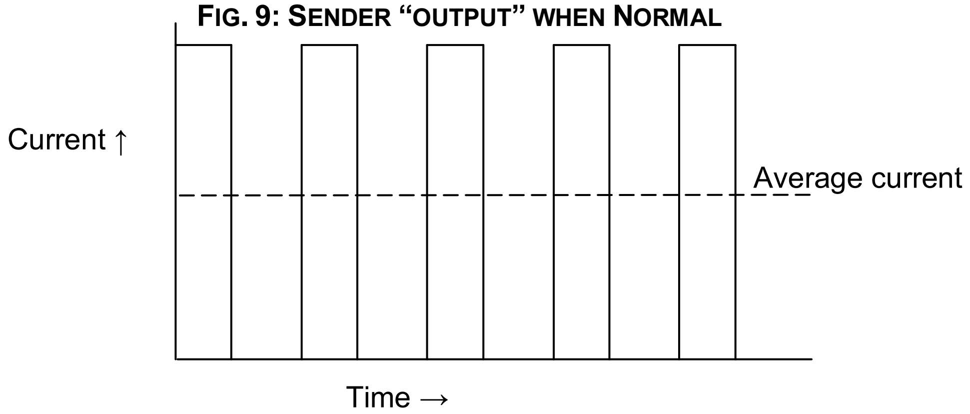
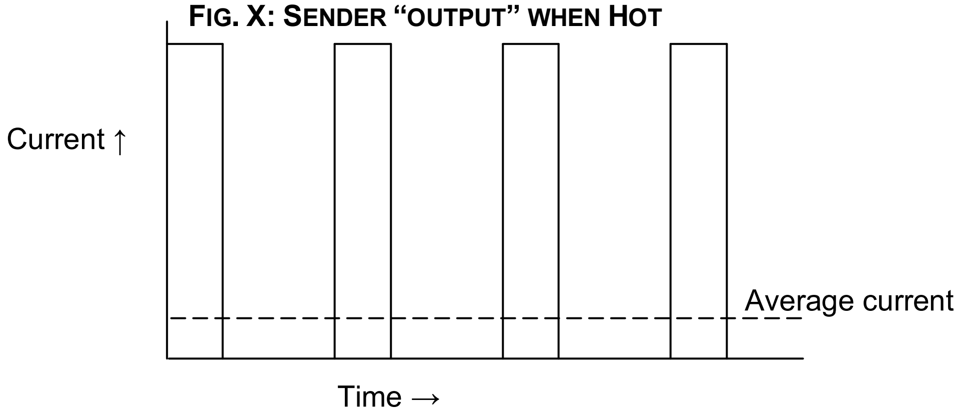


FIG. X: SENDER "OUTPUT" WHEN HOT



This interrupted current, hence heating effect in the gauge, can be equated to a series resistance passing the average current and the calibration of these gauges is done in this way. For the record, a resistance of 68 Ohms in series with the gauge should indicate at the COLD scale mark and a resistance of 310 Ohms should have the gauge indicating HOT.

Since the effect of these sensors is to reduce the average current (increase the (effective) resistance) with temperature, these senders are sometimes described as "Positive Temperature Coefficient, or "PTC" senders. All later gauges used "Negative Temperature Coefficient" or "NTC" senders, where the resistance of the sender reduces as the temperature increases.

Varying voltage in the car's electrical system will have little effect on these gauges. Any increase in voltage will increase the heating effect of both heating coils, reducing the duty-cycle of the sender while increasing the heating of the bimetal element in the gauge. The two effects will cancel to produce a substantially consistent value for a given temperature irrespective of the voltage applied (within reasonable limits).

To the best of my knowledge, this type of gauge was never used in Triumph vehicles.

TT1200 series senders are no longer made though N.T.G. Motor Services Ltd. In the UK offer a solid-state (PTC Thermistor) replacement sender for the TT 1200/00 but it is definitely not cheap! If you have a faulty TT 1200/00 type sender, then have a look at the following website which has a good article on repairing/updating these gauges/senders:

https://www.magnette.org/tech-tips/maintenance/miscellaneous/516-the-temperature-gauge-problem-solving

It may be possible to find a visually similar BTnnnn gauge that could be substituted for the X or TE gauge. This would enable an NTC thermistor type sender to be fitted. For Smiths gauge clusters, the gauges themselves are interchangeable between cluster housings that use the same gauge retaining method (clamp/screw) and the faceplates can be swapped if needs be. Another option is to obtain a similar "BT" prefix gauge and swap the faceplates. To preserve the original look, you may need to re-paint the pointer. Done well, the only visible change is that the pointer indicates COLD with the ignition off.

CONSTRUCTION OF A SMITHS THERMISTOR TYPE SENDER.

Fig. 11 below is a sketch of a Smiths TT4802 sender. All Smiths thermistor-based senders about this time use this same construction. Thermistor type senders are used for all temperature gauges other than the "TE" prefixed gauges.

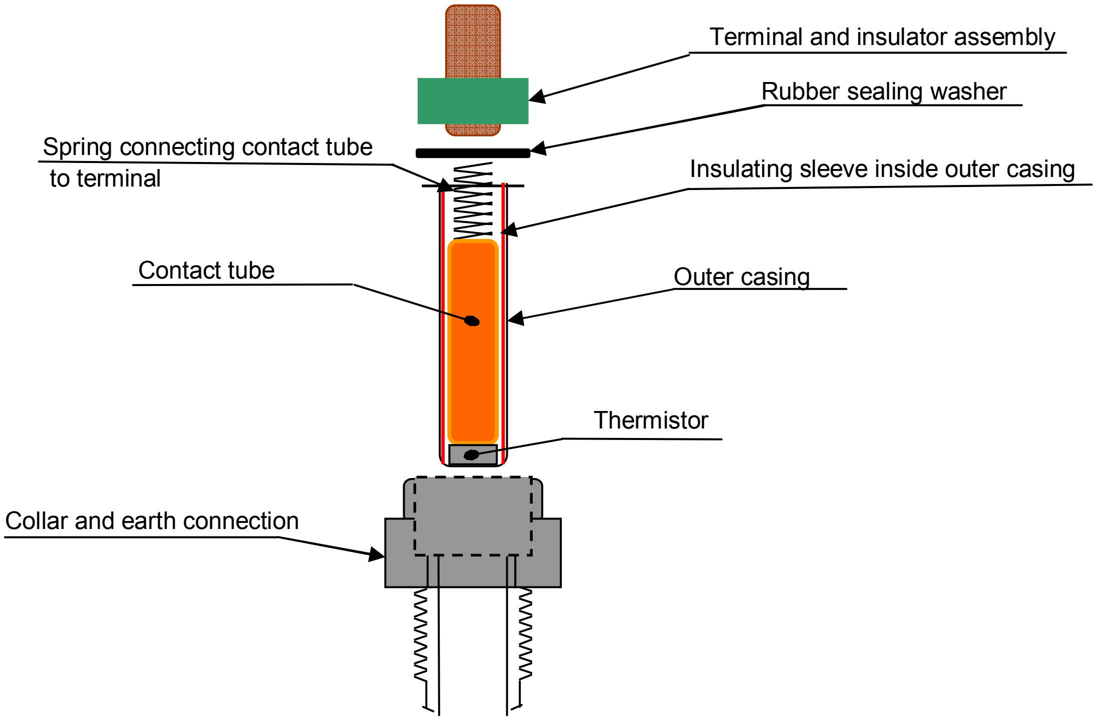


Figure 11: Showing general construction of a thermistor type sender

Fig. 12 at right shows the thermistor element from a Smith sender. This is the item that does the temperature to current conversion to drive the gauge. There are a number of these thermistors used by Smiths in their senders but each thermistor requires the same temperature to resistance characteristic to match that of the gauge. The reason for this is simple. As all gauges of a type are calibrated to the same values, differences in operating heat ranges of the engine and gauge are accommodated by changing the thermistor – a small disc of material 6mm in diameter. No other changes need to be made

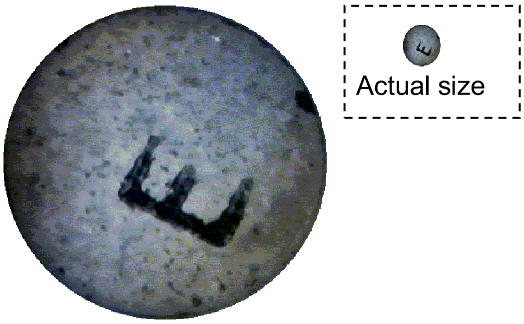


Figure 12: Thermistor disc from Smiths sender

Contact with the thermistor is required over the full area of the disc. This is achieved by applying a thin layer of metal (silvering) to each surface. Fig. 13 shows a "faulty" thermistor disc where part of the silvering has been damaged, either through mechanical abrasion due to a weak contact spring or electrolytic action arising from moisture ingress. The end result was an unusable high resistance as the area of contact has been reduced to only that portion of the disc in contact with the contact tube.

Figure 13: Damaged thermistor disc,

The sketch in fig. 14 at right shows another type of sender construction. Rather than relying on a mechanical contact between the separate components of the sender, here the connections are soldered or welded. This provides a more reliable connection and eliminates the type of failure shown later in fig.13. The sender may be filled with oil to facilitate conduction of heat between the outer case, usually a single piece of brass, and the internal thermistor. This construction is used by at least one manufacturer. Other manufacturers use a similar construction to the Smiths sender above.

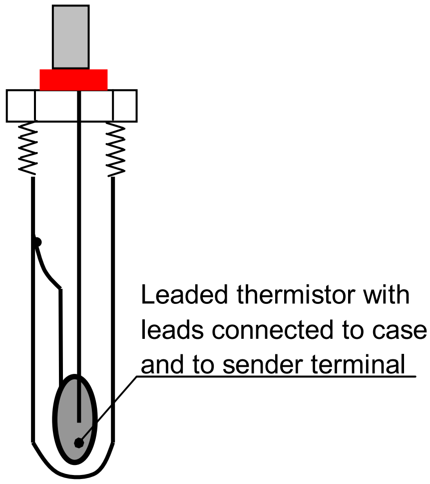


Figure 14: Internal construction of a modern temperature sender.

TEMPERATURE SENDERS DISCUSSION:

A pattern to the numbering system used by Smiths during the 1960s and 1970s can be ascertained. Prior to this time, other part numbers were used. (Prior to being known as a TT4800/00, this sender was listed as a "TT3501/00".) All Smiths temperature senders are prefixed "TT" (for "Temperature transmitter"). This prefix is followed by a four digit number which appears to have the following significance:

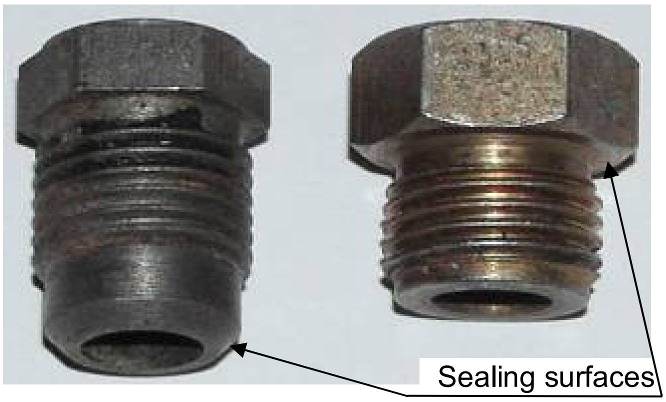


Figure 15: The difference between a TT380x and TT480x is in the collar – TT380x on left, TT480x on right.

Reading left to right, the first digit is either a 1, 3, or 4 for the senders to hand.

"1" indicates the sender is retained by a separate collar or nut as for the TT1200/00 in fig. 5 earlier in this document.

"3" indicates a 5/8 UNF thread and a bevelled seal surface.

"4" indicates a 5/8 UNF thread with a face seal (Fig. 15) and requires a sealing washer.

Do not use thread sealing tapes or compounds when fitting temperature senders. The electrical contact between the sender and the housing is part of the measuring circuit. Poor electrical contact here will cause a gauge to read low or not at all!

The next digit indicates the type of electrical connection. "2" is either a screw or a threaded stud and nut. "8" indicates a ¼" blade terminal.

The next digit is always "0" but it may be that the last two of the four digits together indicate the resistance characteristic of the sender.

The last digit(s) in this group identifies the resistance characteristic of the sender.

Following this is a "/" followed by a further two numbers and possibly a letter. Generally for Smiths, the two digits after the slash indicate a minor change. (Similar patterns can be discerned in the numbering of the gauges themselves.) Letters indicate a significant change in the device. In the case of these senders, an "A" on the end of the part number almost certainly means the collar (see fig. 15 above) is made of steel as opposed to brass in the earlier units.

Colour of the insulator for Smiths senders identifies the temperature range of the sender and are shown in table D. Note the production colour change for the TT4800/00A! (There may be others.)

Table D Sender	Temp. Range deg. C	Collar Colour
TT4800/00 (brass collar)	30 - 110	black
TT4800/00A (steel collar)	30 - 110	green
TT4801/00	30 - 110	cream/white
TT4802/00	30 - 120	red/maroon
TT4803/00	30 - 130	black
TT4804/00	?	red/maroon
TT4805/00	?	
TT4806/00	?	black

No cross reference data is provided for TTnn04 or TTnn06 senders. Currently neither of these senders is available to test. Some vendors' listings show these senders to be equivalent to the TTnn02 and TTnn03 devices respectively. There is some information available on the net that suggests that the TTnn06 may have the same range but a different centre temperature to a TTnn03 and similarly for the TTnn04/TTnn02 senders. Other listings equate the TTnn04 with a TTnn01 and there is some support for this in Triumph service data which implies that the TT3804 is in fact a TT3801 "lite". So for the moment no equivalents for the TTnn04 sender is provided, neither can equivalents be reliably identified.

Note that the TTnn00/00 sender is only used with "TC" gauges.

No valid reference to a TTnn05 device has been found.

Vendors of Smiths (equivalent) temperature senders are inconsistent in the matter of compatibility. Some list a device as being equivalent to both a TT4nnn and TT3nnn unit. They may be electrically equivalent but sealing may be a problem. (As a general rule, a TT4nnn sender could replace a TT3nnn sender but not necessarily the other way round.) (It **may** be possible to get a TT38nn used in place of a TT48nn sender to seal using the old thread locking method of some lead wire wrapped around the sender below the nut but this has not been tried.)

Vendors have been found that say their sender "fits" certain cars but in some cases this may simply means it will fit in the hole provided. Others state that one device replaces several Smiths senders, such as TT4801/TT4802/TT4803. In this case, electrical compatibility may align with one or none of the senders but not all.

One specialist supplier for a certain marque advertises a temperature sender that fits the whole range of a model. Since this model range includes both "TC" and bimetal gauges, two senders should be offered. It's a little disappointing that a "specialist" vendor should get this wrong.

Cross references between sender manufacturers may not be much use if you require a sender with a different thread. Most cross-references will be for senders that are (hopefully) electrically compatible and also physically compatible. Electrically equivalent senders with different threads and/or terminals **may** not be listed as equivalents.

Caerbont/Smiths current offerings in temperature senders now have range of available threads for what are **assumed** to be electrically equivalent senders to some of their earlier senders. At least for the (new) TT3001 and TT3005 ranges. They also list a TT4802/00A which appears to be the same as the older item. Ditto for the TT4803/00A. Maybe. ***None of their current range of senders is to hand at this time***.

MATCHING TEMPERATURE SENDERS WITH GAUGES:

All temperature gauges are calibrated to set sender resistances for each gauge type (TE/TC/BT). The calibration points are marked on the gauge but do not necessarily correspond to the dial marking.

Matching a sender to a gauge is probably less critical for a gauge marked "C-N-H" as opposed to one with markings in degrees Centigrade or Fahrenheit. Fitting the wrong sender may give an increase or decrease in the "Normal" pointer position.

A document by Michael Hartman and Tom Hayden, an inventory of Sunbeam Alpine gauges, (http://mhartman.net/files/sunbeam/Sunbeam Alpine Gauge Inventory.pdf) is of interest here. The dial markings are in degrees rather than the more common C-N-H format. The TT4802 sender is seen to have a range of 50 – 120 deg. Table E below summarises data from the Sunbeam Alpine document (sender data added).

Table E: Sunbeam Alpine data (Hartman/Hayden)

Alpine Series I to V	Gauge	Scale	* Radiator cap – lb/in2	Voltage	* Sender part # Smiths	Rootes
Series I 1959–60	TC4304/00	90-170-190-230 deg. F		12	TT4800/00	P.46371
Series II 1960–63	TC4304/00	90-170-190-230 deg. F		12	TT4800/00	P.46371
Series III 1963–64	BT2201/02	120-170-200-250 deg. F	* 9	10	TT4802/00A	1205552
Series IV 1964–65	BT2201/02	120-170-200-250 deg. F	* 9	10	TT4802/00A	1205552
Series V 1965–68	BT2202/03	50-85-120 deg. C	* 9	10	TT4802/00A	1205552

* Source: Rootes/Chrysler Publication No. 6600992 Reprinted January 1968

Refer to "*Modifying the response of a temperature sender*" on the next page where the effect of adding resistance to a temperature gauge circuit is briefly discussed.

MODIFYING THE RESPONSE OF A TEMPERATURE SENDER:

If you find a transmitter that has a characteristic that is close to what is required, it may be possible to tweak it to match a gauge.

If a gauge is reading high, it is reasonable to add a small series resistance to bring the sender into calibration. The effects of adding series and parallel resistors can be seen in the chart in fig. 16. below.

Note: "||" in the chart legend means "in parallel with".

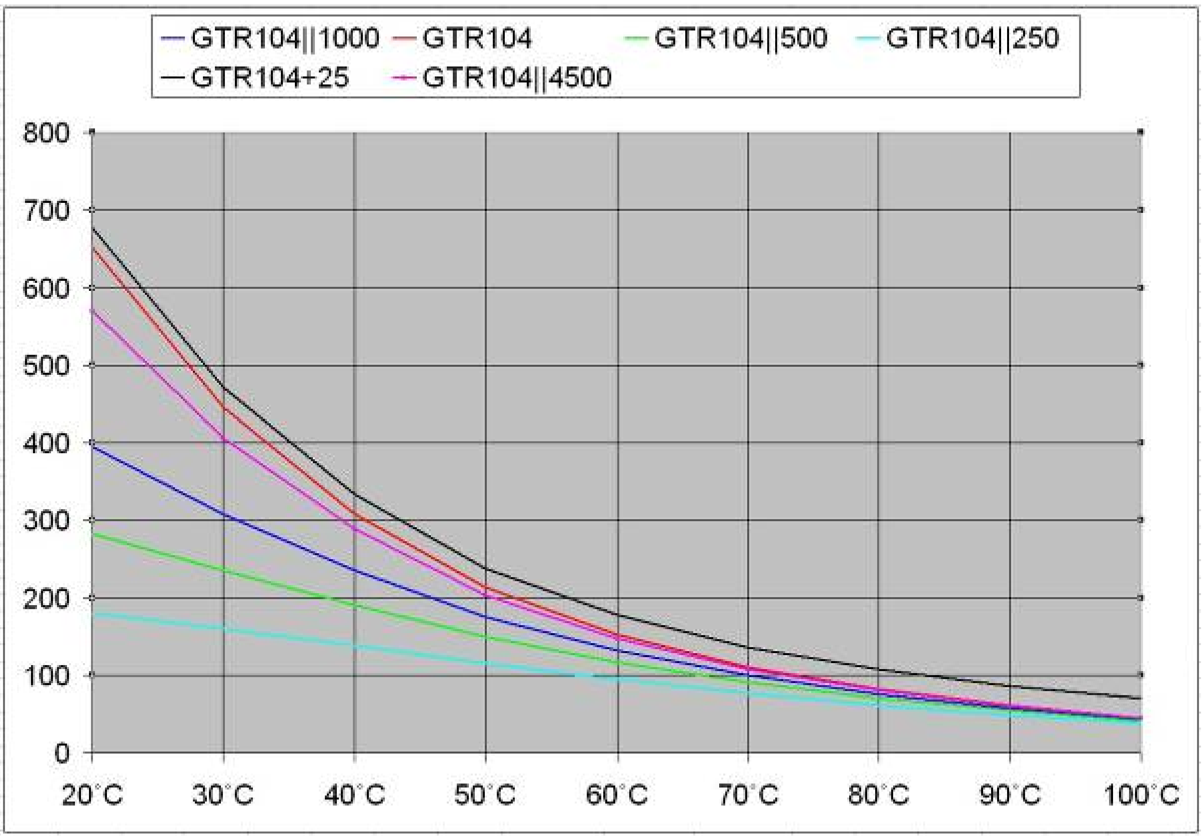


Figure 16: Effect of series and parallel resistors on temperature sender characteristic. In the chart legend, "||" means "in parallel with

The red trace in fig. 16 is for the sender alone. The black trace shows how adding a series resistance simply moves the line upwards on the graph across the full sender resistance range which will slightly reduce the reading on the gauge. The more resistance added, the greater the effect but this will also limit the maximum reading shown by the gauge.

What happens with an added parallel resistor is demonstrated by the light-blue, light-green, blue and magenta traces. The effect of the parallel resistance is to modify the response of the sender, flattening the sender's characteristic at the lower temperatures. Note that very little effect occurs at higher temperatures!

Successfully modifying a temperature gauge and sender will only be achieved if the target sender's resistance is close to that of the original. The better option is to get a sender with the correct response to the gauge. Possibly easier said than done!

TEMPERATURE SENDERS CROSS REFERENCE:

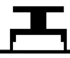
Cross reference information for (older) "Classic" Smiths senders in the following table is taken from manufacturers' cross-reference data. ***It is thought to be accurate though equivalents may not be electrically exact.***

Note that in the case of Intermotor (possibly also FAE) senders, an additional "0" digit was added to earlier part numbers. Thus a 5270 part may also be listed as a "52700".

SMITHS PART #	OTHER MANUFACTURER	OTHER PART #	THREAD	SEAL	TERMINAL
TT3800	FACET++	7.3020	5/8 UNF	Bevel	Blade
	Intermotor	52700 (NLA?	5/8 UNF	Bevel	Blade
	Unipart	GTR102 (NLA)	5/8 UNF	Bevel	Blade
TT3801	CI (Quinton Hazell)	XTT49	5/8 UNF	Bevel	Blade
	FAE	31110	5/8 UNF	Bevel	Blade
	Fuel Parts	CTS6078	5/8 UNF	Bevel	Blade
	Intermotor	52770	5/8 UNF	Bevel	Blade
	Kerr Nelson	STT009	5/8 UNF	Bevel	Blade
	Lucas	SNB125	5/8 UNF	Bevel	Blade
	Unipart	GTR111	5/8 UNF	Bevel	Blade
TT3802	CI (Quinton Hazell)	XTT11	5/8 UNF	Bevel	Blade
	Delco Remy	7954935 SU 6	5/8 UNF	Bevel	Blade
	FACET	7.3021	5/8 UNF	Bevel	Blade
	FAE	31190	5/8 UNF	Bevel	Blade
	Intermotor	52710	5/8 UNF	Bevel	Blade
	Kerr Nelson	STT005	5/8 UNF	Bevel	Blade
	Lucas	SNB102	5/8 UNF	Bevel	Blade
	Unipart	GTR104	5/8 UNF	Bevel	Blade

(NLA) = No longer available. ("Old stock" units may be found occasionally.)

++ A sender packaged as a FACET 7.3020 was obtained but the sender itself is marked "5720" which is the equivalent Intermotor part number. It has been tested against a TT4800/00A and the correlation is excellent!

Smiths part #	Other manufacturer	Other part #	Thread	Seal	Terminal
TT3803	CI (Quinton Hazell)	XTT15	5/8 UNF	Bevel	Blade
	Delco Remy	7954972 SU 7	5/8 UNF	Bevel	Blade
	FACET	7.3046	5/8 UNF	Bevel	Blade
	FAE	31490	5/8 UNF	Bevel	Blade
	Fuel Parts	CTS6077	5/8 UNF	Bevel	Blade
	Intermotor	52760	5/8 UNF	Bevel	Blade
	Kerr Nelson	STT004	5/8 UNF	Bevel	Blade
	Lucas	SNB103	5/8 UNF	Bevel	Blade
	Unipart	GTR101**	5/8 UNF	Bevel	Blade
TT3806	Intermotor	52900	5/8 UNF	Bevel	Blade
	Unipart	GTR103	5/8 UNF	Bevel	
TT4800	No face-sealing equivalent has been found. (See TT3800 for electrical equivalent.)				
TT4201/ TT4801	CI (Quinton Hazell)	XTT14	1/8 NPTF	Face	Stud
	FACET	7.3010	1/8 NPT	Face	Stud
	FAE	32080	1/8 NPTF	Thread	3/16” Stud
	Fuel Parts	CTS6076	1/8 NPTF	Thread	Stud
	Intermotor	52750	1/8 NPTF	Thread	Stud
	Kerr Nelson	STT008	1/8 NPTF	Thread	Stud
	Lucas	SNB108	1/8 NPTF	Thread	Blade
	Unipart	GTR114	1/8 NPTF	Thread	Stud

(NLA) = No longer available. (“Old stock” units may be found occasionally.)

** appears to have a tapered thread also

SMITHS PART #	OTHER MANUFACTURER	OTHER PART #	THREAD	SEAL	TERMINAL
TT4802	CI (Quinton Hazell)	XTT12	5/8 UNF	Face	Blade
	Delco Remy	7966267 SU 15	5/8 UNF	Face	Blade
	FAE	31200	5/8 UNF	Face	Blade
	Intermotor	52720	1/8 NPTF	Thread	Stud
	Kerr Nelson	STT034	5/8 UNF	Face	Blade
	Lucas	SNB105	5/8 UNF	Face	Blade
	Unipart	GTR106	5/8 UNF	Face	Blade
TT4803	CI (Quinton Hazell)	XTT13	5/8 UNF	Face	Blade
	FACET	7.3047	5/8 UNF	Face	Blade
	FAE	31210	5/8 UNF	Face	Blade
	Fuel Parts	CTS6075	5/8 UNF	Face	Blade
	Intermotor	52730	5/8 UNF	Face	Blade
	Kerr Nelson	STT010	5/8 UNF	Face	Blade
	Lucas	SNB106	5/8 UNF	Face	Blade

Note: the only difference between TT4201 and TT4801 senders is the terminal connection – screw vs blade.

Re NPT and NPTF threads. NPT threads require a sealing compound to be leak proof. NPTF threads rely on a metal-to-metal seal, achieved by distortion of the threads themselves when fitting.

(NLA) = No longer available. ("Old stock" units may be found occasionally.)

OIL PRESSURE SENDERS:

The early electrical oil pressure senders manufactured by Smiths were essentially a pressure-variable instrument voltage regulator. An abridged version of the instrument voltage regulator operation, from part 1, is set out below.

THE BIMETAL INSTRUMENT VOLTAGE REGULATOR:

Fig. 17 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. 18 which shows a side view of the works of this voltage regulator.

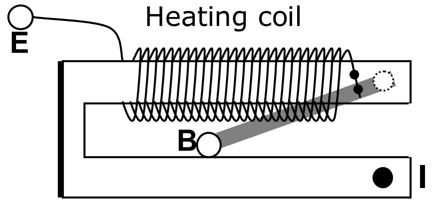


Figure 17: Instrument voltage regulator plan view

Figure 18: 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.

BIMETAL OIL PRESSURE SENDERS ("PT"):

Note: If your oil pressure gauge has an "ACP" prefix it uses a resistive pressure sender and **not** a bimetal type.

As noted above, the bimetal oil pressure sender uses a similar construction to an instrument voltage regulator. It has the same shaped bimetal element as the IVR which provides temperature compensation for the device.

Fig. 19 at right is an electrical schematic diagram of a Smiths bimetal oil pressure gauge and sender. The resistor R_{CALIB} varies with the different ranges (span) of these senders. Given

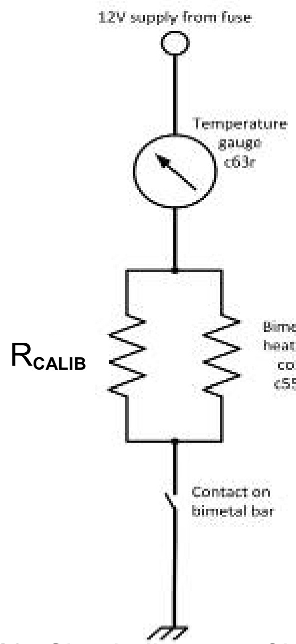


Figure 19: Circuit diagram of bimetal type pressure sender.

that all the gauges are calibrated to the same values, then any difference in scale needs to be accommodated in the sender. This is the way it is done here. The particular 24V unit dismantled here had a 470Ω calibration resistor. Resistor values seen in Smiths 12V units are 130Ω and 270Ω. I am ***assuming*** that the 130Ω resistor would be for a 0 – 60 psi gauge and the 270Ω resistor from a 0 – 100 psi instrument.

Fig. 20 below is a diagrammatic representation of this sender. It works similarly to the TT 1100 senders where the bimetal element breaks or makes the circuit as it heats and cools. In this case, the bimetal element is tensioned by the action of pressure against the diaphragm and the coil has to heat the bimetal bar to a higher temperature to initially remove the pressure-induced tension and then to open the circuit. Due to this higher temperature required the cooling is more rapid and hence the "off-time" of the circuit is shortened. This produces a greater average current at higher pressure.

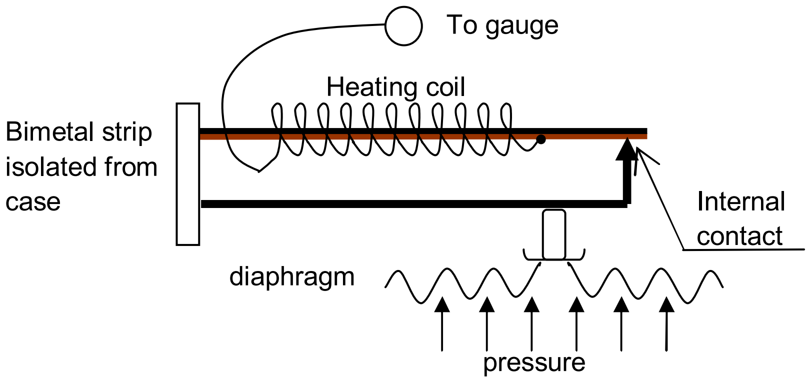


Figure 20: Bimetal oil pressure transmitter

Fig. 21 is a photograph of the "works" of a "PT" type sender. A diaphragm that responds to changes in pressure sits below this assembly and is connected by a short rod that passes through the base plate and bears against the arm sitting below the heating coil on the bimetal element in this photograph.

The hole to the left of and above the zero-adjust cam receives a spigot on the special adjusting tool. The cam itself comprises a circular ramp that lifts the mounting point of the bimetal element. (This is the copper-coloured bar running vertically above the cam itself.)

The calibration resistor can be seen to the upper right of the photo. (Note that this 150Ω resistor is not from the original unit but was one of several different values fitted during testing of this sender.)

Both the zero and span values of the sender are set at the time of manufacture and are not available as user adjustments.

Figure. 21: Bimetal pressure sender internals.

Photos in figs 22 and 23 below show a dismantled bimetal pressure transmitter. This particular unit is a 24V PT 1307/10 sender but is typical of all units of this type. It comprises a hard brass diaphragm fitted between two metal plates with a compressed O-ring to provide an oil seal against the lower (RH here) plate in fig. 22. On the upper part of this capsule assembly (LH here) a pin attached to the bimetal sending unit protrudes through the centre hole and bears against the centre of the diaphragm. This pin transmits the movement of the diaphragm to the bimetal sensor assembly. The formed diaphragm itself acts like a spring to oppose the applied pressure.

Figure. 22: Lower portion of bimetal pressure transmitter .

Fig. 23 below shows the upper portion of the pressure sender. The base is on the right and is dealt with in some detail below. The cover at left is spun over the base and connection to the sender is by way of a spring that bears against the brass disc you can see in the centre of the cover pressing on the right.

Figure. 23: Sender mechanism of bimetal pressure sender .

This resistor is in parallel with the heater winding and is thus switched in and out of circuit. For this reason, "matching" of one of these senders in a manner as described in the section on temperature senders may not be practical. Any external parallel resistor would add a current that varied only with battery voltage, in addition to the switched output of the sender. A series resistor could work but will reduce the maximum reading of the gauge which may not be an issue as it is the lower part of the gauge scale that is critical in these gauges.

At right, fig. 24 shows an underside view of the sender prior to dismantling. There is a small chase cut in the side of the plate that forms the upper part of the pressure capsule and also the baseplate for the sender's electrical bits. This vents the top portion of the sender to atmosphere and the cover rim is centre-punched to mark this point. It is important that this point sits at the lowest point of the sender so that any water that may condense inside the sender can drain. These senders are heated by the engine and cool when the engine cools down after use and movement of the sensing diaphragm will expel or draw air (and moisture) into the sender. If this vent is at a high point water may collect inside the sender over time.

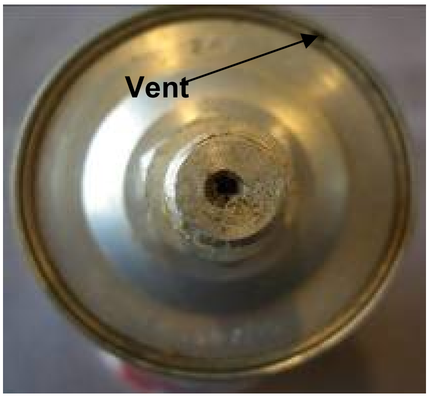


Figure. 24: Bottom view of Smiths pressure sender

VARIABLE RESISTANCE-TYPE OIL PRESSURE SENDER ("PTR"):

Variable resistance senders are used with "ACP" air-cored pressure gauges. The basic operation of a resistance type sender is shown in fig. 25. It is very simple with a crank operated by the diaphragm moving a wiper arm which contacts a resistive element connected to the gauge. The action is simply to place a greater or lesser resistance in series with the gauge which is displayed as oil pressure on the gauge.
This type of sender looks very much like the bimetal type and may be distinguished only by the part number or by measuring resistance between the sender terminal and case. A resistive sender should measure about 240 Ohms at zero pressure where a bimetal sender should read 40 - 65 Ohms provided the internal contacts are closed.

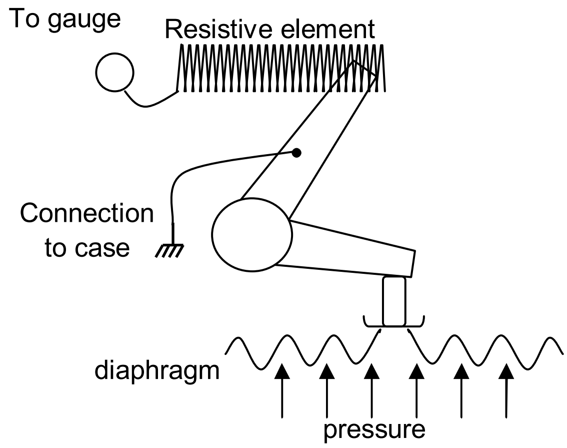


Figure 25: Variable resistance type oil pressure transmitter.

OIL PRESSURE SENDER DISCUSSION:

There are a few things to keep in mind if using these senders. You cannot directly replace a bimetal type sender with a variable resistance type. The bimetal sender may be considered to perform the functions of pressure sender and instrument voltage regulator. It may be possible to replace a bimetal sender with a variable resistance type for the "BP" gauges but the gauge would then need to be supplied from the instrument voltage regulator.

You cannot use a bimetal type sender with an "ACP", or air cored, type gauge. It does not work. Testing indicates that the higher resistance of the "ACP" gauge reduces current to below that required to operate the bimetal sender. The gauge will sit at a fixed high value sensing the combined resistance of the heating coil and any calibration resistor across it (see circuit diagram in fig.19).

TROUBLESHOOTING ELECTRICAL OIL PRESSURE SENDERS:

Bimetal type senders in particular seem to give a lot of trouble. Perhaps this is not surprising as they run at a higher temperature and are subject to vibration from the engine. The weak point is the electrical contacts within the sender. Test the gauge by substituting resistors (240 and 20 Ohms for BP/ACP gauges) at the engine and if the gauge operates correctly then the sender is the problem. Re-check at the gauge if necessary to prove the wiring.

Senders may have tapered BSP or NPT threads. These should not require any form of sealant tape or compound to seal. Some senders seal with a soft (fibre/aluminium/copper) washer against a land on the block casting. Thread seal tape or compound should be avoided. Most senders use the pressure connection as an earth return for the sender and sealing compounds may interfere with this electrical connection.

When replacing a resistance type sender, make sure you get one with the correct resistance range. Smiths use 240 Ohms (zero) to 20 Ohms (full-scale). Common ranges are 10-180 Ohms ("Euro") and 240-33 Ohms (USA) as for fuel tank level sensors. This last will work with Smiths gauges but will tend to read low at higher pressures. Furthermore, senders are calibrated for a particular pressure range. This needs to match the gauge. A sender calibrated for a 0-100 psi range is going to indicate a little over ½ the actual pressure on a 60 psi gauge. On the other hand, a sender calibrated for 0-60 psi is going to give a high reading on a 0-100 psi gauge.

As noted above, the resistance between terminal and case of a bimetal type sender should be 65 Ohms or less. Ideally you would check this resistance with some pressure applied. A cam (fig. 21 above) sets the zero position of the bimetal element and it is possible that with no pressure applied that the internal contacts could be open in which case no resistance can be measured. If testing these senders on the bench apply a little pressure (1 - 2 psi) to the sender to check. A bimetal sender that tests open-circuit with no pressure applied may in fact be serviceable.

APPENDIX A – TRIUMPH SERVICE BULLETIN T-64-38

TO: ALL TRIUMPH DEALERS - WESTERN ZONE

BULLETIN T-64-38

ATTN: SERVICE DEPARTMENT
SUBJECT: TRIUMPH SPITFIRE TEMPERATURE GAUGE TRANSMITTER

DATE: NOVEMBER 25, 1964

For complaints of low or nil temperature reading on the Triumph Spitfire, the transmitter should immediately be suspected, as faults in manufacture have been found.

Each transmitter is date coded in addition to the Smiths part number and codes 5/4, 6/4 and 7/4 (May, June and July 1964) are particularly suspect. Date codes before and after should be satisfactory.

There is also the possibility that another range of transmitter may have been fitted in error, which will also result in a false instrument reading.

In addition to part numbers, identification of the correct transmitter can also be made by the color of the plastic mould securing the Lukar clip which should be Maroon.

Part numbers for Spitfire and other models Smiths Temperature Transmitter are as follows:

Table E: Application data from Triumph service bulletin T-64-38 Nov. 1964

Model	Triumph Part # **	Smiths Part #	Colour	Gauge type **	Scale **	Voltage
Spitfire to FC26303	137386	TT4801/00	White	Bimetal (BT)	C-N-H	10
Spitfire FC26303 on	137705	TT4802/00	Red	Bimetal (BT)	C-N-H	10
Herald Coupe	121997	TT4800/00	Green	Semiconductor (TC)	C-N-H	12
TR4 - domed glass	131062	TT3802/00	Red	Bimetal (BT2300/01)	30-85-120	10
TR4 – flat glass	134435	TT3804/00	Red	Bimetal (BT2203/03)	C-N-H or 30-70-100	10
Sports Six (1600)	121997	TT4800/00	Green	Semiconductor (TC)	C-N-H	**12**
Vitesse 2 L (early)**	137386	TT4801/00	White	Bimetal (BT)	C-N-H	10
Vitesse 2 L (late)**	137705	TT4802/00	Red	Bimetal (BT)	C-N-H	10
** Derived from other sources						

Note the entry (in red) in the "Volts" column. The original Service Bulletin had "10" for this value. This is incorrect. It may be that about this time the "Sports Six" cars (aka "Vitesse") were being fitted with bimetal, or "10 Volt" gauges. Early Sports Six cars have a 12V, TC4303/03 temperature gauge fitted.

CHANGE LOG

Date	Version	Change list
September 2020	1.0	Initial release document
September 2020	1.1	Minor corrections to text. Added Triumph service bulletins.
October 2020	2.0	Major rewrite, Much of the more technical data transferred to part III.
March 2021	2.0	Minor re-wording of some sections, corrected errors in figure references, corrected several typos