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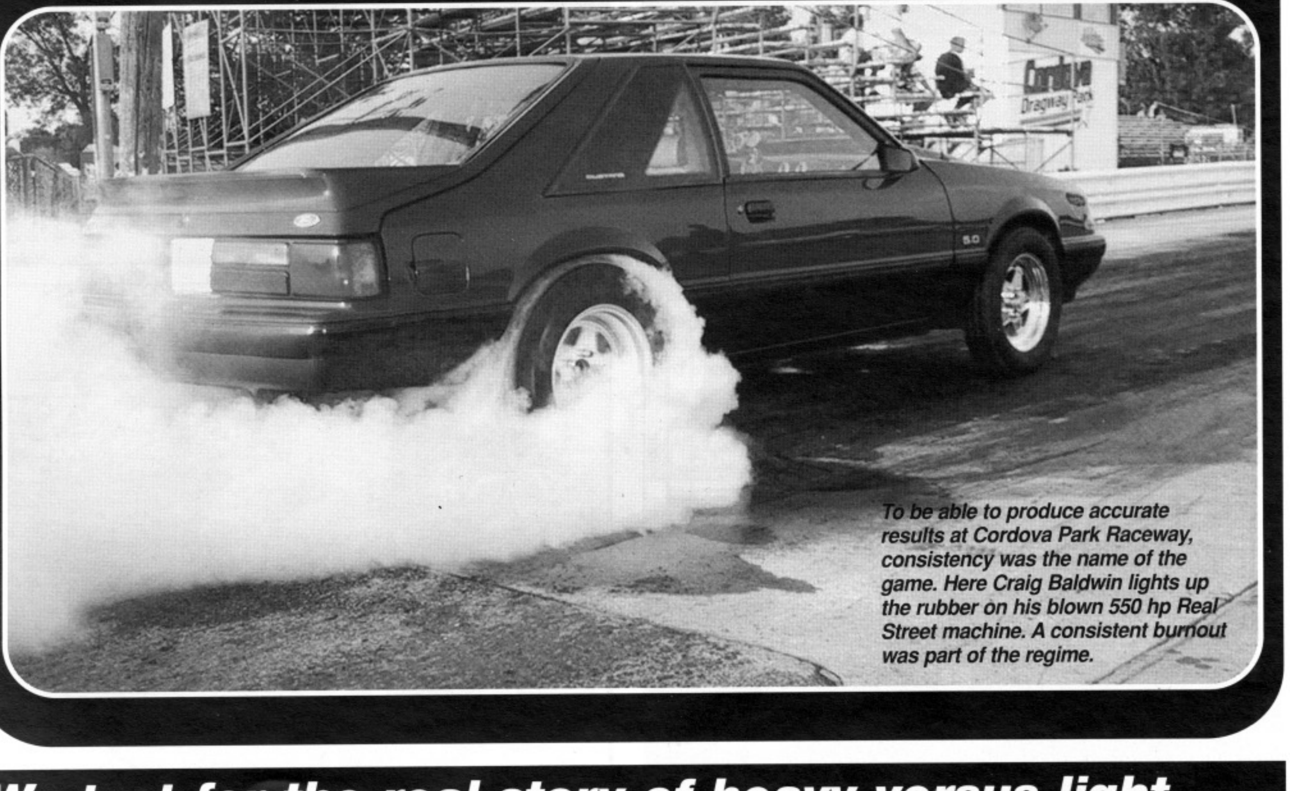
MASS VS. MYTH



To be able to produce accurate results at Cordova Park Raceway, consistency was the name of the game. Here Craig Baldwin lights up the rubber on his blown 550 hp Real Street machine. A consistent burnout was part of the regime.

We test for the real story of heavy versus light clutch and flywheels assemblies.

MASS VS. MYTH

BY DAVID VIZARD

PHOTOGRAPHY AND ILLUSTRATIONS BY THE AUTHOR
TEST RESULTS COURTESY OF MANY WILLING HELPERS.

There are many successful racers, mainly in the lower powered, heavy chassis classes, that claim best ET's are achieved by utilizing the kinetic energy potential of a heavy clutch and flywheel assembly for a better launch from the line. The theory is simple. Pump horsepower into the flywheel just before leaving the line by turning up the engine to a little past peak power or the red line (which ever is higher). Pulling the rpm down to about peak torque as the car is launched then sucks much of this stored energy back out.

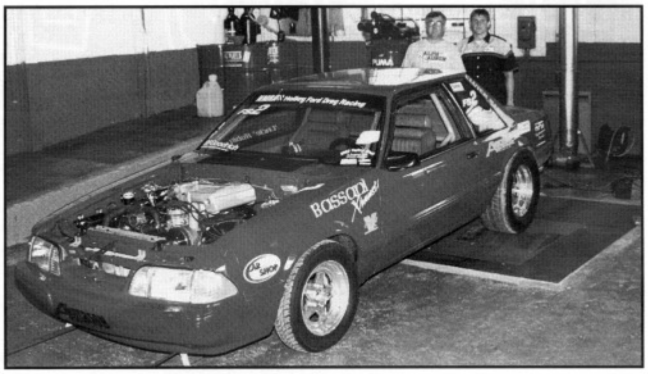
This technique does indeed provide more "available power" for the first and most critical part of the quarter-mile pass, namely the start. On the down side, the flywheel will absorb torque from the engine each time the rpm climbs back up to the shift point. As the shift is made the rpm is once again pulled down and in the process energy in the clutch/flywheel assembly is transferred too the car.

The only chink in the armor is that to transmit all the kinetic energy from the clutch and flywheel to the car neither the wheels nor the clutch must slip. Any slippage that does occur means that a portion of that energy is being converted to heat.

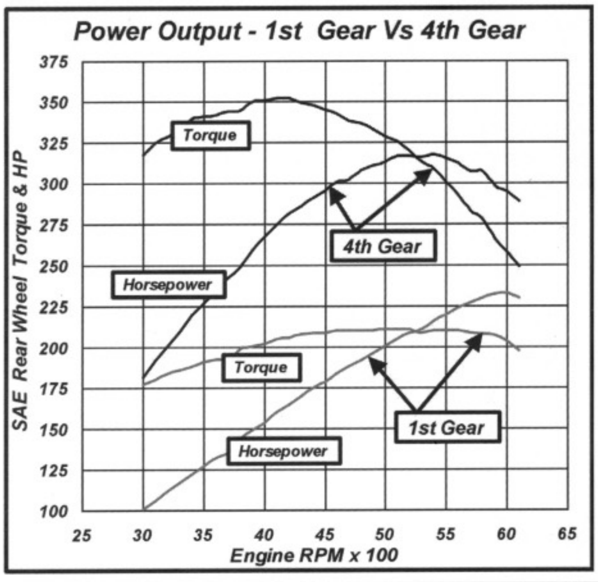
Proponents for light clutch/flywheel assemblies point to the fact that there is more available power when the engine has less rotating mass to accelerate. The lower the gears involved and the more rapidly the rotating parts are accelerated the greater the amount of power absorbed during acceleration (Fig 1). This means after the clutch is fully engaged the clutch/flywheel absorbs the greatest amount of power in first gear right when all the power possible is needed to launch the car. This is the crux of the problem we are addressing.

For a drag racer achieving a good start and a low 60-ft. time is critical toward pulling off a victory. For a road racer the start is almost immaterial (unless some strategic advantage is obtained in the first five seconds) so any advantage a heavy clutch/flywheel might have is completely negated after the first five seconds of the race. After that a heavy flywheel is a disadvantage. For road racing, lightweight has already proven, beyond any shadow of a doubt, to be the way to go.

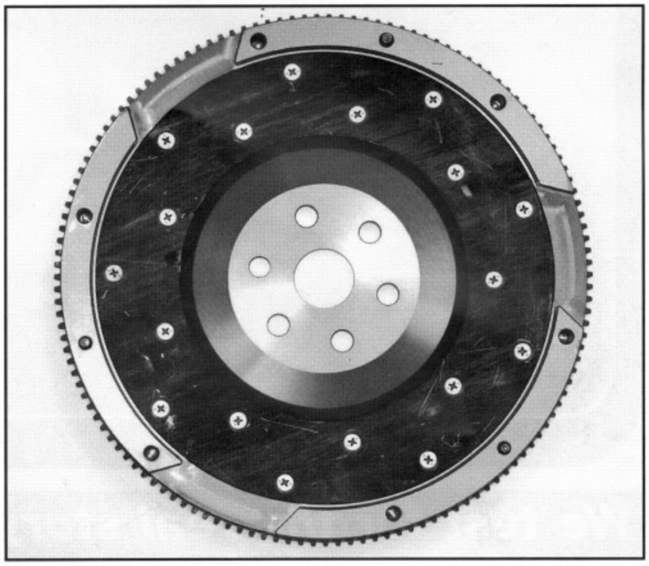
Chris Jewell of Clutch Masters and Lou Fidanza of Fidanza Flywheels are in businesses that manufacture lightweight components. Although their products are extremely popular with road racers they are confronted, on a daily basis, with drag racers wanting heavy rotating parts that they believe will give a faster launch. Both Jewell and Fidanza hold the opposite view. They both firmly believed, from their considerable race experience, that light is the best way to go for drag racers as well as road racers. The problem is there are too many contradictory opinions.



(Right) Here Mike Cerra and Robin Lawrence ready the Factory Stocker for its initial dyno runs. It took about 30 minutes of practice on Robin's part to develop the required consistency run to run.



This graph shows the power available in first gear and forth gear of Robin Lawrence's Factory Stock 5.0. Because of the rapid rate the engine internals and components back to the wheels are accelerated the power absorbed is greater. As can be seen the difference in rear wheel output between first and forth gear is an amazing 85 hp and a staggering 140 lbs.-ft of torque.



At a little over 10 1/2 lbs. this model Fidanza flywheel was used to replace stock style steel flywheels of 23 1/2 lbs.

THE BIG PLAN

About last February I got a call from Jewell. "If I organize a track, cars in the 12, 11 and 10 second range, a chassis dyno, on board data acquisition, drivers and crew, would you care to come along and document the results of light versus heavy clutch and flywheel assemblies?"

What true blue racer could say no to that? Chris did indeed mastermind a plan and, more to the point, pulled it off in a really well oiled fashion. First he enlisted NMRA Factory Stock racer Robin Lawrence as his right hand man and from there on they put what proved to be a highly competent team together.

The venue chosen was Cordova Park Raceway in Illinois. Drivers and cars consisted of Robin with his 12.5 sec Factory Stock 5.0, Mike Hauser with his 11.5-second Pure Street NMRA machine and Craig Baldwin with a Vortech-blown NMRA Real Street 10.5-second car with each accompanied by their crewmembers.

For the dyno facility, Chris and Robin choose Cerra Racing, a facility run by Mike and Jennifer Cerra who are both active racers. The dyno is the latest state of art DynoJet capable of measuring up to 1200 hp.

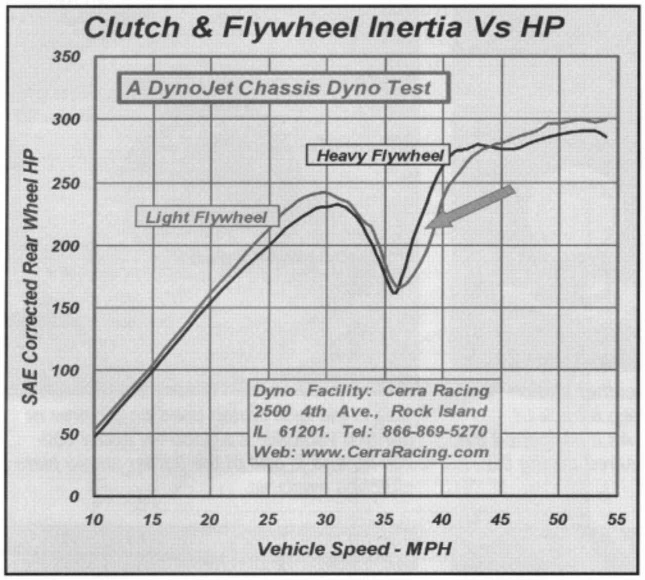
To handle the interpretation of the Auto Meter Data Acquisition system on Robin Lawrence's car Mike Tritle, Auto Meter's chief data interpretation guru came along.

What we were going to test was the lightweight SFI certified clutches and Fidanza flywheels offered through Clutch Masters race/performance street program. The fact they are virtually blow-proof and offer a safety advantage is a given. What we want to establish is how much of a performance advantage they may offer.

When the time came to actually execute Chris Jewell's clutch and flywheel test master plan we worked things such that it involved the quickest and simplest start to finish routine. This dictated that we dyno test with the heavy rotating assemblies first.

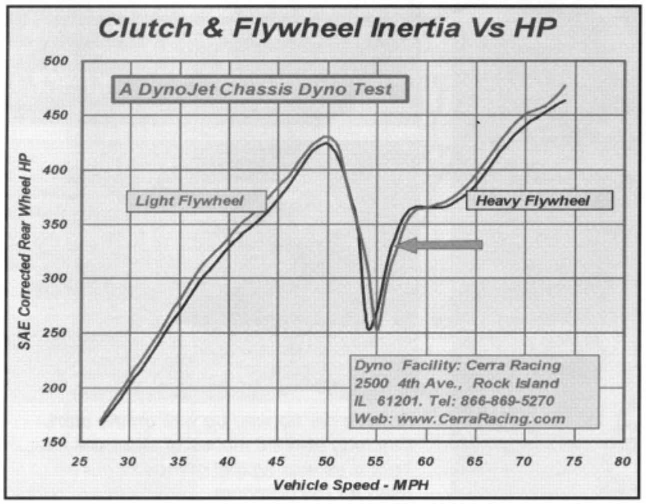
From Cerra Racing's dyno shop we hit the track and tested the heavy assemblies there. After suitable baselines have been established the heavy components would be removed and the lightweight ones installed. That was estimated to about use up a day. The next day the lightweight rotating assemblies would be dyno tested back at Cerra Racing. Although that was the order in which it was planned and executed that's not the order I am going to write it up in. To make it easier to see what's going on I will deal with the dyno sessions first and the drag strip results after so here goes.

FIGURE 2



(Left) The results from Cerra Racing's DynoJet show that the lighter clutch/flywheel assembly out powered the heavier one while the clutch was full engaged. During the shift the heavier clutch/flywheel assembly delivered some of its stored energy back to the driving wheels. Once the clutch was fully re-engaged the lighter components once again produced superior results.

Craig Baldwin's Vortech-supercharged 5.0 made so much rear wheel torque in first gear that we had to make the tests in second and third gears.



(Left) In the supercharged car the lighter clutch/flywheel assembly once again out powered it's heavy counterpart. It was up by as much as 15 hp in second gear and about 11 hp in third.

Here are all those souls that worked on the project at the track The mastermind of the whole plan, Chris Jewell (front row), is the only one not facing the camera.

FIGURE 3

GET THE LEAD OUT

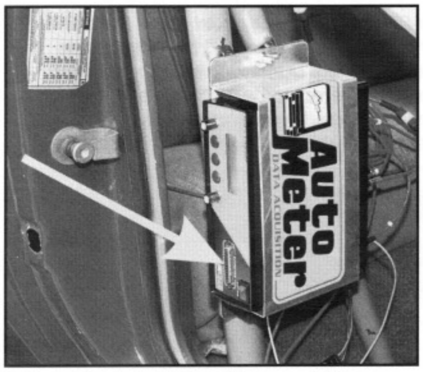
Calculating the effect of reduced flywheel weight on performance is very difficult because when the moment of inertia of the clutch/flywheel changes, the rate of acceleration changes. As a result it's about as complex as computing a launch vehicle's minimum fuel trajectory to the moon. However some down and dirty simple calculations will get some numbers that serve to illustrate the worth of lighter rotating parts.

First let us look at why rotating parts absorb so much more energy when accelerated. In the case of the cars in question we find that although the car itself may have only accelerated to about 35 mph in first the OD of the flywheel actually hit over 220 mph. Its mass not only had to be accelerated forward but also rotationally. On Robin's car our down and dirty calculations (which are well within 10 percent accurate) indicated that we should have seen 14.5 hp increase. We saw just shy of 15 so our test results tie up well with theory.

While we are in a number mode let's look at another way to see what a lighter flywheel is worth. This time we will deal with it in terms of weight. The lighter flywheel used dropped the mass involved from 23.75 lbs to 10.8 lbs for a reduction of 55 percent. The inertia of the heavy wheel was 1.614 in.lb.sec2 versus the light at 0.771 in.lb.sec2.This represents a reduction in rotating inertia of 54 percent. If you have a clutch and flywheel that is anywhere near stock weight it is easy to take some 20 lbs. or so out of the assembly.

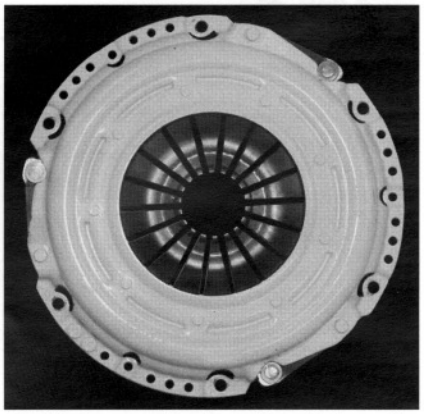
The Clutch Master dual plate mini clutch (good for about 800 hp) and Fidanza flywheel shown nearby weigh in at just less than 19 lbs. That is 22 lbs. lighter than the stock pattern hghi-performance clutch it replaced. That is a reduction of 54 percent in weight. Because the mass of the mini clutch is much nearer the middle of the assembly the rotating inertia is reduced much more and works out to be a reduction of over 65 percent. If a typically geared drag car, at say 3100 lbs., had to be lightened to deliver the same first gear acceleration that the lighter clutch/flywheel delivers, you would have to some suck 320 lbs. out of it! In second gear the equivalency figure drops to about 220 lbs., for third gear 150 lbs and about 115 lbs. for forth gear. Although the car spends much more time in fourth gear, the most influential gear is first. Still sticking to our down and dirty math we find that taking the average of these equivalent weight reductions gives a figure that can be used to estimate the effect on the drag strip. The average works out to be 205 lbs.

A basic rule of thumb for a typical weight, door slammer in the 10-12 sec range, is that the ET drops one-tenth for every 100 lbs. the car is lightened. On that basis the lighter flywheel and clutch shown here should be worth right on two tenths of a second improvement. Here the case rests for light flywheels and clutches.



This is the Auto Meter data acquisition system on Robin Lawrence's Factory Stock car. Mounting on the roll cage as seen here puts the socket for the lap top (arrow) in the most accessible place.

We had the necessary weather station equipment on hand to keep a track of atmospheric conditions. As it happened the amount of correction required during the test period was minimal.



This is the race clutch used on all three of our test vehicles. It's good for about 650-700 hp and is one of the lighter single plate clutches available.

(Left) Auto Meter's Mike Tritle is seen here downloading a batch of data. This is done by plugging in the laptop and pressing the appropriate buttons. The accelerometer, which is the heart of the device, is seen mounted on the roll cage by Mike's left hand.

Robin's car hooked up well on the start. Catching about 6 inches of air under the front tires was typical of those runs we used for the numbers.

TESTING—THE METHOD

The first set of wheels to turn the rollers of Mike Cerra's state of art dyno was Lawrence's Factory Stock car. The planned test procedure was to roll reasonably smartly, and more to the point, consistently, into the throttle from as low an rpm in first gear as possible. At the shift point second gear would then be selected as per the drag strip and run out to the two-three shift rpm at which point the test would be finished. On these runs the rear wheel hp would be measured in relation to speed and time. What we expected to see here was the power absorbing effect of all the rotating parts during 'in gear' acceleration. During the shift we expected to see some of the stored energy of the rotating parts appear as rear wheel hp.

Although the DynoJet dyno was perfectly capable of performing such tests, for them to be meaningful, the driver had to perform very consistently. This was easier said than done as even Robin's car, the least powerful of the group, was, at some 350-flywheel hp, nothing short of a wildly bucking bronco in first and second gear. It took about 30 minutes of practice for Robin to get the hang of driving the car on the dyno.

Eventually he hit his stride and did a great job. We eventually were repeating numbers as close as about 5 hp over some 95 percent of the curve. This I felt was OK as the plan was to take the three most consistent runs and average the numbers in a spreadsheet. Seeing the difficulty of driving a car drag strip style on the dyno our other two drivers, Mike and Craig, elected to have Robin at the controls of their cars during the dyno testing.

TESTING—THE RESULTS

Tests were run on Robin's, Mike's and Craig's cars but a problem cropped up with Mike's Mustang at the strip. After changing out the heavy flywheel for the light one Mike made a pass that looked really good. About 20 minutes later he made another run to back it up and the car went slower. A seemed as the car had a slight trace of a misfire. Another pass confirmed it was a miss and getting worse. In spite of working on the car the source of the miss was not found for certain so we never finished the tests with what was our intermediate power Mustang. I felt for these guys, as they towed from five hours away to make this test and put on a great show but this last minute hiccup cancelled out all their efforts. Thanks all the same fellas.

Comparing the before and after dyno tests on the two remaining cars clearly showed that, regardless of the power available, the resulting numbers indicated that reducing the rotating mass helps hp during the "in gear" accelerating phase. The dyno also showed that as the energy from the flywheel was re-absorbed by the drivetrain/wheels during the shift, the heavier rotating assembly could produce higher figures during that transitional shift period. After the shift, when the clutch was fully engaged, the lighter rotating assembly once again showed its superiority.

Let's consider Robin's car first. Figure 2 shows the results. The relatively rapid "throttle roll in" technique that Robin used gave a full throttle dyno reading from about 8-9 mph (1300-1450 rpm) so data was used from 10 mph (1600 rpm) up. As can be seen from Fig 2 the light rotating assembly gave superi-

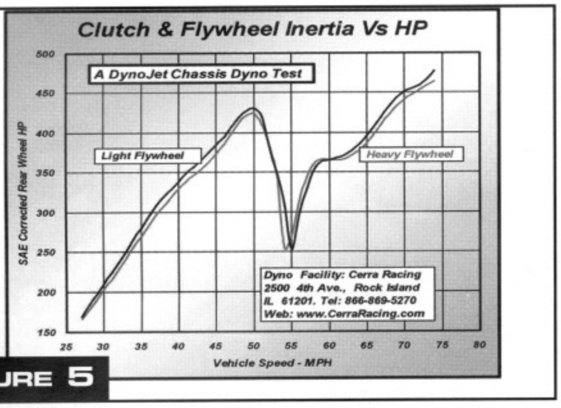


FIGURE 5

When used in the higher-powered Vortech supercharged car, the lighter components returned an even bigger reduction in ET. However all may not have been as good with the power plant during the light component tests as the mph was consistently down. This could have been due to excess heat build up from so many runs. After about an hours cool down the car made its fastest pass of the day at 132 mph.

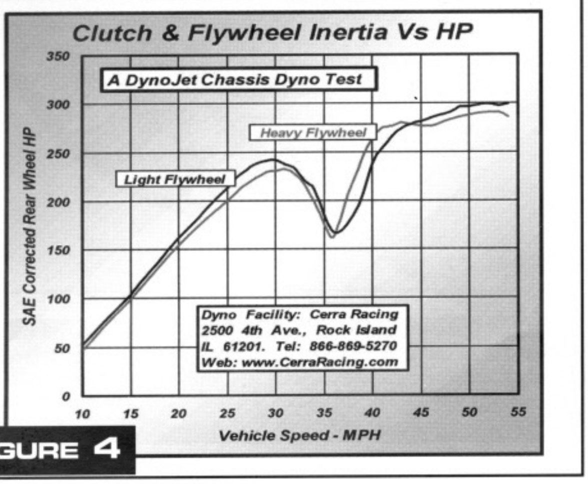
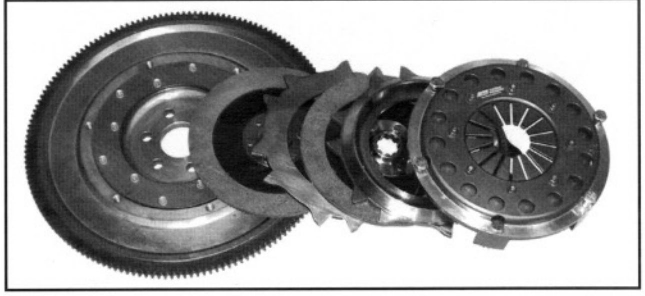


FIGURE 4

This chart shows the Factory Stocker was faster in every respect except mph at the eighth-mile with the lighter components. Most important was the ET reduction of a little over 1 tenth of a second.



If really light weight is your goal, then a smaller diameter, twin plate clutch can offer even greater returns than the larger diameter single plate clutches we tested here. This particular clutch is going into a NASA series road racer. At a little under 19 lbs. total it offers some meaningful straight line acceleration advantages.

or results all the way through to the 36-mph (5800 rpm) shift point. Between 10 and 36 mph less mass meant between 6 and 15 hp more was available at the wheels. Then comes the shift. Here a major proportion of the kinetic energy contained in the heavier flywheel is returned to the drive train and subsequently, the wheels. As a consequence the output during the 9 tenths of a second transitional clutch engagement period between 36 and 43 mph shows more power available than its lightweight counterpart. For a tenth of a second or so there was nearly 40 hp more with the heavy parts and during the shift period the average increase was no less than 22 hp. From 43 mph on up the lightweight parts once again rule.

Moving along to the dyno tests on Craig's supercharged car, we find similar things happening but in different proportions. Check out the curves in Fig 3. Because of the very much higher output we had to do the tests starting in second gear and then going to third. As per the lower powered car the lighter weight rotating parts showed more power. The difference during the full clutch engagement period from 27 mph (3100 rpm) to 55 mph (6500rpm) shows the lightweight parts are between 4 and 15 hp up in second gear and a consistent 10-11 hp up in third. Had we been able to run a first gear test the difference between light and heavy could have easily been close to 20 hp.

Test procedure differences between the heavy to light component affect what we are looking at in Fig 3. Because the shift points where unintentionally higher for the lightweight components this tends to blur result interpretation at the shift point so some clarification is called for.

The shift light prompted Robin's shift. Because the lighter parts accelerated the car faster an identical shift reaction time meant the rpm shifted at was a little higher. This makes the comparison during the shift phase (arrowed) a little difficult to make. The time difference meant that the shift with the lighter parts was some 150 rpm higher than with the heavy parts. Although this was not what we intended this test does start to show us another factor in the equation—namely the effect that increased rpm has on the energy available at the shift point. Check the shape of the curves and the distance apart in the region indicated by arrows in both Fig 2 and 3. There is a much bigger area on Robin's car than there is on Craig's. This bigger area represents the difference in energy being paid back to the driving wheels during the shift. The amount of energy involved is proportional to the mass x rpm 2 . With Craig's car we can see that just 150 rpm more before the shift (which results in almost 5 percent more available energy) with the lighter rotating mass added what appeared to be about enough additional energy to compensate for the reduced weight involved.

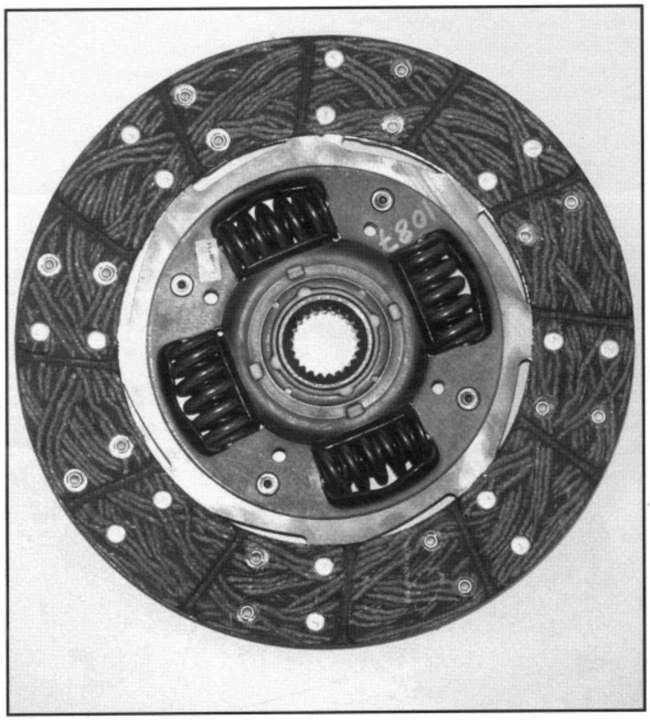
So what have these dyno results told us so far? In simple terms they demonstrate three important factors. These are:

That while the clutch is fully engaged the use of a lightweight clutch and flywheel assembly is definitely advantageous.

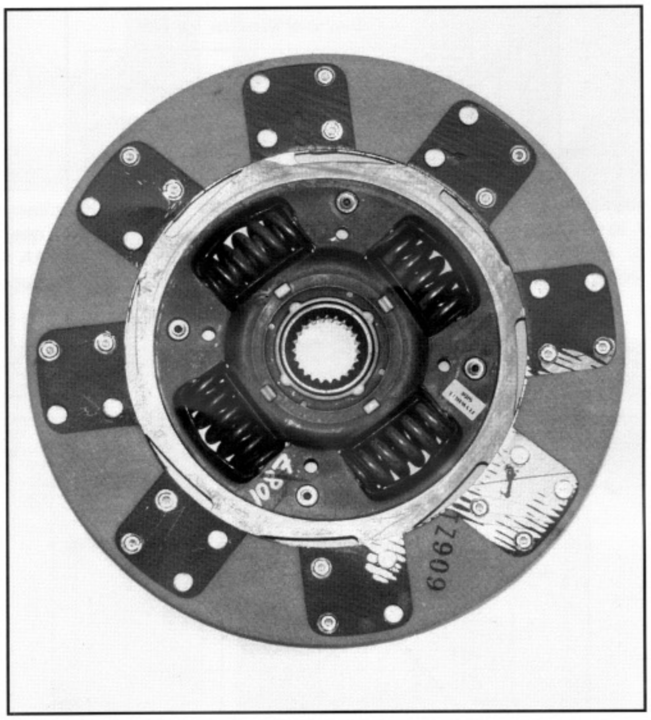
During the shift phase the heavier clutch and flywheel can pay back a greater amount of stored energy than the lightweight setup can.

If more rpm is used with the lighter setup then the difference in stored energy can be compensated for.

The $64,000 question is does the stored energy of the heavier setup, which is available for the launch and each subsequent upward shift, compensate for the reduced output during full



This organic disk is about the most popular choice for Mustangs up to about 500 rear-wheel hp. It offers smooth engagement and good pedal feel (modulation).



This segmented Kevlar disc is great for the street machine with a high output that is also raced at the strip. It provides smooth operation and good pedal feel for easy street driving and will handle up to 650-700 hp.

clutch engagement periods. Since the most critical part of a fast quarter-mile time is the launch where the extra energy is available with no prior penalty it seems the answer is anything but obvious in the case of Robin's lower output machine. With Craig's car we can see that a small change in launch rpm will cancel out any advantage the greater rotating mass may have had on the line. It seems that Craig's car is almost a clear-cut case for lighter parts, but for Robin's the only way we will get a definitive answer is to go to the track and test.

TRACK TIME

Before getting into details I would like to thank Cordova track owner/manager Scott Gardener and his management crew for catering so well to our needs for the day. Also a special thank you to our dedicated starting line man Jay.

The main focus of our trackside attention was on Robin's car because a) the higher percentage of released energy at the shift and b) it was equipped with an Auto Meter data acquisition system.

While all three cars were getting some shake down runs in to familiarize themselves with track conditions I made it my business to keep a running record of the ambient atmospheric conditions so as to correct for any changes in that department. Fortunately for us the weather played into our hands. The corrections for the five hours covering the actual testing were very minimal and actually worked against us. As the day wore on an incoming wet weather front increased the amount of water vapor content in the air. By 6 p.m. we had only 99.8 percent of the oxygen per cubic foot that we had at 1 p.m. Since this is such a minimal change I let the after numbers, which would have had a very small positive correction, stand as they were recorded.

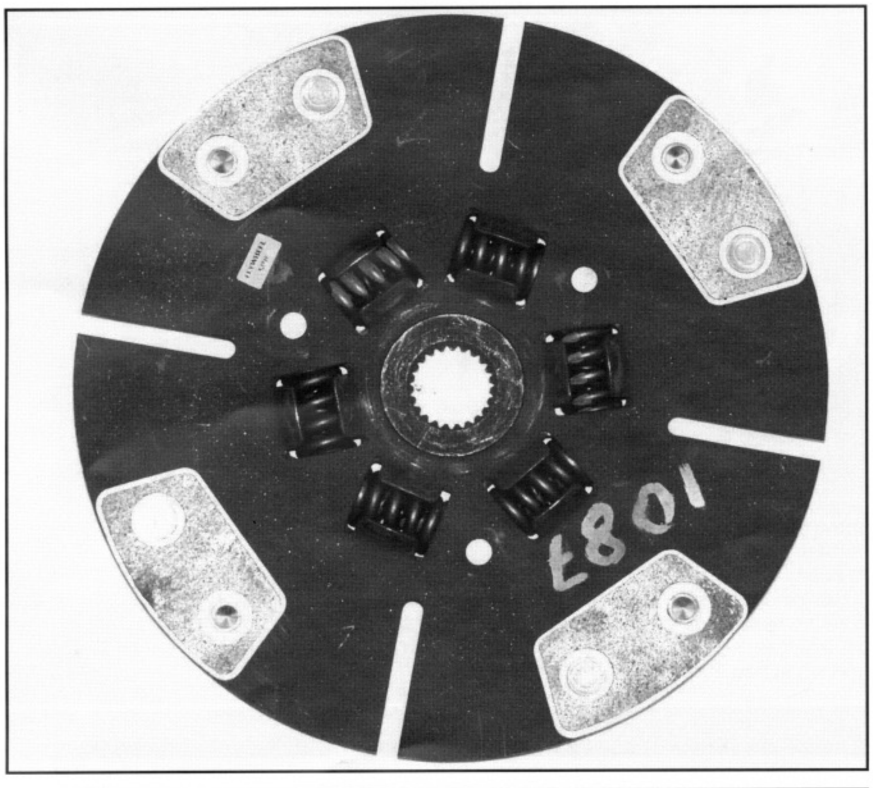
Now we come to the time to put theory to the test. From past experience Robin knew that with the heavier of the clutch and flywheel assemblies, best 60-foot times were achieved by leaving with 3000 rpm on the tach. This would of course vary slightly depending on traction but on this day 3000 was it. Bear in mind that this class of car must use a treaded tire so a small but significant traction penalty is involved. Any more than 3000 rpm and the tires would momentarily break loose, any less and the motor would go into an almost imperceptible bog. All this is the kind of stuff that shows up on the data acquisition system.

With Auto Meter's Mike Tritle on hand to read the downloads optimizing by knowing what was happening in the first place was a lot easier and more to the point, faster, than guessing from time slip data. After making about five consistent runs the numbers were averaged out to show that Robin was running 12.390 seconds at 109.757 mph.

LESS MASS—THE RESULTS.

After the lighter clutch/flywheel assembly was installed, it became quickly evident that the launch procedure had to be changed. The ET slip showed that the average 60-ft. time had increased and Tritle discerned from the Auto Meter data acquisition system that the motor was dropping far more rpm during the clutch engagement period. Mike's advice—more rpm at the launch.

Based on this Robin worked his way up his Auto Meter Monster tach scale until the best launch rpm was established. This turned out to be 3500 rpm instead of the original 3000. The results of these tests are shown in Fig 4. As you can see the



The four-puck disc shown here is for the driver who wants the clutch to bite right now. It is very aggressive and will comfortably handle 700 hp.

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lighter clutch/flywheel with a higher launch rpm won out everywhere except (for some reason I have not yet figured out) the eighth-mile speed. Over a tenth was shaved off the ET and the trap speed was up by a little over 6 tenths of a mph. These results pretty much state the case for a lighter clutch/flywheel assembly. Robin's car was, as the dyno figures indicated, the car with the question mark. Now we will consider Craig's car.

After quite a few runs the best start line rpm with Craig's car proved to be 4600 rpm. Using this Craig delivered three close runs from which to generate our baseline. After the clutch/flywheel assembly was swapped out for the lighter version Craig set about determining the new launch rpm. By the time he had raised the anti to 5000 off the line the ET numbers were really starting to drop and three runs of similar ET were posted. These were used to generate the results in Fig 5. However the trap speed seemed not to keep pace with the ET improvements and actually dropped almost 1 1/2 mph.

Still we had figures that more than proved the worth of a lighter clutch and flywheel assembly. At the 1000 ft. mark the lightweight parts were over a tenth and a half faster. After looking at the average numbers Craig commented that he felt the car was laying down at about the 1000 ft mark. Since the final ET reduction was less at 1302 ft than 1000 this made sense. However the time to gather data was done.

At this point Craig looked into what, if anything, may be causing the car to slow after the 1000 ft mark. I can't say for sure what it was, but heat buildup from so many runs was suspected. About 30 minutes after we had finished packing up our gear Craig made a blistering 132-mph pass. This indicated that our tests had not pulled the best possible numbers from the light weight clutch/flywheel runs with Craig's car. Since the point was already proven I let the numbers stand but you can figure that had this latent top end power loss not showed up the mph with light parts would certainly have been faster than with heavy ones.

CONCLUSIONS

There is not much that can be said here except that for almost all cases lighter is better. In the case of a clutch and flywheel we are dealing with its rotating inertia. This is not only affected by the mass involved but also by the distance it is from the center. Obviously with a given mass the further it is from the center of rotation the slower it can be accelerated by a given torque. The only scenario I can see where a heavy flywheel would pay off is when the first gear is very high and there is absolutely no chance of a decent 60-foot time without the aid of a massive amount of stored flywheel energy. No Mustang that I can think of comes close to those criteria so light is what you need to strive for. If you want to make the selection of a clutch and flywheel assembly easy for your Mustang, Clutch Masters has a "Mustang only" catalogue that will steer you right to what is needed.

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