Project 328

Build a LED oil temperature meter for your vehicle

Knowing your engine oil temperature can be very valuable, this instrument employs a readily available dipstick probe with a thermistor mounted in it as a sensor and displays temperature on a row of LEDs.

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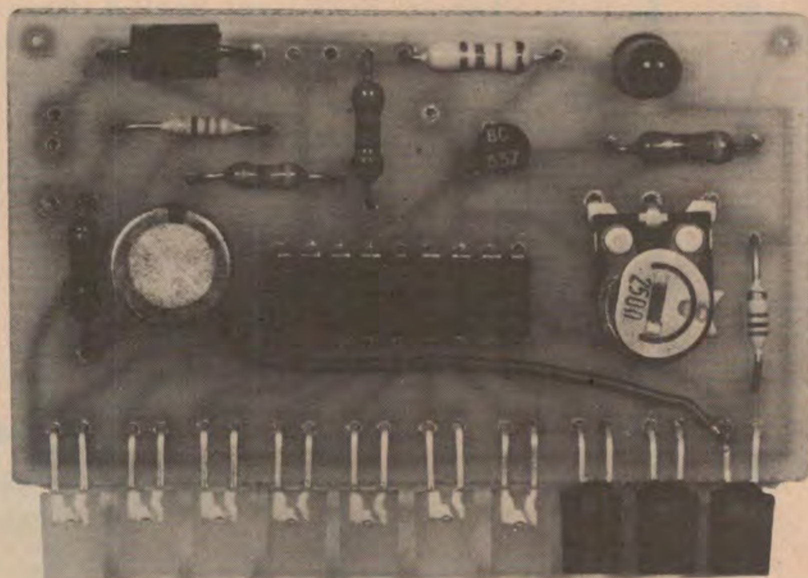


JUST AFTER WWII, one of General Motors' vice-presidents located a virtually brand-new Bugatti Royale — one of Europe's most sought after collector's vehicles and of which a mere thirteen had been made. This example had run less than a hundred kilometres since new and had been stored throughout the war.

When the engine was subsequently stripped down *it looked totally worn out*. Every single bearing surface was damaged beyond belief.

Ten years later, GM's Bedford truck division began an extended study into similar phenomena. A striking example was two truck fleets running similar vehicles but in dissimilar service. Fleet 1 was in long distance haulage (London-Edinburgh) and averaged 500 000 km. Fleet 2's business was house-to-house coal deliveries in London's suburbs. Their record was *less than 20 000 km* between major overhauls!

In the case of the Bugatti and Fleet 2, the mechanical carnage was caused by acid build up in the vehicles' sumps. The wear was *chemical* not mechanical.

How it's caused

When a petrol engine is switched off, a quantity of unburnt and partially burnt fuel remains in the combustion chambers. This condenses on the cylinder walls and drops down into the oil in the sump. This condensed fluid consists mainly of water and sulphuric acid.

The acid content is boiled off when the oil exceeds 80°C (176°F). But if that temperature is not reached and maintained for at least some minutes (or if acid-diluted oil is left in the engine for extended periods) engine longevity will be massively reduced.

For most commuters the problem tends to be oil that's running too cool rather than too hot. Only too often an engine that appears to use no oil is simply having a regular top-up with acid!

If your vehicle usage is limited to short runs there's not a great deal you can do about it except be aware of the problem. If you care about it sufficiently, take the car for a good long run (at least 40 km) at least once a fortnight — or at least change the oil every second month regardless of distance driven. At least you now know why cabs regularly exceed 300 000 km between engine changes!

Too hot

Apart from its lubricating function, engine oil 'washes' heat from engine components. Its ability to do this decreases rapidly beyond 135°C (275°F). There is also evidence that some multi-viscosity oils revert permanently toward the lower end (i.e: thinner) of their range of viscosity if overheated.

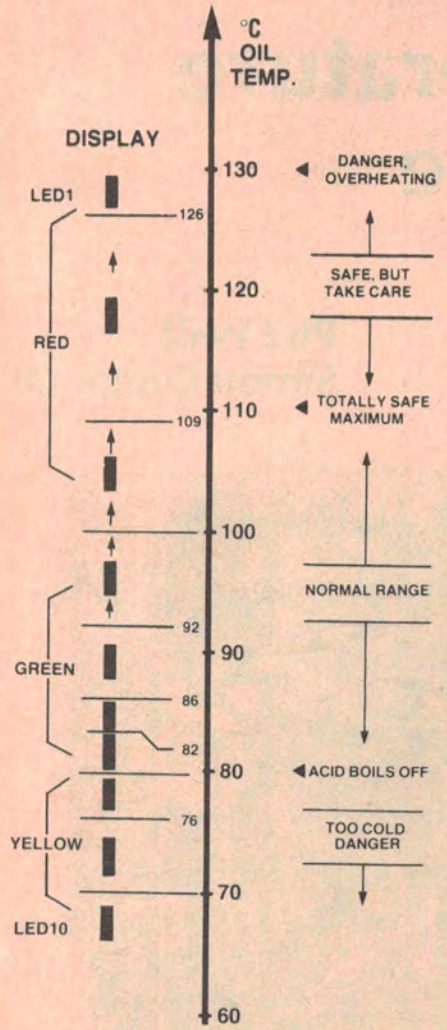
The *totally safe* oil temperature for continuous running is 110°C (230°F). Some oil companies quote 132°C (270°F) as an absolute maximum. Our Managing Editor's own experience (whilst with GM) is that, with the exception of air-cooled engines, 125°C is safe for continuous operation.

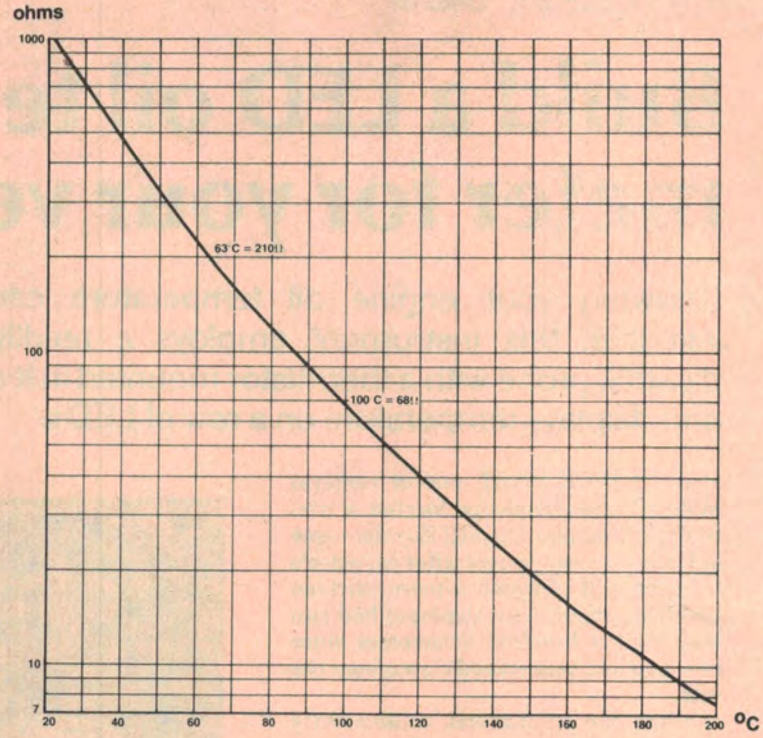
Few modern vehicles suffer from overheated engine oil (transmission fluid is something else again though!) A notable exception is some VWs (particularly Kombi versions) — few can be driven hard in an Australian summer without severe oil overheating and the risk of consequent severe engine damage.

Overheating engine oil is simpler to cure than oil that's insufficiently warm. Simply add an oil-cooler; obtainable from most specialist parts suppliers.

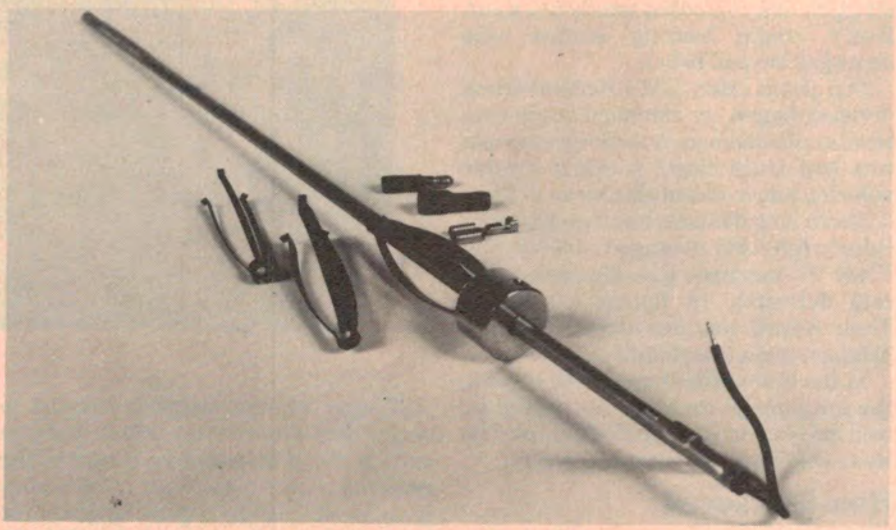
A monitor

Most cars these days, with the exception of Volkswagens, are fitted with some sort of water temperature indicator. Often this is no more than a warning light which hopefully never comes on during the life of the vehicle, and if it ▶





Calibration curve for the NTC thermistor in the dipstick probe.



The V.D.O. dipstick probe with its associated parts. Full assembly details are given on page 43.

does it's probably too late to avoid some engine damage.

Since the coolant temperature is controlled by the car's thermostat and radiator it is not a good indication of oil temperature, or true engine temperature.

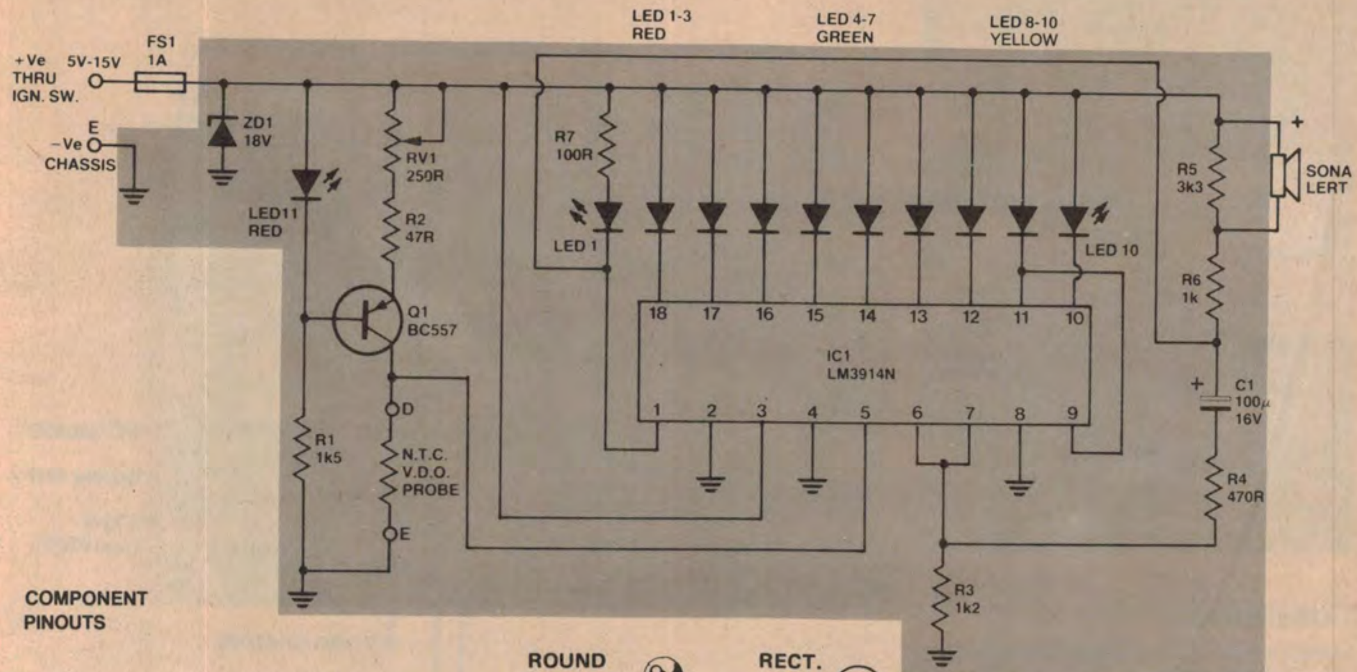
Monitoring the oil temperature is a much better indication of the engine's operating temperature but the problem is how to measure it. Any temperature probe will have to be inserted deep inside the engine or through the sump. Accidental loss of oil caused by the sensor falling out would be *catastrophic*, not to mention very expensive. The most practical way to insert a probe into the engine is through existing holes, such as the sump plug or the dip stick hole. In fact, VDO instruments make thermistor sump plugs and dip stick probes for use with their oil temperature meters.

We have chosen the VDO dipstick probe for our project as it is easy to install without having to drain the sump, and the wiring to the probe is well protected in the engine compartment. The last thing you want is a heavy-fisted mechanic tampering with wires to the sump plug every time the coil is changed.

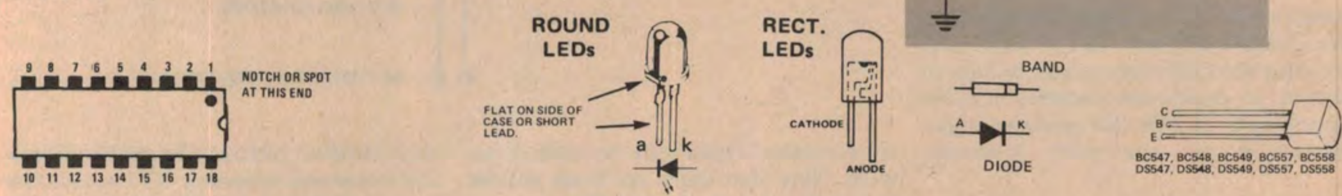
By the way, we *strongly suggest* you don't try to make your own dipstick probe as there is too much risk of something falling off with the severe vibration and temperature changes experienced inside the engine.

The temperature display employed in our project uses ten LEDs in a 'dot' mode (single LED lit at a time) bargraph display and is designed as a matching instrument to our LED Expanded Scale Voltmeter (ETI-326, September 1980). The display covers the range 70°C to 126°C with the first LED lit at temperatures below this range and the last LED remaining lit above this range as well as sounding an optional piezo audio alarm. Yellow LEDs are used for the 'cold range' to 80°C, when acids remain in the oil. Green LEDs are used for 80°C - 100°C in the normal operating range and red LEDs are used for the 'hot' range above 100°C. As we mentioned previously, some engines operate safely up to 110°C and may light the first red LED.

The instrument is easily calibrated by adjusting a trim potentiometer for a reading of 100°C when the thermistor probe is placed in boiling water. Water boils at very close to 100°C at sea level.



COMPONENT PINOUTS



HOW IT WORKS — ETI 328

The circuit consists of a thermistor temperature sensor in a dipstick probe driven by a constant current source, the voltage across the thermistor, which is proportional to the oil temperature, being sensed and displayed by an LM3914 LED bargraph driver chip. The display is a series of ten LEDs, the LM3914 being operated in the 'dot mode' so that only one LED lights at a time.

The LM 3914 is operated at maximum sensitivity, as a 0 - 1.2 V voltmeter, with ten display steps at 120 mV intervals. An alarm function (optional) is provided by a piezo audio alarm driven from the LED that indicates the highest temperature. Reverse polarity and over-voltage protection are provided by the zener diode, ZD1.

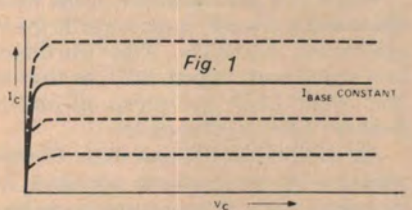


Fig. 1

First, let's see how a constant current source works. Transistor Q1 and associated components provide the constant current source for the probe. Figure 1 shows the collector characteristics of a typical silicon transistor. They show that, if you hold the base current constant, the collector current will

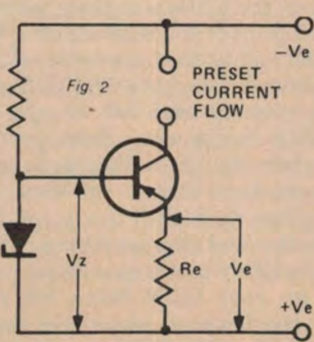


Fig. 2

remain substantially constant for a widely varying range of collector voltage. Figure 2 shows the general circuit of a constant current generator. The voltage between the base and the emitter return (common, the +ve supply line here) is fixed by the zener diode. Thus, the voltage across the emitter resistor (Ve) is fixed at a value equal to the zener voltage (V_z) minus the base-emitter voltage drop of the transistor (0.6 V for silicon transistors). With a fixed voltage across R_e, the current through it will be constant. Thus, the emitter current, and therefore the collector current, of the transistor will be constant. The resistor supplying current to the zener is generally chosen so that zener current is five to ten times greater than the base current of the transistor.

With this circuit, so long as there is about one volt between the emitter and collector, the collector current will remain constant at the chosen value until a load of too large a value robs the collector of its working voltage.

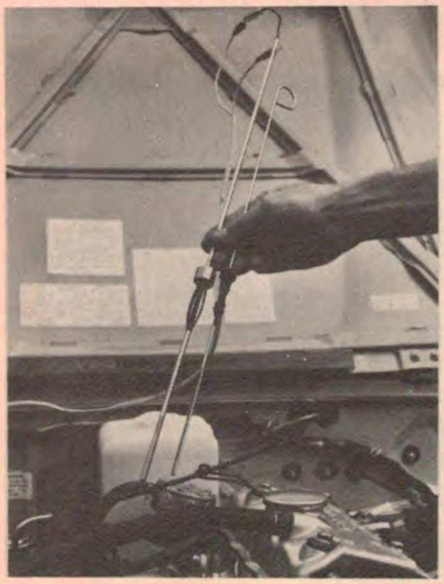
In the project circuit diagram, a LED (LED11) is used instead of a zener diode. The forward-voltage drop of a red LED is about 1.6 V and thus the base of Q1 is 'clamped' at about 1.6 V below the positive supply rail. Thus, the voltage across R2 and RV1 will be 1.6 V less the base-emitter junction drop of Q1, about 0.6 V, leaving 1 V. Thus, with RV1 at minimum resistance, the emitter current (and thus the collector current) through Q1 will be close to 20 mA. With RV1 at maximum, it will be about 3.4 mA, giving a range of about 6:1 variation which is more than adequate for calibration, yet provides a smooth adjustment.

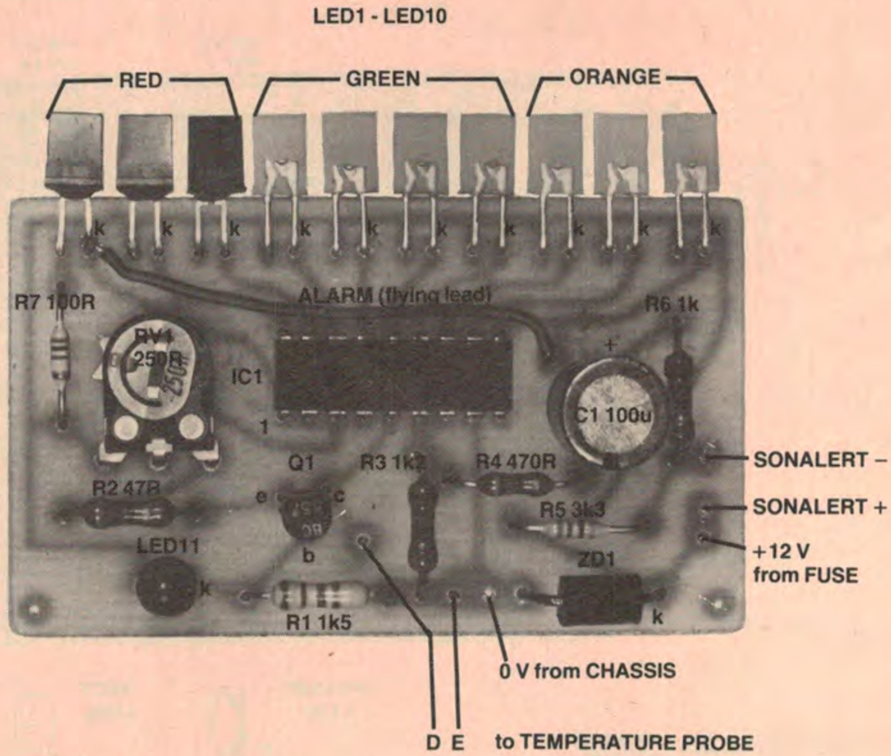
As the temperature of the probe increases, the thermistor resistance will decrease. Since the probe is driven with a constant current, the voltage across the probe decreases linearly with its resistance and independent of supply voltage fluctuations. The temperature scale resulting is non-linear however, because the resistance variation of the thermistor in the probe is not linearly related to temperature. A graph has been provided in the main text.

The temperature range of the instrument, and therefore the calibration, is set by adjusting the current passing through the probe by means of RV1.

A complete description of the operation of the LM3914 was provided in the article on the Expanded Scale LED Voltmeter, ETI-326, published in the September 1980 issue of ETI.

Project 328





Construction

Construction of the unit is simple and straightforward, but take a little care juggling the LEDs into place. In fact, it is best to commence construction by mounting the LEDs. We used rectangular LEDs for our unit, however, conventional types may be used if you wish. Note that there are three yellow, four green and three red LEDs.

The easiest way to ensure correct insertion of the LEDs is to place them on a table in front of you with all their leads oriented just as they are to be mounted in the board. Insert the first LED (red if you're working from left to right with the LEDs facing away from you), but don't solder it in place. Position it so that when you bend it over, the base of the LED comes flush with the board. Don't fumble this and attempt it twenty times or you're likely to end up with very short leads on your LED! When it's right, solder the leads in place and bend it back upright. This LED then becomes a guide for the correct lead length of the others. Insert the rest one by one so that they line up with the first LED and, when the row is finished, bend them all over and they should all lie flush with the edge of the pc board. Refer to the overlay photograph.

The rest of the components can be mounted, taking care with the orientation of the LM3914, Q1, LED11, the electrolytic capacitor and zener diode. The alarm lead is a length of insulated hookup wire, soldered directly to the cathode of the last red LED (see the overlay).

Calibration

When construction is complete, the display requires calibration. Basically, this involves putting the probe in boiling water and adjusting RV1 so that the required LED lights. The display can be adjusted to cover a variety of temperature ranges, but we found the range shown to be the most useful.

Calibration is best done away from the vehicle, mainly for convenience. You'll need some place to boil water and a power supply, nominally 12 Vdc, to power the unit. Connect the thermistor dipstick probe and the power supply but keep the probe out of the water to start with. When you apply power, the first yellow LED should light. Hold the end of the probe in the boiling water, but not too close to the bottom of the vessel to avoid hotspots or direct contact with the source of heat, otherwise you may obtain a false reading.

When you put the probe in the water, the display should 'step' towards the hot end (three red LEDs). After the display has stabilised, adjust RV1 so that the *last green LED* just turns off and the *first red LED* just turns on.

As the boiling temperature of water varies with atmospheric pressure, and therefore with elevation above sea level, if you're calibrating the unit at altitudes over several hundred metres above sea level, adjust RV1 so that the second-last green LED just goes off and the last green LED just turns on.

The temperature range of the display should now correspond to the scale shown.

PARTS LIST — ETI 328

Resistors .... all ½W, 5%

R1	1k5
R2	47R
R3	1k2
R4	470R
R5	3k3
R6	1k
R7	100R

Capacitor

C1	100u, 16 V electro.

Semiconductors

IC1	LM3914
ZD1	18 V, 1 W zener
LED 1 - 3, LED 11	TIL220R red LEDs, or similar
LED 4 - 7	TIL220G green LEDs, or similar
LED 8 - 10	TIL220Y yellow LEDs, or similar

(Note: LEDs above are conventional but rectangular types have been used in our prototype).

Miscellaneous

ETI-328 printed circuit board; Piezo alarm Sonalert or similar type; VDO temperature probe dipstick with NTC thermistor sensor (see text).

Price estimate

We estimate that the cost of purchasing all the components for this project will be in the range:

$18 - $22

(excluding the dipstick probe)

Note that this is an **estimate** only and **not** a recommended price. A variety of factors may affect the actual price of a project, whether bought as separate components or made-up as a kit.

ASSEMBLING THE DIPSTICK PROBE

The VDO dipstick probe is supplied with the probe rod, several steel finger springs, a felt washer, steel collar and connectors. Two probe lengths are available, one 300 mm and the other 500 mm long, to suit a variety of cars. We fitted ours to a Suzuki four-wheel drive with an 800 cc engine and a 1950 model Dodge truck with an engine capacity close to five litres — just to make sure! The supplier of the probe will help you choose the correct one.

After you have purchased the probe, you will have to select the correct spring set and set the probe insertion length inside the engine. The accompanying diagrams show the assembly of the probe.

Panel 1
Three spring sets are supplied with the 500 mm probe and two with the 300 mm type. The spring set selected depends on the dipstick hole diameter in the engine block.

Panel 2
Compress the spring fingers with your finger and slip on the felt washer.

Panel 3
Holding the springs compressed, insert the ends into the steel collar. Release the springs and ensure their ends catch in the groove inside the collar.

Panel 4
Press down the felt washer into the bottom of the collar.

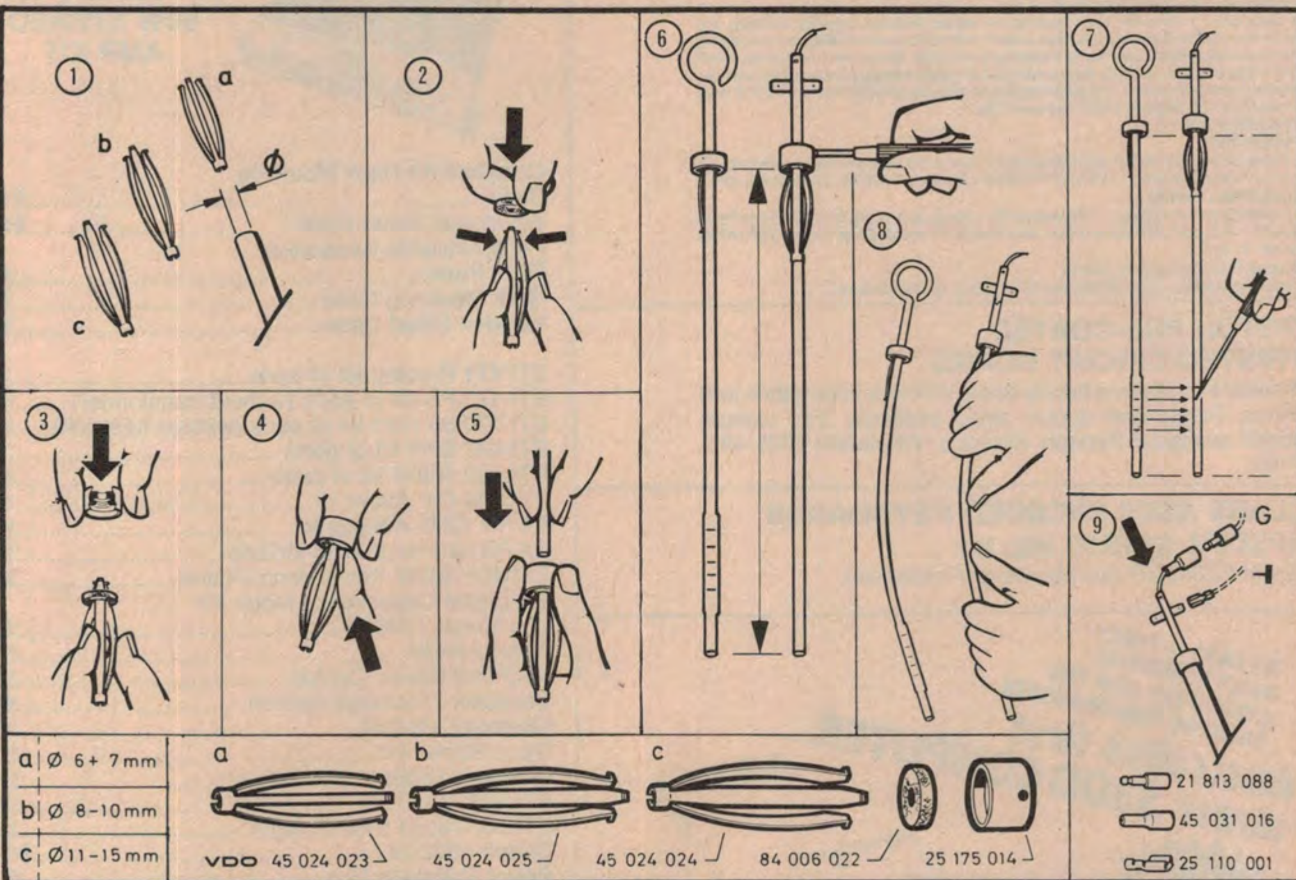
Panel 5
Slide the whole assembly over the probe. This may be a tight fit as the probe holds the ends of the spring fingers in place in the groove inside the collar so there is no danger of the springs falling out.

Panel 6
Remove the original dipstick and place it next to the dipstick probe. Slide the collar and spring assembly along the probe so the length to be inserted into the engine block is exactly the same as with the old dipstick. This is **very important** as an incorrect length will give a false oil level indication as well as possibly colliding with the crank shaft! Tighten the grub screw in the collar firmly.

Panel 7
The oil level mark can be scribed on the new dip stick or lightly engraved.

Panel 8
If your original dipstick is bent, the new dip-stick probe can be carefully bent to the same shape.

Panel 9
Finally, connect sufficient wire to pass through the firewall and under the dash to the display pc board. We used 'figure-8' power flex soldered to the spade and in-line connector supplied with the probe.



Installation

The display pc board can be mounted in any convenient position in or under the dash of the vehicle, to the side of the driver's field of vision. For good visibility it should be mounted away from direct light. As mentioned earlier, the instrument has been designed to match the LED Expanded Scale Voltmeter and the two can be 'sandwiched' together, track side to track side with a spacer between the boards, and mounted in the vehicle. The high voltage end of the voltmeter will then be opposite the high temperature end of the Oil Temperature Meter.

The wires from the dipstick probe should be passed through the firewall alongside existing wiring or the speedometer cable, and taped to a support to prevent them catching in the fan. The battery supply can be taken from any convenient point under the dash, such as the fuse box, but make sure the instrument is switched off with the ignition. The 0 V connection can be made to any convenient chassis point. ●