AUTOMOBILE TEST SET

MICHAEL TOOLEY B.A. DAVID WHITFIELD M.A. M.Sc.

PART TWO

IN the first part of this article the principles of operation of the various functions of the Auto Test Set were described in detail, together with their usefulness to the troubleshooting and performance-conscious motorist. This article carries on from the detailed circuit description by covering the construction of the complete instrument, and concludes with a detailed series of tests and calibration steps, together with some fault-finding hints and suggestions.

CONSTRUCTION

A diecast box is used in the construction of the Auto Test Set to ensure that the final unit is rugged enough to with stand hard use. The majority of the small components are mounted inside the box on a single-sided printed circuit board. The copper foil pattern for the board is shown in Fig. 7, with the corresponding component layout in Fig. 8. The interconnection wiring points have been labelled for later identification. No special handling procedures need to be observed in mounting the components on the p.c.b., but constructors may wish to use 14-pin d.i.l. sockets for mounting IC1 and IC2. Care should be taken to ensure the correct orientation of all of the polarised components (semiconductors and electrolytic capacitors) before soldering them in place. The use of terminal pins is recommended for ease of installation of the interconnection wiring.

When all of the components have been mounted on the p.c.b., a careful visual inspection of the track side of the board should be made before proceeding. Particular attention should be paid to soldered joints, and all dry joints and solder bridges should be rectified at this stage. After a final check on the orientation of polarised components, the p.c.b. may be mounted in the base of the diecast box using four short pillars. When positioning the board, adequate clearance should be left for the d.c. supply sockets, SK3 and SK4, which should be mounted on the side of the box and adjacent to pins A and B. Short lengths of insulated wire should then be used to connect SK3 (red) to pin B, and SK4 (black) to pin A; the wire links used should be long enough to allow the p.c.b. to be easily removed from the box for troubleshooting.

The remaining components are mounted on the lid of the diecast box, as shown in Fig. 9. The assembly sequence is simplified if all of the necessary holes are cut before any of the components are mounted. Marking out of the holes is simplified if the lid is first covered with masking tape, and the hole positions marked on the tape before being centre-punched. The cutout for the meter is most easily made by drilling a series of holes around the circumference to remove the majority of the metal, and then cleaning up the hole with a file until the meter is an easy fit. When the meter, switches, terminals and l.e.d.s have been mounted, the next step is to fit the remaining components to the switch and meter terminals as shown in Fig. 9. It should be noted that, when making up the necessary values for R28 to R31, it may be easier to use a number of standard values in series/parallel, e.g. R28 may be made up from two 100 kilohm resistors in parallel.

The final assembly step is to install the interconnection wiring between the p.c.b. and the components mounted on the lid of the box. Ribbon cable provides one of the most convenient methods of installing the wiring, and it is suggested that one piece be used for each of the four groups of terminal pins. The cable lengths should be adequate to allow the lid to be laid flat alongside the box during calibration. The wire from S2 to one end of R33 should be connected as shown by the solid line, and R33 should temporarily be fitted as a short length of wire. A final check of the wiring should show that pins J and K on the p.c.b. are the only ones left unconnected; these may be used if an alternative buzzer is to be used off the board, but otherwise they may remain unconnected.

TESTS AND ADJUSTMENTS

The initial tests and adjustments require the use of a power supply or battery capable of delivering 12 volts at up to approximately 120mA. Ideally, the supply should have an electronic over-current trip, but if this is not available, an appropriately rated line fuse will suffice to protect against catastrophic failures or errors. Before connecting the supply, the controls on the Auto Test Set should be set to the following: S1 to the 'Carry' position; S2 to the '4 cyl' position; S3 to 'Off'. The power supply should be connected to SK3/SK4 via a multimeter set to the d.c. current range rated at a minimum of 100mA.

Switching on the supply to the Auto Test Set should cause the 'NOGO' and the 'Power' l.e.d.s to be illuminated; no other l.e.d.s should be illuminated. The supply current indicated should be approximately 40mA, but only significant variations from this value should be considered as significant. Should neither of the l.e.d.s be illuminated and no supply current be drawn, the polarity of D12 and the power supply wiring should be carefully checked. Moving the instrument sharply should show that the meter movement is significantly damped; if not, the wiring to S1 and ME1

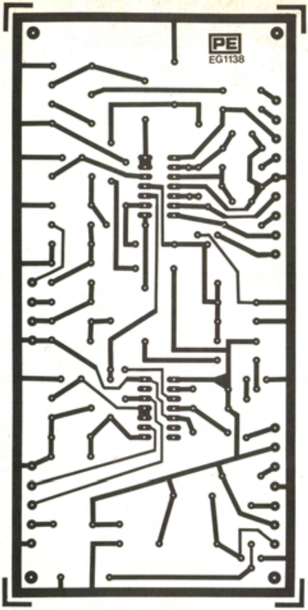

Fig. 7. Foil pattern for board underside

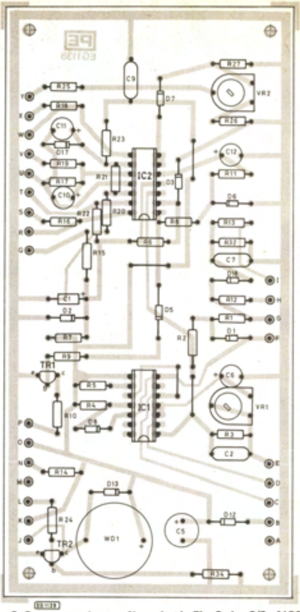

Fig. 8. Component layout. Note that in Fig. 2 pins 3/2 of IC2a should be reversed

should be re-examined. If the supply current is significantly lower than expected, and everything appears as normal except that no l.e.d.s are illuminated, then it is possible that the polarity of the l.e.d.s is incorrect. When these initial tests are satisfactory, the functions may be tested.

The function switch should now be moved to the '0 to 15V' position, and the circuit shown in Fig. 10 set up to allow testing of the two voltmeter ranges. As the potentiometer is varied from minimum to maximum setting, the meter indication should move over the full scale. Significant scale errors should lead to investigation of the wiring to ME1, S1, and the value of R12. As the setting of the potentiometer is increased from minimum, D4 should become illuminated at a potential of approximately 1V. Should the l.e.d. fail to illuminate, the polarity of D3, D4, D5 and TR1, and the power supply to IC2 should be checked to determine the source of the problem.

The offset zero voltage range is checked using the same arrangement as shown in Fig. 10, but with the function switch now set to '10 to 15V'. Varying the voltage applied to SK1/SK2 over the range 10 to 15V by means of the potentiometer, and comparing the measured voltage with that indicated by the test set should produce a response of the type shown in Fig. 11. Any significant movement of the curve up or down the axis, representing consistently high or low indications, should initially lead to a check on the value of R13. The most likely cause, however, is that the nominal Zener voltage of D18 is at one end (high or low) of the tolerance band, and this may be cured by either replacing the diode with an alternative, or by padding the diode.

Calibration of the dwell range involves selecting the 'Dwell' position on the function switch, and disconnecting all inputs from SK1/SK2. In this condition the meter should indicate very close to zero, and D4 should be extinguished. Possible problems in the l.e.d. circuitry should already have been eliminated, so any significant meter indication would suggest a fault around IC2b. Calibration of the range involves the correct adjustment of VR2, and this is done most easily by connecting a lead between SK1 and SK3. VR2 is then adjusted to produce a full-scale meter indication,

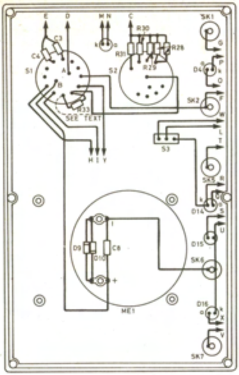

Fig. 9. Interconnection wiring

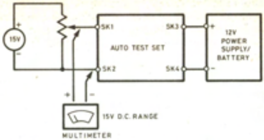

Fig. 10. Test configuration for the voltmeter ranges

equivalent to 100% duty cycle. With the component values and types specified, it is possible that the maximum indication which may be achieved by adjusting VR2 will be just below full-scale on the meter. In such cases D6 may be replaced by a diode rated at 6·2 volts, or a silicon diode (e.g. 1N4148) may be wired forward-biased in series with the existing diode. The calibration of the dwell meter scale is independent of the setting of S2, and depends only on the number of engine cylinders; Table 1 shows the way in which the meter markings correspond to the dwell angle. As a final stage in the calibration the scale may optionally be checked at mid-scale by applying a square wave signal, amplitude between 5 and 12V pk-pk and frequency between 10 and 300Hz, and verifying that a half-scale indication is obtained.

The tachometer ranges are calibrated by adjusting the setting of VR1, and determining the value and position of R33. The setting up procedure starts by selecting the '1500 RPM' position on S1, and ensuring that S2 is still set to '4 cyl'. A signal generator producing a signal at 50Hz (corresponding to a 4 cylinder engine at 1500 RPM) and an amplitude of 5 to 12V pk-pk should be applied to SK1/SK2. The circuit shown in Fig. 12 may be used in place of a signal generator if none is available. The setting of VR1 should now be increased from minimum until a full-scale indication is achieved. If such an adjustment is not possible, then the values of C3, VR1 and R28 should be checked, followed by a check to the wiring of IC1 and S1/S2 if this does not reveal the fault. When a full-scale indication has been obtained, S2 should be moved from the 4 cylinder position through the other positions. The meter indications should change from 1500 RPM (4 cylinders) through 1200 RPM, 1000 RPM to 750 RPM (8 cylinders) as the switch is rotated. Any errors would indicate that the values of R28 to R31 should be re-checked. The calibration of the basic range is now complete, but now the two ranges must be made to track correctly, and this involves R33. S2 should be set to the '4 cyl' position again.

Table 1. Showing meter indication of dwell angle

Meter Indication (μA)	Equivalent Dwell Angle (°)			
	4 cyl	5 cyl	6 cyl	8 cyl
0	90	72	60	45
10	72	57·6	48	36
20	54	43·2	36	27
30	36	28·8	24	18
40	18	14·4	12	9
50	0	0	0	0

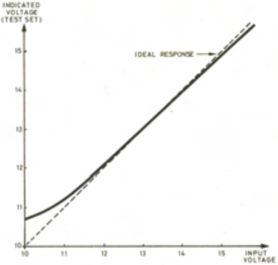

Fig. 11. Typical response for the offset zero voltmeter range

Fig. 12. A tachometer calibration signal source

If moving S1 from '1500 RPM' to '5000 RPM' still produces an indication of 1500 RPM, then R33 is unnecessary, and the wire link should be retained in its place. The more likely result, however, is that the value indicated will be either too high or too low, by up to approximately 10%. If the new indication is too high, the temporary wire link should be replaced by a suitable fixed resistor (typically in the range 1 to 4·7 kilohms) to restore the correct reading. If the new reading is too low, the wire from S1 to S2 should be reconnected in the position shown by the dotted line, i.e. at the other end of where R33 will be. VR1 should now be re-adjusted to produce an indication of 1500 RPM. S1 should then be moved back to the '1500 RPM', where the reading will now be too high. R33 is now selected to return the reading to 1500 RPM, and a value in the same 1 to 4·7 kilohms range is to be expected. It should be noted that the use of a single tracking correction resistor is a compromise to simplify the interconnection wiring; ideally a different value should be used for each of the ranges selected by S2. However, the error introduced will be small enough to be ignored in most cases, but the unused half of S2 may be used if necessary to allow individual calibration of the four ranges.

Verifying the correct operation of the lamp/fuse testing facility requires two fixed resistors, having values of 100 and 270ohms, respectively. S2 should be set to the 'Z' position, and with nothing connected to SK5, D14 should be illuminated, D15 should be extinguished and the buzzer should be silent. With the 270ohm resistor connected between SK5 and SK6 there should be no change in this situation. Replacing the 270ohm resistor by the 100ohm resistor, however, should cause the buzzer to sound and D15 to become illuminated. It is quite normal for D14 not to be totally extinguished. Any deviation from this behaviour should lead to investigation of IC2d and its associated components. Moving S3 to the 'Off' or 'V' position while the 100ohm resistor is connected should silence the buzzer but have no other effect. If the buzzer remains on, a check of the wiring of S3, the value of R34 and the polarity of TR2 should be made.

The circuit tracer facility is the only remaining part of the Auto Test Set to be tested. The configuration of Fig. 10 may be re-used for this purpose, but with SK7 and SK6 substituted for SK1 and SK2, respectively. S3 should be switched to the 'V' position. As the input voltage is increased from zero, D16 should become illuminated and the buzzer should sound at a level of approximately 9 to 10 volts. Moving S3 to 'Off' should silence the buzzer. Any error in the operation of the circuit tracer should lead to an investigation of the circuitry associated with IC2c.

This completes the testing and calibration of the Auto Test Set, which is now ready for use.