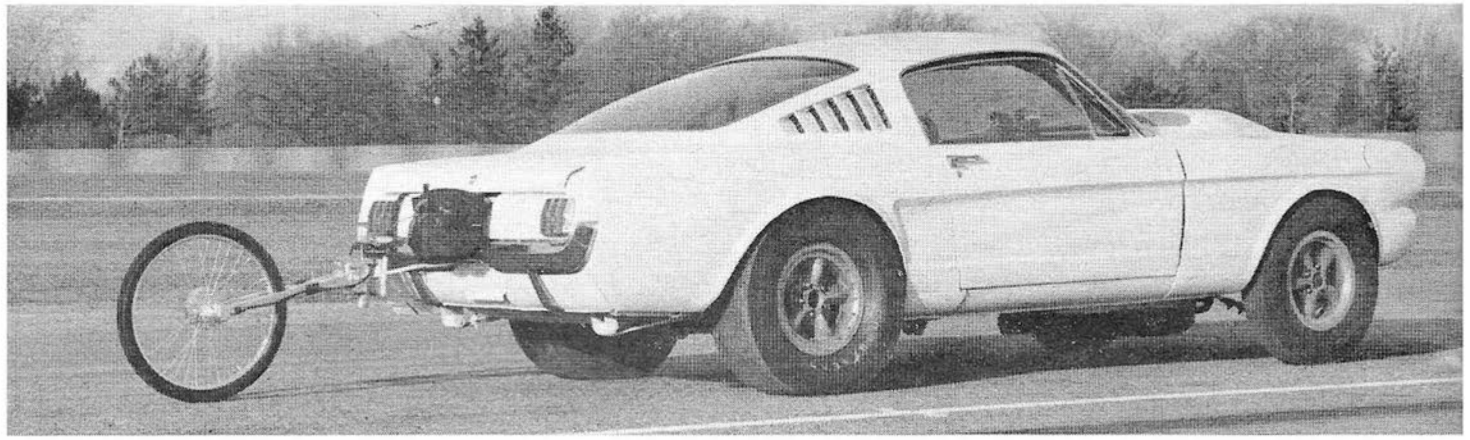


MEASURING THE MUSTANG

Instrumentation Documents A/FX Performance

BY ROGER HUNTINGTON

BENCH RACING is one of the more pleasant aspects of any form of motor competition. When it's too cold, too wet or too dark to be out on a track racing fender to fender, bench racers sit around in garages and talk about the technical angles. Some weird and wild theories develop out of this indoor sport.

There is a packet of recent information that makes wonderful fodder for drag-racing bench sessions. People often argue about things such as instantaneous acceleration rates of a drag machine, how speed and distance covered increase with time, and how much engine rpm rises on a shift and how much it drops when the clutch is engaged on the line. Here, at last, are some authoritative answers. Ford Engineering ran extensive tests on the 1965 A/FX Mustang to pinpoint how some of these parameters vary as the car moves down the dragstrip on a typical all-out run. Ford needed to know these things to help develop design of oil pan baffles, engine oil passages, valve springs, clutch plate pressure and rear-end torque arms.

Ford released some of the test figures for publication in *CAR LIFE* and they are presented here for the amateur drag racers who don't often have the chance to obtain technical data that require a million dollars worth of test equipment and engineering brainpower to gather.

First, a word about the test car and test equipment: The car was the A/FX Mustang that Ford Engineering used for research last year. It did not run in competition, though its specifications were equivalent to those of the racing cars. It carried the standard sohc 427 engine that developed approximately 600 bhp at 7200 rpm. Axle gear ratio was 5.14, with 10.50-15 Goodyear 10-in. slicks on the rear at 10-15 psi inflation. The close-ratio Ford 4-speed transmission was used for these runs, although an experimental manual-shift torque converter transmission was installed in the car later. Test weight of the car was approximately 3240 lb.—just above the allowable minimum for the A/FX class. Test equipment was quite heavy, so it was necessary to strip some weight out of the car to bring it down to a typical A/FX figure. Dick Brannan, who is Ford's drag racing technical consultant, did the driving, so this added another 130 lb. to that 3240. Gross weight was 3370 lb.

The test equipment mounted in the car was capable of recording four parameters simultaneously on all runs —car speed, engine rpm, distance covered and the instantaneous acceleration rate. These parameters were reduced to varying electrical current signals and fed into a transducer which converted the signals to light pen movements on graph paper that unrolled under them. In other words, Ford engineers acquired a long roll of tracing paper with four jagged lines showing how the four individual parameters varied second by second as the car moved down the strip.

The graph paper unrolled in the transducer at a precisely constant speed —so each inch on the trace represented a certain fraction of a second. The car speed and distance were measured by a fifth wheel at the rear of the car. The fifth wheel drove an integral generator to provide a signal current proportional to speed and the generator was rigged to produce a blip on the graph for every foot forward the fifth wheel advanced. These blips were added up to give the total distance covered from the start. The tachometer that recorded engine speed was a conventional electric type working off ignition pulses—but much more accurate than most inexpensive accessory equipment. Finally, the accelerometer was of the strain-gauge type, which converts inertia force of a mass into a varying electrical current. This type of accelerometer is quite accurate and sensitive, is well damped and lends itself well to electrical recording.

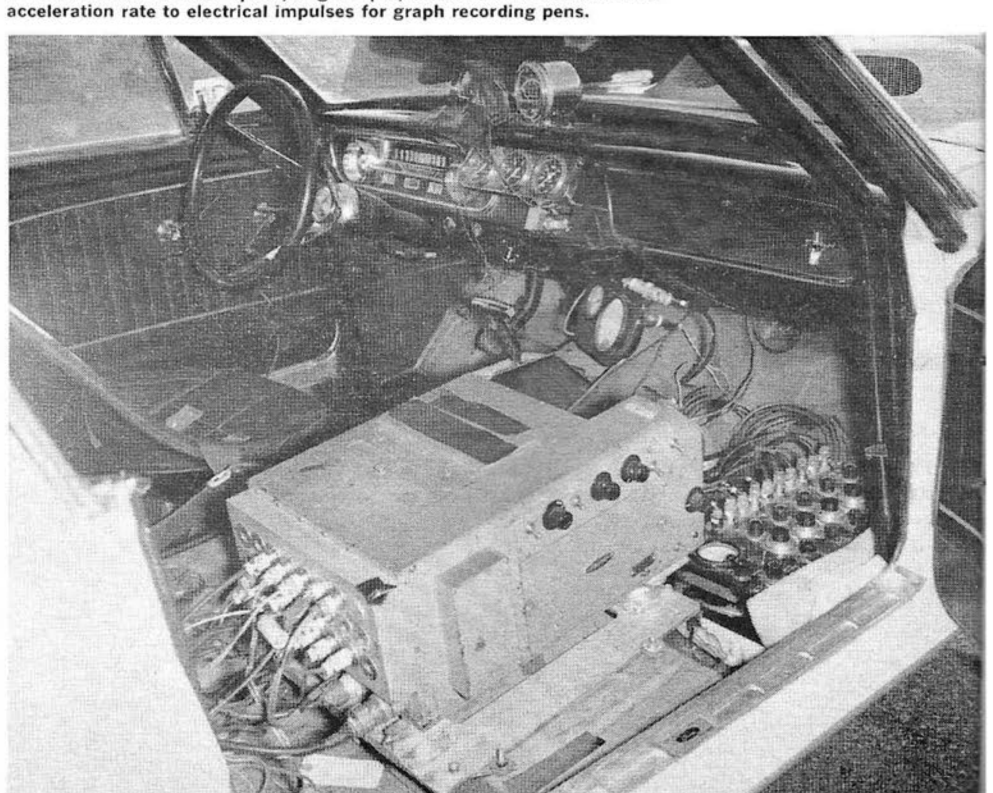
Here are some of the test results. A test trace for a typical run is shown on an accompanying graph. This isn't exactly the way the figures would appear on the original trace; the curves are greatly compressed. The original graph was about 40 in. long for the 1320 ft. The original lines are more jagged due to vibration in the car. Also, the curve for distance covered did not appear on the original. This information was in the form of blips along the top of the trace that had to be counted to determine distance. Otherwise, the values on this graph are very close to the original measured values.

NOTE THE CURVE of car speed in relation to time. The times for the full quarter-mile are 11.7 sec. e.t. at 128.6 mph terminal speed. This is only a so-so time by competition standards. But the tests were run on Ford's asphalt straightaway test strip in Dearborn, Mich., where traction is not nearly as good as most dragstrips. This same run might have returned an e.t. in the very low 11s or high 10s on many strips with like terminal speed. Now note some of the times from a standing start to various speeds. The 0-30 mph time is 1.8 sec. The 0-60 time is 3.7 sec. and the car got up to 100 mph in 7.5 sec. Drag enthusiasts have often speculated about true 0-60 times on high-performance drag racing machines. It is impossible to measure this from the speedometer because of tire-spin and instrument lag. Even with a fifth wheel and stopwatch it's difficult because of uncertainty about the precise moment of starting. So here is the best answer yet: Figure many A/FX cars do 0-60 in 3-4 sec. And note, also, that the car didn't start to move until between 0.1 and 0.2 sec. after the driver began to engage the clutch. Nothing is instantaneous—even in drag machines.

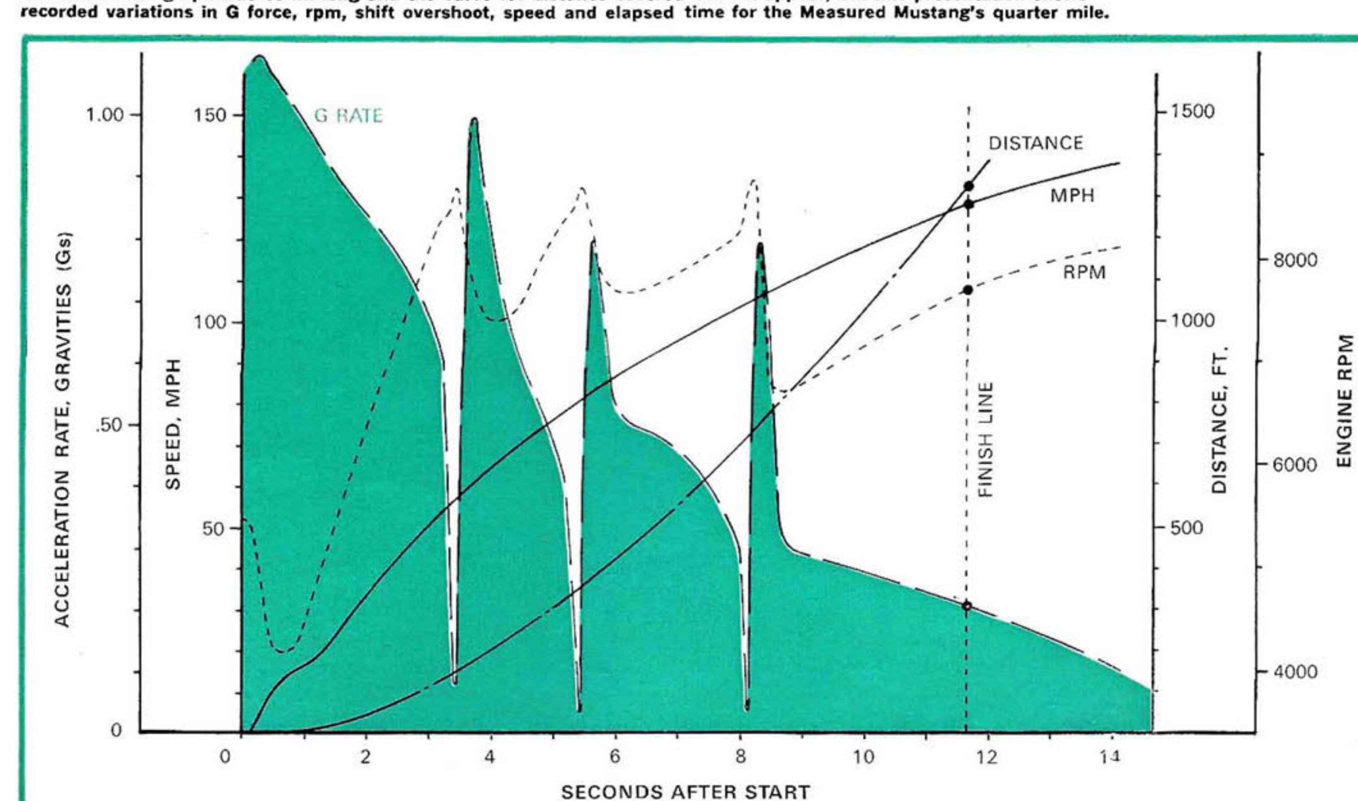
Now look at that curve for the acceleration rate. The values are measured in terms of "G," or gravity. One G equals 32.2 ft./sec./sec. of acceleration. Note that a peak acceleration figure of approximately 1.1 G is reached just as the car lunges off the line. Ford engineers believe this is fairly accurate, even allowing for a certain amount of lag and undamped motion in the accelerometer.

Of course, from the value of 1.1 G, it is easy to calculate the maximum effective tire traction coefficient. Look at it this way: The static front/rear weight distribution of this car is roughly 50/50. The wheelbase is 106 in. and the c.g. height is about 24 in., so the front-to-rear weight transfer at 1.1 G acceleration is 25%. Thus the car has 75% of its total weight on the rear tires at 1.1 G. And the effective tire traction coefficient under these conditions is 1.1/0.75= 1.47. This sounds reasonable, in view of the inferior traction of the Dearborn test track. Some drag slicks provide coefficients approaching 2 under better conditions.

Trace the acceleration curve across ▶



TEST GEAR reduces car speed, engine rpm, distance and instantaneous acceleration rate to electrical impulses for graph recording pens.



THE ORIGINAL graph was 40 in. long and the curve for distance covered did not appear, but this presentation shows recorded variations in G force, rpm, shift overshoot, speed and elapsed time for the Measured Mustang's quarter mile.

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and note that it drops off to near zero on the shifts, then jumps up again when the clutch is re-engaged. The rate shoots back up to 1 G on the 1-2 shift, and up to nearly 0.8 G on the 2-3 and 3-4 shifts. This indicates how the high rotational inertia of the fast-spinning engine and flywheel gives the car a short boost of acceleration when the lower gear ratio tries to pull down engine speed after the clutch is re-engaged. The engine and flywheel tend to keep spinning at the same speed—so when the gear ratio is dropped the result is a short burst of extra acceleration while the clutch slips. Drag enthusiasts often have wondered just how much of a burst of extra acceleration is produced from engine and flywheel inertia on a fast speed shift. There's the answer.

Note that the car still has a very healthy 0.2 G of acceleration at the finish line of the quarter-mile. A rough idea of the true engine horsepower output can be obtained from this figure. Trace back to the peak of the power curve of around 7200 rpm, which is 120 mph car speed. The G rate here is 0.25. This means that just about 300 bhp is being absorbed in accelerating the car mass at that speed. The wind and tire rolling resistances, which appear to be approximately 400 lb. each at 120 mph, absorb another 250 bhp. Allowing for a 10% friction loss in the drive-line, the total engine output at 7200 rpm apparently is a little more than 600 bhp. This checks well with the factory dynamometer figures for the sohc 427 engine.

Now look at the curve for engine rpm. Note the "static" rpm of 5500 on the starting line. Brannan uses 6000-7000 rpm on a good traction strip; but 5500 was as high as he could go on the Dearborn track without excessive rubber-burning. Then note how the engine speed drops to 4200 rpm in the first 0.5 sec. as the clutch is engaged off the line. It hauls from this point in low gear, with apparently very little tire spin. On this particular run, then, the engine's mid-range torque had some effect on the e.t. On another run, perhaps, where the driver could come off the line at 6500 rpm and never drop below 5500, mid-range torque would be less of a factor. Driving technique and traction conditions have a great effect on e.t., but less of an effect on trap speed.

THE SHIFT point on the 1-2 and 2-3 shifts is about 8350 rpm. (Ford engineers point out that this is higher than most driver wind the sohc 427; but they were experimenting with some other ideas on this particular run.) Note that the engine speed jumps to 8700 in the 0.3 sec. or so while the shift is being completed. Brannan's style is "speed-shifting," with foot full down on the gas pedal. Most drivers don't allow for this 300-400 rpm overshoot when they select shift points. An engine can be ruined easily. It takes an expert driver a good 0.3 sec. to complete a shift with a good 4-speed gearbox and the time probably is closer to 0.6 sec. for the average driver. The engine can gain very high rpm in this time. Look at the 3-4 shift on the graph. The shift is started at 8250 rpm and the engine speed overshoots to 8750! Is this an argument for quicker-shifting transmissions or for less foot-down speed shifting?

There is another interesting point about the rpm curve. Note that the rpm drop is much less on the 1-2 and 2-3 shifts than on the shift into high. The gear ratios in the transmission aren't really that much closer; it's just that the clutch is slipping a great deal more on these shifts, possibly due to the heat build-up on the initial take-off. Don't get the idea that those very strong, 2500-lb., drag racing clutches don't slip. They have an extremely difficult job to do and controlled slip is the only way they can do it. Flexible couplings are at two points in the drive-train—at the clutch and at the rear tires. They both slip.

The curve of distance covered in relation to time is mainly of academic interest. It is interesting to note, however, that the distance required to reach 60 mph from a standing start is only 175 ft. Think about that for a second. It would be great in the Stop Light Grand Prix, wouldn't it? Fans of ⅛-mile drags may note the time for this car for 660 ft. is 7.7 sec. e.t. at 102 mph trap speed. Very passable. Times of 7.5 e.t. at 105 mph are considered good for exhibition cars on the short strips.

This is a lot of fodder for bench racing sessions. It is the straight dope—no estimates, no guesswork, no Mickey Mouse instrumentation, thanks to Ford Engineering. ■

A FIFTH WHEEL, a very sensitive electric tachometer and a strain-gauge accelerometer took the pulse of the A/FX test car as Ford engineers sought performance data. Test equipment weight necessitated paring pounds from body and chassis.