A GENTLEMAN'S GUIDE

TO

SMITHS ELECTRONIC TACHOMETERS

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A gentleman's guide to Smiths electronic tachometers

1 Introduction:

Smiths Motor Accessories produced a variety of tachometers, not to mention a wide range of other automotive instruments, over the years. Many English and European cars were fitted with these devices and electronic tachometers were also sold as accessory instruments. In some cases, the original equipment instruments were branded "Jaeger" but were otherwise the same.
There are three broad classes of tachometer (and speedometer) – mechanical, electrical and electronic.

Mechanical, cable-driven tachometers were of three types:

Type	Identification	Approximate usage period:
Governor	X.nnnnnn	Supplied from 1920 to late 1940s
Chronometric	RC nnnn	Supplied from 1930 to 1970s
Magnetic	RN nnnn RSM nnnn	Supplied from 1940s to mid/late 1970s RSM mainly/only used for motorcycles

The above tachometers had the same internals as the comparable speedometer, without the odometer bits, and were driven by a cable connected to the camshaft or distributor, as in the Spitfire, Vitesse etc. The chronometric type was mostly found on motorcycles although chronometric instruments were frequently fitted to "competition" cars due to their excellent accuracy. ***(Some faultfinding information for cable-driven instruments is provided in appendix C to this document.)***

Two classes of electrical tachometer are found:

Type	Identification	Approximate usage period:
Voltmeter	RV nnnn (early Xnnnnn & Znnnnn)	Supplied from ???? to early 1970s
Electromag	RE nnnn	Supplied from 1950s to 1970s

RV electrical tachometers are mostly found on Jaguar/Daimler vehicles. These use a generator mounted on the engine, usually attached to the camshaft, and the indicator is a voltmeter that measures the voltage produced by the generator and is calibrated in rpm rather than Volts. These use the same style meter movement as used in the later Smiths electronic tachometers until the early 1970s.

Electromag instruments were a hybrid electro-mechanical instrument only ever fitted to commercial vehicles, primarily Leyland, and comprised a multi-phase generator as a sensor and an electric servo-motor driving an "AT" magnetic movement to indicate speed.

Later on, transistors and integrated circuits were utilised to eliminate expensive transmitters and drive cables. These electronic instruments could be readily fitted to any car, either as original equipment or as an accessory after a vehicle had been purchased. Various types were manufactured by Smiths. The RVI and RVC types detect pulses generated by the ignition system. For the RVP and RGP diesel tachometers, a pulse generator was still required to be fitted to the engine.

Electronic impulse tachometers:

Type	Identification	Approximate usage period:
Current sense	RVI nnnn	Supplied from mid 1960s to early 1970s Two distinct types of RVI were produced but external wiring is similar for each.
Contact (voltage) sense	RVC nnnn	Supplied from early 1970s
Pulse generator	RVP nnnn RGP nnnn	Used for commercial diesel vehicles and worked with an external generator similar to the RV device. Both 12V and 24V instruments are found.

The remainder of this document will deal only with RVI and RVC electronic tachometers.

1.1. *Identifying a tachometer:*

Mark Olson of Accutach uses a scheme for categorising the different Smiths tachometers and I am not about to re-invent the wheel so have used his system within this document. Mark's document can be found at https://accutach.com/smiths-tachs and it is well worth looking at. To summarise, tachometers are classed as three "generations", to which I will add three further classes, generation 0, generation 0.5 and generation 4. These generations are:

Generation 0 (**RV**) - an electrical tachometer which required a generator producing a voltage proportional to r.p.m. Circuitry comprised a full-wave (bridge) rectifier and a wire-wound calibration resistor. These instruments are mainly found in Daimler/Jaguar cars of the 1950s to 1960s. The movement in these instruments is physically the same as that used in generation 1 to 3 instruments.

Generation 0.5 (marked "RVI") – The first Smiths electronic tachometer. The indicator head had two spade terminals on the rear similar to the RV instrument. This connected to a remote sensing module which had a single connection to the distributor side of the ignition coil. Mainly found on early 1960s Volvo cars but may also have been used on other vehicles. Though it used a single wire connection to the coil as for the RVC type, these instruments were marked "RVI". A wiring diagram for this instrument is given later in this document – see "RVI 1310/00 - A Special Case". (Information on these instruments was gathered mainly from www.sw-em.com and www.VolvoSoultions.com) . This tachometer was only manufactured for about three years before being replaced by the generation 1 tachometer.

Generation 1 (**RVI**) – the second electronic Smiths instrument which used two transistors in a monostable multivibrator configuration. These instruments used an inductive pickup within the instrument to sense ignition current. The transformer primary connection was by way of a loop of wire in series with the ignition coil and attached to the instrument on the rear of the case.

Generation 2 (**RVI**) – also used inductive coupling to the ignition system but used a single transistor in a blocking oscillator circuit. The transformer primary winding was inside the case and connected to the car wiring via two bullet connectors – one male, one female – mounted on the rear of the case.

Generation 3 (**RVC**) – sensed voltage spikes at the coil to trigger the instrument. An integrated circuit is used to drive the meter. Connection to the coil was by either a single bullet connector on the rear of the case for the OEM type or to a spade terminal for the accessory tachometer.

Generation 4 (**RVC**) – A new meter movement but a similar circuit to, and using the same integrated circuit and voltage sensing as "Gen-3" above. Meter mounting screws form a "Y" pattern rather than the previous rectangular pattern. Connection to the ignition coil is by way of a connector protruding from the back of the case. The printed circuit board of the earlier tachometers was replaced with a "thick-film" board.

1.2. Other Smiths tachometers

You may come across Smiths ATRC tachometers. These instruments are designed for use in industrial applications and require a special generator to supply the speed signal. Not something you would normally fit to a vehicle.
These ATRC instruments are similar to the Smiths "Electromag" instruments ("RE" prefix) used in some commercial vehicles.

2. The Smiths RVI electronic tachometers

The "RVI" tachometers sensed ignition system current using a transformer to transfer pulses to the tachometer circuitry without any direct electrical connection to the ignition circuit. These instruments are identified by the letters "RVI", followed by numbers, printed on the dial. These identification characters are sometimes printed on the edge of the dial and may be hidden in normal use by the instrument bezel.

As noted earlier, there are two quite different versions of the RVI tachometer. These can be differentiated as follows.:

The "early" or Gen-1 type instrument has a pulse lead looped through a small nylon block and iron core (metal clip) assembly outside the case. This type uses two transistors in a monostable multivibrator circuit.

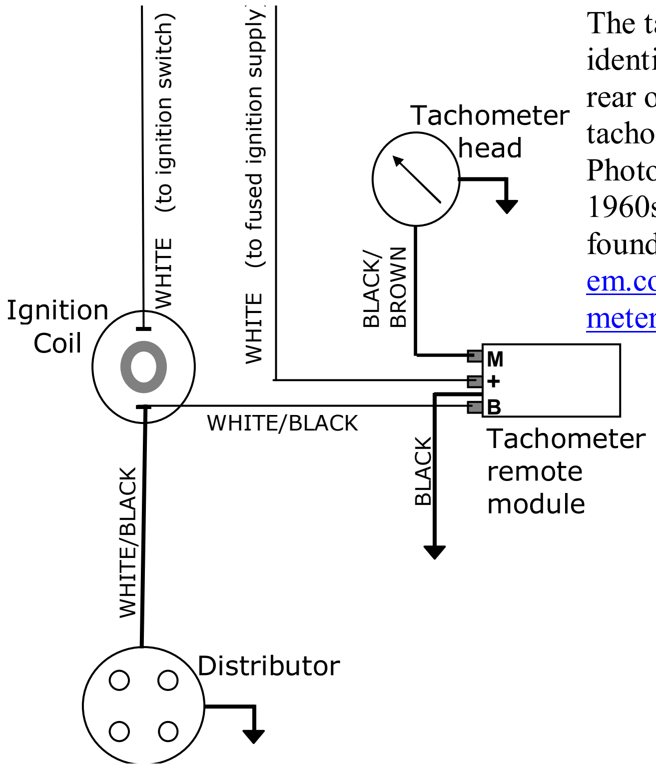
The "later" or Gen-2 type instrument has two bullet type connectors protruding from the rear of the case and a single transistor blocking oscillator monostable circuit inside.

There is no difference in the external wiring between the Gen-1 and Gen-2 type tachometers, both of which are marked "**RVI**". The pulse leads are placed in series with the coil, either in the coil supply lead from the ignition supply to the coil or between the coil and the distributor. The sense, or polarity, of pulse leads is critical to the operation of both types. *(Refer "4.2.1. Smiths RVI tachometer triggering", page 16.)*

2.1. RVI 1310/00 - A Special Case:

An exception to the above is the tachometer I referred to as "Gen-0.5" earlier. This is most commonly encountered in the 1961 – 1963 P1800 Volvo, aka "Jensen-Volvo". This instrument has a remote electronics module that was mounted at the front of the car which is connected to the ignition system by a single wire, as for the later "RVC" type tachometers. From the mid 1960s on Volvo recommended replacement of these instruments with the later Gen-1 unit.

"GEN-0.5" TACHOMETER WIRING AS PROVIDED IN VOLVO SERVICE MANUAL. THIS APPLIES ONLY TO THIS INSTRUMENT!



The tachometer head of these instruments can be identified by the presence of two blade connectors on the rear of the case as the only electrical connections to the tachometer.
Photographs of the various Smiths tachometers fitted to 1960s era Volvo cars, including this instrument can be found at <http://sw-em.com/Smith%27s%20Tachometer.htm#Smiths_Tachometers_Gen1_vs_Gen2_vs_Gen3> .

Regarding the sw-em site above, three generations of tachometer are defined which are not the same as generations defined here.

sw-em website generation	Gentleman's Guide generation
Gen 1	Gen-0.5
Gen 2	Gen-1
Gen 3	Gen-2

Figure 2.1: Gen 0.5 tachometer wiring. As fitted to the early 1960s Jensen-Volvo P1800 cars.

2.2. RVI Gen-1 tachometers:

As noted above, there are two versions of the RVI type tachometer and within each type there are two sub-variants:- OEM and Accessory. The rear of the Gen-1 type is distinguished by the external pulse loop assembly.

2.2.1. RVI Gen-1 OEM tachometer:

Figure 2.2: Rear view of the Gen-1 OEM tachometer which has one of the power supply connections internally connected to the metal case. In most cases the "red-line" will be marked on the dial.
Similarly, polarity may be marked on the dial as shown below.
Dashed white lines show the "rectangular" layout of the meter mounting screws in these instruments.

<u>CAUTION:</u>

If the connections on the back of the tachometer look like those in this picture, be very careful. This type of tachometer was produced in both positive and negative earth versions. Some positive earth instruments may have been internally converted to negative earth. If you are buying a second-hand tachometer, marked "positive earth", check with the seller as to the electrical polarity of the vehicle it came from or test as set out in the Appendix B, *"Checking an electronic tachometer"* later in this document
There is nothing special about the pulse lead wire, so if in poor condition or to eliminate unnecessary joints, replace with a new length of wire rather than risk later problems with faulty joints. Use 16 AWG/1.5 mm or 18 AWG/1.0 mm wire for this job.

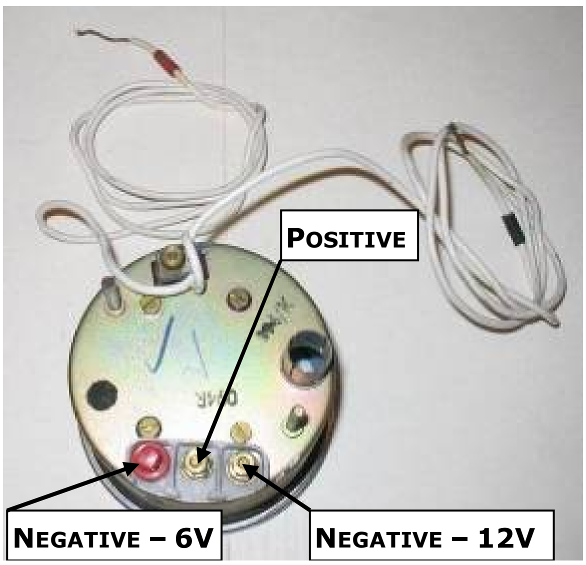


FIGURE 2.3: Gen-1 accessory tachometer.

2.2.2. RVI Gen-1 accessory tachometer:

Accessory tachometers, *fig. 2.3*, have no internal electrical connection to the instrument case. Two or three terminals for power supply connection are provided as can be seen in the lower part of the picture. This particular example has two connection terminals, the third terminal being covered by a red plastic cap. The centre terminal is the positive connection. The right-hand terminal, as shown in the picture, is the negative 12V connection and where provided (uncapped), on early production units, the left-hand terminal is the negative 6V connection.

2.3. RVI Gen-2 tachometers:

Gen-2 OEM tachometers were, in the majority of cases, negative earth instruments. Some are "caseless" instruments, notably the RVI 2832/00A fitted to the Rover P6 3500 saloon. Most were produced as 4 inch diameter instruments but both 3 inch (Rover) and 5 inch (Daimler/Jaguar) were also made.

2.3.1. RVI Gen-2 OEM tachometer:

The photograph in *fig. 2.4* shows the connections to the later RVI tachometer.

The male pulse lead connector goes to the power supply, the female connector connects to the coil on these negative earth instruments.

Gen-2 tachometers have the pulse coil assembly inside the case with connections brought out to bullet connectors as shown.

This later type appears to have been produced in negative earth versions only for OEM instruments but see note on next page.

Note the yellow object inside the case and labelled "Calibration adjustment". This is a potentiometer that may be used to fine-tune the calibration. This adjustment, requiring only a small blade screwdriver, is often covered with a piece of adhesive paper or in some cases, a rubber plug.

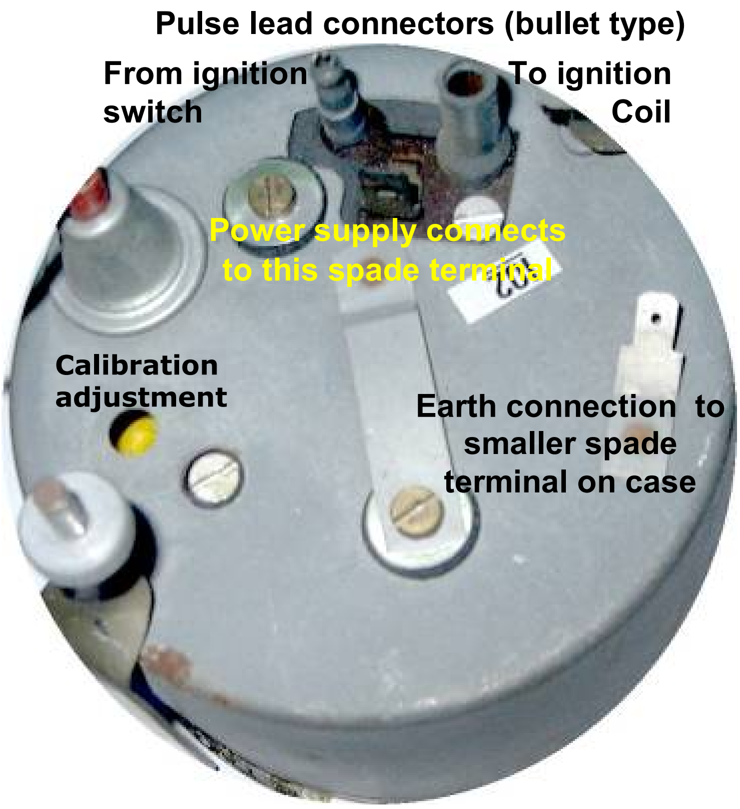


FIGURE 2.4: Typical Gen-2 OEM tachometer.

When finally fitting the tachometer to the vehicle, replace the rubber plug or place a piece of adhesive tape over this hole to keep dust out.

FIGURE 2.5: Example of a 3 inch diameter Gen-2 tachometer as fitted to some Rover P6, S1 and S2, 2000/2200 cars fitted with the Smiths "Ribbon" ("strip") speedometer.

(This page has been lifted from another document and goes in to a bit more detail than was originally intended for this guide.)

Note:

It is possible that some positive earth Gen-2 instruments may exist. Two different circuit boards have been found inside this model tachometer. Later production circuit boards could only ever be used on negative earth vehicles. Early production boards could be fitted to cars of either polarity.

Should you have removed a Gen-2 movement from its case, *figs 2.6 and 2.7* show the difference between the two circuit boards used in these instruments.

The late production Gen-2 circuit board is shown in *fig 2.6* and is the more common circuit board found in these instruments. The negative supply circuit board tracks around the mounting screw holes make electrical contact with the body of the meter and hence the chassis of the vehicle.
The upper left hand track is not generally connected but provides a negative supply connection point for a caseless instrument. Hence these instruments are always negative earth as isolation cannot be readily or reliably achieved due to the copper tracks extending to the edge of the mounting screw holes.

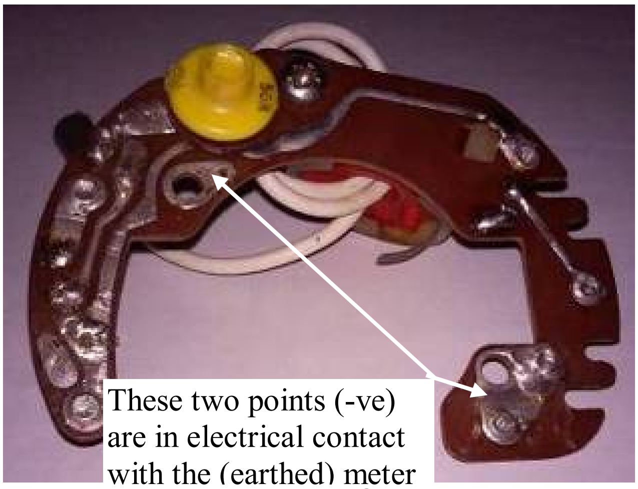


FIGURE 2.6: Later production Gen-2 tachometer circuit board for negative earth vehicles.

Fig. 2.7 shows a circuit board from another Gen-2 instrument, presumably earlier, with a slightly different track layout. It will be noted that the circuit board tracks, for both positive and negative tracks, are located at the mounting screw points and the copper track is set back from the mounting holes to prevent connection with the mounting screws. One supply track must be insulated from the meter frame by way of an insulating washer fitted between the circuit board and the meter frame. If this board is mounted without an insulating spacer then a dead short exists between the power supply terminal and the earth.
This particular board can thus be configured for positive or negative earth vehicles though this would have been a factory, rather than a user, option.

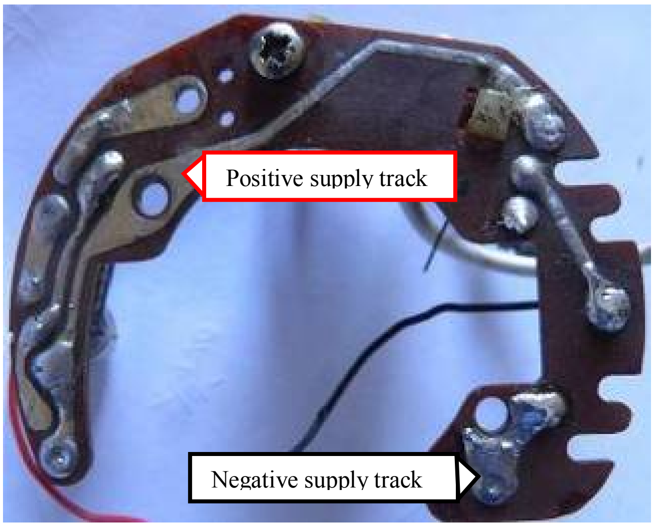


FIGURE 2.7: Early production Gen-2 tachometer circuit board suitable for positive or negative earth vehicles.

2.4. RVI Gen-2 accessory tachometer

Smiths produced a plastic cased "pod-style" instrument in the Gen-2 range. This was the RVI 5000 series and was mainly sold as an aftermarket tachometer.
This tachometer is shown in *fig. 2.8* at right.
Pulse leads are white and, when new, are marked with short red and black sleeves near the end of the wires. The red marked pulse lead should connect (for a negative earthed vehicle) to the ignition supply. These could be used with both 6V and 12V supplies.

FIGURE 2.8: Gen-2 RVI 5000 series tachometer

Isolation of the internals from the vehicle chassis allowed these to be fitted to both positive and negative earth vehicles. These were also fitted to some Volvo vehicles as standard equipment and marked RVI 5411/xx and RVI 5413/xx. The difference between the accessory and OEM versions is the provision of a 6 Volt connection option inside the rear of the case as shown in *fig.2.9*. The rear case cover simply pops off to provide access.

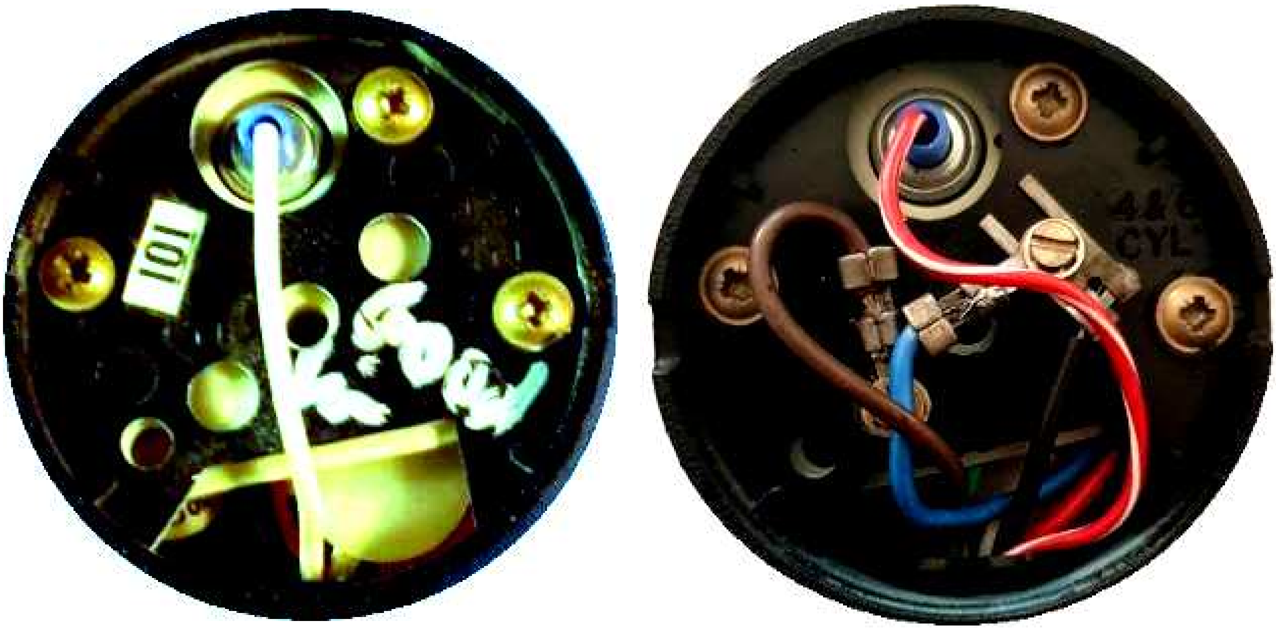


FIGURE 2.9: RVI 5000 series tachometer. At left is the rear view of an OEM tachometer, with the cover removed and without a voltage select option. The right-hand picture shows the same view of an accessory instrument and the voltage select terminals. The blue wire is the -12V connection, the brown wire the -6V connection. The black wire is the lead to the vehicle's negative supply. Changing voltage simply involves transferring the black wire to the terminal corresponding to the required voltage.
(Left-hand photo supplied by Mark Olson)

As the case of the accessory tachometer is electrically isolated from the car, a green wire is provided as a dedicated earth for the light and always connected to the car's chassis.

3. The Smiths RVC electronic tachometers:

Where the RVI tachometer senses current in the ignition circuit, the RVC type senses voltage pulses at the coil. RVC tachometers will work with most ignition systems. The pulse sensing is via single wire connected to the coil on the distributor side and requires no further modification of the cars wiring beyond providing power and light to the unit. The current loop of the RVI instruments is no more. All OEM instruments were negative earth.
Internally these instruments are very different to RVI instrument. An integrated circuit is used rather than the discrete transistors used previously.
There are also significant internal differences between Gen-3 and Gen-4 instruments though external connections were the same.

3.1. RVC Gen-3 tachometer:

The Gen-3 instruments retained the same style meter as previous models. Pointers and dials could be swapped between Gen-3 and the earlier instruments if desired. This ability permitted the works and case from a Gen-3 to be used to upgrade an earlier RVI tachometer.

3.1.1. RVC Gen-3 OEM tachometer:

The early model RVC tachometer, with meter mounting holes in a rectangular pattern, is known to have been fitted to MG and Jaguar vehicles in the early 1970s. The "MGB-style" shown in *fig. 3.1* looks almost identical to the Gen-2 RVI model except that the dial is marked "RVCxxxx" and the female pulse lead bullet connector is replaced with a rubber plug. OEM instruments retained the bullet style connector for the pulse lead in most cases.
Jaguar vehicles used this same model tachometer with the pulse and supply leads brought out to a 4-pin connector with a white wire looped between two of the pins as in *fig. 3.2*.

Note that caseless instruments of this type were also manufactured. The later Rover P6 3500 cars are fitted with the RVC 2812/00 caseless tachometer.

Figure 3.1: Rubber plug here in lieu of female bullet connector on the RVI tachometer.

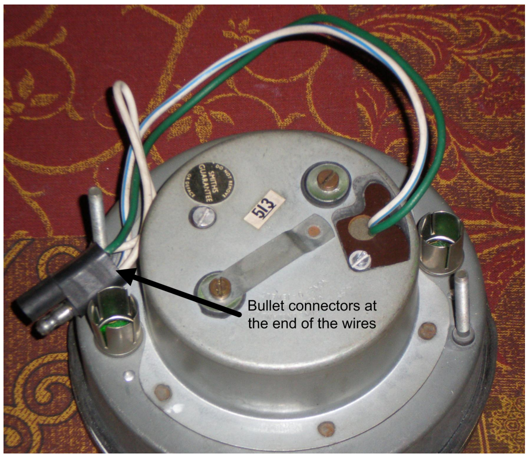


Figure 3.2: Jaguar RVC tachometer photo courtesy of Mark Olson,

3.1.2. RVC Gen-3 accessory tachometer:

(No photographs of this one.)
A cylinder select switch was provided and accessed via a hole in the back of the tachometer case.
Power and pulse connections were by way of three spade terminals in the same configuration as the Gen-4 instrument and the wiring is the same as for the Gen-4 instrument.

3.2. RVC Gen-4 tachometer:

The Gen-4 instrument was the last of the "classic" Smiths tachometers. Internally there were significant changes as electronics were now effectively a single component and a new type of meter (for Smiths) was used. The mounting screws for the meter were now of a "Y" pattern rather than the rectangular pattern of earlier instruments. There were also changes to the taper on the meter spindle and the positioning of the dial mounting screws. You cannot readily fit an earlier dial or pointer to a Gen-4 tachometer.

3.2.1. RVC Gen-4 OEM tachometer:

Connections in a late model RVC OEM device consist of a blade connector for power supply, a spade connector spot-welded to the case for negative or earth connection and a single "bullet" type connector for the pulse lead as shown in *fig. 3.3* at right. The "Y" mounting screw layout of the Gen-4 instrument is plain to see here (dashed lines).

There were also caseless versions of the Gen-4 instruments manufactured. Gen-4 caseless instruments (e.g. RVC6419/00) were fitted to Triumph TR7/TR8 cars and possibly in other marques.

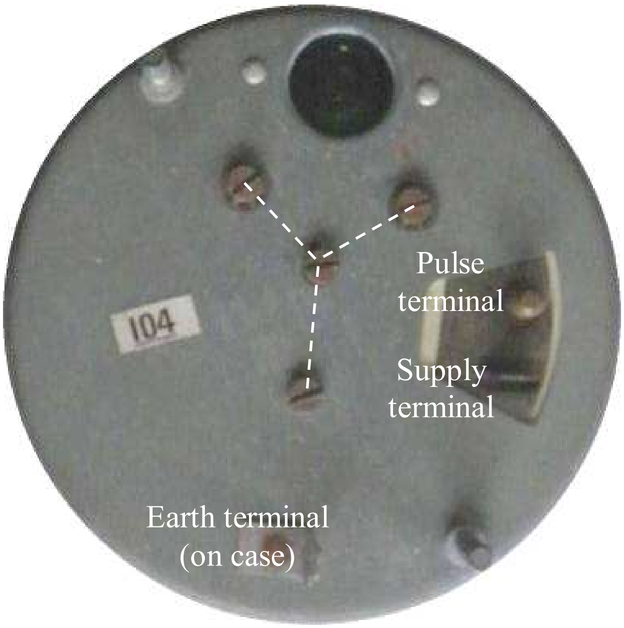


Figure 3.3: Gen-4 OEM tachometer showing terminals. Dashed lines show "Y" shape of meter mounting screw pattern.

3.2.2. RVC Gen-4 accessory tachometer:

Fig. 3.4 below shows the rear of the "accessory" type Gen-4 tachometer. As with earlier accessory instruments, the electronics inside are electrically isolated from the case.

Note the white selector switch next to the terminals. This selector switch is only found on Gen-4 instruments, Gen-3 RVC tachometers used a switch accessed through a hole in the rear of the case.

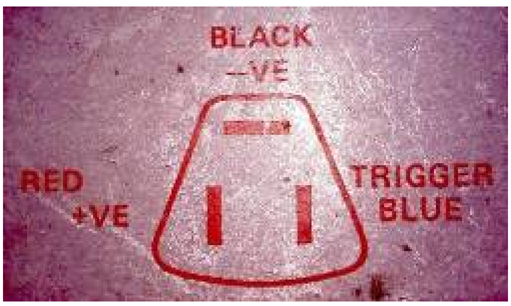


FIGURE 3.4: Rear view of Gen-4 accessory tachometer. Terminals at bottom with white cylinder select switch above. Enlarged view of terminal identification at right.

Fig.3.5 shows the RVC range's answer to the RVI 5000 series instruments. This comprises a small indicator head designed to be mounted on a dashboard with sticky pads fitted to the base. Four wires (2 for meter, 2 for lighting) lead from the underside of the indicator head through a hole cut in the dashboard. All the electronics are housed in a rectangular metal case which is intended to be hidden behind the dashboard. Power and pulse connections are made at the electronics unit and are the same as those shown for the Gen-4 accessory tachometer above.
A two-pin cinch socket for connection to the indicator pod meter is provided and located in the hole above "SMITHS".

***FIGURE* 3.5:** Gen-4 pod style tachometer comprising FVG 1021 head unit and separate FVG 1022 electronics module for mounting under dashboard.

4. Fitting a tachometer to the car – and getting it working!

Any tachometer that relies on the case for one of its supply connections will be permanently damaged if connected to a vehicle with opposite polarity, as will any accessory tachometer if the power supply is connected the wrong way around. Note, if present, the polarity printed on the dial of the instrument and if it does not agree with what you have determined, then get it checked out. Note that most Gen-2 OEM instruments and all Gen-3 OEM and Gen-4 OEM instruments will be negative earth as supplied by the manufacturer.

4.1. All Smiths tachometers:

First step when fitting any **OEM** tachometer is to check the polarity and voltage is correct for the target vehicle. If you had a working tachometer and it has stopped working, refer to section "*5.4. Troubleshooting tachometer – already fitted*" later in this document.

Note: The presence of an alternator on a car does not mean it is negative earth as some may tell you. Back in the day, BMC, and possibly other car manufacturers, equipped some of their positive earth vehicles (Notably Austin/Morris/MG…) with alternators. Probably not many around now but you have been warned.

Take some time to make sure of the polarity as if you get this wrong the tachometer will need repairing. The germanium transistors used in these tachometers are not readily available and they are expensive. *(Refer to Appendix B if polarity of an OEM tachometer cannot be determined.)*

For accessory instruments, with no electrical connection between the internal electronics and the case, this simply means wiring the power supply terminals correctly and selecting the correct voltage.

Once the polarity is known and is correct for the target vehicle, the power supply can be connected to the instrument.

4.2. Smiths RVI tachometer wiring:

While there are significant internal differences between the Gen-1 and Gen-2 tachometers, they connect to the vehicle in the same ways – and the terms "OEM" and "accessory" are used to differentiate between the wiring configurations usually used in each case. These two wiring configurations are shown in *figs 4.1 and 4.2* below. Irrespective of which wiring option is used, all the current drawn by the ignition coil, and only the coil current, must pass through the pulse lead.

Any ignition system that does not permit the RVI tachometer's triggering transformer to fully magnetically energise (saturate), or "de-energise" will adversely affect operation.

Both the power supply to the tachometer and the pulse lead sense are polarity sensitive. Connecting the tachometer supply with the wrong polarity will damage the tachometer, so make absolutely certain that it is connected correctly before powering up.

Connecting the pulse lead with the wrong polarity will not damage the tachometer but it will not work well if it works at all. If an RVI tachometer is known to be good and does not operate when installed in a vehicle then swap the pulse lead connections. This should have the tachometer working

Where points have been replaced by a solid-state switch (TAI), these tachometers will still work. They will not work with any ignition system that drives the coil directly, such as capacitor discharge systems.

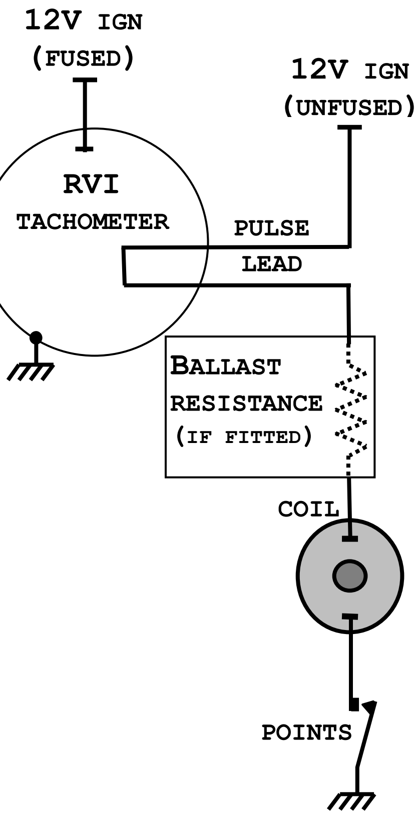


FIGURE 4.1: **OEM-STYLE** WIRING:

The pulse lead is connected in the supply to the ignition coil. Ignition coil supply is taken from the (un-fused) "Ign" terminal on the ignition switch or electrically equivalent location. Tachometer supply is taken from an ignition-controlled source through a fuse.
This wiring configuration is used where tachometers are fitted to a vehicle by the manufacturer and cannot be easily duplicated for an aftermarket tachometer where wires may be joined within the vehicle's wiring loom.

For an accessory type tachometer, the earth connection will be to a terminal and not to the case as shown here.

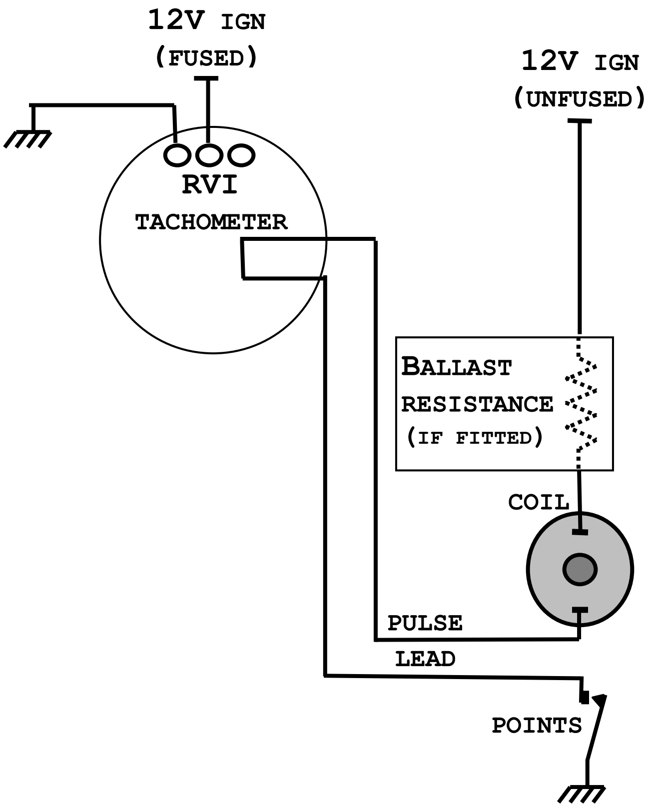


FIGURE 4.2: **ACCESSORY-STYLE** WIRING.
The pulse lead is connected between the coil and the distributor, replacing the existing wire. This configuration guarantees that only the coil current passes through the pulse lead.
Tachometer supply is again taken from an ignition-controlled source through a fuse. If no fuses are fitted in the vehicle, then fit an in-line fuse for the tachometer.

For an OEM type tachometer, the earth connection will be to the case and not to a terminal as shown here.

Fig.4.3 below show the wiring for the pulse lead assembly attaching to the back of Gen-1 instruments. Accessory type instruments had coloured markers at the end of the long pulse leads when new but these markers were almost always cut off once the tachometer was fitted to a vehicle.

Without the "iron core", the tachometer will not work! One could easily be made if required. This "little bit of tin" completes the magnetic circuit that allows the tachometer to sense pulses.

The plastic former shown in the diagram holds the pulse lead in place to prevent the wire chafing against the iron core and shorting out.

A replacement can be fabricated and it is a fairly simple matter to make a new iron core and/or former. See Appendix C to this document for details.

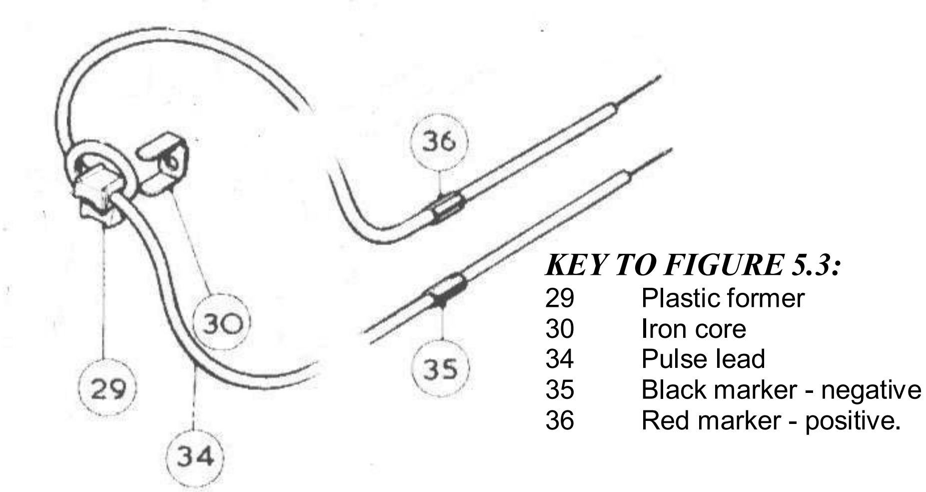


FIGURE 4.3: Early type RVI pulse lead assembly. Note how the pulse lead is threaded through the plastic former. When replacing this lead try to route the wire the same way which may save some trial and error when re-fitting.

If you have replaced the pulse lead on a Gen-1 tachometer you may have reversed the magnetic field generated by the pulse lead/iron core assembly. This will require swapping the ends of the pulse lead. Or rethread the wire in the plastic former as in *fig.4.4*.

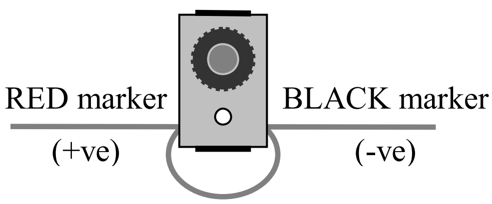


FIGURE 4.4: View of assembly as mounted, from rear of tachometer. Positive end of lead enters plastic former from the left through upper hole, loops and exits through lower hole at right.

4.2.1. Smiths RVI tachometer triggering:

The following is Smiths description of operation for the Gen-1 instrument. The Gen-2 instrument operates similarly.

> "The primary of the triggering transformer (pulse lead) is connected in series with the primary of the engine ignition coil, so that when the contact breaker in the engine distributor closes, the current flowing to feed the ignition coil passes through the primary of the transformer energising the core. When the contact breaker opens to provide a spark to the engine, the flux in the transformer core collapses and appears as a short duration voltage pulse across the secondary of the triggering transformer."

This "short duration voltage pulse", in Smiths description of operation above, must be of the correct polarity to turn a transistor on. The polarity of this pulse is determined by the direction of the magnetic field generated by the coil current flowing in the pulse lead.

So if the current flowing in the pulse lead is flowing in the wrong direction, the generated pulse will try to turn an already turned off transistor, off. So nothing happens!

The voltage generated by the triggering transformer is a function of the rate of change of the magnetic field and this is very fast when the points open. It is much slower when the points close, due to the characteristics of the ignition (or any) coil.

The purpose of the iron core (aka "clip", "Pole piece" "horseshoe"…) is to couple the magnetic field generated by the pulse lead to a similar core in the internal triggering winding. Thus the tachometer cannot work if this is missing.

The triggering transformer in the Gen-2 tachometer is housed within the tachometer case and only the pulse leads are externally accessible, at the connectors on the rear of the tachometer.

NOTE: If the car is fitted with a ballasted ignition coil then the ballast resistor must be left in circuit but the tachometer will still work. The system may use a ballast resistor a resistance wire, often yellow or pink, embedded in the wiring loom. A ballasted system is essentially a lower voltage coil with a series resistance to limit current. At a continuous 12V, this coil is unlikely to last long.

4.3. Smiths RVC tachometer wiring:

Wiring RVC accessory tachometers is relatively straightforward. Connect power and connect the trigger terminal to the distributor side of the coil.

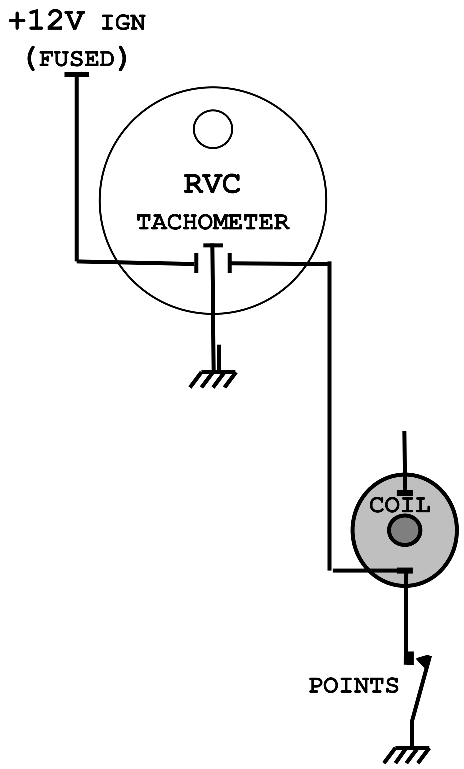


FIGURE 4.5: **Accessory-STYLE** WIRING:

The pulse lead is connected to the distributor side of the ignition coil.

Tachometer supply is taken from an ignition-controlled source through a fuse.

This wiring diagram assumes vehicle is negative earth. Swap supply and earth connections if vehicle is positive earth.

Wiring this way should work with most ignition systems.

May not work on "tachometer" outputs from electronic ignition systems!

Things can become interesting when it comes to OEM tachometers. For tachometers fitted to vehicles with points-based, or Kettering, ignition systems the above wiring will work.

Problems arise where vehicles are fitted with factory electronic ignition systems such as the Lucas OPUS ignition system. These systems have a dedicated "tachometer" terminal which is a switched 12V signal. They may neither work nor survive connection as in *fig. 4.5* as the trigger voltage from the coil will be in excess of 200V. (*Refer also "5.3.1. Interfacing RVC tachometers when replacing OPUS ignition system"*)

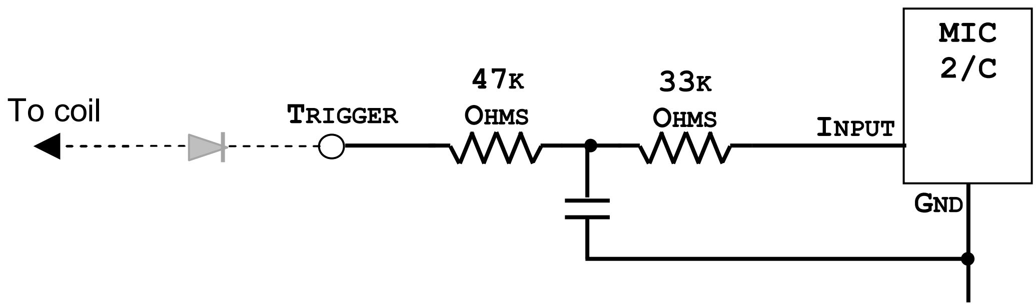


FIGURE 4.6: Input circuit diagram for Gen-4 accessory tachometer RVC 1002/00F

Fig. 4.6 shows the input circuit for an accessory type tachometer. Compare resistance values with those in *fig. 4.7* for a vehicle using an OPUS ignition system. It is likely that an accessory tachometer, or one from a vehicle using a points-based system, will not work when connected to a dedicated tachometer terminal on an electronic ignition system. This will have to be determined for the electronic ignition system of interest.

The diode shown (dashed/greyed) in *fig 4.6* may need to be added for some aftermarket electronic ignition systems. If all else fails then try a readily available 1N4007 diode or similar. The diode will need a reverse voltage rating of 1000V and a maximum current rating of at least 1 Amp.

Referring to *fig 4.7*, when connecting this tach directly to a coil the dashed resistor and wiring needs to be added. Some experimentation with values of this resistor may be required – start high and reduce if necessary to provide reliable tachometer operation. Refer also to section 5*.3.1 "Interfacing RVC tachometers when replacing OPUS ignition system*".

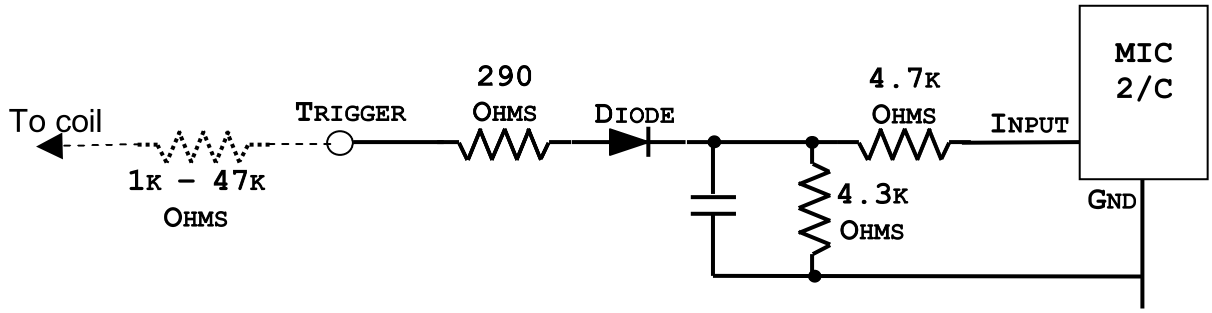


FIGURE 4.7: Input circuit diagram for Mk III Jaguar E-Type Gen-3 tachometer for use with Lucas OPUS ignition system. (Circuit provided by Mark Olson)

In most cases the Smiths RVC tachometer circuitry will be similar to the accessory tach so the wiring diagram in *fig. 4.5* will do the job. In the event that you are having tachometer issues after upgrading a car's ignition system, try to find someone who has done a similar upgrade and has solved the same issues. Vehicle specific forums on the internet are a great place to start. .

5. Tachometer troubleshooting notes:

If the tachometer is not working, recheck the voltage supply to the instrument paying particular attention to the earth connection. Use the spade connector on the case, or if not present, secure the connection under one of the meter mounting screws on the case, using a proper terminal rather than a loop of wire. **Hint:** If the tachometer operates until you turn the lights on, then you have a tachometer earth problem.

5.1. RVI type:

If the tachometer is an RVI type check the pulse leads are correctly connected in series with the coil and that the iron core is properly fitted. The legs of the external iron core should sit inside those protruding from the case. Try swapping the pulse leads (again) to see if it works/improves. (This should not be an issue if replacing an OEM unit with an equivalent good replacement unit but will be required if changing vehicle from positive-earthed to negative-earth.)

Note 1: If the pulse lead is connected on the supply side of the coil, then check for "extra" connections at the coil. There should be only one wire connected (plus possibly a suppression capacitor) to the coil supply terminal in an un-ballasted ignition system and two wires for a ballasted system. Either re-locate any extra connections or wire the tachometer pulse lead between the coil and distributor. (Thanks to Brian Gough of Vancouver, Canada for raising this.)

Note 2: The RVI tachometer is a very reliable instrument but it is also very fussy. If the current drawn by the coil is too high they can play up. Ignition coil currents in the range 3 to 4 Amps are what it's designed for. If a sports or high-performance ignition coil has been fitted the tachometer may not operate correctly or at all. If this is the case, temporarily replace the higher spec coil with a standard coil to determine whether this is the problem. There is not a lot you can do with a Gen-2 instrument in this situation but the Gen-1 instrument can often operate with a high-performance coil if the loop on the pulse lead is removed so that the pulse lead passes through the plastic block without looping.

If you have replaced a Gen-2 RVI tachometer with an RVC type then check that the old tachometer pulse leads have been joined together. Failing to do this, or to run a new ignition supply wire to the coil, will leave the coil unpowered. In a car with a ballasted coil, there will be spark when cranking the engine but not otherwise!

5.2. RVC type:

For an RVC type meter make sure the pulse is taken from the distributor side of the ignition coil.

In the case of a Gen-4 RVC tachometer reading zero with the engine running, firmly tap the tachometer glass a couple of times to free a stuck meter. These instruments are prone to the needle sticking at zero. It may be that it will also free up itself at higher revs. *(For one explaination why Gen-4 tachometers can stick on zero, see article at http://www.team.net/TR8/tr8cca/wedgelab/other/tach/tach.htm.)*

If everything seems to be correct but the tachometer is not reading correctly, most probably the needle wavers at higher revs, check the points gap, condenser and coil.

Check the current drawn by the tachometer. There should be some but it will only be a few tens of milliamps. If no current can be measured, the instrument needs servicing or the external wiring is faulty. Check connections.

If you are a dab hand with a multimeter and soldering iron, and have some basic knowledge of electronic circuits, then almost all the data you need to repair one of these instruments is available on the internet. Otherwise find someone with the necessary skills to check/repair it.

5.3. Modified ignition systems:

None of the Smiths tachometers described in this document are suitable for use in systems using multiple coils.

If a Transistor Assisted Ignition (TAI)/Transistor Assisted Contact (TAC) system is installed with an original specification coil then the RVI tachometer should continue to work.

Any other ignition enhancement system will have RVI systems struggling to work consistently, if at all.

An RVI tachometer may not work without modification in systems with high (>4 Amps) coil primary current. Gen-1 instruments may be adapted by reducing the number of turns of the pulse lead in the pickup. Pertronix provide some information on this modification at http://support.pertronix.com/kb/faq.php?id=34 . RVI tachometers may not work with systems that alter the dwell time of the ignition system as Lumenition ignition systems appear to do.

RVC instruments should work in almost all cases. Further information may be available from the ignition system manufacturer so check their website.

For many cars supplied with RVI tachometers there may be an equivalent RVC version available from a later model vehicle. Gen-0 to Gen-3 instruments all used the same meter movement so swapping dials and pointers is possible with little trouble. Gen-4 tachometers use a different meter, different pointers and dial mounting hole spacing, so swapping out parts is not readily done.

MG and Jaguar owners are well catered for here as visually similar, or identical, tachometers were used in later cars so replacing an RVI instrument with an RVC type can be readily done. Note also the caseless tachometers (Gen-2/Gen-3) fitted to the Rover P6 mentioned earlier.

For Capacitor Discharge Ignition (CDI) systems, RVI tachometers are unlikely to be capable of working and should be replaced by an RVC type. CDI ignition systems typically generate very short ignition pulses and run at several hundred volts, which exceeds the voltage rating of automotive electrical cable. Voltages of this magnitude behind the dash don't bear thinking about. Similar comments apply to RVC tachometer wiring and this would need to be considered for any CDI system without a dedicated tachometer output. Even then, some modification to the RVC pickup wiring may be required even if a dedicated "tach" output is provided. Again, check the CDI manufacturer's user manual.

5.3.1. Interfacing RVC tachometers when replacing OPUS ignition system:

For most RVC tachometers, upgrading an ignition system should not be a problem. If you have upgraded from an Opus ignition system then put a series resistor in the pulse lead to the coil. A 47k Ohm resistor should be sufficient though you may need to experiment starting with this value and reducing it as required. The issue is that the pulse input circuitry to tachometers from some Opus systems has a very low resistance and components can be damaged if a series resistor is not fitted. This has been noted when fitting a Lumenition ignition system but will likely apply for other Brands of electronic ignition systems.

Thanks to Martyn Smith of the United Kingdom for bringing this to my attention.
(*See section 4.3. "Smiths RVC tachometer wiring" on pages 17, 18.)*

5.3.2. External tachometer interface modules:

Interface modules are available that allow RVI tachometers to work with modified ignition systems. Two examples may be found at:
http://www.technoversions.com/TachMatchHome.html (U.S.A)
and
https://www.spiyda.com/tachometer-electronics.html (U.K.)

I have not used either device and there may be others out there. The reader will have to judge for her/himself whether options such as these present a suitable solution.

5.4. Troubleshooting tachometer – already fitted:

This section assumes that a tachometer has been fitted to a car some time ago, possibly as original equipment, and has now begun operating erratically or is determined to be out of calibration. It is further assumed that the first step already taken has been to check the ignition system and adjust or repair as necessary.

Ensure that all connections to the tachometer are secure. Pay particular attention to earth connections behind the dash, both at instruments themselves and the connection to the body of the car.

Have there been any additions or modifications done to the car in the recent past that could affect the instrument? Bear in mind that the tachometer could have been out of calibration for quite some time before you noticed the fact. RVI instruments may np longer work if a bit of "extra" current has been added to the pulse lead, such as using the 12V coil terminal to supply some other device.

Beyond carrying out the steps set out above there is really nothing that can be done without removing the tachometer and opening up the case. Another tachometer could be obtained and fitted but unless its maintenance history is known you may be no better off.

These instruments are decades old and have possibly had no maintenance nor been otherwise serviced for a considerable period, if at all. The internal electronic components inside are affected by age. Lubricants can thicken over time to the point that they behave more like glue and the needle exhibits slow or jerky movement. Do not squirt CRC or similar on the bearings – it may improve things temporarily but don't do it. Cleaning and adjusting the meter is to be preferred. Lubrication requirements for the meters are not too arduous but clearances are tight. End float on the meter spindles of most of these instruments should be 0.003 to 0.004 inches. If this reduces for any reason then meter (pointer) movement will be sluggish/erratic/cease and will be worse at low temperatures.

Balance of the meter and pointer is achieved by adjusting weights on the meter assembly itself. For the Gen-0 to Gen-3 instruments, these are held in place by friction. If a tachometer has been dropped then one or more of these "balance weights" may have moved which will affect the linearity of the instrument. It may read low over the first half of the range and high over the upper half of its range or vice-versa. This will require that the meter is balanced ("poised" is the term used in Smiths literature) which is a fiddly job at the best of times and also requires that the instrument is removed from its case and is operable.

With the exception of the Gen-4 instruments, there is a calibration potentiometer that may be tweaked to improve calibration but it may not be enough and it will not correct linearity errors. This calibration "pot" may not be accessible without removing the instrument from its case.

The circuitry within these instruments is simple and considerable service information is available on the internet and will not be presented here. These instruments are readily repaired by almost anyone with a basic knowledge of electronics and proficiency with a soldering iron. There are also plenty of companies that are able to repair these for a fee.

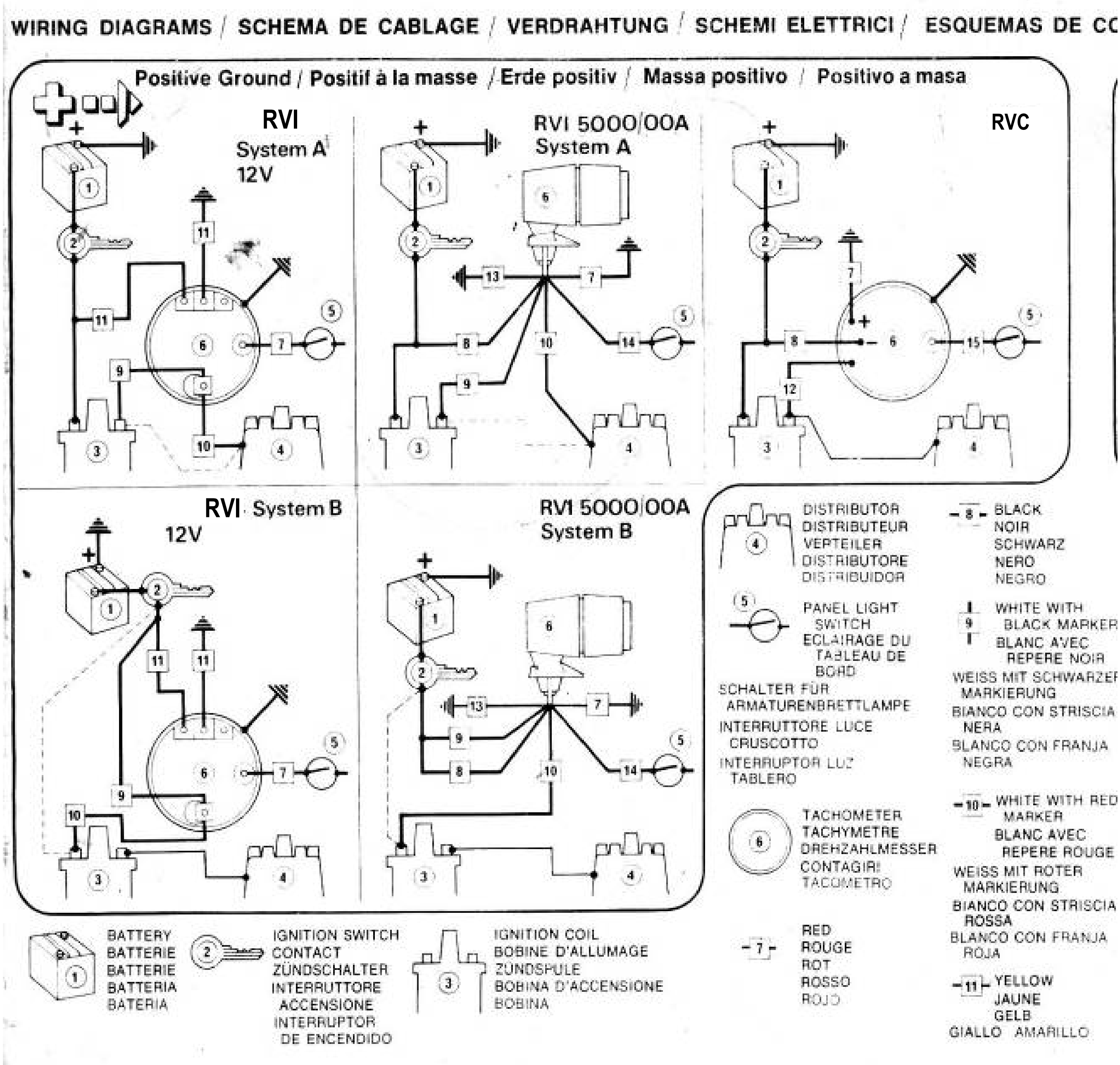
The meter movements used in these tachometers are not normally prone to failure other than for the Gen-2 tachometer. If the tachometer is connected with the wrong supply polarity and left powered for any length of time then the meter coil will overheat and melt the plastic coil former usually locking the armature/pointer assembly in one spot. Only sure repair is another meter (from another Gen-2 tachometer).

Meter coil resistance in the Gen-2 is about 10.5 Ohms. All other Smiths tachometers have coils of resistance 70 Ohms or more.

Appendix A:- Smiths accessory tachometer wiring

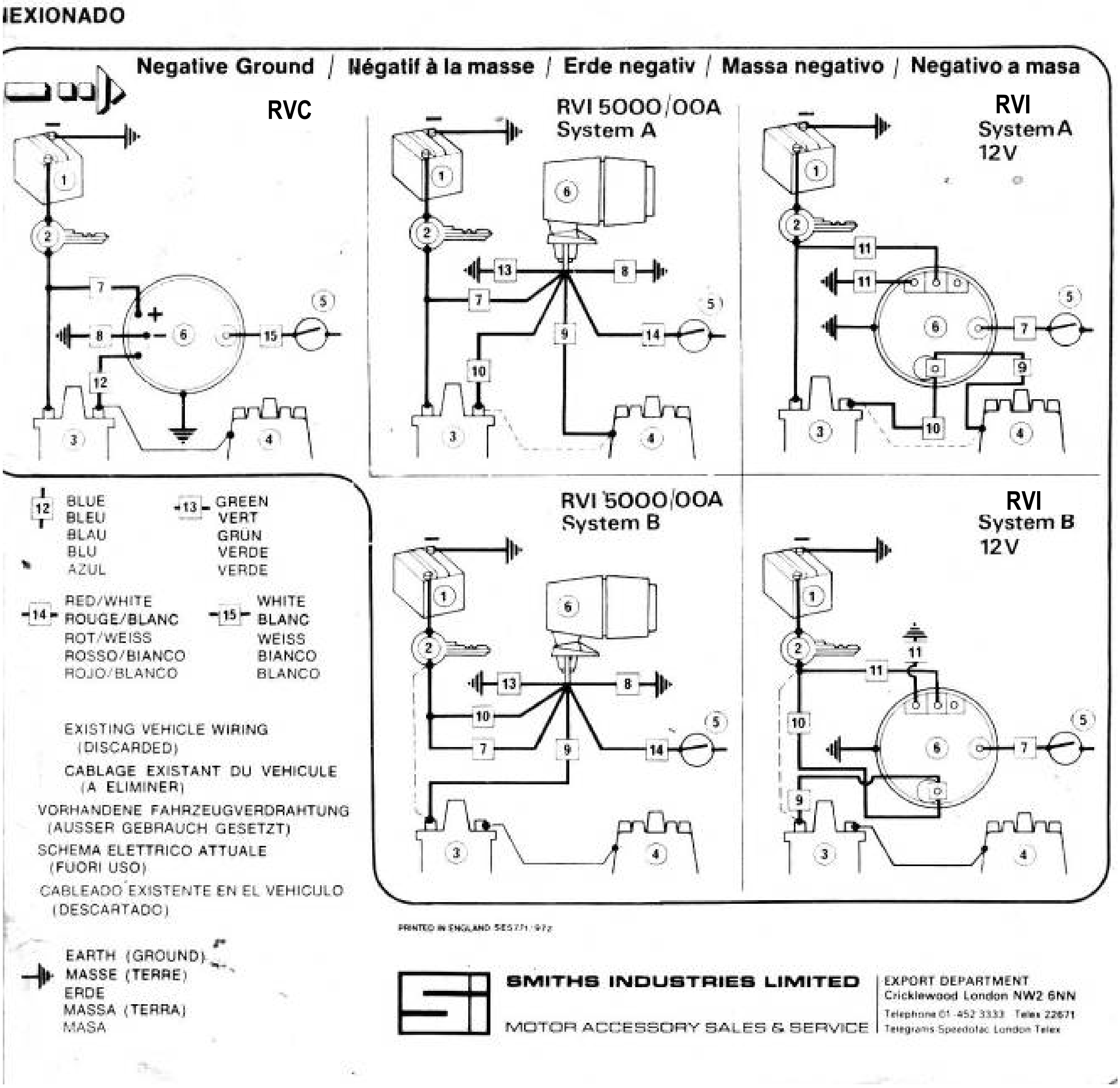
In the following wiring diagrams, for RVI tachometers, “System A” corresponds to “Accessory style” wiring method and “System B” the “OEM style” in the section “Smiths RVI tachometer wiring” earlier in this document.

Positive earth vehicle



Appendix A:- Smiths accessory tachometer wiring continued

Negative earth vehicle



Appendix B:- Checking an electronic tachometer:

The following tables set out a few quick checks that can be made, prior to connecting, to determine if an OEM tachometer has a chance of working. Connections will differ on Accessory type tachometers but values should be similar. These are listed below for each type I have available to test.

The only tool required is a multimeter that can measure both resistance (Ohms) and current draw in milliamps. Generally a digital meter has the red lead positive on resistance ranges, but it is negative on an analogue multimeter. To make life easier, tests have been carried out using each type of meter and the results set out in separate tables for each multimeter type. Where resistance values are given, these will help determine the polarity of the tachometer.

The "supply" terminal is the one that connects to the car's ignition controlled supply, the other lead to case earth. For accessory-type tachometers, which have isolated terminals for positive and negative, the "supply" terminal for these measurements is the positive terminal of the tachometer.

THE RESISTANCE READINGS ASSUME A NEGATIVE EARTH TACHOMETER BUT IF THE READINGS ARE "BACK-TO-FRONT" THEN, EITHER THE POLARITY OF THE MULTIMETER LEADS IS NOT WHAT YOU THOUGHT OR THE TACHOMETER IS POSITIVE EARTH. CHECK POLARITY OF METER LEADS FIRST.

Perform the resistance check first, using the nearest range on your meter to that given in the table. Avoid using the higher resistance ranges on multimeters.

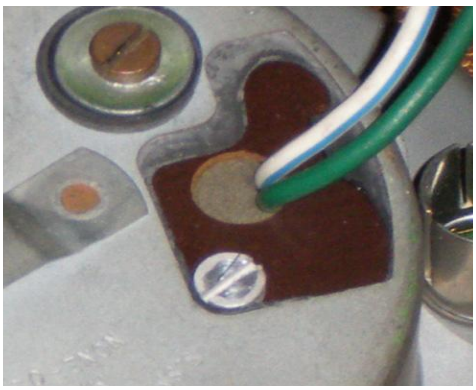
Notes:

Values in the tables below apply only to instruments fitted with their original Smiths circuit boards. If the internals have been altered or replaced quite different readings may be observed.

The measured resistance may "wander" when the meter leads are first connected to the instrument. Allow reading to settle down to a steady value before checking against values provided.

If resistance checks are satisfactory proceed to check the current drawn by the tachometer. In any event a substantially different resistance or current reading, lower or higher, than the range provided in the table implies a fault in the tachometer.

If testing Jaguar tachometers, make sure you identify the correct type, which is printed on the dial but may not be legible. The left-hand tachometer in the picture is a Jaguar Gen-2 RVI tachometer (two white leads from inside case), the one on the right a Gen-3 RVC (single white/blue lead from inside case). Use tests below appropriate for type.



TEST METHODS – DIGITAL MULTIMETER (Red lead positive)	**TACHOMETER IDENTIFICATION**
RVI Gen-1 monostable type with external pulse coupling. Positive and negative earth OEM versions available. One instrument tested using meter's **0-2000Ω** range. Measured resistance should be in the range 600Ω to 900Ω with the red meter lead to (12V) supply terminal. Measured resistance should be in the range 300Ω to 600Ω with the black meter lead to supply terminal. Tachometer draws about 50mA to 60mA from power supply with no input pulse. No current indicates an open circuit inside the tachometer. A significantly different current indicates tachometer needs service.	
RVI Gen-2 blocking oscillator type with internal coupling. Two instruments tested using meter's **0-2000Ω** range Measured resistance should be infinite (no reading) with the red meter lead to supply terminal. Measured resistance should be in the range 150Ω to 300Ω with the black meter lead to supply terminal. Tachometer draws no indicated current from power supply with no input If a current is measured with no pulse input, transistor is leaky/shorted. This test does not detect open circuit transistor, resistor or open winding in the pulse transformer.	
RVC Gen-3 early type with rectangular pattern mounting screws. One instrument tested. Read about 6.6kΩ irrespective of the polarity of the leads. Current draw with no pulse lead connected is about 30mA.	
RVC Gen-4 later type with "Y" pattern mounting screws. Negative earth OEM instrument only. Five instruments tested using meter's **0-20kΩ** range Measured resistance should be in the range 6000Ω to 7000Ω with the red meter lead to supply terminal. Measured resistance should be in the range 4500Ω to 5000Ω with the black meter lead to supply terminal. Current draw with no pulse lead connected is about 30mA.	**OEM**  **Accessory** 

TEST METHODS – MOVING COIL MULTIMETER (Red lead negative)	**TACHOMETER IDENTIFICATION**
RVI Gen-1 monostable type with external pulse coupling. Positive and negative earth OEM versions available. One instrument tested using meter's **Rx100Ω** range. Measured resistance should be in the range 600Ω to 700Ω with the red meter lead to supply terminal. Measured resistance should be in the range 900Ω to 1200Ω with the black meter lead to supply terminal. Tachometer draws about 50mA to 60mA from power supply with no input pulse. No current indicates an open circuit inside the tachometer. A significantly different current indicates tachometer needs service.	
RVI Gen-2 blocking oscillator type with internal coupling. Two instruments tested using meter's **Rx100Ω** range Measured resistance should be in the range 150Ω to 300Ω with the red meter lead to supply terminal. Measured resistance with the black meter lead to supply terminal should be infinite (no reading). Tachometer draws no indicated current from power supply with no input If a current is measured, with no pulse input, transistor is leaky/shorted. This test does not detect open circuit transistor, resistor or open winding in the pulse transformer.	
RVC Gen-3 early type with rectangular pattern mounting screws. One instrument tested using meter's **Rx100Ω** range Measured resistance 1200Ω with the red meter lead to supply terminal. Measured resistance should be in the range 4500Ω with the black meter lead to supply terminal. Current draw with no pulse lead connected is about 30mA.	
RVC Gen-4 later type with "Y" pattern mounting screws. Negative earth OEM instrument only. Five instruments tested using meter's **Rx100Ω** range Measured resistance should be in the range 3000Ω to 5500Ω with the red meter lead to supply terminal. Measured resistance should be in the range 4500Ω to 5500Ω with the black meter lead to supply terminal. Current draw with no pulse lead connected is about 30mA.	**OEM**  **Accessory** 

Appendix C:- Possibly useful information ?

Mechanical tachometer woes

Mechanical tachometers are fairly reliable but will lose accuracy over time and will need re-calibrating. Internal wear can also cause them to lose accuracy and read erratically. Specialised equipment is required to recalibrate these.
Some faults with these tachometers are external to the instrument. The following table provides some troubleshooting tips for these tachometers.
Note that these "faults" also apply to any cable-driven instrument such as a speedometer.

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING/SOLUTION
Instrument doesn't read	Drive/drive cable faulty.	Disconnect drive cable from instrument and remove inner drive cable. If broken or worn then replace. Re-connect drive cable and check the inner cable turns when engine cranked/run. If cable/drive serviceable, refer to "Needle doesn't move…" below.
Needle doesn't move or pointer moves erratically	Internal wear and instrument needs repair. Inner drive cable may be too long.	Wear in the instrument. Speedcup (drag-cup) is pinched between thrust plate in rotor and top bearing in older instruments. This could be due to old age and/or a too long inner drive cable. There must be no end thrust applied to the instrument head by the drive cable. Check the length of the inner drive cable by undoing the cable nut at the rear of the instrument and check that the ferrule on the end of the outer cable butts up to the instrument body readily without applying any force to the instrument.
Needle wavers at low revs	Drive cable	The drive cable needs replacing. Also check tachometer shaft is not binding or hard to turn else a new cable will only be a temporary fix.
Needle flicks to full scale or beyond	Severe internal wear or oil in instrument.	Replace or repair instrument. Replace oil seal on driving gear.

Instrument drive cables comprise an inner wire core with closely wound layers of thin wire wound over this core. Each layer is wound in the opposite direction to the previous one. The end result is a cable with very little torsional movement (twist) when new. These deteriorate over time and allow the cable to "wind-up" in use. This leads to erratic operation or "wavering" in the needle at lower indications.

Bezel refurbishing:

A word of explanation: *Throughout this part of this document I use the word "meths" to refer to methylated spirits which in other parts of the world is called "denatured alcohol".*

Smiths bezels incorporated a resilient material to retain the instrument glass and seal the "front" end of the instrument. Over time, this loses its resilience and may break down and "bleed" onto the glass. For 4" instruments, remove the bezel and replace the resilient seal material with 4mm diameter sponge rubber cord.
For 2" instruments, 3mm sponge cord works well.

In New Zealand Para Rubber do/did stock 4mm sponge cord. Rubbermark stock 3mm and 4mm sponge cord. Rubbermark's stock codes are:

73.16030N SPONGE CORD 3MM DIA (Neoprene)
73.16040E SPONGE CORD 4MM DIA (EPDM)

To remove the old (formerly) resilient material from chrome bezels:

1. scrape out with a piece of wood (toothpick e.g.) or plastic. If it's so hard a toothpick won't touch it then go to 2.
2. soak the bezel in meths overnight and remove the resulting gunge with a toothpick or stiff brush (an old toothbrush works just fine).
3. Repeat step 2 until clean.

Give a chrome bezel a touch up with metal polish once cleaned.
Do not soak (black) painted bezels or the paint finish will be damaged.
Note that chrome-finish bezels are made from brass and painted bezels are steel. (It may be that older bezels are brass, newer are steel.)

Join rubber foam cord using contact adhesive - a butt joint should be OK. If using cyano-acrylate (Super-glue) or similar rigid adhesive, use a lap joint.
Make sure all the rust and old rubber has been cleaned from the outer rim of the instrument case before refitting the bezel. A light smear of K-Y jelly (the best rubber lubricant known to man!) on the sponge cord prior to assembly helps too.

If you want to replace a bezel in poor condition, then those from a Smiths speedo or instrument cluster of the same physical size works as they are the same part. There are at least two styles of bezel used so try and find one with the same shape.

Tabbed bezel removal:

For most OEM instruments the bezel is retained against the rim of the case by 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 the glass is broken, carefully remove which will release pressure from the joint.

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 each of the six tabs. This will break any bond that may have formed between the bezel tabs and the case rim. In some cases this may be all that is required to free the bezel sufficiently for it to be removed.

Mark Olson of Accutach advises that a pair of strap wrenches can be used to remove a bezel. Strap wrenches will give you better grip on the components.
Don't get too carried away with this method as cases are made from thin steel and too much pressure could distort or dent these.

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 in a similar manner to that set out for meths in "Bezel refurbishing" above.

Note: Do not use boiling water if using this "hot water" method! There is a risk that very 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.
As a method of last resort, the above method in "Bezel refurbishing" for removing old sponge seals from the bezel dissolves the adhesive that held said sponge seal in place but can also dissolve the material itself. However, meths can also assist with separating a stubborn lugged bezel from the instrument case.

Place the instrument face down on a flat surface. Sheet plastic with cloth on top serves well to protect the bench top from any damage meths may cause.

Using an eye-dropper, brush or other means, apply, around the full circumference of the bezel, enough meths to wet the rim of the bezel where it meets the case flange.

Allow to soak for several minutes then try rotating the bezel keeping the tachometer face-down to ***prevent meths contacting the trim ring or dial***. The bezel should now turn reasonably easily and can be removed.

Separate glass, trim ring and bezel and allow to air dry to avoid damage to the sponge seal.

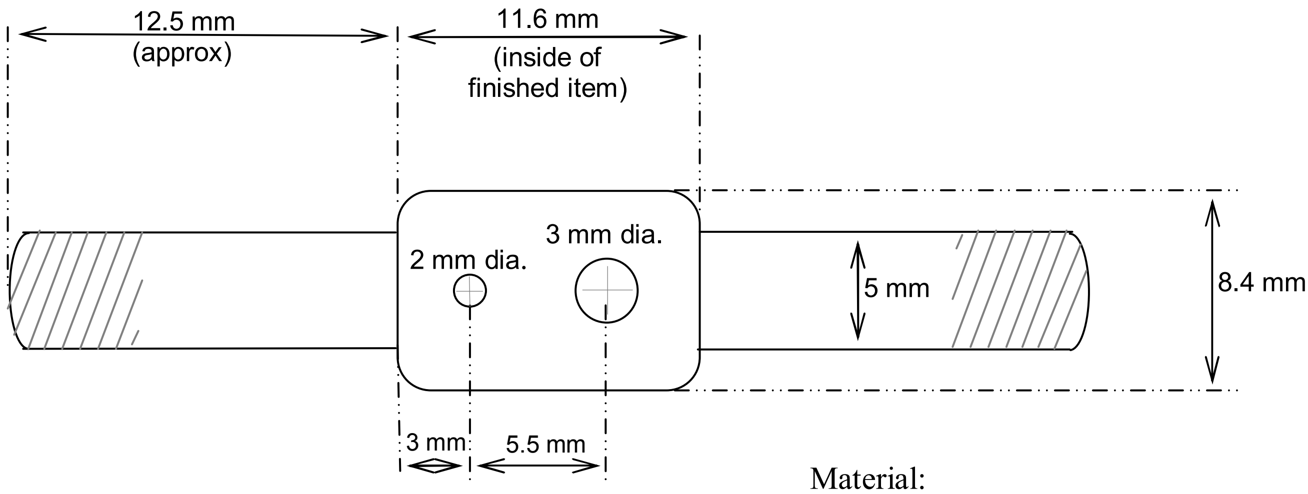
Note that this may separate the sponge material from the bezel. Replace when dry.

The reason this works appears to be that the meths penetrates and lubricates the joint between the bezel seal and case. This method has been successfully used with bezels fitted both with original sponge material and where this sponge has been replaced with alternative material as described in "Bezel refurbishing" section above.

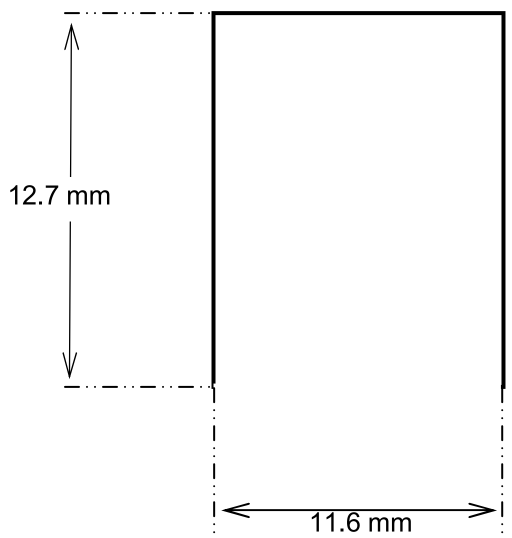
Both the meths and hot water methods can be used if the glass is cracked and meths may be the better options in these cases.

Appendix D:- Gen-1 tachometer iron core and plastic former:

The sketch below is a pattern the iron core of the Gen-1 tachometer. One can readily be made if required. Dimensions have been obtained from a Smiths item in good condition.
The material used should be soft iron or mild steel. Do not use high-tensile steel, such as roofing iron.
The thickness is not absolutely critical. 24 to 28 s.w.g /23 to 27 a.w.g/0.4 to 0.6mm is the ideal range. Thinner material may be too flimsy and thicker material may not fit properly. The legs should be a sliding fit inside those protruding from the tachometer itself to provide good magnetic coupling between what is two parts of a transformer core..
If you can find a dead oil-filled ignition coil, an old power transformer or a largish audio transformer, the laminations that form the core of these are an ideal material for these clips.
The 2mm hole shown accepts the nub formed on the top of the plastic former. This will not be necessary if you also have to make a former to hold the pulse lead. The mounting bolt passes through the 3mm dia. hole.
It is important that the hatched area in this plan is free of paint, including varnish, and burrs to provide maximum contact area with the internal clip. Tinplate may be OK but thick zinc (galvanising) should be removed.
When making these, I have always used transformer core laminations.
The extra width of the centre part is primarily to provide support around the mounting bolt hole. A strip of metal 5mm wide could be used for the whole thing but I would suggest in this case a brass washer is placed beneath the securing nut.
Make sure that any ragged edges and burrs on the completed core have been removed.



Material:
0.5 mm (25 SWG) soft iron (annealed low-carbon steel).



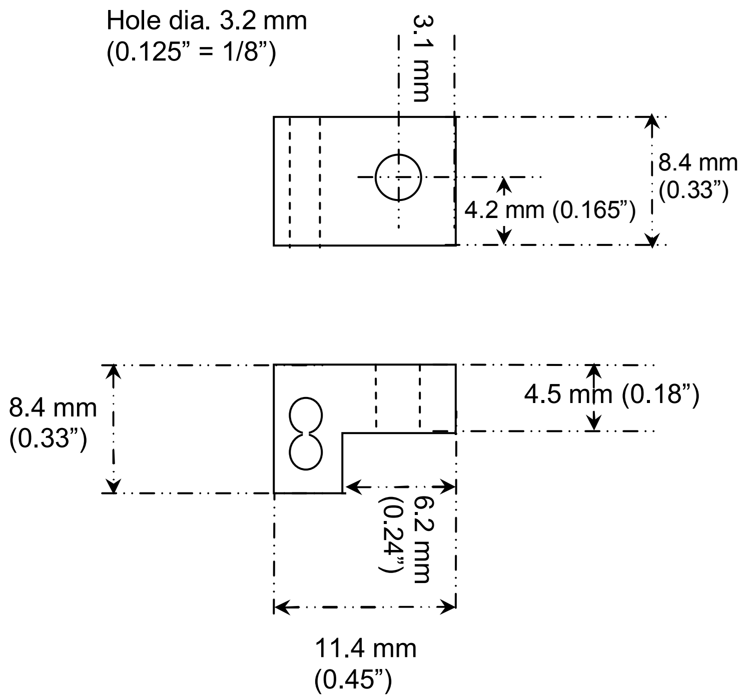
Edge view of the finished article. Length of the legs should be within +1/-0mm of that shown. The width of each leg should be within ± 0.5mm.

The plastic former (below) is not critical in most dimensions and can be made from any insulating material. Possibly the most available would be polyethylene from an old kitchen cutting board.

The sole purpose of this block is to prevent chafing, and eventual shorting, of the pulse lead wire against any metal components. The original item has raised guides to locate the iron core. These have not been shown here. If it was desired to more accurately mimic the original then increase the width between the legs of the iron core by 1 mm and cut a 5 mm chase, 0.5 mm deep, on each side of the block to locate it.

The most critical dimensions are the overall width that fits inside the iron core (previous page), the overall height (needs to be close). The chase cut to clear the nut supporting the internal core/coil assembly must be sufficient to clear the nut (approx 4 mm). If no chase is provided for the clip legs, a small dab of silicone sealant between the plastic former and the iron core would prevent movement.

Siamesed holes for the pulse lead wire are shown as for the original pattern and are 3.2 mm (1/8") diameter. The holes can be separated slightly if needed and the pulse lead wire should be a firm fit through them.. Some modern automotive electrical wires have thinner insulation and such wires will be loose within the plastic former. Apply a dab of silicone adhesive/sealant here if needed.



Change log:

Date	Version	Change list
Dec 2019	2	Re-order document. contents Add section for Gen 0.5 instrument Change (widen) acceptable resistance values for Gen-1 testing to account for variations between accessory and OEM types. Section on replacing mechanical tachometer with electronic removed.. Added comments re other types of tachometer (ATRC etc.) Gen-1 pickup clip details added
Dec 2019	2.1	Minor cosmetic changes. Some minor changes to wording (grammar/typography).
April 2020	2.1	Add tips for removing bezel. Rename "Miscellaneous" to "Bezel refurbishing".
June 2020	2.1	Additional warning text added to "Tabbed Bezel Removal" section. Section re-ordered.
July 2020	2.1	Minor enhancements to text/illustrations
November 2020	2.2	Added information on the "Gen-0.5" tachometer.
March 2021	2.3	Added section describing the differences in Gen-2 circuit boards. Added further information on the Gen-0.5 instrument. Also insulating block dimensions for Gen-1 tachometer.
July 2021	2.4	Added section on mod to RVC wiring when replacing Opus ignition.
December 2021	3.0	Rewrite of RVI sections and addition of wiring diagrams and tachometer triggering sections.