Second Edition

Chevrolet Inline Six-Cylinder

POWER MANUAL

Everything the engine builder and enthusiast needs to know to rebuild the Chevy six for power.

Covers 194, 230, 250, 292 car and truck engines for street, strip, or other racing applications.

Leo Santucci

Chevrolet Inline Six-Cylinder

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Front Cover
The engine shown on the front cover belongs to the author. The block is a Duggan aluminum HD-MD of 381 CID. The head is a hybrid aluminum SBC 23º featuring 220cc intake runners. The beautiful headers are designed by Armond Orr and fabricated by Tubular Automotive. Turbo is a TO4. Intake is a Clifford adapted to the hybrid head with a Four Shooter from Ron's Fuel Injection running on methanol. The vintage valve covers (cut and rewelded) are Mickey Thompson SBC.

Back Cover
Both of these cars are the author's. The 1950 Chevy was destroyed in a spectacular crash in 2003. The best time for the car was 10.02 ET @ 131.10 MPH.

The replacement car is a 1954 Studebaker Starlight pillared coupe that enjoys the distinction of being the first full-sized American car powered by a Chevrolet L6 to run in a 9 second ET on October 17, 2007. This photo was taken at New England Dragway September 16, 2009, when it reset the Inliners International record (CCA/A) for the third time in as many months. The record time was 9.48 ET @ 138.77 MPH in the quarter mile.

Title Page
Mike Barile's immaculate '23 T Altered powered by a 258 CID STD-LD Chevy inline. It is naturally aspirated and runs on gasoline. The altered has run a best of 9.16 ET @ 142.68 MPH and is an attraction wherever it appears.

Inliners International is an organization everyone interested in Chevrolet sixes can benefit from greatly. Formed in 1981, its growing membership now totals more than 1,500 members. The organization's *12-Port News* is packed with projects and how-to information. www.inliners.org.

Notice: The information in this book is true and complete to the best of our knowledge. It is offered without guarantees on the part of the author or California Bill's Automotive Handbooks. The author and publisher disclaim all liability in connection with the use of this book.

Table of Contents

Teri and Leo Santucci say good-bye to the 1950 Chevy that was destroyed in a freak accident at New England Dragway in Epping, New Hampshire.

The author has traveled extensively to research the historical and advanced aspects of Chevrolet inline six-cylinder engine building and is shown here on a road trip to Durant, Oklahoma visiting with Glen Self.

The author, Tom Langdon,- and "California Bill" Fisher.

Acknowledgments

When I think of all the Inliners who have helped in seeing this manual to completion, I realize how fortunate I am to have been able to tap into this river of knowledge from so many talented and generous individuals.

I would particularly like to thank the following:

Tom Langdon for his tremendous technical and engineering knowledge that kept me from getting off course.

Pat Smith for his crew chief's eye that kept us from missing the overall picture.

Sarge Nichols for his encouragement and racing knowledge.

Mike Kirby who provided a sounding board and made sure we didn't leave out anything critical.

Ron Sneddon, the "master of CAD" for the beautiful line drawings.

Mike Barile, for his constant enthusiasm and his "never say die" attitude.

To the many other racers, enthusiasts, engine builders, and shop owners who were generous with their time, thoughts and pictures—they are noted throughout the text.

To my late parents Leo and Gloria who put up with my learning curve on *their* daily transportation.

Last, and certainly not least, I thank my lifelong love, Teri, who has served in every capacity from typist, to pit crew, to editor, to photographer, to dial-in advisor at the track. She is a true one-of-a-kind sweet lady. Thank you, Queen Bee!

The author just back from another test run at New England Dragway.

Leo debuts the "new" 1954 Studebaker Starlight pillared coupe/Chevy six combo at the first annual Northeast Inliners picnic 2004.

About the Author

The first new car I remember our family getting was a 1954 Chevrolet 2-door hardtop, standard shift, Blue Flame six. I can still see her sitting there in the driveway—turquoise and white, fresh from the factory! I got my driver's license with that car and began working after high school at a local garage where I started to learn about cars and engines. The other mechanic took me to a nearby airport and introduced me to a new sport . . . Drag Racing. I had "the bug"!

My Aunt donated her 1950 Chevy hardtop 235 Powerglide to the cause and I was on my way. (Of course, the Powerglide had to be replaced with a standard shift!) The names Frank McGurk, "California Bill" Fisher and Wayne Horning echoed in my brain.

Over the years, my attention has been on drag racing and always with a Chevy inline six—first the 235, then 261 and now the 292. I've collected just about every article on sixes published in the last thirty years and interviewed many six-cylinder stars such as Kay Sissell, Mike Kirby, Cotton Perry, Jim Headrick, Glen and Kevin Self, and Rob Harrison. Yet, I never imagined I'd be the one to put this manual together.

The information contained in this manual is from my own experiences (which are, no doubt, limited), along with corrections, adjustments and additions from longtime six-cylinder enthusiasts Mike Kirby, Tom Langdon, Sarge Nichols, Pat Smith, and Mike Barile. The information is meant as a starting point for your own departure into sixology.

Of course, it goes without saying, that using the information presented in the manual is without warranty. All the risk for its use is entirely assumed by the user. Good luck on your new adventure!

Planning Your Project

- How to plan an inline project
- Theories and formulas about how to make horsepower

So now that you've made the decision to take "the path less traveled" and build a unique inline six, the question becomes "where do I start?"

Before jumping into the nuts and bolts, so to speak, it is always worth your time to thoroughly contemplate a proposed plan of action for your engine.

Setting Goals

The questions you need to ask yourself are:

1. Will I want this engine for street, strip, oval track, or…?
2. What particular attributes will my engine need for my use—be it street, drags, oval track, hill climb, sports or swamp buggy?
3. What weight vehicle will the engine need to propel?
4. Do I have a realistic budget for this project?
5. Can I reasonably expect to make enough horsepower and torque to achieve my goals?
6. At my projected horsepower level, can I expect reasonable engine life?
7. Will I have the perseverance to go where few have gone? Can I maintain a course of action without regard to discouragement, opposition, or previous failure? Taking a different engine path is not easy, but it is very rewarding.

Jack of all trades, master of none is a phrase that could easily apply to an engine. The reason is a simple one. As we modify an engine to a specific task, it requires compromise in another area. Every change in one direction produces an effect in another. For example, a full race cam will produce great top-end power but will extract a woeful effect on low-speed performance. On the other hand, a good low RPM torque cam will be next to useless for high RPM racing situations. This is why dual purpose engines are counter-productive. Decide now or lament later!

Once you know what specific purpose you are building the engine for—then you need to emphasize those characteristics most desirable for the project. If you build an engine for hill-climbing, you want to emphasize low-end torque production—a much different theme than a high RPM drag strip engine.

When you think about performance, you also have to consider the vehicle weight. Generally, the heavier the vehicle, the more power is required to move the vehicle, thus adding more stress to the engine. Therefore you should always build as light as either feasible or allowable under the prevailing rules for your application.

You need to have an adequate budget to purchase the right parts. If you don't—do not proceed! Be smart. Save so you can do it right—the first time. If you don't, you'll wind up doing it over, and paying twice.

Plan conservatively when contemplating horsepower and torque levels. Don't expect a mildly configured engine to suddenly come alive with the addition of a 200 HP nitrous kit. It more likely will come to a sudden death.

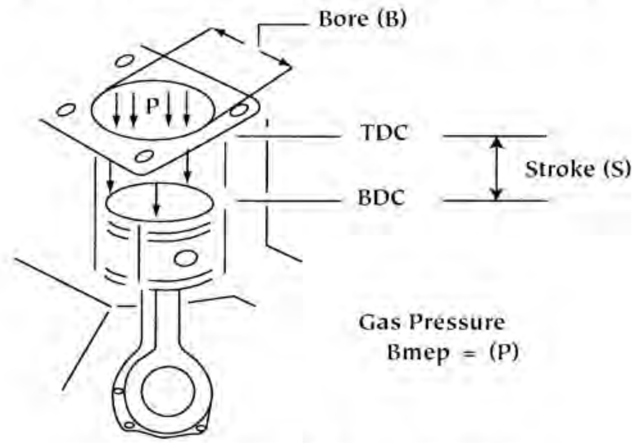
Finally, if the engine will produce, let's say 500 HP, be sure all the components have been sufficiently upgraded to handle this power level. Conversely, if the engine needs to produce only 250 HP, then most stock components will be adequate. Upgrading beyond stock would simply be a waste of your resources.

Remember, a problem well stated is half-solved. So, spend your time making sure you have set realistic goals for your engine and chassis before you plunge in.

Paths to Power

Along these lines, let's review what Roger Huntington used to call *The Paths to Power*. Here I've updated the basic five paths Roger described. They are as valid today as they were when he wrote about them in the late

POWER PRODUCTION



$$HP = \frac{TORQUE \times RPM}{5252}$$

TORQUE= PLA
P= BREAK MEAN EFFECTIVE PRESSURE (Bmep)
LA= DISPLACEMENT (D)
D= 4.72 × Stroke × (Bore × Bore)
(L6 CYLINDER DISPLACEMENT)

Power production—horsepower formula.

forties and early fifties. If we want to make more power and torque, we can:

1. Increase the piston displacement (read cubic inches/ liters). You accomplish this by either boring the cylinders larger or increasing the length of the stroke—or both.

2. Increase the weight of the charge inducted. Here you want to supply the engine with cool air (ducted) from outside the engine bay and cool the fuel with a cool can. This allows a denser mixture.

You could also use a fuel other than gasoline, one with a higher latent heat such as alcohol. You might also use a fuel that carries more oxygen with it, such as nitromethane. You can even inject nitrous oxide into the gasoline mixture and achieve a similar result. Of course, to get more fuel and air in, you'd want to port and polish (airflow) the head and use a high performance intake system. You can also add more carburetion (or increase the capacity of the fuel injection system), as well as putting in a longer duration, higher lift camshaft. Last, but not least, you can force more air by either supercharging or turbocharging.

3. Increase the efficiency of combustion. Here, you can raise the compression ratio and alter the deck height of the block to obtain proper squish or quench. (This is the area that creates turbulence in a wedge style cylinder head. It is this turbulence that creates a more complete combustion.) Proper piston design, along with an optimum fuel-air mixture and an efficient ignition system also works. You need to remember not only to burn the mixture, but also to get rid of it with a properly designed exhaust system.

4. Increase the RPM/HP curve. The reason why we can gain power by increasing the RPM is that we can generate more power strokes within a given time frame. Today, there are special lightweight pistons, pins, rods, pushrods, rocker arms, valves, and valve spring retainers. You can also lighten the crankshaft, harmonic balancer, flywheel or flexplate. Any of these changes allow you to use a camshaft that will produce more horsepower at the top end. Along with this, you need to be sure everything is in perfect balance.

5. Decrease friction and pumping losses. Of course, you need adequate lubrication at all times—the higher the RPM the more oil pressure is needed. You can also use special coatings, platings, or surface treatments on pistons, valves, the crank, as well as use synthetic motor oil. You might also want to increase the bearing clearances slightly to provide a greater cushion between parts and you want to control where the oil gets thrown—a modified oil pan with crank scrapers, pan baffles and side kick out. You may even try a dry sump oiling system.

Finally, you need a proper exhaust system to eliminate back pressure and complement your intake system and camshaft timing to maximize power.

Another way to view making horsepower in an internal combustion engine is to look more closely at the underlying formulas that determine this power. This allows you to choose the most appropriate modifications for your application.

Bear in mind inline engines were engineered to be high torque/low RPM machines. It is important for you to not only recognize these facts, but also to utilize them when you modify your engine for high output.

Power Formula

Horsepower is described by the following formula:

HP= (Torque × RPM)/5252

Horsepower is a way to express how much work an engine can do. Work is really equal to force times distance. Notice in our horsepower formula that torque is the force. Torque being the twisting force of the crankshaft that gets applied to the rest of the drive line. Revolutions per minute (RPM) is the distance traveled by our crankshaft. The number 5252 converts this information into units of measurement. So let's look at what makes up torque, T.

T= PLA

P = brake mean effective pressure (Bmep) or the pressure pushing the piston down the cylinder bore.

L= length of the stroke.

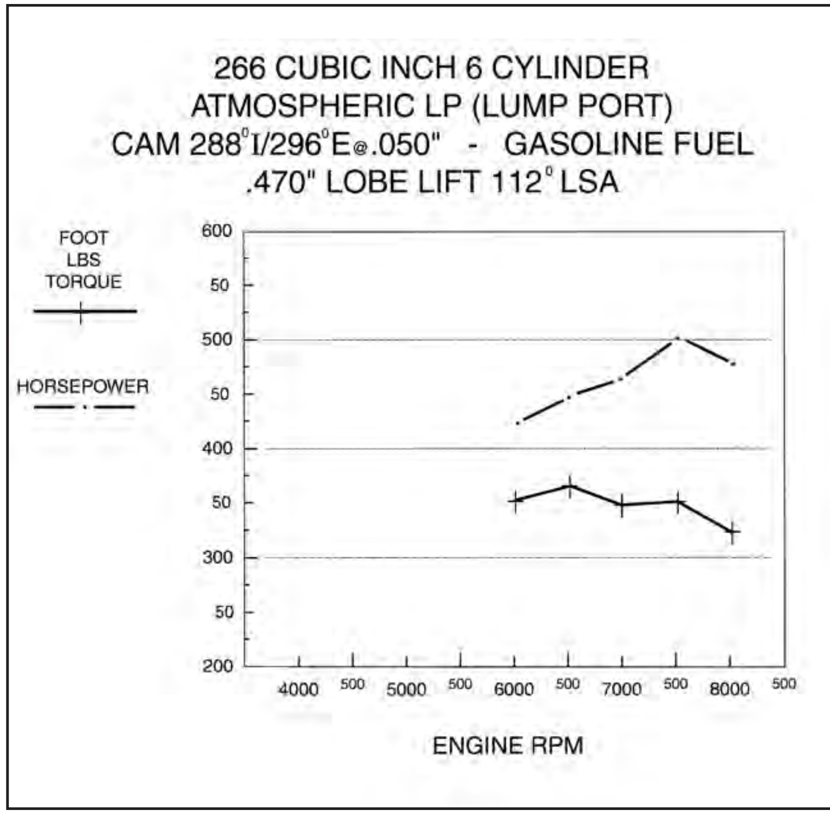
A= size of the bore.

LA= D = displacement.

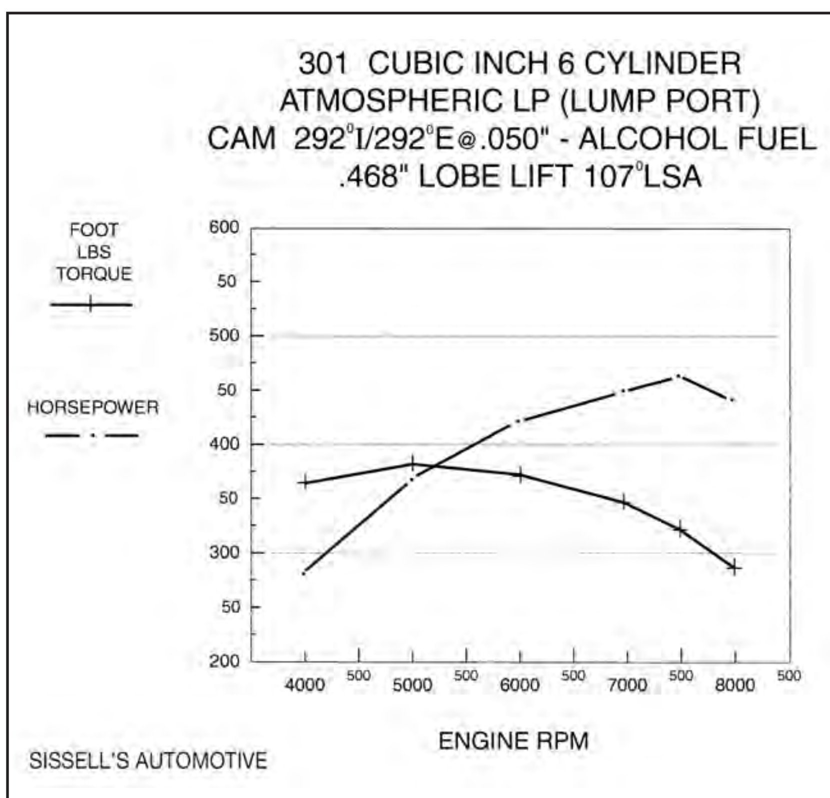
D= 4.72 × stroke × (bore × bore)= six cylinder engine displacement in cubic inches.

Discussion

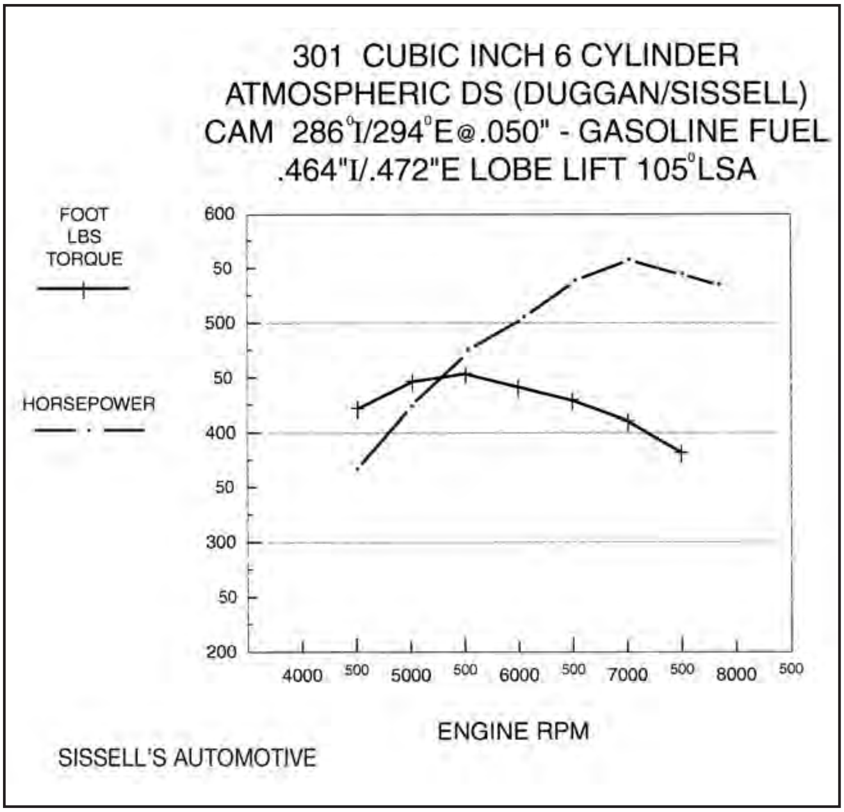
We see in our formula that displacement is one of the two ways to increase torque at all RPM ranges. Before we talk about the second way to achieve this, let's see what increasing displacement does for power.



Self Racing Heads & Engines' STD-LD dyno-graph lump port stock-type head.



Sissell's Automotive HD-TD dyno-graph lump port stock-type head.



Sissell's Automotive HD-TD dyno-graph 12 port aluminum noncrossflow head.

Mike Kirby at the Sissell dyno searching for more horsepower.

By looking at the formula, we can see that increasing the bore will give the maximum value for the money. In fact, tests have shown that while a .125" increase in bore can add about a 10 percent increase in power, the same .125" increase in stroke yields only about one half that amount. Besides, there are physical limits to increasing D and it goes without saying that to achieve even these gains, you need to improve volumetric efficiency proportionally.

The second way to increase torque is to increase the P (bmep). In a naturally aspirated (atmospheric) engine, this can be achieved by increasing the compression ratio while maintaining the highest average cylinder pressure through proper cam timing and cylinder sealing. We could also introduce a fuel that carries more oxygen than gasoline, such as methanol, nitrous oxide or nitromethane. In a supercharged or turbocharged engine, this is achieved by increasing the boost pressure available.

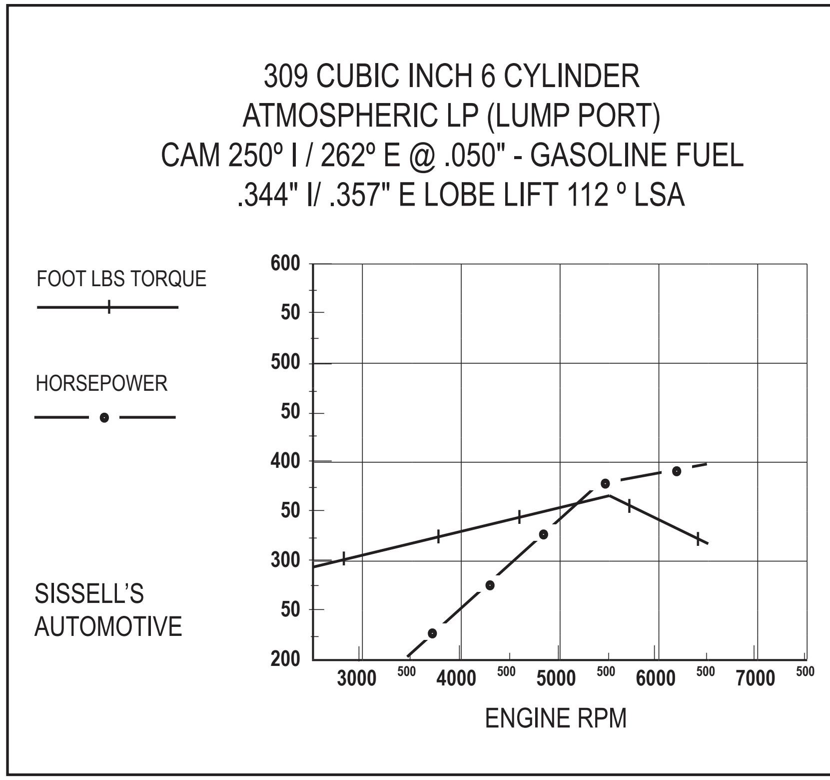
Now let's talk about the role of RPM for a minute. We could make more horsepower by increasing RPM, but we have already said inlines are not created to be RPM machines. Limits exist due to the long crankshafts and inherent imbalance of the design.

Remember: Loads on the rods and pistons increase as the square of the RPM. This means that when you raise the RPM to create more horsepower, for example, by going from 6,000 RPM to 7,200 RPM, you increase the loads by 44 percent! It is easy to see that, even using the best rods and pistons, this avenue will lead to increased parts breakage.

Looking at the big picture, where does this leave you? The most highly modified competition inline atmospheric engines of this design can achieve a maximum power level of about 2.3 times displacement. This translates into 593 HP for a typical "250" + .060 over = 258 CID and 695 HP for a "292" + .060 over = 302 CID engine. The modifications necessary to create these extreme power levels are only compatible with full competition usage.

So what are the practical street level limits on gasoline? These are on the order of 1.1 times displacement or 284 HP and 332 HP respectively. Bear in mind, even these are substantial horsepower increases and require compromises in drivability.

Drivability is created by reasonable RPM limits (small intake ports, conservative camshaft profiles and high velocity intake systems). This is the exact opposite of what we do to create power with atmospheric—naturally aspirated—engines!

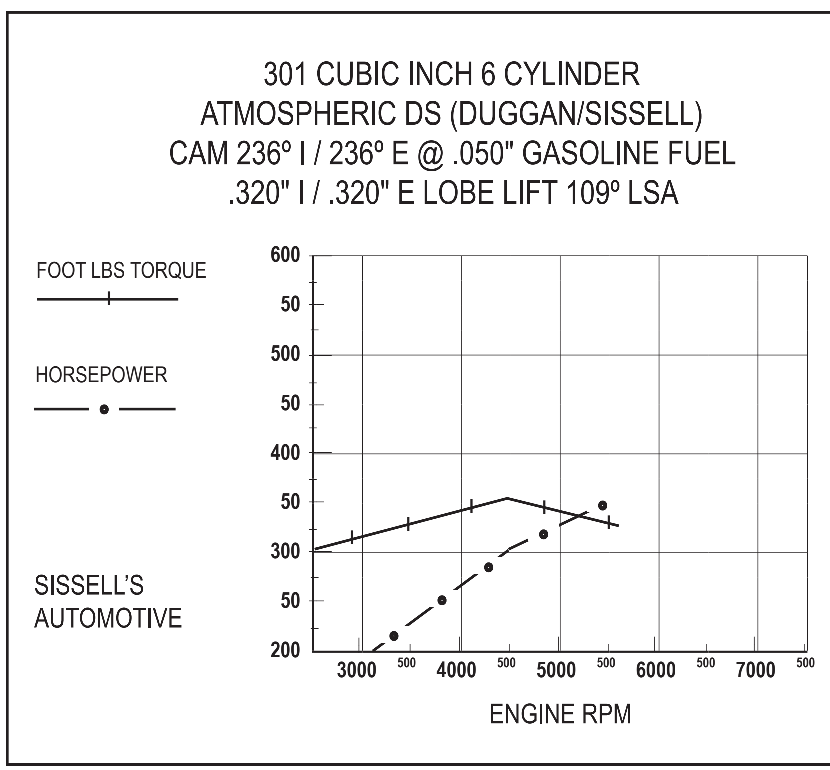


Sissell's Automotive HD-TD (Bore 3.935˝/stroke 4.225˝) dyno-graph lump port stock-type head. Max street mechanical roller cam, Weber manifold and Sissell EFI, CR 11 to 1.

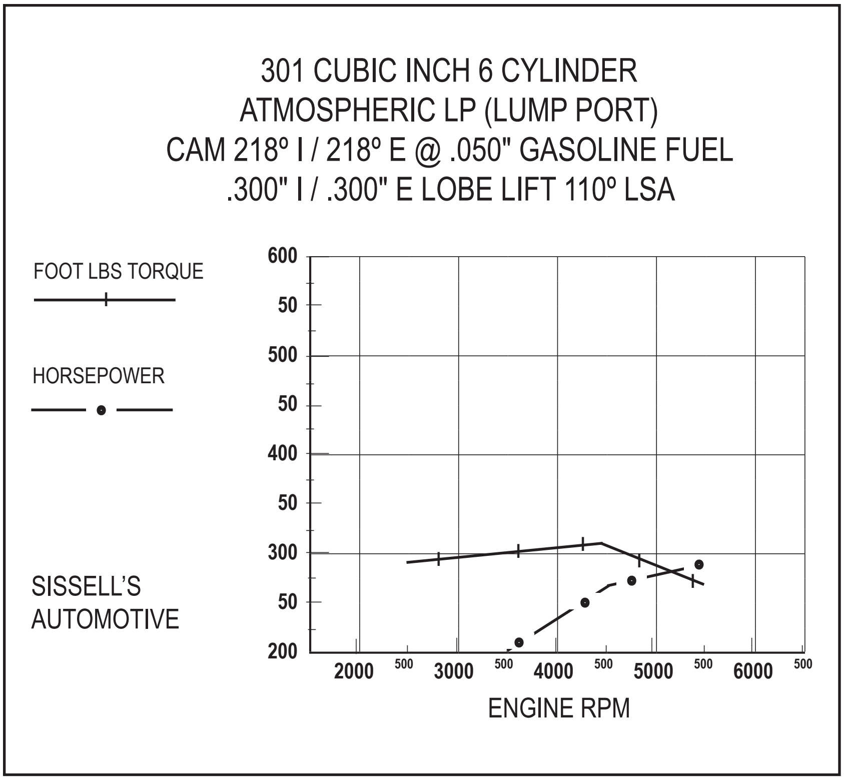
Conclusion

The formula T = PLA shows the best method to gain HP is to increase P through forced induction and here adiabatic (heat) efficiency weighs heavily towards turbocharged engines or nitrous oxide systems. The best thing about this is that inline engines are a near perfect match for the project. A properly forced induction engine has a short duration, low overlap cam design, port sizes on the small side for high velocity at low speeds, strong bottom end (seven main bearings) and a moderate RPM range, typically 6,000 RPM or less.

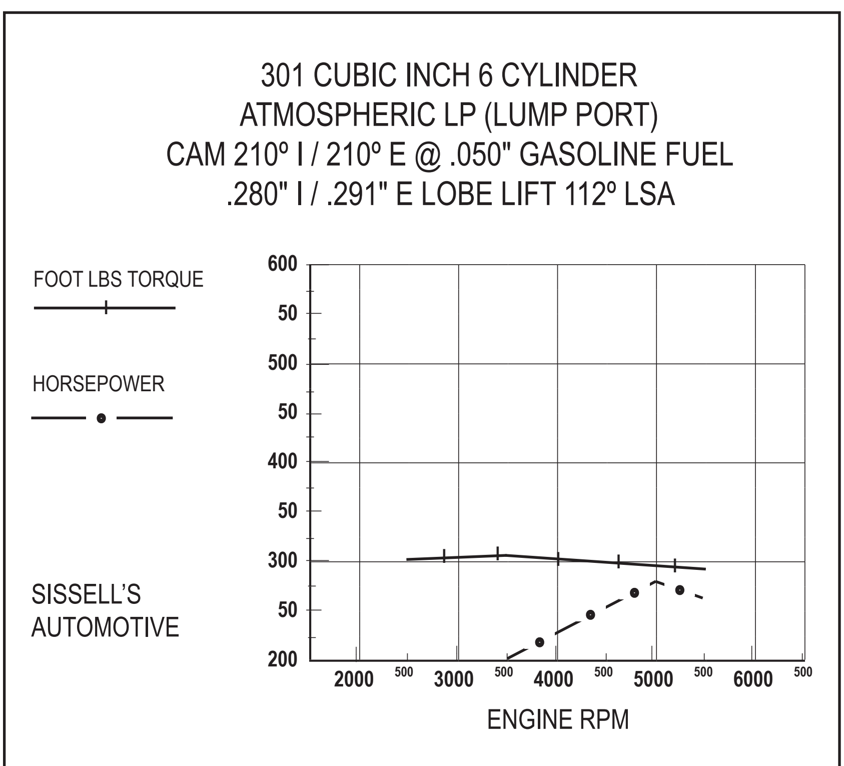
What kind of horsepower can be made? With a nitrous system, you could add 200+ HP for short durations. With a turbocharged engine, no one really knows the limit. Purpose-built Grand Prix turbocharged engines



Sissell's Automotive HD-TD dyno-graph 12-port aluminum non-crossflow head. Street use, hydraulic flat tappet cam, Duggan/Sissell four-barrel manifold, Holley #4776 / 600 CFM (DP) carb, CR 10.5 to 1.



Sissell's Automotive HD-TD dyno-graph lump port stock-type head. Street use, hydraulic flat tappet cam. Offenhauser four-barrel manifold, Holley #4160-c/390 CFM carb, CR 9.5 to 1.



Sissell's Automotive HD-TD dyno-graph lump port stock-type head. Street use, hydraulic flat tappet cam. Clifford four-barrel manifold, Holley #4776 /600 CFM DP carb, CR 9.5 to 1.

produce horsepower of 15 times displacement!

Practical street power at only six pounds boost (see chart page 140) could average 344 HP for the 258 CID and 402 HP for the 301 CID—definitely worth a second and third look, wouldn't you say?

Critical Parts

When all is said and done, if you plan to run a healthy Chevy six, the most critical parts you will need are:

For Longevity:
1. Torsional damper (Harmonic Balancer) i.e., Fluidampr, ATI, Innovators West, etc.
2. Aluminum rods for drag racing. Upgraded steel rods for the street. Custom steel rods for oval track.

For Power and Torque:
3. Precision head work.
4. Proper camshaft design.

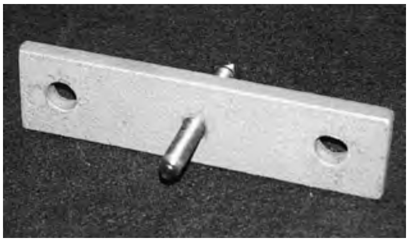
You will need to allocate your available dollars to these areas first.

DON'T SKIMP HERE!
Once you have decided on your plan, there are several tools that you need to make or buy that will greatly aid in the proper building and tuning of your engine.

Important Tools

Consider this a basic list for building a serious inline engine:

1. Positive piston stop.
2. Piston ring squaring tool.
3. Block and head integrity tester.
4. Harmonic balancer installation and removal tool.
5. Flywheel locking tool.
6. Crankshaft turning tool.
7. Torque plate for boring and honing.



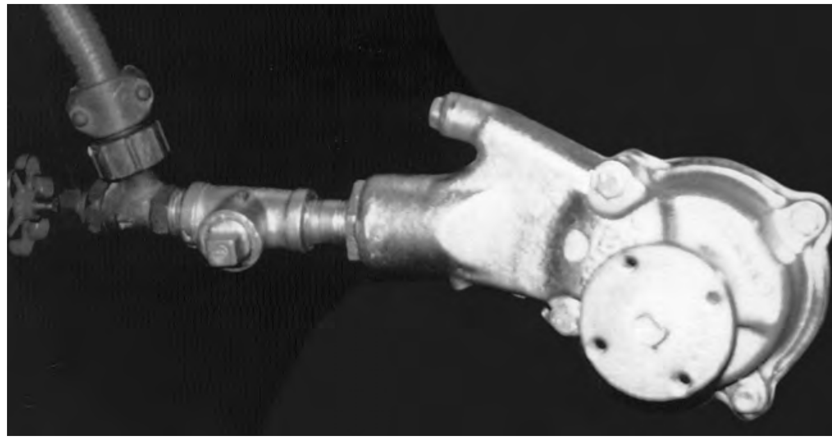
Homemade piston stop, stock-type head. Note elongated holes (due to head bolt spacing variations).

Positive stop when head is on the engine (screws into the spark plug hole).

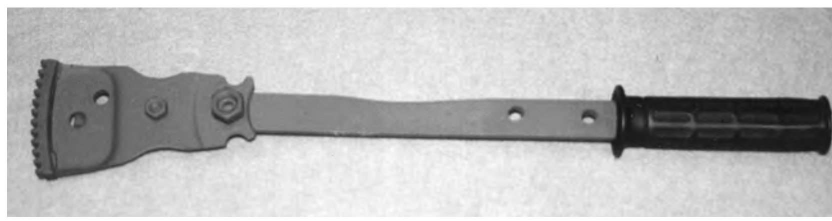
Homemade piston ring squaring tool, simply an old piston with the compression ring in place. Invert the piston, place ring in the cylinder and push down until the compression ring on the piston stops against the block. Remove the piston and measure the ring gap.

8. Adjustable pushrod.
9. Engine leak down tester.
10. Dial indicator with magnetic base and degree wheel (minimum 9-inch diameter).
11. Compression gauge.
12. Timing light.

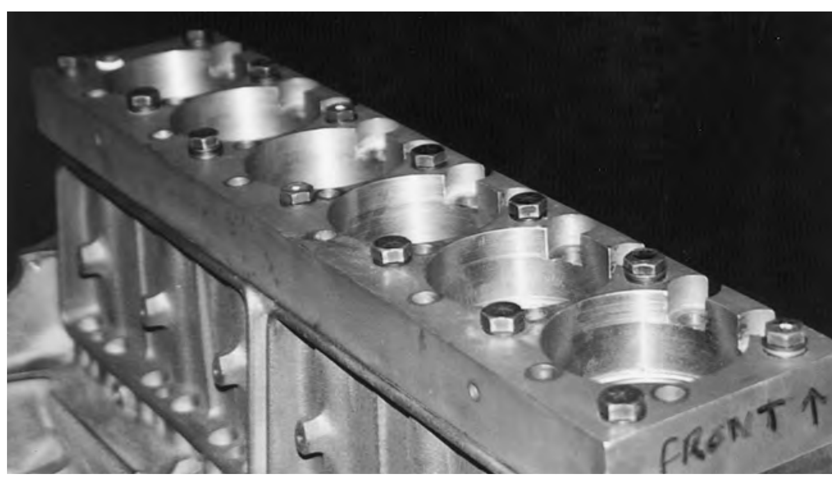
Not included in this list are standard rebuilding tools.



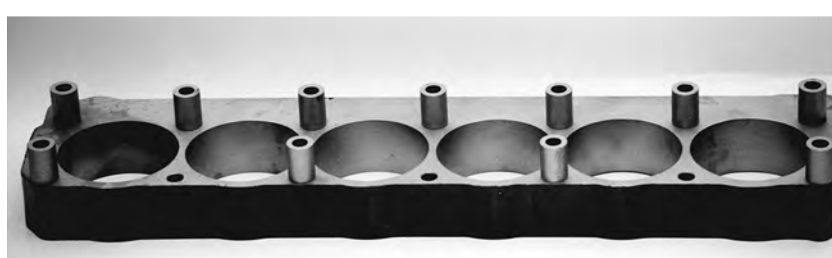
Block integrity tester is made by epoxying the inlet spigot to an old water pump. It is used in conjunction with a gasket and torque plate in order to pressure test any potential block.



Homemade tool cut from an old flex plate to lock the engine to torque either the flywheel or harmonic balancer retaining bolt when the cylinder head is on.



Torque plate—shown as dual pattern for stock bolt pattern and also for hybrid head (Chevy V8).



Traditional torque plate by Yother. This plate, when bolted to the block, simulates the effect on the bore when the cylinder head is bolted on. Note spacers added to top of plate. This allows the use of stock-length bolt or stud, which simplifies using this plate. A thick plate is necessary to duplicate stresses created by the cylinder head.

Harmonic balancer installation and removal kit. Never EVER think of installing the harmonic balancer any other way! Hammering on a harmonic damper can damage its rubber isolating ring leading to a potentially catastrophic separation later.

Adjustable pushrod allows you to determine the exact length for perfect rocker geometry.

Crankshaft turning tool—for use with a degree wheel. Several variations of this tool exist, take your pick (whatever fits the small block Chevy V8 fits both inline six series engines).

The leak down tester uses compressed air to verify piston and valve sealing conditions.

Camshaft degreeing kit with a 12-inch diameter degree wheel. The larger wheel is substituted for the standard 9-inch diameter for greater accuracy.

A compression gauge gives a good indication of the dynamic seal of the engine (valves and piston rings).

Strobe timing light allows accurate setting of total timing.

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