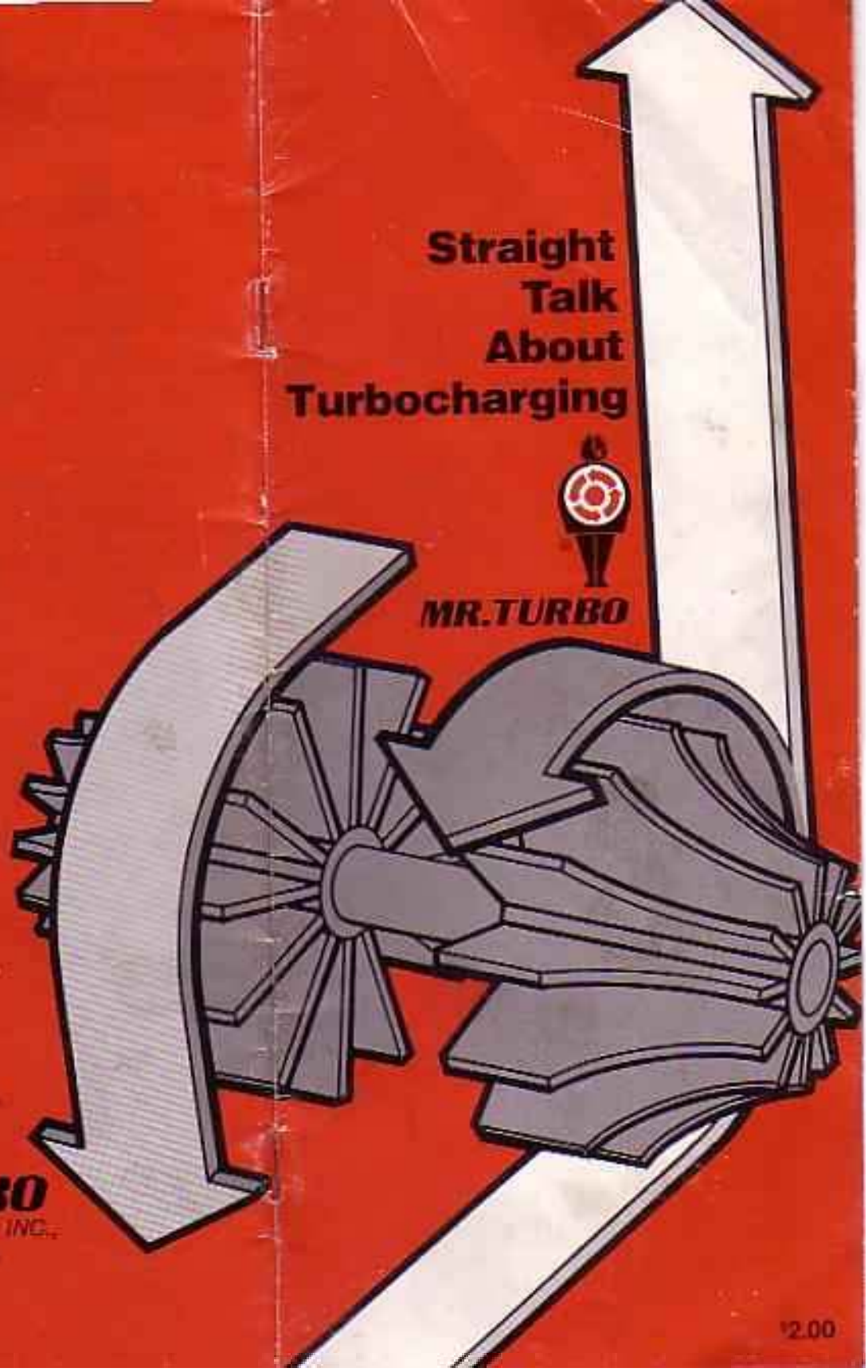
Straight Talk About Turbocharging

MR.TURBO



Manufacturers of Turbocharger Kits and Accessories

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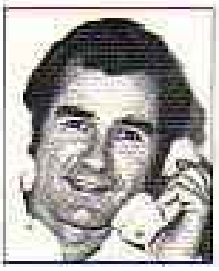


Turbocharging adds an exciting new dimension to motorcycling.

Put in its simplest terms, the new dimension is MORE SPEED, MORE TORQUE. When you can increase the horsepower of a motorcycle by as much as 100 to 150% (if you wish) you're entering a new world of motorcycling. And, as you move into that new world of increased performance, your common sense and good judgment must increase, too, because you're in command of a faster machine that requires more of these factors if you're going to extract the maximum fun and enjoyment turbocharging can bring you. There are various degrees of turbocharging that provide performance increases to suit just about any rider's style. At Mr. Turbo, we stress the point that, however you ride, you should always ride with due care for yourself, your machine and everyone else.

Ted Hofmeister

What is Turbocharging?

A motorcycle engine—like any other reciprocating engine—is a pretty efficient means of generating power. The operating principle is fairly simple. The engine's pistons pull atmospheric air into the cylinders where it's mixed with fuel supplied by the carburetor or fuel injection system. The mixture is compressed and fired by the plugs to produce energy—power. The burned gasses are forced out of the cylinders and exhausted to the atmosphere while a new fuel-air mixture is entering. And so on and on and on.

The power you can get out of the engine is in direct proportion to the amount of fuel and air burned (actually exploded) in the cylinder on each cycle. To get more power, you can go one of 3 ways: (a) increase the size of the engine cylinders; (b) increase RPM by modifying the engine, or (c) simply force more air and fuel into each cylinder to get a more powerful push on the piston each time the plug fires.

That last option—forcing more air into each cylinder to get a bigger, potentially more powerful fuel-air mixture for the plugs to fire—can be done by supercharging—stuffing a "super" large charge into the cylinders. That's where a TURBOCHARGER comes into the picture.

But, first, let's differentiate between "turbocharging" and "supercharging" as the terms are generally used. A turbocharger or a supercharger is nothing more than an air pump . . . a device that pumps (forces) air into an engine's cylinders. The difference between the two is how the compressor—the wheel that does the work—is driven. A supercharger is driven by a belt or gearing which takes away a certain amount of engine power. A turbocharger, on the other hand, is driven by the burned gasses (exhaust) which are forced out of the exhaust system at very high velocity. It's this highly pressurized stream of waste gasses that is used by a turbocharger to produce more engine power.

The turbocharging systems we build are beautifully simple and elegant answers to getting more horsepower and performance from a given engine. I hope this booklet will provide answers to some of the questions you might ask about turbocharging your motorcycle engine.

Mr. Turbo turbocharged Goldwing

questions and answers

Q. What is the largest engine you think should be turbocharged? What is the top and bottom limit?

A. That depends on what you're going to do. If you're racing, that's one size; if the engine is in a street or touring bike, that's another.

Q. Can you enlarge on that?

A. The smallest engine that can be turbocharged efficiently is a 500 c.c. engine. There is no limit on the largest. The trend to turbocharging is toward the smaller displacement engines. They're less expensive and easier to handle.

Q. Does turbocharging alter low end performance?

A. No . . . not with the Turbo Kits as we engineer and build them. Our design retains the stock performance figures on the low end.

Q. I've read articles describing how a lot of modifications were made on a cycle engine before a turbocharger kit was installed. Is it necessary to re-work an engine before adding a turbocharger?

A. No. It's not necessary. If a person wants more horsepower—more performance, he can add, with a turbocharger kit, 5 to 7 pounds of boost on a completely stock engine and run it indefinitely. The only thing to be careful of is to keep engine detonation down.

Q. What do you mean by detonation?

A. Detonation is the erratic burning of the fuel, which causes the pinging that you hear in the engine.

Q. What if a guy wants more power/torque than the 5 to 7 pounds of boost gives him?

A. Then I recommend that some engine modifications be made.

Q. What modifications?

A. I recommend forged pistons, welding the crank (when necessary), heavy duty rods, cylinder studs, valve springs, timing chains, and clutch.

Q. When does the turbocharger cut in? At what RPM?

A. Actually, the turbocharger is always spinning because its' driven by the engine's exhaust. But as engine RPM increases, the turbine wheel begins to spin faster and over-rides the naturally aspirated condition of the engine and begins to build a boost condition. But, to give you a number, it's usually around 4500 to 5000 RPM, depending on the engine. On our Touring Kits, the boost comes in around 3500 to 4000 RPM. That's the point where you would normally get what you call "cut-in".

Technically speaking, boost starts sooner than that, but you don't feel it or see it on a dyno. You're actually overriding a vacuum in the intake system and when you get to a zero condition—when the boost pressure equals or exceeds the vacuum—you can see boost buildup on an instrument on the dyno.

Q. What effect does a turbocharger have on torque? And what is torque as applied to a motorcycle's performance?

A. In this context, torque is created at lower RPMs—what many people call "stump pulling" power. For example, say you're riding in flat pavement and begin to go up a steep hill or grade. Your engine should be shifted into lower gear to put more torque through the rear wheel and onto the pavement.

Q. How fast does a turbine wheel spin?

A. Depending on the size of the turbine, at maximum it will turn somewhere in the range between 125,000 to 225,000 RPM. The smaller turbine we use on 550 c.c. engines will turn up to 225,000 RPM.

Q. How much does a turbocharger increase horsepower?

A. A turbocharger can increase basic engine horsepower as much as 100% and even more, depending on how much boost you use. At the race track, for example, we use up to 27–30 pounds of boost and the maximum horsepower increase in that range is as high as 150–200%. But, you have to remember, racing bikes have extensive chassis modifications in order to handle all that power. And the rider has to have the experience and skill to control it.

Q. But for street riding an increase like that doesn't make sense, does it?

A. Absolutely not.

Q. From your experience, what kind or type of rider is going to turbocharging?

A. There are actually two general types of riders who are going to turbocharging. First, there's the "touring rider" and then there are the racers—the guys who compete in sanctioned events. The touring riders want a different kind of turbo performance. They want the extra power and torque at lower RPMs because they're riding in all kinds of terrain, usually on a bigger, heavier road-type machine. Say, they're riding at 50 mph and want to pass a slower vehicle. They've got saddlebags, maybe a trunk or even a trailer (you see a lot of them out West these days) and they want to pass quickly and safely. He wants to twist the throttle and instantly get that extra punch and torque to get by without having to downshift. Then, there's the racer who wants maximum performance for relatively short periods during a race. But that's another subject I'd like to talk about later.

Q. OK, let's talk about turbocharging and touring. Would you say that there's more interest shown in turbocharging by the touring rider than the racers?

A. Very definitely. And there are more of them. For example, one of the biggest, most active groups of touring riders are those who own Honda Goldwings. They have organized clubs, shows, rallies, concourse events, group tours, etc. The Goldwing is offered in two sizes—1000 and 1100c.c.—both are water-cooled, direct-drive bikes, beautifully engineered and very comfortable touring machines. Many owners have sidecars; some pull trailers and very often ride double. When these riders are on touring trips, they want the reserve of extra power and torque a turbocharger gives them. Our Goldwing Kit is one of the most popular kits in the line. And, like most of our kits, it's a simple bolt-on that requires no modifications to the machine.

Q. What other motorcycles does Mr. Turbo supply kits for?

A. At Mr. Turbo, we're concentrating on building kits for 4 and 6 cylinder Japanese machines—Kawasaki, Honda, Suzuki, etc.

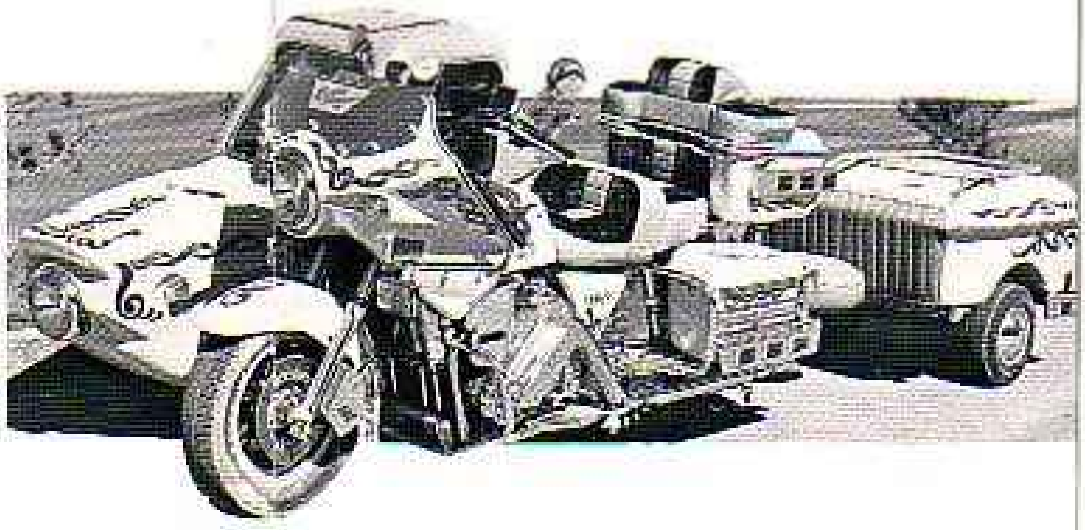


Photo courtesy of Custom Dressers, Oklahoma City.

Q. How difficult is it to install one of your kits? Or should I say "How easy is it to install one?"

A. It's not difficult at all, assuming you have some tools, normal dexterity and can read and follow instructions. Most of the street and touring kits we sell are installed by the bike owners themselves. We've taken a lot of pains to make sure our installation instructions are clearly written and well illustrated so they're easy to follow. On the other hand, when our high performance racing kits are to be installed on competition machines, that require modification, unless you're a skilled machinist and/or mechanic it's best to have a professional do the work.

Q. If I install one of your Turbo Kits on my Suzuki, what chance will I have to blow off my racing buddies?

A. That depends on how good a rider you are. A turbocharged motorcycle is only as fast as the rider can ride it. For example, say a machine is capable of doing the quarter-mile in 9 seconds: one rider can do it in 9 seconds; another will take 11 seconds to do it. It depends on your reflexes, how you handle the power . . . how you dial on the power. A really good rider can go down the strip faster on a stock machine than one who doesn't know how to handle all the power a turbocharger can add.

Q. What kind of fuel does a turbocharged engine require—say in a street or touring bike?

A. No special fuel is required as long as the premium grade carries the required octane number specified for the engine by the manufacturer. Of course, poor grade or low octane fuel will produce detonation in any engine—not just a turbocharged one.

Q. What about the effect of high boost—say 9 to 12 pounds on detonation?

A. Unless you've got a tank of top grade premium, you could get detonation at those rates. However, we have an answer to that in the form of water or water/alcohol injection which serves to bring down engine heat which is one of the primary causes of detonation.

Q. Is there some kit available to get this water or water/alcohol injection? How is it done?

A. We design and build water injection kits at Mr. Turbo. They come complete with all the hardware and instructions.

Q. Who needs or buys injection kits?

A. Generally, people who want to do street racing. You seldom see an injection system on a touring machine because the people who ride them are pretty careful to see that they get nothing but a high grade of fuel. Besides, they very seldom turn up the boost beyond a reasonable limit in the kind of riding they do. However, in mountain riding, a tourer might be turning up the boost which would overheat the combustion chambers and water injection could prove very helpful.

Q. Is turbocharging the only way to increase the horsepower of a stock engine?

A. No, there are other ways to do it—with engine modifications, etc. But in the long run, it's generally true that turbocharging is the easiest and least expensive way to go. To modify a naturally aspirated engine and get power and torque increases that don't come near equaling what turbocharging provides, can get complicated and expensive.

Mr. Turbo sponsored Burns, Berry & Hahn world record Funny Bike.

Q. How so?

A. For starters, you have to have the cylinder head modified—which should be done only by experts who know how. That costs. Then you need special carburators which don't come cheap. Also, you need a complete new exhaust system if the job is to be done right. And to get the power increase required for racing, you need a lot more —like special balanced pistons, camshafts, etc.

Q. Any problems running a hopped-up naturally aspirated engine on the street—compared to a turbocharged engine?

A. Yes. Running a hopped-up naturally aspirated engine on the street you have very high compression on the modified engine and that causes heat which leads to detonation under all conditions of operation. You don't have the same problems in a turbocharged engine operating at what I would call "normal" boost—in the range of 5 to 7 pounds—yet you have all the power and torque you'll ever need. More, in fact, than the average rider should ever use.

Q. So you say that turbocharging is a more practical way to achieve increased power and torque?

A. Absolutely. More practical and less expensive. A turbocharged engine is more adaptable to various riding conditions; it's subjected to less continuous strain and it will be less prone to problems as engine hours add up.

Q. What does one of your Turbo Kits include?

A. Everything you need. The diagram shows the components in our kits. They include the turbocharger itself, carburetor, electric fuel pump, air filter, intake manifold, exhaust header and exhaust pipe, heat shields, adjustable waste gate, boost gauge and all required brackets, hoses and associated hardware for the specific motorcycle.

Q. What's a "stock" carburetor in your kits?

A. It starts out as a stock Keihin, but we modify it to provide better flow characteristic with a turbocharger.

Q. I hear about the advantages of slide carburetors in naturally aspirated engines. Do they work OK with a turbocharger?

A. No. We do not use them in turbocharging because the basic principle of a slide carburetor is counter-productive in turbocharging.

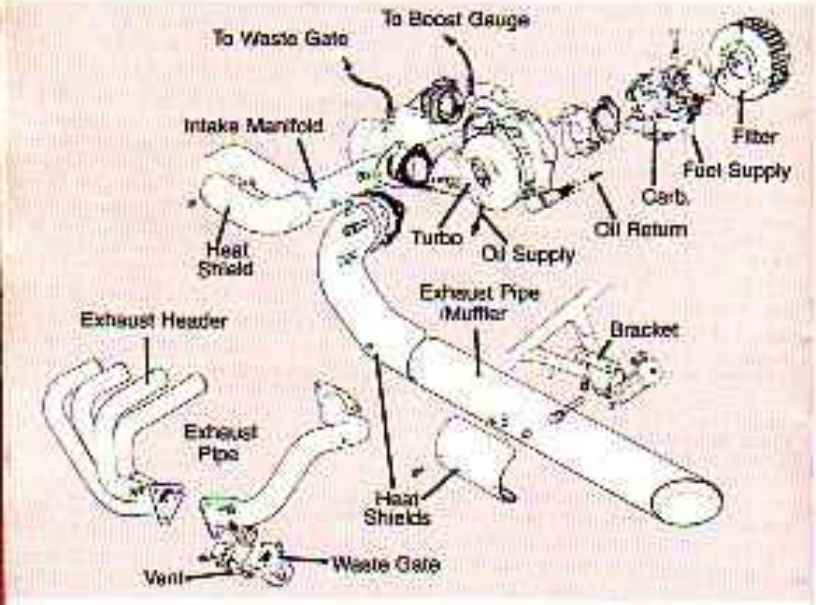
Q. Why is it counter-productive?

A. In a slide carburetor, you have a piston that moves up and down, and under extreme boost conditions, you have an extreme amount of vacuum coming through the carburetor. When you back off the throttle, you can't because the vacuum has the slide sucked to the side and it won't close so you can shut down the engine. For this reason, we do not use them and do not recommend their use on a turbocharged engine.

Mr. Turbo powered Bonneville Salt Flat Machine. Photo courtesy of D & E Performance, Memphis.

Q. What's the story on fuel consumption in a turbocharged engine?

A. You'll use more fuel when you're on boost—and the higher the boost and the longer you stay on it, the more fuel you use. That's why our Turbo Kits include an electric fuel pump—to deliver a steady flow of fuel to the carburetor when the engine is on boost. With the engine on boost, a float carburetor with gravity feed would run dry at about the end of second gear. Here's an example: in a quarter-mile run under approximately 20 pounds of boost, you would use about a quart of gasoline. So, in 9 seconds or so, there goes a quart, and if you stayed on boost for a mile, a gallon of gas would leave your tank! 20 pounds of boost is a lot of boost and the average enthusiast wouldn't (or shouldn't) use that much boost at any time. 20 pounds is only for racers.



Q. Is a separate oil pump, filter and tank required in a turbocharged engine?

A. Only under extreme boost applications. A separate system for the turbocharger would keep the oil cooler and give much more oil flow through the turbo. We are working on a kit of that kind now. But I want to emphasize—it would be recommended only under extreme boost conditions—such as in racing.

Q. What boost pressures do your Turbo Kits provide? And are they adjustable?

A. Boost pressure varies, depending on the type of kit. Our Touring or Street Kits have from approximately 4 to 15 pounds; the Racing Kits produce, on the average, from 10 to 30 pounds and all of our units have an adjustment on the wastegate allowing the rider to lower or increase boost. It's a simple, easily made adjustment, so you can adjust boost for the kind of riding you're doing. Boost conditions should be limited to ¼ mile blasts. If you are doing a high speed roll-on, get up to your desired speed and back off the throttle enough to hold the speed you want or to slow down.

Extended wide open throttle creates a tremendous amount of heat because of the horsepower a turbocharged engine creates. Horsepower is heat and the engine was not designed to dissipate that much heat.

Use BOOST wisely and you will not have problems. If you do not use it wisely engine failure is guaranteed.

Q. Is water/alcohol injection now available and is it initiated by boost pressure or a form of detonation detection?

A. It is available and in every system I know of for motorcycles, the injection is initiated by boost pressure. A check valve is used in the line coming from the water/alcohol tank to the carburetor and as boost pressure starts to come up, it pressurizes the tank and overrides the check valve spring and begins injection into the engine. It's a self-compensating system because, as the boost pressure gets higher, you have more pressure in the tank which causes more volume to be injected.

Q. Are electronic rev-limiters available? If so, do you recommend them?

A. Yes, they are available. The only time a rev-limiter is useful is in case you miss a shift. Generally, I don't think a rev-limiter is necessary to keep you from over-winding your engine.

Q. Is a spark retard system available to control detonation?

A. Yes, there is a system on the market and if it's available for your bike, it would be a good idea to install one—especially if you like to run under high boost or if you have a problem getting good fuel. We distribute the BHP Spark Retarding System and have had excellent results with it.

Q. Is a CDI (Capacitor Discharge Ignition) System recommended when turbocharging an engine?

A. Yes—again in situations where the engine is run on sustained high boost (as in racing) the higher the compression you have, the more spark you need. Higher compression caused by the boost will have a tendency to blow the spark out.

Q. How about plugs? Should a colder plug be used in a turbocharged engine?

A. That depends. For touring—no. Stock plugs are fine. For racing, we recommend one heat range colder than stock.

Q. You said intake manifolds are important components. How does the manifold in your kits accomplish even distribution to all four cylinders under boost conditions?

A. We have designed our intake manifolds so they extend a precise distance beyond the last port. That "dead" space beyond the last port creates a violent turbulence that keeps the distribution even.

Q. How about the headers you supply? Are they very different from stock?

A. Yes, they are special equal length, rotational firing units.

Q. What compression ratio would you recommend for a maximum boost pressure of 15 pounds with water injection?

A. I would use turbo pistons which are 7.8 to 1 or 8 to 1.

Q. What engine modifications would you recommend for fairly sustained operation at 10 to 15 pounds of boost? Crankshaft, rods, rings, etc?

A. At 10 to 15 pounds, you're on the edge of stock and the need for engine modifications. If you know what you're doing, you can get away with 10 to 15 pounds as long as you have water injection to keep detonation down and a rev-limiter would be useful in case you miss a shift and bang a valve on a piston and break the valve. Turbo pistons have a deep enough valve pocket and, assuming you've installed racing valve springs for more tension to keep the valves from floating, you don't have the interference at that point.

Q. Do you recommend O-ringed cylinders or only over a certain number of pounds of boost?

A. For some installations, we always recommend O-ringing the top of the cylinder liner by cutting a groove at the top to contain a piece of copper wire. When you crush the head gasket into it, it creates a very good seal. Added pressure within the cylinder has a tendency to blow the head gasket. That's why we O-ring the cylinder in very high performance engines. I would recommend O-ringing any time you bore out a cylinder or change pistons—just for safety's sake.

Q. What drive train modifications do you recommend—sprockets, chain, swing arm, etc?

A. We recommend installing a heavier duty chain. Sprockets will take the extra power OK. When you go to over 10 pounds of boost, you should use a longer swing arm to help keep the front end on the ground. A good set of shock absorbers to prevent bottoming out and poor handling should be added, too.

Q. What about turbo cams? Do you recommend them?

A. Only for racing. For normal street use, I don't think they are required—even for short bursts of boost up to 20-25 pounds.

Q. What have you done to solve the Kawasaki and Suzuki oil problems that cause oil starving at the oil pickup?

A. We've got a deeper oil pan so that under hard acceleration the oil does not run away from the pickup. We've also created an oil pressure booster that supplies extra oil at the turbo for more reliability. This is different from the racing oil pump mentioned earlier.

Q. What about use of Nitrous Oxide in a turbocharged engine?

A. Nitrous Oxide should be used with caution. It's an oxygen-releasing agent—a gas. If you inject N_2O into the intake tract, you also have to provide more fuel to the engine or it will be starved. N_2O serves to make the engine run cooler and it is used in all-out racing. Someone once said "When all else fails, use Nitrous Oxide!" But—as long as you ask, let me tell you a little more about how Nitrous Oxide works. Normally, it's injected under full throttle application by means of a micro switch on the throttle. It is also controlled by a master switch on the handlebar. It's a constant flow proposition—that's why most users 2-stage it—especially in a turbocharged application. For take-off, one set of nozzles with specific openings injects the prescribed amount; the system includes a pressure-sensitive switch in the intake manifold which clicks in when boost reaches a certain point and injects more N_2O on top of the first shot. Some people even 3-stage it.

RECOMMENDED IGNITION TIMING/ CARBURETOR JETTING

Boost	Approximate Ignition Timing		Mr. TURBO Carburetor Jetting	
	2 Valve	4 Valve	Up to 1200 CC	Over 1200 CC
5–10 lbs.	36°	30°	BLUE	YELLOW
10–15 lbs.	34°	28°	YELLOW	RED
15–30 lbs.	32°	26°	RED	GREEN
30 lbs. up	30°	25°	RED	GREEN

CAMSHAFT TIMING RECOMMENDATIONS	Starting Point	
	Intake	Exhaust
	110° 113°	110° 108° Modified

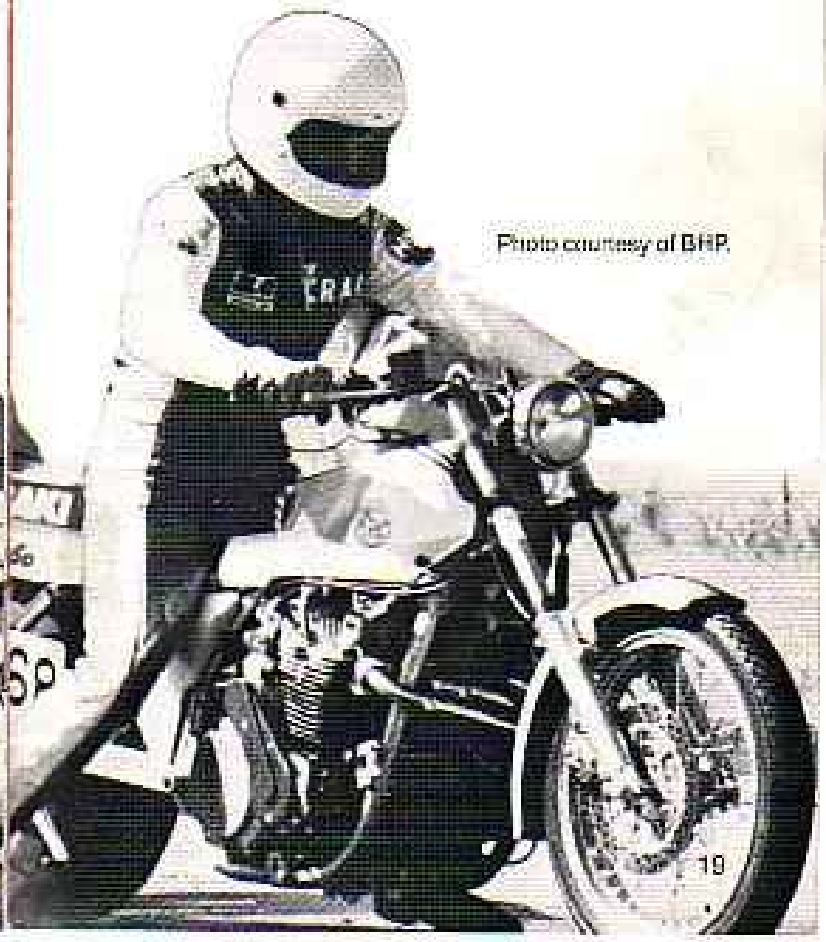


Photo courtesy of BHP.