A 500 HP 390 budget motor??? Read on as we build a…

Low Buck Street/Strip FE

For years FE stood for "Freakin' Expensive". The good factory performance parts were scarce even in the engine's heyday, and when Ford stopped producing them in the early 1970s demand soon outstripped supply, resulting in a high per HP cost for any serious FE build. Things have changed over the last few years though, and now a multitude of aftermarket manufacturers are producing blocks, heads, and stroker kits, leading to a resurgence in popularity for the venerable engine. The end result is that it's now possible to put together a strong FE combination using aftermarket parts, and do so without breaking the bank in the process.

We decided to take a stab at putting together an economical FE engine with a target of 500+ HP and 500+ ft-lbs of torque, based on a readily available stock block and bolt on aftermarket parts. From the beginning, two versions of this engine were planned. The street version was designed for boulevard superiority duty and the occasional trip to the track, while still maintaining reasonable street manners. The strip version was more purpose built for a bracket car, usable in an eleven second car as is, with significant upside power potential if given the addition of a roller cam and associated valvetrain.

Millions of 352, 360, and 390 engines were manufactured and can still be found cheap in junkyards and back yards all over the country. The local junkyards yielded several truck FEs in the $125-$175 range that were likely candidates for this project. But in the end we found an old 390 circle track warrior with the factory adjustable rocker arms and Mercury pentroof valve covers for $300 and brought it home to start the project.

The first call was to Barry Rabotnick at Survival Motorsports. The Engine Masters guru suggested a stroker kit to reap the benefits of more cubic inches. The 4.25" stroke was nearly ½" bigger than stock, and with a .040" overbore we got 446 cubes, a good start to the project. For $1949 we got the crank, 6.700" long big block Chevy based rods and Probe pistons, plus the complete ring and bearing package, balanced and ready to install.

Rather than spend a grand to revamp and port the stock 390 heads, we opted for a set of Edelbrock FE heads. They're aluminum and offer a more modern chamber than the stockers, and they flow like 427 medium riser heads out of the box, offering good HP potential. To keep the costs down we elected to use the factory valvetrain and a Comp Cams solid lifter cam with matching springs. Also required was the addition of rocker shaft end support stands from Precision Oil Pumps.

We topped off the street version with an Edelbrock Performer RPM dual plane intake and a 750 Holley double pumper, and sent the exhaust on its way with a set of Dynomax truck headers. Ignition was handled with a remanufactured Ford Duraspark electronic distributor and Accel wires.

The strip version got a beefed up bottom end, with H-beam rods, a high volume oil pump and heavy duty drive, and a Rollmaster indexable timing set. The Edelbrock heads got a street/strip porting job, and a switch to bigger 2.19/1.71 valves with 11/32" stems, resulting in intake flow of over 300 cfm.

For top end performance we chose an Edelbrock Victor intake and an 850 Holley, plus a set of Hedman 2" primary headers to fit a Mustang chassis.

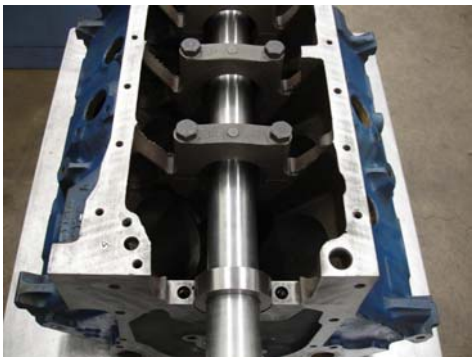
The end result is 500 ft-lbs and 500 HP for $6000 with the street version, and a bump to 550 HP for the strip motor, with plenty more available from a cam swap. That's enough to turn an old Fairlane, Galaxie, or Mustang into a serious street bruiser or strip contender. The FE is back!

Survival Motorsport's basic stroker kits include a cast Scat crank, 6.700" I-beam rods, and Probe pistons, plus rings, bearings, and balancing. The deluxe kit upgrades to H-beam rods and Diamond pistons, plus a better bearing package. The basic kit is suitable for most street applications, while the deluxe kit is just right for track use.

Machine Work

Since we were using so many new pieces for this build, machining operations were focused on the block, so we hauled the pistons and block over to R&R Performance in Spring Lake Park, MN, for the required machine work. After some measurements the block was align honed, then decks were cut to square them up with the crank centerline. Next the cylinder bores were power honed to .040" over to fit the pistons. Finally the block was washed and new cam bearings were installed in preparation for the build. Final machine work tally came to about $700.

Bryan Hansen at R&R Performance measures the diameter and runout of the 390 block's main bearing bores. A straight machinist's bar was laid into the main saddle, and feeler gauges were used to see if any of the main bearing bores were out of alignment. The bores proved straight, but a check of the roundness with the dial bore gauge showed the bores were slightly egg shaped, so the block was align honed.



Decking the block starts by bolting this reference bar into the block's main saddle, to provide an index to the crank centerline.

Next this plate is bolted to the block, indexing the crank centerline and the cam centerline. The 45 degree flats on the plate will be used as a reference to measure the block decks.

Heads

We selected the 428CJ version of Edelbrock's FE heads over the 427 version for it's superior, smaller chamber and sixteen bolt exhaust pattern, allowing different header combinations to fit. We started with the fully assembled heads for the street engine. Examination of the new heads showed the opportunity to pick up some easy horsepower with a home porting job. The heads were disassembled and the intake bowls and ports were cleaned up, first with a burr to rough in the shape, and then with a Summit Racing sand roll porting kit. Flow numbers on the top end of the lift scale improved noticeably, but the numbers below .400" lift remained about the same, reflecting the limitations of the single angle stock type valve job and 30 degree intake seat angle.

The flat bar with the dial indicator is used to determine the relative block deck heights from side to side. Running the dial indicator along the block deck will give a measurement for how far out of square the deck is with respect to the reference plate. A machinist's straightedge across the decks had shown that they were flat within a thousandth or so, but the dial indicator revealed that the decks were not the same height side to side, and also out of square with the crank centerline.

We needed to cut the decks a total of .022" on both sides to true them up. The plate bolted to the block was also used as a reference when setting up the machine used for this operation.

Dale Pelvit at R&R Performance power hones the bores to .040" oversize. Each piston is measured to the ten thousandth of an inch to confirm size consistency from piston to piston, and then the cylinders are honed to match for a precise skirt clearance. Three different sets of stones and one bottle brush hone is used to achieve the desired cylinder wall finish. Dale says, "The surface finish resulting from this technique yields peak cylinder bore sealing and performance with today's modern piston and ring packages."

Edelbrock's Performer RPM heads for the FE feature 427 medium riser ports and flow numbers, plus 428 Cobra Jet valve sizes. The heads are available completely assembled, or as bare castings for those who would rather add their own components. For our street motor we started with the assembled set, and then swapped in the 930-16 Comp Cams springs recommended for our cam. The springs were a direct replacement for the Edelbrock springs; even the installed height was correct!

For the strip version, we started with a set of bare Edelbrock castings, and acquired new valves from Survival Motorsports. The larger 2.19/1.71 valves featured 45 degree seats and 11/32" stems for improved flow. At R&R the stock 3/8" guides were replaced with 11/32" guides, the intake seats were cut for the 45 degree seat angle, and a street/strip porting job and competition valve job were done. Springs, retainers, and locks from Comp Cams rounded out the strip engine head assemblies. Our efforts were rewarded with 300+ cfm on the intakes, making these heads capable of supporting 600 HP.

Flow numbers from the three different head variations show the effects of the different modifications. The home port job left the standard 2.09/1.66 Cobra Jet valves in place. On the intake side, opening up the bowl and removing the pinch in the port opening improved flow at the higher lift levels. The same effort on the exhaust side resulted in no improvement, so those ports were left as is. The stock valve job limits potential improvements to the flow.

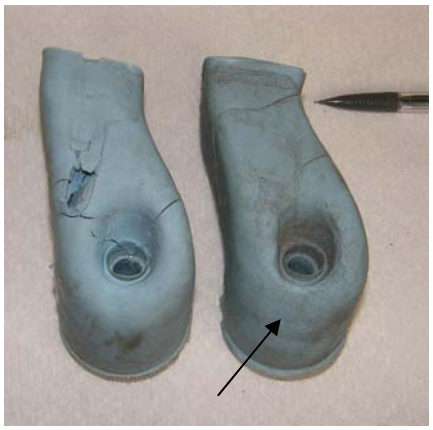
The street/strip porting job gave away some flow in the lower lift ranges on the intake side, because the stock 30 degree valve seats flow better at low lifts than the 45 degree seats. However, by 0.300" lift, the bigger valves and 45 degree seats are seriously out flowing the stock setup. The porting job resulted in an average flow improvement of 10% on the intakes and 20% on the exhausts.

Intake Port Flow Numbers

Valve Lift	Edelbrock Stock	Home Port	Street/Strip Port
0.100	89	87	76
0.200	156	155	141
0.300	182	183	200
0.400	214	218	248
0.500	242	250	285
0.600	253	269	299
0.700	260	277	304

Exhaust Port Flow Numbers

Valve Lift	Edelbrock Stock	Street/Strip Port
0.100	53	61
0.200	99	118
0.300	132	168
0.400	170	202
0.500	191	221
0.600	200	236
0.700	206	244



RTV castings were made of the stock Edelbrock intake port, and revealed a necked down area just inside the port entrance (pencil). Also a flat area in the intake bowl was discovered (arrow). The modified port (left) corrects these issues, and leads to improved high lift flow from a two hour home porting effort.

Oiling System

Turning your garden variety FE into a street screamer requires some key modifications to the oiling system. Early 428 Cobra Jet Mustangs had oiling issues because with only five quarts in the meager passenger car pan, three quarts were circulating in the engine while it was running, and a hard launch would shoot the remaining two quarts to the back of the engine away from the pickup. Result: bearing carnage. Three important things you must do to save your FE from oil starvation death:

1. Run a good oil pan and windage tray
2. Run six quarts of oil in the five quart pan
3. Restrict oil to the rockers

The pan needs to be baffled properly to keep the oil near the pickup, and the windage tray is necessary to keep oil off the spinning crank when using a stock capacity pan and six quarts of oil. Restricting oil to the rocker shafts keeps more oil in the pan and bearings where it belongs.

For our street engine we selected the Milodon stock replacement FE pan, which has a much better baffle arrangement than the stock pan. For the rigors of the track that the strip engine was expected to encounter, we elected to go to a Milodon 7 quart pan and pickup.

The factory oil pan shown on the right is not ideal for performance use. The baffle contacts the bottom of the pan near the back of the engine, and there are open spaces at the contact point allowing oil to pass under. On acceleration the oil can race away from the pickup causing oil starvation. The Milodon pan is superior due to the tight fitting baffle positioned farther forward in the pan, and should be considered a minimum for any serious performance use.

The primary function of the factory windage tray, shown here installed on our engine, is to keep the extra quart of oil in the pan away from the spinning crank. Always run at least six quarts of oil, even in a five quart pan! Mark your dipstick tube accordingly. More info at 428cobrajet.com.

Restricting oil to the rocker shafts in an FE head is a simple matter of dropping a drilled orifice into the oiling passage in the head. For the Edelbrock heads, you can spend $5 on a restrictor kit from Precision Oil pumps, or just take some 3/16" round brass stock and drill a .070" hole through the middle before dropping it into the oil hole. The rocker assemblies will still get plenty of oil, and more will be available for the mains and rods.

Cam and Valvetrain

To keep the costs down we decided to go with a flat tappet cam and mostly stock valvetrain for this project. The cam is a Comp Cams 306S grind for the FE, a single pattern grind featuring .640" peak lift and 260 degrees duration at .050" lobe lift. The matching valve springs recommended by Comp are the 930-16 springs, which provide about 150 pounds on the seat and 360 pounds full open.

Cam and compression have to be matched for a strong engine, and with this cam's late closing intake valve we needed a pretty good squeeze. The engine still had to run on pump gas though, so we dug out the Dynamic Compression Ratio (DCR) calculator and punched in some numbers. Comp recommends a compression ratio of 11.5:1 with this cam, and for this engine the associated DCR was 8.1:1. Generally a DCR of up to 8.25:1 with aluminum heads will still allow operation on pump premium fuel, so we took Comp's recommendation on the compression ratio and specified the pistons accordingly.

The stock FE valvetrain is up to the task for a big solid cam, with one exception. The end rocker arms on the shafts are located on a cantilevered portion of the shaft. Without a support on both sides of the rocker, this portion of the shaft is prone to breakage through the rocker shaft bolt hole. The solution is a set of rocker shaft end stands from Precision Oil Pumps. These stands will clear all the factory style valve covers, and provide the support necessary to keep the valvetrain together at higher engine speeds and with higher than stock spring pressures.

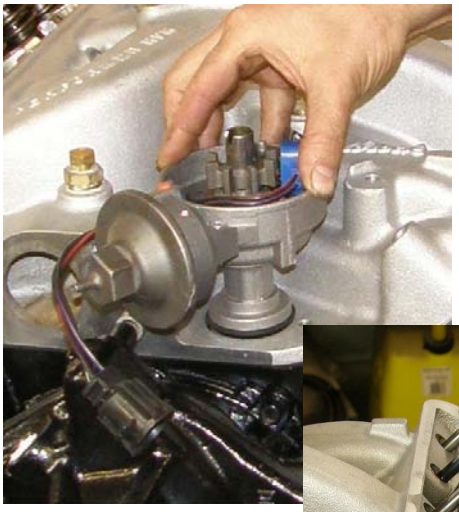
The headers for the street engine are Dynomax truck headers designed for a 390. The emissions era FEs have the exhaust ports positioned lower on the head than 427 or 428CJ engines, and of course the Edelbrocks. These headers were designed to fit the lower ports, so in order to avoid a major port mismatch, we slotted the header mounting holes so that the whole header could be shifted up ¼" or so. We also took the opportunity to clean up the port inlet with a bur. The photo shows the modified port on the right, and the port as received on the left.

Intake and Exhaust

An Edelbrock Performer RPM dual plane intake and a remanufactured Holley 750 double pumper carb topped off the street engine, promising good midrange torque in addition to top end horsepower. For the strip engine we chose the high RPM potential of the Edelbrock Victor intake, with a race calibrated 850 double pumper Holley.

For exhaust the street engine got 1 ¾" primary Dynomax truck headers, while a set of 2" primary Hedman headers for an early Mustang were selected for the strip motor.

The rocker shaft end stands from Precision Oil Pumps provide support on both sides of the end rocker on each shaft. The factory stands do not provide this support, leading to frequent shaft failures with higher than stock spring pressures. The rockers are the factory adjustable units, and the pushrods are also factory 3/8" ball/cup units. This valvetrain is good to 6500+ RPM with a solid cam and spring pressures up to 400 pounds.



Installing the intake is a tricky part of FE engine assembly. After setting the intake down on the engine with the gaskets in place, temporarily install the distributor and move the intake fore and aft to get the distributor lined up with the distributor hole in the manifold. Now scribe a line across the valve cover rail on the intake and the head on each side, so that you can reinstall the intake again later and keep this alignment. If the distributor hole in the intake is misaligned with the distributor, it will leak oil.

Now you can put in a couple of bolts to cinch the intake down into position, and measure the difference in height of the valve cover rail. In this case because the block was decked, the intake rail was .040" higher than the head rail. Anything more than .015" or so is too much, and may result in a leak, or the pushrods hitting the holes in the intake. We removed the intake and machined .025" off each head mating surface to make the fit acceptable. On final assembly make sure you check for pushrod to intake interference through the range of valve motion before bolting on the intake for good.

Parts and Labor Sources

Survival Motorsports
Detroit, Michigan 248-438-6900
www.survivalmotorsports.com

Precision Oil Pumps
Clovis, CA 559-325-3553
www.precisionoilpumps.com

R&R Performance
Spring Lake Park, MN 763-785-1949

Summit Racing Equipment
Tallmadge, OH 1-800-230-3030
www.summitracing.com

Enco Manufacturing
Fernley, NV 1-800-873-3646
www.use-enco.com

Flatlander Racing
Plaistow, NH 603-378-0090
www.flatlanderracing.com

Napa
National chain
www.napaonline.com

Autozone
National chain
www.autozone.com

Dyno Testing

After assembly the engines were dyno tested on a Superflow 901 dynamometer. Prior to beginning the testing, calibration was checked on the dyno's torque link and fuel turbines to ensure accurate results. We started with the street version, and had hoped to use a remanufactured Holley 750 vacuum carb to reduce costs. However, despite making good power numbers, the engine was fussy at idle and in transition with the vacuum secondary carb, so the 750 double pumper was installed. The four corner idle circuit of the double pumper made a world of difference, and the engine idled with a nice lope at 800 RPM and transitioned smoothly into the dyno pull. After making the initial tests on race gas, we filled the tank with 92 octane unleaded premium with 10% ethanol from the local BP station. Jetting had to be adjusted up one step, and total timing adjusted down 2 degrees to 34 total for best power on the pump fuel. The power levels for this engine were just about in line with expectations, at about 500 lb-ft and 500 HP.

The strip version was run on 111 octane Rocket Brand race fuel. With the single plane intake and the big tube headers, the torque peak moved higher in the RPM band by about 1500 RPM, and the engine peaked at 518 lb-ft of torque and 551 HP. The addition of a roller cam and valvetrain would get this engine into the 575-600 horsepower range, making it a very potent package.

Dyno Results: Street Version

Engine Speed	STP Torque	STP Power
3000	457.7	261.4
3100	462.6	273.1
3200	471.3	287.2
3300	478.8	300.8
3400	487.9	315.9
3500	499.6	332.9
3600	498.4	341.6
3700	501.6	353.4
3800	502.8	363.8
3900	498.8	370.4
4000	500.2	381.0
4100	499.8	390.2
4200	495.8	396.5
4300	494.3	404.7
4400	490.3	410.8
4500	488.8	418.8
4600	487.4	426.9
4700	488.1	436.8
4800	478.9	437.7
4900	481.5	449.2
5000	484.8	461.5
5100	479.9	466.0
5200	478.9	474.2
5300	479.0	483.4
5400	469.3	482.5
5500	472.1	494.4
5600	461.4	492.0
5700	460.6	499.9
5800	455.7	503.2
5900	451.8	507.5
6000	440.7	503.5
6100	433.6	503.6
6200	422.5	498.8
6300	410.8	492.8
6400	404.8	493.3

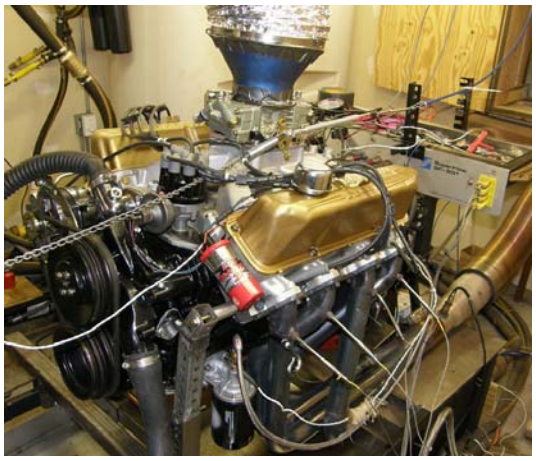
Dyno Results: Strip Version

Engine Speed	STP Torque	STP Power
3000	438.7	250.6
3100	447.9	264.4
3200	449.1	273.6
3300	447.7	281.3
3400	454.2	294.0
3500	454.4	302.8
3600	450.8	309.0
3700	443.6	312.5
3800	445.3	322.2
3900	448.3	332.9
4000	453.7	345.5
4100	466.0	363.8
4200	472.0	377.5
4300	477.9	391.3
4400	465.5	390.0
4500	453.4	388.5
4600	452.5	396.3
4700	463.8	415.1
4800	506.1	462.5
4900	506.3	472.4
5000	513.3	488.7
5100	508.8	494.1
5200	512.7	507.6
5300	518.8	523.5
5400	511.6	526.0
5500	511.9	536.1
5600	503.2	536.5
5700	506.2	549.4
5800	491.3	542.6
5900	486.1	546.1
6000	473.3	540.7
6100	465.2	540.3
6200	465.5	549.5
6300	459.4	551.1
6400	444.4	541.5

With the availability of new aftermarket parts, the FE engine can regain its former glory, and at a fraction of the historical price. A competitive FE is as close as the local boneyard, and if you happen to have a 427 block to work with, 500 cubes and 700 HP is achievable. For the Car Crafter in FE land, things have never looked so good!

Fitting the strip engine onto the dyno was a challenge because the Hedman headers hung down very close to the dyno's frame. Also, the engine had to be mounted in the front so that the headers would clear the mounting brackets. Be prepared for ground clearance issues if you decide to run a set of these headers on the street.

Air/Fuel ratio is monitored on the dyno with the normal air and fuel turbines, plus an Innovate Motorsports wideband oxygen sensor in each collector. During the testing there was good agreement between the dyno A/F numbers and the oxygen sensor numbers, leading to confidence in the results. A/F for the tests ran in the 12.6:1 range, with BSFC numbers hovering in the 0.50 to 0.52 area.



Parts	Source	Street	Strip
390 Core	Private Party	$300	$300
Budget 4.25" stroker kit	Survival Motorsports	$1,949	
Deluxe 4.25" stroker kit	Survival Motorsports		$2,299
Oil Pump (Melling)	Summit MEL-M57	$24	
High Volume Oil Pump (Blueprinted)	Precision Oil Pumps		$80
Heavy Duty Oil Pump Drive	Precision Oil Pumps		$15
Windage Tray (Ford)	Precision Oil Pumps	$40	$40
Milodon Oil Pan, stock replacement	Summit MIL-30740	$116	
Milodon Oil Pan, 7 quart	Summit MIL-31130		$210
Milodon Oil Pump Pickup for 7 Qt pan	Summit MIL-18370		$40
Timing Chain, standard	Summit SUM-G6512	$21	
Timing Chain, Rollmaster Indexable	Precision Oil Pumps		$100
Timing Tape	Summit SUM-164595	$4	
Balancer, Professional Products	Ebay		$78
Edelbrock Heads, assembled	Flatlander Racing	$1,260	
Edelbrock Heads, bare	Summit EDL-60059		$1,039
2.19/1.71 11/32 stem valves	Survival Motorsports		$300
Comp Cams 306S Solid Cam	Summit CCA-33-247-4	$130	$130
Lifters	Survival Motorsports	$65	$65
Comp Cams Springs	Summit CCA-930-16	$143	$143
Rocker Shaft End Stands	Precision Oil Pumps	$120	$120
Headers (Dynomax)	Summit WLKL-85041	$126	
Headers (Hedman)	Summit HED-85141		$743
Edelbrock Performer RPM Intake Manifold	Flatlander Racing	$280	
Edelbrock Victor Intake Manifold	Flatlander Racing		$450
Holley 750 Double Pumper Reman	Summit HLY-65-4779	$390	
Holley 850 Double Pumper	Summit HLY-0-4781C		$484
1/2" 4 Hole Phenolic Spacer	Summit SUM-G1402	$30	
1/2" Open Spacer	Summit SUM-G1405-1		$30
Fuel Pump Blockoff plate	Summit FMS-M-9351-A302	$5	$5
Accel Super Stock Plug Wires	Summit ACC-4041K	$30	$30
Distributor Cap and Rotor	NAPA	$9	$9
Duraspark Distributor, reman	Auto Zone	$40	$40
Distributor Advance Springs	Summit MRG-925D	$4	$4
Autolite 3924 Spark Plugs	Auto Zone	$12	$12
Fel-Pro Complete Gasket kit	Summit FEL-KS2307	$66	$66
Freeze plug/Cam plug kit	Summit MIL-34036	$15	$15
Mr. Gasket Medium Riser Intake Gaskets	Summit MRG-202A	$19	$19
Fel-Pro Oil Pan Gasket (Fel-Pro-1817)	Summit FEL-1817	$14	$14
Engine Paint (Black and Gold)	Auto Zone	$10	$10
Porting Kit	Summit SUM-61060	$30	
Carbide burrs for port matching work on intake/exhaust	Enco 891-4267 Enco 381-9332	$30	
Machine Work			
Check mains and align hone	R&R Performance	$150	$150
Deck Block to 10.148"	R&R Performance	$156	$156
Bore/Hone w/torque plate	R&R Performance	$214	$214
Machine Piston Tops .012"	R&R Performance	$58	$58
R&R Cam Bearings	R&R Performance	$65	$65
Wash Block	R&R Performance	$29	$29
Backcut Valves	R&R Performance		$24
Install 11/32" bronze guides	R&R Performance		$87
Machine for oversized valves	R&R Performance		$92
Street/Strip Porting Work	R&R Performance		$520
Competition Valve Job	R&R Performance		$199
Cut manifold to fit engine	R&R Performance	$45	$45
Total		**$5,999**	**$8,529**