MOPED
Repair Handbook
By Paul Dempsey

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Preface

If you want economical transporation, the maintenance that mopeds demand cannot be farmed out to a dealer. For example, one manfuacturer suggests that the rear hub, a collection of parts that would put a bicycle coaster brake to shame, be dismantled every 6000 miles. Another suggests that the ignition contact points be adjusted or replaced every six months or 3000 miles, whichever comes sooner. Another would have the cylinder and exhaust system decarbonized at 1500-mile intervals, and the spark plug serviced every 500 miles. Clearly, if you want the combination of economy and reliability, you must do some maintenance yourself. This book shows you how to handle all routine maintenance from adjusting the carburetor to truing the wheels.

Even the best maintained moped can fail suddenly and without warning. Most of these surprises are caused by the fuel and electrical systems. I have included detailed troubleshooting and repair procedures, as well as descriptions of the way each component functions, for you cannot repair what you don't understand.

Major engine and transmission overhaul is treated in depth, often going beyond factory manuals, and on the assumption that the reader is unfamiliar with the work. Even readers who are knowledgeable about motorcycles and small engines generally will find that mopeds require special repair techniques, techniques that are strange to American mechanics.

The emphasis is on practical repairs, on restoring the machine to its original specifications. Legal restrictions limit power in most states; for those who are interested, there is information on how to bring these engines up to European standards.

The first chapter is an overview of moped technology, and should be read by a potential buyer. For mopeds are not all alike; each has different capabilities and handicaps, virtues and vices.

I want to thank the manufacturers and importers who have contributed information and, in some cases, bikes and engines for this book. Special thanks to Columbia Manufacturing Company and to Mr. "Bud" Poole, a Steyr-Daimler-Puch dealer in Sabillasville, Maryland.

Paul Dempsey

Contents

Chapter 1
The Mopeds are Coming

Most Americans have never seen a moped. But times are changing: in the 23 states where mopeds were legal last year, nearly 100,000 pedal-poppers were sold. Sales are expected to double this year and the next, peaking out in the 1980s when mopeds will be as common as 10-speed bicycles.

What are mopeds? The name means "motor-assisted pedals," and that just about sums it up. Mopeds are heavy-duty bicycles with tiny motors attached. The rider can pedal for exercise or relax and let the one to two-horsepower engine do the work. Mopeds should not be confused with the old-fashioned motorbike. Motorbikes were, for the most part, unsprung, brakeless wonders suitable only for the very young and brave. Mopeds have large, positive-acting brakes, sturdy frames, and, with one or two exceptions, spring suspensions. Anyone who can balance on a bicycle can ride a moped.

Nor should mopeds be confused with motorcycles, which require coordinated clutch and gear manipulation and have the power to get you in trouble before you can say Banzai. Mopeds are quiet, almost sedate vehicles which go solely upon command of the throttle grip. Hand levers, one for each wheel, stop the bike. Speeds are limited to 20 or, in some jurisdictions, 30 mph.

Mopeds are lightweight machines, able to dart nimbly through traffic and comfortable enough for trips of 20 miles and more. While no one recommends this, Dick Hartnett, a student at the University of North Florida, rode a Vespa moped from Jacksonville to San Diego. This epic, 2617-mile journey earned Mr. Harnett a place in the *Guinness Book of World Records*. He reports that he did not have to pedal-assist the motor and that the only maintenance was changing the spark plug and cleaning the carburetor at the approach to San Diego.

The cross-country trip required 16.5 gallons of gasoline, which works out to 157 miles per gallon. Around the city, the typical moped delivers 130 to 150 mpg. The French Velosolex, the all-time economy champ, can squeeze out more than 200 mpg.

Initial cost ranges from $300 for stripped-down models to $500 for the most sophisticated. Liability insurance is usually not required and in those states that license and register the machines, the fees are nominal. Maintenance costs are low, particularly if you are willing to do the work yourself. In all, the manufacturers are probably right when they say that moped travel costs 1¢ a mile.

While mopeds are new to the United States, they are well known in other quarters of the world. Best estimates put the moped population at more than 20 million, with the greatest concentration in Europe, Africa, and Southeast Asia. Six million mopeds are registered in France alone.

THE LAW

Mopeds have been brought into this country sporadically for decades. New Yorkers might remember the bright yellow Velosolex that stood in the window of Papert, Leonig, & Lois back in the 60s. The ad firm, now defunct but then one of the hottest on the Avenue, had purchased marketing rights for the bike. They couldn't give them away. Some years later Mitsubishi had the same dismal luck with Batavus.

What changed matters was the oil embargo of 1974-75 and the quadrupling of the price of Persian crude that followed. The Federal Government began looking for ways to save energy. Mopeds, which had been classified as motorcycles, were exempted from some safety requirements. For example, turn signals were no longer mandated; stoplight output requirements were cut in half, and brake-fade standards were relaxed. Without these concessions, mopeds would be as heavy

and cumbersome as motorcycles, without the cycle's saving grace of rapid acceleration.

However, this does not mean that moped manufacturers can sell anything they wish here. Mopeds must be equipped with two engine shutdown switches, horn, two-wheel brakes operated from the handlebars, speedometer, and, under just-amended rulings, a 12-square-inch rearview mirror.

Meanwhile, the moped manufacturers had not been idle. Three French firms, Motobecane, Sinfac-Velosolex, and Cycles Peugeot formed the Motorized Bicycle Association in 1975. Since then Motobecane and Sinfac-Velosolex have merged, and the BIA has opened its doors to 11 other manufacturers. Its membership accounts for some 80% of the bikes sold in this market. The purpose of the BIA is to do public relations for the manufacturers, act as a clearinghouse for information, and to lobby for changes in state legislation.

Once the federal government recognized mopeds as a class of vehicle distinct from motorcycles, it was not difficult to persuade the states to follow suit (Table 1-1). So far, 23 states recognize mopeds as "motor-assisted bicycles," "motorized bicycles," or simply "bicycles." Indiana legislators, perhaps in recognition of the fun value of mopeds, call them "therapeutic bicycles." More than half of these states do not require an operator's license, none require liability insurance or crash helmets, and the minimum age for riding a moped ranges from none to 17 years. Most do not require registration and only Texas insists on annual inspection.

Where legal, mopeds have about as many legal restrictions as bicycles.

On the other hand, the states did not give this freedom without imposing some restrictions. Mopeds cannot be used on limited-access freeways and are subject to the same traffic regulations as automobiles. Performance is curtailed by limits on engine displacement, horsepower, maximum speed, or all three in concert. Multispeed transmissions are legal providing they are shifted automatically and not by separate control.

Manufacturers have accepted the 50-cubic-centimenter displacement limit imposed in most states and do not build larger engines for use in those jurisdictions that allow them. Some detune their products for this market and sell 20, 25, and 30-mph versions of the same bike.

Table 1-1. Current Moped Legislation. New York Statutes Are Too Complex To Be Tabulated Here and, At Any Rate, Require Administrative Clarification.

State	Defined	Displacement	Horsepower	Max. Speed	Min. Age	License	Registration	Insurance	Helmet	Comments
ARIZONA	pedal bicycle with helper motor	50 cc or less	1.5 bhp or less	25 mph or less	16	any valid	yes	no (financial responsibility)	no	law effective 9/22/76
CALIFORNIA *bicycle license	motorized bicycle: automatic trans required, except if electric powered	none	less than 2 gross bhp	30	15	any valid or learner's permit	*	no (financial responsibility)	no	
CONNECTICUT	bicycle: automatic trans required	less than 50 cc	no more than 2 bhp	no more than 30 mph	16	any valid	no	no	no	
FLORIDA * may not operate at more than 25 mph	moped, under bicycle definition	none	max. of 1.5 bhp	*	15	no	no	no	no	
HAWAII	bicycle	none	1.5 bhp or less	none	15	no	no	no	no	
INDIANA	therapeutic bicycle	none	less than 1 bhp	none	none	no	no	no	no	
IOWA * any valid or motorized bicycle license. At age 14 no road test	motorized bicycle or motor bicycle	no more than 50 cc	none	no more than 25 mph	14	*	yes	no (financial responsibility)	no	
KANSAS * any valid or written only at 14	motorized bicycle: automatic trans required	no more than 50 cc	no more than 1.5 bhp	no more than 25 mph	14	*	yes	no (financial responsibility)	no	law effective 7/1/77
LOUISIANA	bicycle: automatic trans required	no more than 50 cc	no more than 1.5 bhp	no more than 25 mph	16	any valid	no	no	no	law effective 10/2/76
MARYLAND	bicycle	less than or 50 cc	less than 1 bhp	none	16	any valid	no	no	no	
MASSACHUSETTS	bicycle: automatic trans required	no more than 50 cc	no more than 1.5 bhp	no more than 25 mph	16	any valid or learner's permit	yes	no	no	
MICHIGAN	bicycle: friction trans	none	less than 1 bhp	25 mph	15	no	no	no	no	
NEVADA	moped: pedals required	none	none	30 mph	16	any valid	no	no (financial responsibility)	no	
NEW HAMPSHIRE	moped: automatic trans required	no more than 50 cc	no more than 2 bhp	less than 30 mph	16	any valid	yes	no (financial responsibility)	no	
NEW JERSEY	bicycle	less than 50 cc	no more than 1.5 bhp	25 mph	15	no	no	no	no	
NORTH CAROLINA	bicycle	none	less than 1 bhp	20 mph	16	no	no	no	no	
OHIO	bicycle: friction trans	none	less than 1 bhp	20 mph	none	no	no	no	no	
PENNSYLVANIA	motorized pedalcycle: automatic trans required	no more than 50 cc	no more than 1.5 bhp	no more than 25 mph	17	yes	yes	no (financial responsibility)	no	law effective 7/1/77
RHODE ISLAND	motorized bicycle	none	no more than 1.5 bhp	no more than 25 mph	16	any valid	yes	no	no	
SOUTH CAROLINA	bicycle	none	less than 1 bhp	20 mph	none	no	no	no	no	
TEXAS * annual inspection required	motorized bicycle *	less than 60 cc	none	20 mph	15	yes (written only)	yes	no	no	
VIRGINIA	bicycle	none	less than 1 bhp	20 mph	16	no	no	no	no	

DEFINITION

OPERATING INSTRUCTIONS

While some states are expected to liberalize moped regulation there has been backlash in the East. The New Jersey State Police would have them reclassified as motorcycles. The troopers argue that it is difficult to enforce the minimum age (15 in that state) because kids do not carry identification and some mopeds can exceed the 25-mph speed limit. The police are also irked by drunks who ride mopeds recklessly with immunity from DWI charges.

THE CUSTOMERS

Who buys mopeds? The data is sketchy, but it is obvious that the market is not the same as for motorcycles. Executives at Steyr-Daimler-Puch, one of the largest manufacturers, suggest that they are suburban, middle-class, "opinion leaders." According to Chalek & Dreyer, the ad agency that handles Motobecane, the market is 70% male and between 25 and 55 years old. Other ad execs see a much broader market with retirees at one end of the spectrum and high school students at the other.

THE RISKS

A recent study of vehicular fatalities in Europe indicates that mopeds are three times safer than motorcycles and six times more lethal than bicycles, but there is no reliable data on moped safety in this country. This is partly because police departments and hospital emergency forms do not yet have a category for mopeds. In so far as the equipment is concerned, the Americanized moped should be somewhat safer than its European counterpart; it is typically less powerful and has superior brakes and lights.

At any rate, mopeds share the road with automobiles that outweigh them by a factor of 15. When the moped driver disputes passage with one of these behemoths, he is always wrong. The best passive safety measure is a good crash helmet.

The baseline of helmet quality is the Z90. 1 sticker (or its equivalent) of the AAMVA (American Association of Motor Vehicle Administrators). Helmets so identified meet minimum federal impact standards. An SHCA sticker means that the manfuacturer has submitted to inspection and quality-control procedures devised by the Safety Helmet Council of America. Since helmet testing is destructive, the

helmet you wear has not been tested, but SHCA certification improves the odds that is will work when you need it. And finally, there is the hallmark of quality—the Snell Foundation sticker. Only a few helmets can meet Snell Foundation standards, which are much more rigorous than the Z90.1.

As mentioned earlier, 12-square-inch mirrors are required for new bikes. The reason for the requirement is that mopeds cannot keep up with fast traffic and must hug the shoulder, where they are subject to being struck from behind by overtaking autos. Bikes sold before the new standard was in effect should be updated with one of these mirrors (Fig. 1-1).

But passive measures—improved brakes and lights, helmets, and rearview mirrors—cannot substitute for alertness, skill, and the sense of vulnerability that all two-wheel motorists should cultivate. Be aware of the vehicles

Fig. 1-1. A rearview mirror that meets the new regulations and folds for storage.

behind you and of obstacles ahead. One very great danger, well-documented in bicycle safety literature, is autos that turn right, crossing your part of the lane. Another is the door that opens as you pass a line of parked cars. Motorists frequently don't see or hear a moped approaching from the rear. Use caution on steel bridge surfaces, and cross railroad tracks at right angles to the rails. A diagonal approach can mean loss of steering control and a spill.

THE MANUFACTURERS

While there has been no census of moped makers, they number in the hundreds. Mopeds are built wherever there is a supporting bicycle technology, from Taiwan to Norway. Most manufacturers are small and purchase engines, wheels, and sometimes frames from outside sources. Their markets are accordingly restricted. A few, like Motobecane, Puch, Peugeot, and Batavus, and giants with global ambitions, build almost every component under their own roofs. Design philosophies vary from the stark simplicity of the Velosolex to the baroque complexity of the Tomos.

Batavus

Batavus bikes are famous for their finish and workmanship, and because of this reputation for quality were among the first to be imported into the U.S. Chrome parts—fenders, rims, handlebars, and controls—are triple-dipped for durability (Fig. 1-2). The frames are painted with epoxy enamel, a product that retails for $40 a gallon. The most durable, fade-resistant paint known, epoxy is also used on commercial airliners and zero-maintenance merchant ships.

Their design philosophy is conservative, as befits a firm that dominates its home market in the Netherlands and has been manufacturing since 1904. The engine has the direct simplicity associated with a classic, with none of the compromises or afterthoughts that seem characteristic of contemporary designs. The crankshaft is counterbalanced by honest bobweights and supported on massive bearings; the crankcase halves are simple castings, joined on the vertical axis; the head and barrel are held down with studs, a practice made famous by Norton and other pioneer engine builders. One touch uncharacteristic of European engines is the use of

Fig. 1-2. The Batavus VA Deluxe is an example of honest Dutch craftsmanship.

reed valve induction. Reed valves generally improve midrange torque and always make for a more civilized idle. This engine was copied bolt-for-bolt by a competitor—the ultimate accolade.

Primary drive is by belt and pulley. Belt drive is hardly on the cutting edge of technology, but it is smooth, quiet, and inexpensive to repair when the belt finally wears out.

Batavus frames are made of mild steel tubing and, in theory at least, are superior to the steel stampings used by most other manufacturers. The VA series has the conventional step-through frame; the HS-50 (Fig. 1-3) is styled like a small motorcycle, with a top tube between the seat and steering head and a fairing forward of the rear wheel. It has the strongest frame in the industry and has additional advantages of a real, honest-to-God saddle and a fuel supply that gives 150 miles between fill-ups.

Motobecane

Motobecane is the General Motors of moped-dom. It was founded in 1923 to manufacture motorcycles and branched out into bicycles and mopeds a few years later. Since 1949, Motobecane S.A. has produced nearly 20 million mopeds,

Fig. 1-3. Excepting the frame, the 50 VL shares components with the VA series.

making it the largest and most experienced manufacturer in the world. New production facilities outside Paris have a capacity of a million units a year.

Motobecane offers a wider variety of models and accessories (Fig. 1-4) and spends more on R & D than any other manufacturer. Judging from results, the research effort is conservative—a matter of making a good product better, rather than seeking out new directions. The basic machine has not changed in more than a generation.

The size and growth of the organization—over 200 new dealers signed up in 1976 when mopeds were legal in fewer than 20 states—means that customers can expect good service and parts availability. Motobecane has five major warehouses sited throughout the U.S. and operates dealer schools on the east and west coasts. In contrast, some other manufacturers operate on a shoestring, not even supplying service manuals, let alone factory training.

Figure 1-5 illustrates the 50VL model. It features a stainless-steel front fender—much more durable than chrome—and a variable-ratio belt transmission. This moped shifts automatically from low to high range, giving better acceleration than fixed-speed models. The frame is well thought out, with side luggage racks and a covered storage

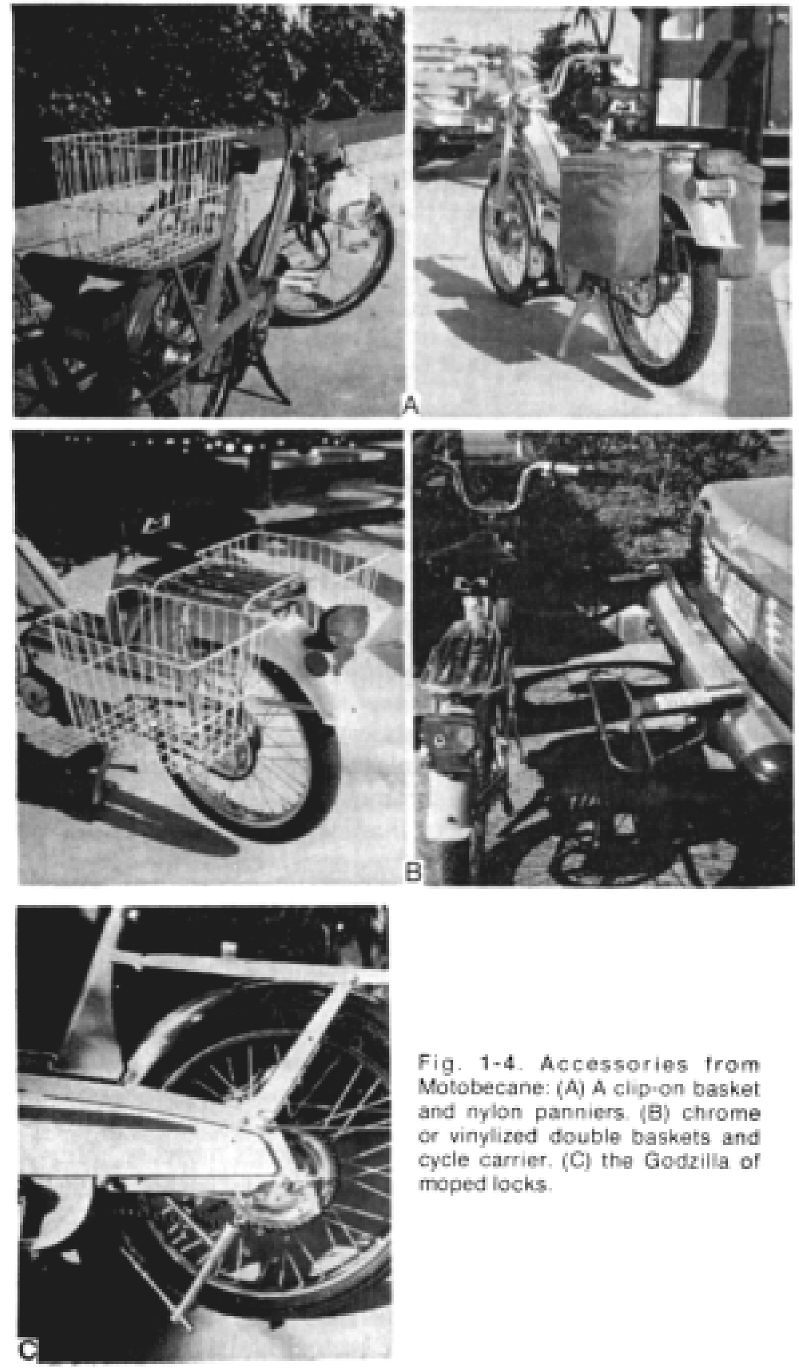


Fig. 1-4. Accessories from Motobecane: (A) A clip-on basket and nylon panniers. (B) chrome or vinylized double baskets and cycle carrier. (C) the Godzilla of moped locks.

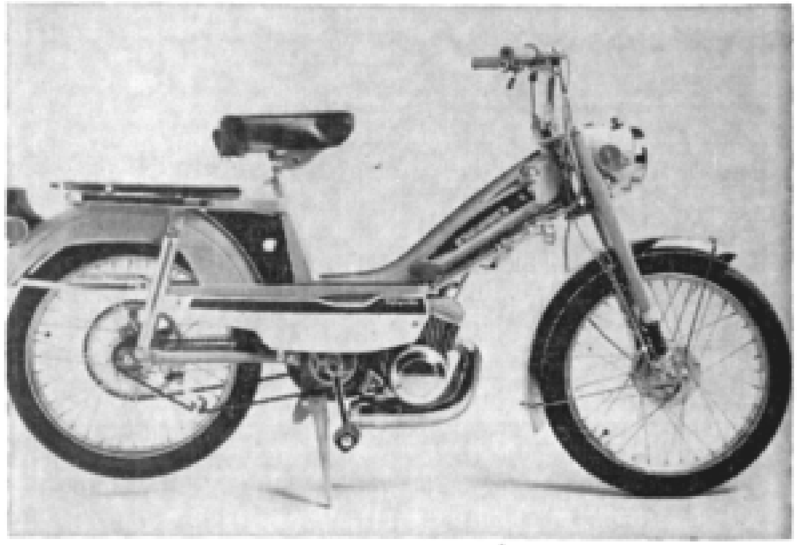


Fig. 1-5. The elegant Motobecane, perhaps the best-realized moped.

space for small items. Other models have single-speed transmissions and, at the bottom of the line, dispense with the rear shocks. All share the same engine, derated as necessary to meet various state requirements.

The engine is superbly finished with clean castings, high-quality bearings, and a chromed cylinder bore. Chrome makes a more durable cylinder than cast iron (used on most other bikes) and provides a better seal against the rings. Production tolerances are meticulous: there are eight stock piston-cylinder combinations for the same engine, allowing the piston to be perfectly matched with the bore. Not surprisingly for a machine of this refinement, dealer mechanics report almost no warranty claims. Though it may be lacking in flash, the Motobecane is as reliable as the Brooklyn Bridge.

Velosolex

Velosolex has a claim on anyone who loves mopeds. Until recently it was the moped of France, as much a part of Gallic scenery as pretty girls and sidewalk cafes.

Mention Velosolex to a competitor and he will mutter darkly about friction drive, springless suspension, and the tiny engine, some 15 cc smaller than the maximum under the law. Even in its heyday, when you could buy one at the factory door

for $80, the Velosolex was an anachronism. Other machines were more powerful, rode better, and looked more modern.

The Velosolex is the Model T of mopeds, a resemblance that was even closer when it came only in black (Fig. 1-6). Like that earlier vehicle, the 'Solex put a generation on wheels by using radically simple solutions to problems. Friction drive may not be entirely positive, but as long as the tire and drive roller are free of oil, it works. And friction drive invites the simplest imaginable clutch—the drive roller, engine and all, is lowered against the tire. While the engine rides high over the front wheel, it looks more intrusive than it is. The engine weighs only a few pounds and the rider soon learns to compensate for its effect on steering. Nor is the ride as harsh as a solid suspension would suggest; compliance built into the wheels and frame muffles most road irregularities.

While its power is nothing to write home about, the bike weighs only 68 pounds. Pedal assistance is not that much of a

Fig. 1-6. The Velosolex, the Model T of mopeds: reliable, unbreakable, and aging.

chore, and the owner may get some satisfaction from the fact that the Velosolex is the most economical form of motorized transportation known to man. Under ideal conditions, a 'Solex will travel 218 miles on a gallon of fuel.

Motobecane purchased Velosolex a few years ago and markets the machine in this country as "The Horse." Velosolex owners benefit from the parent company's extensive training programs and parts distribution network.

Puch

There seem to be three ways to produce a quality moped: build it from long experience, with improvements made as the need arises; scale down a motorcycle, simplifying the controls and detuning the engine; or build it from a pool of engineering talent, borrowing techniques from several specialities. The Puch is an example of the last method.

Steyr-Daimler-Puch is a giant industrial complex, the result of the merging of three pioneer Austrian manufacturers of motorcycles, automobiles, and airplanes. Two of the greatest names in automotive history—Dr. Ferdinand Porsche and Hans Ledwinka—were in their employ. Today, in addition to mopeds, the conglomerate builds auto accessories, utility and military vehicles, motorcycles, bicycles, and the famous Mannlicher rifle.

Steyr-Daimler-Puch is making a serious effort to increase its share of the American market. Hundreds of dealerships have been established, many of them veterans of the snowmobile trade and thus familiar with two-cycle engines. The firm has set up training programs and has gone to great lengths to assure the availability of spare parts. Even some internal parts for the rear shocks are inventoried—something unheard of in the rest of the industry.

The Puch (pronounced "pook") Maxi has clearly had the attention of an industrial designer. Wheels, fenders, headlamp, fork, and frame are integrated so that the bike seems of a piece, and not a collection of miscellaneous parts (Fig. 1-7A). Wiring and control cables are unobtrusively tucked out of the way.

The finish is on a par with a high-class automobile and much superior to the average European motorcycle. Thoughtful touches abound. The luggage rack is spring-loaded to hold small parcels; two chromed handles assist in getting

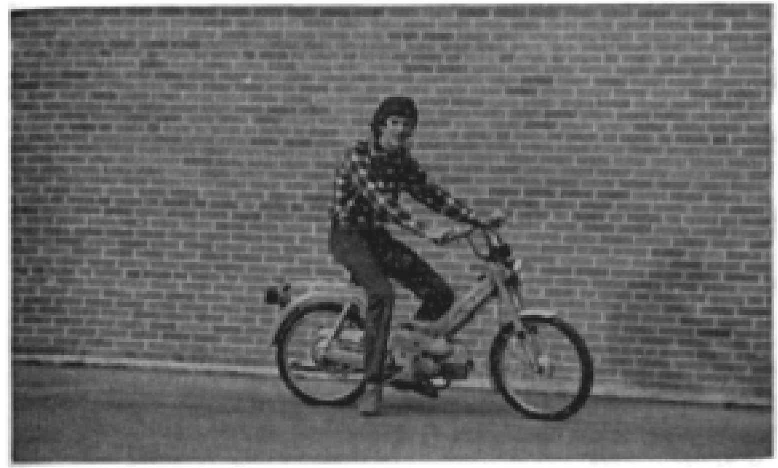


Fig. 1-7A. The Puch Maxi—big-time technology in a small package.

the bike up on its center stand; front fender and engine covers are molded in soft, resilient plastic on the judo principle that it is better to give way than to stand and be broken.

The engine is obviously a moped engine, designed from the start for this purpose. The cylinder is horizontal to use space more efficiently and to keep the center of gravity low (Fig. 1-7B). Engine castings are clean and crisp, which indicates a heavy investment in foundry equipment. Fins and bearing

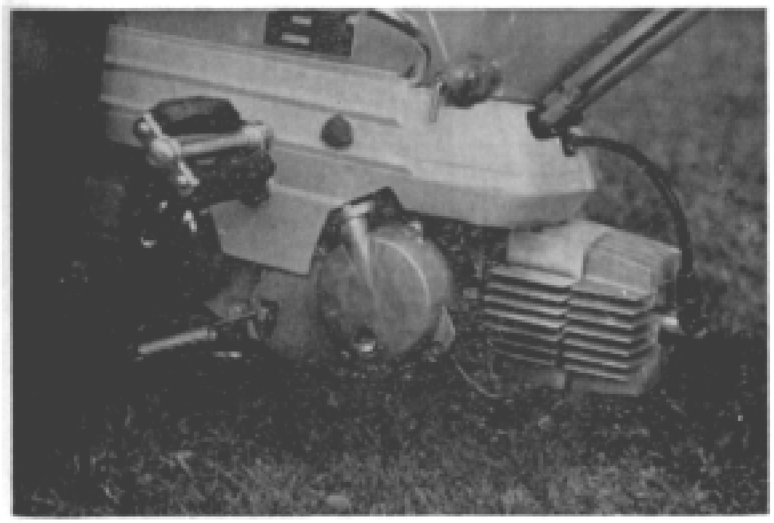


Fig. 17-B. The Puch engine and transmission reflect careful design.

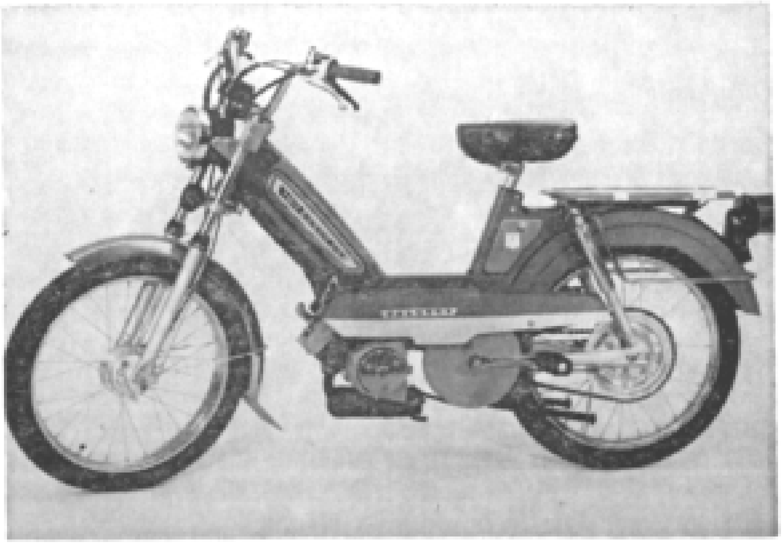


Fig. 1-8. If Motobecane is the General Motors of French mopeds, Peugeot is Ford and Chrysler. The 103-U3, shown here, features Ceriani-type forks and an automatic transmission.

webbing appear to have been computer-designed for best effectiveness. The cylinder bore is plated with long-wearing chrome and the piston is hand-fitted. The internal finish and the cleanliness of new engines is evidence of careful assembly.

Primary drive is through a centrifugal clutch and gear train running in oil. Oil-cooled clutches are theoretically superior to dry or air-cooled clutches and can take more abuse before failure. Separate pedal and engine chains are used, a somewhat anachronistic feature, but one that simplifies the transmission. New models can be purchased with attractive cast-aluminum wheels that are stronger, lighter, and require less maintenance than spoked wheels.

Peugeot

Like other products from the house of the rampant lion, the Peugeot moped combines engineering elegance with visual appeal (Fig. 1-8). The engine is famous for its durability, and durable it should be. The castings are simple, heavily webbed for stress, and thicker than they have to be. Chrome plate protects the cylinder bore and the crankshaft rides on main bearings that would do justice to a truck transmission.

Primary drive is through a V-belt which, on the 103-U3, is combined with a speed-sensitive engine pulley. As the engine speeds up, the pulley flanges move together, progressively gearing the bike higher. The rims are 17 inches in diameter—an inch larger than most—for better stability and responsiveness. Another nice touch is the way the spoke holes are dimpled for strength. Peugeot supports its product with a six-month warranty, twice as long as the industry average.

No motor vehicle, however durable, is entirely free from service problems. Peugeot recognizes this and has set up a factory school in Gardena, California for dealer mechanics and interested owners. No other factory has been so thorough in the matter of special tools. There is a tool for almost every job on the bike. Not all of these tools are absolutely necessary—an owner can get by without most of them—but they make the job go better and faster.

Columbia

The Columbia Commuter is unique: the only moped to be assembled in the United States (Fig. 1-9). The Columbia

Fig. 1-9. The Columbia Commuter is the first to be designed specifically for this market and assembled by American labor. It may be the herald of a new industry.

Manufacturing Company of Westfield, Mass., is a major bicycle manufacturer, tracing its lineage back to the nineteenth century when it was founded by the legendary Colonel Pope. Two years ago the firm decided to enter the moped business, assembling components purchased in Europe. As sales warrant, Columbia intends to build more and more of the bike here.

For the customer this means a somewhat lower cost for a quality bike, while imported bikes are subject to duty, most duties do not apply to parts. Columbia contacted parts makers early while the better components were still available, and maintains a complete inventory of spares on this side of the Atlantic. Today the parts factories are working at full capacity and a newcomer would have to take what he could find.

The bike uses a series 505 Fichtel & Sachs engine, designed specifically for mopeds by the largest small-engine maker in Europe. Sachs occupies the same position in the European utility engine industry as Briggs & Stratton does here. In addition, the sprawling complex in Schweinfurt, West Germany builds motorcycle and snowmobile engines, antifriction bearings, and transmission components. In 1976 their sales totaled $413.9 million.

The 505 is the most modern moped engine on the market (Fig. 1-10). Others may be as good, but none benefit more from contemporary skills. Sachs' engineers probably know more about two-cycle engines than any other firm's: the 505 is prime evidence.

First of all, a moped engine must be compact and should house the primary drive components. The 505 crankcase halves enclose the primary gear train—with helical teeth for silence—and the pedal mechanism. The entire package is only 16 inches long, 85 inches wide, and 7.5 inches high. The all-up weight is just under 24 pounds with muffler attached.

Another requirement is that the engine be adaptable to different markets. Where appropriate, the 505 can be purchased with a two-speed, manually shifted transmission and 2.5 horsepower. The version used by Columbia is detuned to 2.0 hp at 4500 rpm, but has a torque curve as flat as West Texas.

The carefully shaped ports, the seemingly casual disposition of the cooling fins, and the brutal simplicity of the transmission attest to years of experience. Sachs engineers can distinguish between what is important—port profiles and and transmission-shaft rigidity—and what is not—fin symmetry.

A moped engine should be durable, and the Sachs promises that. The crankshaft is massive, fully counterweighted, and mounted on large-diameter antifriction bearings. The connecting rod has needle bearings on both ends, at the wrist pin as well as the crankpin.

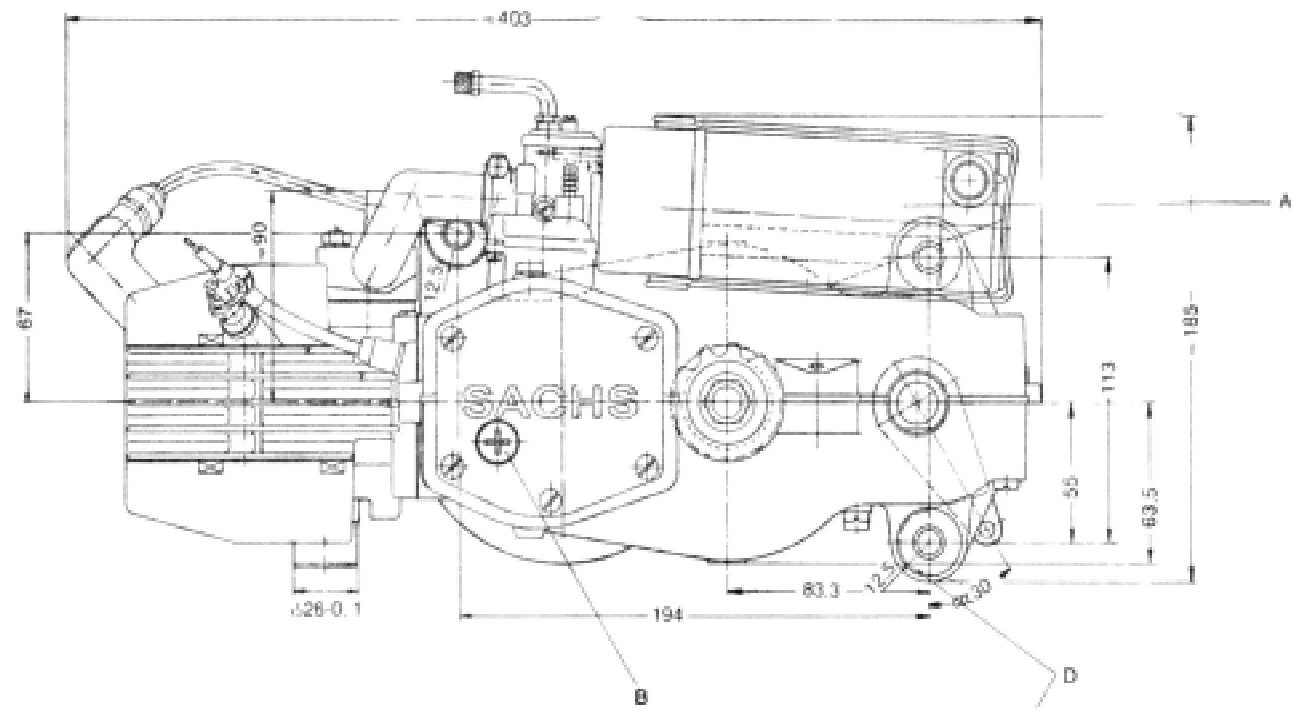
When overhaul time does roll around, you'll appreciate the horizontally split crankcase. The engine opens as easily as a sandwich. All other moped engines are split vertically and require a safecracker's touch to get them apart without permanent damage to the castings.

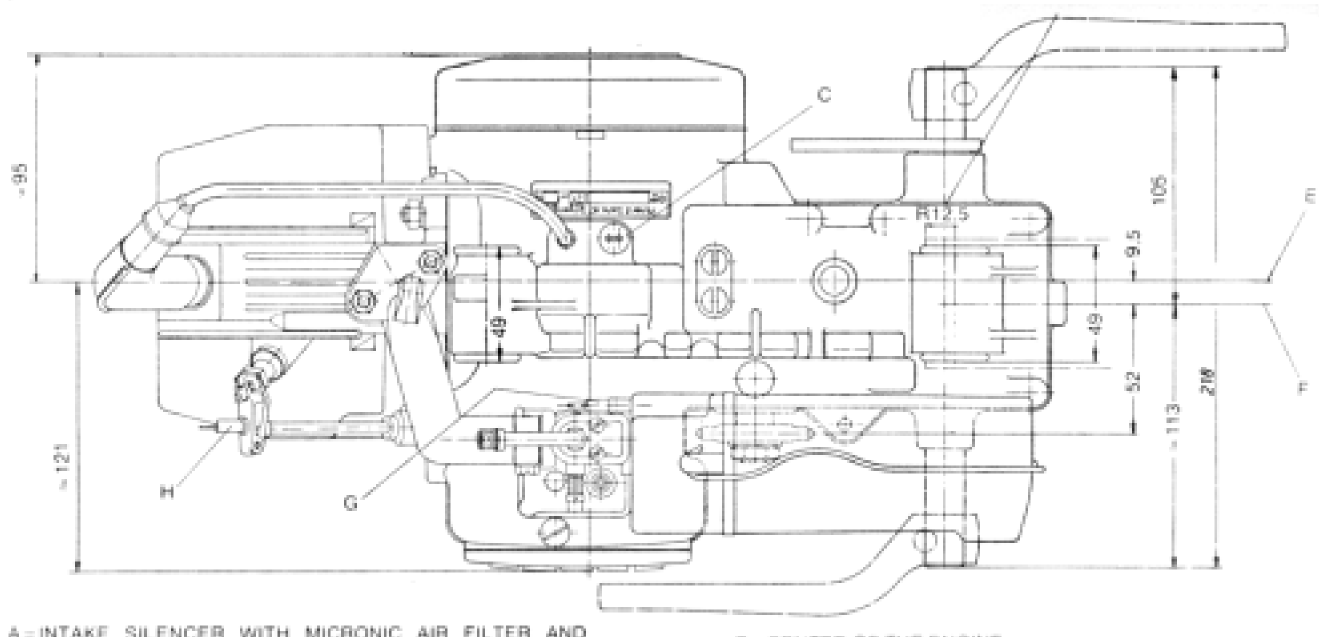
The Commuter frame is a rugged piece of work, obviously tailored to this market. Slightly larger than the run of European bikes, it rides on 21-inch wheels for stability in the rough. Large, motorcycle-type hub brakes provide sure stops and the frame is reinforced. Chrome plating, always expensive and never as weather-resistant as paint, has been kept to a minimum. Fenders have rolled edges to resist cracking and the engine cowlings are made of shock-absorbing plastic.

Jawa

Jawa is a big name in off-road motorcycle competition, but what is not so well known is that the Czech firm makes a very advanced moped (Fig. 1-11). The Babetta is an honest moped, with few concessions to the mass market. While the frame is made of pressed steel, the angles are sharp and clean; front forks and centerstand appear almost spindly; the steering head, the most important single part of the frame, stands naked and unshrouded. Even if the angularity of the bike wasn't a sufficient clue, the black anodized engine and lightening holes in the headlamp bracket should tell you this is a serious moped, built by people who have dominated European motorcross racing for a generation.

The engine is typically Jawa—thick, clustered fins, antifriction bearings on all shafts, needle bearings on both ends of the con rod. A complex double-chain drive transmission is enclosed within the engine castings. Major repair work is not for the amateur. The Babetta is the only moped with a transistorized ignition system, guaranteed to extend spark plug life and make starting easier.





A = INTAKE SILENCER WITH MICRONIC AIR FILTER AND BUILT-IN STARTING DEVICE
B = OIL CHECK AND OIL DRAIN PLUG
C = ELECTRIC LIGHTNING CABLE OUTLET
D = CONTOUR FRAME-CLIP

E = CENTER OF THE ENGINE
F = CENTER OF THE FRAME
G = CONTROL CABLE FOR CHOKE DEMAND
H = CONTROL CABLE FOR STARTING AND DECOMPRESSOR LEVER (FOR STARTING CLUTCH)

Fig. 1-10. The Fichtel & Sachs 505/1 engine.

Fig. 1-11. The Jawa Babetta—a thoroughbred.

Cimatti

The Cimatti City Bike is the most inviting of all mopeds, styled with excitement and verve (Fig. 12A). The frame is tubular and the fuel tank mounts, logically enough, over the rear wheel. The bike has been proved in the marathon of the moped world—rental service.

Its Minarelli V1 engine is used by several other manufacturers, a testament to its durability and a convenience for owners, who thus have several sources of parts and service (Fig. 1-12B). While the basic mechanism—a piston-ported cylinder, single-speed gearbox, and integral pedal mechanism—is fairly simple, the detail engineering is first rate. For example, the primary gears are helically cut to reduce noise and the final drive is by a single chain to the rear wheel. All engine-driven shafts are mounted on ball bearings pressed into the heavily webbed crankcases. A flywheel fan keeps air moving over the cylinder fins to prevent piston seizure after long periods at idle.

Tomos

Tomos Koper is known throughout eastern Europe as a builder of bicycles, motorcycles, outboard motors, and other leisure products. Current moped production is pegged at 200,000 a year. Two models are imported to this country: the 30-mph A 3S and the 20-mph A 3S Super Sport.

Fig. 1-12A. The Cimatti City Bike

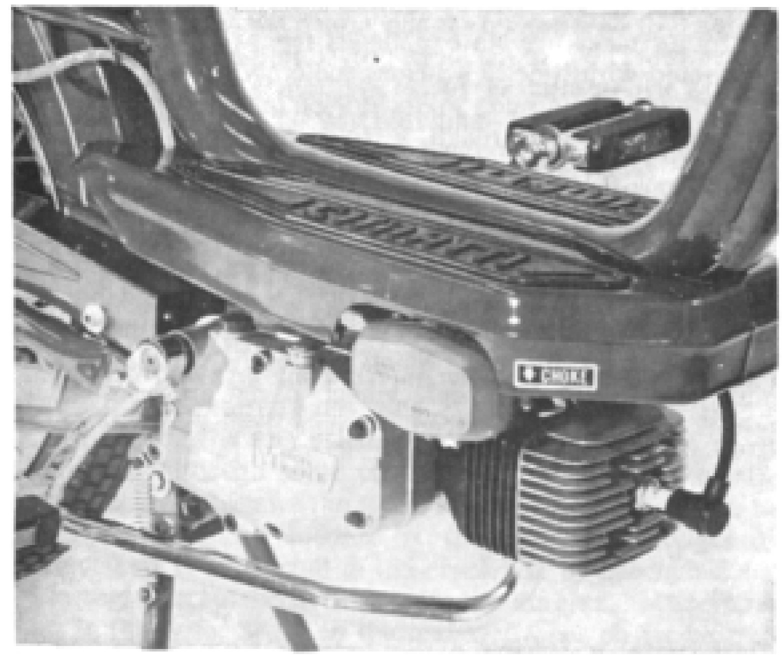


Fig. 1-12B. A closeup of the Cimatti's Minarelli engine

Fig. 1-13. The Tomos A3S—mechanical sophistication in an unpretentious package.

Tomos bikes are state-of-the-art machines with features that would do justice to a luxury motorcycle (Fig. 1-13). All engine and transmission shafts ride on antifriction bearings; primary drive is through a fully automatic, two-speed gearbox; secondary drive is via a single chain to the rear wheel; both wheels have full-width hubs, and the front fork is hydraulically damped. No other moped has all these features.

On the debit side, Tomos does not, as yet, have much of a dealer organization. Parts and service are hard to find in some areas; the owner is on his own and will not get too much help from the shop manual, which is poorly translated and illustrated. However, replacement parts are reasonably priced and can be ordered through the central depot in Summerville, South Carolina.

Chapter 2
Engine ABCs

Moped engines have three moving parts: *piston, connecting rod,* and *crankshaft* (Fig. 2-1). The piston moves up and down in the cylinder bore. The small end of the connecting rod reciprocates with the piston, and the big end describes a circle, driving the crankshaft.

The cylinder, sometimes called the barrel or jug, is finned for cooling (Fig. 2-2). The part that closes off the top of the cylinder is called the cylinder head. It is secured by several bolts and may be fitted with a soft metal or composition gasket to make a gas-tight joint over the barrel. The spark plug threads into the head, also using a gasket for sealing.

The piston is a close fit in the bore and, for a more perfect seal, is grooved to accept a pair of piston rings. The rings expand under gas pressure and hug the bore, forming a barrier to leakage. The wrist pin passes through the piston and is held by a circlip on each side.

Both ends of the connecting rod usually ride on needle bearings, although some engines use bushings at the small end. Figure 2-3 shows the small-end bearings clearly; the big end bearings are hidden by the crankshaft webs. The crankshaft is supported in the crankcase by needle and ball bearings. A steel thrust washer locates the crankshaft fore and aft in the case. Seals on the outboard sides of the bearings prevent crankcase gases from escaping around the crankshaft

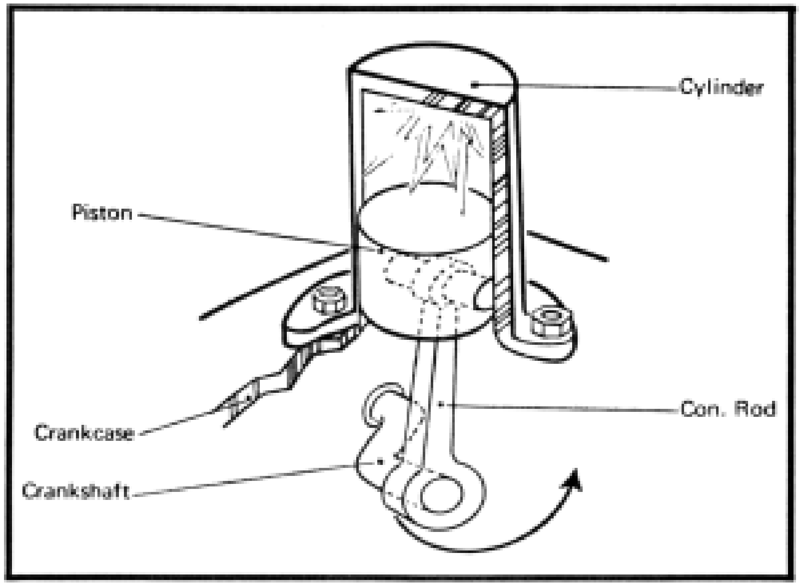


Fig. 2-1. Basic engine nomenclature. (Courtesy Pacific Basin Trading Co.)

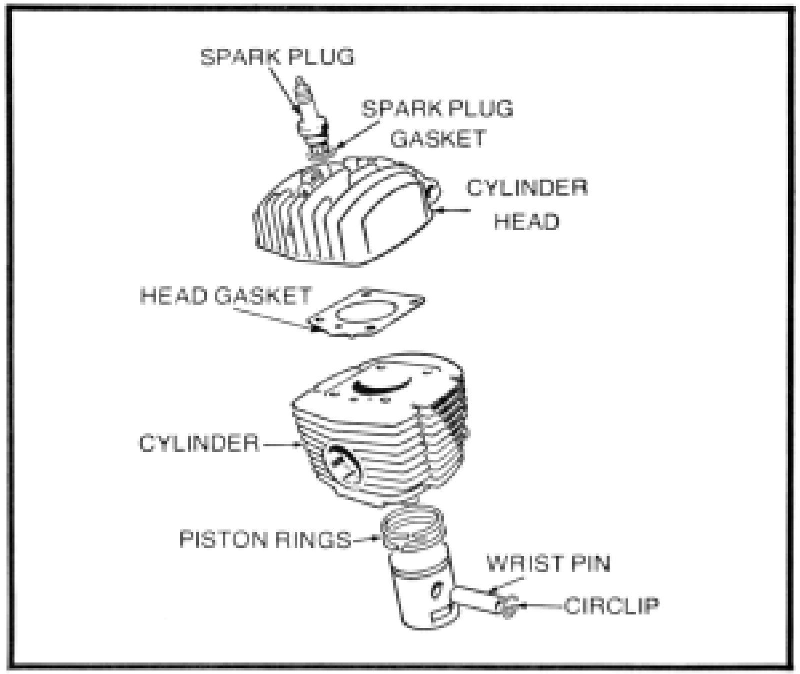


Fig. 2-2. The Motobecane upper engine assembly—typical of mopeds.

ends. The crankcase is split for easy access and is usually, though not always, gasketed.

OPERATION

Gasoline engines work on a cycle of five events: intake of the fuel charge, compression of the charge, ignition, expansion of the burning gases, and exhaust. Current imported moped engines accomplish this in a single revolution of the crankshaft or, phrasing it another way, in a single up-and-down stroke of the piston. Engines of this type are known as two-stroke or two-cycle engines.

Piston-Ported Engines

There are two varieties, distinguished by the way fuel and air is admitted into the crankcase. *Piston-ported* engines—the most popular—employ a cylinder pierced by three holes known as the inlet, transfer, and exhaust ports. The inlet port opens to admit the air-fuel mixture into the crankcase; the transfer port conducts this mixture into the cylinder; and the exhaust port channels the spent gases out of the cylinder and into the muffler. The ports are opened and closed by the movement of the piston.

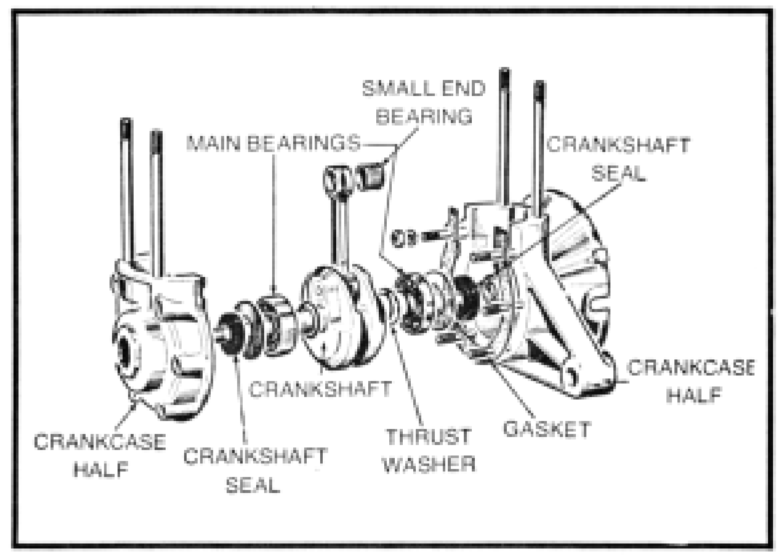
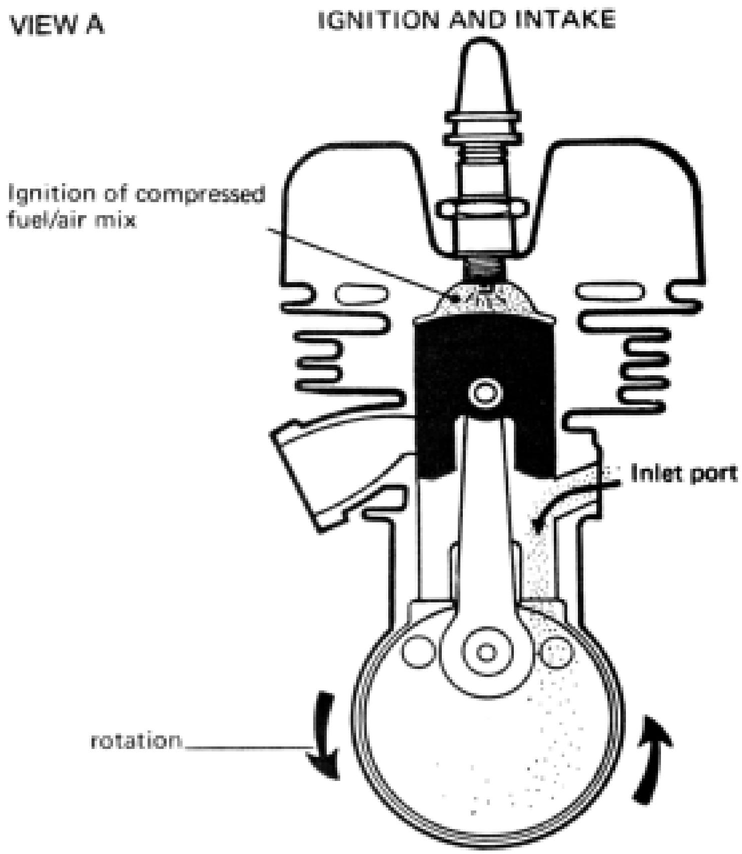
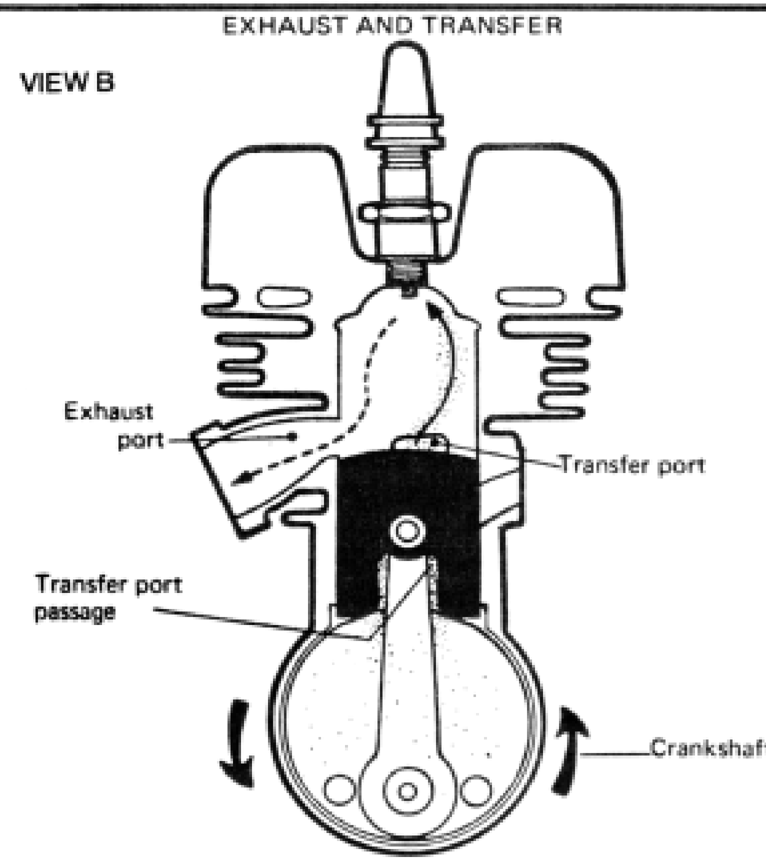


Fig. 2-3. The lower engine assembly converts the reciprocating motion of the piston into rotary motion. This Peugeot block illustrates typical moped practice.



The piston has reached top dead center (T.D.C.) and ignition is taking place. Note the inlet port below the piston; arrow shows path of incoming fuel/air mix from carburetor.

Several events occur simultaneously, and you must look closely at the drawings in Fig. 2-4. View A shows the piston at the top of its stroke, a position called top dead center (TDC). At this point, the exhaust and transfer ports are closed. The inlet port is open and a fresh charge of air and fuel is entering the crankcase, below the piston. At the same time, the top, or crown, of the piston has compressed air and fuel in the



Cutaway drawing of the F 480 two-stroke engine. Solid arrow depicts path taken by incoming fuel/air mixture. Dotted line arrow indicates exhaust exit path. As this is a sectional drawing, only one transfer port is shown.

Fig. 2-4. Two-cycle engine operation. Most mopeds use the piston-controlled, or third-port, system shown, but other two-cycle engines may use a rotary or leaf inlet valve. (Courtesy Pacific Basin Trading Co.)

cylinder. This highly explosive mixture, more explosive than an equal weight of TNT, is ignited by a spark from the spark plug.

In Fig. 2-4B the piston, impelled by the force of burning gasoline and superheated air, has moved to bottom dead center (BCD). Early in its downward travel the piston closed off the inlet port, trapping the air-fuel charge in the crankcase.

The upper edge of the exhaust port is uncovered and then, a few degrees of crankshaft rotation later, the piston passes the transfer port.

As the piston falls it compresses the air-fuel charge below it. Once the inlet port closes, there is no escape for the charge until the transfer port is uncovered. When this happens the charge passes out of the crankcase and into the cylinder where it will be burnt during the next crankshaft revolution.

To return for a moment to events above the piston: the exhaust port is always cut higher in the bore than the inlet port and so opens earlier. This is to allow most of the spent (but still high-pressure) gases to "blow down" or exit through the exhaust port. Blow-down ceases when the pressure of the gases equals atmospheric pressure, so some exhaust residue remains in the cylinder and must be forcibly ejected—otherwise the fresh charge would be contaminated. The process of purging the cylinder is called *scavenging*, and has given two-cycle designers many a sleepless night.

There are several ways to scavenge a cylinder; all of them depend on using the incoming fuel charge as a kind of battering ram to force the spent gases out the exhaust port. The trick is to do this without losing too much of the fresh charge in the process.

Moped engines use what is called *cross-flow* scavenging. The incoming charge is divided between two transfer ports on opposite sides of the cylinder. The piston is slightly domed and the transfer-port exit ramps are angled to converge the charges at the center of the chamber. The charge streams meet and loop, forming a miniature hurricane that drives the exhaust gas out before it.

Reed-Valve Engines

Batavus, Peugeot, and Puch bikes use *reed-valve* engines. While piston-ported engines have three ports, reed-valve designs have only two—a transfer and an exhaust port. (Fig. 2-5). The reeds are made of spring steel and are mounted between the carburetor and the crankcase. They open when crankcase pressure drops below atmospheric pressure, and close, trapping the mixture, when the pressure relationship is reversed. Piston-ported engines have a tendency to spit back through the carburetor at low speeds, upsetting the mixture and covering the carburetor with a layer of oily grime. A reed

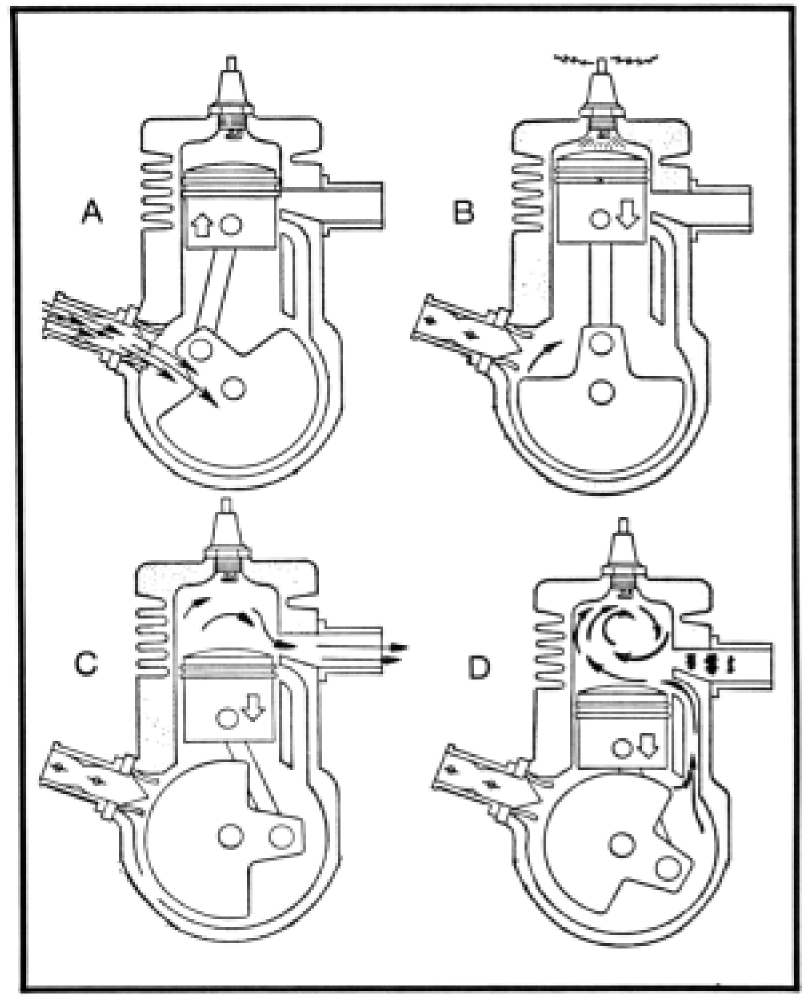


Fig. 2-5. A reed-valve, loop-scavenged engine. As the piston climbs in the cylinder, crankcase pressure drops in its wake. The reed valve opens (view A). The sparkplug fires (view B), igniting the mixture and sending the piston back down the bore (view C). Crankcase pressure closes the reed while, at the same time, the exhaust port is uncovered. Most exhaust gases blow down. Further downward piston movement (view D) opens the transfer port, and the cylinder fills with a fresh charge. The port is angled to loop the charge.

valve keeps the mixture in the crankcase where it belongs and, since the valve responds to vacuum, the engine is fed as much fuel as it can consume at all speeds. Torque is improved over piston-ported designs, especially at part throttle.

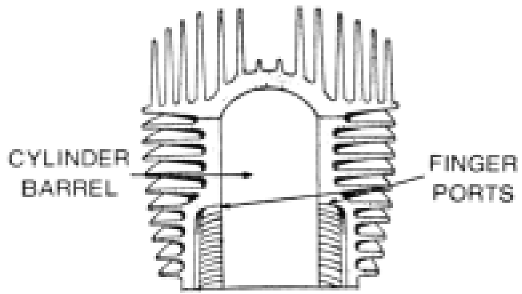


Fig. 2-6. "Finger ports", ports that open to the bore along their full length, are used on some moped engines. The illustration shows the dual, diametrically opposed finger ports on a Peugeot.

As a point of interest, Peugeot and Puch transfer ports are open to the bore along their full length (Fig. 2-6). While go-kart engines are sometimes modified this way to increase port area, the reason here seems to be manufacturing convenience.

The easiest way to tell whether an engine is reed-valve or piston-ported is carburetor placement. The carb on a piston-ported engine is always positioned with its intake tube (the single-cylinder equivalent of an intake manifold) leading to the base of the cylinder. A reed-valve engine's carb is mounted on the crankcase.

ENGINE DIMENSIONS

The basic dimensions of any engine are the bore and stroke (Fig. 2-7). The bore is the diameter of the cylinder; the stroke is the distance the piston travels between bottom and top dead centers. The stroke is determined by the throw, or offset, of the crankshaft.

Moped engines are built in countries that use the metric standard of measurement. Bore and stroke dimensions are expressed in millimeters (mm). For example, the Jawa Babetta has a bore of 39 mm and a 41 mm stroke. In American terms these dimensions are expressed as 1.55 × 1.61 inches.

Displacement

Displacement is a measure of how much air and fuel the engine "inhales" during each revolution of the crankshaft. It is the volume that the piston sweeps as it moves from top to

bottom dead center, and is equal to the stroke times the area of the bore. Displacement does not include the clearance volume above the piston at top dead center.

Displacement is important in the legal definition of a moped. In most jurisdictions, "motor-assisted bicycles" are limited to 50 cubic centimeters of displacement. The reason for this restriction is to limit the power of the engine. In engines of equal refinement, power is directly related to displacement: the greater the displacement, the more horsepower and torque developed. A quick formula for calculating displacement is:

$$\text{Bore} \times \text{Bore} \times \text{Stroke} \times \text{Number of Cylinders} \times 0.7854.$$

Since all moped engines are single-cylinder devices, we can disregard the number of cylinders. It is important to use uniform units of measure. If we express bore and stroke in inches, the answer will be in cubic inches (cu. in. or, sometimes, CID for cubic inches of displacement). If we use millimeters the answer will be in cubic millimeters, a legitimate but rarely used unit of measure—it is traditional to express metric displacement into cubic centimeters (cc). To convert cubic millimeters in cubic centimeters, divide by 1000.

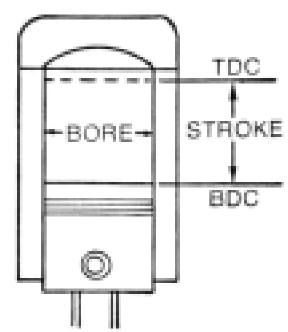
The displacement of the Babetta calculates as:

$$39\text{mm} \times 39 \times 41\text{mm} \times 0.7854 = 48978.33\text{mm}^3$$

$$\frac{48978.33\text{mm}^3}{1000} = 48.98 \text{ cubic centimeters}$$

We can convert to cubic inches by converting the millimeters into inches or by multiplying the cc displacement

Fig. 2-7. The bore is the diameter of the cylinder, and the stroke is the distance the piston travels from bottom to top dead center.



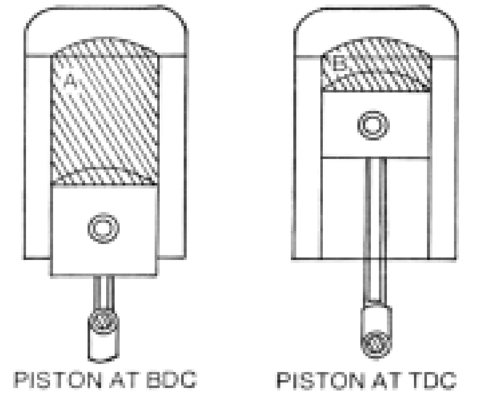


Fig. 2-8. Compression ratio is the ratio of the cylinder volume with the piston at bottom dead center to the volume at top dead center.

by 0.061. The Babetta displaces 2.99 cu. in. As a point of comparison the Chevrolet workhorse V-8, by no means the largest engine in the stable, displaces 350 cu. in.

Compression ratio is the cylinder volume at bottom dead center divided by the volume at top dead center (the clearance volume). Mopeds have compression ratios of about 8:1 (Fig. 2-8). Higher compression ratios give more power, but increase engine temperatures and require high-test fuel.

Engine power is expressed in units of horsepower and torque. These two terms are distinct, but interrelated. Torque is a measure of instantaneous twisting force. You exert torque when you open a jar lid, pedal a crank, or turn a wrench (Fig. 2-9). In our system, torque is expressed in pounds-feet, e.g., 10 pounds of force acting on a lever 1 foot long produces 10 pounds-feet of torque. The metric system uses kilograms and meters to measure torque. For an engine, torque translates as acceleration and the ability to keep slogging under load.

Unlike torque, which is a force sensed at a given moment, horsepower involves the concept of time. One horsepower is the ability to lift 550 pounds one foot in one second. One hp equals 550 ft-lb of work per second, or 33,000 ft-lb per minute. Horsepower and torque can be estimated from a vehicle's performance, but exact measurements of an engine's output requires a dynamometer.

A dynamometer is a machine that monitors rpm and torque while a brake applies a variable load to the engine. Some dynamometer brakes are mechanical, others are electrical; most are hydraulic and use water as the working fluid. Figure 2-10 illustrates a Go-Power engine dyno, intended for small two-cycle engines. The engine is bolted to

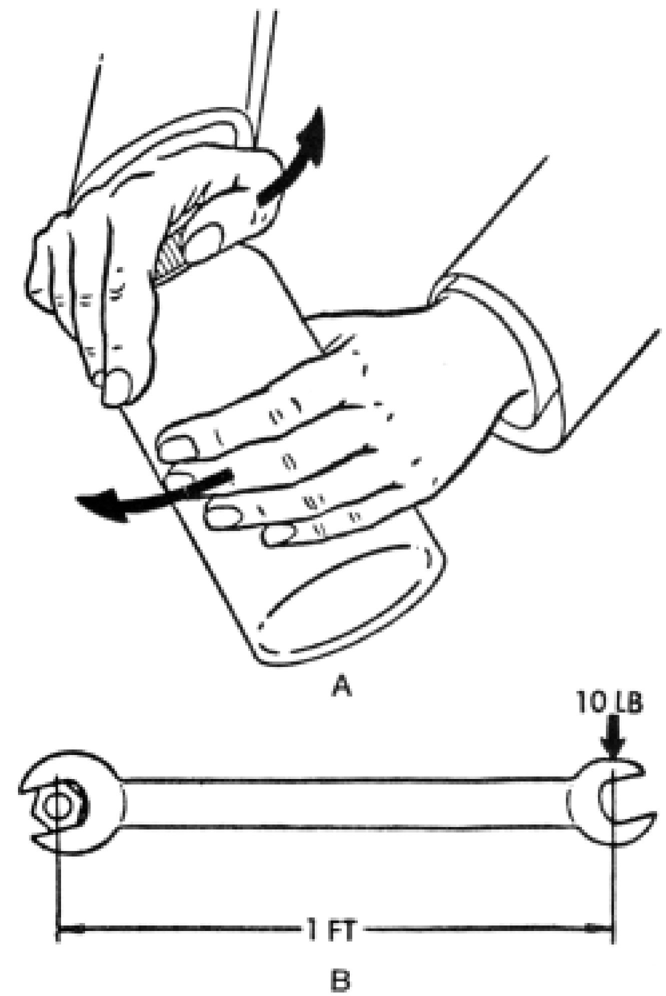


Fig. 2-9. Torque is a term for twisting force. You exert torque when you open a jar (view A) or turn a wrench (view B). A force of 10 lb exerted on a lever 1 ft long is 10 lb-ft of torque.

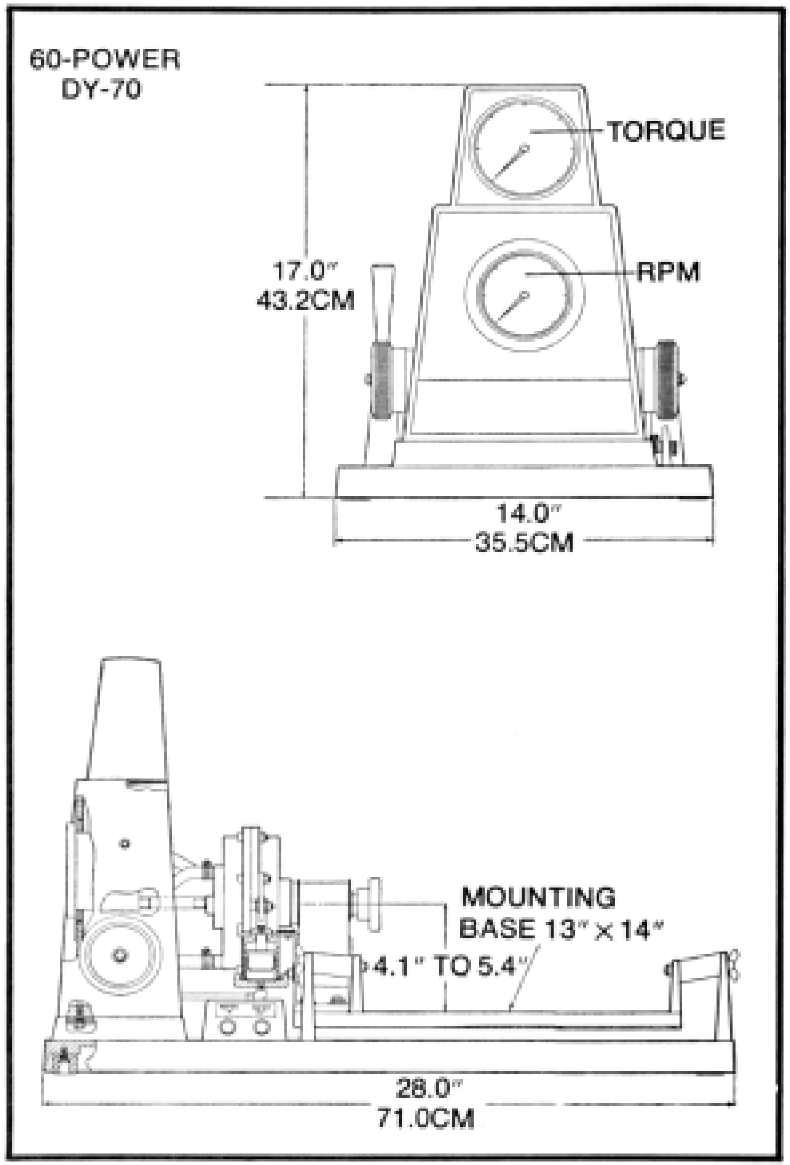


Fig. 2-10. Horsepower yields speed, but the relationship is not linear.

the mounting plate which is suspended on flexible rubber snubbers; the crankshaft is coupled by an adaptor to the driveshaft of the water brake. The amount of water going to the brake and the drag it generates is controlled by the valve

on the right of the instrument stand. Two instruments are provided, a mechanical tachometer and a torque gauge.

This and most other engine dynos work on a very simple principle known as Newton's First Law of Motion: every action has an equal and opposite reaction. The force generated by the crankshaft to overcome the drag imposed by the water brake is the action. The reaction is the tendency of the engine to rotate around the crankshaft: this rotation has the same force as the crankshaft output, but is in the opposite direction. It acts through the flexible mounting base and is measured by the torque gauge.

Once rpm and torque are known, it is simple enough to convert to horsepower:

$$\text{brake horsepower} = \frac{\text{rpm} \times \text{torque (lb-ft)}}{5250}$$

The term brake horsepower (bhp) signifies that the figure has been measured on a dyno and is not estimated or guessed at.

Horsepower translates as speed, but the relationship is not linear. As speed increases, more and more power is needed to

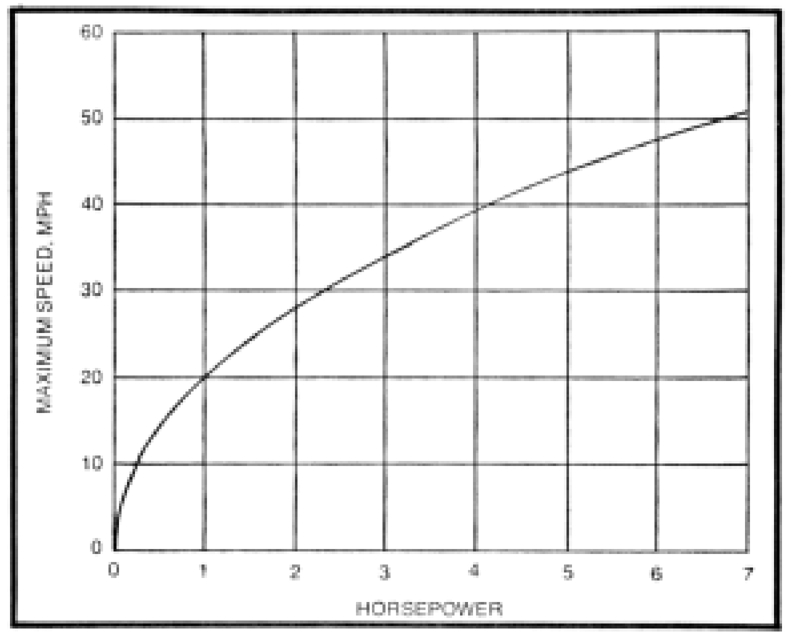


Fig. 2-1. Basic nomenclature. (Courtesy Pacific Basin Trading Co.)

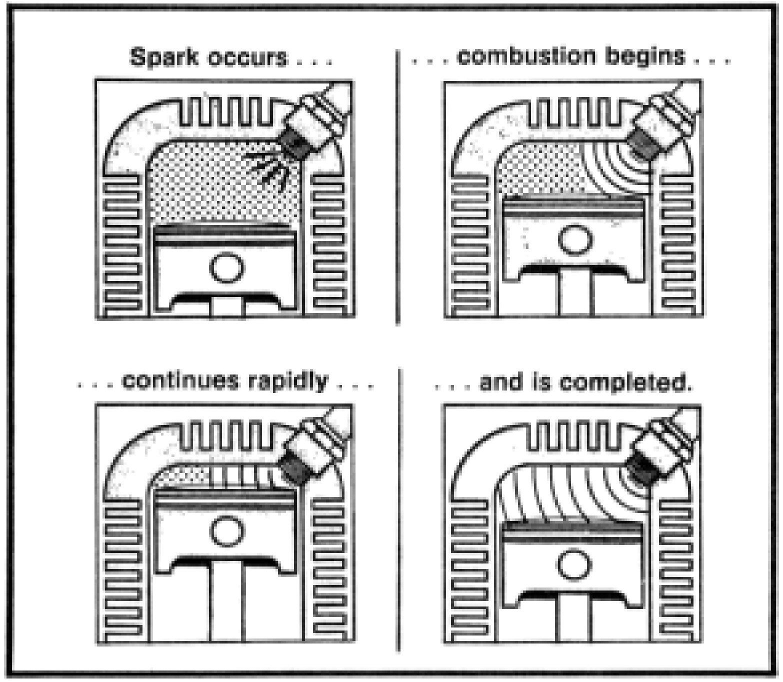


Fig. 2-12. Normal combustion. (Courtesy Champion Spark Plug Co.)

overcome air resistance, the friction losses in the transmission, and the rolling resistance of the tires. Figure 2-11, prepared from data supplied by several moped manufacturers, illustrates this. One horsepower will propel a moped and a 160-lb rider at approximately 20 mph. Doubling the horsepower increases the speed to slightly less than 30 mph; tripling the power only gives 35 mph. About 6 hp would be required at 50 mph.

COMBUSTION

Normal combustion is an orderly process, a kind of controlled explosion initiated by the spark plug. The spark leaps between the plug's electrodes, ignites the mixture near the spark plug, and the flame front moves progressively out and into the far reaches of the chamber.

As you can see from the drawing at the left of Fig. 2-12, the spark occurs early, before the piston reaches top dead center. About 0.03 second is required for the flame front to move across the chamber and generate peak pressure. Unless the

spark is advanced (occurs before TDC), the pressure will peak late, after the piston has descended in the bore. Most of the explosive energy would be wasted.

There are two forms of abnormal ignition. One is called preignition, or early ignition, and the other is detonation. Preignition occurs when the mixture is ignited by a local hot spot before the spark plug fires (Fig. 2-13). The piston rises against increasing pressure and the two flame fronts—one generated by the hot spot and the other by the spark plug—collide, generating more heat and pressure. The result can be a melted piston, as shown in Fig. 2-14.

Most hot spots are caused by partially detached carbon deposits that glow incandescent red when the engine is working under load. Other culprits are "hangnail" spark plug threads extending down into the chamber, the edges of the exhaust ports, or a head gasket that overlaps the chamber. Inadequate lubrication or dirty cooling fins can raise internal temperatures enough to contribute to the problem.

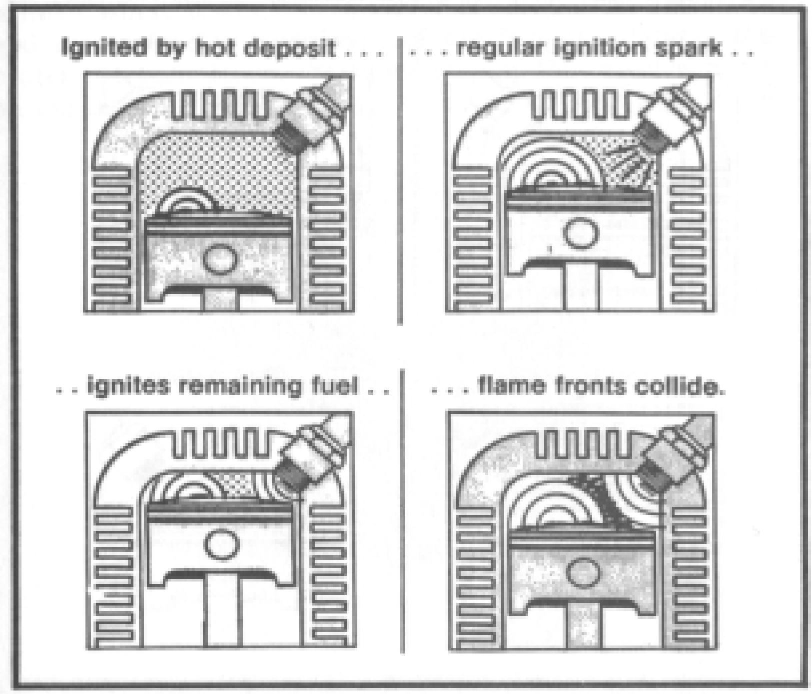


Fig. 2-13. Preignition occurs early, before the spark plug fires. (Courtesy Champion Spark Plug Co.)

Fig. 2-14. Preignition does this to a piston. (Courtesy Champion Spark Plug Co.)

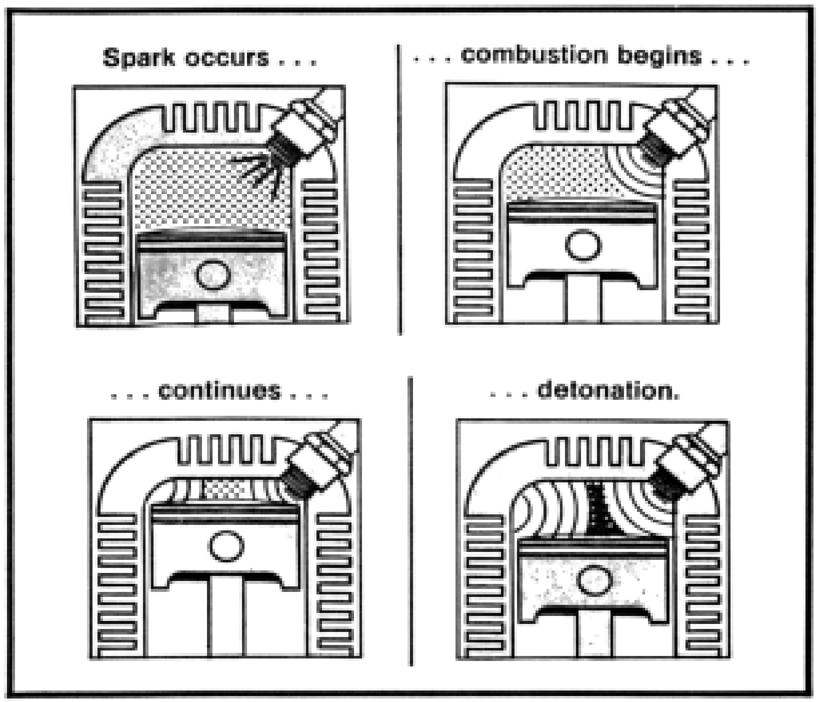


Fig. 2-15. Detonation occurs late, after normal ignition. (Courtesy Champion Spark Plug Co.)

Detonation is a maverick explosion that occurs *after* normal combustion has begun. The spark plug fires and the flame front moves out into the chamber (Fig. 2-15). As it moves it compresses the unburnt charge ahead of it. Under certain conditions this unburnt charge can detonate, releasing a tremendous burst of energy, and you can actually hear the piston and cylinder head "ping" under its impact. The result is a dented or holed piston (Fig. 2-16).

Detonation is caused by too much ignition advance, poor-quality (low-octane) fuel, fuel-lean mixtures, or carbon deposits in the cylinder that raise the compression ratio beyond factory specs. Dirty cylinder fins and inadequate lubrication can also contribute.

Good combustion begins with the shape of the chamber. The one shown in Fig. 2-17 follows the best modern practice: spark plug threads are recessed and the outer edges of the chamber are undercut to form a squish band. The relief at the spark plug port protects the threads and reduces the possibility of one coming unglued and extending into the chamber where it would be a source of preignition. The swish band increases the turbulence of the fuel-air mixture: the greater the turbulence, the more quickly the mixture burns and the less likelihood of detonation. At top dead center the

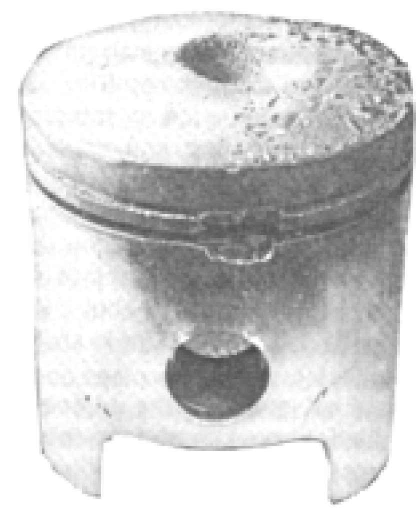


Fig. 2-16. Detonation makes short work of pistons. (Courtesy Champion Spark Plug Co.)

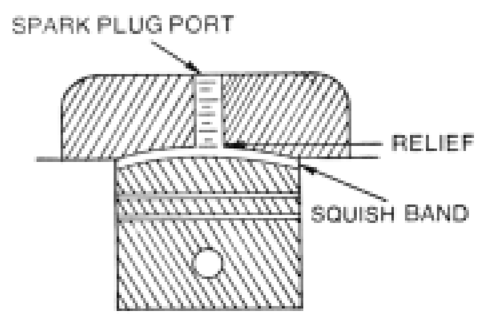


Fig. 2-17. A moped chamber in cross-section.

piston almost touches the squish band. Fuel trapped there squishes inward, toward the spark plug and the flame front.

LUBRICATION

Two-cycle engines are lubricated by oil mixed with the fuel. Since the crankcase is part of the intake tract, there is little choice in the matter. While a few European service stations sell premixed fuel, or petroil, in this country the owner must do his own mixing. The fuel-oil ratio varies with the manufacturer and the type of oil.

Check the owner's manual for instructions that apply to your machine. Too lean a mix can result in piston seizure and connecting rod failure; too rich a mixture will fog the neighborhood, foul the spark plug, and may cause overheating and detonation.

The proper way to mix the fuel is in a separate container. Pour the gasoline in first, add the oil, screw the cap down, and shake vigorously. In extreme cold, things go better if you warm the oil. Premix is fairly stable, but if the bike has been idle for several weeks, it is a good idea to shake it from side to side before starting.

The amount of oil going to the engine depends on the throttle setting. Under most conditions this works out fine, since the engine's need for lubrication and cooling is proportional to speed, but it can cause problems when on long downgrades. The throttle is almost closed while the engine is turning rapidly. Enough of this and the piston will run dry and

seize in the bore, welding itself to the cylinder walls. Prevention is simple—merely open the throttle occasionally to introduce a fresh charge of oil.

COOLING

Moped engines are air-cooled, and depend on fins to dissipate the heat generated by combustion and internal friction. Most of the fins are clustered near the sources of heat, on the cylinder head and barrel. A few engines have one or two vestigial fins on the crankcase, more for looks than for function. The fins radiate some heat, but most cooling, more than 90% of it, is done by convection.

Convection depends on a current of air passing over the fins. The current does not have to be very strong, but it must keep moving. Velosolex and Minarelli V1 engines use a flywheel fan and shrouding to divert air to the fins. The engine is cooled whenever it runs. While such forced-air cooling is admirable, it may not be necessary for mopeds and does cost a little power, since the energy required to drive the fan is taken from the crankshaft.

Other manufacturers depend upon the forward movement of the vehicle to generate the air current. Engines built on this system are called free-air cooled, since no power is absorbed by the cooling system. Most motorcycle engines are cooled this way, as are high-performance snowmobile plants.

The designer must allow for fairly long periods of idle, when the vehicle is stationary. These periods are more frequent in a moped than in recreational vehicles. In addition, the designer must consider that moped engines are subject to occasional overheating when climbing long hills and sudden cool-down on the reverse slope.

Figure 2-18 is a cutaway of the Sachs 505/1 free-air cooled engine. The cylinder fins are shown clearly. Note their wide spacing, for good air flow at low velocities. Fan-cooled engines have narrower, more thickly clustered fins cast symmetrically and enclosed in a shroud (Fig. 2-19).

Free-air engines gain temperature stability from the mass of the finning, which is large in comparison to the size of the bore. The Sachs engine has fins stacked atop fins. The engine is slow to heat, which means that it can tolerate some abuse before the piston sticks, and it is slow to cool, giving some protection from overcooling on long hills. Stacked fins are

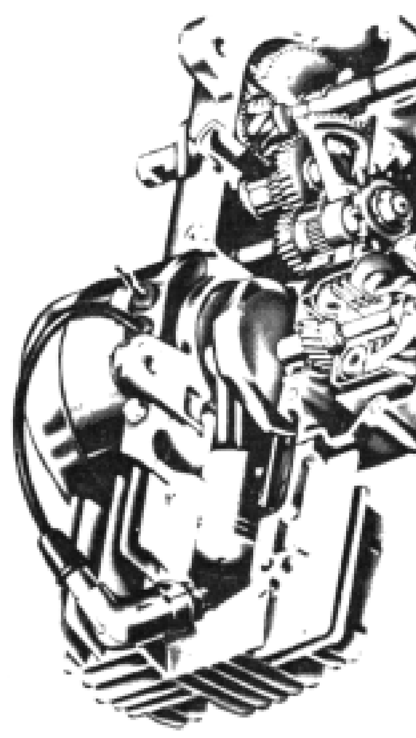


Fig. 2-18. The Fichtel & Sachs 505/1 engine in cutaway.

almost unknown outside of moped technology, but are a mark of the better engines.

The Puch Maxi engine is another example of careful fin design. Figure 2-20 illustrates the cylinder barrel. Note the displacement of fins to the left, two of which have a second fin grafted onto them. The reason is to balance the cylinder mass on the offset block in order to give the engine the appearance of symmetry. While this is not an engineering consideration, it does give some insight into the level of professionalism that can go into moped design.

While you would have to measure the fins to notice this, those on the lower side of the barrel are slightly longer than those on top. This is an engineering consideration; the additional fin length is needed to cool the exhaust port. The small hole on the face of the cylinder is the exit port for the compression release fitted to European models. Rather than

release pressure to the outside of the cylinder, where the fuel and oil mix would dirty the fins, Puch engineers have diverted it to the exhaust.

The cylinder head is detachable (much to the mechanic's convenience) and deeply finned. The horizontal spark plug interferes with finning much less than the angled plug used by Sachs. A heat dam, formed by the absence of fins at the head/barrel joint, prevents heat from bleeding out of the head and into the barrel, where it could damage the piston.

DETUNING

You will recall from Chapter 1 that moped engines undergo one or more detuning stages to make them legal in various states. It is interesting to consider how this is done, since it is the reverse of most engineering practice. In other

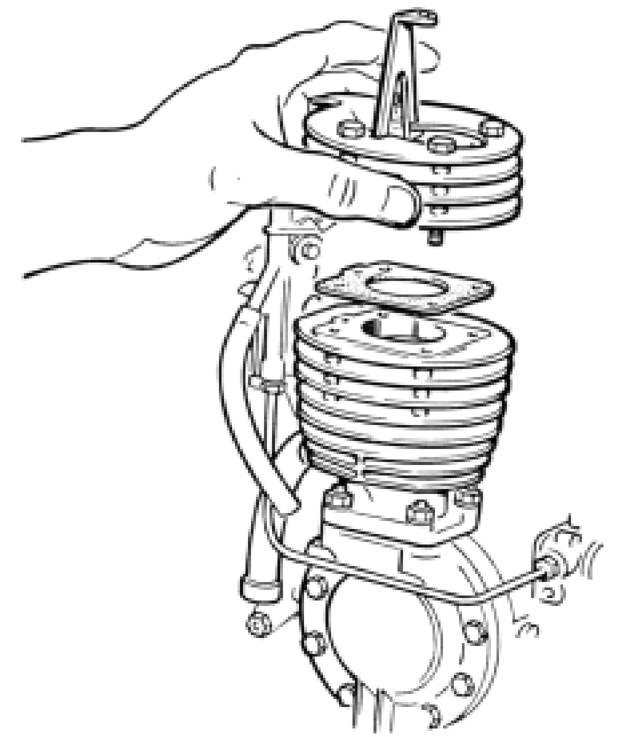


Fig. 2-19. The symmetry and narrow spacing of Velosolex fins are a dead giveaway that the engine is fan-cooled.

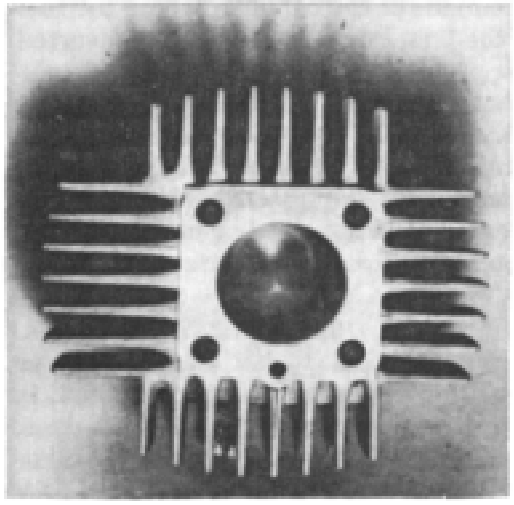


Fig. 2-20. A Puch cylinder barrel.

industries the emphasis is on more, rather than less, performance.

The most obvious way to cut power is to reduce the engine's displacement, but few manufacturers go to this expensive extreme. There are easier ways.

One method is to reduce the compression ratio, for the more tightly the air-fuel mixture is compressed, the more power it releases during combustion. Puch engines have as many as three paper-thin aluminum spacers between the cylinder head and the barrel. While these spacers do not seem thick enough to have much effect, together they drop the compression ratio by one point. Removing them gives the engine more power than the frame can comfortably absorb, and converts a pussycat into a real tiger. Other manufacturers use a relatively thick gasket between the cylinder barrel and block for this market and a paper gasket in Europe.

Another approach, often combined with a lowered compression ratio, is to restrict the size of the carburetor bore. Again using Puch as an example, 12-mm carburetors are fitted to the 17 and 20-mph machines; 25 and 30-mph bikes have 14-mm carburetors. Jawa bikes lose 0.6 hp in translation by virtue of a restrictor plate between the carburetor and cylinder. The plate blocks most of the intake port, throttling the engine.

Two-cycle engines are very sensitive to exhaust back pressure. Moped designers understand this and may include a

deliberately restrictive muffler in their recipe for less power. Batavus has three sets of baffle plates, each more restrictive than the last, for the 30, 25, and 20 mph machines.

In addition to engine modifications, gearing may be changed to accomodate the law. For example, the Puch 20-mph bike has a 13-tooth engine sprocket; along with other changes, the 25-mph machine has a 14-tooth sprocket for slightly "taller" gearing. The rear wheel turns further with each revolution of the engine, enabling higher speed at a given engine rpm.