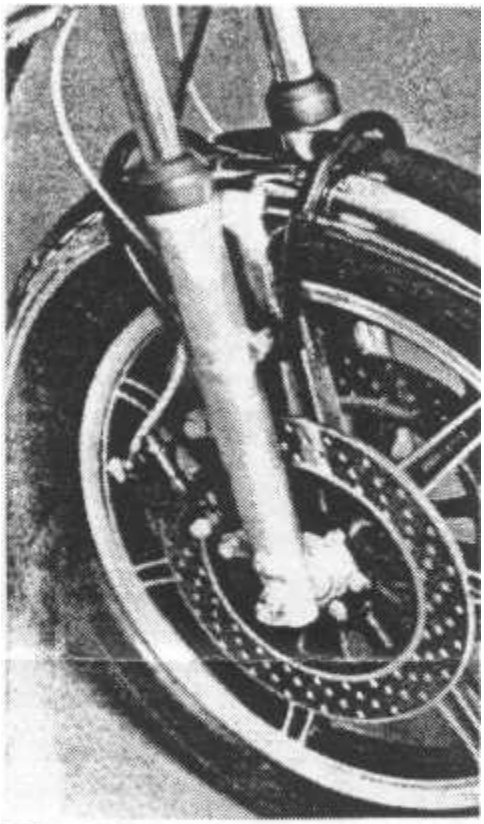
BUILDING A BETTER TWIN

by Joe Minton 1981

The Yamaha 650cc twin has been made for more years than any other Japanese motorcycle. Introduced in 1968, as the XS-1, the 650 has, with many chassis updates and one engine design change, been selling strongly ever since. Variously designated the XS-1, XS-2, TX650, and XS650, Yamaha's SOHC 650 sells to first-time riders who do not want to spend the big money for a four, or to those who simply like the way it looks and sounds and feels. Yamaha's first Special was the XS650, and the bike started a styling revolution that is still going. Each year we hear rumors of how "Yamaha isn't going to make any more 650s next year," and each year they make and sell another 10 or 15,000. The recent past has seen them get quieter (EPA), cleaner (EPA) and a bit faster (Yamaha). And each year they shift just as badly as the year before. Owners and magazines testers really love or really hate them, which to some people qualifies the TX/XS650 as a real motorcycle.



The basic high-performance front end: drilled discs, stainless brake lines, fork brace, and good tires all help.

The big twin's heritage is older and more interesting than you might think. During the early 1950s, Japanese motorcycle manufacturers were frankly copying European designs. It was during this period that the seed was planted which was to become the XS650 of today. Horex, in Germany, designed a 500cc SOHC vertical

twin that was thoroughly modern in concept and execution. The impecunious and enthusiastic engineer of Hosk in Japan made an Oriental version of the Horex. The Hosk was rather expensive - and fast. It was the only Japanese bike that could challenge the English singles and twins for performance. Eventually Hosk's constant cash-flow difficulties delivered them to the arms of Showa, which continued to produce an improved version of the Hosk (many of the Hosk engineers went to work for Showa when they took over the Hosk factory). Showa sold to Yamaha in 1960 and the old Horex-inspired 500 twin went with it. Before the sale, the same engineers who had copied the Horex designed a 650cc version of the Hosk which incorporated all that they had learned during the ten years of production of the 500cc version. The 650 promised to be simple and cheap to manufacture - and very strong. After a six-year hiatus Yamaha built a similar bike and has been doing so ever since. Your XS650 can be traced, directly, back to a design of the early 1950s, almost 30 years. Since the bike has been around for over a decade and has sold like mechanical hotcakes, it was a natural to include in our update series. It also has enough well-known glitches, which could use some attention, but we were surprised to find that it hasn't received a lot of attention from after-market companies. In fact, we eventually had to design our own pipe and piston kit to get the kind of performance we were looking for. We wanted the modified 650 to have the broadest possible power spread; people who ride twins lug them around, so we wanted to find some lugging power. We also decided to build a 750cc version of the bike. After all, Kenny Roberts used to race them that way. The displacement boost got results. If you build either of our engines, you'll get a real power boost, you'll lose no reliability, and you'll own something that is unusual and fun.

STAGE 1 CHASSIS

BEARINGS: Both the steering and swingarm-pivot bearings are substandard on the XS650 and should be replaced by superior aftermarket bearings. Tapered-roller steering bearings are far better than the cup-and-cone, loose-ball bearings supplied as standard equipment on the Yamaha and most other medium-sized, medium priced motorcycles. Tapered-roller bearings will last the life of your bike (if lubed properly), giving superior feel and, in some cases, better stability. There are currently two tapered roller bearing assemblies available on the market: the Dresda and those available from Racer's Supply (Japanese). The Dresda bearings are a little easier to install and have more bearing area, due to the larger rollers and races. However, they are hard to find. But the difference between the Dresda and the Japanese is largely theoretical anyway. We have installed both on many bikes and neither has failed. The Dresdas cost about $35, the Japanese cost around $30. Installation is the same as with standard cup-and-cone type bearings. You must pay particular attention that you do not damage the surface of the races when you install them; there is a thin edge that you can drive against on the outer races. Use a punch with a carefully ground, squared end on it so that when you place it against this thin edge of the roller bearing's outer race there will be little tendency for the punch to slip and mar the working surface of the race. Apply some grease to the outside surface of the race to make it slip into the frame more easily. Adjust the steering bearings so that there is no free play detectable when you grab the front fork tubes near the bottom and push them fore and aft; the fork should, however, be free to rotate under the influence of its own weight. After a couple hundred miles of riding, recheck the bearings' adjustment; a bit of play may develop after some use and you'll have to tighten down on them

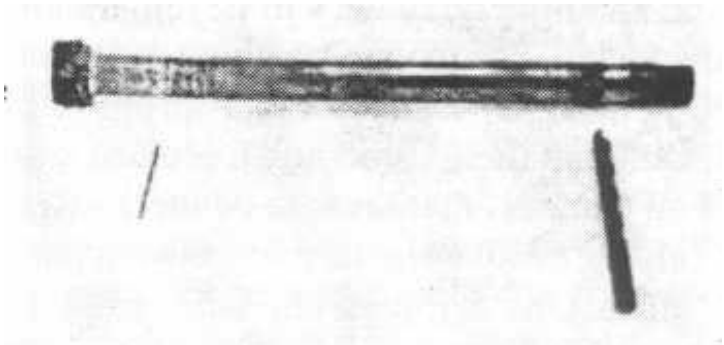
some more. Lubricate the steering bearings with quality grease such as the moly-filled constant-velocity-joint grease available through Volkswagen dealers. Yamaha fits the now-infamous plastic bushings to the XS650's swingarm pivot. They wear out by just talking about them and, when worn, make the bike feel as though it has a hinge in its middle-because it does. Get rid of them. Pro-Tec and Racer's Supply sell bushings that will last a long time. These bearings require no special installation procedure. Smear a thin film of grease on the outside of the bushings to make driving them home easier, and use a large socket or other object as a buffer between the bushings and your hammer. These bushings ride on a ground steel sleeve that has a rather poor finish. Clamp the sleeve (replace it if it's galled) in a vise and polish the bearing surfaces with 400 wet-or-dry sandpaper. The original rough surface has small pieces of steel sticking out that embed themselves in the bushing, then act as cutting tools to cause rapid wear of the bearing assembly. Polishing the bearing sleeve removes most of these chips and greatly extends the life of the bearings. Use the same grease recommended above. If you want a real surprise, change both the steering bearings and the swingarm bushings at the same time. The improvement in steering and handling qualities will be remarkable, considering you have only changed from one bearing type to another.

REAR SUSPENSION: Yamaha's rear spring-rate selection is pretty good, although there is too much preload and the springs are mounted on dampers that seem to be there just to keep the springs from flying away. The rear suspension has too little travel (three inches), no compression dampening, and too much rebound damping. After trying several different damper/spring brands and configurations, we found one that works very well. Fox Shox has introduced

a line of street bike dampers derived from their very successful dirt-oriented units. We found that the part No. 38-0097 (S-3) dampers were perfectly suited to the Yamaha twin. We chose 13-inch dampers to give a substantial increase in ground clearance. If you fancy yourself a canyon racer, you may prefer to do the same, but the longer shock will raise the saddle height and center of gravity a little. If you like the ride height of your 650, buy the 12.5-inch version of the S&W D-series damper. (Fox doesn't make a 12.5 inch model.) If you weigh less than 200 pounds, you will probably prefer 85-115-inch/pound springs. Riders over that weight and those who regularly carry a passenger will need the 95-125-inch/pound springs. Fox also supplies tow-rate springs, but none of them are suitable for the 650. With Fox dampers fitted to the project bike, we could not induce the rear-wheel bounce that was formerly so common when riding the XS650 on bumpy roads. The ride was soft, yet hard riding brought no signs of under-damping or instability. Fox street dampers are of the nitrogen-emulsion type and are pressurized via a Schroeder valve at the top of the shock. They are rebuildable and have proven to be of high quality even though they do not have the window dressing of many of the better-known street-oriented damper lines. I recommend them and feel that they are the best-performing street dampers currently available.

FORK: There are two ways to go in modifying the front fork assembly: air-assist and conventional. Both have advantages and drawbacks, but both improve ride and control. Late XS650 forks are good in most respects but share some of the same faults found in most current fork assemblies. There is excessive seal-drag and the good-looking but inferior-performing dirt-scrapers cause unnecessary sticktion. The XS fork (as with other recent Yamahas) has too much rebound dampening that will result in wallow and rough riding on bumpy roads. The 650 also

has too much compression damping, which contributes to its jolting behavior when it encounters a single bump such as an expansion joint in the roadway. To modify the damping, remove the wheel, fender, brake calipers, fork caps, and springs. Make a tool from a bolt with a 17mm head and two nuts to fit in the bolt. Screw the two nuts onto the bolt and tighten them against one another. Fit a socket over the nut(s) and tape it in place so that when you hold the assembly upside down the tape will not allow the bolt to fall out. Now find all the extensions you own, clip them together, and put them on the taped socket. Fully compress the fork leg and insert the extension/socket/bolt assembly into the fork tube and twist it around until the bolt head drops into the top of the damper rod. Fit an 8mm Allen wrench to the damper-fixing bolt in the bottom of the fork leg and loosen it, while preventing the damper rod from turning with the special tool you have made from a bolt and four yards of extensions.



Drilling additional holes in the fork damper rods makes a remarkable improvement.

Remove the damper rod from the fork tube. Note: There is a copper washer under the head of each of the damper rod fixing bolts. It may be stuck in the fork leg, which is fine: just be sure it is there when you reassemble the fork. Make sure you have recovered the anti-bottoming pistons that slip over the bottom of the damper rods; they must go back in place when you reassemble the fork. (If you put a small amount of grease on them, they will stay on the damper rod while you insert it into the fork leg.) There are two quarter-inch holes near the

bottom end of the damper rods. Drill two more quarter-inch holes through the rods so that there are a total of four around the bottom of each rod. These holes control the compression damping; you have just reduced it by about 40 percent. Near the top of the damper rod there is a small hole. Use a No. 54 drill to slightly enlarge that hole, and then drill all the way through to the other side of the damper rod. You will have two holes when you are finished. De-burr the damper rods and thoroughly clean them. You may wonder why we don't just use thinner fork oil instead of drilling holes. We could, but this gets better results. Besides, 10W oil is a better lubricant than 5W. At this point, you have to decide whether you are going to install air caps. If not, purchase a pair of 1976 Yamaha IT400 fork seals and install them in the fork legs. If you are going for the air-fork option, install 1976 Yamaha YZ250 fork seals. These seals have less friction than any seals we've used. Yes, we know. The XS650 has 35mm fork tubes and the recommended seals are designed for 36mm tubes-but they work. The stock springs are of the correct spring rate and length for the XS and need not be changed. The stock pre-load cam also offers a useful range of adjustments, although the front end will dive excessively under heavy braking. To control front-end dive, we recommend adding more than the normal quantity of fork oil. This will introduce an air-spring effect that will increase the total load capacity of the fork, while decreasing dive. With the fork compressed fully and the spring out of the fork tube, pour Kal-Gard 10W fork oil in until it is six inches from the top of the fork tube. Pump the fork slowly until all the air is out of the damping cavities and add oil, if necessary, until it is six inches from the top of the tube, install the springs, caps, brakes, fender, and wheel. The XS fork will work best as an air fork. The initial travel will be softer, braking dive is well controlled. And, of course, the forks are wonderfully adjustable for different riding conditions or varying rider

moods. We have modified several of these forks to air-assist and have had no leakage problems. Make the same damping modifications detailed above and use the same amount of the same weight oil. You will need different springs; S&W No. SP-1530-19 fork springs should be cut to 18.5 inches and installed with S&W air caps. If you wish to use some other brand of fork caps, be sure that the springs are cut so that there is .7 inch of spring preload when the caps are fully seated. We found that 10 psi was a normal working pressure for all-around use. Twisty-road riding was more comfortable at 14 psi, and cushy freeway comfort came at 7.0 psi. Like the steering bearings and swingarm bushing modifications, the fork and rear damper changes are best done at the same time to fully realize just how much the Yamaha can be improved. We think that you will find the difference remarkable. Your bike will ride much better and handle much more securely.

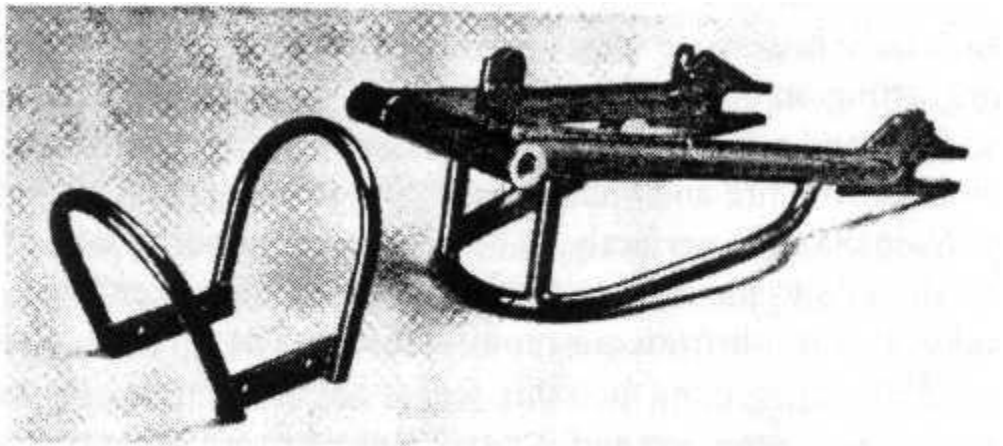
STAGE II CHASSIS

BRAKES: Yamaha brakes are among the best in production today; they are fitted with rigid calipers and have a solid feel that gives the rider excellent control. However, they can be improved. The disks themselves are rather heavy (the heaviest in the industry), and Yamaha's disc material leads to galling. Small pieces of the disc material are torn loose and imbed themselves in the brake pad. These imbedded particles then act as cutting tools that gouge grooves in the disc and reduce its effectiveness as a braking surface. There is a simple solution to this problem: drilling the disc. If the disc is drilled in such a manner that the entire surface of the pad is swept by holes, the metal particles are carried away, and galling will never take place. In fact, galled disc drilled in this manner will polish up and work much better than it did before being drilled. The holes should be left somewhat

sharp at their edges - not so sharp that you might cut your finger on them, but sharp. Specialists II will drill Yamaha discs with a 168-hole pattern that will do the job for $40. There is nothing you can do that will improve your Yamaha's brakes as much as this drilling operation. The holes will not improve wet braking much, if at all, but they will greatly improve the effectiveness of your bike's brakes. Perhaps you ride hard or carry a lot of luggage. If so, you might want to install a second disc on your XS. Europeans buy the XS650 with two discs installed at the factory; those conversion parts are available from your Yamaha dealer. Have him look on the 1978 or '79 parts microfiche; near the bottom is a special section devoted to the part numbers needed to convert the XS to double front discs. The conversion is not cheap. We found a second disc and caliper at a motorcycle salvage yard for a much lower price. You may use one of the calipers from the XS750 but must change the pads to the same ones used on the 650. There are two different pad materials available to fit these calipers: those fitted to the 650 (and XS11) and those furnished with the 750 triple. The 650 pads are softer and require less lever pressure to operate but do not perform as well in the wet. Either pad set will last a long time and wear need not be of any real concern. We recommend -3 stainless steel braided Teflon brake lines for the improved rigidity and feel they give the brake system. You may purchase these lines from Russell Products. When fitting twin discs, you may wish to use the larger master cylinder from the XS750; we did not and prefer the light, two finger brakes that result with two discs being fed by the original 14mm-diameter master cylinder.

BRACING: The Yamaha's frame is fully up to the stresses of hard riding and bumpy roads. The fork, however is not, and neither is the swingarm. If you really want to fly on your XS, you will need to fix the fork-flex problem, and if you want the

most rigid chassis possible you should stiffen the swingarm. Many current production motorcycles share a shortcoming with the XS; the front axle is not clamped securely on both sides of the front fork. The front axle is clamped by a cap on one fork leg and merely passes through the other leg. Fork rigidity is very much influenced by this. If you have the opportunity, stop by your dealer and compare the fork stiffness of your bike with one of the new Yamahas that has the axle clamped on both sides. To do this, face the bike and put the front wheel between your legs; grasp the handlebars and pull them from side to side as though you were trying to turn the wheel. There will be a lot more flex in the fork of a bike with the axle clamped only on one side than with the two-clamp design.



Three steps to a tighter chassis: fork brace, bronze bushings, and braced swingarm.

Okay, so your bike's fork flexes. What can you do about it? The answer is as simple as bolting on a fork brace. We used one of the braces sold by Racer's Supply. These braces are made by Racer's World, cost $59.95, and work. The brace is made of two pieces of steel tubing bent to fit over and around the bike's fender and welded to steel bars drilled to fit the fender-mount lugs on each fork. Some care should be exercised in fitting this brace to your bike's fork. Individual motorcycle tolerances make it almost impossible for Racer's World to make every fork brace fit every bike. It

is very important that the fork brace be a slip-fit between the fork legs. If there is any stress between the brace and the legs, there will be an undesirable increase in fork stiction. Usually only a bit of filing is needed to fit one of these braces. Just be sure that the fit between the legs and the brace is snug and does not result in any side pressure on the fork legs. Bumpy, curving roads will flex your bike's swingarm. The heavy cast rear wheel on the Special versions of the X650 particularly affect handling. If you really wish to prepare your XS for the best possible handling and stability, you should seriously consider bracing the swingarm. Racer's World has a series of weld-on swingarm braces for popular superbikes. These cost a lot less ($60) than the custom swingarms and are effective and simple to install. (You just take the brace and swingarm to a certified welder and let him do the work.) We talked them into manufacturing weld-on braces for the XS650. The braced swingarm they furnished us fit, was straight, and made a big difference in the stability of our XS650. You can purchase one of these braces (even if you own some other bike) from Racer's Supply. We recommend them to anyone who wants to have the best possible chassis performance.

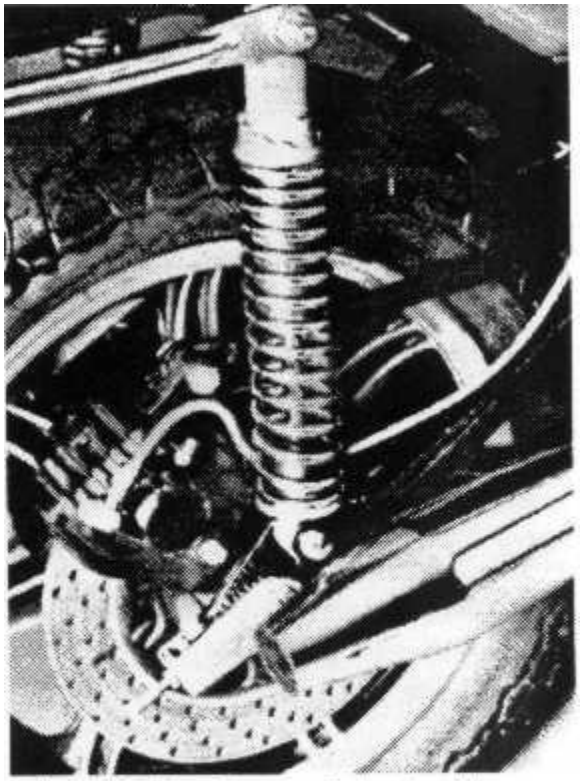
TIRES: Roadrace-quality handling will do nothing if you don't have tires to go with it. We tried several sets of tires before setting on our preferred set: a sport-compound Metzler on the front and a Pirelli MT28 on the rear. The Metzler is a round-profile tire and complements the steering geometry of the Yamaha twin perfectly. The sport compound version of this tire allows the rider to take advantage of the excellent brakes that result from our modifications. The Pirelli is also a round tire that retains the same feel at any lean angle. Its traction is above reproach and it lasts. But there are other tire combinations that perform well on the XS, depending upon how you use your twin. There is no better

touring setup than the Conti twins. These tires will give the best ride, last at least as long as anything else, and will give more traction than the stock chassis can handle. One rear tire (16-inch) gave one staffer's XS650 11,000 miles before needed replacement. If you must ride in the wet, we strongly recommend Dunlop K181's. These tires are magical in the rain. They probably won't last as long as the Contis, but they will make *you* last longer in the rain. I have used ACP balancing fluid for four years and have never had a balance problem during that time. Tires wear evenly, and even at 130 mph I have a smooth ride.

STAGE I ENGINE

EXHAUST: Although the 650's exhaust system proved to make excellent power at higher rpm (more about that later), it also killed power in the 3,000 to 4,000-rpm range. Even before we took the bike to Jerry Branch's dyno, it was obvious that the 650's low-end torque and response could be improved, so we tried some aftermarket exhaust systems. We tried all the variations we could find: two-into-ones, replacement mufflers, and one set of replacement header pipes. They were all unsatisfactory in one way or another. The two-into-ones reduced ground clearance on the right so much that the bike was not fun to ride. Besides, they really didn't improve the power enough to overcome the ground-clearance objection. Replacement mufflers had no chance to succeed; for, as we sawed the factory mufflers from the stock header pipes, we found the source of the stock exhaust's anemic behavior: the inside diameter of the stock pipe is just 1.125 inches. Racing versions of the XS are regularly fitted with pipes that are a full 1.75 inches in diameter. The replacement headers were excellent: they were a desirable 1.5 inches in diameter and 33 inches long—almost perfect. The problems were that we could not find a

satisfactory muffler to go with them and their exhaust flanges broke because they were too fragile. Through quirky circumstances we found a manufacturer who was willing to make exhaust pipes to fit our specifications: Bub Enterprises in San Jose, CA. We got our exhaust pipe specs from available literature regarding such things and from Jerry Branch, who is the most successful horsepower-getter in the motorcycle industry. Jerry agreed with our 1.5-inch-diameter-by-32-inch-length design, saying that it would probably give the XS650 the kind of performance we were looking for: excellent mid-range torque and the broadest possible powerband. The design later proved to be a complete success.



The Bub pipe adds bottom-end power, Fox dampers put it on the ground, and Pirelli Phantom tire improves the traction.

Bub Enterprises quickly made up a prototype pipe and rushed it through the chrome shop so that we could take the photos you see in this article. While he had the bike, he also made up a set of two-into-ones that were of the same diameter and length and would not drag. This is the pipe that is on the bike in the lead photo. Bub felt that many XS owners would prefer the slightly less expensive pipe even if the two-into-two proved to give better performance. Both Bub pipes were designed to give the greatest possible ground clearance and will clear the right engine case enough to allow the installation of the

Lockhart oil cooler fittings, something the late stock pipes will not allow. The Bub two-into-two is fitted with Bub's Norton-Commando replica, straight-through muffler. It is made of .065-inch-thick tubing and is well chromed. Although a little loud, the louvered construction of its silencer tube gives the exhaust a very pleasant sound that fairly shouts, "motorcycle!" The two-into-two pipe costs about $165, in chrome only, from your dealer and the two-into-one retails for $145 in chrome and $135 in black.

IGNITION: Most of the battery problems that XS650 owners suffer with are directly due to the poor performance of the stock ignition coils. The voltage drop that occurs when the starter motor is used is often enough to prevent the ignition coils from making enough voltage to cause a spark in the combustion chamber. This leads the rider to run the battery down trying to start his bike, and many XSs run around with poorly charged batteries. One of the symptoms of this problem is that it may kickstart easily but is reluctant to go when prodded by the electric foot. Andrews Products makes a replacement coil for the Yamaha RD400 that fits in the rather cramped space under the tank of the 650. This coil has a three-ohm-resistance primary winding and really puts out the pressure, even when you use the electric starter on a cold morning. After we installed a set of these coils, we never had another problem with cold starting nor any other sign of a low battery-charge condition. We bought ours from Racer's Supply although you should be able to get them through your local motorcycle dealer. They retail for $20 each and are worth the tariff. Your bike will start better and respond more willingly, and the extended life of a fully charged battery will be worth more than the cost of these coils. We have many thousands of miles on the Martek 1000Y ignition, and it has performed flawlessly. However, when we installed the low-resistance Andrews coils, we had to replace the Martek with

one of the later, higher-current-capacity, Martek 1000Ys or one of Dyna lll's D-36-1 units. Either of these ignitions will take the higher current flow of the Andrews coils. The Dyna lll has the added advantage of allowing you to adjust the timing of each cylinder separately. You can determine the suitability of a Martek ignition for use with the Andrews coils by looking for a connector in the wiring harness leading from the black box to the sensor plate. If there is no connector, the ignition should not be used with Andrew coils (unless you install an automobile ignition ballast resistor in series with each of the power leads to the coils). Electronic ignitions will, of course, eliminate points care and reduce ignition maintenance to an occasional plug change and a dab of lube to the advance mechanism every once in a while.

Be sure to check your Yamaha's advancer for correct timing at full advance. Some of these units have been known to over-advance the ignition. If yours does, have your dealer carefully bend the advancer's flyweight stops until the fully advanced timing and retarded (idle) timing are correct.

CARBURETION: On pre-1980 XS650s, the Mikuni carbs can be tuned by moving the needle position or by replacing jets. Post-1979 bikes are fitted with the Hitachi units with all the jets pressed into place; there is little you can do with these units but replace them. But if you really want power on the top end of the rpm spectrum, replacing the carbs is a good idea, no matter which carbs your bike came with. Bub pipes require jetting changes to the stock Mikuni carbs. We found that K&N R-135/2 air filters (they replace the airbox) are quieter and cheaper than the OEM-type K&N replacement filters. After fitting the Bub pipes and K&N filters, the main jets should be replaced with No. 145 jets, the needle should be dropped to its lowest position (remember, lower the needle not the clip), and the plastic caps removed from the

idle mixture screws. Adjust the mixture screws for fastest idle, keeping the idle speed down to less than 1200 with the idle-speed screw. The idle-mixture screws should be set so that turning them a quarter-turn in either direction will cause the idle speed to fall slightly. If you own a 1980 or '81 XS, or if you want a substantial power gain above 6,000 rpm, fitting accessory carbs becomes necessary. Jerry Branch developed a 36mm Mikuni carb set for the XS that will give you more immediate response and more power. The kit is complete with carbs, cables, and manifolds and is available with jetting for either Stage I or Stage II engine. We fitted these carbs to both versions. They work. The kit is available from Branch Inc. for $169.50. If you would like the additional advantage of accelerator pumps and really beautiful carburetors, you might consider fitting Dell'Orto 36mm pumper carbs to your 650 as one staffer did to his personal bike. The Dell'Ortos cost more than the Mikunis, but they work wonderfully and are very responsive with their adjustable accelerator pumps. Engine Dynamics Company will supply you with filters, adapters, cables, and fuel lines for $268.30. Be sure to specify whether you are running the Stage I or Stage II engine.

CLUTCH: The XS650 has a richly deserved reputation for poor shifting. What is not generally known is that this common shifting difficulty is due to clutch drag. We have not been able to totally eliminate clutch drag in our project bike but we have found ways of minimizing it. Late in 1979, Yamaha introduced a new clutch-hub design in many of their bikes. This hub incorporates a Belville washer to widen the engagement zone of the clutch and to eliminate the shuddering that occasionally crops up among XS650s. Unfortunately, it also decreases the separation of the plates, which promotes clutch drag. We found that changing to the earlier hub helped the problem. The greatest decrease in

drag was obtained by fitting one of the high-performance clutches supplied by RC Engineering. These plates have proven to be the most durable available for dragracing. For our use, though, they are superior for other reasons. The RC clutch has the smoothest engagement of any clutch we tried (and we tried every clutch we could find). It also had substantially less drag than any other. Even with the power we later got with the Stage II engine, the stock clutch is good enough, but if you want the best shifting, fit the RC clutch for $61. It includes friction discs, copper-coated steel plates, and somewhat heavier springs. Installing the good clutch hub and exotic plates will do little if you don't follow up on the other cause of bad shifting and clutch drag: lubrication and adjustment. There are two adjusters on the clutch cable. One is at the lever end and the other is at the bottom of the cable, where it runs into the left engine case. Screw both of these adjusters in as far as they will go. There will be excessive play in the lever as a result of this. Use the clutch pushrod adjuster in the side case to set clutch free plan. By following this procedure, you will have put the clutch pushrod actuator in the best position to assure maximum clutch plate separation when you pull in the lever. After all this, there is one more thing to attend to: lubrication. We recommend the cable lubricator sold by Yamaha. It clamps over the end of the cable and allows use of one of the aerosol cans. PJ1 chain lube works very well as a cable lube, so does Molly Blue, if you can find some. Lube the clutch cable every time you change oil, and you will assure yourself of the best possible clutch action.

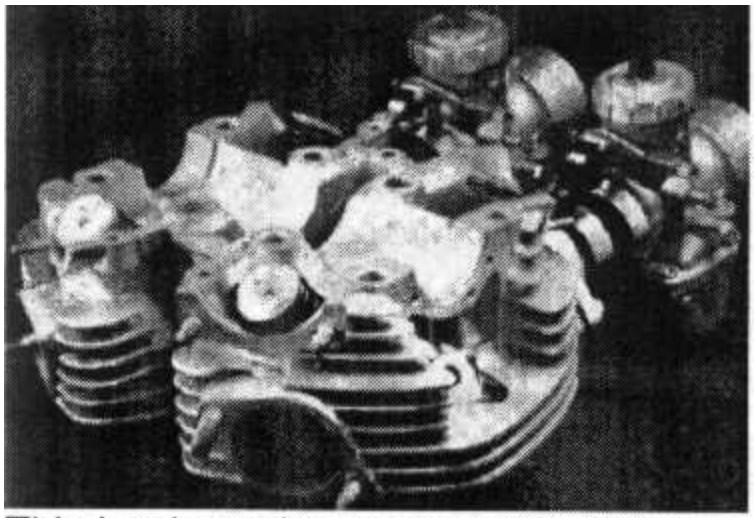
STAGE II ENGINE

Our stage II engine is the result of much research and effort on the part of both Motorcyclist and several talented and interested people in the industry. Upon committing ourselves

to developing the 750cc version of the Yamaha, we had no idea what we were undertaking; surprisingly little development had been done on street versions of the successful dirt track version of the 650. All the 750cc kits we investigated were developed during the early '70s when gasoline was of better quality than is available today. Consequently they had high compression-ratios that demand better gasoline than we now get. Most kits develop a compression ratio of about 10.5:1-too much to be reliable unless treated kindly and kept in excellent tune. We found several XS owners who had installed 750 kits and experienced severe problems due to detonation. There were other problems: cylinder sleeves (they have to be replaced to make a 750) that were too thin to remain round and straight during hard running, soft sleeves that wore rapidly, poor rings, and unreliable pistons. Many owners have made 650/750 conversions and have had no trouble whatsoever. However, we insisted upon retaining the stock engine's reliability. We wanted a kit that would give satisfactory performance even if it was installed with less than professional care. After a lot of work and critical advice from some very experienced engine builders, we succeeded. One of the benefits of our work was the development of a street 750 conversion that will work with today's gasoline and that reflects the latest thinking in combustion-chamber design. After consulting with Jerry Branch, the foremost filter-person for what works, we knew what we had to have to achieve the engine performance and reliability we had in mind.. Instead of trying to build an engine that would give the best quarter-mile times and speeds, we wanted a broad powerband with lots of real-world, useful power-which is what we got.

CAMSHAFTS: The cam had to be a torquer with generous lift and short duration. Most of the cams readily available at the time were biased toward the top of the rpm range and had

been developed for dirt trackers that had to compete against the dominant Harley XRs. We found two cams that seemed to fit our requirements: one from Shell Thuet and the other from Megacycle. The Shell cam is his No. 1 cam and is a regrind. It has a lobe center of 100 degrees and the timing of the intake and exhaust are symmetrical about top dead center (the intake opens as many degrees before TDC as the exhaust closes after). Megacycle recommends this cam for TT racers, since it gives a very broad power band - as we found out. The Megacycle cam is a welded-up and reground cam with lobe centers of 104 degrees. The Megacycle cam has .030 inch more lift than the Shell Racing cam (.440 Vs .410 inch). It promised more peak power with some small loss of bottom end power when compared to the Shell cam. We were never able to find out We simply ran out of time before we had a chance to try the Megacycle cam. The Shell cam is cheaper because it takes less time to regrind a stock cam than it does to weld on the hardface material and ten grind the cam as is done on the Megacycle cam. The exchange price of the Shell Racing No. 1 cam is $78; there is a core charge of $90, so you should furnish your old cam when ordering. The Megacycle cam sells for $139 exchange with the same $90 core charge. Neither of these cams requires any modifications to the valve gear; stock valve guides will work and there is no problem with valve-spring coil-bind. For best results, they must be timed so that the intake opening and exhaust closing are symmetrical about top dead center. Follow the general procedures outlined in the October 1980 issue of Motorcyclist. Timing cams is rather imposing, until you have done it once. You will need a degree wheel and some method of finding TDC (we used a two stroke timing tool). If the cam is not in the right place, you must press the cam sprocket off and reposition it to change the timing. This isn't very difficult but will require a press.



This is where the power comes from: Branch heads and free-flowing carbs.

PISTONS & SLEEVES: The Yamaha 650 needs a piston limited to about 9.5:1 compression ratio and there should be generous squish area in the combustion chamber. These features lead to high detonation resistance and lower operating temperatures. Megacycle supplied us with the piston from which we were to develop our desired final product. they a 10.2:1 piston of 80 mm diameter (753cc) that has the proper shape and is of excellent quality. However, it did live too far from the head surface to give the necessary .040-.050-inch clearance for proper squish effect. We found that if the dome of that piston was raised and the top was machined off, we would have our piston. Not surprisingly, it turned out to look very much like the pistons used in the Harley-Davidson XR750 dirttracker.

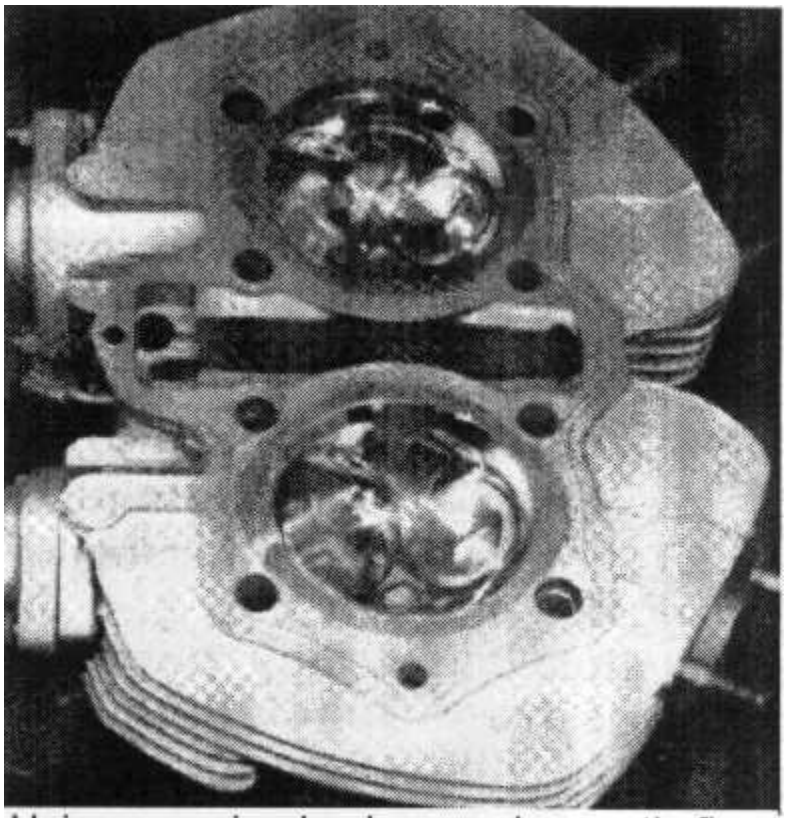
The sleeves most vendors use are a little thin for long-term dimensional stability, so we requested-and got- thicker ones. There are compromises to be made with cylinder sleeves. If they are too thin, they will warp and the engine will not seal well. It they are too thick, the rings will not receive the cooling they need for long life. Branch recommends a sleeve that is between four and five millimeters thick. Megacycle ordered thicker sleeves from the manufacturer and will furnish them with the pistons. Piston rings were not a problem and neither were piston pins. Megacycle has been selling a set of American-made rings that have been installed in many hundreds of 750s and that work and last. The best

pin for the Yamaha is the stock item, so we used them. There were only two head gaskets available for the 650/750 conversion: one made in America and the other in Japan. Fore several reasons we decided that the Japanese had the better product. We used it, and Megacycle will include it in their conversion kits. The piston kit, including gaskets, retails for $218.

CYLINDER ASSEMBLY: Next we looked into who could install the cylinder sleeves and bore the cylinders for our conversion. We didn't have to look far to find two sources whose work is beyond reproach: Vance and Hines Racing and Engine Dynamics, both here in California. VHR did ours, and with our precision bore gauge, we could not see *any* variation in roundness nor could we detect any taper. We have seen examples of the work done by Engine Dynamics, and it too is as near perfect as we have had the privilege of fondling. Never, never underestimate the importance of the quality of a bore job or cylinder honing. If the rings don't seal, you lose power. If there is not full contact between the rings and cylinder, the rings will overheat, and you lose power. Taper, at high engine speeds, can cause the rings to lose contact with the cylinder walls and flutter, and you lose power. If you cannot fully trust your local machinist to install the sleeves and do the boring, take the time to send the job to one of these companies. It will be worth the wait. VHR charges $45 for sleeve installation and $36 for boring. They hone the aluminum cylinder block before installing the sleeves to increase the contact area and therefore, heat transfer. To ensure maximum cylinder cooling and stability, we sent our cylinder to Plasma Technology (the people who make those lovely metal-sprayed brake discs) to have the sleeve/cylinder interface filled with a Loctite material. This is done by immersing the cylinder assembly in a vat of thin liquid and then evacuating the sealed vat. The Loctite is

sucked into the sleeve/cylinder space and "kicks over." The hardened plastic material transfers heat about 25 times better than air and strengthens the assembly. Plasma Technology will provide this service for $10 per bore, and we recommend it if you want to go all out.

PORTING: Jerry Branch did some of the engine development work for the Yamaha racing effort when Kenny Roberts was racing here in the early '70s. He ported any heads for Yamaha and for nearly everybody else. He assured us that he could improve the flow (and therefore the power) of the XS head by almost 25 percent. His work consists of reshaping the valve pockets and ports and installing his excellent guides. The valves were increased in diameter 3mm on the intake side and 2mm on the exhaust side. The Branch valves are tough, shaped according to what he found works on the flow bench, and have chrome-plated stems for extreme durability. Branch valve guides are made of a material (aluminum-silicone bronze) developed for radial aircraft engine valve guides. They are so durable that XR Harley tuners only replace them when the heads are brought up-to-date (every couple of years or so). Included were the best valve guide seals around: Perfect Circle's Teflon seals. They simply don't wear out.



Using oversized valves and expertly finished and shaped ports upped flow 25%.

Careful port work is the main reason our engine developed as

much power as it eventually did and is largely responsible for the incredibly broad powerband of our 750. If the port works well, radical cams are not necessary. Good ports and moderate-duration, high-lift cams will make the most power over the broadest rpm range. Nothing you can do will give your bike as much performance improvement as Branch's excellent port work. Of course, you must also do the rest to avoid choking up those beautiful ports. The price is high for the complete job but it is the most cost-effective modification you can make. Besides, it won't wear out. Labor for porting is $225 and the rest (valves, guides, seals, and springs) bring the total up to $339.50.

ENGINE ASSEMBLY: The XS650 is a simple straightforward motorcycle; it has no complex parts assemblies, nor does it require special tricks to avoid disaster. The factory shop manual is complete and confidence-inspiring. Completing the Stage II engine won't necessitate purchasing special tools. You may need the services of someone with a hydraulic press to help with cam timing, but that is all!

Rather than furnish step-by-step directions for assembly of the 650/750 conversion as we have with our previous update articles, we will confine our comments to a few pointers on what to do and what not to do.

DO: Use a gasket sealant such as Yamabond on the base gasket; it'll leak if you don't. Retorque the head after the bike has been run for the first time. Install a Lockhart oil cooler. (We used the temperature-controlled 600 series.) According to Shell Thuet, you should not be tempted to place the cooler in series with the cam box oil supply line (the chrome tube running between the cylinders) as it will not be effective with the small oil flow that results. Before you assemble the piston rings to the pistons, put each ring in the cylinder bore

(you can push it in with the piston to be sure it is square with the bore) and measure the ring end-gap. It should be 13-14 thousandths of an inch. If not, file or stone the ring ends until it is. The oil-scraper rings may have a little more end-gap but the top and second compression rings should be rather close for best seal life.

DO NOT: Some people recommend drilling out the restrictor that controls the oil volume to the head. It is located at the base of the cylinder and the oil feed tube is joined to it. Drilling this is a mistake; increasing the size of the hole will not help top-end oiling, but it will reduce the amount of oil getting to the crankshaft and therefore to the cylinders and pistons. If you are concerned about cam scuffing, use straight 40W Kendall GT1 oil and Kal Gard "Engine Gard" plus the oil cooler. As with any engine that really breathes well, our 750 conversion will make power well beyond the redline. We have been assured that even the short-rod version of this engine (made after 1974) is safe at 8,000 rpm. Our 750 will make power well beyond that point; you can no longer shift by "holdin 'er wide open 'till the power falls off." Watch the tach. This is one of the toughest engines ever built, but it's not made of impervium.

THE RESULTS:

Part of this project included dyno testing at Jerry Branch's facility. Rather than go to the dragstrip with the stock bike and then the Stage I and Stage II versions, we chose to put the bike on the pump. Dragstrip testing is limited in that it will not provide a very good idea of how a motorcycle will accelerate at low rpm, and since one of our main goals was to develop useful power throughout the engine's rev-range, we felt that comparing the stock engine to the Stage I and Stage II versions should be done on a dynamometer.

Our first trip to the dyno was with the stock bike and with the Stage I components. The stock (1979 Special) engine performed about as expected, although it made more peak horsepower than anticipated. Power in the lower half of the power band was unimpressive. As the tach climbed from 5,000 toward 7,000 rpm, the XS began to wake up and run. Above 6,000 rpm, the torque began to drop off and the horsepower followed the downward trend. By 7,000 rpm the engine was really suffering and fell on its face at 7,500. The stocker reached a peak horsepower reading of 42 at 7,000 rpm.

Our first modification was to install the Bub Enterprise two-into-two exhaust. It was a bit scary; we were going to find out if our pipe design was really going to work. No wild claims could change the cold reality of what the dyno found. The first horsepower sampling was taken at 4,000 rpm, and gave a 37-percent increase in power over the stock engine at the same rpm! Our Bub-piped stock engine made 27.6 horsepower whereas the factory-stock engine gave only 20.1. By 6,000, the Bub two-into-two's advantage had dropped to only six percent and we were disappointed until it occurred to us that riders hardly ever rev their XSs that high. Jerry also suggested that perhaps the stock carburetors were beginning to adversely affect performance. So we added the 36mm Mikuni kit to the Bub pipes and made another run at the dyno.

The Branch Mikuni kit did not improve power output until the engine was past the 6000-rpm mark on the tach. Then the restriction of the stock carbs became very noticeable in comparison. The stock (with Bub pipes) carbureted engine reached peak horsepower at 6000 rpm. Adding Mikunis moved the peak power rpm up to 7500. The useful power band was raised 1500 rpm by simply bolting on a set of

carbs. Peak horsepower went from 42 to 48. Just to see what the Mikunis would do for the XS by themselves, we replaced the Bub pipes with the stock items and made a final run with the Mikunis in place. There was a two-horsepower gain at 4000 through 6000 and a whopping 4.7-horsepower gain at 7500, where we stopped the run. The gain at the top of the engine's range was expected: the fact that the carbs made more power at low rpm without the Bub pipes simply told us that the jetting was not correct for the Bub pipes.

The combination of the Bub Enterprises two-into-two pipe and the Branch-Mikuni carb kit raised the power output 26 percent at 4000 rpm and 14 percent at 7500. This is a big improvement and *feels* like more than the numbers would have you expect. The real surprise was just how nice the immensely broadened power band is to use on the street. We found ourselves spending a lot of time in fifth gear instead of fourth and not bothering to downshift when passing. The Branch/Bub engine is more responsive, faster and-get this-*smoother* running. Maybe it was the pipes or the phases of the moon, but the project bike vibrated less after we installed the pipes and carbs.

After building the 750 version, we went back to the Branch dyno. We knew from the way the thing responded and sounded that we were going to see some results worth bragging about. We weren't disappointed. At 4000 rpm, the Stage II engine (with Bub pipes and Mikunis) made 29.1 horsepower, 45 percent more than stock! At 5000 there was a 27-percent advantage and at 7000 rpm the Stage II engine made 52.1 horsepower for a 24-percent increase over stock. It wasn't through: at 8000 the Stage II engine reached 54.5 hp for a 30-percent gain over stock. All this even though the engine was running a bit rich. A full 60 horsepower is

probably available, and the jetting we finalize will be furnished with the Branch Mikuni kit.

You have been reading a lot of numbers and, we hope, been impressed by what can be done with the XS. The finished bike's performance is much more than impressive numbers. The Stage I bike is good-handling, fast, responsive, sounds great, and doesn't cost much to build. Stage II costs a lot more, but will blow the doors off stock 750 fours in a roll-on, and it will handle well enough to roadrace. The continued sales success of the big Yamaha twin clearly states the case for simple strong, and traditional motorcycles. Since many of the XS650's purchasers are first-time buyers who don't want to spend a bundle. Yamaha has cut a couple of corners. For those of us who want the XS for its character and would prefer more quality and performance, there are aftermarket parts to help. We hope that you are more than tempted to take advantage of some of the things we have learned about improving this venerable twin. You will be pleased with the results.

There are many hop-up parts out there for the XS650; many exhausts, cams, and piston kits. Do what you think is right, but remember; If you duplicate our Stage I or Stage II engine, you *Will* get the same results, no guessing. Enjoy your Excess 650.