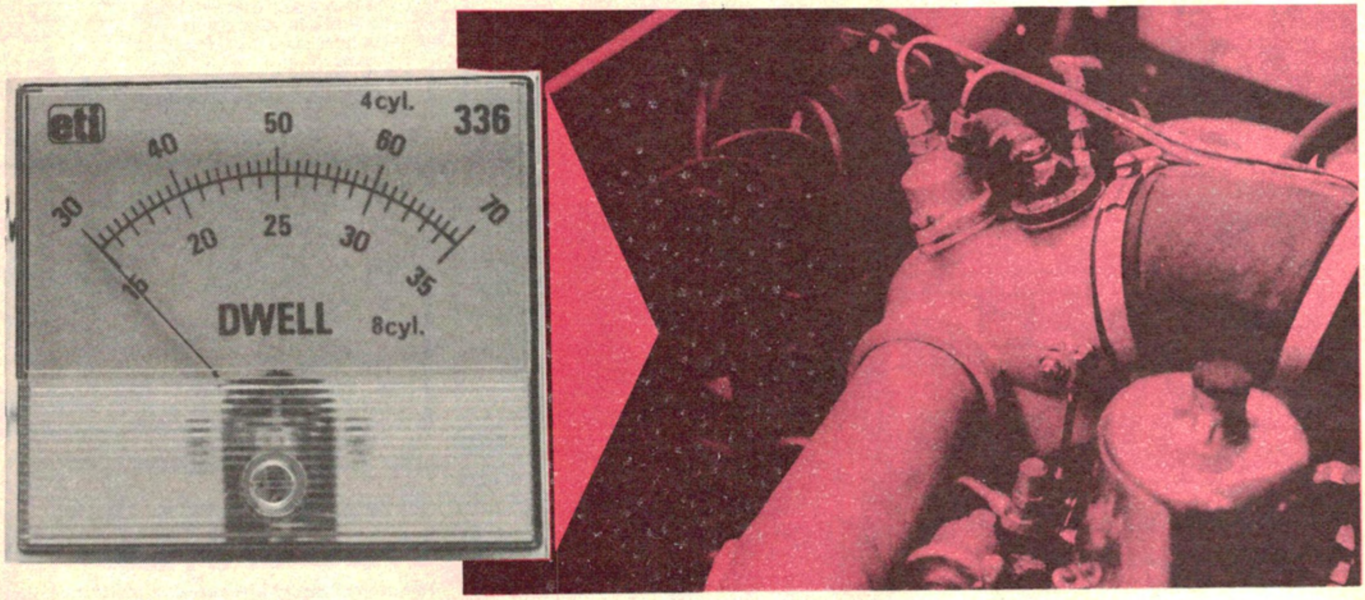


Low-cost dwell meter for vehicle tune-ups

You can do your own vehicle tune-ups at home and save the cost and inconvenience of sending it to the garage. Just about the most useful device you could have is a dwell meter. They can be bought 'over the counter', but you save even more money and increase your personal satisfaction by building your own.

Jonathan Scott

THE FACT THAT you've started to read this article means you probably know quite well what *dwell* is, and the advantages of owning a dwell meter, rather than letting your regular mechanic do the adjustment periodically. (If not, please see the section explaining dwell in automotive ignition systems, because that is where the automotive content of this article is dealt with.)

You are possibly also aware that one can readily buy a tacho/dwell meter in local automotive or electronic shops for around $25-$30, which is marginally more than the cost of this project, box and large meter included. So why describe a project that merely reads dwell?

The reasons are threefold: First, if you have ever dissected one of the commercial units, you may be aghast to note the lack of any transistors — often they rely on diodes alone, and a few quarter-watt resistors on a small board. The circuit, though ingenious, is rather simple and does not inspire this author to praise the accuracy or long term stability.

This project, once calibrated carefully (emphasis on this, as there are pitfalls, outlined later), will be as good as the components you use, which is comparatively very good. In addition, if you have built the thing yourself, it is easy to repair should anything go wrong, from a blown transistor to a crushed meter, and there is a good chance of that if you throw it around like other car tools.

Secondly, this project can be quite cheap. The major expense is the meter, so if you wish to build it as an addition to a multimeter and house it in something cheap, or not at all, it becomes very economical. None of the components is critical, except those resistors specified as high-stability types (readily available these days), so it can be a junk-box job if you need.

All you require in addition is a microamp-to-degrees conversion scale (see later) and you're away.

A second advantage occurred to me as I wandered from car to car-testing the prototype. The board is sufficiently cheap that you could leave one connected permanently to the car (it does not affect the running) and, if you are into stacks of dials on your dash, have another one!

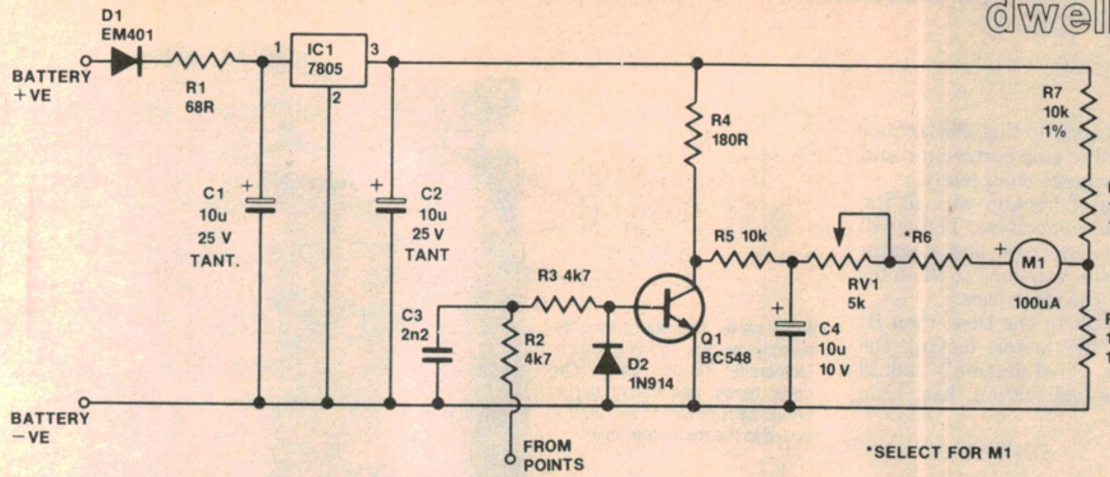
Finally, many cars have tachometers of the electronic genre already, and offer more accurate rpm indication than the cheap commercial tacho/dwell units anyway. If you have such a car, there is no incentive to have a second tachometer function which clutters up the scales, etc.

If you want to add a tachometer function to the dwell meter circuit described here, it is an elementary task to fit the circuitry of one of our previous projects in the same box, using the same meter which, as I have said, is the major cost of the whole thing.

Having justified the usefulness of this design, let's get on with it!

Construction

Construction of the Dwell Meter is very straightforward. The first step, if you are going to mount it in a case, is to cut the



HOW IT WORKS — ETI 336

The dwell meter is simply a 'duty cycle' meter with a zero offset and suitable scale markings on the metre face. It measures the closed-to-open ratio of the vehicle points.

Referring to the circuit diagram, D1 and R1, in conjunction with ICl, provide a reverse polarity protected +5 volt supply from the car battery. Capacitors C1 and C2 remove interfering pulses and ensure that IC1 remains stable.

The square wave voltage created by the 'points' opening and closing is filtered to remove the inductive 'spikes' by R2, R3 and C3. Diode D2 protects Q1 from negative voltages which may appear at the input. The square wave is then inverted and set to a fixed amplitude by Q1, which alternately turns hard on (saturates) and cuts off as the points open and close, respectively.

The average voltage appearing on the collector of Q1 is thus proportional to the time the points spend closed, ranging from almost zero for open points to +5 volts when the points are closed. Resistor R5 and capacitor C4 filter this square wave to reveal a relatively steady level. Metre M1 and surrounding components are set to give a minimum scale reading of 33 % and a FSD reading of about 78%. This corresponds to a range of 30-70 for four cylinder engines, 20-47 for six cylinders, 15-35 for eight, 24-56 for five 10-23 for twelve, etc. It is simple to calculate the duty cycle given the formula:

% duty cycle = (Degrees of Dwell) x (No of cylinders) x (100/360).

Resistor R7 is selected to allow for the internal resistance of the meter. The meter type used in the prototype had a resistance of about 1800 ohms. The sum of meter resistance and R7 should equal a little under 3000 ohms. The trimpot, RV1, is set to calibrate the meter full-scale deflection (FSD). Meter zero is held correct by the resistors R7, R8 and R9 which provide an 'offset' voltage.

Without the points connected, the meter needle goes to full scale as the positive terminal is returned to +5 V via R4, R5, RV1 and R6, while the negative terminal is at a lower voltage via the R7-8-9 voltage divider. This will not damage the meter.

meter mounting holes. Once you are satisfied that the case is prepared, check the printed circuit board to ensure that the holes on it are of a suitable size. If you intend to mount the board on the rear of the meter itself, as I intended, ensure that the meter connection holes are large enough to fit the meter posts.

Once prepared, mount the components on the pc board, taking care to orientate the IC and other semiconductors correctly. Also check that the electrolytic and tantalum capacitors are the correct way around. Reversing C4 could produce devious and subtle problems! While attaching the components, tin the copper areas around the meter mount holes so that the meter post nuts make good contact on to ▶

DWELL IN AUTOMOTIVE IGNITION SYSTEMS

The distributor in the standard type of car has two functions. First, it 'distributes' the spark energy from the ignition coil to each spark plug in turn by means of the rotor and cap of the assembly. This is the most obvious job of the distributor, and the one from which it gets its name. But it is not the most critical, or the one requiring the most attention and adjustment.

It also contains a mechanism for opening and closing the points, which interrupt the ignition-coil primary current and generate the spark itself.

These points are subject to considerable wear and, as they affect both the spark strength and its timing, they are perhaps one of the weakest links in the ignition system.

The lower assembly of the distributor must open and close the points **once** for each cylinder for each **two** revolutions of the main engine shaft. Each time it is responsible for ensuring that the coil has enough time to build up primary current, and that the opening occurred at the correct moment, accounting for engine RPM and possibly also the degree of vacuum fed to it down a small pipe from the inlet side of the engine carburettor.

The two functions which must be adjusted are **dwell** and **timing**. These are analogous to the duty cycle and phase of the square wave (current) generated by the regular opening of the points. Dwell actually means the amount of time, per revolution of the distributor shaft, which the points spend closed.

Timing means the relative phase, referred to the moment when the piston is at the position of maximum compression (top dead centre or 'TDC'), of the moment of delivery of the spark energy. The latter can be set statically by aligning marks at various positions, and the former by judicious use of feeler gauges on the points, but neither method is as accurate as the electronic methods.

A stroboscope is used for the timing adjustment, and a duty-cycle meter, called a dwell meter, with special scales, is used for the dwell measurement.

Dwell is specified, not by the kind of figure that an electrical engineer would expect — namely a % duty cycle or a number of electrical degrees — but by the actual number of mechanical degrees traversed by the distributor shaft while the points are closed.

Thus, although the actual duty cycle may be similar in all engines, irrelevant of number of cylinders, the degrees of dwell specified appears to change with the number of cylinders. This is because the distributor must deliver one spark for each cylinder in each 360 degrees of revolution.

A four-cylinder car has 90 degrees (360/4) of revolution, so a specified figure of 50 degrees of dwell means 50/90 or 56% duty cycle. A 12-cylinder car has only 30 degrees per cylinder, so 17 degrees of dwell means about the same duty cycle.

Clearly, it is possible to convert any quoted dwell figure into duty cycle by knowing the number of cylinders, then a universal scale of duty cycle on a duty cycle meter would suffice. However, it is usual practice to have several scales on the meter face to achieve the same thing.

Also, since doubling the number of cylinders merely means that the scale reads twice the actual mechanical reading, scales for four and six cylinders enable easy use on eight- and 12-cylinder cars, merely by halving the read value.

Equations for converting dwell into duty cycle and vice versa are given in the 'How it Works' section, so if you happen to have an engine with an unusual number of cylinders you may construct a scale for yourself, or convert the manufacturers specified dwell for, say, a five-cylinder car into what the meter will read on the scale for a four-cylinder car.

the board. If you do not do this, the lacquer put on the pc board to stop corrosion could insulate the meter posts completely.

Connect lengths of hookup wire to the battery and points connections. These will be led out of a hole in the case, and alligator or other suitable clips attached to them for connection to the car electricals.

Next fit the meter in the case, then fit the pc board to the meter, leaving the trimpot accessible. Final assembly should be left until the calibration has been completed.

Calibration

A known calibrating signal will be required to set up the meter. It is not advisable to use a sinewave source (such as from a low-voltage mains transformer) as this can introduce some error. A square waveform is desirable. This must be of known duty cycle. If you have a signal generator which delivers a known duty cycle square wave, typically 50%, set it to deliver 10 to 30 volts peak-to-peak output, and adjust the trimpot for the correct reading.

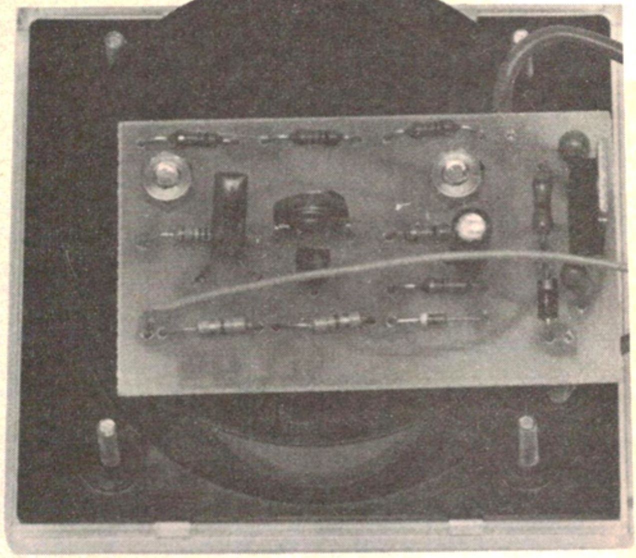
The calibrating signal must have a duty cycle of between 40% and 78%. The higher the better, for accuracy.

If you do not have access to a suitable source, proceed as follows. You will need a sinewave of between 20 and 50 volts peak. If you have a transformer delivering nominally between 7 and 20 volts RMS, it will do nicely. Connect the transformer to put the full ac voltage between the 'batt-' terminal and the 'points' input. Adjust the trimpot for a reading of 50% duty cycle, or 45° dwell on the four-cylinder range. If an oscilloscope is available, it may be used to check the duty cycle at the collector of Q1, and the trimpot used to set the meter to agree with the measurement taken by the oscilloscope. The frequency of the input is not important, of course, provided it is less than a few hundred Herz. (The mains is 50 Hz.)

Using it

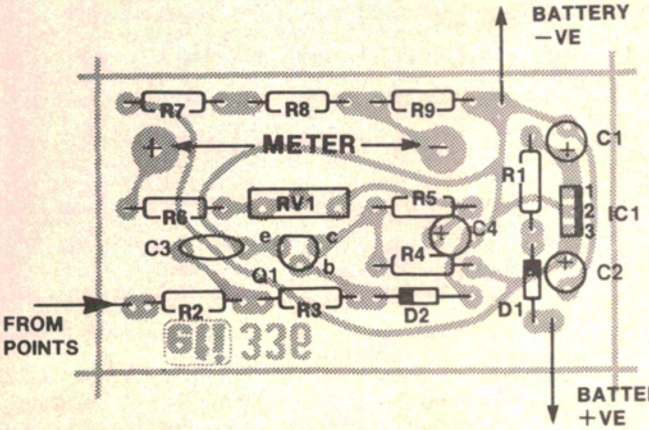
Use of the dwell meter, if you have never used one before, is elementary. Simply place the meter in a convenient location near the engine bay. Note that the typical panel meter changes its calibration when it is moved from the horizontal to the vertical, *so it should be used in the position in which it was calibrated initially.*

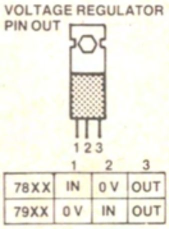
Connect the 'batt+' lead to the car battery positive terminal, and the 'batt-' lead to the battery negative connection. Connect the points lead to the junction of the ignition coil and the points in the distributor. When the car is running the meter reads dwell. Adjustments should be made according to the manual for the particular car, but in an emergency all cars are likely to have dwell specifications which lie roughly at the half-scale point on the meter.

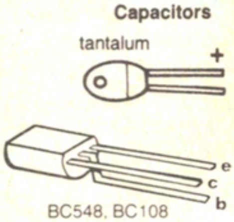


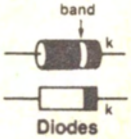
Rear view. The board mounts directly on the terminals of a University TD-86 meter. On other types, use heavy-gauge tinned copper wire to secure the board to the meter terminals.

See Shoparound in this issue for suppliers of kits and components for this project.

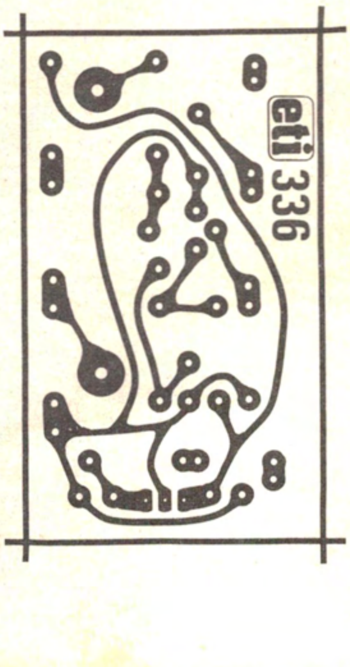








Artwork. Full-size reproduction of the printed circuit board, copper side.



PARTS LIST—ETI 336

Resistors	all ¼W, 5% unless noted
R1	68R
R2, R3	4k7
R4	180R
R5	10k
R6	1k selected, see text
R7, R8, R9	10k 1% or 2%
RV1	5k min. trimpot
Capacitors	
C1, C2	10u/25V tantalum
C3	2n2 greencap
C4	10u/10V single-ended electro.
Semiconductors	
D1	EM401, EM402, 1N4001, 1N4002 etc
D2	1N914, 1N4148 etc
IC1	7805 or 78L05 etc
Q1	BC108, BC547/8/9 etc
Miscellaneous	
M1	100uA panel meter, e.g: Minipa MU-65, University TD86

ETI-336 pc board; case to suit; three alligator clips; hookup wire; meter scale to requirements, etc.

* R6 selected so that R6+meter resistance equals a little under 3k.

Estimated cost: $16-$24

Meter scales. Full-size reproductions of scales for University TD-86 and Minipa MU-65 meters.