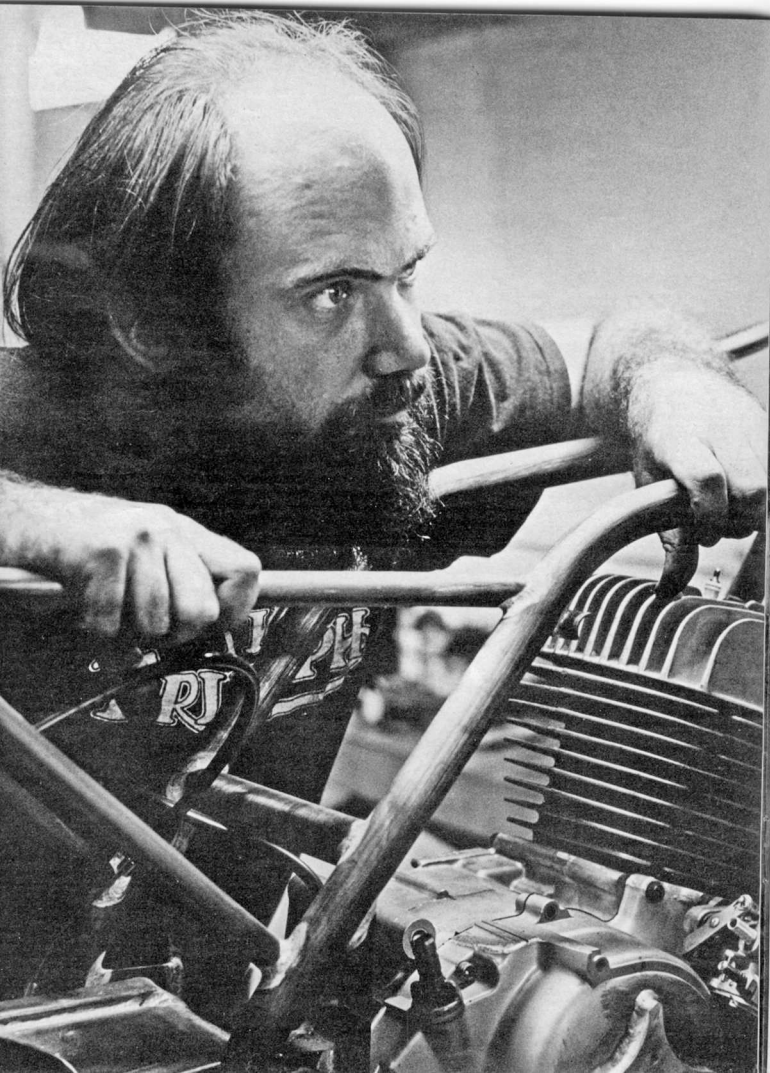




350 Kawasaki Bighorn Roadracer

By Phil Schilling

Take one Bighorn, conceived and built by Kawasaki as a dirt machine. Give it to Kevin Cameron, Doctor of Mechanical Transvestism. Lo! Out comes a roadracer.

PHOTOGRAPHY: CHEH NAM LOW

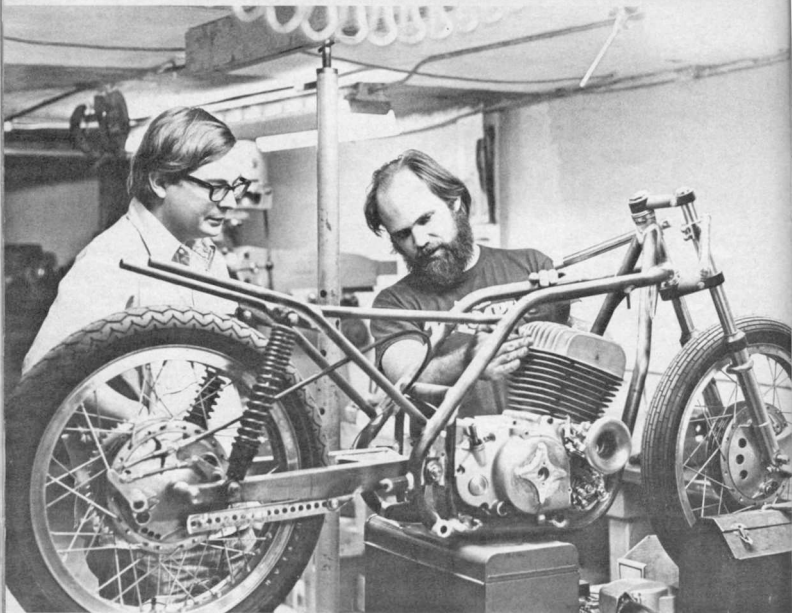
Orthodoxy in AMA lightweight road racing is spelled only one way today: Yamaha 250 TD2. Inch-for-inch no other machines have matched these Japanese two-stroke twins for speed, reliability and repeatability in the winner's circle. There has been an unwritten rule: if you're not on a Yamaha, you're not in the hunt. So at the close of 1969, the AMA shifted the ground rules of the lightweight class in an attempt to encourage wider brand participation. The new formula admitted certain specified 350s: four-stroke twins, and two-stroke and four-stroke singles to 350cc. But things change slowly. In 1970 Cal Rayborn had brief success with a factory 350 H-D Aer-macchi, winning at Kent, Washington and finishing second at Laconia. Harley lost interest, and that was the end of that effort. Jess Thomas, *Cycle's* Technical Editor, has kept his Honda 350 in the chase; he has been getting progressively better results. But no one has busted the Yamaha 250 Trust in the lightweight class. No one has shaken the orthodoxy.

Enter Kevin Cameron—tuner, builder and thinker. In the basement machine shop of Arlington Motor Sports in Arlington, Massachusetts, a diminutive roadracer, powered by a modified 350 Bighorn F5 two-stroke single, has taken shape over a six-month period. The machine is Cameron's brainchild; he has pondered, designed, engineered and built it. Constructing a special usually means a project conceived in high expectation, executed in hot enthusiasm and terminated in grim disappointment. Things don't happen that way in AMS's basement workshop. Cameron—full coverage beard; retreating hairline; hard, intense eyes; and a wit with a Platinum-Plus edge—doesn't gush enthusiasm. His mind calculates.

To beat TD2s, Cameron reasons, you must exploit their weaknesses; soft points of which he has first hand knowledge, because Cameron has tuned his share of Yamaha roadracers. The TD2 twin is relatively wide and high, and it pushes quite a bit of frontal area through the air. At 240 pounds, the Yamaha roadracer isn't especially light either. And TD2s, when ridden on the limit, don't have flawless handling; among other things, they tend to lift their front wheels when accelerating hard out of corners. Their powerband is narrow. Handling, wheel-lift, powerband—these problems won't confound a talented rider, but any rider must learn to work around and compensate for such problems. Subtract the riding difficulties, Cameron observes, and you reduce the machine variables and free the rider for greater concentration on the race, the traffic and the course.

Compared to a TD2, Cameron continues, a 350 two-stroke single can be lighter, lower and blessed with better handling. The 350 can have less frontal area and therefore needs to shove less air around. With the right porting and piping, a 350 will develop nearly as much horsepower as a TD2 and possess a broad spread of power. This happy combination, together with better handling, will make it possible to get more power on the ground through corners. One final thing—Cameron calls it "recoverability." A small 350, he believes, by virtue of better handling, broader power, and lower weight will be easier for the rider to recover in a corner. Like small 50cc or 125cc roadracers, Cameron points out, the 350 should be more responsive to rider inputs if the bike gets a little out of control. So the rider can work toward that thin outer line of final tire traction with greater confidence.

Cameron's conception of the 350 Kawasaki racer is an integrated, non-divisible thing. The hot-rod approach—



piecing a motorcycle together out of accessory house parts, or putting 350 Bighorn engine into an AIR or HIR Kawasaki frame—wouldn't work. Every characteristic and feature of the machine must relate perfectly to all the other components. It's like building an intricate jig-saw puzzle; to mean anything, all the pieces must fit together. So Cameron built the 350 Kawasaki roadracer the way he planned it. From scratch.

The machine is as low, narrow and light as possible. The frame, designed by Cameron and built by Frank Camillieri, is constructed from seamless 1018 mild steel tubing. The gas welding was done with Eutectic #16 low temperature brazing rod and with an in-line fluxer. The rear section of the frame which supports the shock absorber tops is fashioned from 3/4-inch diameter tubes. The main duplex cradle is built from 1 1/8-inch tubing. Why didn't he use 4130 chrome-moly which doesn't get brittle with welding and which is stronger than 1018? Cameron replies that chrome-moly would

have been too difficult to form since his frame design has lots of bends in it, and chrome-moly doesn't bend easily. While chrome-moly resists vibration better than 1018, Cameron points out that the deflection rates of 4130 and 1018 are essentially the same up to a point. "Only if you pick your crashes carefully will you fully benefit from a 4130 frame; you have to be sure to crash hard enough to bend 1018, but not hard enough to deform 4130."

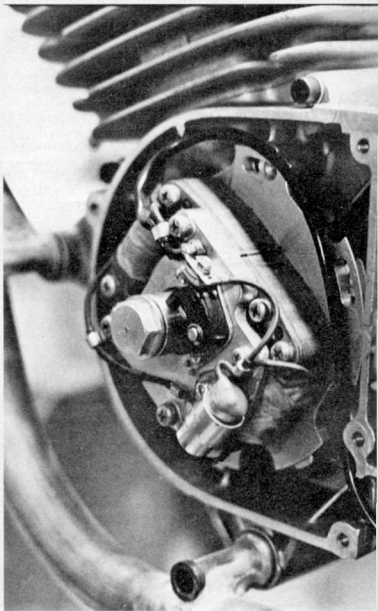
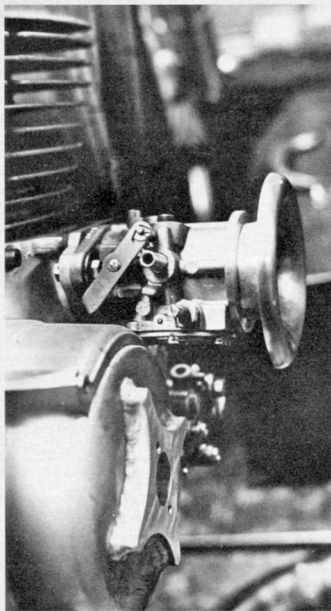
The massive box-section swinging arm, built out of hot-rolled 16 gauge mild steel, locates the rear axle 18 3/4-inches from the swinging arm pivot pin. An adjustable pivot pin, roughly similar to the Rickman pattern, provides movement to take up chain slack.

The rear suspension units are 11.9-inch Girlings which mount to the frame and swinging arm through flexible rubber bushings. Viewed from the rear, the shock absorbers cant inward toward the top. There is neither law nor reason, Cameron believes, forbidding such an arrangement. Therefore,

it logically follows, why not?

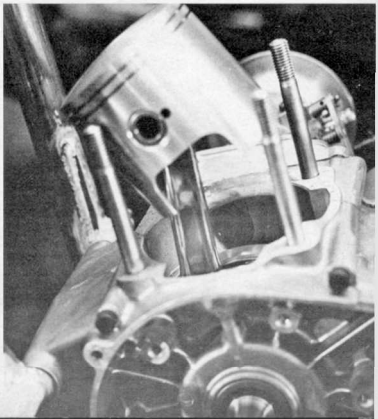
Small, short Baroni roadracing forks, the size commonly fitted to 125 roadracers, take care of the front suspension. On full compression of the suspension (4.6 inches of travel in the front forks, 3.2 inches at the rear) the distance between the underslung expansion chamber and the ground falls to zero. That's right, zero. Furthermore, under full braking, with a calculated 1/2-inch front fork deflection, the front tire will just kiss the front of the exhaust pipe/chamber. Nothing measures more than it must; it's not accidental, it was plotted that way.

The engine is just as low and far forward as it can be placed. Cameron didn't design his frame with engine position as an afterthought; he engineered the frame around engine placement. In positioning the engine low and forward, Cameron is merely working in the same general direction as other builders of special roadracing frames—Colin Seeley, Spondon Engineering, Rob North to name a few.



(Left) Engine is placed as far forward and as low as possible in the frame cradle. (Above) The 42mm Tillotson carburetor has been shortened at both ends. (Right) Ignition system out of a 100cc Green Streak Jr. replaces standard 350 unit. Note huge countershaft sprocket. (Below) Two-ring piston comes out of the FS Speed Kit.

The rigidity of the frame interests Cameron far more than things like rake and trail. The rake happens to be 29 degrees, but he is convinced that 28 or 27 degrees would also work. Trail is about four inches; Cameron confesses he doesn't know the precise measurement. Astonishing? Maybe not. Cameron believes that rake-and-trail dimensions have become a fetish because traditionally a lack of frame rigidity made these measurements important. "Calibrated Flex," he calls it. "The frames of old time roadracers flexed, and it was important for the factory to calibrate the rake and trail with the frame by experiment. If later you upset the calibration by changing the rake and trail, 'that good handling' just disappeared. Had the



frames been rigid in the first place, as tradition said they were, then the handling wouldn't have vanished."

Fashionable things Cameron can do without; things like monster brakes. His Kawasaki 350 carries a 180mm four-shoe Fontana on the front and a 180mm Fontana at the rear. "There's a great deal of fashion in roadracing these days. It's the kind of thinking that says if a big brake is good, then a huge brake will be that much better. So you see a 250mm Fontana on someone's TD2—as if somehow the size of the hardware will determine the outcome. This 350 isn't a locomotive and doesn't require monster brakes to stop it fast." Enough for the job, but no more. The same thing goes for the 18-inch tires. No wide section tires—2.75 inch front, 3.00 on the rear.

The results? An incredibly small, light, lowslung 350 roadracer: although the bike has a pretty standard 52-inch wheelbase, the exhaust chamber rides less than three inches

away from the pavement, the engine cases are less than 13 inches wide, dry weight is 200 pounds, and the distance from the top of the fork crown to the ground is 32 inches—just about the normal saddle height of a street machine.

The same kind of Cameron calculation went into the engine, which is basically a Kawasaki 350 F5 unit; but beyond the basics, it's all Cameron. The filter-to-carburetor or air passage that Kawasaki casts into the cases behind the cylinder has been pared away. The outside vertical face of the left-side crankcase-half has been machined back about $\frac{3}{8}$ -inch in order to keep the engine width at a minimum. Cameron would have cut away more, but this would have removed the engine number, an item which the AMA requires. The standard Bighorn ignition system which utilizes a 7 pound external rotor has been replaced by a smaller, more compact ignition unit from the 100cc Kawasaki Green Streak Junior. The replace-

ment unit has a lighter ($1\frac{1}{4}$ -pound) internal rotor. The switch required some machining to reduce the diameter of the leftside crankshaft; otherwise the installation was fairly straightforward. However, Cameron does not intend to stick with the contact-breaker ignition for long. The Arlington Motor Sports HIR Kawasaki has been using Krober ignition with good results during the 1971 roadracing season, so the 350 will soon be changed over to the Krober CDI system.

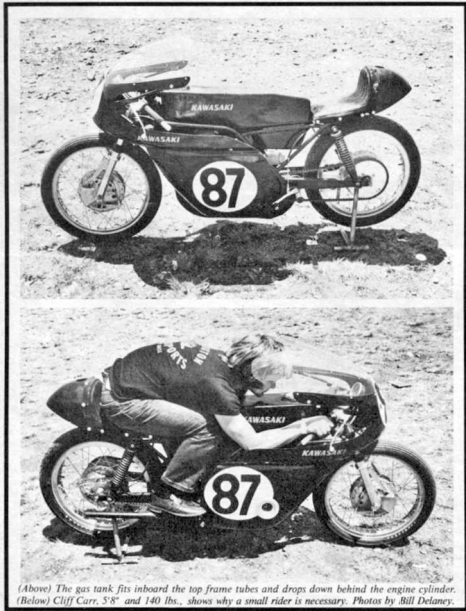
Inside the cases more machining was necessary so that a close-ratio five-speed transmission could be fitted. The standard F5 Bighorn transmission is a wide-ratio box, and big gaps between the gears just don't make it in roadracing. Where did the close-ratio gear set come from? Out of a 250cc Kawasaki A1R production roadracer. Some of the transmission gears had to be narrowed, but the shifter drum and forks are standard Bighorn pieces. There was a snag to the installation: on the stock wide-ratio gearbox, a clutch rod, passing through the hollow center of the mainshaft, actuates the clutch pressure plate; but the mainshaft of the A1R close-ratio gearset is solid. Consequently, Cameron had to move the clutch control mechanism to the right side of the engine. He reinforced the outer case over the clutch by heliarcing on a star-shaped aluminum plate on which the clutch arm assembly mounts. The clutch throwout is an H1R unit; the clutch hub is an A1R part, and the clutch drum remains a standard F5 Bighorn item.

With the clutch throwout mechanism moved to the right side of the engine, Cameron could increase the size of the countershaft sprockets (27-30 teeth). This change should minimize chain stretch by cutting down the angular acceleration of the #428 drive-chain.

One good look at the carburetor and expansion chamber (the biggest section is some 5 inches in diameter) will convince any fool that Cameron didn't buy his performance pieces at some accessory house. What he knows about two-stroke technology has come from two sources: technical papers and Yamaha roadracing engines. Cameron has a long bibliography of technical papers dealing with two-strokes and diesels. "SAE papers, if you sit down and go through them carefully, yield some good information; the most useful papers are the 1966 and 1968 articles done by Yamaha engineers. The *Bulletin of the Japanese Society of Mechanical Engineers* also has good stuff. The people who know the most about two-stroke design have one thing in common. They all have Japanese names."

But Cameron hasn't spent all his time in the library. Year after year he has measured

(Continued on page 68)



(Above) The gas tank fits inboard the top frame tubes and drops down behind the engine cylinder.

(Below) Cliff Carr, 5'8" and 140 lbs., shows why a small rider is necessary. Photos by Bill Delaney.

every dimension of the latest Yamaha roadracing engines and expansion chambers; you get the feeling that nothing has escaped his scrutiny and everything has been noted, curved, charted, compared and pondered. He has seen what changes have been made, and he knows why. Two stroke design is no child of luck and sorcery: "There is really quite a bit of method in it." Every bit of that method Cameron has focused on the 350's disc and port timing, carburetor size, compression ratio, and expansion chamber configuration.

Cameron will volunteer theory; he's very much at home in that world. And no great veil of secrecy shrouds more specific information. Cameron doesn't guard the intake-transfer/exhaust timing as if it were the combination to a secret bank vault. The exhaust port opens at 80 degrees ATDC, and the transfer ports open 30 degrees later. The rotary disc valve opens the inlet port at 71 degrees BTDC and closes it at 135 degrees ATDC. This timing, when matched to the carburetion and expansion box (Cameron's own design), should give usable power as low as down as 5800 rpm, and the powerband should stretch upwards to 8000 rpm. As development proceeds, Cameron intends to build a slightly different chamber which will produce peak power at 8500 rpm. "When you plot out your figures, those are the rpm-answers you get. But then again, you don't for a fact know till you try it."

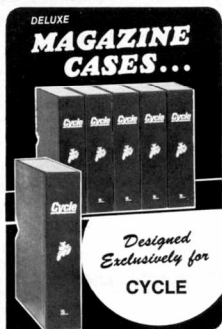
The 42mm Tillotson carburetor has been shortened by about 3/4-inch by milling both ends of the body. Cameron designed on the Tillotson because it could be mounted further inboard than a 42mm Dellorto which physically is a larger instrument than the Tillotson. Not only would a huge carb body be more vulnerable in a spill, but a large protruding carb—given the low mounting of the engine, could ground on hard right-handers. To mount the carburetor to the engine required extensive remachining of the rotary valve cover, since the bore of the Tillotson is larger than the outside diameter of the intake manifold which, on the standard F5, is cast as part of the rotary valve cover.

The oil pump no longer meters oil into the intake port; now it simply feeds oil to the right-hand mainbearing and then, by way of an oil pickup ring, to the big-end of the connecting rod. A 20:1 premix goes into the gas tank.

Nothing is special about the lower end, other than polishing crankshaft and connecting rod. Cameron doesn't believe in polishing, but he did it anyway—maybe just for drill, maybe just for the hell of it.

The forged piston with two chrome rings come directly out of the Kawasaki Speed Kit for the 350 Bighorn. The aluminum head on the 350 racer, which once contained two sparkplug holes in standard form, now carries a single centrally-located sparkplug hole. The size and shape of the

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spherical combustion chamber remains unchanged. Compression ratio is about 6.5:1. It's low because big two-strokes can't stand the compression of small ones, and because the 350, thanks to its iron-lined barrel, can't dissipate heat as quickly as a chrome-on-aluminum barrels. Cameron looks at the iron liner with an evil eye. "Iron liners mean poorer heat dissipation, greater running clearances, and less efficiency. Yamaha's greatest achievements have been in metallurgy. Their racing engines with chromed bores, cast pistons and nodular iron rings run reliably at very close clearances. It's nice to be able to rebore iron liners. But it's nice to win races too."

Without the right rider—no matter how much engineering brilliance goes into the machine—you don't win, or even come close. A six-foot Stewart Slugmug wouldn't—couldn't—make it. There isn't the room. Physically, the 350 roadracer requires a relatively small rider. Realistically, the rider must be experienced enough with both small and powerful roadracers so that he can give Cameron accurate feedback from the saddle. Without this basic rider/tuner communication, continued development of a special either stops dead or meanders off in a dozen different directions. Finally, the rider must be accomplished enough to exploit the advantages of the 350 on race day. Cliff Carr, a veteran of British short circuits and the Continental Circus, fits the bill. The 5'8", 140-pound Englishman, who is spending the road racing season in the Americas this year, has already demonstrated at Daytona and Road Atlanta (aboard the Arlington Motor Sports HIR) that he can cut it in AMA road racing.

To build a privateer's special is one thing; to get AMA approval is quite another. For starters, Cameron had to get approval from the Kawasaki Motor Corporation since the AMA requires distributors to endorse equipment which departs from standard factory design. Shortly before Laconia, Arlington Motor Sports submitted photographs to the Kawasaki Motor Corporation as the first step toward approval. At Laconia Cameron learned two things from Bob Hansen, who heads up Kawasaki's racing efforts in the United States. First, Cameron had failed to send proper photographs to the distributor; instead of photographing all the separate pieces of the 350 (as required by the AMA), Cameron shot the assembled machine. Second, all those changes subject to AMA approval must be in the hands of the AMA thirty days before the running of the event in which the motorcycle is to be raced.

On its face, this is a very reasonable regulation. The ruling was made in an effort to stop distributors from seeking on-the-spot approval for new equipment on race day. There was, however, one drawback. People like Cameron didn't know about the new thirty-day waiting period in advance. Even Jess Thomas, Cycle's Technical Editor, who is a member of the AMA

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Executive Committee, didn't know about the new rule until the day before the Laconia weekend began.

Apparently even fewer competitors were aware that a period of grace was still in effect at the Laconia event. This period of grace, during which the thirty-day rule was temporarily suspended, was adopted by the AMA so that entrants—who knew nothing of the new rule and expected race-day approval—would not be caught by surprise and eliminated. Hansen did not realize at the time that Laconia was being run under grace. Only the week after Laconia did Hansen find out that Cameron's machine could have been approved under cover of the grace period. And it was more than two full weeks after Laconia that Cameron learned anything about any period of grace.

The one man who on race weekend could have unravelled the situation and who knew exactly the status of the rule was Russ March of the AMA. But Cameron didn't know March, and the two never got together. Such a meeting wouldn't have solved all Cameron's problems because the photographs of the 350 special did not meet AMA specifications. In retrospect it appeared that (1) the Bighorn racer could not have been approved under the thirty-day rule about which few people knew; but (2) the machine could have been approved under the period of grace about which still fewer people knew; but (3) the motorcycle could not have been approved in any case for lack of proper photographs of all the pieces.

Hindsight makes the tech inspection episodes with the Bighorn racer seem even more bizarre. On practice day the unapproved—and apparently unapprovable—350 Kawasaki passed technical inspection; on race day, this decision was reversed, not because the machine wasn't approved for competition, but because an official contended that the gas tank had been changed between tech inspections—and the tank fitted on the second pass was not legal. In point of fact, only one gas tank in the world fits the Cameron-designed 350: it could not have been changed between the first tech inspection and the second.

Everything was left in a state of confusion, not because the AMA was out to get Kawasaki, or Arlington Motor Sports, or Cliff Carr, or Kevin Cameron. There was no real malice—just the standard muddle of an AMA race weekend. It was exactly the cloth of which those AMA Mickey Mouse Tee-shirts are cut. And the stuff wears poorly.

Two major tasks lie ahead for Cameron: first, getting the machine approved for AMA competition; second, sorting out the little roadracer itself. Cameron is too experienced to have any illusions. The first problem may be difficult; the second will be no cinch either. "So many guys who build specials run out of energy after the machine is built—but doesn't work in its first few times out. That's the difference

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between innovative privateers and the factories. The factories stay with it long enough to get results. The private, lone builder just gets discouraged and gives up, long before what is supposed to happen actually happens."

The 350 Bighorn racer bowed into competition with almost unbelievable promise. After shaking down the machine and dialing in the carburetion, Cameron and Carr set off for an AAMRR event at Summit Point, West Virginia, where the Bighorn put up the fastest lap in the 350 GP class as Carr pulled through the field to finish sixth after starting dead last on the grid.

The debut wasn't without its problems. During practice at Summit Point, the expansion chamber grounded repeatedly, and the stinger came off. Carr concluded that the motorcycle could stand an additional half-inch or so of ground clearance. Meanwhile Cameron hiked around the course and returned with the stinger which was welded back in place. Then the clutch throwout mechanism gave trouble which Cameron remedied. The front suspension felt too soft to Carr, but he could live with the bother until more suspension tuning could be done. Likewise, there was no quick-fix for the front brake which felt mushy at the handlebar level. The shoes just weren't getting a good bite on the drums. Finally, the bike proved to be a hard starter.

"Nevertheless," Carr smiled afterward, "the motorbike performed beyond my wildest dreams. I didn't expect the engine to run so strongly. I dropped into the slipstreams of some good Yamahas, ducked out around, and left them for dead. Surely those Yam 350s will motor past on down the straight, I said to myself—but it didn't happen. I stayed clear until the carb bell-mouth fell loose from the carb, so the engine lost its edge about four laps from the end of the race. The powerband is a bit up from where we thought it would be; the engine wants to rocket right up to 9000.

"Steering-wise, the 350 reminds me of a Buellco 125 TSS roadracer. The bike goes exactly where you put it. It's fantastic in traffic because you can pick it up and put it down again and it stays put.

"The front brake bother was a shame, but when it's sorted, I reckon there's another four seconds that can be shaved off around Summit Point. Best of all, though, the engine didn't go bang and stop."

Promising beginnings are just that, Kevin Cameron observes, and more. "You know," he says, "they just don't give out trophies or money for such things nowadays." He says this matter-of-factly, in a casual, absent-minded way: because his eyes are trained once more on his creation; because his mind is busy calculating again.

Cameron has a tremendous amount of talent and patience and experience. Enough to see him through the AMA approval hassles. Enough to see him through the development snags. Enough, someday soon, to shake the Yamaha orthodoxy. ●

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