Buick GSX Engine Rebuild Alan Haime (WA Buicks)

This article is for the serious Buick performance person who wants' to get the most out of his engine, not just the occasional burst but reliable tub-thumping enjoyment over and over again on the road or the race track. We all know the temptation to push the old girl along now and then just to see what it can do, with the result that there are usually oil leaks, smoke, rattles and other undesirable outcomes that make us wish we hadn't tried it. If you want reliable high engine performance you must pay attention to every conceivable detail at every step of the rebuild – the more performance that you aim for requires an exponential rise in attention to detail. If your aim is to restore your Buick engine to factory performance level, this article will provide some useful points for you to consider. If you require more performance this article covers some fundamentals for increasing torque and horsepower yet still maintaining reliable performance.

I base my article on the Buick 455 cubic inch engine. It is not well known in Australia that the 455 is a classic muscle engine in the USA. In its day it ate more than its fair share of 427 Hemis on the track and this soon cemented the engine's place in the annals of motoring history as the "Hemi-Killer". In 1970 GM finally lifted its corporate ban of engines larger than 400 cubic inches in the intermediate A-Body cars and Buick responded by fitting an all new 455 cubic inch engine into its restyled GS. The 455 boasted more displacement, larger diameter valves, and a more aggressive camshaft than the 400 it replaced. It was mated to a cold air induction through functional hood scoops. The 455 was factory rated at 350bhp, with a stump-pulling 510 ft-lbs of torque. This was the highest torque rating of any production engine at the time, aside from Cadillac's 472 and 500 cube V8s. No other engine achieved that level of torque at a lower rpm (2800). To take things up a notch, Buick introduced the Stage 1 package which featured a more potent cam, bigger valves, and a re-worked carburetor (Buick claimed this engine produced 360hp but most people in the know believe this to be closer to 400hp).

My interest in aiming for a higher-than-factory performance 455 engine was kindled after attending the BCA Buick Centennial in Flint in 2003. There were a number of immaculate GS455s and GSXs on display with high performance engines. The owners recommended TA Performance as a reliable source of specialised Buick aftermarket equipment and parts for 455 engines. Lois and I were travelling down Route 66 and happened to call into TA Performance on the outskirts of Phoenix Arizona and when I saw the range and quality of their stock, I was hooked. On returning to Perth I obtained a spare 455 engine and transmission, ordered pallets of goodies from TA Performance and began the rebuild.

455 Engine Rebuild Goodies from TA Performance

I had to overcome a few problems with the engine, as will be discussed later in these articles. I eventually sorted these out and resolved that I really needed a nice looking muscle car to do the engine justice. Lois and I were attending the BCA 2007 National in Seattle and decided that we would take time to search for a 70-73 GS with the right body and finish. After arriving at Los Angeles we drove to Las Vegas on our way to Seattle and lo-and-behold there sitting in the Imperial Palace Auto Classic Museum on the Strip was a 72 GSX clone with "buy me" written all over it – how could I refuse. The next day the car was mine and on it's way to Fremantle. Lois and I were able to enjoy the rest of our road cruise to Seattle without having to look any further for a car. After arrival in Perth the engine was fitted and modifications were carried out on the new GSX and in March 2009 she did an 11.49 second @ 118 mph quarter mile at the Perth Quit Motorplex. It runs on 98 octane pump gas and drives well on the street and strip.

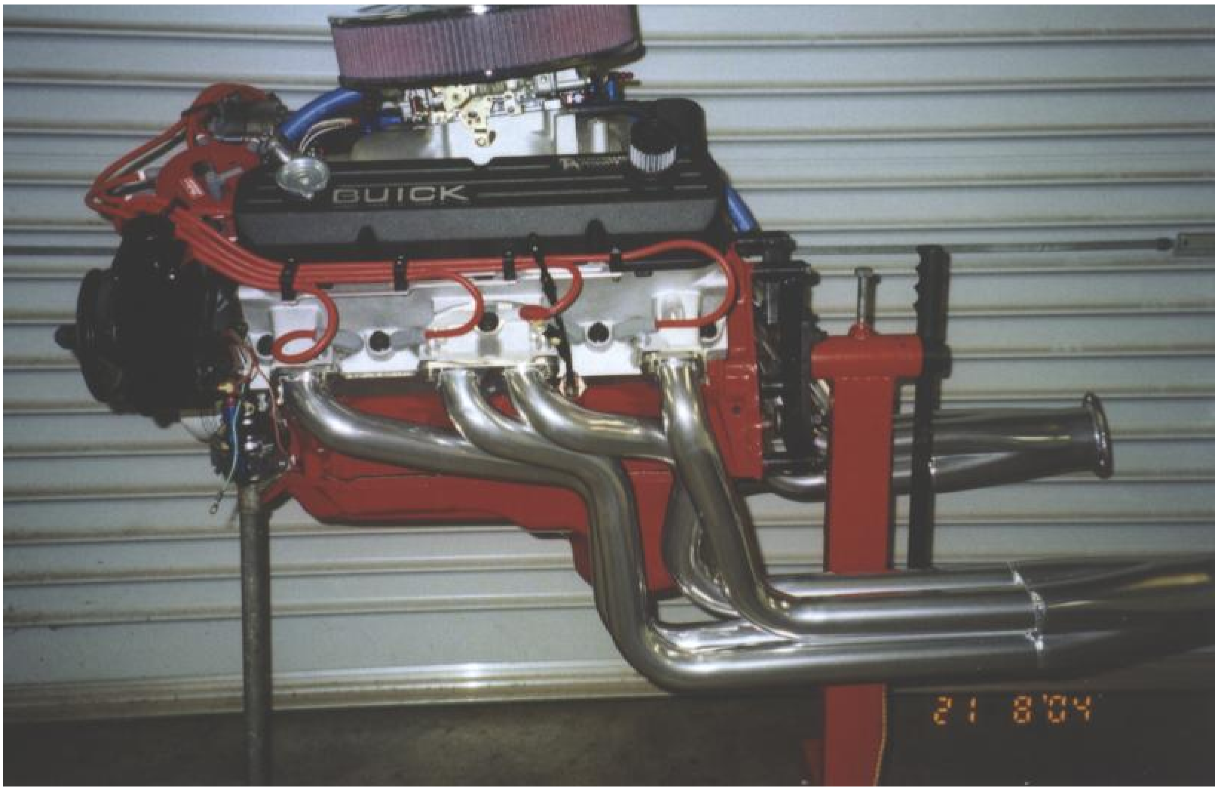
The GSX in Las Vegas

Working the Engine

In the beginning you need a good strong block. I decided that rather than work on my matching number Stage 1 engine I would purchase a second engine as insurance against the unthinkable. The Buick 455 engines changed little between 1970 - 76 and most parts are interchangeable. The important engine and gearbox bellhousing mountings are the same as are the head, manifold and timing cover bolt holes patterns. Post 1970 engines had a 5/8" oil pickup tube and 9/16" oil suction passage in the block which is an improvement over the earlier ½" oil feeds. One of our Club members had a spare 1974 455 engine lying around and although not too happy about seeing it used for the workover I proposed, soon came round when the readies rustled.

The Buick 455 blocks are great for standard performance, being some 100lbs lighter than the Chevy big block. This weight advantage comes at the price of thinner castings all round including the webbing, particularly to main bearings #2 and #4, and around the lifter bores. For serious horsepower and engine rpm the rule of thumb amongst Buick enthusiasts is that should you require 600+HP and/or 6000+rpm performance a 455 block girdle is a must to stop the block flexing excessively under the unintended tortuous conditions. In my experience, following multiple replacements of damaged main bearings, I would be more conservative and recommend that you go for a block girdle for 500+HP and/or 5500+rpm applications. Since fitting the block girdle my mains have remained as good as new. I also fitted a lifter girdle, which strengthens the lifter bore walls and protects against the additional sidewall stresses when using a roller cam.

The block girdle should be fitted by your machine shop; it is not a job for amateurs. The girdle mounts to the block using the existing oil pan bolt holes. The bearing caps must be machined to fit inside the girdle and the whole assembly line honed to ensure the bearings line up exactly. Buick bearings are relatively large diameter (3¼") and the main bearing clearance is critical. Buick specifies .0007" - .0018" main bearing clearance – it takes very little main bearing misalignment to throw the main bearing clearances out of whack. My machine shop insisted that the main bearing clearances should be around .002" which is probably not a bad thing, provided the oiling is adequate. This brings us to the next critical item, namely the oiling system, to be covered in the next part of this article along with more on the engine rebuild.



Rebuilt 455 Waiting for a Suitable Car

Buick GSX Engine Rebuild – Part 2

Alan Haime WA Buicks

In Part 1 of my article I discussed the desirability of fitting a block girdle to a high performance engine and the need to ensure that the main bearings are line honed for precise alignment. The next critical item to consider in a rebuild is the Buick 455 oiling system which should be upgraded for a high performance engine. This can be achieved by:

1. Using a 5/8" oil pickup tube and drilling out the diameter of the oil suction passage from ½" to 9/16"on 1970 455 blocks – not necessary on later year blocks which already have a 5/8" oil pickup tube and 9/16" suction passage.

2. Enlarging the oil pressure passage from the oil pressure sender hole to the LHS lifter gallery from 3/8” to 7/16”, making sure that it is clean and without restrictions. Serious users drill out this passage to 1/2” or even 9/16”, however care must be taken to ensure the hole is not drilled too deep and into the cam bearing gallery.
3. Installing double grooved cam bearings to increase the oil flow to the LHS lifter gallery. The double grooves are on the outside of the cam bearings, allowing extra oil to flow between the bearings and block surface. Normally the oil is fed via a groove in the camshaft through holes in the bearing, which is adequate for normal performance engines, but can lead to LHS lifter and valve train oil starvation on high performance engines.
4. Increasing the maximum oil pressure from around 60 to at least 80psi at high rpm. This requires a new pressure relief spring in the oil pump. Adjustable units are available which are ideal for setting the required pressure. Obviously the oil pump should be in good condition – I purchased a new timing cover and oil pump assembly with larger than stock oil passages and an adjustable higher rated relief spring to be sure. Don’t be put off by “rules of thumb” that say 80psi is too high and there will be oil leaks and so on – the high pressure works just fine. Some really high performance Buick engines, well beyond my league, run on more than 100psi oil pressure!
5. Although not essential, I installed more secure threaded front gallery plugs in place of the freeze plugs used by Buick. Care needs to be taken to ensure that the plugs do not protrude into the oil passage behind and interfere with the oil flow.

The block girdle drops the oil pan by about 1” and you need to take care that there is sufficient clearance to the front cross member, especially if you intend using a deep sump pan. After spending a lot of time trying to raise the engine slightly with things like shims under the front engine mounts, I bit the bullet and had my oil pan remodeled to ensure sufficient clearance. Raising the engine slightly also had the disadvantage of reducing the air cleaner to hood clearance, which was tight at the best of times.

I initially experienced a number crankshaft thrust bearing failures. After considering a raft of reasons for this happening, I found that it narrowed down to the type of torque converter I was using. I started with JW hi-stall converters, made in Florida and supposed to be the ant’s pants for drag racing. Each time I wrecked the thrust bearing I found my transmission fluid was full of bronze filings from the JW converter. JW make their converters to fit both GM and Ford boxes and there is a redundant bronze bush not required for the T400 gearbox. Somehow this bush was making contact where it shouldn’t and apparently exerting excessive forward thrust on the crankshaft, as well as polluting the transmission fluid with bronze. I swapped to an Australian made Dominator converter designed specifically for the T400 and had no more problems. To be on the safe side I had my machine shop drill a 2mm hole from the centre main bearing oil passage to the thrust bearing surface, thus supplying plentiful oil to the thrust surface. I also had my crankshaft nitrided to provide an extra hard finish to the bearing surfaces, including the thrust bearing.

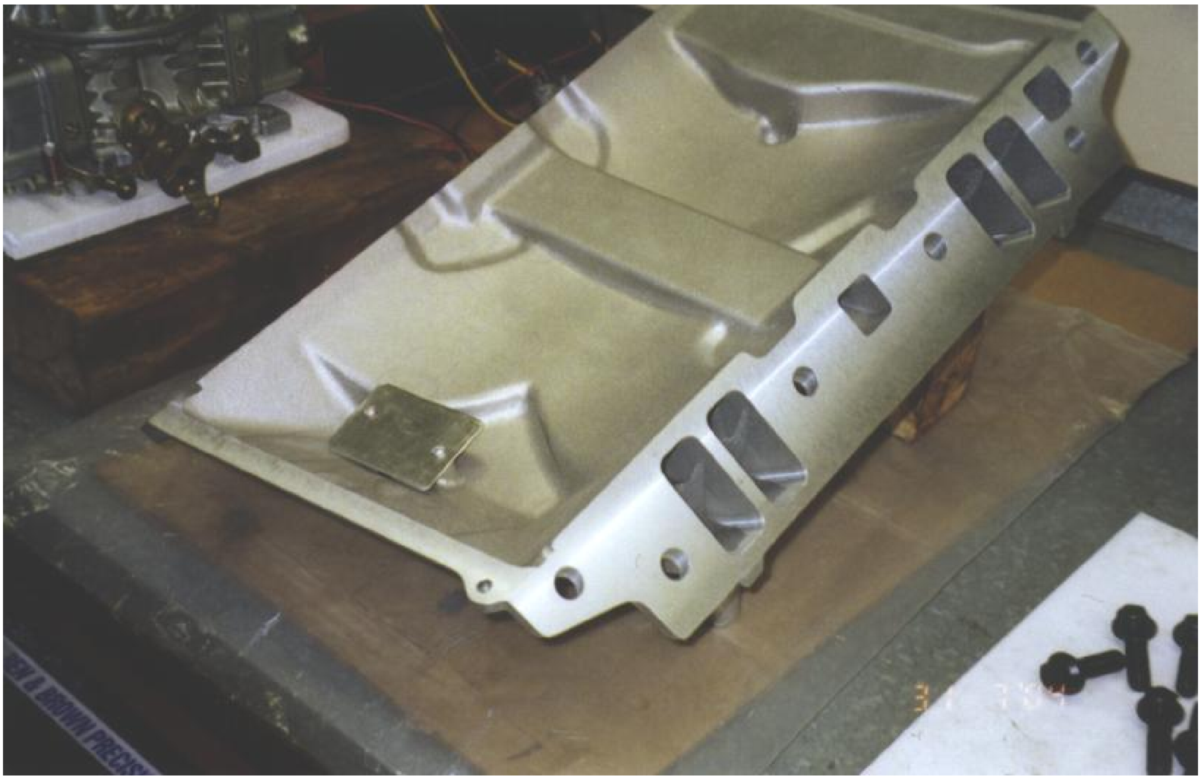
I used front and rear neoprene crankshaft seals in place of the factory rope seals. The front seal came fitted to the new timing cover and has proved to be ideal. The rear seal was a different story. After wrecking a number of seals that either spun and/or melted at high rpm, I was advised to remove 0.015” from the crankshaft rear bearing surface. This was another costly exercise getting the crankshaft out, machined and re-nitrided; however it worked. Evidently for standard engine performance enough oil is splashed onto the neoprene seal to keep it cool, but not at high rpm. Shaving the crankshaft reduces the seal bearing pressure sufficiently for the oil to keep it cool whilst not allowing oil leaks.

Whilst on the subject of oil leaks, big block engines are noted for creating high crankcase pressure which in turn can cause annoying leaks around the oil pan and bearing seals. The crankcase pressure is caused in part by piston ring blow-by which can be quite high especially prior to the rings fully bedding-in. Normally the PCV system will take care of excessive crankcase pressure however I found I needed something more. I used moly rings, which exacerbated the blow-by problem as they take longer to bed-in than the standard cast iron rings. To reduce the crankcase pressure I had a crankcase vacuum pump installed on the engine in place of the PCV system – see Photo#1. The pump runs off the crankshaft pulley at half engine rpm and delivers between 4 to 10 inches of crankcase vacuum via the PCV valve port on the intake manifold.

1. Crankcase Vacuum Pump and Oil Catcher on RHS and LHS of alternator, respectively

I retained portion of the original Buick valley pan metal gasket and installed a baffle plate on the inside of the manifold to limit the amount of internal oil splash reaching the underside of the PCV valve port as shown in Photo#2. An oil catcher was required to collect the small amount of residual oil sucked out through the vacuum pump. Draining the oil catcher now and then is preferable to leaving annoying oil puddles from engine leaks each time I park the beast. Care must be taken to ensure the crankcase vacuum is not too high otherwise it will do nasty things such as suck in gaskets and seals. The crankcase vacuum can be adjusted via a bleeder valve installed in place of the mechanical fuel pump on the timing cover. Care must also be taken not to over rev the vane type vacuum pump hence the large pulley on the pump.

Now to take a look at the top side of the engine. I used replica Stage 1 aluminium heads, SRP notched racing pistons, Crower forged rods and decked the block to zero, giving a compression ratio of 11:1. The car runs on pump gas without a hint of detonation/pinging. The roller camshaft is suitable for street and track with strong mid-range to top-end power and fair idle. The camshaft specifications are 0.576/0.584” intake/exhaust lift at valve with 1.6:1 roller rockers, 238°/248° intake/exhaust duration at 0.050” lobe lift and 112° lobe centres.



2. Baffle Plate on underside of Intake Manifold

I experienced repeated valve stem seal failures when I first used the aluminium heads. This was both puzzling and frustrating until I discovered that it was caused by the dual valve springs moving around on their seats in the head and rubbing up against the seals, resulting in almost instantaneous seal destruction followed by the predictable and embarrassing oil burning. It turns out that the heads were supplied without spring locators, a shortcoming that the vendor has rectified since. Meanwhile I sourced suitable locators, had them installed to stop the springs moving about on their seats and hey presto, no more damaged seals.

Buick GSX Engine Rebuild – Part 3

Alan Haime WA Buicks

Following from Part 2 of my article where I covered the necessity of using valve spring locators to prevent seal damage, the next item of concern was the valve train, including the lifters, push rods, rockers, valves and springs. Initially I used a hydraulic cam with standard lifters and valve springs, and roller rockers set with 0.004” valve lash. Until I invested in a roller cam and heavy duty springs I had nothing but trouble keep the valve train under control at high rpm. This severely limited the top end performance of the engine and it did not sound very healthy either. Evidently the valves were floating and rattling like a charity collector’s tin on a Friday. The horsepower and torque reached a respectable 485HP/510 ft-lb as shown in the Figure 1 dyno curves but nose-dived noisily beyond 5000rpm. Removing the valve lash and using anti pump-up lifters made some improvement but did not fix the valve train float problem. The second dyno curve showed that considerable improvement was made by replacing the standard hydraulic lifters with solids but with the same old valve springs and hydraulic camshaft unhealthy noises prevailed at high rpm.

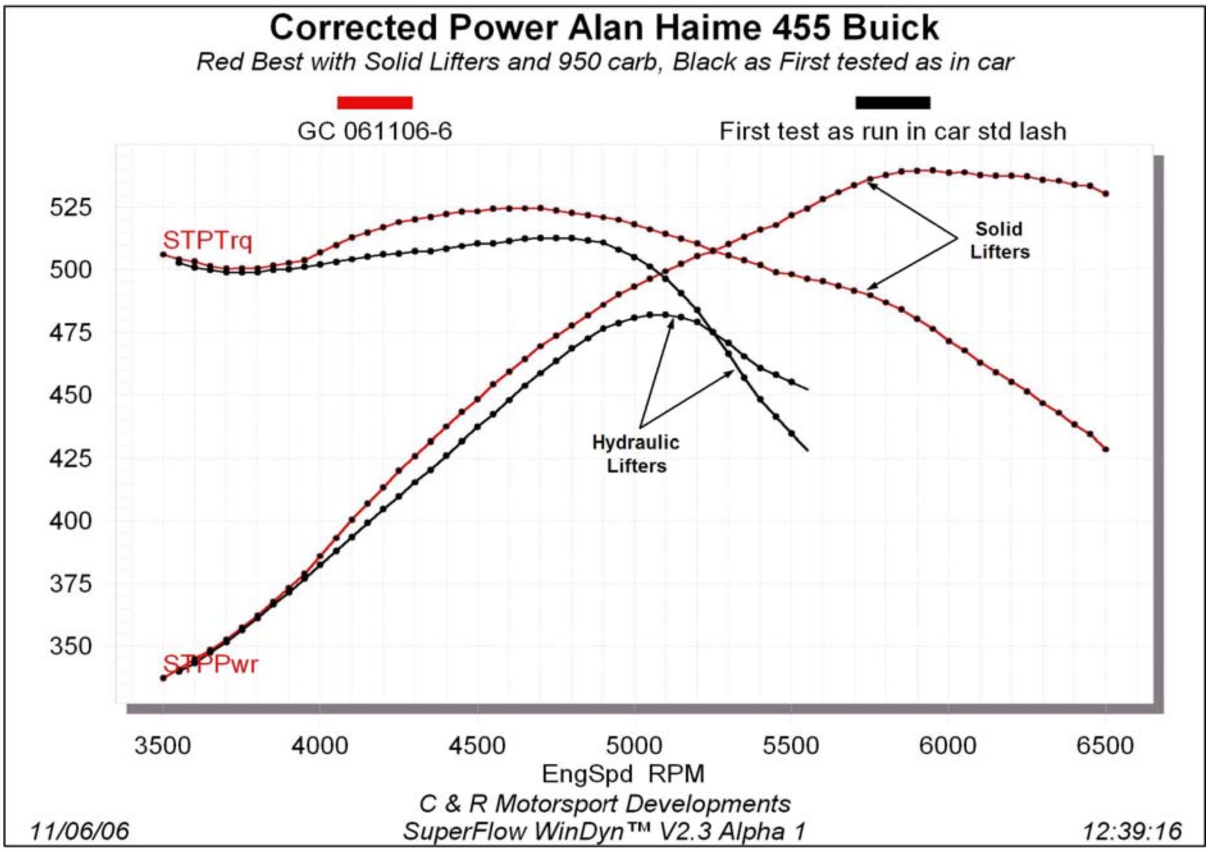


Figure 1. Initial dyno curves with hydraulic cam.

The installation of heavier dual valve springs, solid roller lifters and roller cam soundly fixed the valve float problem once and for all. The springs were shimmed to provide 280lb closed and 600lb open pressure taking care to ensure they were compressed to no more than 0.1 inch before bind. The resulting dyno curves in Figure 2 clearly shows that the engine now revs effortlessly to 6000+rpm producing a meaty 563HP/559ft-lb and without a peep out of the valve train – note how the curves are smoother than the early ones. The engine is now far more reliable and the car has repeatedly run a sub 12 second quarter mile at the track with an 11.49sec/118mph best result. The car has plenty of scope for upgrading the camshaft and moving into the 600+HP category…..but as Lois will tell you that is another dream!

Torque & Horsepower

Torque is what the dyno measures. Horsepower is derived from torque using the following formula:

$$HP = \frac{\text{Torque (ft – lbs) x RPM}}{5252}$$

At 5252 rpm HP is equal to torque. That is why all HP and torque curves using the above units cross at 5252 rpm.

For an interesting and informative discussion on horsepower versus torque visit:

http://www.stealthauto.com/horsepowertorque.aspx

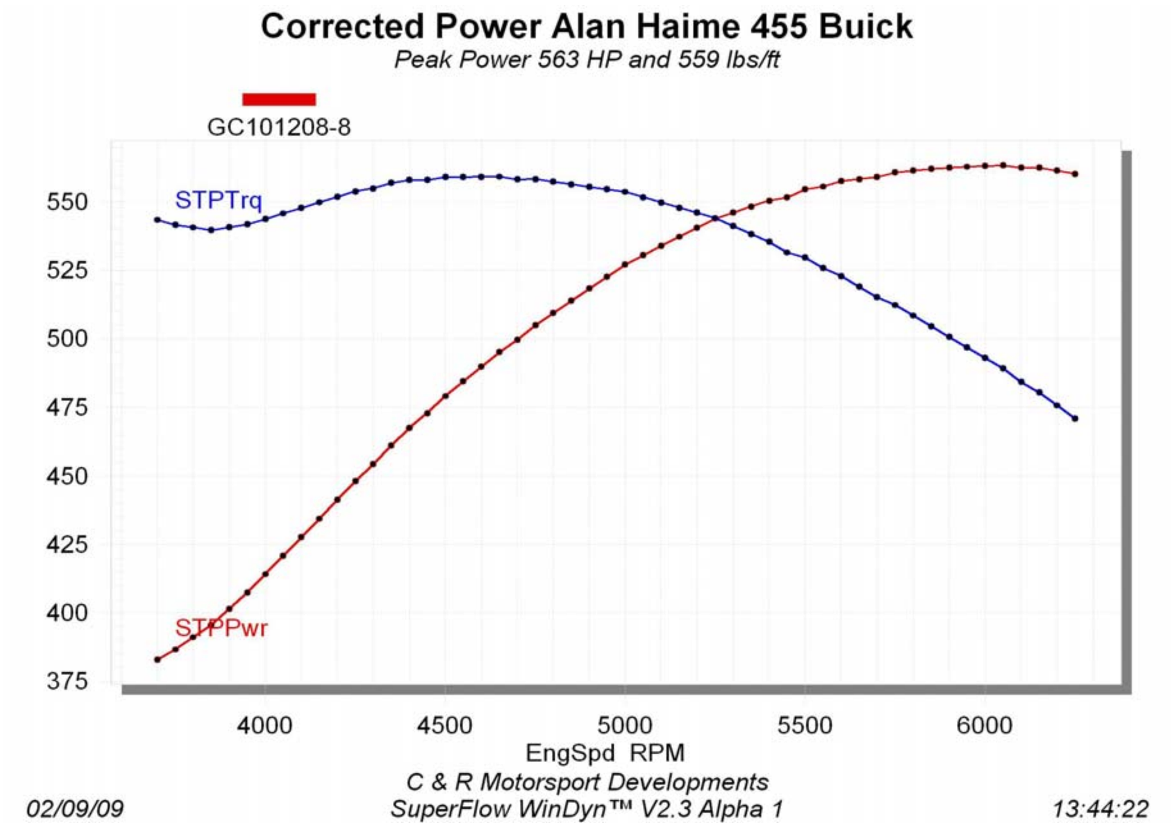


Figure 2. Final dyno curves with roller cam and solid roller lifters.

The 455 engine performance is dependent on valve and ignition timing. Getting these right usually requires a bit of vendor advice together with some trial and error - and luck. I purchased a double roller timing chain with multiple keyways for adjusting the timing. Since changing the valve timing involves serious engine work I decided against the trial and error approach and had the valve timing set to the vendor's recommended 4 degrees advance during the engine assembly (evidently the stock Buick timing sets had a built-in 4 degrees advance). For the ignition system I purchased a Mallory distributor with mechanical but no vacuum advance. The mechanical advance is set to 14 degrees maximum at 2,600rpm and the idle ignition timing to 20 degrees, giving the 34 degrees advance that flat-out Buick engines love. As for the valve timing I have not messed about with the ignition timing – I guess I have been satisfied with the performance.

Before I carried out the engine modifications I found that my stock 800cfm Quadrajet carby was not up to scratch, "bogging" badly each time I attempted hard acceleration from standstill. I invested in a Holley 950cfm HP Series double pumper and single plane intake manifold which overcame the bogging completely and simultaneously drove down my fuel consumption. Some may argue that 950cfm is excessive for my engine, however I have never experienced a hint of top end power loss due to restricted airflow. The engine is probably not as "sharp" as the purists say it would be with a smaller, say 800cfm, carby at lower rpm but this has not given me cause for concern. The engine has plenty of room for higher 6000+rpm performance should the need, and permission from Lois, arise.

Other useful bits and pieces include electric fans, headers and a lightweight starter motor. The electric fans have completely overcome the overheating problems that I have experienced with the stock mechanical fan and shroud – so much so that I am seriously considering fitting electric fans to my Riviera. I do not believe that stock 455 fans were ever seriously designed for heavy airconditioned cars in the desert! The 2 inch headers with 3½ inch collectors fit very snugly and help scourge the exhaust gases through hi-flow mufflers and 3 inch pipes to the outside world. The lightweight starter turns the engine faster than the stock motor and can easily be supported with one hand whilst installing – no more juggling the stock monster into place!

Figure 3. GSX Engine on dyno machine

The transmission and wheels must be capable of delivering the performance engine torque to the road or track. As mentioned I use a Dominator 3000rpm stall converter. My T400 transmission is stock except for a smaller modulator and a slightly higher pressure relief valve spring to smarten up the gear changes, which are effected by a B&M ratchet type floor shifter. A 6000rpm shift light is fitted to the steering column to indicate when to shift gears. The rear axle is the stock 3.73:1 posi-traction with 15x10 inch rims, street legal 275x15 slicks and Edelbrock anti-hop bars. A tailshaft hoop is fitted, as required for sub-12second cars to prevent the “60ft pole vault” should the front universal fail. The break locker is useful for locking the front wheel whist warming the rears, whilst a five point driver’s harness is fitted should things go pear shaped.

Table 1 summarises the GSX specifications and Table 2 provides an indication of current engine parts costs in US dollars. Machine shop costs can be significant and personal hours spent are through the roof. But at the end of it all, the satisfaction of having a reliable high performance car is worth the cost and effort. And don’t be put off by age – I was over 65 when I ran my first quarter mile at the track and I enjoy every second of it. Racing the GSX makes me feel young again in fact I’m becoming younger as the days go by, doing I the things I couldn’t afford when I was a teenager!

Table 1. GSX Specifications

- Engine: 1974 Buick 455 cubic inch block bored out 0.40” with SRP notched racing pistons; Crower forged rods; TA Performance ported aluminum (aluminium if you prefer) Stage-1 11:1 CR heads; block and lifter girdles; TA single plane manifold; 950 CFM Holley double-pumper; Mallory distributor and ignition; 2” headers with 3½” collectors; electric fans; deep sump baffled oil pan; crankcase vacuum pump.

- Cam & Valve Train: Roller cam, 0.576/0.584” intake/exhaust lift at valve, 238°/248° intake/exhaust duration at 0.050” lobe lift, lobe centre 112°; solid roller lifters; Crane push rods; 1.6:1 roller rockers; dual valve springs 280/600lb closed/open; 3/8” stem stainless steel valves; Teflon valve stem seals; cam bumper.

- Timing set at 34° BTDC at 2,600rpm; cam advance 4°; bench run-in on dyno, producing 563HP/559ft-lb using local 98 octane pump gas.

- 3-speed T400 auto, B&M shifter, 3000rpm hi-stall converter, 3.73:1 posi-traction limited slip diff, tailshaft lop; anti-hop bars, brake locker, hood tacho, front discs, 15 x 10 inch rear sports wheels with street legal slicks, 5-point harness.

Table 2. Indicative Engine Parts Costs in US$

Stage 1 Aluminum Heads with Valves & Springs	2450
Racing Pistons & Moly Gapless Rings	1000
Forged Rods	775
Heavy Duty Dual Valve Springs	300
Roller Cam	700
Roller Rockers	750
Roller Solid Lifters	700
Intake Manifold	400
Block Girdle	500
Lifter Girdle	400
Distributor & Ignition System	700
Carburetor 950cfm	720
Headers	500
Oil Pan Deep Sump	450
Starter Mini Size	300
Electric Fans	250
Crankcase Vacuum Pump	300