
GO FAST

YAMAHA 250 ROAD RACER

History of the Privateer's Best Friend · By Kevin Cameron

● In the years following World War II, many riders in England and Europe learned roadracing on single cylinder Manx Norton production racers. These 500s and 350s were designed to be simple, maintainable, and effective. Above all, they were available. Those who didn't race 30M and 40M Nortons very likely went to starting grids on AJS 7R and G-50 Matchless models. Riders on their way up were spared the tasks of engineer, machinist and financier, and were thus able to concentrate on riding. The British singles gained a reputation as rugged, well-engineered motorcycles.

A similar situation exists today, but the brand is different. Yamaha 250 production racers have been the standard mount for beginning roadracers for ten years now, and they have dominated international 250 racing for five years. In any country of the world where roadracing exists, you will find most riders and tuners are thoroughly familiar with these machines.

The engines are derived from road models, and at the present time, the frames, forks, and other important parts are shared with the street-going counterparts as well.

How has this situation come about? What combination of circumstances has led this company to produce hundreds of basically simple machines that win both club events and international races?

Many companies in postwar Japan saw diversification as a key to economic survival. Cheap transportation was needed, and motorcycles were a good answer. Yamaha made the improbable jump from pianos to motorcycles. The early machines closely resembled European models. If you have no national motorcycle industry, you get a piece of someone else's. By license agreement and exchange of engineers, Europe's motorcycle design traditions were absorbed by the budding Japanese manufacturers. About 1955, such an exchange took place between Yamaha and the German Adler firm. Germany had been the birthplace of effective two-strokes with the prewar DKW machines, and had continued to lead the world in two stroke design. The first Yamaha two stroke twins strongly resembled the Adler. The carburetors were bolted to the crankcases, feeding the cylinders through slots. The clutch was crankshaft-mounted.

Rivalry among the new companies in Japan was strong, and the leading race of that time was the Mt. Asama cinder-track "roadrace." Competing against such now-defunct names as Tohatsu and Meguro, the Yamaha company was determined to win this event, which took place in the shadow of Mt. Fuji.

This first Asama racer was the most distant forerunner of the production racers of today. The first machines were made with two different bore/stroke ratios, the P model having the dimensions 54 x 54mm, and the PQ measuring 56 x 50.

In 1956, Fumio Itoh succeeded in winning the Mt. Asama event for Yamaha, which increased the determination of the management to seek further successes. The Honda Motor Company could only look on enviously at this time, but later the two firms would meet in competition on the Asama course, a foretaste of the great European GP struggles they were to fight out years later.

The design of the P model required the cylinder to be sunk very deeply into the case, thus limiting fin area. The pistons of the time were made, like car pistons, from a fairly soft, high-expansion aluminum. These two facts made trouble for the racer. The gearbox held only four speeds, creating a further limitation.

Two stroke tuning in Europe was receiving a powerful impetus from the East German MZ firm, which was building on the knowledge gained by DKW. Their 1953 125cc racer gave a pitiful 9 bhp at 7800 rpm, well below the performance of contemporary four strokes. In the next five years, they tried and discarded a fantastic array of strange designs, finally emerging with what was to be the definitive two stroke powerplant of the future. This was the loop-scavenged, disc-valve-inlet engine, exhausting through a baffled megaphone, or expansion chamber. The 1960 version of this 125 single gave 22 bhp at 11,000 rpm, for a bmep (brake mean effective pressure) of 104 psi.

Yamaha kept informed of trends in European design, and they too saw the advantages of this layout. They began their own work with this type, and brought their first rotary valve racer to Europe in 1961. This 250 RD-48 model gave 35 bhp at 10,000 rpm, 94-psi bmep. The engine was air-cooled, pump and gas/oil lubricated, and housed in an open-loop frame much like that of the G-50 Matchless. It was no match for the championship-winning Honda of that year, but it added greatly to Yamaha's growing knowledge of racing two strokes.

While this European effort was getting under way, management looked into exporting road machines to the United


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Reaching predominance in 1965, the little twin-cylinder two-stroke has been at the very heart of motorcycle pavement racing competition ever since. Along the way it has taught tuners how to tune, riders how to ride and winners how to win.

Robert Winters, John Buckner and Ralph White, all on Yamahas, in 1966. Winters won a squeaker.

States. The new American organization also decided to use competitive success to further sales and reputation, so Fumio Itoh came to compete in the Catalina races here in 1958.

Getting away in 47th position, Itoh amazed the onlookers by passing all but two of his competitors up the first straight, then by broadsliding even the paved turns feet-up. His P model suffered its traditional piston problems, and Itoh dropped back. The following year, similar machines were entered in the events at Dodge City, and this time it was Larry Beale who demonstrated the surprising power of the new machine. Once again the Yamaha was stopped by problems.

Unreliability usually means either incompetent design or a very rapid rate of development. In this case, certain aspects of the design outstripped the capabilities of the rest of the machine. Yamaha had found that traditional ideas of port timing were much too conservative, and that great power could be unlocked from small cylinders by long exhaust and transfer timings, used with the correct exhaust pipe. This produces high piston temperatures, as early release of exhaust means higher exhaust gas temperature.

For 1960, the P and PQ models were dropped, and a new engine emerged. It was a notable advance. The cylinders were all aluminum, and the carburetors fed them directly. Pistons of much higher silicon content ran directly on the aluminum cylinder wall, which had been hardened by anodizing. This was a bold step to take, and it showed great promise. By eliminating the junction between an iron liner and aluminum cylinder, a great barrier to heat rejection from cylinder and piston was removed. Other companies had used plated cylinders before, but it was Yamaha's persistence that made this innovation work on racing two strokes.

The trick was to match the metallurgy of piston and cylinder so that the required running clearance didn't disappear, even under high-power running in hot weather. Conventional piston alloy, containing up to 13% silicon, had been a failure in the P model. Therefore a new technology was created on the spot, by which the hard-to-manage ultra-high silicon alloys were made to behave during the casting process.

A late-model Yamaha train: Gary Fisher, Don Castro, Kel Carruthers, Dave Smith, Ron Pierce.

The 1960 competition machines, referred to only as "Yellow-tankers," were essentially RD-48 frames, wheels, brakes, and tanks, with the new piston-port anodized-cylinder engines fitted. This new engine shared the crankcase of the iron-cylinder road model YDS-2. Instead of the two piston rings of earlier models, this racer used a single ring 1.5mm thick. It gave a better compromise between friction loss and life in racing use.

The new pistons and cylinders worked much better than the early hardware, but continuing trouble with the anodized cylinder surface led four stroke fans to call the new Yamaha the fastest way from the start to five laps from the finish.

Research continued which was financed by the considerable commercial success of the company. The main thrust of competition development was by now directed toward the European theater where Honda was making a worldwide reputation. The RD-series of air-cooled twins elevated the horsepower in the 250 class rapidly, making Yamaha for the first time the world's foremost practitioner of two-stroke design. MZ, while long on talent, was short of development money.

Vesco hooked up with Carruthers in 1971; between them they won most lightweight events.

Carruthers at speed at Daytona in 1971. He brought much to Vesco, including Krober ignitions.

From the 35 bhp of the RD-48, power rose in 1963 to 48 bhp, 115-psi bmep at 11,000 rpm, and on to the final 1965 form, the RD-56, giving 56 bhp, 135-psi bmep at 11,000. New knowledge was accumulating fast in the Yamaha camp.

Encouraged by results with the "Yellow," President Kawakami and US General Manager Skip Clarke decided to produce improved racing machines and sell them to anyone with the money to buy one. Racing in the US was slanted towards the production racer concept by the AMA Class C rules, which required a large quantity of complete racing machines for approval. Selling 200 racers would put a large number of Yamahas on the start line of any AMA 250 race, and basing the racer on a road machine would make the cost acceptable. If the machines were successful, it would be a great boost to sales and public awareness of Yamaha.

They did it. Even though the piston-port TD1-A, as it was called, used a frame already discarded by the GP program, it was good enough for a production racer. The brakes, tank, seat and other running gear of the obsolete RD-48 were used as well, effecting a further savings—plans and jigs for manufacture already existed.

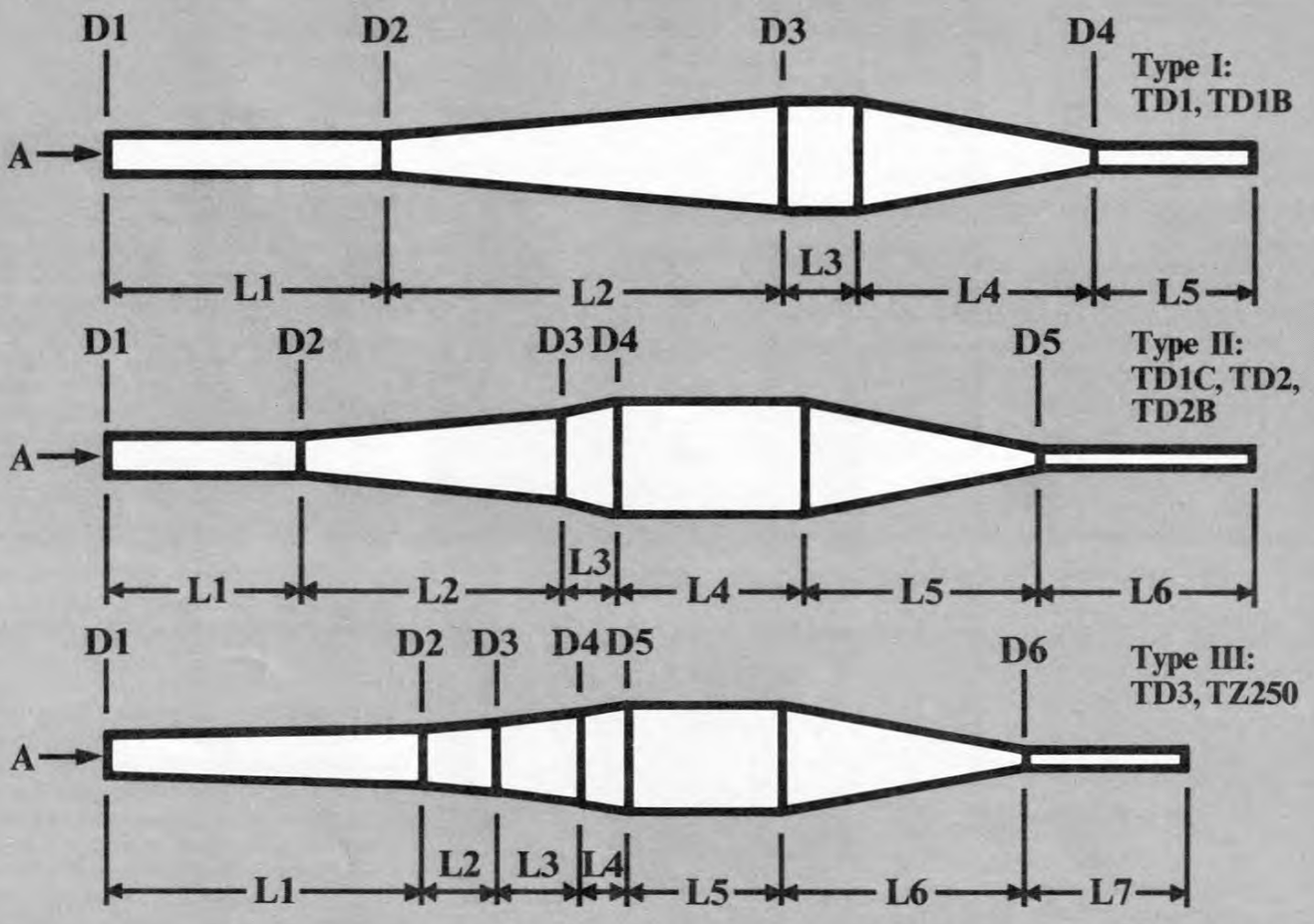
The first sales of the TD1-A took place in late 1962. It inherited the 27mm pot-metal carburetors of previous models, along with the MC-2RY magneto and wide-ratio five-speed gearbox. Again, metallurgy problems stopped many fine rides, but the production racer started winning AMA nationals in 1963, and has seldom missed since.

There were problems outside the cylinders. Ducati and Parilla riders of that time sneered at the amazing behavior of the "flexible flyer" frame, with its 125 lb/inch "rigidimatic" rear springs and rebound-damped-only front fork. The brake linings faded out early. The crank-mounted clutch slipped, and often was good for only one fast start. The crank extension on which it rode would snap off next to the flywheel, the clutch then bursting out of the side case with terrific force.

Ratios in the five-speed transmission were a compromise between roadracing and street figures. The very low first made the in-or-out clutch easier to live with, but was no use at all out on the track. The change to second gear either put the engine below the power, with a long struggle for revs, or required risky clutch slipping.

	Bhp @ rpm (est.)	Bore, mm	Stroke, mm	Transmission speeds	Piston skirt length mm	Piston crown bevel mm	Clearance height mm	Exhaust open, ATDC deg.	Transfer open, ATDC deg.	Blowdown period deg.	Intake open, ATDC deg.	Carb, remote float mm	Carb, center float mm
TD1A-1963, '64	28@9500	56	50	5	63	—	1.2	85°	111°	26°	70°	27	—
TD1B-1965, '66	32@10,000	56	50	5	54	2.3	1.2	79°	111°	32°	90°	27	—
TD1C-1967, '68	40@11,000	56	50	5	54	2.3	1.2	79°	111°	32°	99°	27	—
TD2-1969, '70	47@11,000	56	50	5	54	—	1.2	79°	110°	31°	97°	—	30
TD2B-1971	49@11,500	56	50	5	54	—	1.2	79°	110°	31°	97°	—	30
TD3-1972, '73	52@10,800	54	54	5/6	56	—	.0	79°	111°	32°	101°	—	34
TZ-250-1974	54@11,000	54	54	6	56	—	.0	79°	111°	32°	101°	—	34

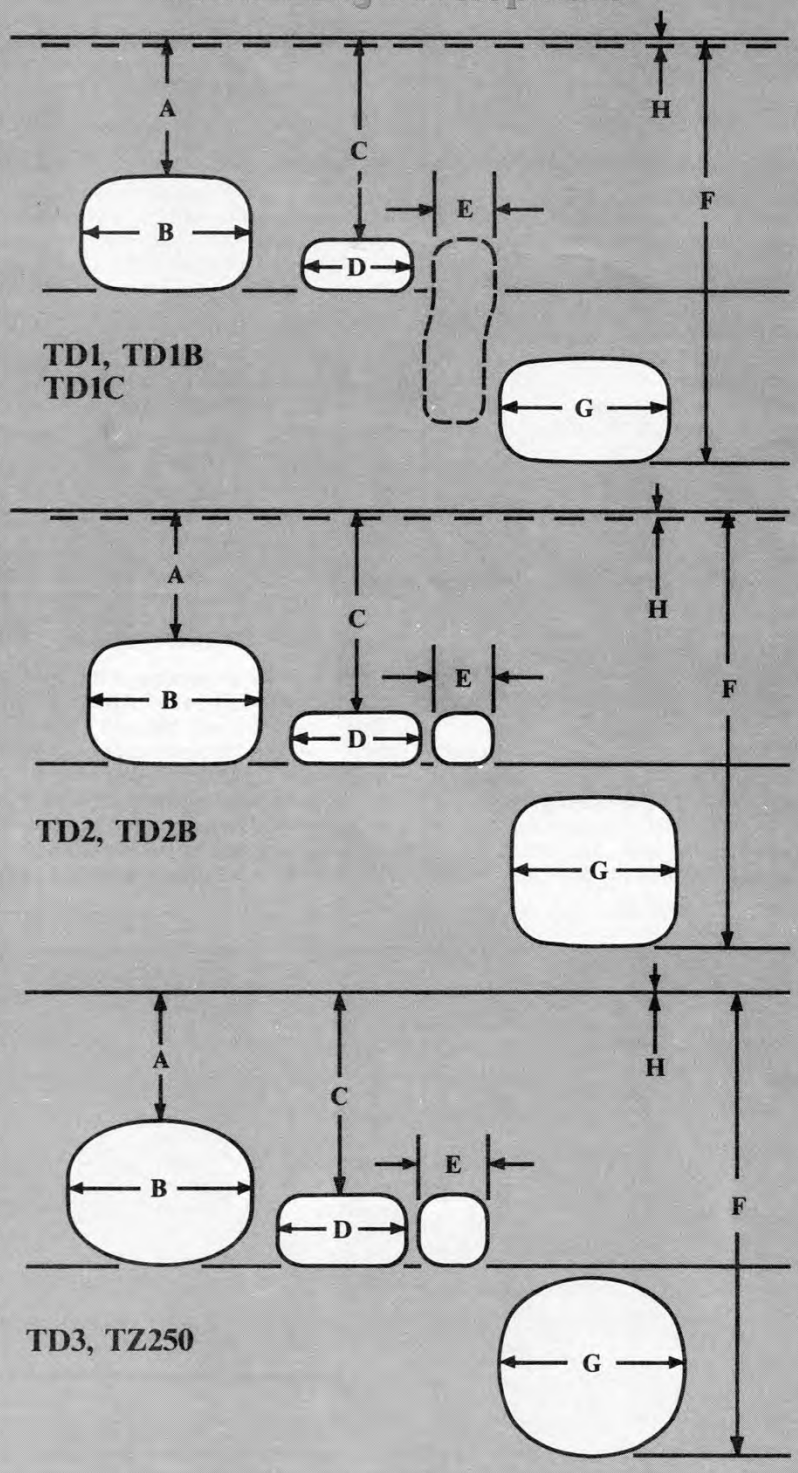
Expansion Chamber Development



		A	D_1	D_2	D_3	D_4	D_5	D_6	L_1	L_2	L_3	L_4	L_5	L_6	L_7
TD1A-1963, '64	I	75	37	37	76	32	—	—	250	290	50	200	200	—	—
TD1B-1965, '66	I	85	37	37	97	23	—	—	250	350	135	210	185	—	—
TD1C-1967, '68	II	85	38	38	80	97	22	—	175	230	50	165	210	190	—
TD2-1969, '70	II	85	39	54	80	97	20	—	266	190	45	160	175	175	—
TD2B-1971	II	85	39	54	80	97	20	—	236	190	45	160	175	175	
TD3-1972, '73	III	80	39.5	54	65	81	92	20	285	65	75	40	150	215	148
TZ250-1974	III	80	39.5	54	65	81	92	20	285	65	75	40	150	215	148

All dimensions in millimeters "A" = distance from piston face to pipe inlet

Port Timing Development



	A	B	C	D	E	F	G	H
TD1A	27	34	39.5	22	—	84	34	1.2
TD1B	27	34	39.5	22	—	84	34	1.2
TD1C	27	34	39.5	22	12	87.5	34	1.2
TD2	25	35	39.5	26	12	86	33	1.2
TD2B	25	37	38	26	12	86/87	33	1.2
TD3	25	37	39.5	24	14	91.5	37	0.0
TZ250	25	37	39.5	26	14	91.5	37	0.0

All dimensions in millimeters

Whatever the troubles, it was a start, and for many Americans, the TD1-A was the first real racer they had owned.

For the 1965 season, the new TD1-B carried another crucial improvement from the GP program. The anodized wall coating was replaced by porous chromium plating. This plating retained oil, but did not "retain" the piston, as the A-cylinders so often had done.

The cylinder was a new casting, but kept many features of the A model. Cylinder bolts were spread out, allowing more base area for the transfer ports (in their cross-section where they emerge from the crankcase). The transfer windows were as before as was the exhaust port. Exhaust timing, however, was advanced by notching the piston about 2mm on the exhaust side. This increased in blowdown time-area coupled with an all-new expansion chamber of recognizably modern proportions, allowed an increase in peak revs from 9500 to 10,000.

Concentrating as they were on rotary-inlet-valve machines for GP racing, Yamaha had somewhat neglected piston-port inlet design, but now inlet timings emerged from the dark ages. In European practice, a 60° inlet timing was considered radical. The jump from TD1-A to TD1-B saw inlet timing shoot up from 70° BTDC to 90° BTDC. Working with this new timing was the same old pair of 27mm Amal-type carbs, with their remote float chambers bracketed from the rear of the engine. This made the engine run lean under acceleration and rich under braking, a very poor arrangement.

Claimed power remained at 35. The weak crank extension shaft was increased from 20 to 25mm, stopping the breakages.

The earliest B models showed the haste that was often to characterize the preseason of Yamaha racers. The annual deadline is Daytona, and a suitable number of machines must already be in America for AMA approval. To get under the wire, the first B bikes were cobbled together from any available parts. The remnants of the RD-48 "watermelon" gas tanks, wide-ratio transmissions, and even a few sets of sand-cast crankcases were pressed into service.

The later versions of the B had crack-resistant painted pipes, hung in spring mounts. The bulbous tank was replaced by a "forward-look" model unlike anything else. Brake linings were improved.

With the new reliability combined with horsepower, the TD1-B began to win US races in a big way, though some problems remained. The skinny frames were still desperate wigglers, and engine mounts continued to crack. Clutches still needed loving care, even if they no longer fell off completely. The chrome on the cylinders would get tired after awhile and flake, which would snag the ring.

When everything worked, which was

(Continued on page 100)

YAMAHA HISTORY *Continued from page 81*

increasingly often, the problems were far overshadowed by the satisfaction of easily overtaking the droning Ducatis and Parillas, passing them sitting up, and then pretending to adjust your goggles.

With the large number in circulation, it wasn't long before someone succeeded in getting more power from the B-type. There are conflicting stories concerning he who first added go-kart-type extra transfers to a TD1-B cylinder, fed through holes in the pistons, but it was done. Perhaps several people had the idea at the same time. Small gullies were dug into the cylinder wall on either side of the inlet port, leading up to exit just behind the standard transfers. The gain in transfer time-area was small, but significant.

As the story goes, a set of these modified cylinders made their way to the Yamaha headquarters, where they were greeted with derision. "It won't work," the eager tuner was told. "Our tests have shown that the standard set-up gives the most power."

Nevertheless, they kept the cylinders, and in 1967, sure enough, back they came as the new model, the TD1-C. The gullies had been deepened and refined by Yamaha engineers, and power went up to 36–38 bhp at 10,000 rpm, for a creditable piston-port bmep of 100 psi.

Piston ring thickness dropped from 1.5mm to 1.2. Away went the poxy crank-mounted clutch; in its place was a bigger, stronger unit on the transmission input shaft. This made possible the screaming, clutch-slipping banzai starts Yamahas do so well, and this unit would do it time and again without tiring.

TD1 Yamahas had been winning AMA races regularly for three years, but in European races, after the works GP bikes went by, the next machines were usually Bultacos and Aermacchis. Efforts to compete in European club and national races on TD1-B Yamahas were usually failures. The machines weren't understood as widely as in the United States, and parts were hard to get.

With the arrival of the first TD1-C engine, brought to England in a Frank Camillieri frame by Dave Browning, the new wave began to break.

Now the Yamaha 250 production racer became the standard privateer's mount the world over, having already monopolized AMA 250 racing in the United States. Still, it was a poor, weak thing compared with Yamaha's 250 GP racer of that year, a four-cylinder disc-valve model giving over 70 bhp at 14,000 rpm, with a high bmep of 132 psi.

All the while, a vast body of Yamaha tuning know-how was being built up. Tuners who had run the earliest Yamahas, men such as Don Vesco and Mel Dinesen formed the core of a growing number of skilled Yamaha racing specialists, and standards for machine preparation began advancing steadily.

Brakes and handling began to fall behind horsepower and riding technique. Closer and closer competition had made junk out of the brake that had been a marvel four years earlier. A new brake drum might endure as little as one race of heavy usage before beginning to crack up. It was time for some changes.

The tip-off came in Canada, where Yamaha importer, Fred Deeley, Ltd., had a very good rapport with the Japanese concern. Their machines often appeared at the Canadian races with tantalizing GP bits such as big magnesium brakes. In late 1968, Yvon duHamel's Deeley 250 appeared at Mosport, Ontario, with the first TD2 engine in its C frame.

This put an end to rumor and speculation about total modernization, with rotary valves, water-cooling, and the like. If the introduction of the TD2 didn't see all these sought-after features, it did bring with it a big brother, the 350 TR2.

The T1 frame finally died, and yet another spark off the GP program took its place. This was the RD-56 frame, used on the final models of the air-cooled GP twin. This frame was of the "featherbed" type, like the original Rex McCandless design for the Manx Norton.

Simply because there were more tubes, enclosing more space, this frame was a great improvement, but there were a few imperfections. The swing arm was carried on weak, loose-fitting fiber bushings, and was none too stiff itself, being built-up from light gauge steel pressings.

For this new 250, the claim was "more than 44 phi at 10,000" which translates to a bmep of 116 psi, a big leap forward from the TD1-C engine. The increase came from improved inlet and transfer arrangements, with modest increases in blowdown and exhaust time-area.

The 27mm carbs and remote floats had gone into the junk. Shiny aluminum center-float Mikunis took their place, now in anti-vibration mounts. Now the main jets would see an unchanging fuel level during acceleration. Carb size jumped from 27 to 30mm, an area increase of 23%.

The oval shape of the new inlet and exhaust ports showed what Yamaha had learned about piston and ring longevity. The squared-off ports long favored by tuners would round off piston rings and beat in inlet skirts.

The biggest change was redesign of the vertical-split crankcase to feed four large transfer ports directly from the case, doing away with the slot ports and piston holes of the C-type. Transfer time-area and horsepower increased tremendously.

Piston ring thickness was reduced again, this time from 1.2 to 1.0mm, in the interest of better high-rpm durability.

Although some GP-type electronic ignitions were tried on works entries at Daytona in 1969, troubles forced a return to the magneto that had served with little change for eight years.

The new machine emerged just when

the big factories were dropping out of European GP racing. The cost of competitive technology was just too high to be worth it. The FIM decided to limit lightweight machines to two cylinders and six speeds, making the TD2 the ideal GP racer of the future. Since that time, Yamaha production racers have dominated the 250 GP races in Europe, just as they have done here.

Some degree of cooperation was evident between the Yamaha factory and the "private" riders who competed in the GP races. Little by little, improvements were made. Thirty millimeters were cut from the exhaust header pipe. Exhaust timing was advanced a bit by notching the exhaust side of the piston. The usefulness of these detail changes was enough to require a new model—the TD2-B.

In the TD2-B, the advanced exhaust timing of the TD2-A was exchanged for a 2mm increase in port width, for a similar gain in blowdown time-area without loss of power stroke. The shorter exhaust pipe became standard.

The speed of the 250 racer had increased steadily from the 116 mph of the earliest models to Neville Landrebe's 1970 Talladega qualifying lap at 139. With the TD2-B, trap speeds at Daytona went up to 146 mph, and these 250s were timed in foreign races at over 150 mph.

Though the magneto was still standard, two electronic systems now appeared to fill the need for better timing accuracy over long races, improved starting and resistance to plug fouling. The Spanish Femsa became standard fit for European GP Yamahas, while the German Krober became very popular in the US after its introduction by Kel Carruthers.

To free tooling for other products, Yamaha decided to redesign the 250 and 350 to share crankcases, frame, forks, and other running gear. The 56 x 50mm bore/stroke of the TD2-B had endured from the days of the archaic PQ model, but to provide a stroke suitable for both 250 and 350, the 54mm figure was chosen, making the new machines 54 x 54 and 64 x 54. Both would have modern, horizontally-split crankcases, share a common transmission and ignition.

The new racers, TD3 and TR3, were built with six-speed transmissions, with provision for blocking out sixth where rules required. Both carried a new, magnet-triggered CDI ignition.

The new designs brought another benefit to the privateer, in that a rider could buy one bike, plus the parts required for conversion to the other displacement, and so ride in two classes without double expense. The scheme had its drawbacks, but a lot of people did it.

This new 250 design wasn't a performance bombshell, as all previous big changes had been. This change was for production convenience, not horsepower increase, and the improved performance wasn't there. The first time out the TD3

was humbled by the earlier design. This sent Yamaha's new American race chief, Kel Carruthers running for the dyno room. When he came out, there was no looking back, and the TD3 became the new king of the 250 class.

The big, square-finned cylinders mounted larger 34mm Mikunis on spacer blocks. An organic-faced dry clutch replaced the wet clutches of the previous models. This dry unit worked well, offered light action at the control lever, but grip quickly deteriorated in the presence of any oil leak.

The CDI ignition could be a bother, either progressively clipping revs off the top, or simply stopping. The fault was commonly with the stator, an example of the questionable practice of locating high-voltage, fine-wire coils on the hot, vibrating engine.

Crankshafts tended to spread at the pressed crankpins, overloading the outer main bearings, particularly after two or more rebuilds.

Nevertheless, they won the races easily once they got their stride. Only an occasional good show by a Kawasaki 350 single or Aermacchi's new two-stroke GP racers marred the picture.

Even though there was no real threat in the US, a further refinement was put in hand. The radiator and waterpump of the 350 racer were used with new parts to make a water-cooled 250 racer, which brings the Yamaha to its present point of development, the TZ-250.

With small increases in base and window transfer areas, the liquid-cooled engine is basically similar to the air-cooled TD3. The main performance benefit comes from constant, controlled cylinder, piston and head temperatures.

With free-air cooling, engine temperature goes up and down with the air temperature and with the velocity of the cooling air through the fins. Piston and cylinder metallurgy is supposed to save us from seizure as these temperature changes expand and contract all the parts—a very touchy business.

With water-cooling, a radiator large enough to overcool the engine can be provided, and a thermostat placed between it and the engine, so that just the required temperature is reached, no more and no less. The tuner can now rely on the radiator for cooling, so there is no need for over-rich mixtures. Compression and spark lead no longer have to be tailored to the worst case.

The production racer is out there by the hundreds, and everyone who has one is constantly dreaming up ways to make it better. The production racer is a Yamaha, all right, because that's where it's made. But it's also the fellow who cut the first finger ports in a TD1-B; it's Carruthers and Vesco and Mel Dinesen, and all the other lesser known people who have improved the design. It's been a long cooperative effort. ◉