HUSQVARNA TRANS-AMA REED VALVE PROTOTYPE

We test and tear down one of the hottest 250cc motocross machines ever built. Chalk it up to a unique new reed valve system that brings "overlap" to the two-stroke engine.

By Gregory J. Gore

■ Last year during the Trans-AMA motocross series (becoming better known as the "summer" series), Husqvarna was not as well represented as they might have been in terms of both men and machinery. This year things will be different; three of the factory's top riders will represent the marque mounted on perhaps the fastest 250's ever to hit a motocross track.

I recently had the chance to test one of these super-fast racers. Right off I was told that the machine I was going to test ran to 12,500 rpm on the dyno and out on the course made tracks like a super-tuned 400. Sound unbelievable? I thought so too, but how wrong I was.

What makes the big difference in this particular 250 Husky is a new concept in reed valve design developed by Husqvarna's former East Coast technical representative, Eyvind Boyesen. That one day Eyvind would develop something like this isn't surprising considering his background. Before joining Husqvarna, Eyvind was a product development engineer working on flow instrumentation for S & K Instruments, and his name appears on several patents held by that company. Now he's getting his own patent on a new reed valve system that seems to be a big improvement over any other.

Boyesen has always considered reed valves to be the answer to efficient intake timing, and he has been experimenting for years with more or less stock set-ups. The most difficult problem he encountered was tuning the tension of the reeds for a smooth power band. Too much spring and the reeds wouldn't work well at low rpm, too little spring and the reeds would "float" at high rpm. In either case power was lost from one end of the rpm-spectrum. His solution was to have two separate reeds, one for low rpm and one for high rpm. Sounds simple enough, but there's actually much more to it than that.

As soon as he tried the dual system

there was a dramatic change in horsepower. None of the old single-reed arrangements would even come close to the performance of the new dual reeds.

Shortly after his discovery he made a cylinder and reed set-up available to Mr. Ruben Helmin at the Husqvarna factory. Mr. Helmin is the man in charge of everything to do with the motorcycle branch of the company. Years ago he began reviving this segment of the company, which had all but died in the fifties, and today it's the fastest-growing part of Husqvarna's production. Much of Mr. Helmin's success was due to very careful product development, which has been very conservative.

Boyesen's cylinder worked well, but Helmin wasn't going to rush into anything. (Eyvind regrets that Husqvarna hadn't picked up on his idea sooner; they might have beaten Yamaha to the punch with reed valves.) Recently Eyvind received word from Mr. Helmin in Sweden that his reed valve system looked like Husqvarna's best chance for victory in the Trans-AMA series.

To see just how much more power over stock he was getting from the dual reeds, Boyesen put his modified 250 engine on the dyno. The results were astounding. The stock 250 Husky engine responded very well to the set-up. The 250, it seems, has a very mild port timing – very similar to that of a stock street Yamaha DT-1 – and the reed valving was just what it needed.

The dyno time on the new cylinder and reed manifold was well spent, and many interesting aspects of tuning the reed valve engine were discovered. For one thing, the stock 250 needed very rich jetting to get the highest dyno full-throttle readings, a mixture that, as it turns out, is impossible to use out on the track. If you tried riding the machine with the dyno mixture, the engine would load up as soon as you shut off the throttle. With the reeds, however, the right full-throttle dyno mixture was also the right mixture for riding.

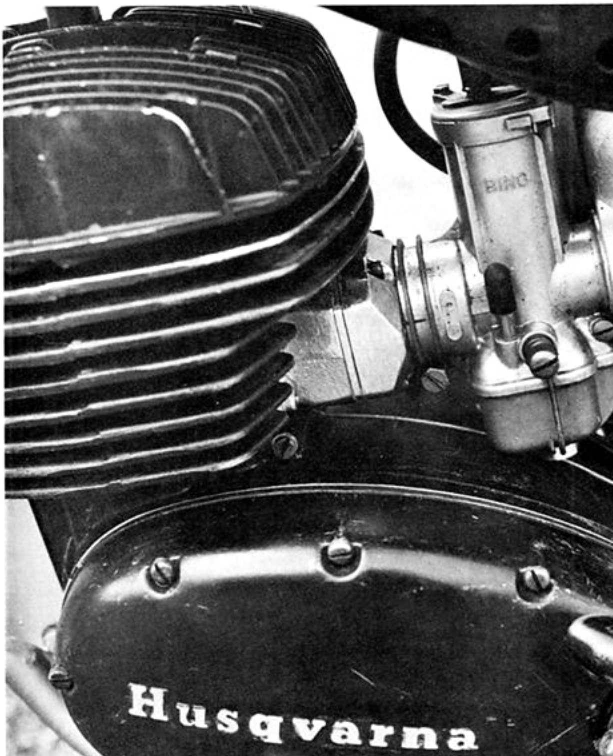
Boyesen also found that when you switch to reed valves you have to go one or two settings richer on the needle, and one or two numbers richer on the main jet. The slide cutaway turned out to be very critical, too. His carb slide needed a bit more cutaway for smooth running.

Our comparison graph shows four power curves. The lowest curve is the power output of a stock 250 five-speed running on the rideable mixture. The next curve is the same engine running on the optimum dyno jetting. The third curve is the optimum dyno curve (also the rideable curve for reeds) for the engine using only Boyesen's reed manifold with a matching piston and ported cylinder. The highest curve has the Boyesen intake goodies, special transfer and exhaust porting, a 38mm carb and a special expansion chamber. This last curve is close to what the factory riders will be working with.

As you can see, comparing the two rideable power curves – the stock versus intake-modified-only – power below 5,000 rpm is up about 50 per cent. Power above 9,000 rpm is double, and more at higher rpm.

Out of curiosity, Eyvind put his intake-modified engine in neutral and cranked it on to see how high it would go. The last figure he saw on the tach before shutting down was 12,500 rpm. In comparison, the box-stock engine wouldn't rev past 9,500 rpm; at that point it just put out enough power to keep itself turning. Keep in mind that these horsepower figures are readings taken at the rear wheel. Given the five-speed gearbox, the factory riders will probably seldom drop below 30 horsepower!

Where is all this power coming from, you ask? Here is how it is constructed and how it works. The reed bodies and manifold are very similar to those of other production items, but a pair of reeds with a different size and tension are fastened one on top of the other. The larger, stiffer reed is on the bottom and covers the entire reed plate. A smaller, looser reed sits on top of the big reed, covering a hole in its center.



Reed valve conversion requires some milling to bring manifold in close to the cylinder. Once bolted up the conversion allows stock placement of the carburetor and air cleaner.

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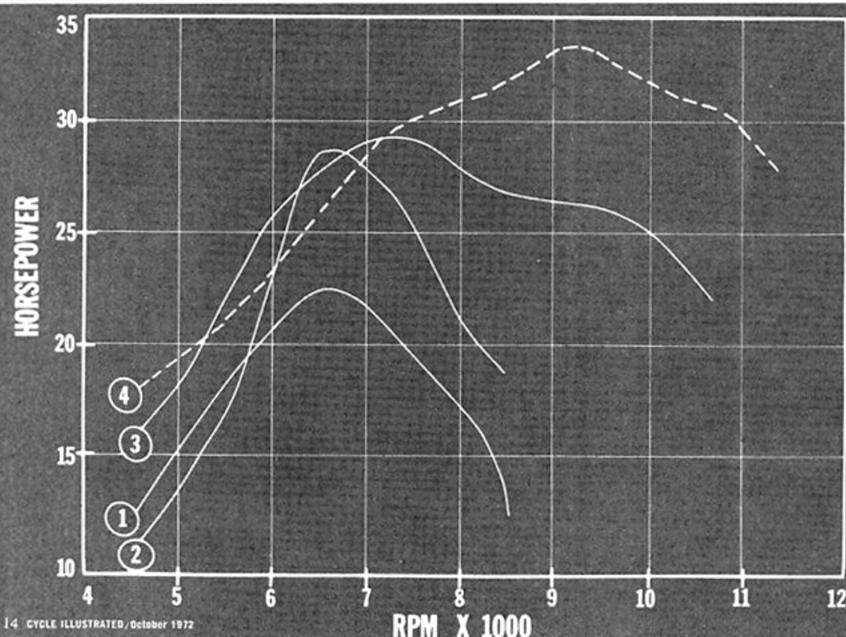
At low rpm the small reeds open easily and feed the cylinder through the ports cut into the back of the big reeds. As the rpm increases, the low-tension reed begins to float, taking some of its pressure off the back of the larger reed which then starts working too, uncovering the total reed area for maximum flow. At higher rpm, the small reed is unable to return at all and stays wide open, while the large reed still has the necessary tension to maintain its timing. Blowback through the small ports at high rpm is prevented by the restriction of their small size and the momentum of the high-velocity intake charge. This system gives good timing throughout the entire rpm range and the right valve area (small area at low rpm, larger area at high rpm) for high velocity through the reed assembly at all times.

To my way of thinking, the very high rpm power made possible with the Boyesen conversion is due to "overlap," a common condition which is taken advantage of in all four-stroke engines but which has never before been possible with two-strokes. Other methods of intake timing – namely, piston porting and rotary valves – all have their intake ports closed at bottom-dead-center, the point at which a good expansion chamber is supplying its greatest amount of suction. With the Boyesen set-up the small reeds never close at high rpm and feed the demands of the exhaust system, which draws the intake charge directly from the reed valves with no intermediate passage through the crankcase. At super-high rpm it seems unlikely that the crankcase pumping is doing anything to pull in fresh intake mixture; the exhaust is doing all the work. "Short circuiting" – the loss of fresh mixture out the exhaust at high rpm – is prevented

1. Stock 250 5-speed carburetted as you ride it.
2. Same as No. 1 but with optimum jetting for full-throttle dyno readings.
3. Same as No. 2 but with Boyesen reed valves and intake/porting. (carburetion rideable)
4. Same as No. 3 but with 38 mm carb, transfer and exhaust porting and modified expansion chamber. (test bike)

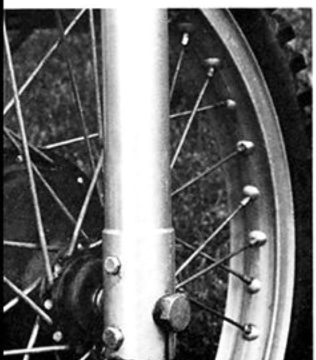


simply because there isn't enough time for the mixture to travel that far.

Another great advantage of the Boyesen valving at high rpm is that the intake flow is more constant and therefore greater. Valves that completely open and close more or less have to stop and then start the mixture flowing again as it passes through the valve area. With the dual-reed system, the flow never stops at high rpm and less time is wasted trying to get it started again.

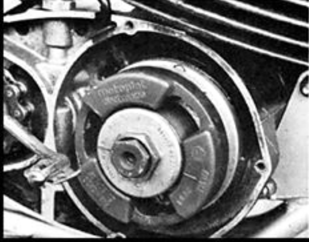
Also, the very free-moving small reeds that work at low rpm allow a much more efficient porting of the cylinder and the piston. Single high-tension reeds, which need greater vacuum to open, require that the piston close off the intake system from the crankcase so that it can build up the necessary vacuum. The dual reed system, however, may have porting directly into the crankcase at all times, giving it better flow at low rpm.

The fully modified prototype test bike came out of the corners hard, screaming away somewhere above 10,000 rpm. Test bike weighed between 190 and 200 lbs. Handling was superb.



The fork legs on our test bike were turned down to reduce unsprung weight. This modification will very likely be carried over to the Trans-AMA bikes.

Motoplat transistorized ignition has small internal rotor with very little flywheel effect.



Dyno curves look great and theories sound fine, but unless they translate into positive improvement out on the track, they are useless. I'm happy to say that everything the dyno curves promised was delivered out on the track – in spades.

The prototype machine that I was given for testing was far different from a current stock 250 with engine modifications. The first thing that you'll notice from the pictures is that the engine is an old four-speed and not one of the new MJ series five-speeds. The frame was stock except for one degree of additional rake at the steeringhead, bringing the old frame up to MJ specifications. The fork tubes had been turned down on a lathe to reduce unsprung weight, and the rear shocks were replaced by a pair of five-inch-travel Carnutts. Other changes included a glass tank by Cycle Craft and fenders by Rahm Engineering. In addition to the reeds, engine modifications included a Motoplat 603 ignition, a 36mm Bing carburetor which had been bored to 38mm, extensive cylinder porting everywhere and an expansion chamber modified by header section and the main body section to tune it for higher rpm. This particular machine was Boyesen's own bike, and changes to the frame and running gear were made to suit his personal tastes. They will not necessarily be duplicated for the factory team.

At the track the Boyesen-Husqvarna fired up on the second kick after some liberal flooding of the huge Bing. As we warmed the engine, blipping the throttle let us know right then that the dyno tests were no fluke. This engine was far from stock. It made noises like a burp gun, or a good chain saw, for that matter.

Keeping in mind the claims of the engine's explosive power-to-weight ratio, I moved out cautiously for a few warm-up laps. Going up through the gears gingerly produced my first riding impression: the throttle was ultra-responsive. Investigating this further I puttered along in second and cracked the throttle. Wham! Instant

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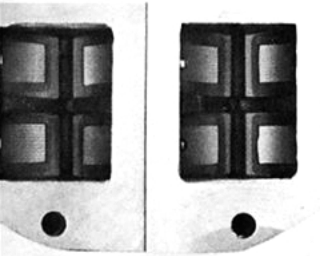
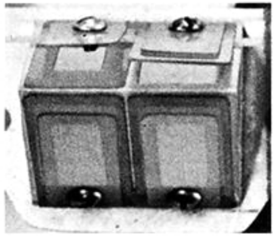
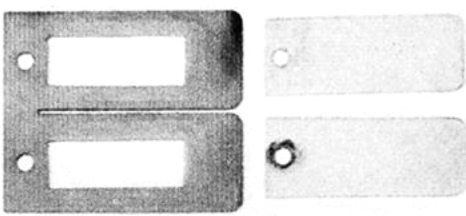


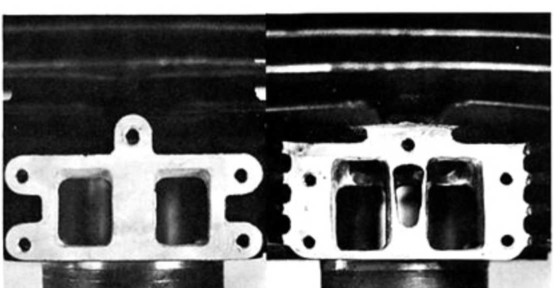


Here you can see the two valve areas – small reed open only (low rpm) and both reeds open (high rpm).

Using 8 reeds instead of four, gives about the same total valve area, but with much smaller and lighter reeds giving them greater high rpm capabilities. Reed material is Formica G-10.

Boyesen's trick system employs compound, dual-stage reeds with varying tensions to suit both high and low rpm power. Another interesting feature is that the large reeds, because they are vented, are very light and thus respond better at high rpm.



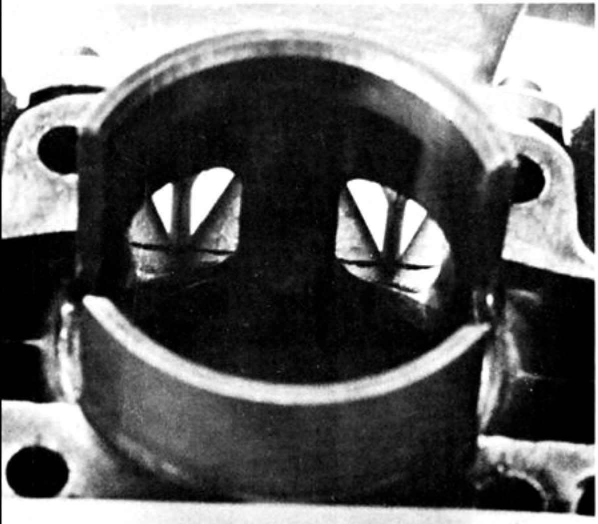


Comparison between the stock cylinder on the left and the Boyesen ported cylinder on the right shows how neatly additional porting feeds the upper cylinder directly. With proper lighting you can actually see out the exhaust port from this angle.

acceleration. Hmm . . . I tried it again. Wham! Same thing. "Why is this thing so responsive?" I'm saying to myself. I'm puttering along now at about 3,000 rpm, listening to the engine. As I crack the throttle I can actually hear the reeds working in there, but there's no sound with the throttle off. Why, of course, that's it. The reeds respond not only to the crankcase pressure but also to the differential of pressures on either side of the manifold. With the throttle closed, manifold vacuum is actually greater than crankcase vacuum and the reeds aren't opening at all. But as soon as you crack the throttle, the manifold vacuum drops to zero (the carburetor side of the reeds) and – zap! – the reeds spring wide open, delivering gobs of intake charge almost instantly. The carburetor slide, then, is actually part of the reed valve system. By working the throttle you're indirectly working the reed timing and the extent of their opening. And that's just what it feels like. Then I started remembering what Eyvind had said about the slide cutaway being critical. It all made sense.

Heightening the throttle's hyper-responsiveness was the Motoplat 603 ignition, which has a very small motor with very little flywheel effect. With very good power coming on at small throttle openings, this meant a throttle that felt more like working a kill button with the carb slide stuck wide open. It had two settings: off and on. The next lap I really cranked her on. I changed my mind – there were actually three settings: off, on, and *super-on*. That first sample of high rpm power was instantly followed by snapping the throttle back to the "off" position. Boyesen was right and the dyno hadn't lied: this 250 did have the power of a good 400, maybe more.

On a surface that could provide the necessary traction I found it very hard to keep the front wheel down even when accelerating in third gear. The very high rpm that showed up on the dyno was there, too; the Boyesen-Husqvarna simply refused to run out of breath. Once I shifted up at such a high rpm that I was sure I was doing damage – and there was more to go! At that point I found myself



Reed pyramids are set very deep into the cylinder. Note porting work done on the standard transfers. Cylinder heights of both transfer and exhaust ports were also altered on the all-out prototype bike, but we were not permitted to take any photographs.

This is the piston as it came out of the test bike. The intake side of the piston skirt is ultra short and heavily ported for most efficient breathing.

rocketing into the next corner. Locking up both brakes was the only thing that kept me from leaving the track.

The rest of the testing session was spent enjoying the very solid mid-range power (about 4,000 rpm to 8,000 rpm) and trying to master even throttle control in the bumpy corners. I could run it in that range and really move around the track, holding a good line and accelerating hard out of the corners. It would take a pro to fully utilize the high rpm power, but after all, this is a machine meant for the pros.

After the riding session the personality of the Boyesen-Husqvarna was clear: it has all the mid-range power of the single-reed set-ups plus a very high rpm range that's out of sight. The power spread is very wide: the bike pulled like hell between 6,000 and 11,000 rpm, and that's the wildest power range we've ever encountered. The factory pros will be able to get the most from it and Boyesen expects that they will be shifting at between 10,000 and 11,000. If the engines can stay glued together, there's not much going to stay with them on the straights.

The very next day, with Boyesen himself weilding the wrenches, the engine was taken apart so I could see exactly what I had been riding. Everything came apart easily and within five minutes we were comparing the Boyesen-modified cylinder with the stock part.

In Eyvind's cylinder there were five transfer ports, three extra in the back of the cylinder wall which fed the intake. With the piston at bottom-dead-center there wasn't much cylinder wall showing. Piston life, though, Boyesen says, is very good and not too different from stock reliability. The piston was heavily ported and well worn. Boyesen explained that he had seized it several times when experimenting with the carburetion.

Looking at the reed set-up, everything was exactly as Eyvind had explained. One of the large reeds had a chip out of one corner. Eyvind said it must have been hitting the casting wall due to poor alignment. The two thicknesses of Formica G-10 used for the reed material (.026 in. for the large reeds, .014 in. for the small ones) gave two very different tensions when picked off their seats. Eyvind expects good wear from the Formica material and no fatiguing, sometimes a problem with metal reeds.

At the time this is going to press, the Trans-AMA machines have not actually been prepared, but there are four Boyesen conversions in operation. Glen Vincent, a top East Coast motocrosser, has been running one and is delighted with it. Another is in the hands of enduro ace Ron Bohn. Ron is giving the dual-reed set-up a long-term endurance test. Boyesen hasn't received any feedback from him yet. The fourth machine was our test bike. There will be more, though, many more. Eyvind thinks Mr. Helmin is finally convinced, and he is sure this system will be adopted on future Husqvarna machinery.

Even though Boyesen will hold the patent on the dual-reed system a link-up with a large Japanese manufacturer sounds logical and would probably put his design into the hands of the greatest number of riders. His hopes at this point are only to start producing conversion kits for CZ, Husqvarna and Maico machines that he will market on his own. Interested parties may contact him at Two-Stroke Engineering, 1201 Papermill Road, Huntington Valley, Pa. 10006.●

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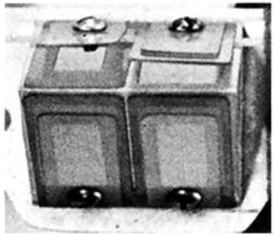

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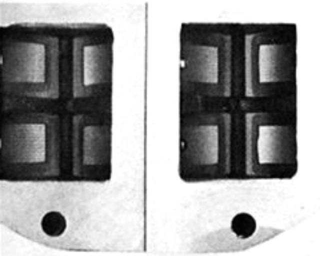

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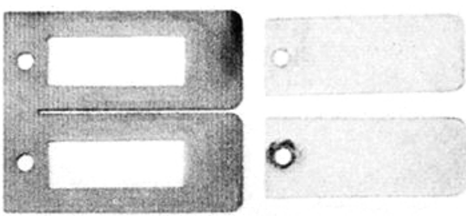

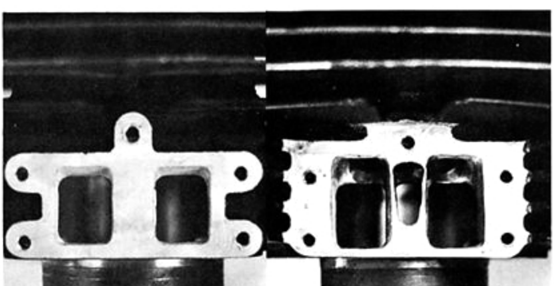

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