1—BASIC MECHANICAL SKILLS

ABOUT THIS CHAPTER

This chapter has several sections. It should be read carefully to prepare for using all the other chapters.

The first section is **GENERAL TERMINOLOGY OF BICYCLE PARTS.** This section covers only the most basic and universal terms. The other chapters will each start with a terminology section with terms that are more specific.

The second section is **THREADS.** Understanding thread descriptions and thread types is perhaps the most important basic mechanical skill.

The third section is **PRESS FITS.** Press fits are a means of holding pieces together other than by threading them. It is a system with its own unique set of techniques and rules.

The fourth section is **LUBRICANTS.** Understanding the proper use of greases and oils is critical to being a good mechanic.

The fourth section is **CLEANSERS AND POLISHES.** This section covers what types of cleansers, solvents and polishes might be used, and how to use them properly.

The last section is **TOOLS.** This section covers use of common mechanic's tools. The other chapters describe how to use bicycle mechanic specific tools. A list of recommended tools is in the appendix.

GENERAL TERMINOLOGY OF BICYCLE PARTS

Chapters on individual component areas of the bicycle have more specific terminology and definitions. For the purpose of this manual, the following terms apply to the frame and basic components.

Frame: The structural piece, usually a number of tubes joined together, to which all of the components are attached.

Fork: The structural piece that attaches the frame to the front wheel. The fork turns to allow the rider to control the bicycle.

Frame set: The frame and fork combination.

Head tube: The near-vertical tube that is the forward most part of the frame.

Top tube: The upper tube of the frame that extends back from the head tube to the seat tube.

Down tube: The lower tube of the frame that extends from the bottom of the head tube to the bottom of the frame (the bottom-bracket shell).

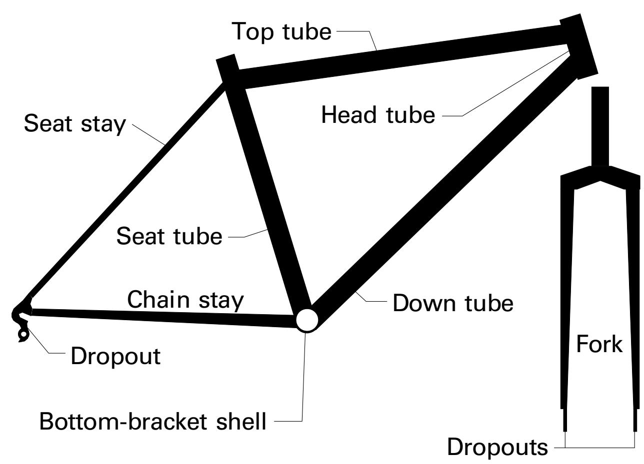
Seat tube: The near-vertical tube that is at the middle of the frame, which the seat post slides into.

Bottom-bracket shell: The portion of the frame that contains the crankset bearing parts, which are called the bottom bracket.

Seat stay: The two tubes of the frame that start from below the seat and meet the chain stays at the center of the rear wheel.

Chain stay: The two tubes of the frame that go from the lower end of the seat tube and meet the seat stays at the center of the rear wheel.

Dropout: The fittings at the end of the fork, and at the juncture of the seat stays and the chain stays, to which the wheels are attached.



1.1 *Parts of the frameset.*

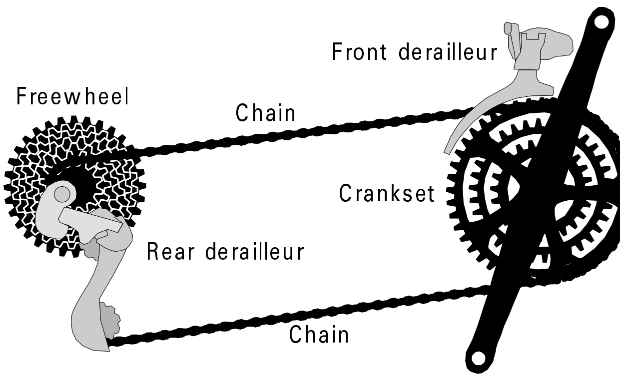
Derailleur: There are two such mechanisms: a front derailleur and a rear derailleur. The front derailleur moves the chain between the selection of gears on the crankset; the rear derailleur moves the chain between the selection of gears on the rear wheel.

Chain: The loop of links that connects the front gears to the rear gears.

Freewheel: The set of rear gears. Freewheels and freehubs have a confusing overlap of terminology. *For clarification, see the terminology section of the chapter regarding these items.* In a general sense, the freewheel is the set of gears that the chain turns in order to apply drive forces to the rear wheel.

Crankset: The mechanism that is turned by the rider's feet. It consists of two lever arms called crank-arms, one to three gears called chainrings, and a bearing assembly that the crank arms rotate around called the bottom bracket.

Bottom bracket: The bearing assembly that allows the crankset to rotate in the bottom-bracket shell.



1.2 *Parts of the drivetrain.*

Wheel: The assembly consisting of the hub, spokes, rim, tire and tube.

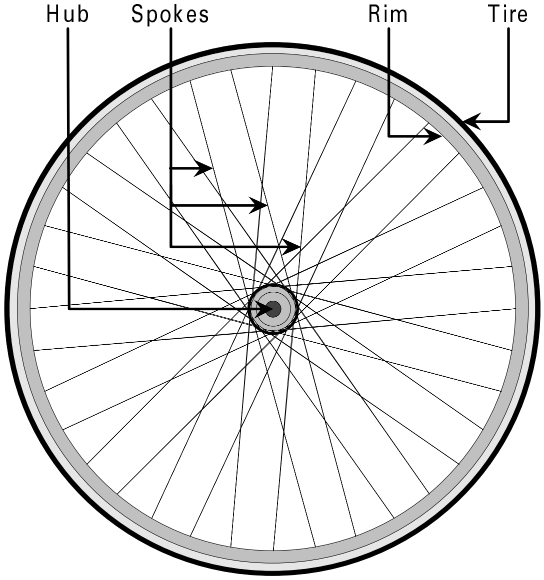
Hub: The assembly at the center of the wheel that houses the axle bearings, and to which spokes attach.

Freehub: A hub and freewheel that have been combined into a single integrated assembly.

Spokes: The tensioned wires that join the hub and rim together.

Rim: The hoop at the outer edge of the wheel to which the tire is mounted.

Tire: The rubber hoop at the outer edge of the wheel assembly.



1.3 *Parts of the wheel.*

Headset: The bearing assembly that connects the fork to the frame and allows the fork to rotate inside the head tube.

Pedal: A mechanism that supports the rider's foot. It contains a bearing assembly and is mounted to the crank arm.

Seat post: The pillar (usually a tube of metal) that attaches the seat to the frame.

Saddle: The soft structure that supports the rider's posterior.

Stem: The piece that connects the handlebars to the fork.

Handlebar: The piece that supports the rider's hands and is turned to control the bike.

Brake lever: The levers that are operated by the rider's hands to control the braking function.

Shift lever: The levers operated by the rider's hands that control the derailleurs.

Brake caliper: The mechanisms that squeeze against the rims to control the bike's speed.

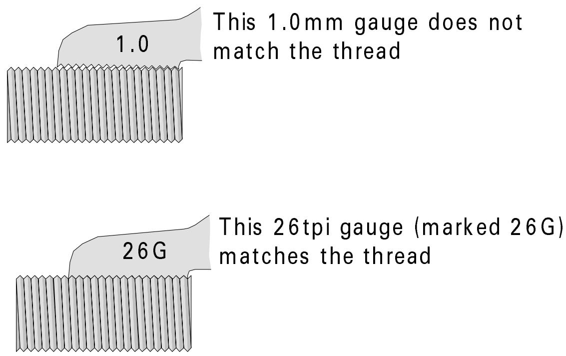
THREADS

THREAD IDENTIFICATION

One of the key challenges to the mechanic is to be able to replace or upgrade parts with compatible parts. One of the most significant obstacles to be overcome is the number of different thread standards used on bicycles. For example rear axles alone come in seven different varieties. Threads are described by a two part number, such as 3/8" × 26tpi or 10mm × 1mm. The first number refers to the diameter of the male version of the thread and the second number refers to the pitch. When identifying a thread, start with pitch.

The first step to identifying a thread is to measure the pitch with a pitch gauge. Pitch is a measurement of the frequency of threads, or the distance from one thread to the next. In an inch system (BSC and Whitworth), pitch is measured by the number of threads that occur in one inch of thread length, and in a metric system pitch is the distance from one thread to the next.

Pitch is measured with a pitch gauge by mating the gauge to the thread. If the gauge can be held down in the thread at both ends simultaneously, the thread is identified (see figure 1.4). The best pitch gauges available come with both metric and Whitworth gauges. Although Whitworth is quite rare, Whitworth pitch gauges are compatible with the BSC (British Standard Cycle) threads found on many bicycle parts. Although gauges are not normally marked with the appropriate units, the thread is metric whenever the number includes a decimal point, and the pitch is in inches whenever the number on the gauge is followed by the letter “G” or the letters “TPI” (for Threads Per Inch).



1.4 *When the teeth of the thread pitch gauge will all go into the threads simultaneously, then the gauge matches the thread.*

The next step to thread identification is to measure the diameter. Diameter is a measurement of the male thread’s outside diameter (O.D.). It is usually a nominal measurement. A measurement is a nominal measurement when an actual measurement is rounded up to an even number. For example, a thread with a 6mm diameter is only *nominally* 6mm. The actual diameter is more like 5.9mm.

Metric bicycle threads are available in .5 millimeter increments, so always round the actual measurement up to the nearest .5mm to arrive at the nominal measurement. Inch bicycle threads are available in minimum 1/16 inch increments, so always round up to the nearest 1/16 inch or its decimal equivalent to arrive at the nominal measurement.

Examples:

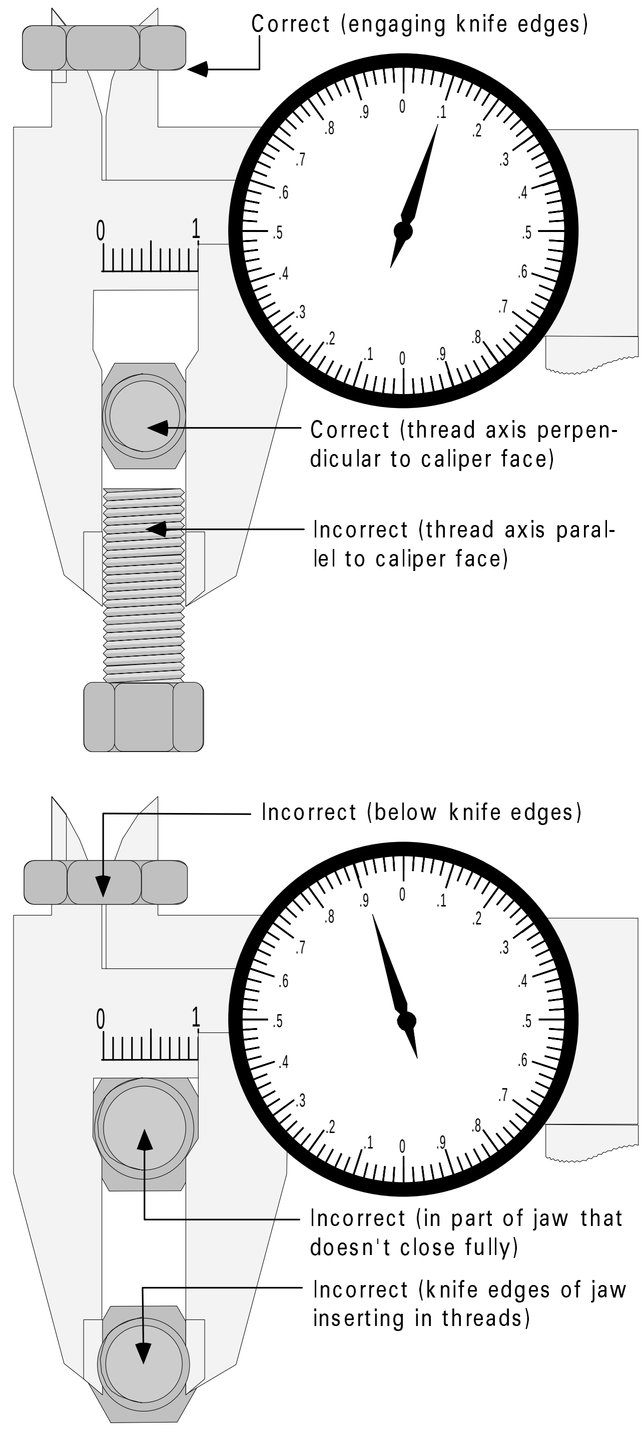
If the thread measures 5.9mm— it is 6.0mm.

If the thread measures .370"— it is .375".

If the thread measures 23/64"— it is 3/8".

Diameter may be measured in inches or millimeters. The best way to determine which units to use is by measuring the pitch first, because the diameter is almost always in the same units (a 1.0mm pitch threaded item is sure to have a metric diameter). The exceptions are on Italian-manufactured frames, which have metric diameter and inch pitch on the fork and in the bottom-bracket shell, and on Italian-made hubs, which may have metric diameter axles with inch pitch. Italian bikes will also have this combination of metric diameter and inch pitch on the freewheel mounting threads, but in this case it is not an issue because the Italian thread happens to be compatible with the common BSC freewheel threads. Also, Jou Yu (Joy Tech) hub axles have metric diameter combined with inch pitch in some inconsistent cases.

When measuring diameter use a caliper. Measure the thread with the axis of the thread perpendicular to the face of the caliper, the axle centered in the caliper jaws and not on any slot in the threads.



1.5 *Correct and incorrect ways to measure thread diameter.*

Female thread diameters are rarely provided. When the pitch is 24tpi, 26tpi, or 1mm the inside diameter will be approximately .7–.9mm less than the male.

Following is a chart of useful equivalents of thread diameter. Start by taking a measurement in inches or millimeters and then look in the right-most column for the nominal thread diameter.

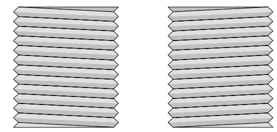
THREAD DIAMETER EQUIVALENTS (table 1-1)

Approximate measurement in millimeters	Approximate measurement in inches	Nominal fractional inch thread diameter
7.7mm	.303"	5/16"
9.4mm	.366"	3/8"
12.5mm	.492"	1/2"
14.1mm	.555"	9/16"
25.2mm	.992"	1"
28.4mm	1.118"	1–1/8"
31.6mm	1.244"	1–1/4"
34.7mm	1.366"	1–3/8"

Approximate measurement in inches	Approximate measurement in millimeters	Nominal metric thread diameter
.149"	3.8mm	4.0mm
.189"	4.8mm	5.0mm
.228"	5.8mm	6.0mm
.307"	7.8mm	8.0mm
.351"	8.8mm	9.0mm
.346"	9.3mm	9.5mm
.389"	9.8mm	10.0mm
.976"	24.8mm	25.0mm
1.358"	34.5mm	34.7mm
1.370"	34.8mm	35.0mm
1.409"	35.8mm	36.0mm

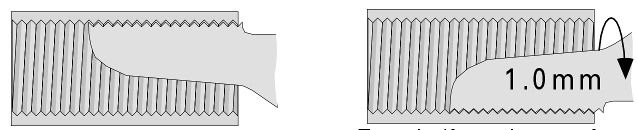
On all pedals and most bottom-bracket threads (as well as other rare occurrences), the final aspect of thread identification is the thread direction. Right-hand threads (most common) tighten or are installed with a clockwise rotation and loosen or are removed with a counterclockwise rotation. Left-hand threads (left pedals, some right-hand-side bottom-bracket parts, and certain freewheel cones and dust caps) tighten or are installed with a counterclockwise rotation and loosen or are removed with a clockwise rotation.

Thread direction of male threads may be identified by observation. Held vertically, the threads on a right-hand thread will slope up to the right, and the threads on a left-hand thread will slope up to the left (see figure 1.6).



1.6 Whether the thread slopes up to the left or up to the right shows the thread direction.

Female threads may be identified as left or right by the following test. Install a matching thread pitch gauge into the thread in question with exactly one tooth of the gauge left outside the thread. Rotate the gauge in the threads at least one-half turn clockwise. Observe the amount of gauge teeth outside the thread at this point. If they have increased, it is a left-hand thread. If they have decreased, it is a right-hand thread. If the gauge is rotated counterclockwise instead of clockwise, the results will be opposite.



1.7 Rotate a thread pitch gauge in a female thread to determine the thread direction.

THREAD TENDENCIES

It is helpful to know what threads are likely to be encountered in certain situations. The country of origin of a bicycle frame is likely to determine the thread used in the bottom bracket and the fork/headset. Different countries tend to use different thread standards. The standards are BSC (British Standard Cycle), Metric, Italian Whitworth, and ISO. ISO stands for the International Standards Organization. The ISO has adopted many existing thread descriptions to be the ISO standard. Some of these existing threads are metric, and some are BSC. ISO standard threads may have a metric or inch description.

Bicycle frames made in Taiwan, and Japan are certain to be BSC or ISO thread. Bicycle frames made in the U.S. are also virtually certain to be BSC or ISO thread, but sometimes small manufacturers of top end racing bikes use Italian threads. Bicycle frames made in Italy are virtually certain to be Italian thread. French bicycles are the greatest source of confusion because they used to be French thread, then switched to Swiss thread, and finally have switched to ISO threading. Bicycle frames from other countries are seen much more rarely, and it is best to rely strictly on measurements in these cases. See the bottom bracket and headset chapters for description of BSC, ISO, French, Swiss, and Italian threads.

The country of origin of a component is useful in determining the thread type of fittings within the component, but the threads that attach a component to another component or the frame may be unrelated to the country of origin. For example a bottom bracket made in Japan for an Italian bicycle would be Italian thread. Another example would be that an Italian made freewheel installed as original equipment on an older French bicycle would probably be a French thread. The threads used within any Japanese, Taiwanese, or French component are likely to be metric. The threads used within any Italian component are likely to be metric or Italian Whitworth (a bizarre combination of metric diameter and inch pitch). There is little consistency with U.S. component manufacturers to use metric or inch threads. Those U.S. component "manufacturers" that contract to have their products made in Asia are more likely to use metric threads. For example, Grip Shift uses metric threads on fittings, but fittings on Bullseye hubs use inch pitch threads.

PREPARATION AND ASSEMBLY OF THREADS

The primary form of thread preparation is lubrication. Preparation of threads with oil or grease permits ease of assembly and disassembly. Lubrication makes it easier to feel when the threaded component is becoming tight enough. Corrosion is also prevented by lubrication; however, lubrication is counter effective on threads with nylon inserts.

In most cases the lubrication choice is between oil and grease. Oil is generally used on threads of small diameter or fine pitch. Ease of application is the primary advantage compared to grease. Grease is used on threads of larger diameter and coarser threads. Its advantage over oil is durability under exposure to moisture and less of a tendency to evaporate.

In some cases it is preferable to use a compound called Loctite instead of lubrication. Loctite is a liquid that hardens and expands after application. It is not a glue, but works by expanding to fill a gap and exerting pressure between the parts. Loctite used on threads aids ease of assembly, prevents corrosion, prevents threaded components from coming loose and consequentially reduces the need to over-tighten parts, risking their damage. Loctites generally cure in a few hours. The hard cake that Loctite compounds cure into is not an adhesive. The hard cake deteriorates if the threaded item is turned after curing. Use of Loctite is redundant on threads with nylon inserts. *(Loctite is toxic– minimize contact.)*

There are several grades of Loctite. Some of the following grades are available from automotive stores or United Bicycle Tool Supply, but some must be purchased at industrial bearing supply companies.

Loctite 222 is the lightest grade available and is applicable on thread diameters up to 6mm. Typical uses of Loctite 222 include: accessory mounting bolts/nuts, brake mounting bolts/nuts, and derailleur limit screws.

If only one grade of Loctite were to be used, it should be Loctite 242. It is heavier than the 222, and is used on larger diameter threads. Typical uses of Loctite 242 include bottom-bracket fixed cups and headset locknuts, but it is also acceptable to use it on smaller thread diameters.

Loctite 290 is a special application thread locker that is more heavy-duty than 242, but can be applied to already assembled components to penetrate into the threads. Typical uses of Loctite 290 include already installed accessories (such as fenders) and already installed bottom-bracket fixed cups.

Loctite 272 or 277 are extremely heavy-duty compounds that would not allow removal without damage to the tool or part. They are used when threads are damaged and as an alternative to replacement when permanent installation will not be a problem.

Loctite RC680 serves as a substitute for 272/277 and can be used in other non-thread applications on the bike, such as enhancing the security of a pressed-in part like a headset cup.

Loctite 660 (Quick Metal) is not applicable to threads at all, but will fill gaps for press fits of up to .5mm.

When assembling threads pay close attention to how they feel. Threads that feel tight during assembly should be checked for:

- Thread compatibility
- Paint in threads (Clean with tap.)
- Damaged threads (Clean with tap, die, thread chaser or file.)
- Cross-threading (Restart thread with better alignment.)

That threads feel effortless to assemble is not by itself an indication of thread compatibility. When the female thread is a larger diameter than the male, no effort will be required for assembly, even when there is a pitch mismatch. If pitch match has not been verified but the difference between the O.D and I.D. of the parts is acceptable, then it is acceptable to use test-mating of parts as a way to determine compatibility. This is a useful technique in cases where it is impractical to check the pitch because of small I.D., or short overall thread length.

A thread that gets tight and then feels easier to turn as it is secured is probably stripping.

REPAIR OF DAMAGED THREADS

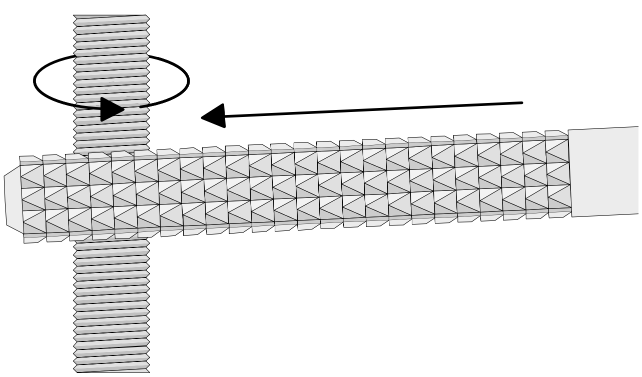
Ideally, when threads are damaged the part should be replaced. If tools are available and the damage is not too severe, it may be possible to repair the thread.

The best repair will be accomplished with a thread cutting tool such as a tap (for internal threads) or die (for external threads). When repairing threads with a tap or die, first make sure the damaged thread and tap or die have compatible thread description. Start the tap or die on the end of the threaded item that is in the best condition to ensure proper alignment.

If the die is a variety with a split in it so it can be compressed or expanded, it should be fit in a special die handle that has expansion and compression adjusters. Thread the die onto the good portion of the thread with it expanded to a loose fit. Then compress it until it is barely snug before starting to cut on the threads that need repair.

An alternative to using a tap or die is to use a thread chaser. A thread chaser does not actually cut threads. It does realign threads that have been mangled. It is most often used on solid axles or the dustcap threads in crank arms.

The least expensive way to repair a thread is with a thread file. The thread file is best when there is just a small ding in a thread. Thread files can be used on mangled male threads. Available from various bicycle tool and general tool suppliers, thread files come in both inch and metric pitches. After matching the pitch on the file to the pitch of the thread being repaired, the file is then stroked in the direction of the thread angle, while the item being repaired is slowly rotated.



1.8 *To use a thread file, match the file pitch to the thread pitch, then stroke the file at the angle of the thread while rotating the threaded item.*

Stripped threads can sometimes be repaired just by chasing them with the appropriate tap, die, or thread chaser. If the thread still does not hold after this repair, repair options include use of Loctite 277 or RC680, drilling the damaged thread out to a larger diameter and re-tapping to use a new size, or replacing the damaged part. Using Loctite is a solution only when there is no further need to remove the part. Converting to a larger diameter thread may be limited by available material or parts. Replacing the damaged part has no disadvantage, except cost or limitations of availability.

To repair a stripped thread by going to the next larger diameter, first drill out the old threads to the appropriate size for the tap that will create the new thread. When drilling to tap, the use of a larger bit than recommended will lead to poor thread depth and will probably result in further thread failure. The use of a smaller bit than recommended will result in the tap jamming and breaking off in the hole. To determine the correct drill size a simple formula can be used. If it is a metric thread, subtract the pitch from the nominal diameter of the thread; for example, converting a stripped 4.5mm × .8mm female thread to 5mm × .8mm requires drilling the hole out to 4.2mm (5.0 – .8 = 4.2). Another example: the correct tap drill for tapping a 6mm × 1mm thread would be 5mm (6 – 1 = 5). For inch thread (which is unlikely to be needed due to the rare use on inch threads on bicycles), a special or unusual drill bit size is needed. Inch size threads require “tap drills” which are unique sizes that are numbered instead of described by dimension. After drilling out the hole use the appropriate tap for the new thread size.

REMOVAL OF DIFFICULT NUTS AND BOLTS

To remove a stubborn nut or bolt *first* use a penetrating oil and allow to soak for a few minutes. Then use the best-fitting tool possible. If it is a screwdriver, apply heavy, downward force while turning the screw. If a screw or bolt head is deformed in the attempt to remove it, try vise grips locked securely on the head. If vise grips fail, use a small saw (Dremel or rotary tool) to cut a slot in the head to fit a slotted screwdriver. Another alternative is to file flats on the side of the bolt or nut head to fit an open-end wrench. If all of the above fail, the next option is to drill a hole in the bolt or screw between one-half and three-quarters of the bolt diameter and then hammer in a screw extractor to turn out the bolt. The screw extractor is the first option if the screw or bolt head shears off. The last resort is to carefully drill the bolt out with the tap drill that is the appropriate size for the existing thread diameter. The method for determine the correct size for the drill bit is covered in the preceding section, **REPAIR OF DAMAGED THREADS**. Then chase the threads out with a tap.

To remove a stripped nut, screw, or bolt that rotates without removing first use penetrating oil. If possible, grab nut, screw, or bolt with vise grip to pull up while unthreading. Another alternative is to insert something like a screwdriver underneath the nut or screw or bolt head and apply leverage while unthreading. The last alternative is to use a saw to cut off the nut, screw, or bolt head.

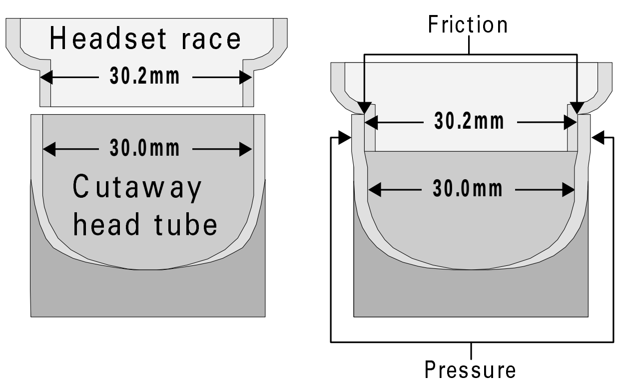
PRESS FITS

DEFINITION AND IDENTIFICATION OF PRESS-FIT TOLERANCES

A press fit occurs when one part is inserted into another with pressure and is held together by the friction between the mating surfaces.

A common press fit is the interference type. With an interference type, the fit is accomplished when a male cylindrical shape is pressed into a smaller hole. The tolerance between the two parts is generally in the range of .1–.3mm (.004–.012"). Examples of interference press fits include:

- Headset races pressed into the head tube
- Headset race pressed onto the fork
- Dustcaps pressed into hub shells and pedals
- Bottom-bracket bearing cartridges pressed into a bottom-bracket shell
- Bearing cups pressed into hub shells and pedals
- Cartridge bearings pressed into bottom brackets and hubs
- Cartridge bearings pressed into pedals



1.9 These cross-sections show a properly sized headset race before installation into a head tube, and again after the head tube has deflected to accommodate the press fit.

Another type of press fit is the tapered press fit. In this case the male component is tapered so that the farther it is pressed in, the tighter it becomes. Examples of this fit include:

- Cotter pins on cotter-type crank arms
- Cotterless crank arms that fit on a spindle with tapered flats

PREPARATION AND ASSEMBLY OF PRESS FITS

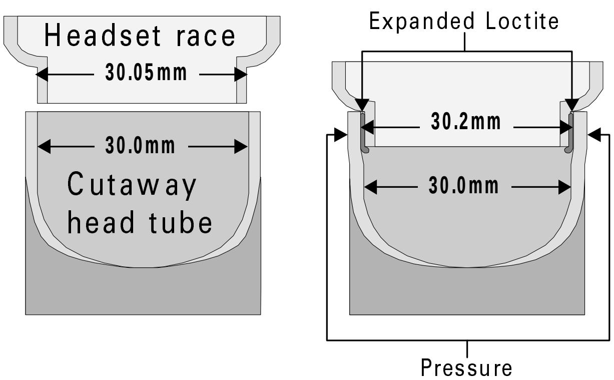
Preparation to install a press fit should include identifying that the male component is a suitable amount larger than the female; cleaning the mating surfaces so that they will be free of lubrication, corrosion, and dirt; and treatment with Loctite 222 if preventing corrosion is a concern.

To install press-fit components, a special pressing tool is often required (see the section of the book that applies to the particular component in question.) In the absence of a proper tool, sometimes a vise can be used, and if that is not suitable, a hammer may be used. In either case, pay particular attention to the alignment of the parts as they go in. With a hammer, use a block of wood or a plastic hammer to protect the components from damage. With a vise, similar types of protection may also be required.

Proper installation of tapered-press fits simply involves pressing the part in hard enough so that it will hold. Preparation to install tapered-press fits includes an examination to determine that the length of engagement is acceptable and cleaning the mating surfaces, so that they will be free of lubricants, corrosion and dirt.

For more information and diagrams concerning tapered press fits see the section of this book regarding crank arms.

When press fits slip together with little or no effort, Loctite compounds may be used to improve the fit. If the fit requires only mild force to install, it will probably creak or slip under operating conditions, or moisture may penetrate and cause corrosion, then the use of Loctite RC680 would be appropriate in most cases. When installing sealed cartridge bearings (hubs, bottom brackets, and pedals) Loctite 242 is preferred, so that removal will not be too difficult. If a press-fit part slips right in with no effort, but does not jiggle about once installed, then Loctite RC680 is required in all cases except for sealed cartridge bearings. Sealed cartridge bearing installation requires Loctite 242, usually. If Loctite RC680 is used to improve a marginal press fit, the fit should be considered as good as new, except that removal and reinstallation would require re-application of Loctite. If the press-fit part is loose and jiggling after installation, it is best to find a better fitting part. If a better fitting part is not available, Loctite RC680 is recommended. Effectiveness may be limited by how loose the parts are initially, and the by fact that with press fitting there is no way to ensure proper alignment of the parts.



***1.10** The headset race and headtube here do not have enough dimensional difference to create enough friction; when Loctite RC680 is added before installation, it expands and creates more pressure (and therefore more friction).*

Loctite 660 (Quick Metal) is a thick paste that will provide security when the male part is up to 1mm smaller in diameter than the female part. No precision alignment of the parts is assured, but loose pieces that cannot be repaired in any other way may benefit from Quick Metal. A good example would be when the head tube on a Murray or Huffy juvenile bike becomes flared and the headset parts are loose and jiggling. Because these bikes use non-standard oversized headset dimensions, there are no practical alternatives for repair except the use of Loctite 660 (Quick Metal).

LUBRICANTS

GREASE

Not all greases are suitable for bicycle use. Bicycle bearings operate in a relatively low temperature range, so grease designed for automotive use often does not become effective at bicycle operating temperatures. Greases made specifically for bicycle use include Phil Wood, Bullshot, Var, Shimano, Finish Line, Pedros and Campagnolo. The best automotive grease is a light grade of Lubriplate.

Grease failure could come at any time. Factory original greases are often of the lowest quality, and also are applied in very limited or erratic quantities. Frames are often inadequately cleaned at the factory, so bottom-bracket and headset grease is often contaminated with abrasives even before the bike has been ridden. For these reasons it is difficult to project the normal time or miles between bearing overhauls. As a soft rule of thumb, 2000–3000 miles or two to three years of generally fair-weather riding should make a bike ready for an overhaul. The best method to determine whether grease is overdue for replacement is inspection. See table 1-2 below, for causes and evidence of grease failure.

The container and applicator of grease is as important as the quality. Open tubs invite contamination; application from open tubs is messy. Grease is best used in squeeze tubes or grease guns.

Whether greasing a thread, insertion, or bearing, an ample quantity of grease will reduce likelihood of drying and moisture contamination. Wipe excesses away when assembly is complete.

Grease should be treated like any other unnatural substance that can penetrate the skin. Minimize exposure or avoid it entirely by wearing disposable latex painter's gloves. Clean hands when exposure is over.

GREASE FAILURE **(table 1-2)**

Cause of grease failure	Evidence of grease failure
Age: This is one of the most likely reasons for grease to fail, particularly on bikes that see little use.	Lack of grease, grease absent from ball path, grease caked like half-dry mud.
Internal contamination: This other highly likely cause of grease failure is caused by particles worn from the bearing surfaces.	Light-colored greases turned dark, translucent greases turned darker and opaque.
Moisture contamination: This cause is only likely when the bike is ridden extensively in wet conditions.	Reddish rust color in grease, rust on bearing parts, water droplets in grease or bearing area. Colored greases turn a lighter shade.
Dirt contamination: This cause of grease failure is most likely if contaminated grease that has oozed out of the bearing is wiped off the wrong way.	Gritty feeling like sand in the grease, not the same as the rough feeling from a tight bearing.

OILS

Oil is used on threads, derailleur pivots, brake pivots, lever pivots, the chain, inside freewheels and inside internally-geared multispeed hubs.

Not all oils are equally suitable for bicycle use. The oil needs to be resistant to accumulating grit, durable to exposure to the elements, and light enough to penetrate into tight areas. These characteristics outweigh the significance of any more technical considerations, such as the type of oil base or whether Teflon is part of the formula. Oils that are specifically suitable to bicycle use include:

Phil Wood Tenacious Oil
Triflow
Bullshot
Superlube
Campagnolo
Allsop
Finish Line
Pedros
Lube Wax

The oils at the top of this list are generally more suited to use in wet conditions while oils that appear lower down on the list are more suitable for use in dry, dusty conditions.

Popular oils that are specifically unsuitable for most bicycle applications include:

WD40
Sewing machine or gun oil
3-in-1 oil
Motor oil

Method of application is very important with oils. Aerosols are environmentally unfriendly and usually lead to excessive application. The only exception to the problem of excessive application is with spray lubricants that are designed to "dry" in a matter of minutes after application (such as Finish Line and Allsop oils), but these may be the worst offenders environmentally. In general, oils used in external applications should be used sparingly to avoid dripping and dirt accumulation, and excesses should always be wiped off immediately. Overall, the best form of application is from drip applicators. They are economical to use as well, because waste is limited.

In addition to their value as lubrication, oils are also used to facilitate disassembling frozen threaded components. Special penetrating oils perform this function best. Triflow, Allsop, and some other bicycle oils are somewhat effective for penetration.

Manufacturers of internally-geared hubs recommend special oils that are generally unsuitable for use elsewhere on the bike. Sturmey Archer Cycle Oil is one of these, but a suitable replacement would be 10-weight motor oil.

CLEANSERS AND POLISHES

One of the cleansers needed for proper bicycle cleaning is an ammonia and water solution for cleaning dirt and removing greasy fingerprints. If using a household cleanser such as 409, Fantastik, or Top Job, they will leave a soapy film that will need rinsing. Window-cleaning compounds clean as well and do not leave a film behind.

For cleaning bearings, drive train components and any other heavily greased or oily components, choose between either mineral spirits or non-toxic biodegradable solvents (such as citrus-based solvents.) These are the environmentally correct alternative to gasoline and kerosene. If using mineral spirits, avoid excess contact with skin, eyes, and fumes by wearing rubber gloves, safety goggles, and by working in a well ventilated area. Mineral spirits and citrus-based solvents leave an oily film and are not suitable as a last preparation before assembling a press fit. Drying time (of mineral spirits or biodegradable solvents) in confined areas such as inside chains, freewheels, derailleur and brake pivots, is quite slow and generally is aided by blowing with compressed air. If using a biodegradable solvent, remember that once it is contaminated with oil or grease it is no longer environmentally friendly.

For certain uses, a more heavy duty solvent (such as acetone) is needed. Use acetone or rubbing alcohol when an oil-free surface is required (press fits, braking surfaces). Use acetone on extremely stubborn dry grease. Both acetone and alcohol are highly flammable and volatile, so do not use them around flames or high heat sources (no smoking). Avoid skin and eye exposure, and keep fumes to a minimum by disposing of soaked rags promptly in a fire-safe self-closing metal bucket. Alcohol is far more environmentally friendly than acetone. There are no biodegradable-type solvents that perform the same function as these two compounds.

Wax or polish is used to improve the appearance of paint jobs and to protect them. Most automotive waxes are suitable for bicycles. Wax should be applied to clean surfaces with light rubbing. After it dries it should be wiped off with a soft cloth. Check the label of any automotive product before using it on the painted surface of a bicycle. Test products of uncertain suitability on the bottom of the bottom-bracket shell.

TOOLS

This section covers the proper use of common tools that are not unique to bicycle mechanics. This section also covers the use of the bicycle repair stand. There is a comprehensive list of common tools and bicycle specific tools in the appendix. The types of tools and concepts covered in this section are as follows:

- Box- and open-end wrenches
- Ratchet drives and sockets
- Torque and torque wrenches
- Adjustable wrenches
- Pliers and vise grips
- Screwdrivers
- Utilizing mechanical advantage
- Hammers
- Hacksaws
- Files
- Grinder
- Drilling
- Taps
- Using repair stands

BOX-AND OPEN-END WRENCHES

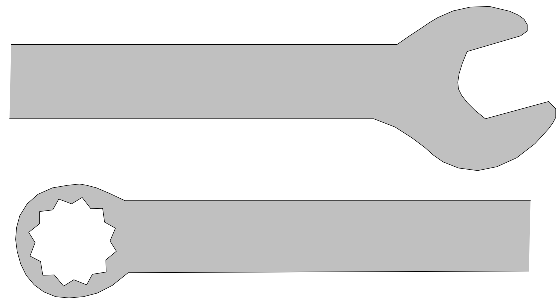
Always use the smallest wrench that will fit. A 16mm cone wrench seems to fit on a hub cone with 15mm flats, but a 15mm wrench is the smallest that will fit. It may be possible to turn a 15mm cone with a 16mm wrench, but it is likely to damage the nut and the wrench.

Box- and open-end wrenches are non-adjustable wrenches that are made in specific sizes that are supposed to closely match the fittings they will be used on. They come in inch and metric sizes. Metric sizes are most common for bicycles. Certain inch and metric sizes are interchangeable in one direction only (because the substitute is only slightly over-sized). These are:

- 13mm wrench on 1/2" fitting
- 14mm wrench on 9/16" fitting
- 16mm wrench on 5/8" fitting

Open-end wrenches contact the fitting at only two points, making them inclined to round off nuts, especially if they are held in poor alignment to the fitting. Their advantage is access from the side of the fitting when access from the end is difficult. They also generally allow a more flush fit against surfaces adjacent to the fitting, so are well suited to low-profile nuts and bolt heads.

Box-end wrenches enclose the fitting and contact it at six points, reducing the likelihood of rounding the fitting under heavy load or poor alignment and fit. Their limitation is with low-profile fittings, or fittings with no access from the end. Box-end wrenches come in six-point and twelve-point configurations. The six-point configuration is more durable and has better purchase (surface engagement), but twelve-point wrenches are quicker to get positioned on the fitting.

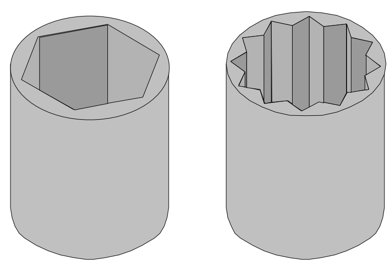


1.11 *Open-end wrench on top, box-end wrench below.*

RATCHET DRIVES AND SOCKETS

Ratchet drives enable working faster because they do not require removal of the wrench on the return stroke. Good applications of a socket and ratchet drive include crank-arm bolts, brake-mounting nuts, axle nuts, and seat-post binder nuts.

Socket wrenches (which can be fitted to a ratchet drive, torque wrench, or socket driver, or may come prefixed on certain spanners) are similar in their advantages to box-end wrenches, but even more useful when there is limited or no side access to the fitting, such as with crank-arm-mounting bolts.



1.12 *Six-point socket (left) and twelve-point socket (right).*

TORQUE AND TORQUE WRENCHES

Torque is a measurement of a force's tendency to produce torsion and rotation about an axis, used most often in bicycle mechanics to describe the tightness of a threaded fitting. It is measured most often in ft-lbs (foot pounds), in-lbs (inch pounds), and kgf-cm (kilograms of force per centimeter).

A torque of 1ft-lb is a pound of force on a lever one foot long. If the lever were six inches long, it would require two pounds of pressure to apply 1 ft-lb of torque. A torque of 1in-lb is one pound of force on a one inch long lever. If the lever was six inches long it would require two pounds of force to apply 12in-lbs of torque (12in-lbs ÷ 6" = 2lbs).

All the torques in this book are in in-lbs. For some of the larger values a torque wrench calibrated in ft-lbs will be needed. It will be necessary to convert. At other times, it will be necessary to convert manufacturers' recommended torques in ft-lbs to in-lbs to use an in-lb wrench. Use the following formulas.

in-lbs ÷ 12 = ft-lbs

ft-lbs × 12 = in-lbs

Sometimes manufacturers provide recommended torques in kgf-cm, which are found on very few torque wrenches. In this case, convert kgf-cm to in-lbs or ft-lbs. Use the following formulas.

kgf-cm ÷ 1.2 = in-lbs

kgf-cm ÷ 13.8 = ft-lbs

These two formulas contain generously rounded conversion factors for ease of calculation. They should be accurate enough for the precision required in bicycle mechanics.

Torque wrenches are tools used to measure torque while tightening a fitting. They come in two varieties. The torque beam variety has a bar that swings across a scale as force is applied. Its advantage is that it is easy to know when calibration is needed and they are easy to calibrate. If the needle fails to return to "0", bend the bar until it points to "0". The preset type has a cylinder that is twisted until the desired torque is set. The head will swivel when that setting is achieved. The preset torque wrench is difficult to calibrate, but has an advantage in that it may be available with a ratcheting drive. It is difficult to know when the preset type is out of calibration (other than experiencing mechanical failures), and it must be sent back to the supplier/manufacturer for calibration.

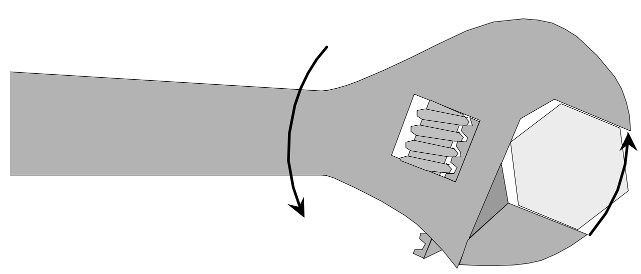
Using torque wrenches is strongly recommended. All mechanics have trouble torquing things correctly by feel. Unfortunately, we learn torque from the negative feedback of numerous failures. All mechanics can benefit from the use of a torque wrench. When a mechanic's feel is off either the part fails (stripped threads or bolt head) as it is tightened or it comes apart while riding the bike.

In many cases the design of a fitting does not allow the use of a socket that fits on a torque wrench. For this reason I have invented a new unit of measure that will be used in this book. After many in-lb notations there will be another notation in parenthesis (the new unit that describe torque). This second notation is the amount of load to place on the end of a common tool to achieve the correct torque. For example, the torque for a hub locknut might be shown as 180in-lbs (45lbs@4"). The notation (45lbs@4") means apply 45 pounds of force at a leverage length of 4 inches. The leverage length will be based on the common tool length used for the job. If there is a wide range of tool lengths commonly used for doing a job, then the leverage length will be based on one of the shorter tools available. If the tool is longer, either recalculate the load or "choke up" on the lever to the stated length.

Even while use torque wrenches, it will be necessary to rely on feel for certain items. The best way to develop the correct feel for those items that a torque wrench cannot be used for, is to feel the torqued item with a regular wrench after *every* time a torque wrench has been used. Since the recommended torques in this book are never the absolute maximum that a fitting can withstand, it is easy to check for the correct feel by advancing the regular wrench no more than a few degrees past the point reached by the torque wrench.

ADJUSTABLE WRENCHES

Adjustable wrenches should be used only when no pre-fit wrench is suitable or available. Always make sure that the adjustable wrench is well snugged before applying force. Position the wrench so that when the wrench rotates, the tip of the adjustable jaw follows the tip of the fixed jaw through the rotation. Rotating the adjustable wrench in this direction is critical because experience shows that the adjustable jaw is less likely to break.



1.13 *Direction to apply force with an adjustable wrench.*

PLIERS AND VISE GRIPS

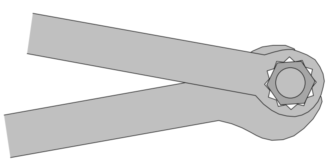
Pliers are used for grasping and holding, not for turning nuts and bolts unless the flats are already distorted so that a pre-fit or adjustable wrench cannot be used. Vise grips are locking pliers that have a much stronger grasp than regular pliers. They are used to hold things firmly, such as when using the grinder on small pieces, and may be used on nuts and bolts when the wrench flats are already destroyed.

SCREWDRIVERS

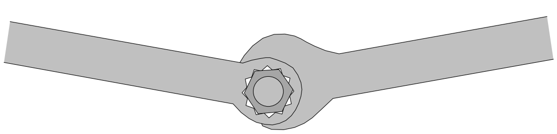
Always use the largest screwdriver that will insert fully into the slot of the screw. This applies equally to slotted screwdrivers and Phillips screwdrivers. Maintain the axis of the screwdriver in line with the axis of the screw.

MECHANICAL ADVANTAGE

With two opposing levers, the shortest lever determines the limit of force that can be applied. Increased mechanical advantage can be achieved by lengthening leverage (by using a longer tool or adding a cheater bar to a tool). Increased mechanical advantage can also be achieved by changing the angle between opposing levers. The worst mechanical advantage is with levers 180° apart, and the best is when the levers are close to 0° apart (allowing clearance for hands and tools).



1.14 *Two wrenches arranged for good mechanical advantage.*



1.15 *Two wrenches arranged for poor mechanical advantage.*

Increased mechanical advantage on a screwdriver can be achieved by wrapping the handle with a rag to increase the diameter. Apply increased force into the screw to prevent the slot from stripping. The tendency, when a screw head is about to strip out, is for the screwdriver to rise up out of the screw head. By pressing firmly down on the screwdriver, it will be kept fully engaged with the screw head. This reduces the chance of the stripping occurring because more material engages the tip of the screwdriver.

HAMMERS

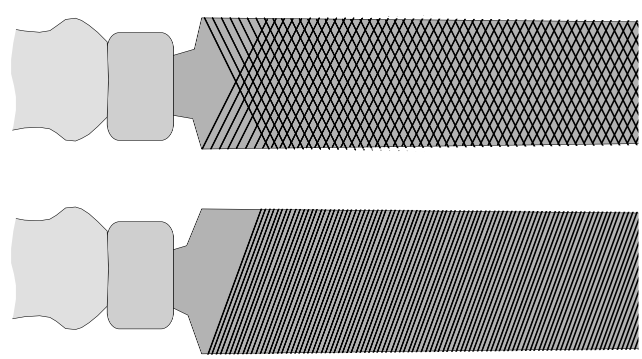
Hammers are used to apply force when removing press-fit items, and to install pressed items when there is no specialized tool. Before using a metal hammer, always try a soft hammer first. Soft hammers are usually made of plastic or rubber. When using a metal hammer, it should be a 12 ounce ball peen, not a claw hammer. Claw hammers have the wrong weight, balance and head shape. Wear eye protection when using a metal hammer to hit anything metal.

HACKSAWS

Hacksaws are generally used for cutting fork columns (steerer tubes) to length, removing locks and chains with lost combinations and keys, and shortening bolts and axles that are too long. For most uses, a blade of 32 teeth per inch is sufficient. Install toothed blades with the teeth pointing away from the handle and apply force on the pushing stroke. Cutting with a hacksaw generates a lot of heat, so be careful when touching items that have just been cut. Metal fragments created by hacksawing can easily get in your eye, so always wear eye protection. Hacksaw blades wear out easily. Replace them regularly.

FILES

Files are used for smoothing a metal surface, particularly after using a hacksaw or grinder, and they are used to alter the fit of parts that are too large. Flat files should be 10–12" long and come in two different cuts: bastard and mill-bastard. Bastard files are coarse files with a crisscross cut that are used for removing large amounts of metal quickly. They often leave a rough finish. Mill-bastard files have a finer cut with no crisscross and are used when little material is to be removed. They leave a smoother finish than the bastard file.



1.16 *Bastard file (top) and mill bastard file (bottom).*

Round files, or rat-tail files, also come in both cuts, and are used for cleaning inside tubing or inside a hole, particularly after cutting a fork steerer tube. For coarse work, use a 10–12" bastard cut. For fine work, use a chainsaw file or jeweler's file. A small triangular file is used for precision inside corners.

With all files, the power stroke is on the push. Applying pressure on the return stroke dulls the file. Files may be used on all types of metal. Wear eye protection when filing. A file card (a special wire brush) is used to clean filings from between the teeth of the file when the build-up reduces the effectiveness of the file.

GRINDER

The grinder is used when a file would be too time consuming, and when there is less need for precision. Only steel can be ground on the grinder; *do not grind aluminum*. Grinding aluminum causes the aluminum to melt, filling the pores of the grinding wheel with aluminum, which renders the wheel useless. Wear eye protection at all times with the grinder. Hold small objects firmly with a vise grip to prevent them from being wrenched from your hand. Reduce heat build-up (which occurs very rapidly with no visible change in the metal) by grinding with little pressure, frequent rests and periodic dips in a water bath to cool the item. *Never* apply pressure to the side of a grinding wheel— it will break. When using a new wheel, give it a hand spin before turning it on to make sure it does not wobble side-to-side, which could cause it to shatter at high speeds. If the grinder loses its flat edge, or becomes clogged with aluminum, it can be improved with a tool called a grinding wheel dresser, which is simply held against the grinding wheel while it is spinning.

DRILLING

Drilling some steels used in bicycle frames and components require the highest grade bits available. These will generally be described as "carbide."

For accuracy, start the hole by making a prick mark with a center punch.

Heat generated by drilling hardens the material being drilled, which dulls the bit and lengthens the job. To prevent heat build-up, drill holes in stages, use moderate speed and pressure, and always use cutting oil. Drill larger holes by starting with a smaller bit first. For example, a 6mm hole might be drilled with a 2mm bit followed by a 4mm bit, and then finally a 6mm bit. This is called drilling in "stages." Moderate the speed and pressure. A variable-speed drill is recommended. Surprisingly, a lower speed will often allow faster progress. Cutting oil should be flooded into the hole regularly because it not only lubricates, but it also cools the metal being drilled, and only a continuous flow of cool oil will accomplish this.

Most jobs will require metric drills. Half millimeter increments from 1mm through 9.5mm should be adequate, with an additional 4.2mm bit for drilling a hole for a 5mm tap.

Drill bits dull quickly. Although it is possible to sharpen them, it is an advanced technique, and it is more economical to simply replace them.

TAPS

When using a tap in existing threads, first verify it is the correct diameter and pitch to match the existing thread. When tapping in a hole without existing threads, first verify the hole is the correct diameter to accept the tap.

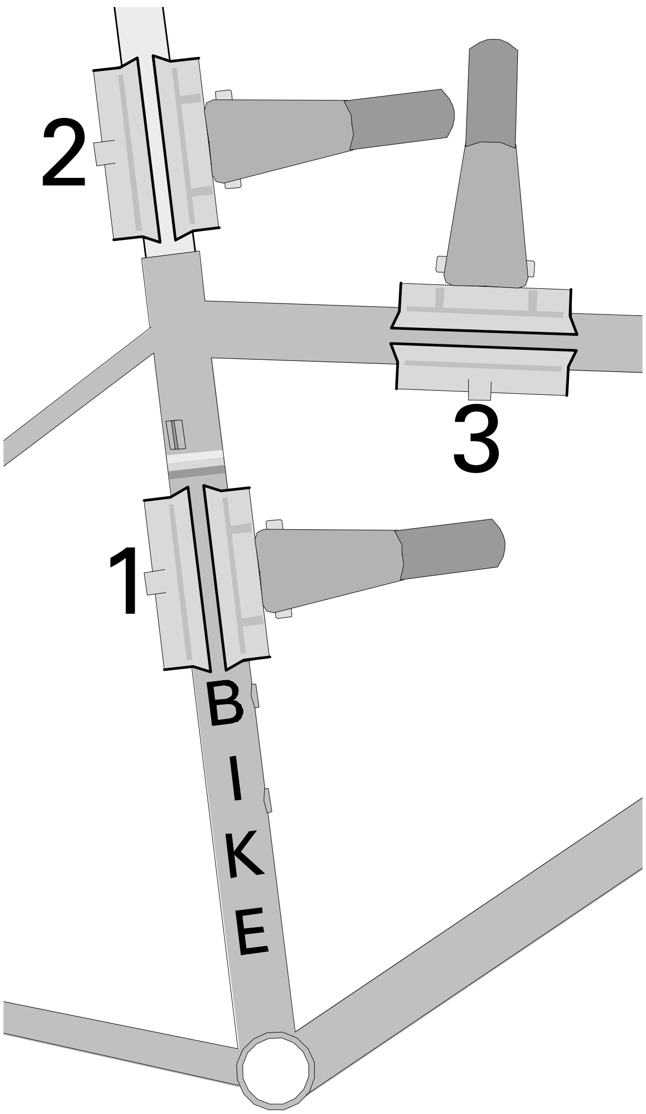
Taps break easily and then are almost impossible to remove, so the following precautions should always be observed. Always flood the hole with cutting oil. Repeated application of fresh cutting oil keeps the material that is being tapped cool and keeps it from hardening. When tapping existing threads, always tap from the end of the hole that has the threads in best condition to ensure good alignment. Never force a tap— it will break. When the cutting gets tough, advance the tap no more than one-quarter turn further, then back it out about one-half turn. Turn the tap in again until it gets tough again, and repeat the process. This procedure clears the cuttings away from the cutting edge of the tap so it does not jam.

General-purpose cutting oil is suitable for tapping in steel, but specifically formulated cutting oil should be used when tapping aluminum, or total thread failure may occur.

Tapping aluminum is much more difficult than tapping steel, and requires more care. Make sure the tap starts cleanly in existing threads because it is easy to start the thread in a new spot, which creates a double thread, which is much weaker. Dull taps are far more likely to tear through, rather than cut through, aluminum. This is called galling. To prevent galling, never use a dull tap, especially on aluminum.

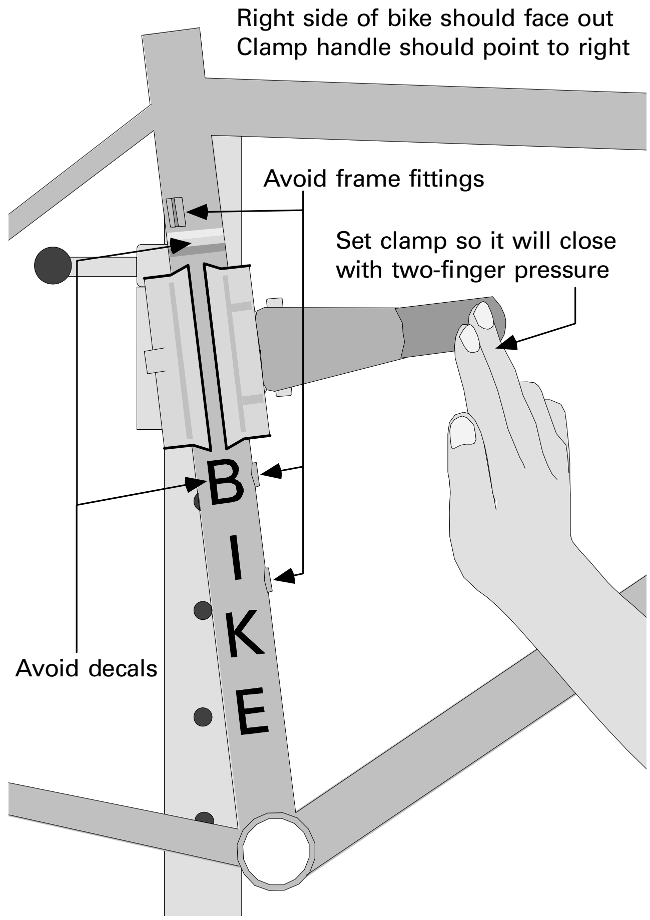
USING REPAIR STANDS

Depending on the clamp used and obstacles on the frame tubes, the clamp should be placed (in descending order of priority): onto the seat tube, the seat post, or the top tube. The clamp should never be placed on top of decals that are not under a clear coat of paint, braze-on fittings, or cables or housings. When possible, clamp onto the portion of the seat tube that is supported by the insertion of the seat post. Always set the clamp for the minimum force required to securely hold the frame in place; this helps prevent crushing a frame tube.



1.17 *These are the three positions that the Park stand clamp can be clamped in. The positions are numbered in order of preference.*

Place the bike in the stand so that the right side faces away from the stand with the bike in an upright position. With Park brand stands, position the clamp with the handle on the right (as you face the stand) before attaching the bike. Using a Park stand this way allows the handle to be accessed through the main triangle. Once the bike is correctly mounted, use all the adjustments built into the stand to put the bike in a convenient position. Avoid decals and braze-ons when placing the clamp on the tube.



1.18 *This bike is properly positioned in a Park stand.*