

DYNO TECH

THE SNOWMOBILE PERFORMANCE PUBLICATION

YAMAHA V-MAX 4

EXCLUSIVE DYNO TEST RESULTS

The second production V-Max 4 in Canada belongs Bill Devlin, owner of Armprior Sportland (Yamaha dealer) near Ottawa, Ontario. The day after it was delivered to him, he brought it here for analysis.

The dyno data is given at crankshaft speed; the two percent underdriven engine output shaft (that carries the drive clutch) actually spins 7840 RPM at a crankshaft speed of 8000. Instead of 130.4 horsepower and 85.6 ft/lbs. of torque that is indicated at 8000 RPM at the crankshaft, the output shaft exerts 87.3 ft/lbs. at 7840 RPM, which equals the same 130.4 horsepower. Because the V-Max 4's tachometer reads in crankshaft speed, we've opted to give our dyno results based upon what the crankshaft is doing.

The 33mm Mikuni flatslide carbs on the V-Max 4 use N102/221 style main jets. These are the small, round jets like those used in stock Phazer carbs. Main jet changing is a bit of a hassle; the airbox should be unbolted and removed, and the rack of carbs must be pulled free of the engine for main jet access. Also, a screwdriver must be used to remove and install the slotted main jets, a clumsy situation at best. Fortunately, there is amazingly good access to the bellypan beneath the engine, facilitating retrieval of dropped main jets. If you accidentally push the needle jet up out of place while installing the main jets, there is no way of telling where the needle jet alignment pin slot is. The part of the needle jet that protrudes into the carb venturi has no markings, orifices, or steps, making reinsertion a hunt and peck affair.

Someone will certainly design a slotted jet changing tool. After a bit of practice, we were able to change mains in about five minutes.

Similar looking, racked RS series Mikuni flatslide motorcycle carbs have their needle jets threaded

into the carb bodies from below. Changing the RS series needle jets is as easy as changing mains, without removing the slides. Unfortunately for tinkerers, changing the needle jets on the V-Max 4 is more of an ordeal; the needle jets drop in from the top, so the slides must be removed for access. This requires unbolting the rack and rack linkage with a special Mikuni hex key. Without that tool, you may go out of your mind. It's about as cumbersome as changing the needle clip position on a standard Mikuni 38mm flatslide. Times four.

More fortunately for tinkerers, the needle jets will probably never have to be changed, unless the airbox is gutted.

Gutting the airbox on the stock V-Max 4 required the installation of much larger needle jets and main jets. It also resulted in almost no increase in airflow and horsepower with the stock carburetors and stock pipes. This is similar to what we found with the Exciter II airbox in Vol. 3 #1. It is quiet and very adequate for the stock engine.

The carbs come with 140 main jets. Using our Mikuni slide rule as a guide we installed 130 main jets to compensate for our 68 degree F Carb Air Temperature. The foam on top of each of the twin airbox openings was left in place. As we can see from the mid to low .60's BSFC, the factory jetting is quite close. V-Max 4 owners won't need to make major carburetion adjustments for good performance.

We used VP C10 unleaded 100 octane gasoline for our test. Like the previous V-Max twin and 570 Exciter, Yamaha engineers elected to inject the engine oil into the fuel pumps (where it will reach the engine from 10-30 seconds after it's injected). So, we elected to premix our gasoline with oil for the dyno test.



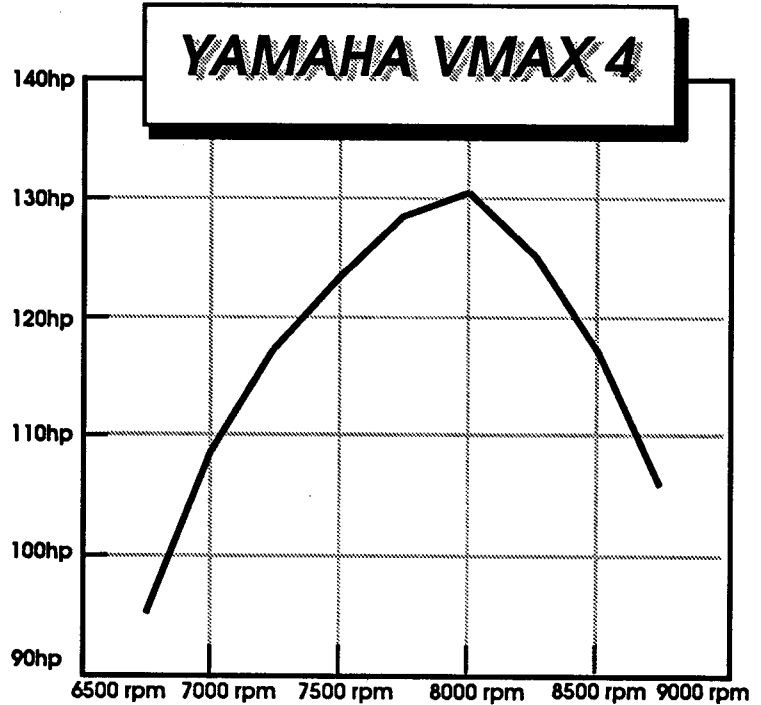
VMAX 4 *continued*

Yamaha is (for now, anyway) in the lead of the muscle-sled stock horsepower "race". How will this all-new chassis put the power to the ground? We'll have to wait and see.

1992 YAMAHA VMAX 4 130 MJ

Data for 29.92 inches Hg, 60 F dry air
 Test: 100 RPM/Sec Acceleration
 Fuel Specific Gravity: .750
 Vapor Pressure: .65 Barometer: 30.18

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6750	74.2	95.4	68.1	181.6	12.2	.73	68
7000	81.2	108.2	69.1	193.0	12.8	.65	68
7250	84.8	117.1	70.7	200.8	13.0	.62	69
7500	86.6	123.7	73.7	205.2	13.0	.61	68
7750	87.1	128.5	75.7	214.8	13.0	.60	68
8000	85.6	130.4	79.7	217.2	12.6	.63	68
8250	80.2	126.0	80.6	218.8	12.4	.66	68
8500	72.5	117.3	82.9	221.6	12.2	.72	68
8750	63.7	106.1	80.8	224.6	12.8	.78	68
9000	43.4	74.4	79.8	228.2	13.2	1.10	68



POLARIS "02" 650 PIPE UPDATE

PRESENT DURING TEST: Terry Miller, Scott Norine, Jim Czekaia

Terry Miller had just taken delivery of a new 1992 carbureted Indy 650, and he brought the engine to the dyno so we could check out our new Starting Line Products stock engine triple pipes.

Visually, the SLP stock engine triple pipes differ from the previous pipes by the "650-S" inscribed on each header pipe.

We also had purchased a new set of Decker triple pipes, and wanted to compare them as well. Our original Decker pipes, purchased in 1989, had metal "DRE" insignias tack welded to the pipes' center sections. The new Decker pipes have "Decker" stamped directly into the sheet metal of the pipes.

We also ran the same PSI Trail Blaster pipes that we tested previously on Scott Norine's engine.

We tested the engine with the airbox gutted, stock needle jets, and main jets that would give us a safe BSFC of .60+.

After a short break-in period on Terry's new engine, we ran several initial baseline tests, and found that the torque and horsepower were down, compared to most of the other "02" engines that we have dyno tested. We

found the timing to be severely retarded, even though the stator plate was aligned correctly, and the flywheel was degreed properly. Either there was a bit more retard in this CDI box, or the stator plate and flywheel were causing the engine to fire late. This may sound strange, but the amount of retard seemed to change as the timing was advanced (?).

At any rate, we "rolled" the stator plate, eventually taking it almost to the end of the adjustment slots counter-clockwise.

This is not the first time we've seen this. We've had to roll the stator plates in four or five of the 20 or so mod "02" engines that we have tested to date in order to get the good horsepower they are capable of producing. Gene Hurin, Jim Appolson, Jerry Noack, and Rob Schooping have all run into this phenomenon on the dyno. And, I would be willing to bet that Kelly Sweet's 650 "02" stocker (Vol 3 #2) that was a bit down on power, has retarded top end timing.

All of the stock or modified "01" engines that we've ever tested made the best horsepower with the timing marks stock, or advanced maybe one degree.

After we finished our test session, Terry installed a set of "Splitfire" sparkplugs in the engine (advertised to do wonderful things) and there was no change in the engine's torque, horsepower, fuel consumption, or anything else.

1992 STOCK INDY 650--230 MJ-- STOCK PIPE

GUT AIRBOX--STOCK TIMING

Data for 29.92 Inches Hg. 60 F dry air

Test: 100 RPM/Sec Acceleration

Fuel Specific Gravity: .750

Vapor Pressure: .55 Barometer: 30.63

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
7000	62.4	83.2	57.4	177.1	14.2	.69	69
7250	63.9	88.2	62.3	182.7	13.5	.71	69
7500	65.3	93.3	64.7	184.9	13.1	.70	69
7750	65.3	96.4	64.6	186.8	13.3	.67	69
8000	64.9	98.9	65.9	186.6	13.0	.67	70
8250	63.4	99.6	66.7	186.3	12.8	.67	70
8500	59.8	96.8	65.9	188.3	13.1	.68	69

1992 STOCK INDY 650-- 230 MJ--STOCK PIPE

GUT AIRBOX--CORRECT TIMING

Data for 29.92 Inches Hg. 60 F dry air

Test: 100 RPM/Sec Acceleration

Fuel Specific Gravity: .750

Vapor Pressure: .55 Barometer: 30.65

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
7000	65.5	87.3	56.5	181.1	14.7	.65	71
7250	67.7	93.5	63.5	185.9	13.4	.68	70
7500	68.5	97.8	66.5	186.7	12.9	.68	71
7750	68.3	100.8	65.4	188.2	13.2	.65	71
8000	67.4	102.7	66.9	188.9	13.0	.65	71
8250	65.3	102.6	65.1	189.2	13.3	.64	71
8500	61.4	99.4	66.4	189.3	13.1	.67	71
8750	57.7	96.1	67.4	188.8	12.9	.71	71

1992 STOCK INDY 650--230MJ--GUT AIRBOX--1989 DRE PIPES

Data for 29.92 Inches Hg. 60 F dry air

Test: 100 RPM/Sec Acceleration

Fuel Specific Gravity: .750

Vapor Pressure: .55 Barometer: 30.66

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
7000	66.6	88.8	59.8	193.0	14.8	.68	71
7250	67.8	93.6	65.1	195.4	13.8	.70	72
7500	68.8	98.2	67.0	196.0	13.4	.69	70
7750	69.8	103.0	66.0	195.7	13.6	.64	71
8000	69.6	106.0	67.2	195.4	13.4	.64	70
8250	71.3	112.0	69.5	195.6	12.9	.62	71
8500	71.8	116.2	70.6	299.3	13.0	.61	70
8750	71.9	119.8	74.0	200.7	12.5	.62	72
9000	71.8	123.0	75.0	204.2	12.5	.61	71
9250	71.1	125.2	75.8	207.1	12.5	.61	70
9500	65.5	118.5	74.5	205.9	12.7	.63	70

1992 STOCK INDY 650--230 MJ GUT AIRBOX--1992 DRE PIPES

Data for 29.92 Inches Hg. 60 F dry air

Test: 100 RPM/Sec Acceleration

Fuel Specific Gravity: .750

Vapor Pressure: .55 Barometer: 30.66

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
7000	65.0	86.6	58.8	193.4	15.1	.68	71
7250	66.2	91.4	63.9	195.7	14.1	.70	71
7500	67.3	96.1	67.4	197.1	13.4	.70	68
7750	68.7	101.4	67.2	197.5	13.5	.66	69
8000	69.8	106.3	67.6	196.8	13.4	.64	70
8250	71.3	112.0	69.8	197.5	13.0	.63	71
8500	71.0	114.9	70.5	200.4	13.1	.62	70
8750	71.8	119.6	73.1	202.0	12.7	.61	70
9000	73.3	125.6	74.3	205.4	12.7	.59	70
9250	72.2	127.2	76.2	209.7	12.6	.60	70
9500	67.3	121.7	77.4	209.9	12.5	.64	70

1992 STOCK INDY 650--230 MJ

GUT AIRBOX---1991 SLP MOD PIPES

Data for 29.92 Inches Hg. 60 F dry air

Test: 100 RPM/Sec Acceleration

Fuel Specific Gravity: .750

Vapor Pressure: .55 Barometer: 30.66

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
7000	65.0	86.6	59.1	196.6	15.3	.69	71
7250	67.1	92.6	63.8	200.3	14.4	.69	72
7500	68.6	98.0	69.3	203.2	13.5	.71	72
7750	69.6	102.7	69.3	202.6	13.4	.68	72
8000	70.2	106.9	69.5	201.9	13.3	.65	72
8250	69.6	109.3	70.0	202.0	13.3	.64	71
8500	68.7	111.2	73.1	203.5	12.8	.66	72
8750	68.2	113.6	74.4	205.9	12.7	.66	73
9000	68.0	116.5	75.2	209.7	12.8	.65	71
9250	66.9	117.8	78.5	211.4	12.4	.67	72
9500	63.4	114.7	79.4	211.5	12.2	.70	72

1992 STOCK INDY 650--230 MJ

GUT AIRBOX---1992 SLP STOCK PIPES

Data for 29.92 Inches Hg. 60 F dry air

Test: 100 RPM/Sec Acceleration

Fuel Specific Gravity: .750

Vapor Pressure: .55 Barometer: 30.66

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
7000	66.6	88.8	59.8	195.6	15.0	.68	71
7250	67.8	93.6	65.5	199.5	14.0	.70	71
7500	69.6	99.4	68.1	201.0	13.6	.69	70
7750	71.4	105.4	68.1	200.9	13.5	.65	71
8000	71.5	108.9	68.0	198.7	13.4	.63	71
8250	70.5	110.7	68.2	198.4	13.4	.62	72
8500	70.5	114.1	69.6	200.5	13.2	.61	71
8750	70.3	117.1	74.2	204.9	12.7	.64	71
9000	69.1	118.4	75.2	208.0	12.7	.64	71
9250	68.6	120.8	77.0	209.8	12.5	.64	72
9500	64.6	116.9	77.5	209.4	12.4	.67	71

1992 STOCK INDY 650--230 MJ

PSI TRAILBLASTER PIPES

GUT AIRBOX

Data for 29.92 Inches Hg. 60 F dry air

Test: 100 RPM/Sec Acceleration

Fuel Specific Gravity: .750

Vapor Pressure: .55

Barometer: 30.65

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
7000	65.4	87.2	69.9	195.4	12.8	.81	72
7250	66.4	91.7	72.6	198.2	12.5	.80	72
7500	67.1	95.8	73.3	197.1	12.3	.77	74
7750	69.3	102.3	70.3	196.8	12.9	.69	73
8000	70.4	107.2	70.7	197.3	12.8	.66	72
8250	70.8	111.2	71.3	198.9	12.8	.65	73
8500	71.3	115.4	70.8	202.0	13.1	.62	73
8750	72.9	121.5	72.8	206.0	13.0	.60	74
9000	71.6	122.7	76.0	209.7	12.7	.62	73
9250	66.5	117.1	77.2	209.7	12.5	.66	73
9500	51.3	92.8	75.5	200.5	12.2	.82	73

ARCTIC
CAT

EXT 550

PIPE TEST AND HOP-UP

Arctic Cat subscribers have been clamoring for an EXT Special performance improvements article.

Regardless of what you may have read in catalogs, there's not much available yet in the way of aftermarket pipes for the Arctic Cat 550 EXT Special. As of August 1991, only PSI had production pipes to ship to us.

We dyno tested a stock 1991 EXT Special, with 260 main jets installed to compensate for the mid 70 degree Carb Air Temperature. C10 unleaded gasoline was used during the entire test session. The following data was obtained with the stock pipe.

1991 EXT SPECIAL 550 STOCK COMPRESSION STOCK AIRBOX---STOCK CYLINDERS---STOCK PIPE 38MM CARBS--260 MAIN JETS

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .750
Vapor Pressure: .70
Barometer: 30.15

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
5250	39.2	39.2	38.3	99.9	12.0	1.01	76
5500	41.2	43.1	38.1	105.5	12.7	.91	76
5750	44.4	48.6	38.6	113.7	13.5	.82	77
6000	48.0	54.8	45.5	119.6	12.1	.86	76
6250	50.7	60.3	43.8	124.3	13.0	.75	75
6500	52.6	65.1	47.9	126.9	12.2	.76	75
6750	54.0	69.4	46.6	131.1	12.9	.69	75
7000	54.3	72.4	48.6	134.9	12.7	.69	75
7250	55.2	76.2	49.3	136.6	12.7	.67	76
7500	55.3	79.0	54.5	137.7	11.6	.71	76
7750	55.6	82.0	52.3	139.8	12.3	.66	76
8000	54.1	82.4	52.0	142.3	12.6	.65	75
8250	51.2	80.4	56.7	143.4	11.6	.73	75
8500	44.6	72.2	57.0	143.1	11.5	.82	77
8750	32.9	54.8	56.4	141.9	11.6	1.07	76

Installing the production PSI twin pipes resulted in the following test results.

1991 EXT SPECIAL 550 STOCK COMPRESSION STOCK AIRBOX---STOCK CYLINDERS---PSI PIPE 38MM CARBS--260 MAIN JETS

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .750
Vapor Pressure: .80
Barometer: 30.13

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6250	51.5	61.3	37.3	126.0	15.5	.64	79
6500	56.2	69.6	49.0	140.1	13.1	.73	78
6750	57.6	74.0	51.4	144.7	12.9	.73	79
7000	58.7	78.2	52.2	145.4	12.8	.70	79
7250	58.3	80.5	51.6	144.4	12.0	.67	78
7500	57.0	81.4	52.4	143.0	12.5	.67	79
7750	57.3	84.6	55.0	144.3	12.0	.68	79
8000	57.1	87.0	48.9	149.1	14.0	.59	79
8250	55.3	86.9	60.8	153.0	11.6	.73	78
8500	44.0	71.2	59.6	150.8	11.6	.88	78
8750	36.3	60.5	60.0	149.5	11.4	1.04	77

Next, we installed the trail ported cylinders that Starting Line Products sent us for testing. These cylinders had the intake ports and transfers rough finished for proper fuel atomization. The intake bridge was fairly blunt, not "knife edged". As is the case with shiny intake ports and transfers, "knife edging" is a thing of the past; knowledgeable engine builders now realize that the subsonic airflow present in the typical two-stroke induction system requires blunt leading edges wherever airflow is divided.

For those who are interested, the altered SLP port dimensions are as follows:

- *Exhaust height-31.2mm
- *Exhaust width-51mm
- *Transfer height-50.7mm
- *Intake bottom-108.5mm

As is the case with any hand ported cylinders, the contours and finish are difficult to describe, but fairly critical to the success of the job.

For comparison's sake, we first tested the engine with the stock heads, stock airbox, and stock pipe.

**1991 EXT SPECIAL 550 STOCK COMPRESSION
STOCK AIRBOX---PORTED CYLINDERS---STOCK PIPE
38MM CARBS--260 MAIN JETS**

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .750
Vapor Pressure: .70 Barometer: 30.14

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
5500	34.3	35.9	35.8	103.4	13.3	1.04	75
5750	38.2	41.8	35.2	110.3	14.4	.88	76
6000	39.0	44.6	35.8	113.5	14.6	.84	75
6250	42.2	50.2	39.2	119.8	14.0	.81	75
6500	45.8	56.7	39.4	124.8	14.5	.72	76
6750	47.9	61.6	39.4	130.0	15.1	.67	74
7000	50.4	67.2	43.9	138.9	14.5	.68	76
7250	51.9	71.6	46.1	143.1	14.3	.67	76
7500	53.3	76.1	51.3	148.0	13.2	.70	76
7750	55.2	81.5	55.0	150.5	12.6	.70	77
8000	54.8	83.5	55.4	151.0	12.5	.69	77
8250	52.1	81.8	57.9	150.2	11.9	.74	76
8500	49.1	79.5	58.2	149.5	11.8	.76	75

It was obvious that the higher flowing cylinders might benefit from removing the baffle from the airbox. As you may recall from our original EXT stock evaluation in Vol 3 #1, this modification did nothing to help the stock engine.

**1991 EXT SPECIAL 550 STOCK COMPRESSION
GUT AIRBOX---PORTED CYLINDERS---STOCK PIPE
38MM CARBS--260 MAIN JETS**

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .750
Vapor Pressure: .80 Barometer: 30.15

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
5500	35.7	37.4	32.6	130.8	18.4	.91	76
5750	38.6	42.3	31.1	138.5	20.4	.77	75
6000	40.0	45.7	36.1	136.0	17.3	.82	75
6250	42.4	50.5	39.5	131.7	15.3	.82	76
6500	46.4	57.4	41.6	138.0	15.2	.75	76
6750	50.2	64.5	42.9	145.2	15.5	.69	75
7000	52.2	69.6	43.6	150.6	15.9	.65	76
7250	54.1	74.7	49.4	155.8	14.5	.69	75
7500	54.9	78.4	49.8	159.8	14.7	.66	76
7750	56.6	83.5	52.3	163.9	14.4	.65	76
8000	55.9	85.1	55.6	165.9	13.7	.68	73
8250	54.4	85.5	56.1	163.6	13.4	.68	76
8500	51.2	82.9	58.1	158.9	12.6	.73	76

Next, we raised the cranking compression, Squish clearance was reduced from .085" to .060".. This should easily be pump gas safe for reasonable trail riding (those who enjoy multi-mile WOT lake runs on "bar" gas might do well to avoid this modification).



Because the SLP pipes we had were prototypes, and PSI's pipes are production versions, we opted not to show them side by side. Suffice it to say that the PSI pipes performed admirably on this trail ported engine. When we do obtain SLP's production EXT Special pipes, and any others that may become available, we'll do a regular pipe shootout. Stay tuned.

**1991 EXT SPECIAL 550 HIGH COMPRESSION
GUT AIRBOX---PORTED CYLINDERS---STOCK PIPE
38MM CARBS--260 MAIN JETS**

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .750
Vapor Pressure: .68 Barometer: 30.26

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
5500	39.2	41.1	36.1	146.0	18.6	.90	72
5750	40.7	44.6	31.1	144.4	21.3	.71	71
6000	43.6	49.8	37.7	142.7	17.4	.78	71
6250	46.3	55.1	38.8	141.4	16.7	.72	71
6500	47.9	59.3	40.8	142.2	16.0	.71	71
6750	50.2	64.5	41.7	145.6	16.0	.66	72
7000	54.4	72.5	46.5	153.1	15.1	.66	72
7250	57.2	79.0	48.2	159.6	15.2	.63	72
7500	59.1	84.4	52.4	166.4	14.6	.64	71
7750	60.2	88.8	53.5	169.2	14.5	.62	70
8000	59.4	90.5	56.2	171.0	14.0	.64	69
8250	57.2	89.9	57.1	173.2	13.9	.65	71
8500	53.1	85.9	59.0	169.0	13.2	.71	73
8750	38.9	64.8	56.9	162.4	13.1	.90	72
9000	26.5	45.4	55.9	155.3	12.8	1.27	72

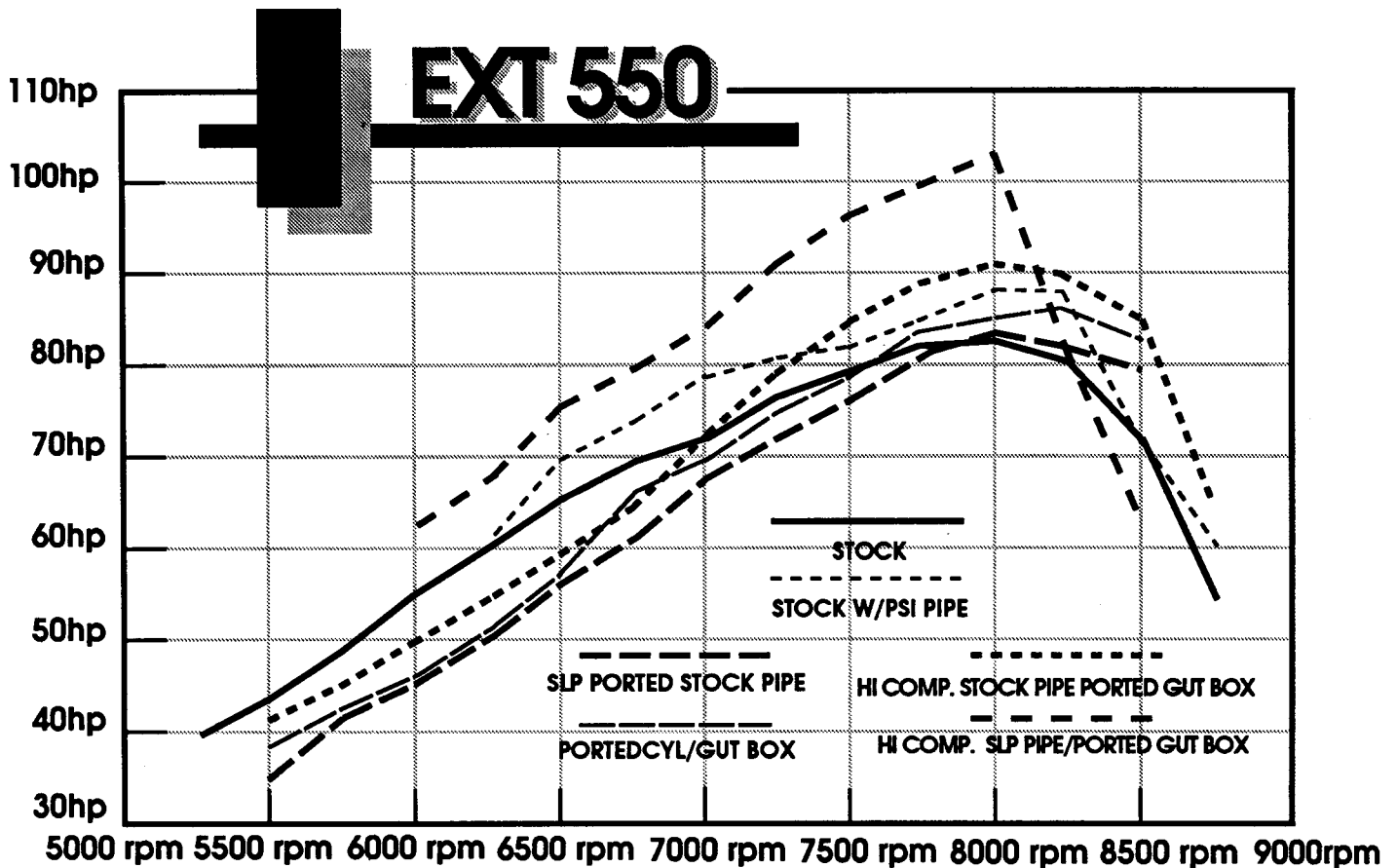
Starting Line Products had just completed a set of prototype pipes (hand welded, fit to the chassis, which would be the models for the stamped production pipes). These were for the stock and trail mod engines. Here they are on the SLP ported cylinders.

**1991 EXT SPECIAL 550 HIGH COMPRESSION
GUT AIRBOX---PORTED CYLINDERS---SLP PIPES
38MM CARBS--260 MAIN JETS**

Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .750
Vapor Pressure: .68 Barometer: 30.25

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6000	54.8	62.6	48.4	153.6	14.6	.79	73
6250	57.0	67.8	46.6	152.3	15.0	.71	73
6500	60.8	75.2	48.9	158.5	14.9	.67	72
6750	61.9	79.6	47.9	161.4	15.5	.62	73
7000	63.2	84.2	48.9	164.9	15.5	.60	72
7250	65.6	90.6	50.0	171.8	15.8	.57	72
7500	67.3	96.1	56.0	176.7	14.5	.60	73
7750	67.4	99.5	58.3	182.3	14.4	.60	70
8000	67.1	102.2	62.1	190.2	14.1	.62	71
8250	51.3	80.6	62.4	185.7	13.7	.80	73
8500	39.0	63.1	61.0	179.9	13.5	1.00	72
8750	33.8	56.3	60.9	168.5	12.7	1.12	73

Next, we installed some 40mm carbs on the engine that, when jetted to the same A/F ratio, provided no airflow or horsepower increase on this engine. The stock 38mm carbs evidently provide an ideal combination of airflow and intake velocity that this engine needed at 8000 RPM. The data was so identical, there is no need to show it.



EXCELLENT ENGINE MOD 700 WILDCAT

John Hooper, owner of Hooper Racing in Goshen, N.H. (603-863-0049) specializes in modifying Arctic Cat engines. This particular Wildcat 700 mod engine/pipe combination was used quite successfully (including wins at Peterborough and Cranberry Lake) last season by Fill oval racer Keith Young.

Using the "cut and test" method on his own computerized, instrumented Stuska dyno, he came up with this mod port spec for the 700 Wildcat. John uses PSI pipes, modified to his own specifications, on his engines. Starting with standard PSI 700 pipes, he shortens the center sections and installs different diameter header pipes. "Stinger" outlets are used.

John's porting technique includes rough finished intake ports, with blunt leading edges.

The basic port dimension changes are as follows:

- Intake ports-** lowered 2.5mm, widened 2mm.
- Exhaust ports-** raised .5mm, widened to 61mm.
- Transfer ports-** raised 1.5mm.

The pistons are stock Arctco, and ignition timing is stock. Stock reeds are retained, with the stops set at 10mm. Compression is a fairly moderate 13.5-1, which is roughly equivalent to a .030" head cut. Squish clearance is .055", with a "reworked" combustion chamber shape.

This engine had 46.5mm carbs, with CC0 needle jets. In each case, the engine was jetted for maximum high octane horsepower. No airbox was used, so no airflow figures were available.

MOD 700 WILDCAT

The gasoline that John uses is Phillips B33, premixed at 32-1. Also, note that the fuel flow figures are a bit erratic; the vibration from the big twin probably caused some occasional float bowl frothing. While it makes fuel flow analysis a bit difficult, the erratic fuel flow has not proven bad enough to cause problems on the race track.

John had recognized this potential fuel flow problem during his own dyno testing. Experimenting with a pork-chop cut, balanced crankshaft, his mod 700 suffered a two horsepower loss (due to excessive crankcase windage, maybe?) in back-to-back dyno tests, when switching from a stock crankshaft to a smoother running, balanced unit. John prefers to let them vibrate.

For comparison, we also tested the engine with stock pipes and a set of PSI 700 trail pipes (using the stock cannister) that John uses as a basis for his mod pipes.

Finally, we installed 14.5-1 compression heads. They also had reworked combustion chamber shapes, with the minimum .040 squish clearance (running a squish tighter than that on a Wildcat engine may result in the pistons "kissing" the heads).

This would be John's short track, or dragracing compression. Once again, in the real world of non-exaggerating dyno testing, 150 CBHP is a tremendous milestone for a production-based modified engine.

1991 700 WILDCAT 500-500 MJ CC0 NJ

46.5mm CARBS

STOCK PIPES AND CANISTER

13.5-1 COMPRESSION HEADS

Data for 29.92 Inches Hg, 60 F dry air
 Test: 100 RPM/Sec Acceleration
 Fuel Specific Gravity: .740
 Vapor Pressure: .20
 Barometer: 29.54

RPM	CBT	CBHP	FUEL	BSFC	CAT
7000	73.1	97.4	67.4	.70	47
7250	76.8	106.0	85.3	.81	48
7500	79.1	113.0	93.1	.83	48
7750	86.3	127.3	83.3	.66	48
8000	87.0	132.5	89.8	.68	48
8250	84.8	133.2	83.8	.64	48
8500	73.8	119.4	72.8	.61	47

CONTINUED

1991 700 WILDCAT--540-540 MJ--CC0 NJ

46.5mm CARBS

STANDARD PSI 700 TRAIL PIPES

13.5-1 COMPRESSION HEADS

Data for 29.92 Inches Hg, 60 F dry air
 Test: 100 RPM/Sec Acceleration
 Fuel Specific Gravity: .740
 Vapor Pressure: .20
 Barometer: 29.54

RPM	CBT	CBHP	FUEL	BSFC	CAT
7000	77.1	102.8	64.4	.63	47
7250	81.6	112.6	81.5	.73	47
7500	85.1	121.5	89.6	.74	47
7750	90.8	134.0	89.3	.67	45
8000	92.5	140.9	85.8	.61	45
8250	92.4	145.1	81.7	.57	47
8500	86.9	140.6	77.5	.56	49
8750	69.0	115.0	90.8	.80	47

1991 700 WILDCAT 560-540 MJ CC0 NJ

46.5mm CARBS

MOD PSI PIPES

13.5-1 COMPRESSION HEADS

Data for 29.92 Inches Hg, 60 F dry air
 Test: 100 RPM/Sec Acceleration
 Fuel Specific Gravity: .740
 Vapor Pressure: .20
 Barometer: 29.54

RPM	CBT	CBHP	FUEL	BSFC	CAT
7250	74.2	102.4	66.2	.65	50
7500	80.6	115.1	89.1	.78	49
7750	81.7	120.6	85.2	.71	50
8000	89.6	136.5	87.6	.65	49
8250	91.8	144.2	83.4	.58	49
8500	91.3	147.8	85.1	.58	50
8000	87.1	145.1	93.1	.65	49

1991 700 WILDCAT 520-520 MJ CC0 NJ

46.5mm CARBS MODIFIED PSI PIPES

14.5-1 COMPRESSION HEADS

Data for 29.92 Inches Hg, 60 F dry air
 Test: 100 RPM/Sec Acceleration
 Fuel Specific Gravity: .740
 Vapor Pressure: .20
 Barometer: 29.56

RPM	CBT	CBHP	FUEL	BSFC	CAT
7250	73.5	101.5	72.3	.72	54
7500	78.7	112.4	89.9	.81	53
7750	85.3	125.9	82.1	.66	54
8000	89.6	136.5	97.9	.73	53
8250	92.4	145.1	86.0	.60	53
8500	92.8	150.2	87.6	.59	54
8750	88.9	148.1	75.9	.52	53

1992 INDY 500EFI

POLARIS

Kevin McClure of McClure Saw and Lawn Equipment (716-592-5212), a Polaris dealer in West Valley, N.Y. was fortunate to have received a 1992 Indy 500 EFI last year. He managed to put around 1500 trail miles on it before bringing it to the dyno.

We ran the engine here on 92 octane unleaded gasoline. During engine warmup, we examined the A/F ratio and BSFC at various throttle positions and RPM. As Kevin predicted based upon his excellent fuel mileage and trouble free operation on 87 octane fuel, the engine was safely lean everywhere we looked.

The '92 EFI 500 twin is identical to the previous carbureted versions, with the exception of much larger intake ports to accommodate the RXL-style 46mm throttle bodies. The transfer ports, exhaust ports and compression are apparently unchanged. Also, the single pipe is identical to that on the carbureted version.

Comparing this engine with the carbureted Indy 500's we've tested in previous issues, we can see that the top end horsepower increase is the result of the engine flowing more air. This higher airflow is packed into an identical combustion chamber (we can safely assume that most of the extra airflow is being trapped and used—not "short circuiting" from the transfers to the exhaust port), resulting in higher running compression and higher horsepower.

1992 STOCK INDY 500EFI

Data for 29.92 Inches Hg, 60 F dry air
 Test: 100 RPM/Sec Acceleration
 Fuel Specific Gravity: .745
 Vapor Pressure: .50
 Barometer: 29.76

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
5750	36.4	39.9	31.2	91.9	13.5	.80	59
6000	36.9	42.2	31.3	92.3	13.5	.76	59
6250	41.5	49.4	35.2	101.0	13.2	.73	59
6500	47.6	58.9	39.5	111.1	12.9	.69	59
6750	50.4	64.8	41.5	118.0	13.1	.66	59
7000	52.6	70.1	43.8	122.7	12.9	.64	59
7250	53.7	74.1	45.8	128.3	12.9	.63	59
7500	53.0	75.7	47.1	132.1	12.9	.64	59
7750	51.3	75.7	49.2	134.6	12.6	.67	59
8000	47.0	71.6	50.6	134.6	12.2	.72	59

We installed a DG single pipe on the engine, and the engine produced the following torque and horsepower.

1992 STOCK INDY 500EFI DG PIPE

Data for 29.92 Inches Hg, 60 F dry air
 Test: 100 RPM/Sec Acceleration
 Fuel Specific Gravity: .745
 Vapor Pressure: .50
 Barometer: 29.76

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
5750	39.6	43.4	30.5	91.8	13.8	.72	58
6000	39.8	45.5	31.7	93.4	13.5	.72	59
6250	44.0	52.4	35.7	101.2	13.0	.70	61
6500	46.4	57.4	38.7	106.6	12.6	.69	62
6750	48.5	62.3	40.2	110.7	12.6	.66	61
7000	51.3	68.4	42.3	117.9	12.8	.64	60
7250	52.1	71.9	44.2	122.8	12.8	.63	61
7500	51.0	72.8	46.7	128.0	12.6	.66	61
7750	48.6	71.7	48.5	129.5	12.3	.69	61
8000	42.6	64.9	50.4	130.0	11.8	.80	59

RAD MORE AIRFLOW = MORE HORSEPOWER

Compare the '92 engine to the stock carbureted '89 Indy 500 engine that we tested in Vol 2 #1, page 2. The Relative Air Density (which affects airflow) on that day was @102 and peak airflow was 130 SCFM (standard cubic feet per minute).

Now, check out the data from the identical '91 carbureted Indy 500 in Vol 3 #1 page 10. On that day the RAD was @106, and the airflow was 135 SCFM. This represents a 4% airflow increase due to the 4% "better" air.

The day we tested the '92 EFI 500, the RAD was only @99, and the new engine flowed 135 SCFM at peak. Interpolating this to 102 air would give the engine 139 SCFM (a 7% increase in airflow over the '89 engine).

Now, interpolating the same data to the 106 air that we tested the '91 carbureted engine in, the '92 EFI 500 would flow 144 SCFM. Again, a 7% increase in airflow over the '91 engine.

Performance Improvements **1991 MACH I**

PRESENT DURING TEST: GARY POTYOK AND CARL SPIERING

Ontario Bombardier sales representative Gary Potyok would have liked to own a 1991 617 Mach 1X, but they were so scarce that he had to make do with a standard 617 Mach 1. Before the season began, he sent his crankcase and cylinders to Gerard Karpik of FAST (218-744-2101) to be modified.

There, the crankcase was "tunnel ported" and the rotary valve cover was reworked to shorten the intake tract eight millimeters. The cylinders were modified by polishing and raising the exhaust to 32mm, and widened to 60.5mm. The transfer ports are at 52.6mm.

A 1989 3-wire ignition was used, with timing set at .080" BTC. Because Gary runs primarily on 100LL av gas, he elected to have the head cut to a fairly high 15.7-1 compression ratio. Squish clearance wound up at .054". Cranking pressure was 175 psi.

44mm carbs were used, with large K&N Filters. Rotary valve timing was 149-79.

Gary had experimented with the RAVE adjustment in the field, and the engine accelerated best with the standard stiff springs, and the adjusting knobs turned out 1/2 turn. On the dyno, that's where the engine performed the best.

With the FAST twin pipes, which are designed for the modified 617, Gary's Mach 1 ran a best of 114 mph (radar) on good ice. That is even more impressive when you consider the fact that Gary is 6'5" tall, and weighs 275 lbs.

1991 MACH I 617 FAST MODIFIED 450-470MJ 44 CARBS FAST TWIN PIPES 149-79 ROTARY VALVE TIMING

Data for 29.92 Inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .700
Vapor Pressure: .52 Barometer: 30.21

RPM	CBT	CBHP	FUEL	BSFC	CAT
7000	69.5	92.6	64.4	.71	73
7250	69.5	95.9	66.6	.71	70
7500	68.6	98.0	70.4	.73	70
7750	70.3	103.7	72.5	.70	72
8000	75.9	115.6	74.2	.66	72
8250	78.0	122.5	77.4	.65	72
8500	81.2	131.4	85.1	.66	71
8750	80.6	134.3	87.1	.66	70
9000	74.0	126.8	85.2	.69	72

Gary tried 141-87 rotary valve timing, thinking that it might improve top end power. After this test, we reverted back to the original 149-79 timing.

1991 MACH I 617 FAST MODIFIED 450-470MJ 44 CARBS FAST TWIN PIPES 141-87 ROTARY VALVE TIMING

Data for 29.92 Inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .700
Vapor Pressure: .52
Barometer: 30.21

RPM	CBT	CBHP	FUEL	BSFC	CAT
7000	66.8	89.0	65.2	.75	73
7250	65.5	90.4	69.1	.78	72
7500	65.9	94.1	72.6	.79	73
7750	67.6	99.8	73.9	.76	72
8000	75.9	115.6	73.0	.65	73
8250	79.2	124.4	81.7	.67	73
8500	81.2	131.4	86.7	.67	72
8750	78.6	131.0	85.6	.67	72
9000	69.6	119.3	86.7	.74	72

For maximum horsepower, we jetted down to 400-420. This dropped the BSFC into the high .50's.

1991 MACH I 617 FAST MODIFIED 400-420MJ 44 CARBS FAST TWIN PIPES 149-79 ROTARY VALVE TIMING

Data for 29.92 Inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .700
Vapor Pressure: .52
Barometer: 30.20

RPM	CBT	CBHP	FUEL	BSFC	CAT
7000	70.3	93.7	63.6	.70	74
7250	71.6	98.8	67.4	.70	72
7500	70.7	101.0	68.0	.69	73
7750	73.8	108.9	67.5	.63	73
8000	76.8	117.0	69.2	.60	72
8250	79.7	125.2	71.9	.59	71
8500	82.1	132.9	75.5	.58	73
8750	82.3	137.1	79.6	.59	73
9000	78.5	134.5	81.5	.62	71

Standard factory 617 Mach 1X twin pipes were installed.



**1991 MACH I 617 FAST MODIFIED
400-420MJ 44 CARBS MACH IX TWIN PIPES
149-79 ROTARY VALVE TIMING**

Data for 29.92 Inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .700
Vapor Pressure: .52 Barometer: 30.17

RPM	CBT	CBHP	FUEL	BSFC	CAT
7000	71.1	94.8	56.6	.61	75
7250	69.8	96.4	60.6	.64	73
7500	73.7	105.2	65.4	.64	74
7750	77.7	114.7	66.1	.59	74
8000	80.8	123.1	69.7	.58	74
8250	81.7	128.3	72.1	.58	74
8500	79.5	128.7	74.6	.60	75
8750	76.0	126.6	77.2	.63	74
9000	59.1	101.3	76.7	.78	74

Standard CrankShop twin pipes, and also the CrankShop high RPM pipes were installed. The CrankShop high RPM pipes were more restrictive, and required slightly larger jets. Like the FAST and factory X pipes, they use the stock exhaust cannister.

**1991 MACH I 617 FAST MODIFIED
400-420MJ 44 CARBS CRANK SHOP TWIN PIPES
149-79 ROTARY VALVE TIMING**

Data for 29.92 Inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .700
Vapor Pressure: .52 Barometer: 30.16

RPM	CBT	CBHP	FUEL	BSFC	CAT
7000	74.5	99.3	62.1	.64	75
7250	76.0	104.9	63.1	.62	75
7500	74.5	106.4	65.5	.63	75
7750	75.3	111.1	66.2	.61	75
8000	80.0	121.9	68.3	.58	75
8250	81.2	127.6	72.0	.58	75
8500	81.4	131.7	76.8	.60	76
8750	78.4	130.6	78.6	.62	75
9000	50.2	86.0	75.5	.90	75

**1991 MACH I 617 FAST MODIFIED
420-440MJ 44 CARBS CRANK SHOP TWIN MOD PIPES
149-79 ROTARY VALVE TIMING**

Data for 29.92 Inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .700
Vapor Pressure: .52 Barometer: 30.15

RPM	CBT	CBHP	FUEL	BSFC	CAT
7000	71.9	95.8	61.9	.66	75
7250	70.5	97.3	64.5	.68	75
7500	71.8	102.5	66.1	.66	75
7750	74.6	110.1	66.3	.62	75
8000	76.6	116.7	68.2	.60	75
8250	79.7	125.2	74.5	.61	76
8500	81.6	132.1	78.7	.61	75
8750	81.8	136.3	76.1	.57	76
9000	76.1	130.4	77.9	.61	75

We installed the stock Y-pipe and single pipe. With a stock engine, the stock pipe provides a relatively flat torque and horsepower curve. The ported engine, however, is a mismatch for the low RPM single.

**1991 MACH I 617 FAST MODIFIED
420-440MJ 44 CARBS STOCK SINGLE PIPE
149-79 ROTARY VALVE TIMING**

Data for 29.92 Inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .700
Vapor Pressure: .52
Barometer: 30.16

RPM	CBT	CBHP	FUEL	BSFC	CAT
6000	68.5	78.3	61.0	.80	74
6250	69.5	82.7	63.5	.79	76
6500	70.7	87.5	66.5	.78	76
6750	70.5	90.6	68.5	.78	77
7000	72.9	97.2	70.9	.75	77
7250	82.4	113.7	72.9	.66	76
7500	79.2	113.1	77.8	.71	76


After reinstalling Gary's FAST twin pipes, we replaced the high compression head with a stock head, milled .010". Squish clearance was .060". The compression ratio figured out to be 12-1. Note that the power peak has slid up to 9000 RPM.

**1991 MACH I 617 FAST MODIFIED 12-1 COMPRESSION
420-440MJ 44 CARBS FAST TWIN FII PIPES
149-79 ROTARY VALVE TIMING**

Data for 29.92 Inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .700
Vapor Pressure: .52 Barometer: 30.14

RPM	CBT	CBHP	FUEL	BSFC	CAT
7000	67.2	89.6	61.6	.71	76
7250	67.3	92.6	64.6	.71	75
7500	67.5	96.4	66.6	.71	76
7750	68.9	101.7	66.7	.67	73
8000	68.4	104.2	66.9	.66	74
8250	74.4	116.9	70.7	.62	75
8500	76.9	124.5	74.1	.61	75
8750	79.0	131.6	77.9	.61	74
9000	78.2	134.0	79.1	.61	75
9250	72.8	128.2	81.5	.65	75

We tried to purchase a set of Decker 617 pipes prior to our test session. They were, however, out of stock.

Also, we replaced the Skidoo oil with some fairly expensive, special oil sold by FAST that they claimed would give us two more ft/lb of torque. The oil performed exactly like the standard Skidoo oil; Gary's engine had been "repeating" tests within a few tenths of a horsepower all day, and continued to do so, even with the "special" oil. No difference. 

PROJECT SLED INDY 500

TURBO

Turbo aficionado Kip Campbell sent us a letter that we published in Vol 2 #6, extolling the virtues and drawbacks of the Middlesex turbo systems. He described to us the excellent success he has had with both his turbocharged Indy 650, and his favorite, the turbocharged Indy 500.

Having owned an Indy 600 turbo, I was aware of the turbo's performance capabilities as well as the potential for fuel delivery problems.

With Kip's claim of having solved the fuel flow problem, I thought it would be interesting to try a Middlesex turbocharged Indy 500 with Forest Lake Motorsports' electronic fuel management system.

I purchased an Indy 500 turbo kit from Mike Mazar, owner of Middlesex Performance of Tyngsboro, Ma. (508-215-8555).

Then, I arranged to purchase a new Indy 500 Classic from Tim Dalbec of Forest Lake Motorsports and have Kip's guys set it up just like his. Kip tried to talk me into having SLP port the cylinder the way his was, but I opted to leave the porting stock, so we could analyze the performance improvement of the turbo alone.

Danny Blachfelner performed much of the work on the new Indy 500 Classic. This included installing forged Wiseco pistons, copper headgasket, SLP nosecone and nosecone radiator, hooker track, Middlesex turbo system, and FLMS fuel system. Terry also installed four colored, rectangular dash lights which turn on sequentially at 5, 10, 15, and 20 PSI of boost. The manifold mounted electric Hobb switches that control the lights also energize the fuel system (at 5 PSI) and the electric pump for the slide rail lube pump (at 10 PSI). A pair of air switches mounted in the turbo controller line served to raise the boost. The whole installation was clean and well thought out.

MINNESOTA LAKE TESTING

Last January, I spent a weekend as a guest of Kip and his wife Pat. On Friday night, the guys finished the turbo installation and picked the track. Saturday, we spent the day breaking in the engine and fine tuning the carbs and turbo controller.

Adjusting the two set screws on the turbo controller is one key to good turbo performance. Doing it correctly is kind of a "black art" which I still haven't mastered. In addition, for the controller to work properly, the carbs must be tuned to perfection. Needle position and needle jet size are critical. If you're off on either, no amount of controller adjustment will work quite right. Fortunately, Kip knew what he was doing, and the controller adjustment worked out fine after a few hours of tinkering.

The custom air toggle switches that raise turbo boost pressure do so by bleeding off the signal to the controller. It's a bit complicated (I still don't totally understand it) but using the pressure bleed-off method to raise the boost is convenient, although it seems to delay the boost pressure rise somewhat. A stronger controller spring, while being more expensive (\$250 for the modification from Middlesex!) results in more instantaneous boost.

With the standard "trail" boost, our stocker generated 11 PSI (a bit high, according to Mike Mazar) of boost pressure, and ran a bit stronger (the dyno would later verify that) than a stock RXL. With the toggle system engaged, the new Indy 500 turbo would produce 15 PSI of boost. At that level, the sled felt like (and the dyno would agree) a stock "02" 650 with good triple pipes.

At 15 PSI of boost, I was also getting a top end misfire, that would be cured later on the dyno by adding three more pounds of fuel pressure.

Kip's modified turbo was also maxing out at 15 PSI (it had previously been running as high as 23 PSI) due to the turbo being a bit "tired". With both sleds set at 15 PSI on VP C-16 gasoline, we ran them side by side on the lake. Then I wished that I had heeded Kip's advice to have the engine ported! The "stocker" seemed to have an edge initially, due to Kip's tired turbo spooling up a bit slower. (or was he just being merciful?), but at about 50 MPH, the modified 500 turbo would walk by and away, putting at least a "boxcar" between the sleds in a quarter mile. I can't imagine the modified engine at 23 PSI of boost!

Now that everything was set, it was back to Western New York and the C&H Dyno to see what we had.

TURBO CONTINUED

STOCK INDY 500 TURBO DYNO SESSION

The first thing we did on the dyno was detonate a piston because of the stale C-16 gasoline in my storage container (see Vol 3 #3, pgs. 11 & 12). With a new piston and fresh gasoline, the following dyno tests were typical of the stock turbocharged Indy 500 engine. Keep in mind that the stock Middlesex fuel system would probably be adequate at the standard 11 PSI boost level, which is supposed to be pump gas safe. When we increased the boost to 15 PSI, the FLMS variable fuel system set at 10 PSI over boost PSI was necessary for steady fuel delivery.

NOTE: The dyno measures boost pressure in inches Hg. A pressure of 2 inches Hg. is approximately equal to 1 psi.

1991 STOCK INDY 500 TURBO 340 MJ P8 NJ STANDARD BOOST 11 psi

Data for 29.92 Inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .710
Vapor Pressure: .26
Barometer: 30.19

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	BOOST (inHg)	CAT
6500	59.0	73.0	72.7	163.7	10.3	.97	21.47	41
6750	61.6	79.2	74.6	175.4	10.8	.92	22.41	42
7000	73.5	98.1	75.7	208.1	12.6	.76	22.59	41
7250	77.1	106.4	73.4	220.0	13.8	.67	23.21	39
7500	76.5	109.2	73.4	221.8	13.9	.66	23.56	40
7750	72.3	106.7	73.4	221.1	13.8	.67	22.69	41
8000	67.6	103.0	76.6	218.7	13.1	.73	23.01	41
8250	62.4	98.0	77.1	214.2	12.8	.77	22.81	41

1991 STOCK INDY 500 TURBO 340 MJ P8 NJ 15 LB BOOST

Data for 29.92 Inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .710
Vapor Pressure: .26
Barometer: 30.07

RPM A	CBT	CBHP	FUEL	AIR	A/F	BSFC	BOOST (inHg)	CAT
6750	68.4	87.9	73.3	187.7	11.8	.82	21.29	45
7000	71.4	95.2	77.8	198.2	11.7	.81	22.76	45
7250	75.0	103.5	78.2	206.8	12.1	.75	24.78	45
7500	80.2	114.5	78.8	217.0	12.6	.68	26.57	46
7750	82.0	121.0	77.6	224.5	13.3	.63	28.46	45
8000	82.3	125.4	77.5	229.5	13.6	.61	30.10	44
8250	77.8	122.2	76.8	228.9	13.7	.62	31.74	45
8500	72.5	117.3	73.5	227.8	14.2	.62	31.97	44
8750	64.5	107.5	73.9	219.0	13.6	.68	30.82	45

NEW YORK TRAIL TESTING

We made another trip to the Old Forge, N.Y. area for some trail riding and lake racing with the stock Indy 500 turbo. The first thing I found out about cruising the trails with this turbo was that the needle clip position had to be exactly right or the engine wouldn't run at all. If the clip position was one step rich, the engine would bog and drown in fuel in the transition from part to open throttle. If the clip position was one step lean, the engine would occasionally lean misfire and sneeze. If it was just right, it was fine. As the temperature changed during the day, I had to change the needle clip position to keep the engine running crisply.

Running the trails with a turbo can be fun; one learns to deal with the minor turbo lag by anticipating in advance when the power is needed. The quiet, vacuum cleaner like "whoosh" of the turbo is quite pleasant.

With the standard boost, the stock turbo 500 runs on the lake very respectably with correctly tuned 617, 650 & 700 stockers.

Turbocharging isn't for everyone; the real enjoyment of the turbocharged stock Indy 500 Classic is being able to run with the big sleds, but still have the advantage of being the "underdog". But the memory of Kip's modified Indy 500 turbo waiting by my stocker lingers in my mind.

FIRST CHOICE AUTO SALES' MODIFIED INDY 500 TURBO

Late last winter, Greg Bennett of First Choice Auto Sales in Avon, N.Y. (716-226-2929), became a Middlesex Turbocharger sales and installation center. Greg is one of the Old Forge, N.Y. lake racing fanatics that I spoke of in Vol3 #2, pg. 2.

After having experimented with normally aspirated full mod engines, nitrous injection, and even supercharging, and after seeing how well Gary Udinson's Middlesex turbo 650 mod did the previous year, Greg hopped on the turbo bandwagon. He spent the better part of a week with Mike Mazar, and now understands the Middlesex systems and how to properly set them up.

Porting the 650 and 500 engines specifically for turbocharging is another area in which Greg spent considerable time experimenting. With the help of Dave Phillips of D.P. Tool and Die in Honeye Falls, N.Y., they came up with some amazing mod turbo Polaris engines. Amazing not only in top end horsepower, but also in building immediate boost for dragracing.

Well tuned turbo sleds typically are a bit lazy off the line, then build boost for a wicked top end rush. But, with a

TURBO CONTINUED

perfect combination of porting, jetting, controller adjustment, and clutching, Greg's own rubber tracked, full bodied modified Indy 500 Turbo comes out of the hole as hard as the best carbureted 650-800 mods up on Big Moose Lake.

As I was observing the festivities at Big Moose Lake, there were a good 15 light and heavy mod sleds that Greg's 500 turbo was giving fits to in 750 feet.

Here's Greg's modified Indy 500 turbo, at 15 PSI boost pressure, with the Middlesex fuel system. Notice that the fuel is just drizzling into the carburetors. This engine is on the ragged edge, surviving this way at boost for 750 feet. Greg might benefit from a better fuel system.

1991 MODIFIED INDY 500 TURBO 340 MJ Q0 NJ 15 LB BOOST

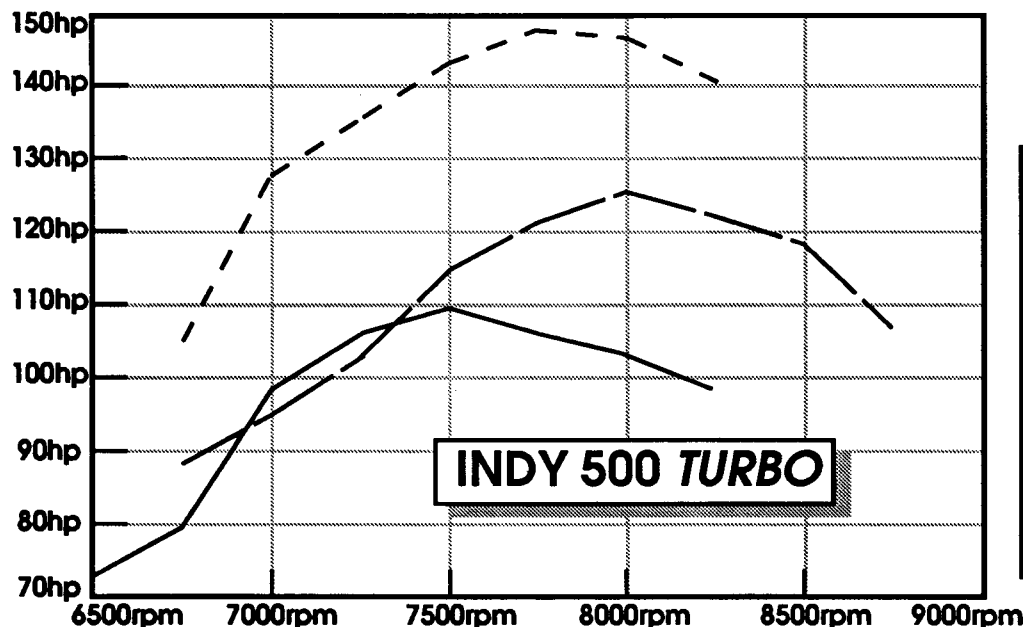
Data for 29.92 inches Hg, 60 F dry air
Test: 100 RPM/Sec Acceleration
Fuel Specific Gravity: .710
Vapor Pressure: .26
Barometer: 30.11

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	BOOST (in Hg)	CAT
6750	82.1	105.5	23.3	227.5	44.8	.22	26.07	46
7000	96.1	128.1	22.2	268.8	55.6	.17	29.13	46
7250	98.7	136.2	22.2	278.8	57.6	.16	29.88	47
7500	99.9	142.7	22.2	289.1	59.8	.15	30.05	48
7750	100.0	147.6	22.2	293.1	60.6	.16	30.15	47
8000	96.1	146.4	.0	297.5	.0	.00	30.80	47
8250	89.1	140.0	.0	296.0	.0	.00	30.25	47

We've dyno tuned enough turbocharged Polaris triples to know that the standard Middlesex fuel system, with its marine "booster" pump, usually works fine with standard boost levels (7-10 PSI). Typically, when boost levels are increased beyond that, the fuel flow of the Middlesex system is at best erratic, often nonexistent. As the boost-assisted resistance of the needle and seats becomes too much for the fuel pressure to overcome, the engine will run for a very short time on the contents of the float bowls, supplemented by an erratic trickle of fuel that delays the inevitable gradual leaning out to misfire or deto.

This is not conjecture; we've seen it many times on the dyno. When boost levels are increased either by changing the turbo controller spring, or interrupting the pressure signal to the controller, fuel flow is compromised. When dyno tuning turbo engines, we always pay close attention to the BSFC readout (the SuperFlow dyno measures and computes the amount of fuel entering the carburetors). When the boost pressure overpowers the fuel pressure, the BSFC rapidly drops from .60 to .20 or lower (an absurd number that shows the engine is operating on the contents of the float bowls!). Then, we have but a few seconds to abort the test before the engine leans out to a sneeze or worse.

The fuel system that Kip Campbell and the guys from Forest Lake Motor Sports use on the high boost turbos is a high pressure EFI electric fuel pump, controlled by an adjustable boost sensing pressure regulator. As the boost increases, the fuel pressure is automatically increased. On the dyno, the Middlesex turbo engines require eight to ten pounds of fuel pressure higher than boost pressure. At 15 PSI of boost, 23-25 PSI of fuel pressure assures smooth fuel delivery.





FEEDBACK

JIM CZEKALA

INDY 500 UPDATE

In Vol.3 #1, we tested Pete Webb's Indy 500 with bored carbs, gutted airbox and increased compression. His wife used it for her trail sled last season, and had 1500 miles of trouble-free trail riding and lake racing miles.

Pete wound up cutting .025" from the head surface, because the copper headgaskets we used for testing on the dyno wouldn't seal consistently. He set the sled up with his bored carbs with 310 main jets, Q-4 needle jets, and stock needles, pilots, and slides, at 20 degrees and 2000 ft. altitude. I saw the sled run in the mid nineties on radar, on decent ice for a distance of 1/2 mile or more, on indicated 92 octane pump gas. No detonation, no problem.

THIS YEAR'S AMERICAN SNOWMOBILER/DYNOTECH MUSCLE SLED SHOOTOUT

Our plan is a bit different this year. The dealers in the Old Forge, N.Y. area are going to police each other to make sure there are no "ringers". As a group, they will visit each dealership to randomly select one of each "entrant", among the many crated muscled sleds in each dealer's warehouse. This year, Big Moose Yamaha/Arctic Cat, Smith Marine SkiDoo, and Don's Polaris will provide test sleds.

This same group will assemble, prep, and preseat each muscled sled, and then bring them to the dyno for breakin, certification (double-checking their "stockness"), and final sealing.

Initially, we're going to be running the sleds absolutely box stock, with no jetting changes, other than those suggested by the manufacturers for temperature and altitude. Each sled will have an identical amount of locally purchased premium pump gas.

There's a good chance that we'll have a set of timing lights this year, eliminating human error from the elapsed time numbers. Tim Bender should be able to drive the sleds again (he doesn't want to miss the famous Van Auken's Inne shrimp cocktail).

After our box-stock test session, we may have the dealers reclutch and rejet the sleds as they may deem necessary, and run them again.

We have a few months before the Old Forge, N.Y. SnoDeo winter carnival. So, anyone with suggestions on how to make this year's shootout "perfect", please drop us a line.

DYNOTECH CLASSIFIED PAGE

We've had many requests to start a subscribers' classified page. So, let's give it a shot. If you are a subscriber, and would like to try selling something performance related (sleds, engines, parts, etc.), send us (mail only, please) some ad copy, and 50 cents for each large word (check, money order, or MC/VISA only).

ASK KEVIN

Kevin Cameron suggested that it might be fun to have subscribers direct technical questions to him, and publish his answers. Two-stroke tuning and theory are his favorite pastime, so feel free to pick his brain.

Send your technical questions to Kevin Cameron, c/o DynoTech, P.O.Box 801, Batavia, N.Y. 14021.

TURBOCHARGING & EFI

We have one subscriber (company) out west who is working with Injection Research Services on developing an EFI turbo kit for most snowmobile performance engines. You may have seen their snowmobile turbo systems and dyno room shown on "Trucking USA" recently. They have an exclusive deal to market the IRS systems that measure positive intake pressure. If and when they have a kit ready for market, we'll try to get one to test.

YAMAHA V-MAX 4 PERFORMANCE IMPROVEMENTS

We've spent probably three weeks (and 450+ test runs) on the dyno so far with Bender Racing and the new Yamaha V-Max 4. Extremely promising prototype pipes and porting specs have been developed. When the production stuff is ready, we'll test it and publish the results.

WANTED...MORE PROJECT TEST ENGINES!!!

Anyone who has a "one step at a time" engine project in mind, please let me know. Start with a stock engine, then try differently ported cylinders, carbs, various compression ratios, head designs, etc.

Gary Potyok has a Formula Plus step-by-step factory hopup in mind. Tim Taylor has some Polaris "02" cylinder experiments he wants to try. Joe DiSpirito is going to examine various combustion chamber shapes on a 700 Wildcat.

Anyone else?

COMMONSENSE COMBUSTION HAMBERS

KEVIN CAMERON THE CELLAR DWELLER

Tuners, sooner or later, come to the question of cylinder head design. The object of the game is to run the highest usable compression ratio, and to shape the combustion chamber so we can run this high ratio without destructive detonation. The variables—aside from compression ratio itself—are squish area, clearance and angle. But what percentage of the bore area should be devoted to squish? What should the squish clearance be? At what angle should the squish band be cut?

Ask ten people about these variables and get ten sets of answers; engine guru A says 50% squish, clearance .036", at twelve degrees, engine guru B says 40%, .040" and fourteen, and so on.

Is there truth in this business, or is there only an endless life on the dyno, trying every combination and permutation?

For years, many tuners and engineers have arbitrarily chosen to use 50% squish. Then, using some arbitrary angle that approximates the outer part of the piston—twelve to fourteen degrees usually—they have tried various combinations of squish clearance and compression ratio to come up with something that works most of the time. This then becomes "truth" for that engine, that tuner, etc.

Let's go back further than this—back to some basics about combustion. When the spark ignites the charge, there is a short delay while the tiny flame nucleus grows large enough to raise cylinder pressure measurably. Then a wrinkled, highly convoluted flame front expands outward from this nucleus toward the cylinder wall.

The remarkable and overlooked fact is that when this flame has moved 80% of the distance from sparkplug to cylinder wall, only half the charge has been burned. As charge burns, it expands, compressing the unburned charge. In a combustion chamber with a central plug, the unburned charge is shoved outward, crowded against the cylinder wall.

Even in an engine with no squish at all, this compression of unburned charge means that 1-3% of the charge is crammed into the tiny crevice volumes associated with the top piston ring. When there is squish, another, far larger volume of charge is jammed into the squish band. Both of these volumes of charge will not burn near TDC because they are so cooled by the near presence of piston and cylinder head metal—thousands of degrees cooler than the flame itself. Much of this hidden away charge will eventually burn, but late in the cycle, when the piston is well advanced into its downstroke. It can't expand out of the squish band or crevice volume until cylinder pressure falls enough to permit it. It will burn when it does escape, and contribute heat, but it will do nothing for peak combustion pressure so it is largely wasted as a source of power.

This is intolerable. Something must be done about it.

But what is the reason for using squish in the first place? Maybe squish is so valuable in its own right that we ought to accept these losses cheerfully.

Squish does two things. First, using squish allows us to make the main combustion chamber smaller, which may shorten its burn time. Second, a jet of fast moving charge is ejected from the squish space as the piston ap-

proaches TDC. This squish velocity peaks at about 10 degrees BTDC. The extra turbulence created by the squish clearance accelerates the flame speed by putting extra wrinkles in the flame front, so it is "eating" charge over a larger surface area.

Why is higher flame speed desirable? Mainly because detonation is a time dependent phenomenon; the longer it takes to burn the charge, the longer there is for the chemical pre-conditions of detonation to occur, and the more likely the engine is to knock. Quick, smooth combustion is what we want.

When we increase the squish area as a percent-

...unfortunately there is only one way to find out what will work; experiment near the edge.

THE CELLAR DWELLER

CONTINUED

age of bore area, we increase turbulence. The same thing happens when we tighten up the squish clearance. Is more turbulence always better? No, for as we increase turbulence, we also increase heat transfer from the hot combustion gases to the piston and head. Adding turbulence eventually reaches a point at which the extra power we might get from raising the compression (permitted by rapid combustion) is more than offset by rising heat loss. This effect is why a big compression increase often helps acceleration but hurts top speed; the extra turbulence is useful at middle RPM where the engine's gas flow supplies less turbulence, but it becomes harmful at top end when the intake process supplies plenty of turbulence on its own. Yes, you can definitely have too much turbulence.

If we arbitrarily choose 50% squish, or a clearance of .040", or whatever, we can find a workable value for the other variables by testing. But that doesn't make the arbitrary initial choices correct, or optimal. Where is the truth?

The truth is this; any volume of charge that is not burned near TDC is a loss. Therefore we must reduce the volume of charge trapped in remote areas--without sacrificing the turbulence we need. How must we do this? First, the squish clearance must be reduced to the mechanical minimum--the point at which any thinner and the piston will strike the head. This will typically be in the range of .015"-.025" and unfortunately there is only one way to find out what will work; experiment near the edge. It's not as bad as it sounds--light contact is seen as a brightened area on the piston, and unless you grab a big handful of negative space, you won't lose the engine.

The question of squish angle disappears once you accept the idea that we want the absolute minimum volume of charge trapped in the squish (or anywhere else) near TDC. Contour the head to match the piston--maintaining the minimum piston-to-head clearance everywhere.

Remember that the purpose of all this is to burn charge that would otherwise be lost in crevice and squish spaces--and to burn it at the highest compression ratio your engine can use. Keep squish clearance at the mechanical minimum and vary only combustion chamber volume by welding and cutting. If the engine knocks at the compression ratio you think you ought to be able to get away with, try increasing the squish area. This means either cutting a new head or filling the head you

have by welding, then re-machining to get a wider squish area, then cutting the chamber to get the compression ratio you want to test. You will have to find the ignition timing for best torque in each test.

This is a laborious process, but it will yield results you will like--not like the old haphazard business of simultaneously changing compression ratio and squish clearance by cutting only the gasket clearance of the head, with your head whirling on a sparkplug mandrel in the old Atlas lathe you bought for \$50. Join the late 20th century.

POSTSCRIPT: Engineers are doing all sorts of things to piston rings and their grooves to get rings to live and not stick when the ring grooves are moved upward toward the piston crown. Moving the ring up reduces crevice volume, as noted above. Yamaha is reputedly plating rings with titanium carbide, a super-hard, slippery semi-ceramic. Honda is anodizing their ring grooves. The same trend has existed in NASCAR racing for years; push those rings up! Everyone is interested in ways to cool pistons more effectively; it is when the ring grooves reach a certain temperature level that carbon formation and sticking occur. On diesel engines, which compress only air, not mixed charge, the rings are located as far down as temperature considerations require--crevice volumes can't hide any fuel. Oils containing large percentages of detergents (such as Yamalube R) are more resistant to sticking (and therefore to high groove location) than are some others. Some synthetics are highly resistant to oxidation and this would also be more tolerancy of high ring location.

The ignition delay period noted above might take up ten or so crank degrees. Firing at the often used ignition timing of 20 BTDC would then produce a glowing flame just at the time that squish velocity was peaking--10 BTDC. Maybe it all works out. 🐼

DYNOTECH is an independent newsletter published by **DYNOTECH** Corp., P.O. Box 801 Batavia N.Y. 14021, in affiliation with C&H Dyno Service, 8 Apollo Drive, Batavia, N.Y. 14020. Subscription rate is \$30.00 per year (six issues). Phone: 716-344-1313. No part of this publication may be printed or otherwise reproduced without express permission from the publisher. Send address changes to **DYNOTECH**, P.O. Box 801, Batavia, N.Y. 14021. **DYNOTECH** makes every effort to assure the accuracy of articles and technical information listed in this newsletter. **DYNOTECH** assumes no responsibility for damages due to errors, omissions, or applications of any information.

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