Volume 1 Number 2 1988

DYNOTECH

THE SNOWMOBILE PERFORMANCE PUBLICATION

RAVE?

'89 SKIDOO MACH I
STOCK DYNO EVALUATION

Our first discovery concerning the Mach I occurred prior to testing–*it requires an all new clutch removal tool.* Since none were available from Bombardier on our scheduled test date, we had to have one custom made. Also, the crankshaft surprised us with a new metric bolt size that resulted in a frantic search around town for a short 14mm bolt to secure our dyno adapter to the crank.

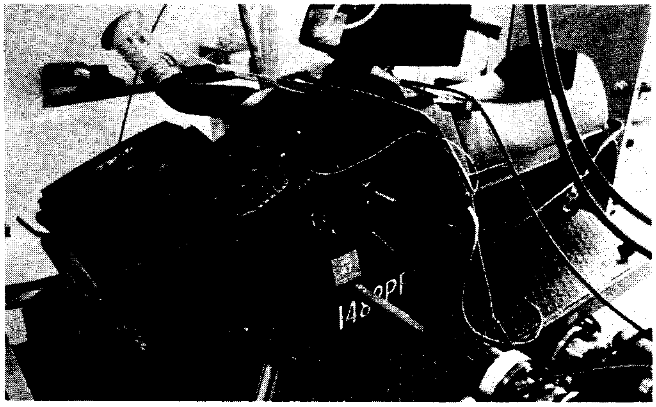
The main jets were reduced according to our Mikuni calculator to 230-260. While breaking in the engine, we checked the carburetion at various speeds and throttle positions searching for lean spots. None were found.

The most unique engineering feature of the Mach I is the **RAVE**, which stands for **R**otax **A**utomatic **V**ariable **E**xhaust. This is a guillotine like valve in the top of the exhaust port that alters exhaust timing as engine speed increases. The valve is controlled by an exhaust back pressure activated diaphragm regulator attached to the top of the exhaust port. Inside the dome of the regulator is an externally adjustable preload spring that comes preset in the tightest position.

(continued on page 2)

PIPE SHOOTOUT #2

Stock Yamaha Phazer



The Yamaha Phazer is one of the most popular sleds on the market and responds beautifully to the addition of an aftermarket pipe.

There are more performance pipes available for the Yamaha Phazer than any other snowmobile. We acquired five new single pipes for our Stock Phazer Pipe Shootout. Additionally, we bought a set of PSI's new twin pipes which are sold only for use on modified engines with slide carburetors--these are being reserved for our upcoming Modified Phazer Pipe Shootout.

(continued on page 4)

STOCK MACH 1
Standard Corrected Data for 29.92 inches Hg. 60 F dry air.

TEST: 100 RPM/Sec Accl.
FUEL SPECIFIC GRAVITY: .711
VAPOR PRESSURE: .70
BAROMETRIC PRESSURE: 29.78

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT	WAT
5000	44.0	41.9	26.8	93.0	15.9	.67	75	97
5250	46.9	46.9	35.0	100.1	13.1	.78	75	97
5500	48.3	50.6	39.2	106.0	12.4	.81	74	97
5750	51.5	56.4	45.8	115.8	11.6	.85	75	99
6000	51.4	58.7	50.3	123.8	11.3	.90	75	98
6250	57.0	67.8	54.5	133.2	11.2	.84	76	98
6500	63.9	79.1	52.4	142.5	12.5	.70	76	98
6750	65.8	84.6	51.6	150.0	13.3	.64	75	97
7000	66.6	88.8	50.8	153.6	13.9	.60	76	97
7250	66.4	91.7	52.5	155.9	13.6	.60	77	97
7500	64.0	91.4	54.1	157.2	13.3	.62	76	97
7750	59.0	87.1	60.5	156.6	11.9	.73	73	98
8000	44.3	67.5	59.0	151.6	11.8	.92	75	98

RAVE LOCKED CLOSED
Standard Corrected Data for 29.92 inches Hg. 60 F dry air.

TEST: 100 RPM/Sec Accel.
FUEL SPECIFIC GRAVITY: .711
VAPOR PRESSURE: .70
BAROMETRIC PRESSURE: 29.77

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT	WAT
5000	42.2	40.2	24.0	88.2	16.9	.63	75	94
5250	47.3	47.3	31.2	96.9	14.3	.69	73	94
5500	51.1	53.5	43.6	108.4	11.4	.85	74	95
5750	56.1	61.4	47.4	115.7	11.2	.81	75	95
6000	64.1	73.2	52.0	130.3	11.5	.74	75	96
6250	66.1	78.7	55.4	137.2	11.4	.74	75	96
6500	66.6	82.4	53.4	141.5	12.2	.68	76	96
6750	65.9	84.7	54.1	145.5	12.3	.67	75	96
7000	63.0	84.0	52.9	148.4	12.9	.66	74	97
7250	57.7	79.7	48.8	148.5	14.0	.65	76	97
7500	47.6	68.0	50.8	146.2	13.2	.79	75	97
7750	36.8	54.3	55.1	141.8	11.8	1.07	74	97
8000	30.4	46.3	56.3	136.4	11.1	1.29	74	97

STRETCH SPRING 1/2"
Standard Corrected Data for 29.92 inches Hg. 60 F dry air.

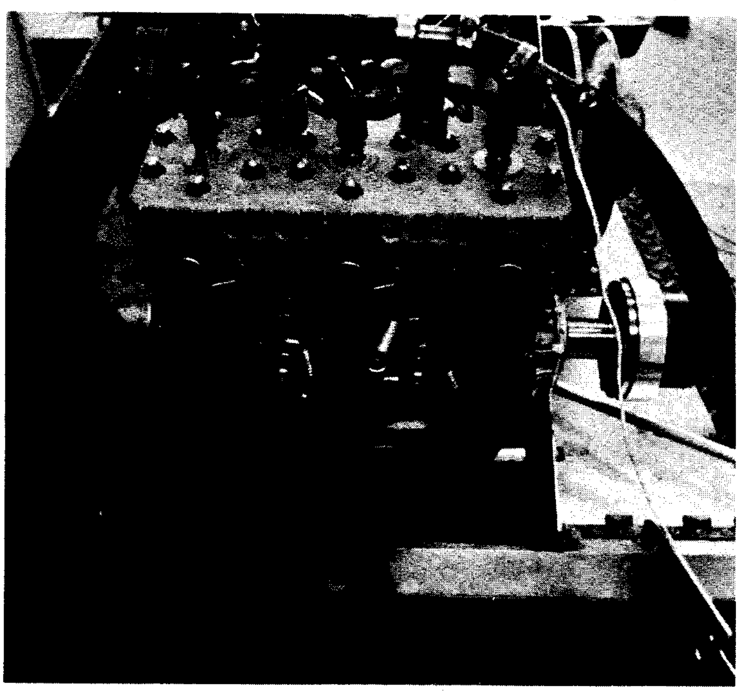
TEST: 100 RPM/Sec Accel.
FUEL SPECIFIC GRAVITY: .711
VAPOR PRESSURE: .70
BAROMETRIC PRESSURE: 29.77

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT	WAT
5000	43.4	41.3	26.8	92.9	15.9	.68	73	81
5250	45.3	45.3	33.8	99.2	13.5	.78	74	81
5500	48.3	50.6	40.8	106.5	12.0	.85	74	81
5750	55.0	60.2	48.9	120.7	11.3	.85	76	80
6000	57.4	65.6	52.2	126.1	11.1	.84	77	80
6250	55.8	66.4	53.0	131.6	11.4	.84	76	79
6500	61.5	76.1	53.7	140.9	12.0	.74	74	80
6750	65.1	83.7	53.3	148.4	12.8	.67	74	80
7000	66.5	88.6	51.9	152.3	13.5	.61	75	80
7250	65.9	91.0	50.8	155.2	14.0	.59	74	81
7500	64.1	91.5	51.8	155.4	13.8	.59	75	81
7750	58.9	86.9	61.0	154.8	11.7	.74	74	81
8000	44.2	67.3	61.4	150.0	11.2	.96	74	82

RAVE LOCKED OPEN
Standard Corrected Data for 29.92 inches Hg. F dry air.

TEST: 100 RPM/Sec Accel.
FUEL SPECIFIC GRAVITY: .711
VAPOR PRESSURE: .70
BAROMETRIC PRESSURE: 29.78

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT	WAT
5000	35.8	34.1	25.6	87.5	15.7	.79	75	89
5250	39.2	39.2	35.2	95.1	12.4	.95	76	89
5500	42.7	44.7	44.0	104.2	10.9	1.04	77	89
5750	49.2	53.9	48.7	115.7	10.9	.95	78	89
6000	53.2	60.8	50.8	124.2	11.2	.88	78	89
6250	57.0	67.8	53.7	131.0	11.2	.83	78	89
6500	62.6	77.5	54.5	139.3	11.7	.74	78	89
6750	64.8	83.3	53.1	144.8	12.5	.67	78	89
7000	65.8	87.7	51.0	150.0	13.5	.61	78	89
7250	66.4	91.7	51.0	153.6	13.8	.59	77	90
7500	64.2	91.7	53.1	155.4	13.4	.61	76	90
7750	60.3	89.0	58.8	154.1	12.0	.70	76	90
8000	47.4	72.2	59.6	150.4	11.6	.87	78	91



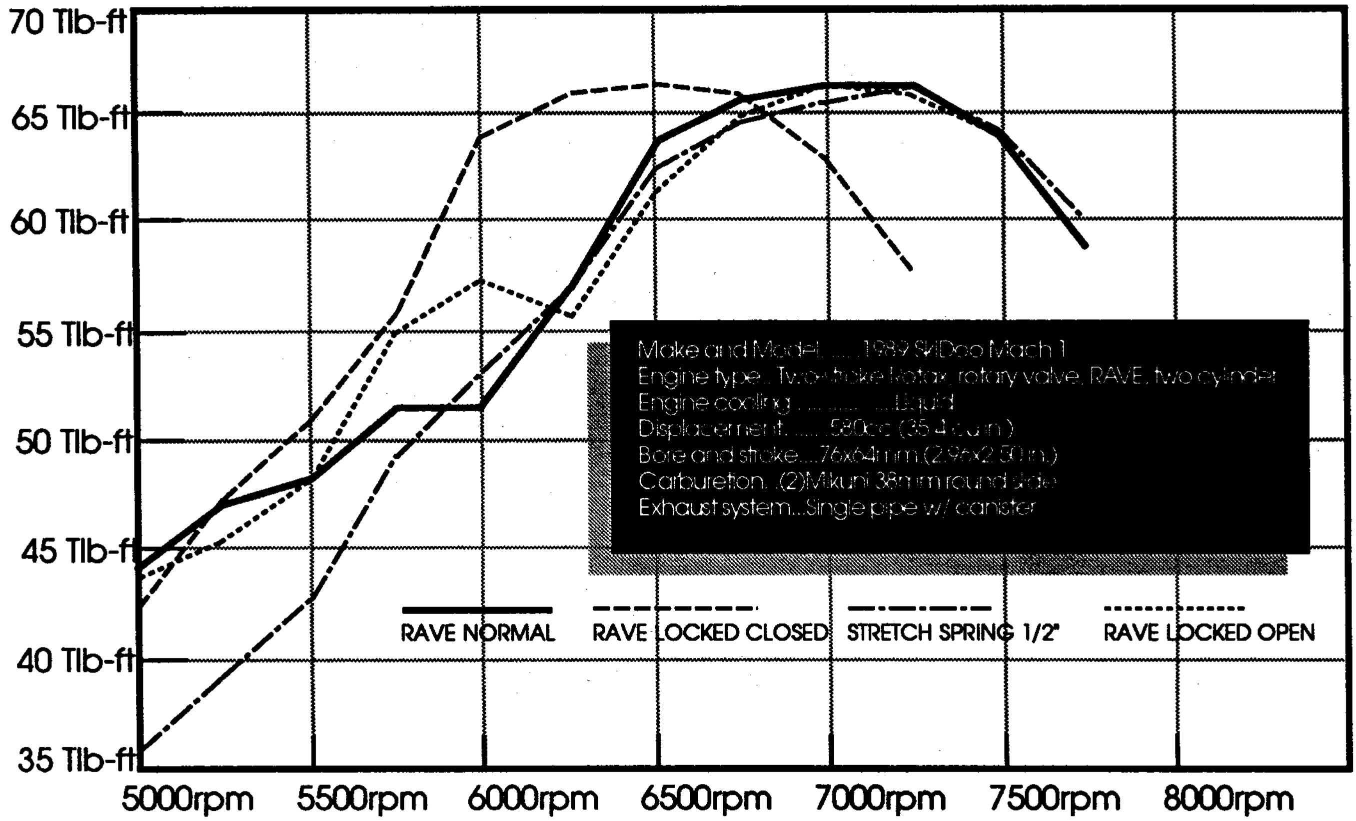
This" MACH 1 1/2", built by The Crank Shop in Essex Junction, Vermont, has two rotary valves and 187+ CBHP.

As revealed in our graphs, the valve opens much too early. To take full advantage of the extra mid-range torque and horsepower available from the variable exhaust, the RAVE should not begin opening until 6500 RPM. Stretching the preload springs 1/2" improved the situation, but a stiffer spring rate appears necessary.

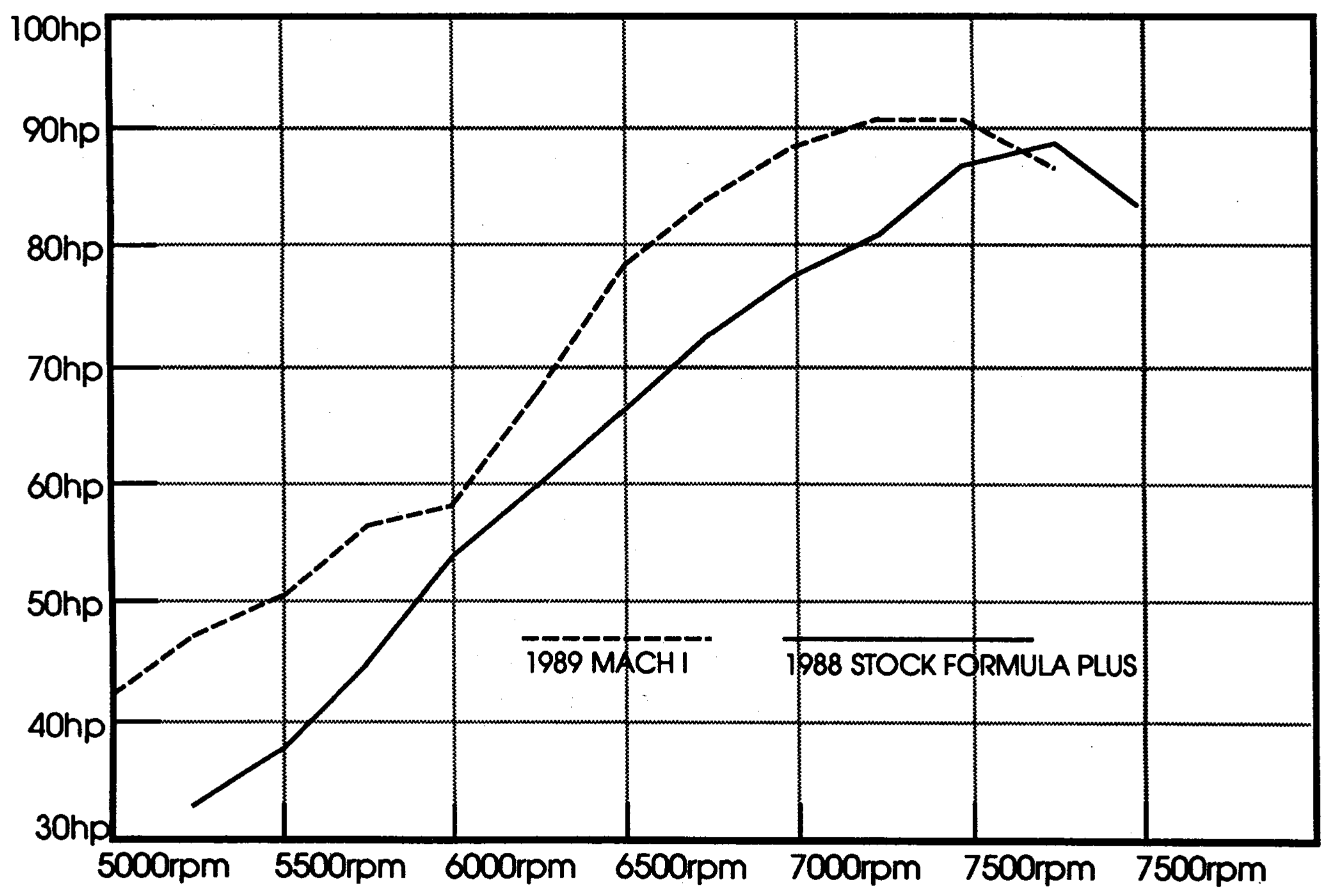
Generally, our dyno runs are conducted slow and gradual, much like accelerating the sled from a standstill in deep, heavy snow. This is when Mach 1 owners have the greatest need for extra torque which the RAVE fails to deliver by opening too soon.

A future DYNOTECH project will involve sampling various springs in an effort to perfect the RAVE functions. We will also increase the acceleration rate of the engine on the dyno to determine whether the RAVE reacts differently. If it does, perhaps the stock spring represents a compromise necessary to allow the RAVE to open quickly during the transition from part throttle, high RPM cruising with the RAVE closed, to full throttle RAVE open. ➧

MACH I RAVE EFFECT ON TORQUE (CORRECTED BRAKE TORQUE)



MACH I VS. 1988 STOCK FORMULA PLUS (CORRECTED BRAKE H.P.)



(Pipe Shootout #2 continued from page 1)

The Phazer engine uses a plastic "boost tube" connecting the two intake ports between the carbs and the reed cages. This enables the alternating cylinders to draw air and fuel from *both* carburetors. When the intake port closes on one cylinder, the high velocity column of air is trapped by the piston skirt and its own inertia. It then bullies its way into the adjacent cylinder, which is conveniently on its intake stroke, via the boost tube. As a result, the Mikuni 32mm butterfly carbs are more than adequate *in terms of air flow capacity.*

The *problem* with the stock carbs is their lack of tuneability in the midrange. You can see from the dyno data that the A/F ratio is quite lean at low speed WOT. As far as we are aware, no one has yet figured a way to richen the low velocity mixture. This is acceptable on stock engines, but can become a problem as more horsepower is developed through porting, higher compression, or feeding cold air to the intake.

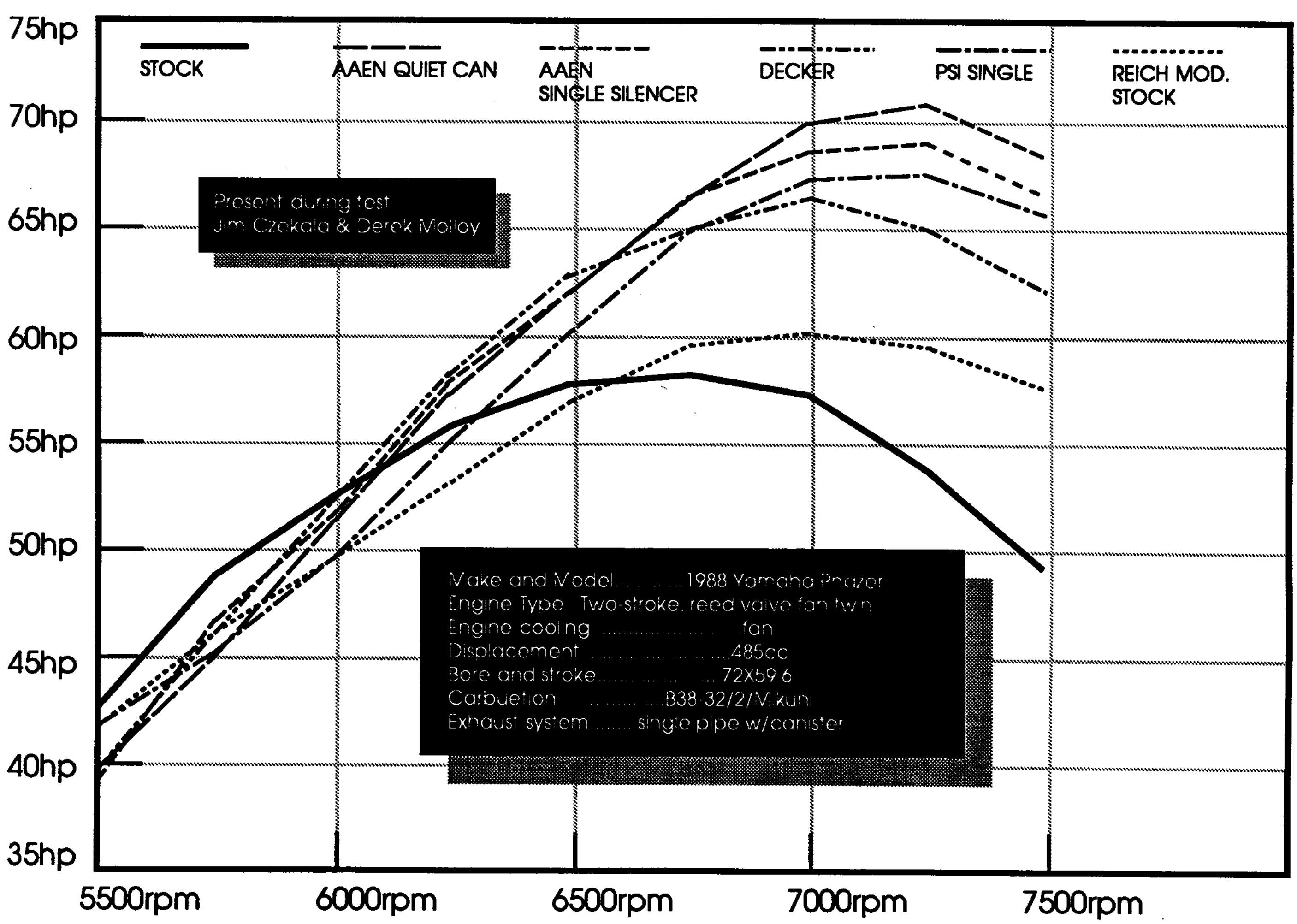
Normally, Phazers make about 52-56 CBHP. The Phazer used for our Pipe Shootout made a strong 58 CBHP--due in part to the VP C-12 gasoline which the Phazer seems to like, and the mid 60's CAT.

Like its big brother the Exciter, the Phazer has been destined by Yamaha to breath nasty 80+ degree underhood air. However, with our SuperFlow air flowmeter installed, the Phazer engine was treated to the cool fall air blowing from our ventilation ducts.

Dyno testing an air cooled engine requires that we pay particular attention to engine temperature in order to obtain the repeatability of results (easily attained on liquid cooled engines) that **DYNO*TECH*** demands. Once the engine was "heat soaked", we allowed exactly three minutes cooling time between acceleration tests on the dyno. Each pipe was run three or more times, and the test data stored on the computer disc.

We tested the engine on the dyno with two different stock pipes to assure a fair and accurate baseline.

(CORRECTED BRAKE H.P).



STOCK PIPE BASELINE...(N/A)dB

Standard Corrected Data for 29.92 inches Hg. 60 F dry air.

TEST: 100 RPM/Sec. Accel.
FUEL SPECIFIC GRAVITY: .695
VAPOR PRESSURE: .52
BAROMETRIC PRESSURE: 29.95

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
5500	40.9	42.8	34.1	112.8	15.2	.81	64
5750	44.7	48.9	37.5	112.6	13.8	.79	66
6000	46.2	52.8	41.0	110.5	12.4	.80	66
6250	47.2	56.2	41.9	108.7	11.9	.76	66
6500	47.0	58.2	41.8	109.0	12.0	.74	66
6750	45.4	58.3	42.3	108.4	11.8	.74	66
7000	42.9	57.2	42.4	107.8	11.7	.76	65
7250	39.0	53.8	41.2	104.5	11.6	.78	66
7500	34.5	49.3	41.2	101.2	11.3	.86	66

REICHARD MODIFIED STOCK PIPE...(N/A)dB

Standard Corrected Data for 29.92 inches Hg. 60 F dry air.

TEST: 100 RPM/Sec Accel.
FUEL SPECIFIC GRAVITY: .695
VAPOR PRESSURE: .52
BAROMETRIC PRESSURE: 29.95

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
5500	40.0	41.9	32.7	112.0	15.7	.80	66
5750	42.1	46.1	35.2	111.0	14.5	.80	66
6000	43.7	49.9	40.3	107.0	12.2	.83	66
6250	44.7	53.2	41.1	107.1	12.0	.79	65
6500	46.4	57.4	42.1	108.4	11.8	.75	66
6750	46.5	59.8	41.8	105.8	11.6	.72	66
7000	45.4	60.5	41.7	109.8	12.1	.71	66
7250	43.4	59.9	42.3	109.7	11.9	.72	66
7500	40.3	57.5	41.6	108.9	12.0	.74	66

PSI SINGLE PIPE...(N/A)dB

Standard Corrected Data for 29.92 inches Hg. 60 F dry air.

TEST: 100 RPM/Sec Accel.
FUEL SPECIFIC GRAVITY: .695
VAPOR PRESSURE: .52
BAROMETRIC PRESSURE: 29.95

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
5500	39.9	41.8	32.6	108.3	15.3	.80	67
5750	41.3	45.2	33.8	108.8	14.8	.77	64
6000	43.6	49.8	39.0	105.8	12.5	.80	64
6250	46.4	55.2	39.3	104.8	12.2	.73	64
6500	48.9	60.5	40.7	105.8	11.9	.69	65
6750	50.8	65.3	41.2	103.6	11.5	.65	66
7000	50.8	67.7	42.7	105.6	11.4	.65	66
7250	49.2	67.9	43.2	108.9	11.6	.65	65
7500	46.2	66.0	43.3	106.7	11.3	.67	65

DECKER PIPE...90 dB

Standard Corrected Data for 29.92 inches Hg. 60 F dry air.

TEST: 100 RPM/Sec Accel.
FUEL SPECIFIC GRAVITY: .695
VAPOR PRESSURE: .52
BAROMETRIC PRESSURE: 29.95

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
5500	38.1	39.9	32.2	109.7	15.6	.83	68
5750	42.1	46.1	34.9	109.6	14.4	.78	68
6000	45.8	52.3	38.7	106.8	12.7	.76	68
6250	49.0	58.3	40.8	106.3	12.0	.72	68
6500	50.9	63.0	41.9	107.1	11.7	.68	67
6750	50.8	65.3	43.3	104.6	11.1	.68	68
7000	50.0	66.6	42.7	105.5	11.3	.66	68
7250	47.2	65.2	43.1	105.2	11.2	.68	68
7500	43.5	62.1	41.8	103.4	11.4	.69	68

AAEN SINGLE SILENCER PIPE...90 dB

Standard Correct Data for 29.92 inches Hg. 60 F dry air.

TEST: 100 RPM/Sec. Accel.
FUEL SPECIFIC GRAVITY: .695
VAPOR PRESSURE: .58
BAROMETRIC PRESSURE: 29.99

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
5500	37.4	39.2	32.2	108.2	15.4	.84	66
5750	42.7	46.7	36.0	110.6	14.1	.79	65
6000	45.5	52.0	40.6	106.3	12.0	.80	67
6250	48.8	58.1	40.8	105.7	11.9	.72	66
6500	50.2	62.1	40.2	106.5	12.2	.66	66
6750	51.8	66.6	41.7	108.2	11.9	.64	67
7000	51.8	69.0	43.1	110.6	11.8	.64	65
7250	50.2	69.3	44.6	108.6	11.2	.66	65
7500	46.8	66.8	45.4	106.2	10.7	.70	67

AAEN QUIET CAN PIPE...88 dB

Standard Corrected Data for 29.92 inches Hg. 60 dry air.

TEST: 100 RPM/Sec Accel.
FUEL SPECIFIC GRAVITY: .695
VAPOR PRESSURE: .52
BAROMETRIC PRESSURE: 29.94

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
5500	38.1	39.9	32.9	105.7	14.8	.85	67
5750	41.1	45.0	34.9	106.9	14.1	.80	66
6000	45.1	51.5	40.2	106.3	12.1	.80	67
6250	48.5	57.7	40.2	105.9	12.1	.72	67
6500	50.2	62.1	39.9	104.3	12.0	.66	66
6750	51.9	66.7	42.3	106.6	11.6	.65	66
7000	52.6	70.1	42.5	111.3	12.0	.62	67
7250	51.4	71.0	44.2	112.9	11.7	.64	67
7500	47.8	68.3	43.0	107.4	11.5	.65	67

The fit and finish of all these aftermarket pipes was excellent. The Reichard pipe was a modified stock unit that had some real obvious welds in the header pipe and center section where it had been cut apart. Like the others, it dropped right in place.

One new feature on the Aaen pipes that deserves honorable mention is the heavy punched steel spring retainers (see photo) that are gas welded to the header pipe. This is a welcome departure from the semi-brazed on U-shaped pieces of "coat hanger" that we've become accustomed to.

We have a modified Phazer waiting in the wings for another Pipe Shootout. At that time we'll discover how this same group of pipes, and the new PSI twins perform at higher RPM on the modified engine.

AIRFLOW

Examine carefully the air and fuel flow data on our Stock Phazer Pipe Shootout. Normally, we expect air flow and fuel flow to increase in proportion to engine speed.

Apparently the "boost tube" in the intake, when used with stock carbs and port timing, is tuned to be most effective, in terms of volumetric efficiency, below 6000 RPM. But why is the fuel flow not proportional to air flow?

Perhaps there is some stratification of the air/ fuel mixture inside the carbs due to the throttle plate dividing the airflow at WOT. It is possible that inside the carb body, the fuel is concentrated in the *lower half* of the carb by virtue of its proximity to the emulsion tube. Therefore, the air feeding the adjacent cylinder through the boost tube (mounted at the top of each carb) may contain little fuel.

FEEDBACK by Jim Czekala

WHAT IS WAT?

As most of you have determined, it's the temperature in degrees F of the water as it leaves the engine during the test.

CHARTER MEMBERS

Our charter members (who subscribed before September 20) will be receiving their charter members' binders under separate cover later this month.

MERCURY 400

In our first issue I neglected to include our final spec main jet size for the Mercury 400 Sno-Twister. This prompted a call from a **DYNO*TECH*** subscriber who had just purchased a stock 400 S/T, and was planning to enter the N.Y.S. Grass Drag Championships. After leaning down 90 sizes to our 210 main jet final spec, Jim Barber took 1st place in the 400 liquid class.

(continued on page 12)

FORMULA PLUS++++

Present during test: Aaron & Arnie Swable, & Tom Waters

Using our stock Formula Plus tested previously as a baseline, we followed Ski-Doo's "Performance Tuning Tips", checking each recommended change on the dyno, one step at a time. Jetting was left stock throughout testing.

The first step on our agenda was to raise the compression. The factory suggests that milling the head to achieve a .050 squish will allow the use of 92 octane fuel. For our dyno tests, we opted to use a borrowed cut head that gave us a .040 squish clearance. The result was a nice 4 CBHP increase throughout the powerband–except beyond the power peak where CBHP diminished:

Standard Corrected Data for 29.92 inches Hg. 60 F dry air.

TEST: 100 RPM/Sec Accel.
FUEL SPECIFIC GRAVITY: .695
VAPOR PRESSURE: .69
BAROMETRIC PRESSURE: 29.95

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
5500	41.0	42.9	35.5	101.8	13.2	.86	77
5750	44.2	48.4	37.8	110.2	13.4	.82	77
6000	48.5	55.4	40.2	118.8	13.6	.76	76
6250	52.3	62.2	44.0	124.3	13.0	.74	76
6500	56.9	70.4	49.2	131.4	12.3	.73	77
6750	60.2	77.4	55.2	137.7	11.5	.75	77
7000	61.8	82.4	59.6	143.4	11.0	.76	76
7250	62.3	86.0	60.9	147.6	11.1	.74	76
7500	64.3	91.8	62.2	153.9	11.4	.71	76
7750	61.7	91.0	64.2	159.0	11.4	.74	76

Ski-Doo's next recommendation is to remove the airbox and go up 70 numbers on the main jets. Examining the A/F and BSFC from our previous test, we decided to chuck the airbox but leave the jets stock. The dyno then indicated a much lower fuel flow and improved BSFC resulting in 5 additional CBHP at the power peak.

Standard Corrected Data for 29.92 inches Hg. 60 F dry air.

TEST: 100 RPM/Sec Accel.
FUEL SPECIFIC GRAVITY: .695
VAPOR PRESSURE: .69
BAROMETRIC PRESSURE: 29.93

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
5500	40.3	42.2	33.3	.0	.0	.83	81
5750	43.9	48.1	34.2	.0	.0	.75	80
6000	47.3	54.0	33.1	.0	.0	.64	80
6250	50.2	59.7	36.3	.0	.0	.64	79
6500	56.7	70.2	43.4	.0	.0	.65	79
6750	61.4	78.9	51.8	.0	.0	.69	79
7000	63.1	84.1	52.6	.0	.0	.66	80
7250	63.5	87.7	56.9	.0	.0	.68	80
7500	64.9	92.7	57.1	.0	.0	.65	80
7750	65.3	96.4	55.3	0	.0	.60	81
8000	62.7	95.5	51.6	0	.0	.57	81

With the airbox removed, our source for airflow readings was lost and the engine was destined to a life of breathing hot underhood air. So we resurrected the airbox, and performed "plastic" surgery searching for any socially redeeming value. Inside we found the Iron Duke of airbox baffles: a heavy steel weldment like you'd expect to encounter in the air cleaner of a Detroit Diesel. No wonder the Formula Plus weighs so much.

With the baffle and foam removed, we had a non restrictive air management system that would prove to actually *increase* CBHP by causing the carbs to run even leaner than they would without an airbox.

Standard Corrected Data for 29.92 inches Hg. 60 F dry air.

TEST: 100 RPM/Sec Accel.
FUEL SPECIFIC GRAVITY: .695
VAPOR PRESSURE: .69
BAROMETRIC PRESSURE: 29.95

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
5500	37.2	39.0	31.0	98.6	14.6	.84	81
5750	40.4	44.2	34.0	106.8	14.4	.81	80
6000	44.3	50.6	35.9	114.9	14.7	.74	80
6250	52.1	62.0	38.0	125.5	15.2	.64	80
6500	57.1	70.7	39.8	132.7	15.3	.59	80
6750	60.1	77.2	42.8	139.1	14.9	.58	80
7000	62.5	83.3	46.7	145.7	14.3	.59	80
7250	65.0	89.7	50.3	155.0	14.1	.59	81
7500	66.7	95.2	54.6	161.2	13.6	.60	82
7750	66.0	97.4	52.8	167.2	14.5	.57	80
8000	61.1	93.1	53.1	170.0	14.7	.60	82

At this point we installed the 207 rotary valve, and monitored its effectiveness. The result was a significant increase throughout the power curve.

Standard Corrected Data for 29.92 inches Hg. 60 F dry air.

TEST: 100 RPM/Sec Accel.
FUEL SPECIFIC. GRAVITY: .695
VAPOR PRESSURE: .69
BAROMETRIC PRESSURE: 29.94

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
5500	36.9	38.6	27.4	97.5	16.3	.74	79
5750	40.2	44.0	30.9	106.0	15.8	.74	79
6000	44.6	51.0	32.4	113.8	16.1	.67	79
6250	52.1	62.0	34.7	126.1	16.7	.59	79
6500	57.6	71.3	38.9	133.5	15.8	.57	79
6750	61.7	79.3	43.0	141.3	15.1	.57	79
7000	64.8	86.4	46.0	149.7	14.9	.56	80
7250	66.6	91.9	49.1	155.7	14.6	.56	80
7500	68.2	97.4	53.4	163.1	14.0	.58	80
7750	67.7	99.9	54.9	171.5	14.3	.58	78
8000	59.7	90.9	51.4	173.1	15.5	.59	79

We now decided to test a swirl canister that had been drilled out according to Ski-Doo race shop specs, with the stock pipe. This amounted to six 3/4" holes drilled horizontally and completely through every layer of steel inside the canister, then resealing the outside holes with welded metal plugs. This gave us two more CBHP, again throughout the power band.

Standard Corrected Data for 29.92 inches Hg. 60 F dry air.

TEST: 100 RPM/Sec Accel.
FUEL SPECIFIC GRAVITY: .695
VAPOR PRESSURE: .69
BAROMETRIC PRESSURE: 29.92

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
5500	39.4	41.3	31.6	96.6	14.0	.81	82
5750	45.5	49.8	36.6	112.8	14.2	.77	82
6000	48.9	55.9	38.1	120.0	14.5	.72	80
6250	56.2	66.9	41.1	130.0	14.5	.64	80
6500	59.0	73.0	45.5	135.2	13.6	.65	80
6750	63.4	81.5	46.3	144.1	14.3	.60	81
7000	66.4	88.5	50.7	151.6	13.7	.60	81
7250	68.1	94.0	52.9	157.8	13.7	.59	81
7500	69.7	99.5	54.9	164.4	13.7	.58	81
7750	68.6	101.2	57.6	174.5	13.9	.60	81
8000	58.7	89.4	55.0	172.9	14.4	.65	83

So far we have taken the stock Formula Plus from 89 to 102 CBHP at 7750–not bad for a head cut, rotary valve, and a little tuning.

Next on the list were the factory race shop's "Plus Power Pipes". These were designed to be used in conjunction with a forementioned drilled canister. The twin pipes resulted in only one more CBHP at a higher RPM. Perhaps they would be more effective on a highly modified engine with larger carburetors–we'll stay with the single pipe.

Standard Corrected Data for 29.92 inches Hg. 60 F dry air.

TEST: 100 RPM/Sec Accel.
FUEL SPECIFIC GRAVITY: .695
VAPOR PRESSURE: .69
BAROMETRIC PRESSURE: 29.92

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
6500	49.8	61.6	39.6	110.0	12.8	.68	84
6750	55.0	70.7	47.2	138.6	13.5	.70	83
7000	57.4	76.5	47.7	147.4	14.2	.66	83
7250	60.3	83.2	51.3	155.5	13.9	.65	84
7500	62.0	88.5	54.2	161.7	13.7	.64	82
7750	62.8	92.7	53.8	167.0	14.3	.61	83
8000	63.7	97.0	54.0	170.0	14.5	.59	82
8250	64.5	101.3	54.6	171.7	14.4	.57	84
8500	63.5	102.8	55.4	175.3	14.5	.57	84
8750	60.0	100.0	56.1	176.8	14.5	.59	83

The 580 Precision Products big bore was next on the dyno. All we did was swap cylinders, pistons and head, which had .070 squish clearance. The single pipe was retained with the modified cannister. Comparing the 580 to the higher compression 521 showed surprisingly identical airflow, with the big motor making slightly more bottom end and slightly less top end CBHP.

Standard Corrected Data for 29.92 inches Hg. 60 F dry air.

TEST: 100 RPM/Sec Accel.
FUEL SPECIFIC GRAVITY: .695
VAPOR PRESSURE: .69
BAROMETRIC PRESSURE: 29.92

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
5500	44.8	46.9	34.9	106.0	13.9	.78	84
5750	47.4	51.9	37.1	113.0	14.0	.75	82
6000	54.5	62.3	39.1	125.5	14.7	.66	83
6250	58.7	69.9	39.5	131.6	15.3	.60	84
6500	61.6	76.2	42.5	136.5	14.7	.59	83
6750	65.0	83.5	47.8	143.7	13.8	.60	83
7000	67.1	89.4	50.9	149.3	13.5	.60	83
7250	68.4	94.4	54.1	156.3	13.3	.60	83
7500	68.8	98.2	57.2	161.9	13.0	.61	84
7750	68.4	100.9	57.5	169.9	13.6	.60	83
8000	64.8	98.7	56.5	173.2	14.1	.60	82

Wishing we had done this earlier, we decided to advance the timing from .069 to .090 BTC. Which, as we expected, increased the CBHP slightly throughout the powerband.

Standard Corrected Data for 29.92 inches Hg. 60 F dry air.

TEST: 100 RPM/Sec Accel.
FUEL SPECIFIC GRAVITY: .695
VAPOR PRESSURE: .69
BAROMETRIC PRESSURE: 29.92

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
5500	44.1	46.2	33.4	105.6	14.5	.76	79
5750	46.8	51.2	37.1	112.4	13.9	.76	80
6000	54.5	62.3	39.5	125.3	14.6	.67	81
6250	60.1	71.5	40.3	134.4	15.3	.59	80
6500	63.6	78.7	45.0	139.9	14.3	.60	80
6750	65.7	84.4	47.4	146.3	14.2	.59	80
7000	67.8	90.4	49.9	151.0	13.9	.58	80
7250	69.5	95.9	54.3	158.3	13.4	.59	79
7500	70.1	100.1	56.8	166.1	13.4	.59	79
7750	69.4	102.4	56.9	173.7	14.0	.58	79
8000	63.6	96.9	55.1	176.2	14.7	.60	80

Our final test involved raising the compression on the 580 cylinder head. We had .020 removed from the head surface, giving us a .050 squish clearance. This raised our peak CBHP to 105, and gave us our best bottom end power as well.

Standard Corrected Data for 29.92 inches Hg. 60 F dry air.

TEST: 100 RPM/Sec Accel.
FUEL SPECIFIC GRAVITY: .695
VAPOR PRESSURE: .69
BAROMETRIC PRESSURE:29.99

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT
5500	47.7	50.0	38.0	107.5	13.0	.79	78
5750	53.1	58.1	39.7	118.6	13.7	.71	78
6000	57.7	65.9	41.6	126.6	14.0	.66	78
6250	60.4	71.9	41.8	132.5	14.6	.61	79
6500	64.9	80.3	43.3	139.1	14.8	.56	79
6750	67.4	86.6	46.0	145.6	14.5	.55	78
7000	70.1	93.4	49.5	151.6	14.1	.55	78
7250	71.2	98.3	53.9	157.2	13.4	.57	78
7500	72.5	103.5	53.2	164.8	14.2	.54	79
7750	71.2	105.1	54.1	171.9	14.6	.54	79
8000	62.6	95.4	53.1	174.4	15.1	.58	76

Conclusion

The Ski-Doo Formula Plus responds nicely to some low dollar modifications. It's amazing that, while delivering a few more horsepower, the 580 big bore had so little effect on airflow through the engine.

1989 INDY 500

Because this Indy 500 was brand new, we elected to run several gallons of VP C-14 pre-mix through it before proceeding with our tests. The SuperFlow dyno has a computer controlled break-in cycler that gradually varies the RPM and load on an engine--while providing continual printouts of engine operating data--so that the internal parts get to "know one another" before the engine is brought up to full running speed.

The 500's 38mm carbs come fitted with 280 main jets. Figuring that Polaris would make the stock carb spec safe to zero, we checked our Mikuni slide rule and decided on 240 mains to compensate for our 70 degree F CAT.

With the 240's in place and watching our A/F ratio and BSFC at various throttle openings and RPM, we failed to discover any lean spots like those existing on last month's stock Exciter. The fuel curve appeared to be excellent.

The following data is typical of the full throttle tests that were performed on the engine.

STOCK INDY 500

Standard Corrected Data for 29.92 inches Hg. 60 F dry air.

TEST: 100 RPM/Sec Accel.
FUEL SPECIFIC GRAVITY: .711
VAPOR PRESSURE: .50
BAROMETRIC PRESSURE: 30.03

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT	WAT
6250	39.9	47.5	34.7	96.1	12.7	.75	70	98
6500	44.2	54.7	36.8	103.1	12.9	.69	69	98
6750	46.2	59.4	37.3	107.7	13.3	.64	68	97
7000	48.2	64.2	41.2	110.2	12.3	.66	69	98
7250	49.1	67.8	44.7	110.6	11.4	.68	69	98
7500	48.3	69.0	44.4	112.9	11.7	.66	68	98
7750	47.3	69.8	47.0	110.6	10.8	.69	70	99
8000	45.2	68.8	45.8	113.0	11.3	.68	70	99

We located a dyno test of a stock Indy 400 in our computer files, and decided to include an overlay plot for a graphic comparison of the two engines. While the 500 enjoys a seven CBHP advantage at peak RPM, the extra 88cc shows us ten more CBHP in the important midrange.

Knowing from previous dyno sessions how well the 650 responds to a gutted intake, we couldn't resist yanking the foam from the 500's conveniently clipped together airbox. The result: a 10% increase in airflow and three more CBHP. We remember the days when Polaris used to glue the airbox halves together. Thanks, guys.

At test time, there were no aftermarket pipes in production for the 500. Several suppliers have advised us that they have seen nice increases with their dyno pipes. When they become available we'll include all the production versions in a Pipe Shootout.

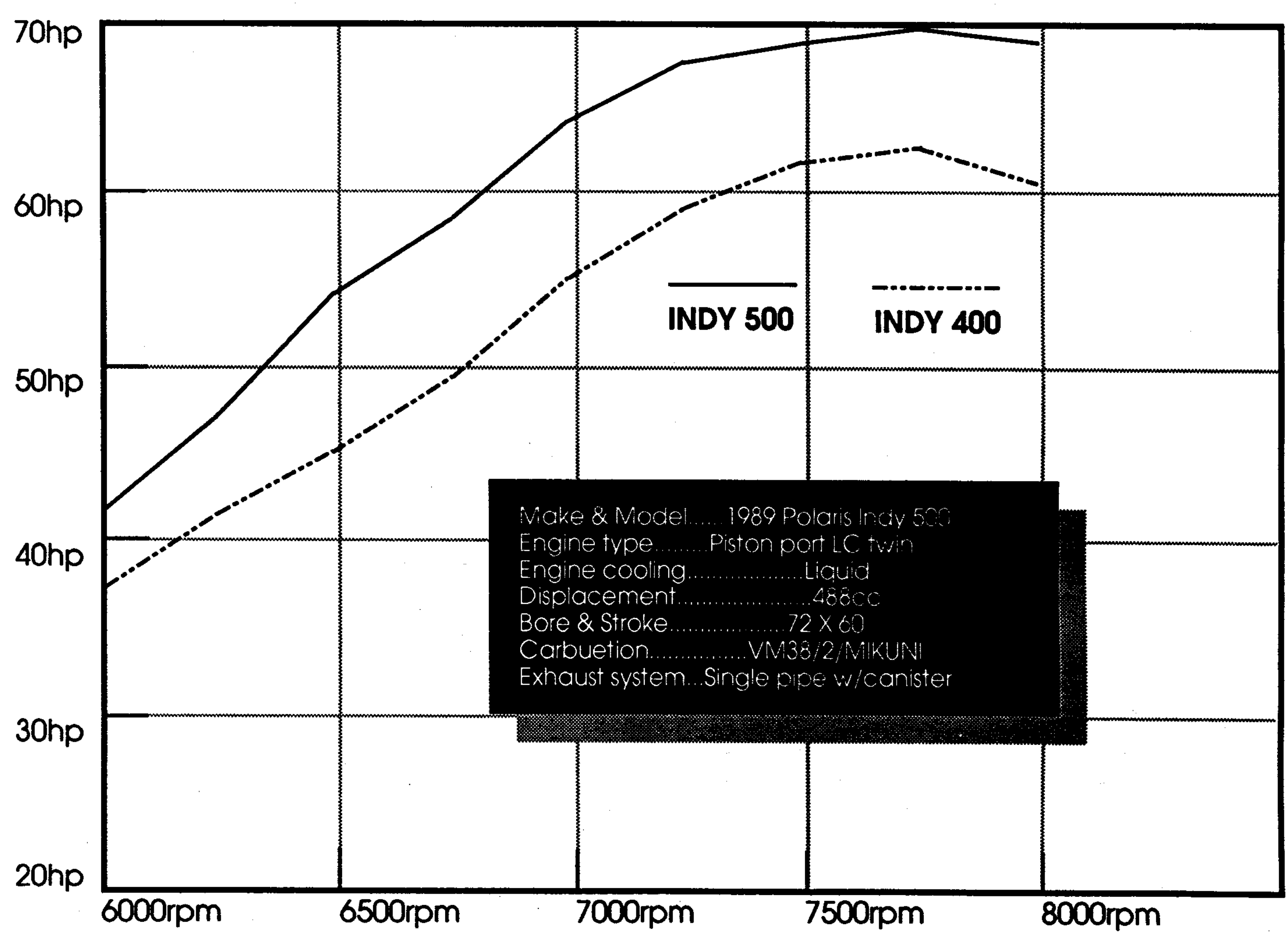
AIRBOX GUTTED

Standard Corrected Data for 29.92 inches Hg. 60 F dry air.

TEST: 100 RPM/Sec Accel.
FUEL SPECIFIC GRAVITY: .711
VAPOR PRESSURE: .50
BAROMETRIC PRESSURE: 30.03

RPM	CBT	CBHP	FUEL	AIR	A/F	BSFC	CAT	WAT
6250	43.2	51.4	34.6	109.0	14.5	.69	71	91
6500	45.6	56.4	34.9	116.6	15.3	.63	69	91
6750	47.4	60.9	36.3	123.7	15.6	.61	69	91
7000	49.7	66.2	39.8	120.5	13.9	.62	71	92
7250	50.9	70.3	42.5	127.5	13.8	.62	70	93
7500	50.7	72.4	45.1	127.9	13.0	.64	70	94
7750	49.2	72.6	43.5	126.7	13.4	.61	69	94
8000	46.1	70.2	44.7	126.8	13.0	.66	71	95

THE INDY'S...400 & 500 (CORRECTED BRAKE H.P.)



THE CELLAR DWELLER

Kevin Cameron

Snowmobiles use simple, powerful two-stroke engines which have only three basic moving parts; piston, connecting rod, and crankshaft. Somehow these few parts do the work of the many in an automotive-type four-stroke engine. the extra parts in a four-stroke are its mechanical intake and exhaust valves, and the cam, camdrive, tappets, springs, etc., required to open and close them. Despite its simplicity, the two-stroke has a far higher power-to-weight ratio than the four-stroke.

The two-stroke's advantage is that it fires twice as often as does a four-stroke (every two piston strokes instead of every four piston strokes). It thus has the potential to make double the power of the four-stroke--if the job of expelling the exhaust gas and replacing it with fresh charge can somehow be done without those extra piston strokes. The technology that does this is in the strangely-shaped exhaust pipe, or expansion chamber. It acts as a pump, works as an exhaust valve, supercharges the cylinder and, incidentally, gets rid of the exhaust gases. It has no moving parts, but it works as if it did.

As the piston moves downward on the power stroke, hot, high-pressure gases from combustion push on its crown and, through the con-rod, generate torque and power at the crank. When the piston has moved about half-way down its stroke, it begins to uncover the exhaust port in the cylinder wall. combustion gases, still at 75-100 PSI and 100-1400 degrees Fahrenheit, rush out through the rapidly-opening port, forming a supersonic jet. Although we think of exhaust as a waste product, this jet contains valuable energy. The pipe will put it to work.

The first part of the pipe (called the header) is made relatively small in diameter, to preserve the high velocity and energy in this outrushing gas. The header pipe may have a very slight taper (typically 1.5 to 4 degrees) which accelerates the outflow, exhausting the cylinder more quickly.

After about 8-12 inches of header, the pipe begins to enlarge like a megaphone--typically at about a 10 degree angle. This widening part of the pipe is called the diffuser. when the exhaust pulse enters this diffuser it expands because it has more room. This sends a wave of expansion--a suction wave--back up the pipe towards the exhaust port and the cylinder. The reason the diffuser doesn't begin right at the port is that its suction wave could not travel up stream at all during the first part of the exhaust process, when outflow is supersonic. However, by the time the exhaust pulse has reached the end of the header, the flow has slowed to subsonic speed and the diffuser's suction wave can move upstream to reach the cylinder and help to remove exhaust gases from it.

Remember that in a two-stroke engine, the crankcase has been filled with fresh mixture from the carburetor during the piston's upstroke. This charge is admitted to the crankcase through a piston controlled port, a reed valve, or a rotary disc valve. Now that the piston is moving downward, this charge is being compressed. After the piston uncovers the exhaust port, and cylinder pressure has dropped, it uncovers the transfer ports--ducts that permit the compressed charge in the crankcase to jet up and into the cylinder. As the piston reaches bottom center, the exhaust and transfer ports are all fully open, and crankcase pressure has done all it can to push fresh charge into the cylinder. Right at this point, the strong suction signal from the pipe diffuser arrives back at the cylinder, pulling even more mixture up from the crankcase.

You might object that a suction signal arriving from the pipe at this time will just suck the fresh charge right out of the cylinder. This is partly true. Some charge is lost, but the transfer ports are arranged in such a way that their streams of fresh charge take maximum time to reach the exhaust. During this time the piston starts back up on compression, and the ports begin to close.

The exhaust pulse traveling down the pipe reaches the large end of the diffuser section, and ceases to send back a a suction pulse. After the diffuser comes a large-diameter, non-tapered part of the pipe. This is called "the can", the "dwell", or the center-section. Its function is one of timing, as we will see.

Back in the cylinder, the piston is rising and has almost closed the transfer ports, but the exhaust port is still about half-open. Unless something is done to stop it, further upward movement of the piston will push the fresh charge out of this open port.

In the pipe, the exhaust pulse reaches the end of the center section and hits the convergence cone, where the pipe contracts steeply (at approximately 20 degrees). Hitting this cone, the pulse is reflected, not as suction, but as a strong pressure wave of several pounds per square inch pressure. This pressure pulse travels back towards the cylinder, arriving just as the piston is pushing the fresh charge out of the exhaust port. As the exhaust port is closing, this pressure wave stops further outflow and then crams the lost charge back into the cylinder, leaving it slightly supercharged. The center section of the pipe puts the convergent cone at the right distance from the exhaust port to correctly time the arrival of this pressure wave. If the convergent cone simply ended in an outlet hole (no tailpipe) the exhaust pulse would expand directly into the atmosphere, creating a second suction pulse that would cancel part of the pressure pulse just generated by the convergent cone. To prevent this, the exhaust pulse is "stored" for a short time in a small-diameter tailpipe, or "stinger", and is released to atmosphere (or muffler) at its end.

During its trip through the pipe, exhaust pulse energy has done these jobs:

1. the suction wave generated in the diffuser draws out exhaust and assists flow of fresh charge through the transfer ports.

2. the pressure wave generated in the convergent horn acts as a valve to stop outflow of fresh charge from the exhaust.

3. the pressure wave also supercharges the cylinder by stuffing lost charge back into the cylinder, through the exhaust port.

All the lengths and tapers have to be just right to achieve maximum effect. Although there are useful rules-of-thumb for beginning a pipe design, getting the desired power and powerband by pipe tuning is still a matter of cut-and-try, best performed on a dynamometer

FEEDBACK

(continued from page 6)

COLD AIR KIT

For those Exciter owners lamenting their 80 degree winter CAT, it's time to rejoice. Yamaha has just released an Exciter cold air kit to be installed *free of charge for anyone complaining about poor high altitude performance*. This kit includes an insulation package for the stock exhaust canister, a new airbox with a topside inlet, and a beautiful rear facing "scoop" that attaches to the louvered panel above the airbox.

This new-found increase in effective RAD will give the PSI piped Exciter we tested last month approximately 97 observed horsepower in winter field conditions. This represents a *10 observed horsepower swing*. A tip of the **DYNOTECH** hat to the Yamaha engineers.

dB METER

The only instrument in our dyno room not monitored by the SF-901 computer is our dB meter, which is observed and recorded manually. As might be expected, this gauge typically receives the least attention while testing. During the Phazer Pipe Shootout, I neglected to record the dB readings on some of the pipes. Rather than print my subjective recollection of the readings, the spaces in your data sheets have been left blank. When we run our Modified Phazer Pipe Shootout, I will note the dB readings allowing you to fill in the blanks.

SLICK 50 TWO STROKE TREATMENT & KLOTZ POWER ADDITIVE

In our first and second issues, we had planned on providing product evaluations of Klotz Nitro Power Additive and Slick 50 two-stroke treatment. They will appear later this season.

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