A Basic Guide to Using Tune-Up Instruments

Do Your Own Electronic Tune-ups, and Save On Gas and Repairs

WHEN ONE HEARS THE WORDS "engine tune-up," they usually bring to mind an automotive service which can result in a bill approaching $100.00 or more. As a result, many of us are content to forget about this facet of automobile maintenance until we are forced to do something because the engine runs very poorly or not at all. The irony of this situation is that while the engine is in such bad condition, it's costing you money in excessive gasoline consumption. Automobile tune-ups are not complicated, and the investment in parts is so small that there really is no reason why anyone, especially anyone who has a serious interest in electronics, should drive a car that is badly in need of a tune-up. The purpose of this article is to discuss the elements which comprise an engine tune-up, and to discuss some of the various electronic instruments which are being used by both professional and amateur car mechanics alike.

If possible, you should refer to the automobile manufacturer's specifications and tune-up procedures as a supplement to the information provided by this article. At the very least, refer to the tune-up information which is contained on a decal and prominently displayed in the engine compartment of your car. This will give the proper specifications for ignition timing, spark plug gap, and idle speed adjustments.

Tachometer. The basic automobile tune-up instrument is a combination tachometer and dwell meter, which is commonly referred to as a "dwell/tach." This instrument is capable of measuring engine RPM, and in those cars which are not equipped with factory installed electronic ignition, point dwell. (More about dwell later). The more elaborate instruments also include additional functions, such as voltage measurements, resistance measurements, and current measurements. For a small additional cost, some instrument manufacturers have included an alternator test function which determines the condition of the alternator diodes by measuring the level of AC ripple voltage appearing on the alternator output terminal.

The tachometer section of the dwell tach measures engine RPM by responding to the pulses which appear at the distributor side of the ignition coil (negative terminal). This is the point where the sensing lead of the instrument is connected. Referring to Fig. 1, a typical schematic diagram of a conventional (non-electronic) automotive ignition system, note that each time the points open, the collapsing magnetic field of

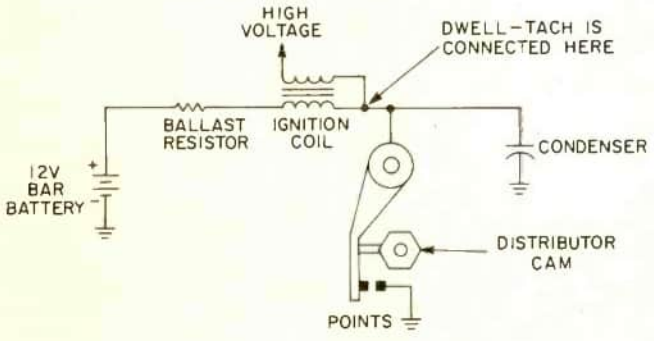


Fig. 1. A simplified schematic of an automotive ignition system using mechanical points (not electronic or "breakerless.")

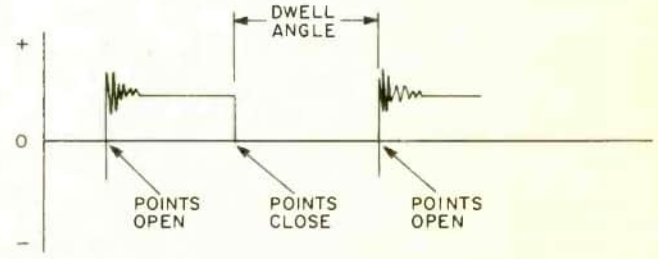


Fig. 2. This is a waveform representation of what occurs as points open and close. Dwell measurement is by averaging.

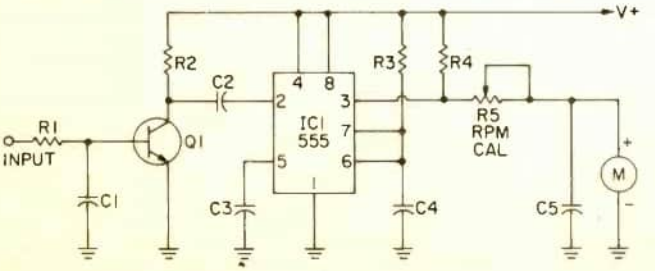


Fig. 3. This is a schematic of a simplified tachometer. It operates by counting pulses which appear at distributor side of coil.

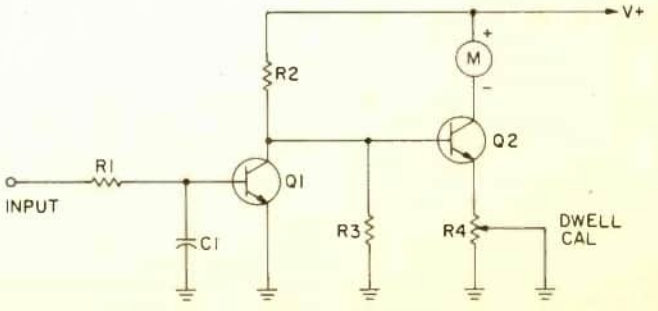


Fig. 4. This simplified dwell meter operates by reading voltage which is inversely proportional to that seen across the points.

the coil produces 20,000-volts or more at the secondary of the coil, and 100-volts or more at the primary. Fig. 2 illustrates the waveform appearing at the primary of the ignition coil, which is the voltage across the points. Since engine RPM is directly related to the number of pulses-per-second at the ignition coil, it can be seen that a simple frequency-to-voltage converter circuit can be used to measure engine RPM.

Fig. 3 is a typical schematic diagram of a tachometer circuit. Each time a pulse appears at the input to the circuit, Q1 conducts current and feeds a negative pulse to the trigger input of a one shot multivibrator, U1. The pulse duration of U1, about 4000 microseconds, is fixed. A resistor capacitor network, R5/C5, acts as a low pass filter to smooth the voltage pulses fed to the meter. The meter responds to the average of the voltage generated by U1, and is calibrated in RPM. Since the number of pulses-per-minute generated by 4, 6, and 8 cylinder engines is not the same, the meter circuit must incorporate a scale factor which automatically provides the correct RPM reading. This is the cylinder select switch which appears on tach's front panel.

Electronic ignition systems provide a special test point which produces pulses for use with standard automotive tachometers. Refer to the service manual for your car, or ask your dealer for the location of the tachometer connection.

Dwell Meter. Point dwell is a measurement of the number of degrees that the ignition points in non-electronic systems remain closed during the rotation of the rotor in the distributor. This measurement is directly related to the point gap, and is a more accurate methor of properly tuning an engine. This measurement is made at the same test point in the system as used for the tachometer connection. Factory installed electronic ignition systems have no points, and therefore no need for dwell measurement.

The number of degrees of point dwell depends on the number of cylinders in the engine. One full rotation of the distributor rotor is 360 degrees, and this is divided up in equal amounts for each cylinder. Thus, an eight cylinder engine can have a maximum point dwell of 45 degrees. 6 and 4 cylinder engines have maximum point dwell angles of 60 and 90 degrees respectively. Proper point dwell angle for these engines is usually slightly more than half the maximum. Typical dwell angles for 8, 6 and 4 cylinder engines would be 28, 36 and 56 degrees respectively.

The dwell meter measures dwell angle by producing a meter reading which is inversely proportional to the average voltage across the points. One such circuit that does this is shown in Fig. 4. The voltage appearing at the points is fed to the base of Q1, so that it is cut off when the points are closed, and saturated when the points are open. The collector of Q1 controls the base of Q2 which is connected as a constant current generator. Meter current is adjusted to full scale value (45, 60 or 90 degrees) by R4 when the sensing lead at the base of Q1 is shorted to ground, simulating closed points. As the points

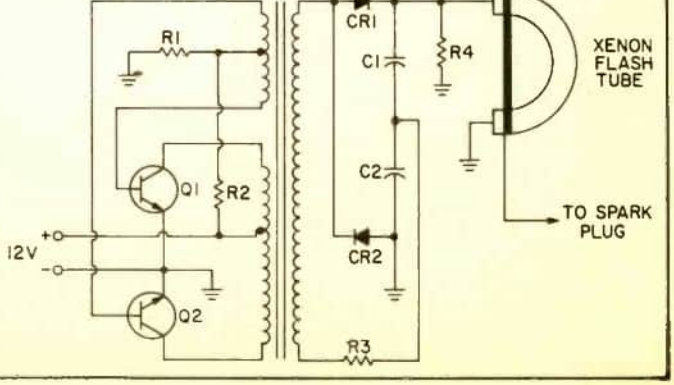


Fig. 5. A timing light uses a DC-to-DC converter to obtain the necessary high voltage used to trigger the flash tube. Stroboscopic action freezes flywheel motion to observe camshaft/valve timing.

Tune-Up

This is a typical ignition tune-up kit for a 4-cylinder car. From left to right: distributor cap, rotor, spark plugs, points, and condenser.

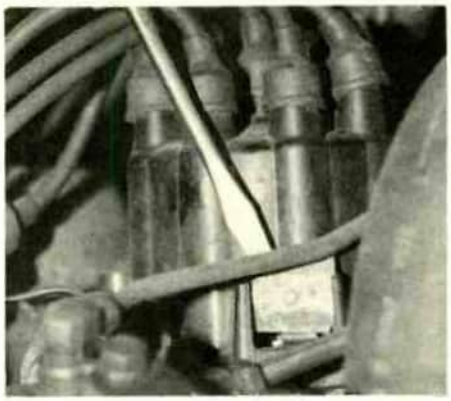
open and close at a rapid rate when the engine is in operation, the meter reading becomes the average of the two conditions and is the actual dwell angle of the points.

Timing Light. One final electronic instrument which is required for engine tune-up is the timing light. Quality timing lights are referred to as "power" timing lights, which means that the energy which fires the xenon flash tube is derived from a built-in power supply. Most units in use today use the car's 12-volt battery as the source of power. Refer to Fig. 5 which is a typical timing light schematic diagram. A DC to DC converter circuit charges two capacitors in a voltage doubler circuit to the high voltage (250 to 450-volts) necessary to fire the flash tube. The spark voltage generated by the car's ignition system provides the trigger which causes the flash tube to conduct, producing a burst of light perhaps 1/1000 second in duration. The car manufacturer has provided a timing mark on the flywheel of the engine, and a timing scale next to the flywheel. When spark plug number one fires, the stroboscopic action of the timing light enables the mechanic to visually determine if the flywheel is in the proper position. This shows engine timing.

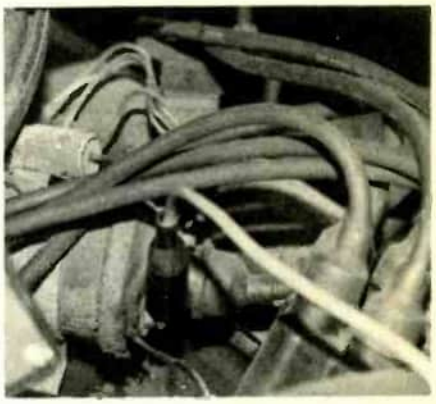
The best timing lights on the market provide inductive coupling to the spark plug wire so that it is not necessary to insert an adapter in series with the distributor wire and number one spark plug. Spark plug wires must never be pierced to make a timing check. To do so will render the wire defective.

The Engine Tune-Up. In addition to making the electrical measurements described above when tuning up an engine, there are certain mechanical procedures which must be performed to do a complete job. These procedures should be performed before making any electrical measurements or adjustments on the engine. It is not the purpose of this article to deal in depth with the mechanical procedures, and they will simply be mentioned briefly.

A complete and proper engine tune-up will include replacing spark plugs, ignition points, and condenser (if so equipped). In addition to these items, the distributor cap, rotor, fuel filter, and PCV valve should be either replaced or examined to make certain that they are still in serviceable condition. The air filter and crankcase ventilation filter should also be cleaned or



Almost all pre-1975 Delco (GM) distributors have a window through which point gap (dwell) can be adjusted while engine is running. This saves the time needed to remove cap and rotor to reset gap.



The input lead to the Dwell/Tachometer is connected to the distributor side of the coil. You can find this terminal by tracing back the wire from the condenser to the coil. Clip on the lead at the coil terminal.

replaced as necessary. The last item on this list are the carburetor and choke linkages, which should be cleaned with a carburetor spray product made for the purpose. Once these procedures have been completed, you are ready to perform the instrument checkout.

The electrical checkout of the engine is made with the engine running and warm. On those cars which use ignition points, it will be necessary to set the point gap to the proper spacing so that the engine can be started. The only exception to this is on General Motors cars which use external adjustment Delco Remy distributors. Replacement points in these distributors usually are preset to such a gap that will permit the engine to be started without any prior adjustment.

A word of caution before making the instrument checkout of the engine: At no time should you permit your hands to come in contact with the metal portion of the test instrument's clip lead as you are connecting or removing it from the engine, if the engine is running. The test point may have sufficient high voltage to cause electrical shock. This may result in personal injury as you jerk your hand away. If in doubt, make your connections with the engine shut off.

Dwell Angle. The first measurement and adjustment to be made is dwell angle, which is necessary on all cars that have conventional (non-electronic) ignition systems. Attach the meter leads to the distributor side of the ignition coil and chassis, observing correct polarity. On negative ground automobile electrical systems (as in all American made cars), the positive lead of the meter is connected to the ignition coil. Follow the meter manufacturer's instructions for dwell measurement, and refer to the decal in the car engine compartment for the permissible range of dwell. If your measurement falls out of this range, the point gap will have to be decreased (for readings too low) or increased (for readings too high). On most General Motors cars, this is a simple adjustment which can be made with an Allen wrench while the engine is running. On other cars you will have to stop the engine, remove the distributor cap, and reset the point gap making it greater or smaller as necessary. Recheck dwell angle with the instrument after readjustment of the point gap.

Timing. After the proper dwell angle has been attained, the ignition timing can be checked and set if necessary. Ignition timing should always be checked after changing ignition points or point gap since any change in dwell angle will cause a corresponding change in timing. Improper timing will affect gas mileage, engine power, and exhaust emissions levels.

Before starting the engine, you can facilitate the timing measurement by cleaning the engine flywheel and locating the timing mark, which is usually a

narrow groove impressed in the flywheel. If possible, apply a small quantity of white paint or chalk to this groove to make it more visible. You must also locate the vacuum advance mechanism which is located at the bottom of the distributor housing, and remove the vacuum advance hose which is connected to the mechanism. Plug the open end of the hose with a pencil. This procedure is necessary if the timing of an engine is to be made with the automatic vacuum advance disabled. Check to see whether or not your car requires this procedure.

Connect the timing light to the number one spark plug according to the directions provided by the timing light manufacturer. Connect the timing light power leads to the car battery, observing correct polarity. Check to make sure that no wires will be caught by the fan or other moving parts. Start the engine and measure the timing. Refer to the tune-up decal in the engine compartment, which should have an illustration of the timing scale for your particular engine. If the timing is out of spec, adjustment is made by loosening a clamp at the bottom of the distributor housing and rotating the unit to the correct spot. Tighten the clamp, and recheck the timing to make sure it did not change. Stop the engine and replace the vacuum hose if it was removed earlier.

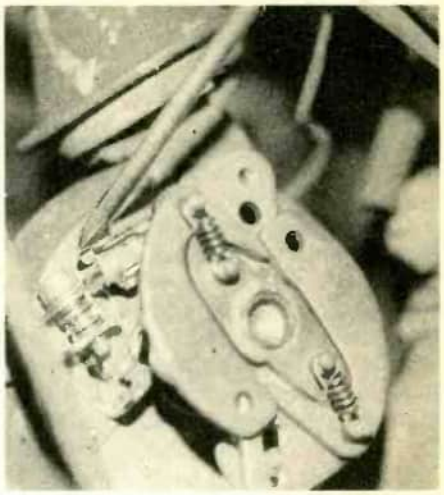
Carburetor Adjustments. All carburetors have some form of adjustment which controls engine idle speed. Single barrel carburetors have one adjustment for idle fuel mixture, and two and four barrel carburetors have two fuel mixture adjustment screws. These adjustments are performed with the aid of the tachometer, since engine RPM will vary as these adjustments are made. Since the order in which these adjustments are performed is important, the best practice would be to follow the vehicle manufacturer's sequence. Some tune-up decals in late model cars contain the proper adjustment sequence. The following procedure should prove satisfactory for most cars. Note: Some cars equipped with extensive emission control equipment have plastic caps covering the idle mixture screws, which limit the adjustment range of these screws. Under no circumstances should these caps be removed to set the mixture screws beyond the normal adjustment range. To do so may upset the engine exhaust emissions and/or affect driveability of the car.

Allow the engine to reach normal operating temperature before adjusting the carburetor. Connect the tachometer to the ignition system according to the manufacturer's instructions so that the meter reads engine RPM. Follow the information provided on the tune-up decal as to whether the transmission should be in neutral or drive, and if the air conditioning or lights should be turned on. (Be sure to set the parking brake securely before placing the transmission in Drive!)

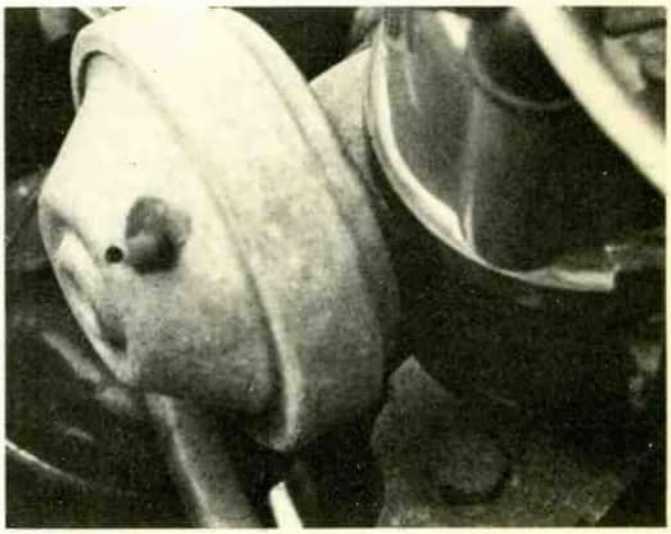
Adjust the idle mixture screw or screws for maximum engine RPM. Do this very carefully since only a small adjustment is usually necessary. Now adjust the engine idle speed adjustment to the engine RPM as specified on the tune-up decal. Very carefully turn the idle mixture screws clockwise to attain a 20 RPM drop in engine idle speed. Reset the idle speed adjustment for the recommended engine RPM.

The method just described is known as the "lean roll" method of setting the idle mixture. With this method, the vehicle exhaust emissions should be within specifications, and it avoids the necessity to use an exhaust gas analyzer for adjustment of the idle mixture.

If you have performed the various engine adjustments as specified, you should have an automobile that performs as well as it was designed. Keep a record of the date and speedometer mileage, so that you will be ready to perform the next tune-up when due. ■



With cap and rotor removed on this Delco distributor, the point gap adjusting screw can be seen. Lift the window in the distributor cap and you can turn this screw to perform point gap (dwell) adjustment.



Release the distributor clamp bolt at the base of the distributor to adjust timing. Some engines need to have their timing adjusted with the vacuum advance (round object mounted on the side of the distributor) connected, and some need it disconnected. Check in your owner's manual or with your dealer.

Use of the timing light allows you to freeze the action of the flywheel and read the timing adjustment. A decal under the hood will list number of degrees (either in BTDC or ATDC) to which pointer on the flywheel must point to on scale next to the flywheel. Timing is adjusted by rotating the distributor body.