THE FORGOT

TTEN BUICK

Building the Overlooked Buick 400

By Steve Dulcich
Photography by Brandan Gillogly, Robert McGaffin, Bryce Mulvey, Rik Panneton, and Steve Dulcich

Buick's 400 earned a respectable reputation as a performance engine, powering the GM division's sporty GS muscle cars over its short production run from 1967-1969. Along with the bigger 430ci engine, the 400 was an all-new engine for the 1967 model year, replacing Buick's long-running Nailhead engine family that preceded it. These new "Big Blocks" from Buick retained the 4.750-inch bore spacing of the Nailhead, but took advantage of newer casting techniques and high nickel iron alloy to produce a lighter engine assembly, while the modern cylinder head design increased its power potential. This engine family reached its peak displacement with the introduction of the 455-cid powerplant in 1970. Built in more plentiful numbers, and with a bigger bore, these 455-cube Buick engines seem to get all of the attention.

The Buick "Big Block" series of 400, 430, and 455ci engines all shared a common stroke of 3.900 inches. The difference in displacement resulted from the bore diameter, measuring 4.040, 4.1875, and 4.310 inches, respectively. External dimensions remained the same. Since the 400 is the smallest-bore version of the late Buick V-8, the larger variants of this engine family are much more popular as the basis of a high-performance engine build. As a result, the 400 is most often built to near OEM specs in the course of restoring classic Buick vehicles. The engine featured here is an exception to that general rule.

CP-Carrillo had an interest in fielding an engine in the 2015 AMSOIL Engine Masters Challenge. CP's Rik Panneton happened to be contemplating the idea of building a high-performance street Buick engine for his '68 Buick Sports Wagon, originally equipped with a 400. Rik discussed the possibility of a Buick entry with fellow CP employee Bryce Mulvey, and this jelled into a team with the goal of building the engine to the rules for the Spec Small Block class of the competition. Oddly, even though the 400 Buick is considered a "Big Block" engine, the factory bore and stroke put it close to the 4.065/4.005 maximum specs allowed in the class. As Bryce explained, "We thought the Buick had a good head, and we had the heads already. The downside was the intake manifold. The rules specified a spec two-plane manifold, and for the Buick application the standard Edelbrock Performer was the only choice, while the other engines could run the much better Performer RPM Air-Gap. We were giving up a lot of horsepower with that intake."

Another difficulty was the bore, since the Buick came from the factory with a bore just 0.025 inch smaller than the maximum allowed. The bores on the wagon's 400 were already too big for the class. As Bryce tells it, "The block we had was already bored, so we needed to find a core with untouched bores. Since the 400 was only built for a few years, they are not that common, especially if you are looking for a virgin core. We had to scour classifieds across the country for months to find a block. We found the block in Ohio and had that shipped out sight unseen. It turned out to be good, and we had the rest of the core parts from Rik's old motor."

Prep on the block was pretty straightforward. "We just did the basic block prep, like bore, hone, deck, and line hone," Bryce detailed. "We did some oil system mods, but nothing too extensive here, just enlarg-

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[1] To meet the bore size maximum of the EMC rules, the CP-Carrillo team needed to start with a standard-bore 400 Buick block. Considerable searching paid off, and this block required only the basic rebuild-style machine work.

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“The heads were one of the reasons we selected the Buick for the competition.”

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ing and streamlining some of the stock passages. Basically, it was all stock Buick, even the main caps. Like all of these Buick blocks, the 400 block is weak in the lifter valley. But from what we saw when sonic checking the block, the 400 has thicker cylinder walls than what you find on the bigger-cube engines.”

Choices in crankshafts were a limitation in the build. Here, the factory cast crank was modified to increase the stroke. Bryce elaborated, “We needed to get as close to the maximum 4.005-inch stroke allowed in competition. The stock 3.900-inch stroke was 0.105-inch short of the spec, so we had the factory crank offset ground. We went with a Chevy big-block journal size of 2.200 inches, and even going to the 0.030-inch undersize spec, we were only able to get 3.975 inches on the stroke. This was the most cost-effective approach, but it left us short 0.030 inch of the maximum allowed in the Engine Masters competition.”

To fill the bores, the CP-Carrillo team had plenty of resources as one of the top manufacturers of pistons and connecting rods in the country. Bryce filled us in, “We took one of the Bullet forgings to make the pistons and made a rod to fit the rules, using a 0.866-inch piston pin size. We can make the rods to any pin, big-end size, and length needed. The rod was really light, and keeping the assembly light was one of our goals. With the tall deck height of the Buick block and the relatively short stroke, there is simply a lot of space to fill. We settled on a 6.535-inch rod length and ended up with a rod weight of 637 g total. We could have gone much longer on the rod but wanted to keep it relatively short, although in comparison to a stroker small-block Chevy, this would be a long-rod combination. We were trying to keep the shorter rod to increase

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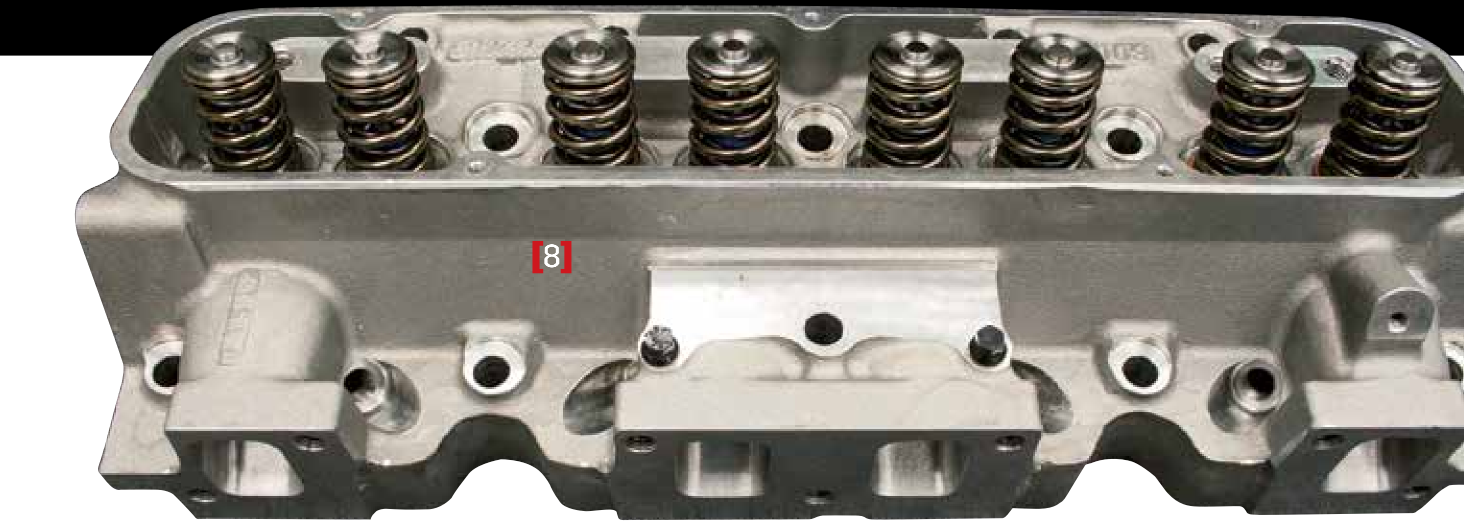

the piston speed off TDC, but anything shorter would have resulted in a ridiculously tall piston. We were already at 1.967 inches on the compression height with the 6.535-inch rod."

The tall pistons featured tricks learned from CP's experience building pistons for a wide range of professional racing applications. Bryce hit on the highlights, "The pistons' cam and barrel profiles were shapes we developed for circle track endurance racing. This piston shape is designed for minimum rock, which improves ring seal, and that will give more power. The strut holes in the piston lighten the pistons, but more than just making the piston lighter, they are what we call a pressure relief hole. This cuts down on the parachute effect of pressure inside the cavity of the piston as it travels downward in an atmosphere of air and oil mist. This reduces the drag to the reciprocating assembly, adding power. These pistons at 1.967-inch compression height weigh just 489 grams and are still thick where needed. We didn't sacrifice strength for lightness. The pistons are machined for 1.2mm compression rings,

[2] To increase the stroke of the stock cast-iron Buick crankshaft, it was offset ground to 0.030-inch big-block Chevy rod journal specs. The resultant 3.975-inch stroke and a 4.064-inch bore yielded 412.5 ci.

[3] CP-Carrillo is a leading manufacturer of rods and pistons. As you might expect, this Buick got some trick parts in this area. The custom pistons and rods were both manufactured specifically for this application using production forgings from CP's Bullet line of products. Note the lightening holes in the tall piston, bringing total weight of the 1.967-inch compression height units down to just 489 grams. Piston pins are 0.866 inch in diameter, while the ring pack is 1.2/1.2/3 mm.

[4] The generously deep valve reliefs give plenty of valve-to-piston clearance to allow for long duration and a very fast rate of lift.

[5] The CP ring set features a nitride steel top ring and ductile iron second rings. An ABS Products ring filing machine made short work of gapping the rings accurately and quickly. Ring gaps were set to 0.024 inch top and 0.048 inch second.

[6] The most accurate way to torque the critical connecting rod bolts is to use a rod bolt stretch gauge to tension the bolts to the ideal torque setting.

[7] To adhere to the class rules for the small-block competition at the 2015 AMSOIL Engine Masters Challenge, a flat-tappet cam was required. The engine was initially assembled with a very aggressive custom piece from comp with duration in the 240s and lift in the mid-800s.

[8] Edelbrock Performer RPM cylinder heads were required by spec to meet the rules of the small-block class of competition. The crew at CP-Carrillo had already developed an insane CNC program for the Buick head, putting the intake flow in the 340+cfm range.

[9] Although the heads were CNC ported using their proprietary program, the final blending was performed by hand to optimize the flow.

SPECIFICATIONS 413 CI BUICK BIG-BLOCK	
BUILDER	CP-CARRILLO
BORE	4.064 INCHES
STROKE	3.975 INCHES
CID	412.5 CI
BLOCK	OEM BUICK
DECK HEIGHT	10.497
COMPRESSION RATIO	11.0:1
ENGINE FASTENERS	STOCK AND ARP
CRANKSHAFT	OFFSET GROUND TO 2.200 JOURNAL AND STROKED TO 3.975 STOCK BUICK CAST IRON 400
CAMSHAFT	COMP HYD. FLAT TAPPET
CAM JOURNAL	OEM
TIMING CHAIN	ROLL MASTER
LIFTERS	COMP CAMS HYD. SHORT TRAVEL
LIFTER DIAMETER	0.842 INCH
PUSHRODS	MANTON
SPRING	MANLEY
INSTALLED HEIGHT	1.850 INCHES
SPRING LOAD CLOSED/OPEN	135/425
RETAINER/LOCKS	MANLEY TITANIUM
INTAKE DURATION	264 DEGREES @ 0.050
INTAKE LIFT	0.722 INCH
EXHAUST DURATION	268 DEGREES @ 0.050
EXHAUST LIFT	0.722 INCH
ROCKER	CROWER 1.8:1 INTAKE AND 1.6:1 EXHAUST
LOBE SEPARATION	108 DEGREES
INSTALLED CENTERLINE	100 DEGREES
TOP RING	NPR 1.2MM GAS NITRIDE
SECOND RING	NPR 1.2MM DUCTILE IRON NAPIER
OIL RING	DANA 3MM
PISTON	CP “BULLET” SERIES
GAS PORTS	NONE
MAIN FASTENERS	STOCK BUICK
MAIN BEARINGS	CLEVITE COATED
RODS	CP “BULLET” SERIES
ROD LENGTH	6.535 INCHES
ROD BEARINGS	CLEVITE COATED

[10] Here we have a look down the intake ports. The hand-buffed runners measured a minimum cross-sectional area of 2.71 square inches and delivered peak flow in the mid-340-cfm range. These ports move an insane amount of air!

[11] Rules for the 2015 Challenge required using the stock Edelbrock valve size—2.125-inch intake and 1.710-inch exhaust on the Buick head. Note the full CNC chamber—a part of the program CP-Carrillo's developed for these heads.

[12] The exhaust ports were likewise fully CNC ported and then hand-finished on this engine. Exhaust flow tops 270 cfm.

[13] The Manley springs are for a Chevy LS engine hydraulic roller application and are installed at 1.850 inches. Spring load comes in at 135 pounds on the seat and 425 pounds open.

[14] Bryce Mulvey bolts on the highly modified Edelbrock Performer RPM heads using 0.030-inch Cometic multi-layer steel gaskets.

[15] Edelbrock's Buick heads are designed to take small-block Chevy rocker arms. This really opens the options in available rocker. These are 1.8:1 ratio Crower steel stud-mount rockers on the intake and 1.6:1 Comp rocker on the exhaust.

“The intake took forever to port just to make it work.”

AMSOIL OIL VISCOSITY	10W-40
MAIN BEARING CLEARANCE	0.0032
ROD BEARING CLEARANCE	0.0027
CYLINDER HEAD	EDELBROCK/AIR WOLF BUICK PERFORMER
COMBUSTION CHAMBER VOLUME	70 CC
INTAKE VALVE DIAMETER	2.125
EXHAUST VALVE DIAMETER	1.710 INCHES
CYLINDER HEAD GASKETS	COMETIC MLS
HEAD GASKET THICKNESS	0.030
PISTON QUENCH CLEAR-ANCE	0.030
INTAKE MANIFOLD	EDELBROCK
CARBURETOR	QUICK FUEL 950
CARB SPACER	
HEADER	TA PERFORMANCE 1 7/8
IGNITION	MSD 6
DISTRIBUTOR	MSD PRO BILLET
SPARK PLUG WIRES	MSD 8MM
DAMPER	INNOVATORS WEST
WATER PUMP	AIR TECH REBUILT STOCK
OIL PAN	TA PERFORMANCE 6 QT.
OIL PUMP	MELLING
FUEL	VP 101 UNLEADED
ENGINE OIL	AMSOIL 5W30


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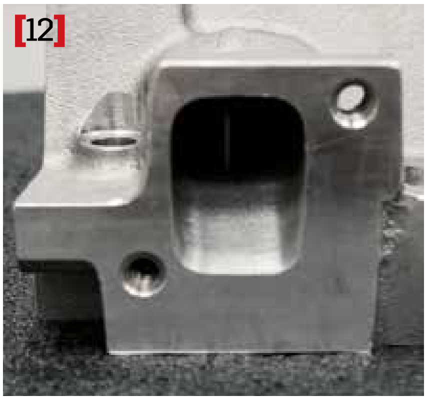
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using our nitride steel top ring set, and a 3mm oil ring assembly. It is a pretty trick piston."

The CNC Edelbrock Performer RPM heads were developed in-house at CP-Carrillo. These cylinder heads were one of the main advantages of the Buick engine, being primarily designed to the larger 455-cube engine application. The heads retained Edelbrock's generous stock valve sizes of 2.125-inch intake and 1.750-inch exhaust, and the advantageous 15-degree valve angle. Bryce told us, "The heads were one of the reasons we selected the Buick for the competition. Since the rules restricted the valve size and angle to the stock Edelbrock RPM specs, the big valves and flat valve angle give these heads a potential flow advantage compared to other small-blocks in the class. One problem is that the chamber width is designed for the 455 bore size, so there is a lot of overhang to the edge of the bore adjacent to the valves on the small bore 400. We ended up with really wide bore notches to smooth the transition. These heads flowed more than 340 cfm at 0.700-inch intake lift, with a 2.71-inch minimum cross-sectional area in the intake port."

While the heads made the Buick an advantageous choice for the Engine Masters Challenge, the intake manifold was a considerable handicap. It is not that the spec Performer intake is a poor design, it just isn't meant for an application like this. With the flow and power potential offered by the heads, the intake was certainly a cork in the system. According to Bryce, "This intake was not the best choice. A single-plane manifold like the T/A intake would provide an advantage of 70 peak horsepower or more on this kind of engine. We ported the manifold and removed a lot of material, but the layout is not designed for high rpm or very high flow. The intake took forever to port just to make it work. We did the best we could with the manifold and then just topped it with a Quick Fuel 1050-cfm carb."

The Edelbrock Buick heads are manufactured to accept small-block Chevy stud-mounted rockers. This greatly improves the component selection for the valvetrain, which allowed the CP team to employ high-ratio Crower 1.8:1 intake rockers and 1.6:1 Comp exhaust rockers from parts it had on hand. Camming this engine presented some real hurdles to the CP-Carrillo team. Rules for its class of competition required a flat-tappet cam and the stock lifter diameter. With enormous flow on hand, the further the valves were open on the team's highly developed cylinder heads, the more power it was going to make. The temptation was there to go aggressive with the cam.

A wild custom flat tappet camshaft from Comp was the result, featuring 242/246 degrees duration at 0.050-inch lift cut on a 107-degree lobe-separation angle, with a sky-high 0.740-inch lift.

The idea here was to retain a high level of torque at the bottom end with moderate duration, while opening the valves wide enough to really tap into the flow available from the cylinder heads. Unfortunately, the cam failed on the dyno, with critical damage to the lobes sending debris through the engine. It seems this lobe profile was not compatible with the Buick's 0.842-inch lifter diameter, edge-riding the lifter to certain disaster. What we had here, son, was a failure to communicate. This forced a full rebuild of the engine only days before the competition, and no time to order a replacement cam. As it was, the engine was reassembled with a borrowed bracket race cam dating to the 1990s and shipped overnight to make it in time to compete in the Challenge.

[16] Buick specialist T/A Performance supplied the 6-quart replacement-style oil pan.

[17] Up front we spy a T/A Performance timing cover. On a Buick, the timing cover also serves as the rotor housing for the oil pump, so a new cover is the only way to get like-new clearances in the pump. The damper is from Innovators West, while the water pump is a generic stock replacement mechanical unit.

[18] Headers are also from T/A Performance, a set of 1 7/8-inch primary units borrowed and well used.

[19] The engine was tested on the dyno at Westech Performance Group just days prior to the Engine Masters Competition. It started off great, but power seemed to drop off steadily. Something was wrong.

[20] When a cam begins eating itself like this, you've entered a world of woes. The metal debris worked its way throughout the engine.

[21] The engine was hastily reassembled just in time to hit the dyno for the 2015 Engine Master Challenge. The cam was replaced with the only stick the team could find on such short notice, and the engine still showed a respectable 484 lb-ft of torque and 542 hp. Not bad at all for a 400 Buick, but still well short of the engine's true potential.

[22] We have to give the team of Rik Panneton and Bryce Mulvey a lot of credit for making last-minute repairs and slamming this Buick back together with borrowed parts just in time to meet their commitment to compete in the 2015 AMSOIL Engine Masters Challenge. Although these guys knew their ideal combination was seriously compromised, they burned the midnight oil spinning wrenches to make the show.

DYNO RESULTS BUICK 413 CID CP-CARRILLO		
RPM	LB-FT	HP
3,500	403	268
3,600	411	282
3,700	415	292
3,800	414	300
3,900	412	306
4,000	414	315
4,100	419	327
4,200	426	341
4,300	432	354
4,400	441	370
4,500	449	385
4,600	463	406
4,700	472	423
4,800	477	436
4,900	478	446
5,000	478	455
5,100	481	467
5,200	483	478
5,300	484	489
5,400	484	497
5,500	482	505
5,600	479	511
5,700	474	515
5,800	469	518
5,900	466	524
6,000	461	527
6,100	459	533
6,200	454	536
6,300	448	538
6,400	445	542
6,500	436	540
6,600	426	535
6,700	416	531
6,800	408	528


[22]

ON THE DYNO

Despite the setback of having to rebuild the engine at the last minute with whatever cam they could shove in the block, the engine made it in time to compete in the AMSOIL Engine Masters Challenge. A Buick is not normally regarded as an existential threat, but this one performed. There was a fairly stock rebuild-style block, a compromised cam, but the engine was filled with that sweet piston and rod combo and those fantastic cylinder heads. The numbers that rolled in were notably stout considering the limitations in play. We had 484 lb-ft of torque at 5,300 rpm, a respectable 1.17 lb-ft per cubic inch. At the top, the engine recorded a peak power number of 542 hp at 6,400 rpm. That is more than we would expect from a flat-tappet, pump-gas Buick 400 with a two-plane intake. Was it up to its full potential? Based on the head flow alone, we would have to say no. According to Bryce, "With the right intake manifold and cam in it, this thing would make well over 600 hp." We believe him. **[EM]**

SOURCES:

AMSOIL
(800) 956-5695
amsoil.com

ARP
(800) 826-3045
arp-bolts.com

COMETIC
(800) 752-9850
cometic.com

COMPETITION CAMS
(901) 795-2400
compcams.com

CP CARRILLO
(949) 567-9000
cp-carrillo.com

CROWER
(619) 661-6477
crower.com

EDELBROCK
Tech Line: (800) 416-8628
edelbrock.com

INNOVATORS WEST
(785) 825-6166
innovatorswest.com

MAHLE/CLEVITE
mahleclevite.com

MANLEY PERFORMANCE
(732) 905-3366
manleyperformance.com

MANTON PUSHRODS
(951) 245-6565
mantonpushrods.com

MELLING
(517) 787-8172
melling.com

MSD IGNITION
(915) 857-5200
msdignition.com

QUICK FUEL TECHNOLOGY
(270) 793-0900
quickfueltechnology.com

T/A PERFORMANCE
(480) 922-6807
taperformance.com

VP RACING FUEL
(210) 635-7744
vpracingfuels.com