COMPUTERIZED ROAD TEST SYSTEM

from Lamar Instruments

Lamar Instruments is producing an automated, Computerized Road Test System based on our general purpose data acquisition system to speed up and simplify the task of performance testing wheeled vehicles. The most recent state-of-the-art, used by auto-sports magazines, required manual data collection by a passenger in the vehicle. It was necessary for the data taker to concentrate on recording speeds and manipulating stop watches while the operator flogged the vehicle unmercifully in an attempt to achieve maximum performance. For the data taker, this was wildly distracting and somewhat discomforting. Maximum acceleration and panic stops from high speeds, for the braking tests, have caused more than one data taker to become nauseous.

This new Computerized Road Test System has many advantages over previous systems. First, the weight of the equipment is 75% less, approximately 25 pounds. There is also no requirement for a data taker as a passenger. This eliminates approximately 150 pounds of uncomfortable passenger from the vehicle as well as his cost in support of the test. This also makes performance testing possible on single occupant vehicles such as motorcycles and race cars.

A NEW STATE OF THE ART

The greatest advantage is probably the speed and accuracy of the new system as well as its data output. Within a few seconds of the completion of an acceleration or braking test run, the Hewlett Packard 97 printer/calculator produces a permanent record of the reduced and formatted data in a form that can be printed directly in a report or studied on the spot for comparison with different test configurations. This is a revolution in the state-of-the-art of data gathering. The old system required reduction of the raw data, sometimes by hand, before the results could be compared in a meaningful manner. Frequently a day of data collection was followed by several days of data reduction.

Additional features of the system include a digital liquid crystal display (LCD), which can permit the driver to read directly; speed in MPH, time in seconds, distance in feet and engine RPM.

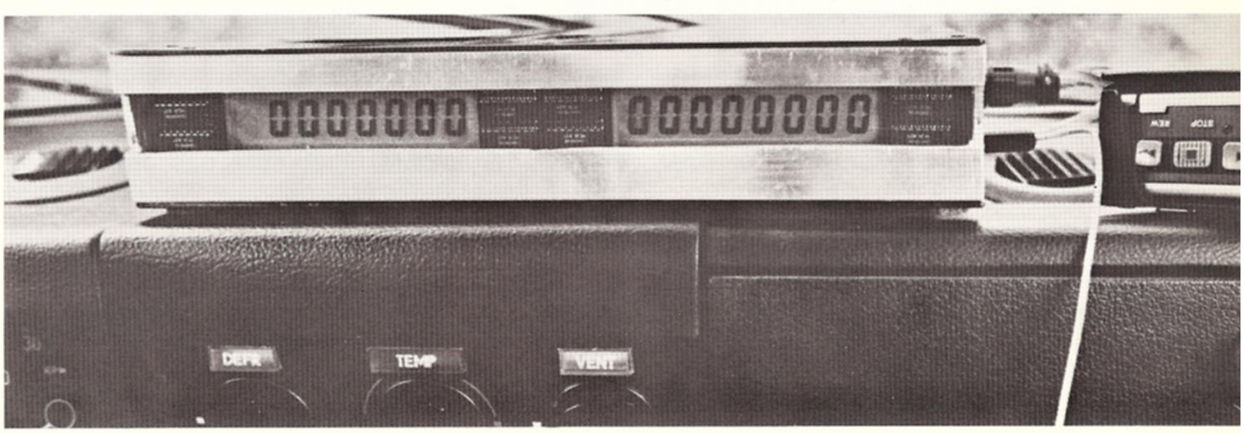
Briefly, the Computerized Road Test System consists of a microcomputer, a keyboard, a fifth wheel to provide the computer with basic speed and distance data and a Hewlett Packard 97 printer/calculator which produces a permanent record of the reduced data in a form ready for publication.

The basic system contains all necessary hardware and software for acceleration and braking tests. Additional software is being developed and can be supplied for aerodynamic drag, road horsepower and various vehicle handling and driver performance parameters.

With the time economies achieved by the Lamar Data Acquisition System you can recover its initial cost in short order.

ELECTRONICS AND PERIPHERAL EQUIPMENT

The computer has 1K bytes of random access memory (RAM) program memory with an additional optional 3K bytes of RAM available, 2K bytes of read only memory (ROM) containing the system monitor, 2K bytes of EPROM Road Test software with an additional optional 14K bytes of EPROM available for user programs and an audio cassette



LAMAR INSTRUMENTS

interface for reading program from tape into the computer and saving programs from the computer on tape. The system requires a 12 volt DC power source such as an automotive battery and draws two amps. The dash mounted liquid crystal display (LCD) has 16 digits, 0.625 inches high, under individual software control. The HP 97 printer/calculator is controlled from the computer. New programs can be written on the built-in hexidecimal keyboard. Addresses, data and op codes are displayed on six, seven segment, light emitting diodes (LED's). The system monitor has edit and single step debugging modes.

STANDARD SOFTWARE

The acceleration program prints elapsed time and acceleration (averaged over a one second period) to the following events: 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110 MPH; 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400 feet. Speed at 1320 feet is also printed to the nearest 0.1 MPH. The liquid crystal displays MPH to the nearest 0.1, elapsed time to the nearest 0.01 second and accumulated distance to the nearest foot.

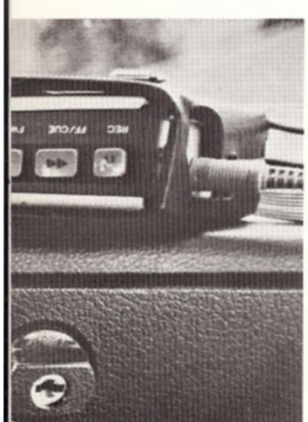
The braking program prints stopping distance to the nearest foot, time to stop to the nearest 0.01 second and speed to the nearest 0.1 MPH at which the driver placed his foot on the brake pedal. The liquid crystal displays MPH, time and distance.

The coastdown deceleration program gives deceleration rate from up to 100 MPH at 30 different MPH set points. When the deceleration rate is multiplied by the car mass in slugs (wt/32) the result is total drag on the car in pounds.

The instrument calibration program prints MPH to the nearest 0.1 MPH and RPM to the nearest 100 upon command of the driver. The liquid crystal displays MPH and RPM.

Work is continuing on road horsepower and various vehicle handling and driver performance parameters. An early goal is to have drag printed out immediately.

Modified systems are presently being developed for customers who have special or unique requirements in addition to the features provided on the standard system.



SPECIFICATIONS FOR COMPUTERIZED ROAD TEST SYSTEM

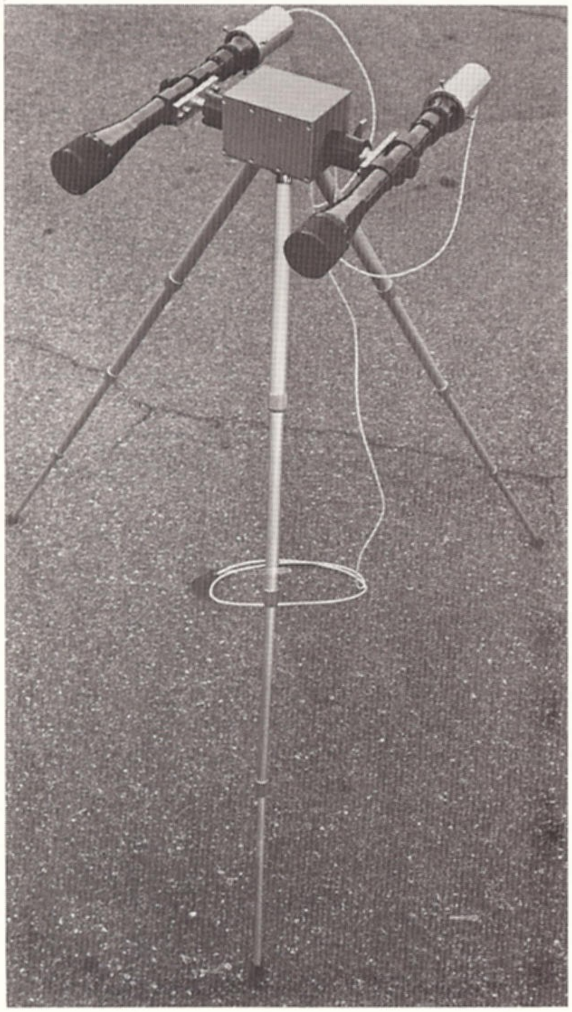
Size of Components

Computer	13″ x 13″ x 2″
HP 97 Printer/Calculator	10″ x 10″ x 2″
Display	12″ x 3″ x 2″
Fifth Wheel	19″ diameter

Weight of Components

Computer	5 lbs.
HP 97 Printer/Calculator	2 lbs.
Display	1 lb.
Fifth Wheel	15 lbs.

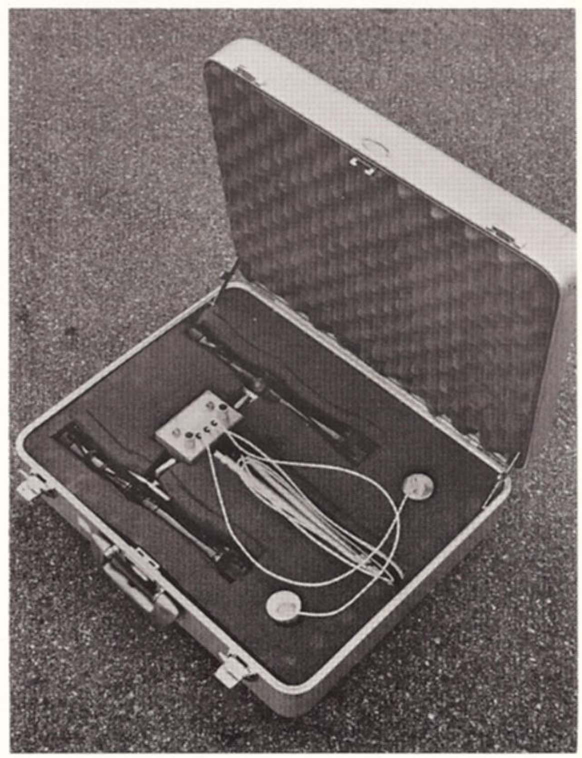
OPTIONAL HARDWARE AND SOFTWARE



The Vehicle High Speed — Transient Handling Tester (THT) consists of two telescopes with photocells attached that can be aimed at a point up to 400 feet away. As a car passes the line of sight of each telescope, the computer is signaled. The THT program prints the elapsed time on the HP 97 to pass both photocells and the average speed over a 700 foot slalom (a weaving course marked by pylons). This THT can also be used to time cars through corners or around various segments of a race course. The time resolution is 0.01 seconds. The computer then disables both photocells for one minute to allow the driver to return to the start of the test course.

CARRYING CASE

Optional fitted foam, metal luggage style carrying cases can be supplied for the standard system and for the optional hardware.



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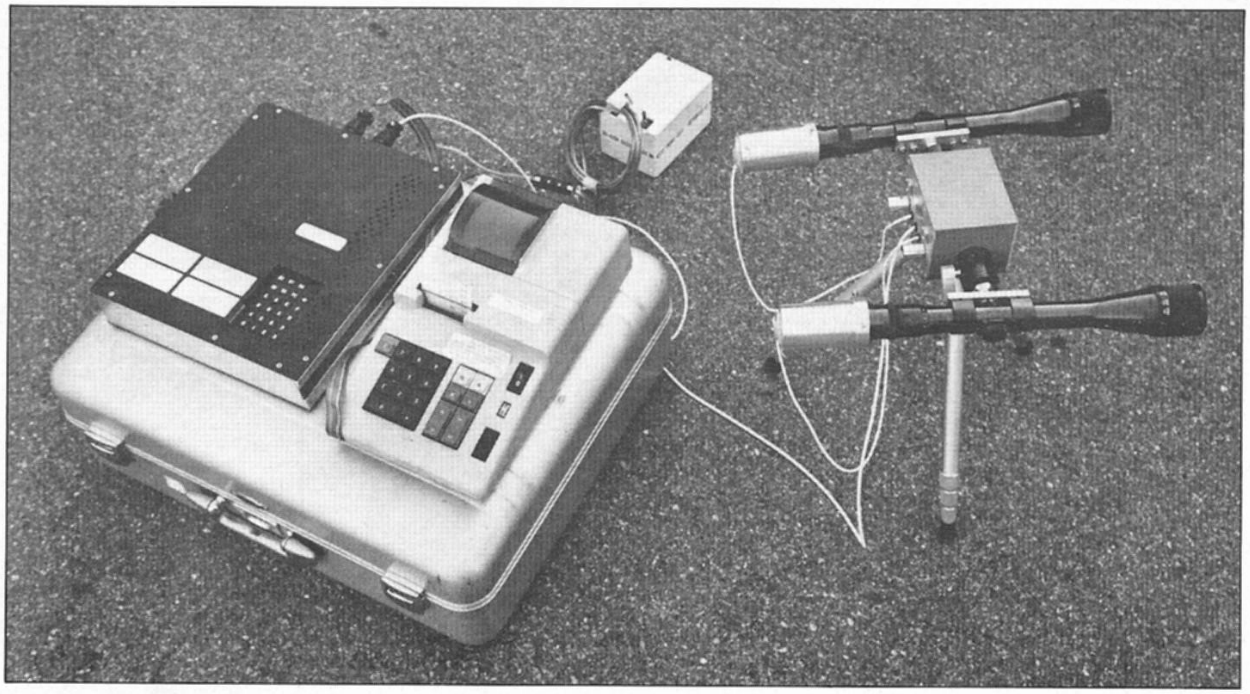


Computerized Slalom & Skidpad Testing

Road testing becomes a 1-man show

BY JOHN DINKEL
Engineering Editor

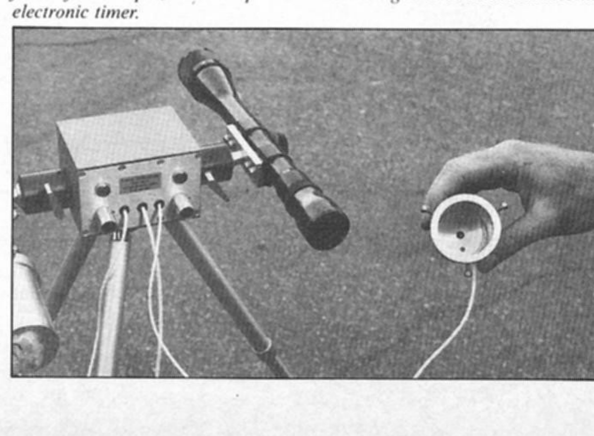
I MENTIONED LAST May in an introductory article describing our new computerized test equipment that Paul Lamar was at work on a slalom/skidpad tester that would allow R&T to time a car in either of these tests without the aid of an outside observer. We've been testing such a device for the past two months and are extremely pleased with the results.

The system Lamar developed consists of two standard Model V Weaver 3-to-9 power rifle scopes attached to a tripod. The scopes are swivel mounted so that the angle between them can vary from practically 0 to almost 360 degrees. An aluminum cylinder containing a photoelectric cell slips over the eye piece of each scope. As a car or other object passes in front of the first photo cell, interrupting the ambient light level, a timer is activated, and as the car passes the path of the second cell the timer stops. Computation of the time occurs in the same microcomputer used for our other testing, which then instructs the modified Addo desk calculator to print out the elapsed time on paper tape.

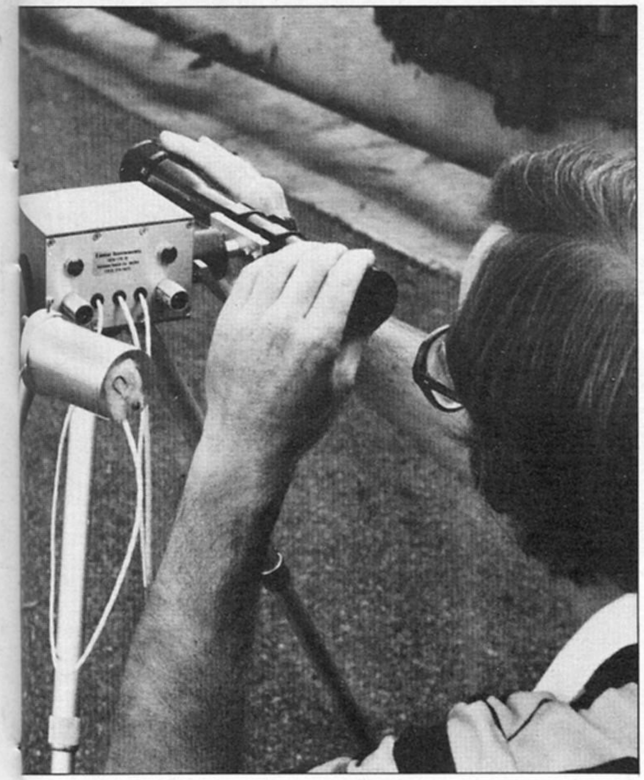
For the slalom tester the cross hairs of one scope are focused on the first pylon and the cross hairs of the other scope are aimed at the last cone. Then the cylinders containing the photoelectric cells are slipped over the eyepieces and tightened. The intensity of light each eye "sees" can be varied by turning a rheostat; normally the light level is set at the middle of the scale. After the microcomputer has been programmed via the Sony cassette tape

Slalom/skidpad test equipment (above). On top of the aluminum case are the microcomputer and the desk calculator. To the right are the two Weaver scopes attached to a tripod. In the background is a unique Gates Energy Cell, a small, light, sealed and rechargeable 12-volt power supply that increases road testing flexibility by eliminating the need for connecting the equipment to the car's battery.

After the scopes are focused on the pylons, an aluminum cylinder containing a photoelectric cell is slipped over each eyepiece. When an object passes in front of the scopes, it interrupts the ambient light level and activates the electronic timer.



PHOTOS BY ROBBIE BELL

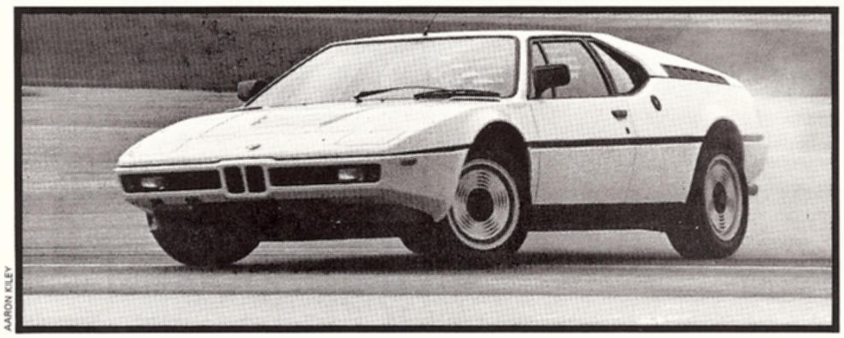


For easy aiming, the scopes are swivel mounted. Focusing is accomplished by rotating the knurled collars at each end of the scope.

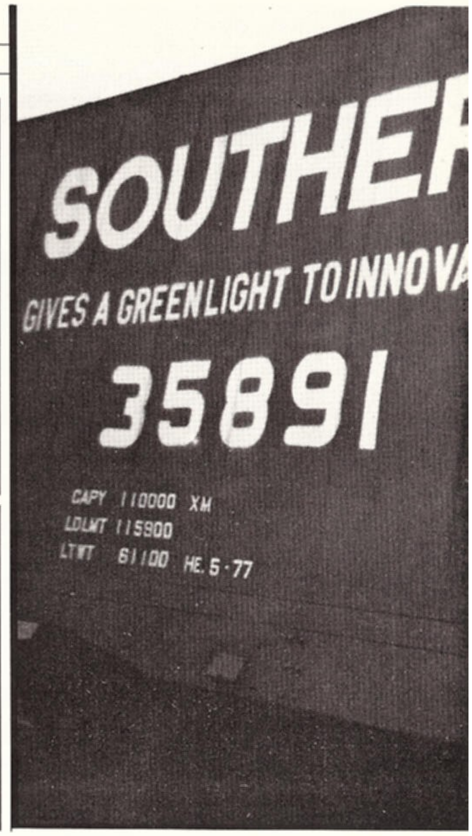
recorder, the driver can begin his runs. Following each run the photo cells are deactivated for 60 seconds, allowing the driver to retrace his steps back to the starting line and also to replace any pylons that may have been knocked down during the previous run. This time delay is variable and can be increased or decreased by merely changing a few steps in the program.

For the skidpad test a slightly different approach is taken. In this case only one scope is necessary. The test equipment is placed inside the circle and the scope is pointed toward the circumference. The point on the skidpad at which the scope is aimed is not critical; what's important is that the scope not move once it has been tightened into place and that the car interrupt the light hitting the photo cell each time the car completes a lap. The microcomputer works like a Taylor/sequential timer on a normal stop watch. When the car trips the beam the first time, the computer's clock starts counting. The next time the car triggers the photo cell the computer's internal clock stops and instantaneously restarts from zero. While the car continues on its second lap the computer calculates the time for the first lap and signals the desk calculator to print out the time. Each additional lap is similarly timed.

There will be no differences in the times and speeds recorded with the computerized equipment versus the hand-held stop watch technique previously used. In several slalom and skidpad runs timed by the microcomputer and two experienced observers using stop watches, we found an insignificant difference in the times recorded. Even now we are investigating additional uses for our computerized test equipment. There's more to come!



AARON KILEY



Have Test Equipment,

Car and Driver's test procedures laid bare.

• Everybody's doing it. The federal government, most car companies, a half-dozen enthusiast magazines, and various other publications offer up whole blizzards of test results, and it's easy to assume that one set of numbers is as good as another. This could hardly be further from the truth, for there is tremendous variation in the scope and precision of automobile testing. At *Car and Driver* we do our utmost to ensure that our test procedures deliver the most complete and precise performance figures possible. In case you were wondering, here's how we get them.

The foundation of our precision is a highly sophisticated, microprocessor-controlled fifth-wheel system manufactured by Paul Lamar of Lamar Instruments in Redondo Beach, California. Lamar first became involved in automobile testing when he worked as the aerodynamicist for Jim Hall's Chaparral team. Later, after forsaking the racing business for computers, he combined computer technology with his testing experience to effect a quantum leap in the state of the automobile-testing art.

The heart of our fifth-wheel equipment is a microprocessor—a compact but extremely powerful computer—that can manipulate time, speed, and distance information in several ways. The fifth wheel itself generates a very precise distance signal in the form of exactly 100 electrical impulses for each foot traveled; the microprocessor measures distance by counting these impulses. (The pulses are produced by a phototransistor at which an infrared light source is aimed, the illumination being interrupted by a toothed ring that rotates with the wheel rim.) Speed is simply distance per unit of time, so the microprocessor can readily compute speed by comparing the number of distance pulses with a time signal available from an internal, crystal-controlled clock, in which each second is subdivided into one million parts. Successive speed calculations are compared to determine acceleration.

The beauty of computer control is its flexibility. With the flip of a switch, the "black box" on the passenger seat changes the way it manipulates the data to match the test being performed. For acceleration, it holds time and distance counters at zero until the very instant the car begins to move; from that point, the times to the various speeds and distances are recorded. Internal counters can also be manually switched on at any point to measure passing times and distances. During brake testing, a pressure switch on the brake pedal conveys the moment of initiation to the computer.

As these tests proceed, a built-in printer records the results on paper tape. Having this feedback available almost immediately is a tremendous advantage because it allows the tester to experiment with and compare the results of different driving techniques; the goal in every test is to measure the *best* the car can do, whether it's the quickest possible zero-to-sixty time or the shortest possible stopping distance for that particular model. A windshield-mounted display instantaneously provides the tester with additional informa-

PHOTOGRAPHY BY GEORGE LEPP

Will Travel

BY CSABA CSERE

tion (time, speed, distance, acceleration), but no hard copy of the displayed data.

Lamar's electronic contributions to our testing procedures have been supplemented by the efforts of *Car and Driver*'s own technical department. Our half of the bargain is mechanical components. In a decade of experimentation, we've made the pieces smaller, added a gas-pressure strut (for wheel downforce and damping over bumps), and devised a special means of attaching the fifth wheel to test cars.

Just like the auto industry, we've gone through several downsizing programs, and now our 60 pounds of equipment fits into one 23-by-21-by-11-inch Cycolac shipping case. Since a container can be no smaller than its largest burden, the fifth wheel itself has been the focus of our downsizing attention. The present unit consists of a twenty-inch bicycle tire mounted on a lightened cast-aluminum rim. A fabricated aluminum fork supports the wheel's bearings and the distance-measuring apparatus. This fork, in turn, trails from a steel-and-aluminum telescoping boom, which is bolted to a universal joint welded to a tripod that permits the camber of the wheel to be adjusted. A ten-inch suction cup attaches the entire fifth-wheel assembly to the side of the test car. Though seemingly a precarious mount, the suction cup (originally designed to transport plate glass) has withstood the rigors of 180 mph, as dished out by a Le Mans–winning Kremer K3 Porsche. Its convenience of attachment and removal is unsurpassed by any bumper-mount scheme we've seen, and the side-mounting design keeps the wheel within the driver's outside mirror.

All this equipment nestles snugly in our case alongside our weather-measurement apparatus, sound-level testing components, tape measure, stopwatch, and several carefully selected tools, ever ready and waiting to be taken to the Chrysler Proving Grounds in Michigan, Orange County International Raceway in California, or any other flat piece of real estate.

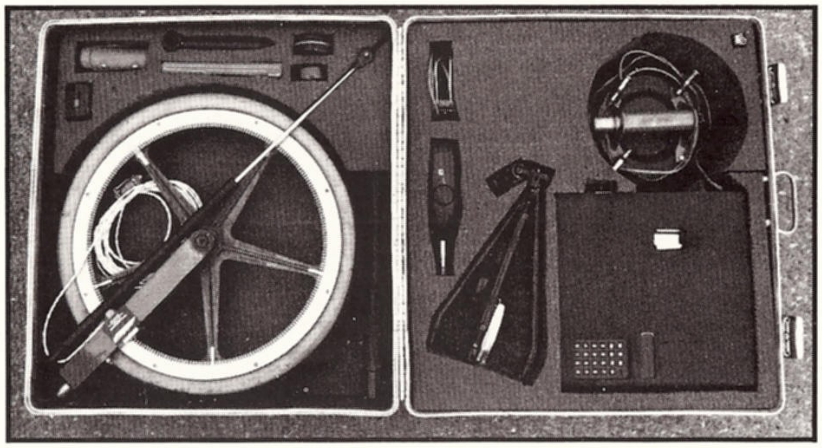
Acceleration

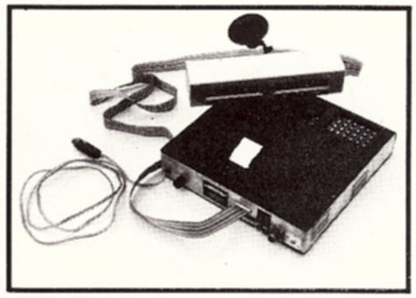
Historically the backbone of the specifications page, acceleration is the one aspect of performance that interests everybody, and it's the first test we perform at the track. Prior to an acceleration test, the gas tank is filled to the brim and tire pressures are set at the manufacturer's recommendations (if available) for light load and high speed. Windows are kept rolled up and the air conditioner off no matter what the weather. After the test runs, we correct the data to standard atmospheric conditions (29.92 inches of mercury, 60 degrees Fahrenheit, and dry air).

In a manual-transmission car we shift as quickly as possible consistent with lifting off the throttle and using the clutch in normal fashion. Usually we light up the tires with true drag-strip technique as we start off the line, and we willingly avail ourselves of all the revs the test car's engine has to offer beneath its redline. We typically do several runs to experiment with shift points and starting techniques, because holding each gear to the redline is not necessarily the fastest approach, especially with the current crop of low-rpm-torquey engines (in these cases, the redline is a durability limit rather than an indication of the whereabouts of the power band). Once all these variables have been taken into account, we give the car a chance to cool off before doing the final—usually the fastest—run.

Automatics are somewhat easier to test, though their performance also benefits from experimentation. We brake-torque them at the start to raise the rpm as high as possible (this is especially critical with turbocharged cars). Since many automatics shift too early, even under full throttle, we also try upshifting manually.

An acceleration run ends when we run out of room. Unfortunately, even on our longest test track (Chrysler's 1.6-mile east-west straightaway) we can achieve top speed only on relatively slow cars. Therefore, it's often necessary to calibrate a test car's tachometer with the fifth wheel and leave the confines of the proving ground to seek more spacious testing venues in the public domain; if a car has no tachometer, we simply time our runs over a known distance. Even in these cases, however, the top speed we report is always the average of the figures obtained





C/D's black box houses a single-circuit-board microcomputer. The central processor is a Commodore 6502, the fastest device of its kind in popular use. It's supported by several memory chips (some programmable), input/output chips, and a compact data printer.

in back-to-back runs in two directions on level road.

Our passing tests, from 30 to 50 and from 50 to 70 mph, measure powertrain flexibility starting from low rpm. First the speed is stabilized in top gear; then the throttle is floored until the desired speed is reached. The published times include any stumbles or hesitations that may occur. Automatics, because they downshift, have a decided advantage in this test.

Braking

Interspersed among the acceleration runs are the braking tests. Each test simulates a panic stop from 70 mph, and measures the ultimate braking capability of a car. We assiduously avoid lockup during the test because it both adds to the stopping distance and flat-spots the tires. (Square tires make testers quite unpopular around the office.)

The procedure consists of accelerating the car a little beyond 70 mph and then quickly applying the brakes and holding them on the verge of lockup until the car is stopped. The pressure switch mounted on the brake pedal signals the microprocessor to record the initial speed of the stop, and to start counting distance pulses; the result is later adjusted to yield the stopping distance from exactly 70 mph. Although we report only the shortest stopping distance obtained, we conduct several tests (with cooling in between) in order to familiarize ourselves with a car and develop the optimal braking technique.

We also record our subjective comments about front-rear balance, modulation, and fade resistance at this time. We do not measure fade resistance quantitatively, because it is so highly dependent on the conditioning of the frictional surfaces of the brakes and on their temperatures. Our subjective evaluation serves only as a coarse indication of fade resistance, since different cars exhibit gross differences in fade during test stops.

AARON KILEY

Testers' Choice*

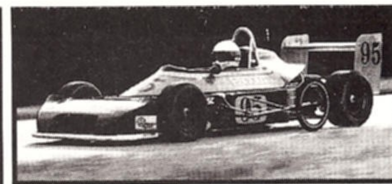
	THE BEST	THE WORST
acceleration, 0-60 mph	Porsche 911SC (6.3 sec)	Chevrolet Chevette Diesel (21.2 sec)
standing ¼-mile	Porsche 911SC (14.7 sec @ 94 mph)	Chevrolet Chevette Diesel (21.8 sec @ 61 mph)
top speed	Jaguar XJ-S (143 mph)	Chevrolet Chevette Diesel (80 mph) Volkswagen Rabbit Diesel (80 mph)
braking, 70-0 mph	Porsche 928S (179 ft)	Chrysler LeBaron (235 ft) Chrysler Imperial (235 ft)
road horsepower @ 50 mph	Toyota Starlet (11.0 hp)	Rolls-Royce Silver Spirit (25.0 hp)
roadholding	Chevrolet Camaro Z28 (0.82 g) Chevrolet Corvette (0.82 g)	Cadillac Sedan de Ville (0.63 g)
sound level @ 70-mph cruise	Lincoln Continental (67 dBA) Mercedes-Benz 380SEL (67 dBA)	Ferrari 308GTSi (83 dBA)
***C/D* observed fuel economy**	Plymouth Horizon Miser (36 mpg) Isuzu I-Mark Diesel (36 mpg)	Rolls-Royce Silver Spirit (11 mpg) Cadillac Sedan de Ville (11 mpg) Jaguar XJ-S (11 mpg)

* limited to 1981 and 1982 production street cars tested to date

Coast-Down Testing

Road horsepower (see box) is measured by accelerating to 60 mph, shifting to neutral, starting the computer, and coasting down to 20 mph. Naturally, a level road is a must, and minimal wind is also important. Any such aberrations that do exist are minimized by following standard Society of Automotive Engineers test and data-reduction procedures. A coast-down test consists of ten runs, five in each of two directions.

DAVE HAWKINS



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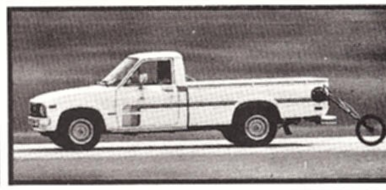

ANDRE LaROCHE

AARON KILEY

AARON KILEY

Road Horsepower and Where It Comes From

• Cars and mules have at least one thing in common: without constant motivation, neither will go anywhere. In the absence of forward pressure from its driving wheels, any car will soon be halted by the relentless retardation of reluctantly rolling tires, the resistance of the air to motion, churning gears, dragging brakes, and various and sundry power-absorbing bearings. With the coast-down test, we quantify the total drag and break it into its two significant components.

The testing consists of coasting a car from 60 to 20 mph and measuring the time intervals from the initial speed to sixteen carefully selected lower speeds. The resulting data, along with the car's weight, its frontal area, and weather conditions, are fed into a Hewlett-Packard 97 programmable calculator. The calculator processes the data using a custom *C/D* data-reduction program, figures the total drag, and separates it into two components: aerodynamic drag, and everything else. To do so, the calculator is programmed to assume that aerodynamic forces are proportional to the square of velocity, while all other retarding forces are velocity-independent, or constant. This latter assumption is not strictly correct, though it is very nearly correct for rolling resistance, which is the major component of non-aerodynamic drag.

From the drag-force results, we calculate the road horsepower; i.e., the amount of power that the tires must put to the ground to sustain a cruising speed of 50 mph. (The actual power that the engine must develop is a bit higher because of losses in the drivetrain.) At 50 mph, the aerodynamic and non-aerodynamic power requirements are typically about equal. As speed increases, however, the aerody-

Efficiency Extremes

	road horsepower @ 50 mph, hp	aerodynamic losses, hp	friction and tire losses, hp
The Most Efficient:			
Toyota Starlet	11.0	7.5	3.5
Ford Escort (3-door)	11.5	7.0	4.5
Ford EXP	12.0	6.5	5.5
Plymouth Horizon Miser	12.0	6.5	5.5
The Least Efficient:			
Rolls-Royce Silver Spirit	25.0	16.0	9.0
Lincoln Town Car	19.0	11.5	7.5
Mercedes-Benz 300SD	18.5	11.5	7.0
Mercedes-Benz 380SEC	18.5	8.0	10.5

Handling

A circle painted on a skidpad is the venue for our roadholding tests. The procedure is to drive around our standard 282-foot-diameter course at the limit of adhesion, while an assistant times each lap. From the average of the two best laps in each direction we calculate the car's speed and consequently its lateral acceleration in gs.

Most cars stick best when turning left, presumably because of the offset position of the driver. Occasional exceptions are cars whose seats have poor lateral support. In these cases, having nothing to lean against when turning left can cause a loss of driver control sufficient to cancel the normal weight-distribution advantage in left turns.

Virtually all cars understeer on the skidpad while under power, but not to the same degree. Some steer close to neutral, while others mechanically grind

namic portion becomes predominant. At 100 mph, for example, aerodynamic horsepower increases eightfold from the 50-mph requirement, while the non-aerodynamic portion merely doubles.

The aerodynamic-horsepower requirement is a much more complete picture of a car's wind-cheating properties than a drag coefficient because it takes into account the car's frontal area. A drag coefficient merely describes the aerodynamic efficiency of a particular shape, irrespective of its size. The coast-down–derived figure is also free from the vagaries of wind-tunnel effects. (In a wind tunnel the road effectively moves along with the car, hardly the case in the real world, and there are other factors that make wind tunnels less than perfect tools for measuring drag.)

The coast-down test is remarkably sensitive when comparing cars back-to-back on the same track. When we tested hatchback and four-door versions of the Chevrolet Cavalier this way, the coast-down results showed the hatchback to be 0.5 hp lower in aerodynamic power requirement, but 1.0 hp greater in friction losses because of its slightly heavier weight and fatter tires.

Naturally, the coast-down results do not totally describe a car's efficiency. Powertrain performance is the other half of the picture. But when we know how much power it takes simply to move a car, we can much better judge whether the engine is holding up its end of the bargain. —CC

Testing Countdown