9 – ADJUSTABLE-CUP BOTTOM BRACKETS

ABOUT THIS CHAPTER

This chapter is about adjustable-cup bottom brackets. Adjustable-cup bottom brackets have a spindle, loose balls or balls in a retainer, and cups that thread into the bottom-bracket shell. There are also sealed cartridge-bearing bottom brackets, which may press into, or thread into, the bottom-bracket shell. These are generally less serviceable, and are covered in a chapter called **CARTRIDGE-BEARING BOTTOM BRACKETS** (page 10-1).

GENERAL INFORMATION

TERMINOLOGY

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

Bottom-bracket shell: The 1.5" diameter 3" long horizontal frame tube at the bottom of the frame that contains the bottom bracket.

Cone: A surface that bearings roll on that is positioned inside the circle of balls. Two cones are built into the bottom-bracket spindle.

Cup: A cup is a surface that bearings roll on that is positioned outside the circle of balls. The cups thread into the bottom-bracket shell.

Race: The cone or cup surface on which a ball bearing rolls. A misuse of this term is to use it to describe a set of ball bearings held together in a holder, which is more properly called a *retainer*.

Retainer: A clip that holds a group of ball bearings that go between a cup and a cone. A retainer is sometimes mistakenly called a *race*.

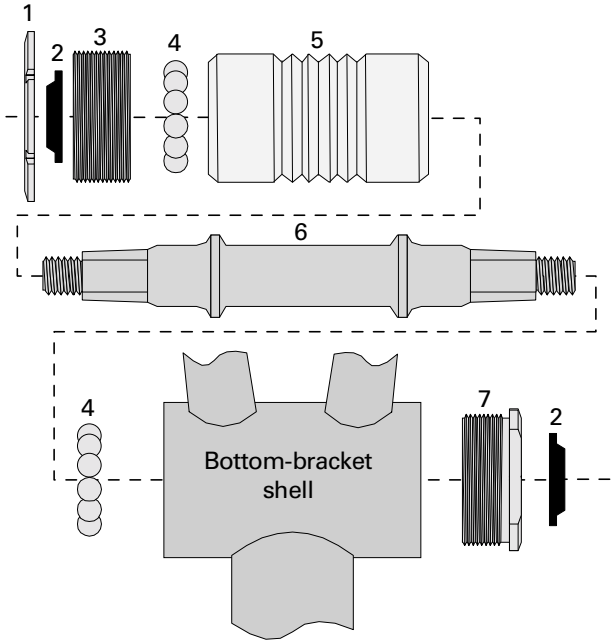
Adjustable cup: A bearing cup that threads into the left side of the bottom-bracket shell, which is positioned further in or out to loosen or tighten the bearing adjustment.

Fixed cup: A bearing cup that threads into the right side of the bottom-bracket shell that is seated fully and left in one fixed position. The fixed cup has a built in flange that stops against the right end of the bottom-bracket shell.

Spindle: The axle that rotates inside the bottom-bracket shell. The word *axle* is sometimes used in the vernacular in regards to the bottom-bracket spindle.

Lockring: A ring with notches on its outer perimeter that threads onto the adjustable cup and against the left end of the bottom-bracket shell, and fixes the position of the adjustable cup relative to the bottom-bracket shell. Lockrings are round and have notches that are engaged by a special tool called a lockring spanner.

Seal mechanism: A rubber insert that fills the gap where the spindle goes through the holes in the adjustable cup and fixed cup.



9.1 *Parts of the bottom bracket: 1. Lockring, 2. Seal mechanisms, 3. Adjustable cup (left side), 4. Ball bearings, 5. Plastic sleeve protector, 6. Spindle, 7. Fixed cup (right side).*

PREREQUISITES

Chainline error

Before removing crank arms the chainline should be checked. The reason for this is that one way to fix a chainline error is to change the bottom-bracket spindle, something that may be done when overhauling the bottom bracket. See the **CHAINLINE** chapter (page 27-1) before removing the crank arms.

Crank-arm removal

In order to overhaul the bottom bracket, it is necessary to remove the crank arms. To just adjust the bottom bracket, it is recommended, and often required, to remove the crank arms. See the **TAPERED-FIT CRANK ARMS** (page 20-6) or **COTTERED CRANK ARMS** (page 21-3) chapter before starting the bottom-bracket overhaul or adjustment.

INDICATIONS

There are several reasons the bottom bracket may need an overhaul, and several reasons it may need adjustment. A bottom-bracket overhaul should be done as part of a regular maintenance cycle, the duration of which will change depending on the type of riding, the amount of riding, and the type of equipment. Adjustments should be done on the basis of need.

Maintenance cycles

If you start out with a bottom bracket known to be in good condition with good quality grease, it should be able to be ridden thousands of miles without needing an overhaul. If the equipment sees little wet-weather riding, then an appropriate maintenance cycle would be 2000–3000 miles in most cases. If a lot of wet-condition riding is done, then the maintenance cycle might need to be as often as every 750–1000 miles. Parts rust whether being ridden or not, so another factor is how long the bike may be sitting before it will be used again. For example, if ridden 200 miles in the rain in the fall, then the bike is put away for four months for the winter, it would probably be a good idea to overhaul the bottom bracket *before* the bike is put away for the winter.

Some other factors affecting the maintenance cycle are whether the bottom bracket is equipped for grease injection and whether the bottom bracket has seal mechanisms. *Grease-injection systems do not eliminate the need for overhauling.* They only increase the acceptable time between overhauls; furthermore, grease-injection systems are only as good as the customer is consistent and thorough about pumping in new grease. Seal mechanisms (adjustable-cup bottom brackets with rubber seals between the spindle and cups) *are not effective water-tight seals*. Their effectiveness varies with the brand and model. At best, they can lengthen the acceptable time between overhauls.

Symptoms indicating need of overhaul

One of the most common symptoms that leads the customer to believe that his or her bottom bracket needs overhaul is noise coming from the general area of the bottom bracket. Most noises that seem to come from the bottom bracket are crankset and pedal noises. When bottom brackets do make noise, it is almost always from a loose cup or lockring and can be fixed without an overhaul. A bottom bracket with enough internal damage or wear to make a noise that is audible while riding, would be an extremely damaged piece of equipment.

So what symptom would indicate that the bottom bracket should be overhauled? The only one is that when performing an adjustment, the looseness (free play) in the bearings cannot be eliminated without the bearing becoming excessively tight (does not turn smoothly). The lack of smoothness could be caused by dry grease, contaminated grease, or worn parts.

Symptoms indicating need of adjustment

The primary symptom that will be experienced indicating that the bottom bracket needs an adjustment is looseness in the bearings. This can be detected by grasping the end of the crank arms and jerking them in and out while feeling for a knocking sensation. Another possible symptom indicating that the bottom bracket needs adjustment is a clicking sound that cannot be solved by tightening the crank arms, chainrings, pedals, or pedal parts. A loose fixed cup or loose lockring can be the source of this sound. Whenever the lockring or fixed cup is loose, it is not adequate to simply secure the loose part, as the bottom-bracket adjustment may have been lost while the part was loose.

One other case in which it is recommended to adjust the bottom bracket is on any new bike assembly. Most bikes come in the box from the factory with an installed bottom bracket. It is common that the factory is not very reliable, and bottom brackets sometimes are completely worn out after as little as 1000 miles of use due to poor factory setup.

TOOL CHOICES

The design or brand of bottom bracket will determine the tools needed. The following list covers tools for adjustable-cup bottom brackets only. This list covers all the tools for the job. The preferred choices are in **bold**. A tool is preferred because of a balance among: ease of use, quality, versatility, and economy. When more than one tool for one function is **bold**, it means that several tools are required for different configurations of parts.

ADJUSTABLE-CUP BOTTOM-BRACKET TOOLS (table 9-1)

Tool	Fits and considerations
FIXED-CUP TIGHTENING (cup already installed)	
Stein FCC2	Attaches to nut-type and bolt-type spindles to retain spanners to cup.
Campagnolo 713	36mm fixed cup (also 15mm pedal flats)
Cobra	36mm fixed cup (also 15mm pedal flats)
Cyclo 1329	36mm fixed cup (also 15mm pedal flats)
Diamond C79	Old-fashioned monkey wrench odd-size fixed cups not fit by fixed cup spanners (special order from Ace hardware stores)
Park HCW-2	35mm fixed cup (also with hinged single peg lockring spanner)
Park HCW-3	Slotted 36mm spanner fits with right crank still mounted, if inner ring does not overlap fixed cup (also fits 25mm one-piece bottom-bracket cones and nuts)
Park HCW-4	36mm fixed cup (also fits pin-hole adjustable cups w/ 29mm dia. hole pattern)
Park HCW-11	16mm flats found on old English and some Taiwan fixed cups (also fits adjustable cups with slots or square holes)
Shimano TL-FC30 (set)	Set includes 36mm fixed-cup wrench
Sugino 201 (set)	Set includes 36mm fixed-cup wrench
FIXED-CUP INSTALLATION AND REMOVAL	
Campagnolo 793/A	36mm fixed cups
Hozan C358	35.7mm and 36mm
Kingsbridge 301	Universal (works by friction, may slip on most difficult removals)
United Bicycle Tool BBCR	Universal (works by friction, may slip on most difficult removals)
VAR 30 with 30/2 & 30/3	35mm, 35.4mm, 36mm, 36.7mm, 37.7mm and 38mm fixed cups
LOCKRING TOOLS (Single-hook design fits all lockrings, but is best used when plier will not fit because number of notches is odd. Pliers are superior grip, but don't fit three-notch lockrings. Multiple-hook design tools fit specific brand of lockring only).	
Campagnolo 712	Multiple-hook design fits Campagnolo lockrings (also fits 32mm headset races)
Cyclo 1333	Multiple-hook design fits Campagnolo lockrings (also fits 32mm headset races)
Eldi 2712	Single-hook hinged design (fits headset lockrings also)
Hozan C205	Single-hook design (other end fits headset lockrings)
Hozan C203	Pliers have excellent fit to all lockrings with even number of notches (also fits headset lockrings with even number of notches)
Park HCW-2	Hinged single-hook design (fits headset lockrings also, and 35mm fixed cups)
Park HCW-5	Single hook design on one end fits all lockrings, multiple-hook design on other end fits some 3 and 6 notch lockrings
Park HCW-12	Single-hook design (also fits 32mm headset races)
Shimano TL-FC30 (set)	Set includes multiple-hook design fits Shimano lockrings only
Stein LW	Vise grip plier has secure grip for stuck lockrings w/even number of notches
Sugino 201 (set)	Set includes single-hook design lockring tool
VAR 16	Plier (bulky and awkward compared to Hozan C203)

ADJUSTABLE-CUP BOTTOM-BRACKET TOOLS (table 9-1 cont.)

Tool	Fits and considerations
ADJUSTABLE-CUP PIN SPANNERS (Adjustable spanners can be adjusted to fit various cups. They may be light duty or heavy duty. Fixed spanners fit certain cups only and are all heavy duty).	
Cyclo 1330	Fixed pin spanner fits Campagnolo cups
Park SPA-1 (green)	Light duty adjustable with 3.0mm pins
Park SPA-2 (red)	Light duty adjustable with 2.4mm pins
Park SPA-6	Heavy duty adjustable with 2.4mm pins (not as stout as VAR 13)
Park HCW-4	Fixed pin spanner (fits many, but not all, pin-hole cups)
Shimano TL-FC30 (set)	Set includes fixed pin spanner that fits Shimano cups
Sugino 201 (set)	Set includes fixed pin spanner that fits Sugino cups
VAR 13	Heavy duty adjustable with 2.4mm pins
SLOTTED ADJUSTABLE-CUP SPANNERS (for adjustable cup with square holes or slots in its face)	
Park SPA-4 (yellow)	Light duty, limited fit
Park HCW-11	Heavy duty (fits cups with 16mm flats also)
VAR 311	Heavy duty, but awkward compared to Park HCW-11
16MM FLATS ADJUSTABLE-CUP SPANNERS (for adjustable cup with 16mm wrench flats)	
Park HCW-11	Good tool, only one made for the job (works on similar fixed cups also)
HEX-FACED ADJUSTABLE-CUP SPANNERS (for adjustable cup with hex fittings on its face)	
Diamond C79	Old-fashioned monkey wrench fits all size hex faces with crank arm removed (special order from Ace hardware stores)
Park HCW-3	25mm (36mm fixed-cup spanner on other end)
VAR 19/1	22mm & 24mm
VAR 19/2	26mm & 28mm
VAR 19/3	22mm & 24.9mm

TIME AND DIFFICULTY RATING

Overhauling the bottom bracket (including crank-arm removal and bottom-bracket adjustment) is a 30–40 minute job of moderate difficulty. Adjusting the bottom bracket alone (including crank-arm removal) is a 10–15 minute job of moderate difficulty.

COMPLICATIONS

Difficult cup removal

Difficulty may be experienced removing the adjustable cup or fixed cup. Using a self-retaining fixed-cup tool such as the VAR 30 and a cheater bar, will generally solve the problem for the fixed cup. When the adjustable cup is difficult to turn, retain the adjustable-cup spanner with something like a Stein Fixed Cup Spanner Clamp (FCC-2).

Difficulty may be experienced threading the cups out even after they have broken loose, or difficulty may be experienced threading them in. In this case, it is recommended to tap the bottom-bracket threads. See the **TAPPING THE BOTTOM-BRACKET SHELL** chapter (page 2-3).

Difficult adjustment

One other difficulty that might be experienced is that it may not be possible to get a good adjustment even with good quality new parts. If the symptom experienced is that the spindle feels smooth through part of its rotation, then gets difficult to turn, and finally easy again, then the bottom-bracket shell may need facing. See the **FACING THE BOTTOM BRACKET** chapter (page 3-4).

THREADS

Bottom brackets thread into the frame. There are several different thread standards listed in the following table. It is necessary to identify what thread standard is used on a particular bike in order to determine which way to turn the fixed cup, or to determine compatible replacement parts. To identify the threads a thread-pitch gauge and a caliper are needed.

See the following page for a table of bottom-bracket-thread information.

BOTTOM-BRACKET THREADS (table 9-2)

ADJUSTABLE CUPS: Always found on the left side of the bike and always are right-hand thread.
FIXED CUPS: Always found on the right side of the bike, see **Right-side thread direction** row below for thread direction.

Thread type	"BSC"[1]	"ISO"[1]	"Italian"	"Swiss"	"French"	"Whitworth"
Typical occurrences	All Asian and most American bicycles, as well as many others. *All unmarked Taiwan and Japan cups are BSC or ISO thread*.		Most Italian, some Mexican and American bicycles	French bikes from the late-seventies to mid-eighties	French bikes from the mid-eighties or earlier	English inexpensive three-speed and ten-speed bikes
Pitch	24tpi		24tpi	1mm	1mm	26tpi
Cup O.D.	34.6–34.9mm		35.6–35.9mm	34.6–34.9mm	34.6–34.9mm	34.6–34.9mm
Right-side thread direction	left-hand thread		right-hand thread	left-hand thread	right-hand thread	left-hand thread
Left-side thread direction	right-hand thread		right-hand thread	right-hand thread	right-hand thread	right-hand thread
Nominal thread description[2]	1.370" × 24tpi[1] (Shimano[4])	1.375" × 24tpi[1]	36mm × 24tpi	35mm × 1mm (left[3])	35mm × 1mm (right[3])	1–3/8" × 26tpi
Shell I.D.	33.6–33.9mm		34.6–34.9mm	33.6–33.9mm	33.6–33.9mm	33.6–33.9mm

[1] BSC (British Standard Cycle) and ISO (International Standards Organization) sizes are fully interchangeable. The .005" diameter difference shown in the **Nominal thread description** row is a difference on "paper" only.

[2] **Nominal thread description** is the name of the thread type. The diameter value is not a measurement, but a value rounded-up from the actual measurement.

[3] French and Swiss threads are identical except that the thread direction of the fixed cup (right side) is left-hand for the Swiss and right-hand for the French. The notations (left) and (right) rarely show up in the nominal thread descriptions, although sometimes the letter "G" (stands for left in French and Italian) might be part of the name (example: 35 × 1G) if it is a Swiss thread.

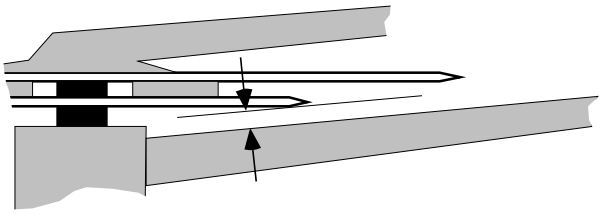
[4] Shimano marks BSC cups "BC 1.37 × 24".

OVERHAUL AND ADJUSTMENT PROCEDURE

NOTE: If just adjusting bottom bracket and not overhauling it, do step 3, turn lockring counterclockwise to loosen it, then skip to step 46.

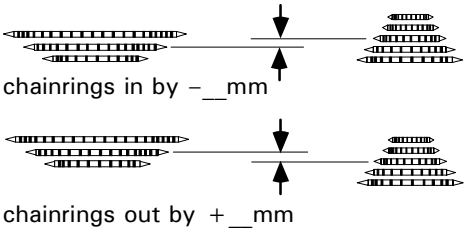
CRANK-ARM REMOVAL

1. [ ] Measure chainring-to-chainstay clearance with stack of feeler gauges: _____mm.



9.2 Check clearance here before removing crank arm.

2. [ ] Measure chainline error (see CHAINLINE chapter, page 27-5). Chainrings are *out* or *in* (circle one) _____mm.

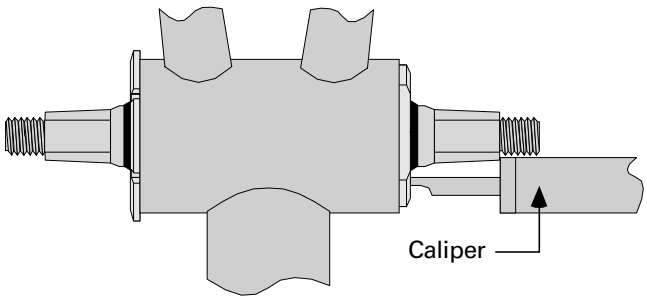


9.3 Determine the chainline error. Write the measurement as a negative number if the chainrings are in.

3. [ ] Remove crank arms.

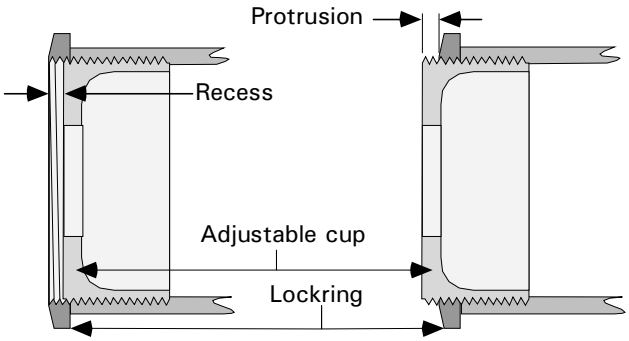
BOTTOM-BRACKET REMOVAL

4. [ ] Measure bottom-bracket-axle right-side protrusion from cup face: _____mm.



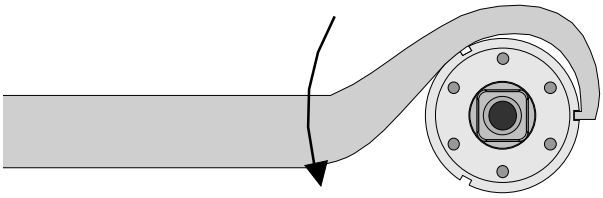
9.4 Measuring right-side axle protrusion.

5. [ ] Measure adjustable-cup protrusion (or recess) from lockring face:_____mm (write recess as a negative number).



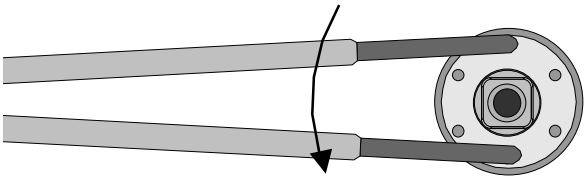
9.5 The adjustable cup should not recess into the lockring at all, but may protrude up to 2mm.

6. [ ] Turn lockring counterclockwise with lockring tool to remove it.



9.6 Remove the lockring.

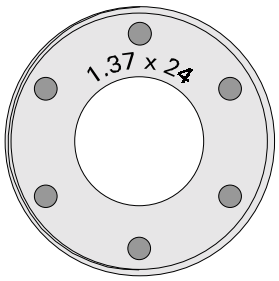
7. [ ] Turn adjustable cup counterclockwise with adjustable-cup tool to remove it.



9.7 Remove the adjustable cup.

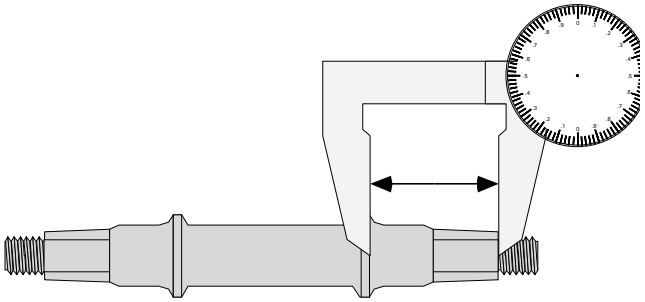
8. [ ] Inspect cup faces for thread identification. Record markings here:

_____



9.8 Inspect cup and lockring face for thread identification (1.37×24 in this case).

9. [ ] ***Only if adjustable-cup markings are inadequate***, **measure cup diameter and pitch and record here:** _____
10. [ ] **Look thread type up in BOTTOM-BRACKET THREADS (table 9-2) from cup marks or from measurements that were taken.**
11. [ ] **From table information, choose whether fixed cup is *right-* or *left-*** (circle one) **hand thread.**
12. [ ] **Remove ball bearings from inside adjustable cup or from left end of spindle.**
13. [ ] **If replacing bearings (*strongly* recommended), pop one out of the retainer and measure it with the Park SBC-1 bearing ruler. Record ball bearing size here:** _____
14. [ ] **Remove spindle (keeping careful track of which end was on the right and which was on the left), measure spindle ends, and note whether *right long?* or *left long?* or *symmetrical*** (circle one).



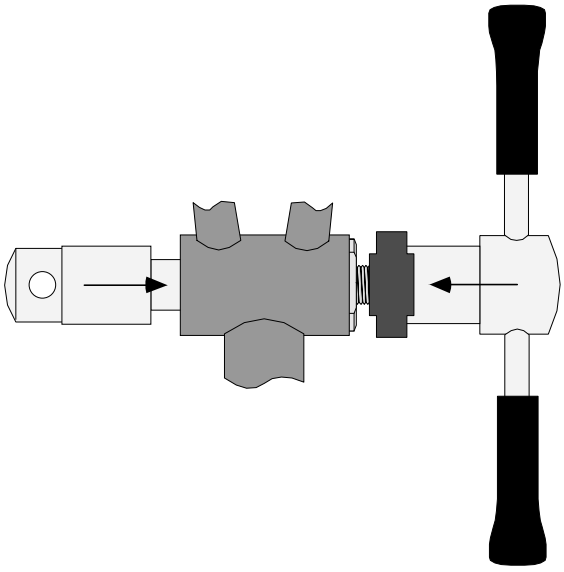
9.9 *Correct way to measure the spindle end.*

If the spindle needs to be replaced because it is worn out or a bad fit (due to poor chainline, poor chainring clearance, or poor adjustable-cup position), a suitable replacement needs to be found. Spindles have code numbers on them that can be used to determine the appropriate solution. There is a section later in this chapter on spindle interchangeability.

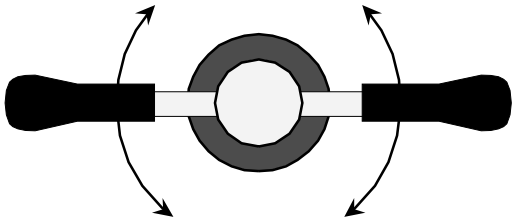
15. [ ] **Note spindle markings here:**

_____

16. [ ] **Remove plastic sleeve if there is one.**
17. [ ] **Remove other set of bearings from right end of spindle or from inside fixed cup.**
18. [ ] **Remove fixed cup with fixed-cup tool (check thread direction noted in step 11).**



9.10 *Assemble fixed-cup tool into bottom-bracket shell.*



9.11 *Turn the fixed-cup tool in the correct direction noted previously in step #11.*

Both cups have now been removed. Was either or both difficult to thread out? If so, it would be a good idea to tap the threads. It can make a big difference in whether the cups might cross-thread when re-installing them, and it will also make adjustment easier. It could be that all the threads need is cleaning, so after cleaning them test install the cups to decide whether to tap the threads.

Many bottom-bracket cups have rubber seals in the hole where the spindle goes through the cup. It is optional to remove these seals, but it helps cleaning if done. The seals are generally soft rubber and pull out easily with fingers. The seals are often asymmetrical, with some sort of lip protruding from one face with no comparable lip on the other face. If put in backwards the seals may not do their job and may interfere with the rotation of the spindle.

19. [ ] **Remove seals from cups (if any) and write down orientations here:**

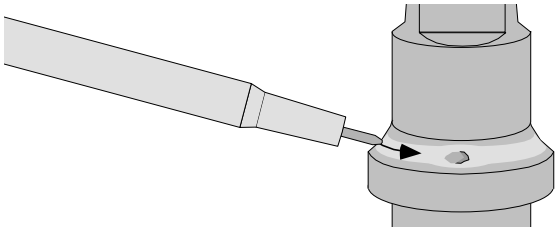
_____

CLEANING THE PARTS

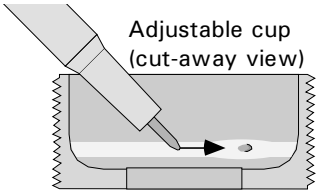
20. [ ] Clean spindle, inside cups, and inside crevasses where any seals were mounted.
21. [ ] Clean inside of bottom-bracket shell.
22. [ ] Clean cup threads and shell threads with toothbrush and solvent.
23. [ ] Clean balls bearings only if re-using them (re-using bearings *not* recommended).

PARTS INSPECTION

When bearings wear out, the surfaces on which the balls roll develop pits (rough craters in the metal) called galling. Once this occurs a proper adjustment cannot be made, and the wear will continue at a high rate. The design of the bottom bracket is such that the spindle tends to wear out first, the fixed cup next, and the adjustable cup last. This order is not cast in stone, especially if all three parts have not been in service an equal amount of time. Although it is sometimes possible to get individual replacement parts, more often than not only complete bottom brackets are available. In any case, if any parts are heavily worn, it is a good idea to replace them all. The ultimate test to determine whether there are pits is to trace the wear path the bearings have left on the cup or the spindle with the tip of a ball point pen. If the tip of the pen catches anywhere, you have found a pit.



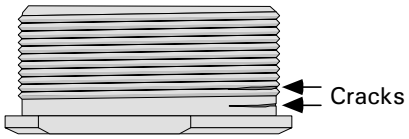
9.12 *Trace the ball path with a ball point pen to check for pits in the cone race.*



9.13 *Check for galling (pits) on the ball path in the cup by tracing the ball path with a ball point pen.*

Inspecting the ball bearings for wear is not recommended. Significant wear on bearings is not necessarily detectable with the naked eye or by feel. Always replace the bearings if going to the trouble to overhaul the bottom bracket.

24. [ ] Inspect cone race on spindle for pits.
25. [ ] Inspect inside cups for pits in ball wear line.
26. [ ] Inspect inside cups for cracks in vicinity of ball wear line.
27. [ ] Inspect in fixed-cup threads for any cracks between threads, particularly at end near cup flange.



9.14 *Cracks can be seen at the points indicated by arrows.*

PARTS REPLACEMENT AND INSTALLATION OF NEW PARTS

Verification of thread compatibility

When replacing parts and old parts are at hand, measure cup-thread diameter and pitch. Observe fixed-cup-thread direction. Verify that replacement parts match in all respects.

When installing new parts with no original parts on hand, measure pitch and inside diameter of the bottom-bracket shell. See **BOTTOM-BRACKET THREADS** (table 9-2), and use the **Pitch** row and the **Shell I.D.** row to determine the thread type.

Spindle compatibility

Spindle interchangeability is a challenging problem. First you must decide if you:

Want the new spindle to match as closely as possible in all respects.
Want the new spindle to move the adjustable cup in or out by how many millimeters.
Want the new spindle to move the chainrings in or out by how many millimeters.

For example, if the adjustable cup is recessed 1mm in the face of the lockring with the original spindle, it would seem that you would want a spindle with 1mm additional width between the cone races. What complicates matters is that cone diameters on the spindle vary from brand-to-brand. A replacement spindle might have the extra millimeter of width between the cone races, but due to a smaller cone diameter no effect will be seen on the adjustable-cup position at all. In regards to chainring position, it would seem that all that matters is the length of the spindle from the cone race to its end. For example, if you want the chainrings to move in 2mm, get a spindle with a right-end length that is 2mm shorter; unfortunately, the thickness of the taper that fits into the crank arm varies brand-to-brand. If the replacement spindle was

2mm shorter on the end, but the taper was thicker, then it could end up that the chainrings would not move in at all. As long as the replacement spindle is a brand match, a simple comparison of width between cone races and length from cone race to end of spindle should be sufficient.

Fortunately most bikes with adjustable-cup bottom brackets use Taiwanese or Japanese parts, which all adhere to the JIS standard. There is a section later in this chapter about spindle interchangeability in regard to these JIS spindles, with a table of dimensions and worksheets for determining appropriate replacement spindles.

28. [ ] If original spindle caused problems with chainline, chainring-to-frame clearance, or adjustable-cup protrusion from lockring, go to *SPINDLE INTERCHANGEABILITY* (page 9-13) to determine appropriate replacement(s).

29. [ ] Replace any worn out spindle, or spindle that is causing problems with chainring position or adjustable-cup position.

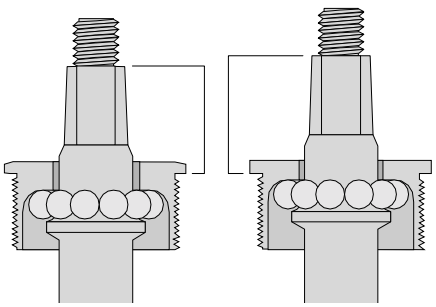
Cup compatibility

Many cups, particularly Asian ones, are compatible fit across brands. Use the following test to determine compatibility between old and new parts.

Check the diameter of the hole in the cup. This will be the minimum for any cup to be considered for replacement.

With the spindle held vertically, place a ball retainer and the worn cup on the top end of the spindle. If it is an adjustable cup, measure the distance from the end of the spindle to the face of the cup. If it is a flanged fixed cup, measure the distance from the end of the spindle to the inside face of the flange.

Install any candidate replacement cup on the spindle in the same fashion, and take the same measurement. If the difference is less than .5mm, the replacement is acceptable. A cup with a difference greater than .5mm may work, but at this point test-assembly of the bottom bracket would be best.



9.15 *The fixed cup on the right has a lower stack height and would position the spindle further out from the end of the bottom-bracket shell. Measure from the back side of the fixed-cup flange to the end of the spindle (as shown) to compare fixed-cup stack height.*

If test-assembling to determine replacement suitability, the lockring must engage three full threads of the adjustable cup, no more than two threads of the adjustable cup should protrude past the face of the lockring, and the chainwheels should clear the frame by at least 2mm.

30. [ ] Replace any worn out or damaged cups.

Replacing ball bearings

The original ball bearings are usually in a retainer (a clip that holds the balls together in a set). There are no mechanical advantages to using retainers, but there can be several disadvantages. Installing loose balls is always recommended, but the following information is provided about retainers in case they come with a new bottom bracket you are installing. If installing loose balls, try to find the highest quality balls available. Good balls are described as *grade 25.* Decent ball bearings might be described in the range of *grade 100* to *grade 200.* Any higher number than these is a mediocre bearing.

Balls in a retainer are more expensive to buy in a high grade, and grade information is rarely available for balls in a retainer. Retainers often have fewer than the maximum number of balls that will fit, leading to an increased rate of wear. Any retainer with 1/4" balls can be replaced by 11 loose 1/4" balls. Any time the original balls were 1/4" (loose or retained), the correct quantity of loose balls to use is 11. If the retainers include a size of ball bearing other than 1/4" (usually 3/16" or occasionally 7/32"), the quantity of loose balls that will fit is less certain. Fill the cups with balls without forcing any in. Retainers can be put in backwards, which can destroy the bottom bracket or drive you nuts when you are trying to adjust the bottom bracket.

Important information if installing ball retainers

Forget any rules of thumb about which way ball retainers face in relation to the cups and spindle. There is only one way to get ball retainers in correctly and that is to test mate them both ways to the spindle and both ways to the cup. In one of the four combinations, the clip that holds the balls together will be obviously contacting the ball race on the spindle or the cup instead of the balls themselves contacting the race. Install the retainers opposite this. If good measurements of the right-side spindle protrusion were taken, and the original retainers were in correctly, and the original (or an identical) spindle has been put in, putting a retainer in backwards will reduce the spindle

protrusion by more than a millimeter. If good measurements of the adjustable-cup protrusion from the lockring face were taken, and the original retainers were in correctly, and the original (or an identical) spindle and adjustable cup has been put in, putting a retainer in backwards will increase the cup protrusion by more than a millimeter.

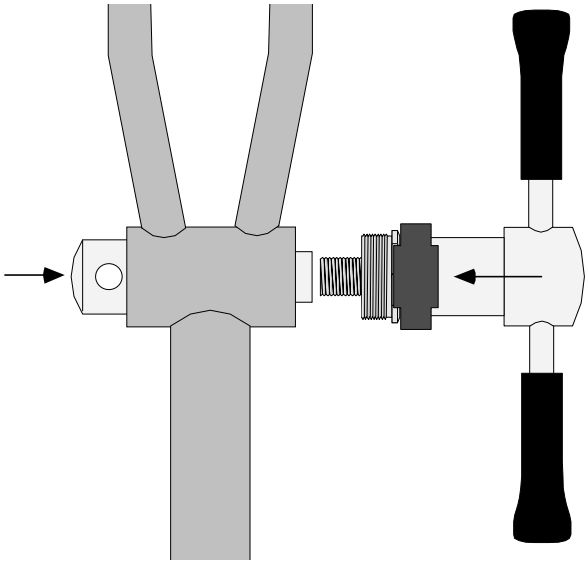
31. [ ] Replace ball bearings.

ASSEMBLY

32. [ ] Loctite fixed-cup threads (Loctite 242).

Cups are about to be threaded into the bottom-bracket shell. It is easy to cross thread them, which can damage the shell and require thread tapping. If fingers are used to start the cups, and no tools are used until the cups have turned in several full revolutions, there is no chance of damaging the shell. If the cups were easy to thread out they should be easy to thread in. If they were hard to thread out, it is best if the shell threads have been chased. If not, be *extremely* careful to not cross thread the cups. If there is trouble getting the threads started, try rotating the cups backwards just until a little "pop" is felt, then turn the correct direction. *Remember*, if the fixed cup was a left-hand thread it turns counterclockwise to install. To avoid the potential for cross-threading, start by installing the fixed cup on a piloted fixed-cup tool, such as the VAR 30.

33. [ ] Put fixed cup on fixed-cup tool and assemble tool together inside bottom-bracket shell with fixed cup. Secure to 25ft-lbs (25lbs@6", on two levers simultaneously).



9.16 *Set-up for using the VAR 30 fixed-cup tool. With the fixed cup already on the handle end of the tool, assemble the tool inside the bottom-bracket shell.*

34. [ ] *Only* if installing balls in a retainer, test mate retainers facing both possible ways in cups and on spindle to determine correct orientation.

35. [ ] Grease seals (if any), then install into cups.

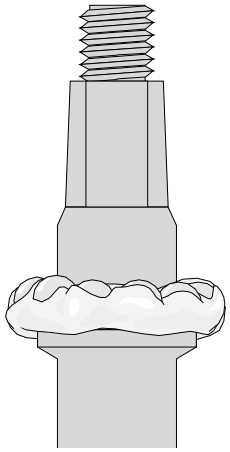
36. [ ] Thoroughly grease adjustable-cup threads on cup and inside left side of bottom-bracket shell.

37. [ ] Put an ample quantity of grease in adjustable cup.

38. [ ] Put bearings into adjustable cup and cover bearings with grease.

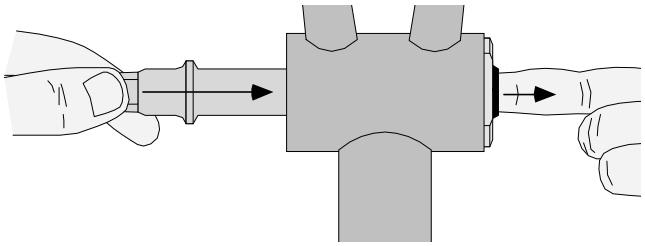
39. [ ] Put an ample quantity of grease onto right end of spindle.

40. [ ] Put bearings into grease on spindle and cover bearings with grease.



9.17 *Put an ample quantity of grease on the bearing race on the right end of the spindle, then submerge the balls in the grease.*

41. [ ] Install right end of spindle into left side of bottom-bracket shell.

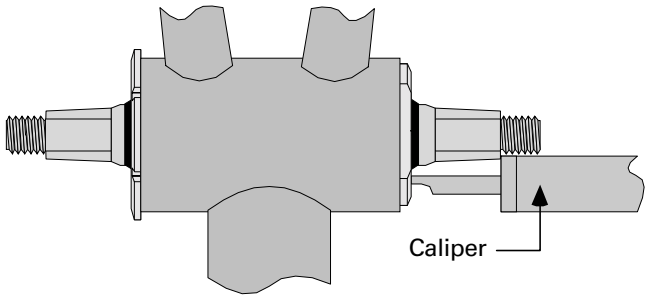


9.18 *Use a finger to guide the right end of the spindle through the fixed cup.*

42. [ ] Install plastic sleeve protector (if any).

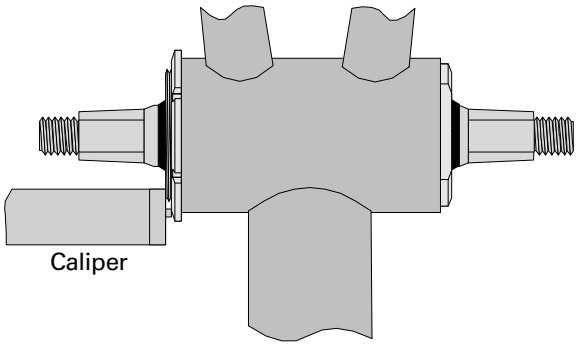
43. [ ] Thread in adjustable cup until it exerts light pressure on spindle.

44. [ ] Verify that right-side spindle protrusion matches pre-disassembly dimension (unless spindle is changed or deliberately reversed to improve chainline).



9.19 Measure right-side axle protrusion.

45. [ ] Hand-thread on lockring and verify that cup protrusion matches pre-disassembly dimension (unless spindle was changed). If cup protrusion has increased and spindle is unchanged, disassemble bottom bracket and find if bearing retainer(s) are out of place or if a loose ball is out of place.



9.20 Verify adjustable cup still protrudes the same distance from the lockring face.

ADJUSTMENT

NOTE: If the bottom bracket was just installed skip to step 50.

46. [ ] Loosen lockring and loosen adjustable cup one full turn.

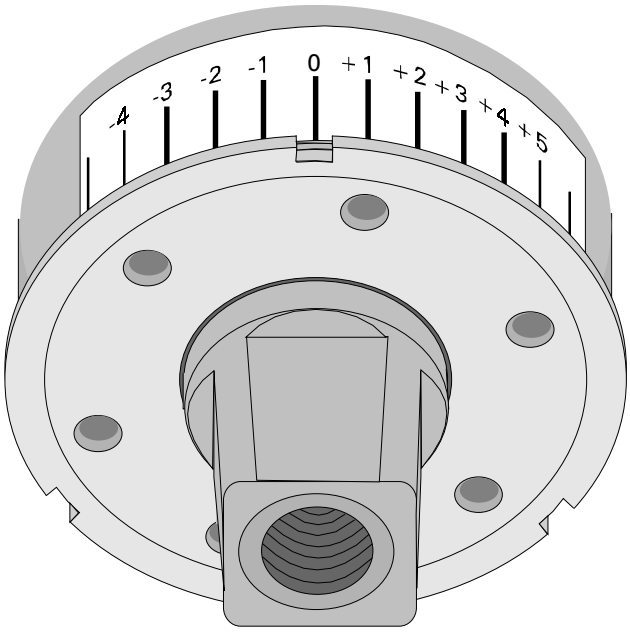
47. [ ] Secure fixed cup to 360in-lbs (30lbs@12").

48. [ ] Loosen lockring one extra turn.

49. [ ] Thread in adjustable cup until it exerts light pressure on spindle.

This book comes with some complimentary bearing calibration stickers sold by Barnett Bicycle Institute. A supply of these stickers is available from BBI for $14.99 (price subject to change). The stickers are used in the accompanying illustrations. If preferred, draw some pen lines onto some 1/2" masking tape at 1/8" intervals to duplicate the function of the sticker.

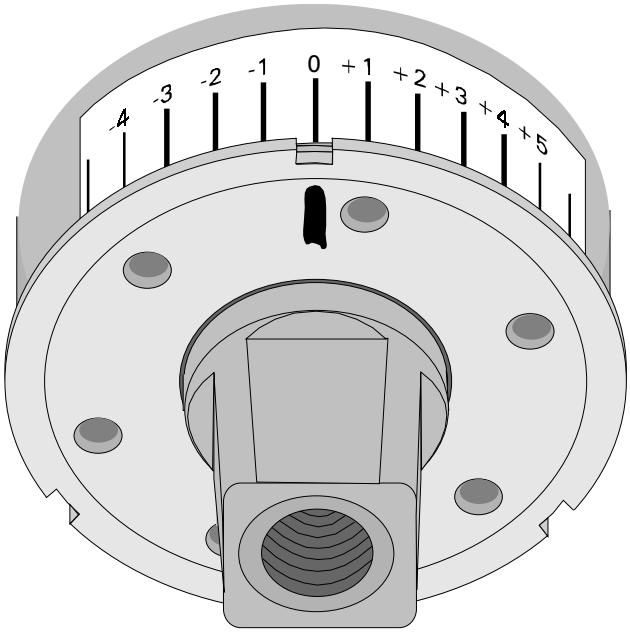
50. [ ] Clean adjustable-cup face with acetone or alcohol and put masking tape or BBI Bottom Bracket Tape sticker.



9.21 BBI Bottom Bracket Tape sticker in place.

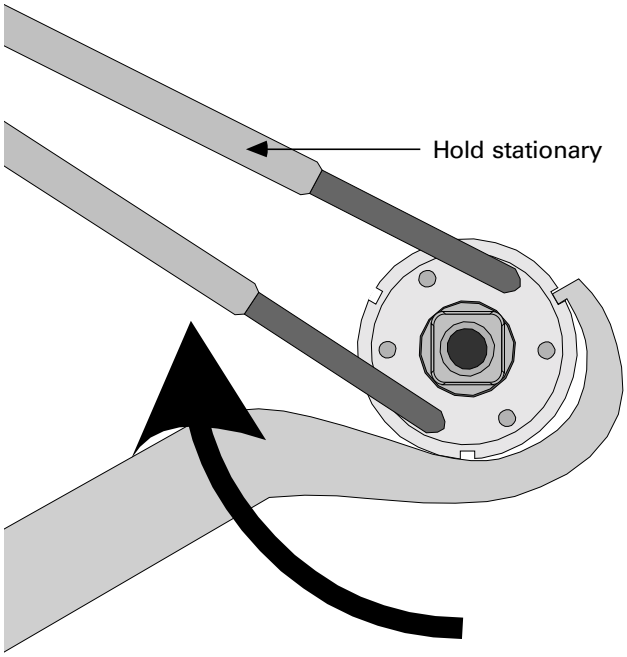
51. [ ] Set adjustable cup to *gently* contact ball bearings.

52. [ ] Use fine-tip permanent marker to put mark on cup face to match "0" mark on sticker.



9.22 Put a mark on the cup face in line with the "0" mark on sticker.

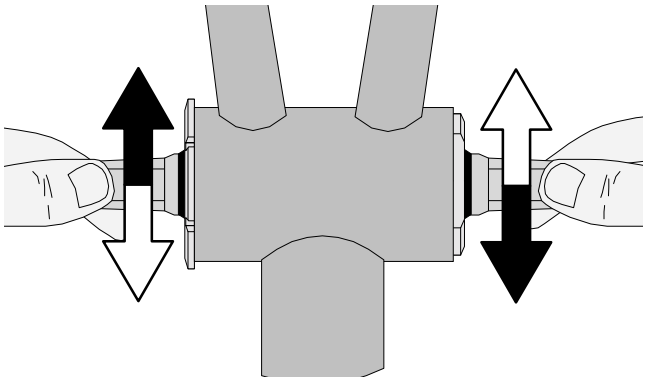
53. [ ] Holding adjustable cup stationary with adjustable-cup spanner, secure lockring with lockring spanner to at least 300in-lbs (38lbs@8").



9.23 Secure the lockring while holding the adjustable cup absolutely stationary.

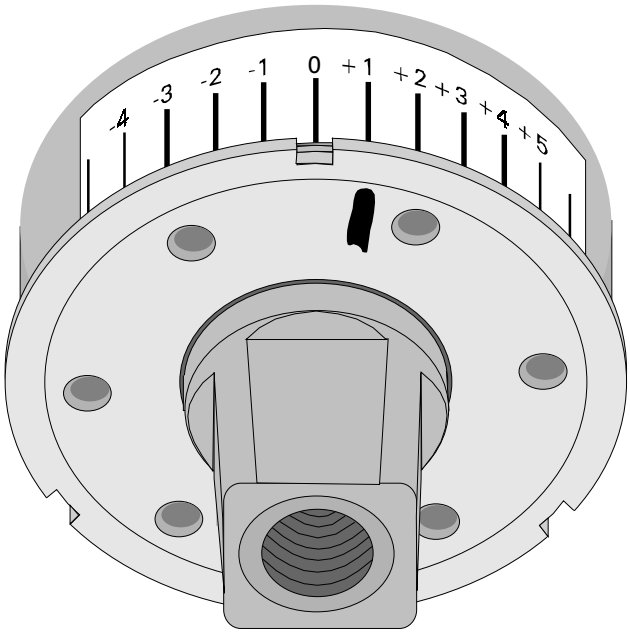
54. [ ] Check that mark on cup still lines up with "0" mark. Reset if cup slipped.

55. [ ] Grasp both ends of spindle firmly and jerk vigorously to check for knocking sensation that indicates adjustment is too loose. If no knocking is felt, reset cup 4 marks looser counterclockwise and check again.



9.24 Jerk spindle vigorously to check for knocking.

56. [ ] Loosen lockring and turn adjustable-cup mark to next clockwise mark on sticker or on masking tape.



9.25 Move the cup clockwise to make the cup mark line up with the next sticker mark to eliminate the knocking.

57. [ ] Holding adjustable cup stationary, tighten lockring to at least 300in-lbs (38lbs@8").

58. [ ] Check for knocking. When knocking is difficult to feel, rotate the spindle to various positions and check further for knocking. Repeat adjustment (steps 56–58) one mark clockwise at a time as necessary until play is eliminated.

When rotating the spindle at the point the knocking seems to be eliminated, it is possible that it might feel sluggish, tight, rough, or tight and smooth simultaneously at this point. How good it feels is largely a function of the quality and condition of the parts, and whether there are rubber seal mechanisms. If the parts were high quality and in great condition, it is likely they will feel great at this point. If there are any seal mechanisms, they will make the spindle feel sluggish when rotated. If an non-overhauled bottom bracket feels sluggish or tight, the grease may be dried out. If the bottom bracket feels rough and has not just been overhauled, the parts are worn out. If the spindle feels tight through a portion of its rotation and loose through another portion, it indicates inexpensive new parts that need break-in, or if using broken-in used parts (or high quality new parts), that the bottom-bracket shell needs facing.

59. [ ] Rotate spindle and decide whether it feels OK

60. [ ] Install right crank arm (see TAPER-FIT CRANK ARMS chapter on page 20-10 for correct technique). If changing spindle, be sure to check chainring clearance, chainline, and front derailleur adjustment.

61. [ ] Rotating crank arm to various positions, jerk vigorously in and out on end of crank arm to see if any knocking remains. If additional knocking is felt, repeat adjustment.

Decide next whether to make a break-in adjustment. A break-in adjustment is one that is left one increment tighter than necessary to eliminate play. The purpose of a break-in adjustment is to compensate for the initial high rate of wear that occurs with new and inexpensive cups and spindles. As an alternative to a break-in adjustment, anticipate needing to readjust the bottom bracket within the first couple hundred miles. If new parts appear especially polished where the balls roll on the spindle or cup, a break-in adjustment would be a mistake. If not sure, then skip making a break-in adjustment.

62. [ ] If desired, reset cup to next clockwise mark for break-in adjustment.

63. [ ] Remove tape or sticker and clean off marks.

64. [ ] Install left crank arm (see crank-arm chapters for correct technique).

SPINDLE INTERCHANGEABILITY

USING THE SPINDLE-INTERCHANGEABILITY WORKSHEETS

Purpose of the worksheets

Spindle-interchangeability worksheets serve the mechanic in three general areas: when the original spindle has been acceptable, but no identical replacement is available; when the original spindle positioned the chainrings in an unacceptable location with regards to chainline and/or chain stay clearance; selecting a replacement spindle when the original spindle put the adjustable cup in an unacceptable position.

About the example worksheets

The worksheet in this chapter (pages 9-16 through 9-18) is a filled-in example. There is a blank worksheet in the **WORKSHEETS** section of the book to photocopy and use. In the following explanation, there are descriptions of what do, followed by notations such as, "**Example worksheet:** The adjustable-cup-protrusion measurement for the example is **3mm**." When encountering one of these notations refer to the example worksheet (pages 9–16 through 9-18) and see how and where the information has been entered.

Preliminary measurements and observations

Measure the adjustable-cup protrusion from the lockring face. If the adjustable cup sticks out past the face of the lockring, give this number a positive value (+). If the adjustable-cup face is recessed in the lockring face, give this number a negative value (–). Record the number in **EXISTING CONDITIONS** box on the first page (9-16) of the worksheet. It goes in the first blank.

Example worksheet: The adjustable-cup-protrusion measurement for the example is **3mm**.

Measure the chainring-to-chainstay clearance. This can be measured from whatever part of the chainring set comes closest to the chain stay. This could be the inner chainring, a middle chainring of a triple, or sometimes the chainring bolt. Record this number in the **EXISTING CONDITIONS** box on the second page of the worksheet (9-17). It goes in the first blank.

Example worksheet: The chainring-to-chainstay clearance measures **1.5mm**.

Measure the chainline error. For a method of measuring chainline error, see the **CHAINLINE** chapter (page 27-5). If the chainrings need to move out, describe the error as a negative (–) number. If the chainrings need to move in, describe the error as a positive (+) number. Record this number in the **EXISTING CONDITIONS** box on the second page of the worksheet. It goes in the second blank.

Example worksheet: The chainrings are in by 3mm, this is a chainline error of **–3mm**.

Spindle information

After removing the spindle, check the spindle for brand markings and identification codes. Record these brand and code marks in both **EXISTING CONDITIONS** boxes on the first and second pages of the worksheet.

Example worksheet: The spindle is of Taiwanese or Japanese origin. Brand is not important, as all current spindles from these countries are of the **JIS** (**J**apanese **I**ndustrial **S**tandard) type. The code on the spindle is **D-5A**.

Find the spindle on the **JIS SPINDLE DIMENSION** (table 9-3, page 9-20) later in this chapter, or measure the spindle as shown in the drawing on the same pages. Record the existing spindle center width in the last blank in the **EXISTING CONDITIONS** box on the first worksheet page (9-16).

Example worksheet: From table 9-3 (page 9-20), the center width for this spindle is **55mm**.

Record the existing right-side axle-end length in the last blank in the **EXISTING CONDITIONS** box, on the second page of the worksheet (9-17).

Example worksheet: The spindle in the bike had the long side on the right. From table 9-3 (page 9-20), the long-side length for this spindle is **32.5mm**.

Completing the worksheet

To complete the worksheet, it may be necessary to add and subtract negative numbers. The following examples explain how to do this using a pocket calculator (other than a Hewlett-Packard). The key to being able to do this is to know how to use a key on the calculator that changes the value of a positive number to negative. This key is usually marked "+/–." In the following examples, each key stroke on the calculator is shown in a set of brackets [ ].

To calculate 3 + 2, enter:
[3] [+] [2] [=]
The answer is 5.

To calculate 3 + (–2), enter:
[3] [+] [2] [+/–] [=]
The answer is 1.

As can be seen in this example, the only difference between the first and second examples is pressing the [+/–] key after the [2] to change the 2 to a negative value.

To calculate (-3) + 2, enter:
[3] [+/–] [+] [2] [=]
The answer is -1.

To calculate 3-(-2), enter:
[3] [–] [2] [+/–] [=]
The answer is 5.

To calculate (–3)–(–2), enter:
[3] [+/–] [–] [2] [+/–] [=]
The answer is –1.

If not using a calculator, two simple rules apply to adding and subtracting negative numbers. To add a negative number, simply consider the value of the number and subtract it. To subtract a negative number, simply add the number as though it were a positive number (the two minus signs cancel each other).

On the first page of the worksheet, fill in all the blanks in the box titled **DETERMINE RANGE OF ACCEPTABLE CENTER WIDTHS**. Work down the box, one line at a time, completing each line before moving down to the next. An arrow points to each blank that needs to be filled in. To fill in the blank, follow the arrow back to its source, and copy the number found there. Be sure to indicate a negative value whenever copying a negative number.

Example worksheet: The value **3** is carried down into both the formulas under **DETERMINE RANGE OF ACCEPTABLE CENTER WIDTHS**.

Example worksheet: The result of the "upper limit" formula is **–1**.

Example worksheet: The result of the "lower limit" formula is **–3**.

At the end of this box are blanks for **Maximum center width** and **Minimum center width**. *If the calculations are correct to this point, these two numbers will always differ by 2.* Transfer the numbers that are filled into these two boxes to the **Maximum center width** and **Minimum center width** boxes on the third page of the worksheet.

Example worksheet: 55 is carried down into the first blank of the **Minimum center width** and **Maximum center width** formulas.

Example worksheet: –3 is carried down to the second blank of the **Minimum center width** formula. The result of the formula is **52**.

Example worksheet: –1 is carried down to the second blank of the **Maximum center width** formula. The result of the formula is **54**.

On the second page of the worksheet, fill in all the blanks in the box titled **AXLE END LENGTH TOLERANCE RANGE FOR ACCEPTABLE CHAINLINE**. Work down the box one line at a time, completing each line before moving down to the next. An arrow points to each blank that needs to be filled in. To fill in the blank, follow the arrow back to its source, and copy the number found there. Be sure to indicate a number has a negative value whenever copying one that is a negative. The result of the first two calculations, labeled UPPER LIMIT and LOWER LIMIT, *will always differ by 4 if the calculations are correct.*

Example worksheet: –3 is carried down into the first blank of the UPPER LIMIT and LOWER LIMIT formulas.

Example worksheet: The result of the UPPER LIMIT formula is **5**.

Example worksheet: The result of the LOWER LIMIT formula is **1**.

The last formula in this box is RESULTING RING-TO-STAY CLEARANCE. Sometimes, if you use the full tolerance range for the spindle, it will result in the chainrings ending up too close to the frame. If this is the case, use the left-hand CORRECTED TOLERANCE box to determine the acceptable tolerance range; if it is not the case, then use the right-hand CORRECTED TOLERANCE box .

Example worksheet: 1.5 is carried down into the first blank of the RESULTING RING-TO-STAY CLEARANCE formula.

Example worksheet: 1 is carried down into the second blank of the RESULTING RING-TO-STAY formula.

Example worksheet: The result of the RESULTING RING-TO-STAY CLEARANCE formula is **2.5**, *indicating only the right-hand box should be used in this example, when moving down the worksheet to the next step*.

Below the box just completed are a left and right box. ***Only one of these boxes should be completed!*** Use the left box ***only*** if the answer in the blank to the left of the statement "*Pick which box below now!" is less than 2.* Use the right box ***only*** if the answer in the blank to the left of the statement "*Pick which box below now!" is 2 or more.* An arrow points to each blank that needs to be filled in. To fill in the blank, follow the arrow back to its source, and copy the number found there. Be sure to indicate a negative value whenever copying a negative number.

Example worksheet: 5 is carried down into the Upper limit blank found in the CORRECTED TOLERANCE box.

Example worksheet: 1 is carried down into the Lower limit blank found in the CORRECTED TOLERANCE box.

On the second page of the worksheet, fill in all the blanks in the box titled **ADD CORRECTED TOLERANCE TO EXISTING AXLE END LENGTH**. Work down the box, one line at a time, completing each line before moving down to the next. An arrow points to each blank that needs to be filled in. To fill in the blank, follow the arrow back to its source, and copy the number found there. Be sure to indicate a negative value whenever copying a negative number.

Example worksheet: 32.5 is carried down into the first blank of both formulas in the last box.

Example worksheet: 5 is carried down into the second blank of the **Maximum axle end length** formula.

Example worksheet: 1 is carried down into the second blank of the **Minimum axle end length** formula.

Example worksheet: The result of the **Maximum axle end length** formula is **37.5**.

Example worksheet: The result of the **Minimum axle end length** formula is **33.5**.

There are blanks at the end of this box for **Maximum axle end length** and **Minimum axle end length**. Transfer the numbers that are filled into these two boxes to the **Maximum axle end length** and **Minimum axle end length** boxes on the third page of the worksheet.

Example worksheet: 52 is carried from the bottom of the first worksheet page (9-16) to the **Minimum center width** box (page 9-18).

Example worksheet: 54 is carried from the bottom of the first worksheet page (9-16) to the **Maximum center width** box (page 9-18).

Example worksheet: 33.5 is carried from the bottom of the second worksheet page (9-17) to the **Minimum axle end length** box (page 9-18).

Example worksheet: 37.5 is carried from the bottom of the second worksheet page (9-17) to the **Maximum axle end length** box (page 9-18).

Search table 9-3 (page 9-20) for spindles that have center width and axle end length that fall in the ranges calculated and list them in the **CONCLUSION:...** box on the third page of the worksheet. It is preferred, but not required, to select spindles that have a long end that is within the axle-end-length range, but it is acceptable to select spindles that have a short end that is correct, as long as the spindle is installed with the short end on the right. *In the case that the worksheet calculates a minimum that is larger than the maximum, the minimum is the only length that will work!* Use the spindle that is in stock and closest in quality to the original spindle.

Example worksheet: JIS 3A is listed as a suitable substitute with center width of **52** and axle end of **33.5**.

Example worksheet: JIS 3P is listed as a suitable substitute with center width of **52** and axle end of **35**.

Example worksheet: JIS 3N is listed as a suitable substitute with center width of **52** and axle end of **36**.

Example worksheet: JIS 3SS is listed as a suitable substitute with center width of **52** and axle end of **37.5**.

NOTE: See example worksheets on next page.

SPINDLE INTERCHANGEABILITY WORKSHEET

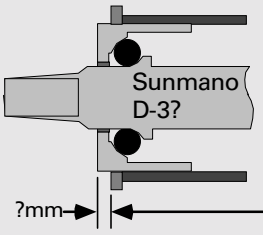
PURPOSE: USE THIS WORKSHEET TO

a) specify suitable replacement spindles that
b) improve or maintain adjustable cup protrusion and
c) improve or maintain chainline while
d) improving or maintaining adequate chainring clearance to the chainstay.

WORKSHEET INSTRUCTIONS

*** *First*, fill in all blanks on the first and second worksheet pages marked with ***.
** *Second*, fill in all blanks on the first and second worksheet pages marked with **.
Third, start at the top of the worksheet, completing each line before moving to the next line down.
Each empty parenthesis is filled in by following the arrow pointing to it back to its source.

EXISTING CONDITIONS



Measure cup protrusion from lockring face *** ___3___ mm

Observe the spindle brand *** ___JIS___ and code *** ___SL___

** ___55___ Measure the distance from the top of one cone profile to the top of the other.

DETERMINE RANGE OF ACCEPTABLE CENTER WIDTH

(The cup face may end up protruding from the lockring face by a range of +2 to –0mm)

DETERMINE TOLERANCE RANGE (for new spindle)

2 - (___3___) = ___–1___ upper limit

0 - (___3___) = ___–3___ lower limit

ADD TOLERANCE RANGE TO EXISTING CENTER WIDTH
(to determine new spindle center width range)

(___55___) + (___–3___) = **52** **Minimum center width**

TO

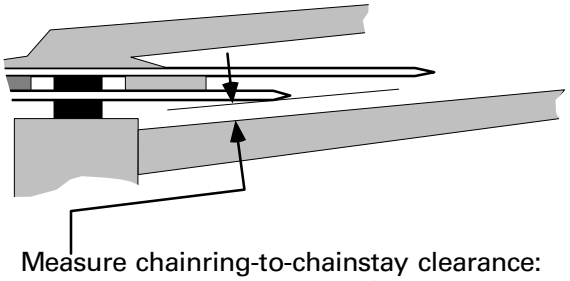
(___55___) + (___–1___) = **54** **Maximum center width**

Numbers in these boxes are the range of acceptable center widths.

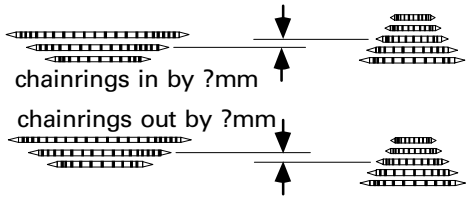
WORKSHEET PART #1

CONTINUE ON NEXT PAGE

EXISTING CONDITIONS



Measure chainring-to-chainstay clearance:
Clearance measures *** 1.5 mm



Measure chainline error and write below.
Write as a negative number if chainrings are in.

Error is *** –3 mm

Observe spindle brand *** JIS and spindle code *** SL

Measure the right end of the spindle from the top of the cone profile to the end:

** 32.5 Axle end length

AXLE END LENGTH TOLERANCE RANGE FOR ACCEPTABLE CHAINLINE

(Chainring center may be ±2mm off freewheel centerline)

UPPER LIMIT 2 – (–3) = 5

LOWER LIMIT (–2) – (–3) = 1

RESULTING RING-TO-STAY CLEARANCE
(rings must clear stays by 2mm)

(1.5) + (1) = 2.5 *Pick which box below now!*

This way only if above is less than 2

CORRECTED TOLERANCE
Upper limit (_____)
Lower limit (_____)

2 – (_____) = _____

ONE ONLY!

This way only if above is 2 or more

CORRECTED TOLERANCE
Upper limit (5)

Lower limit (1)

ADD CORRECTED TOLERANCE TO EXISTING AXLE END LENGTH

or

(32.5) + (5) = 37.5 **Maximum axle end length**

or

(32.5) + (1) = 33.5 **Minimum axle end length**

Numbers in these boxes are the range for acceptable axle end lengths.

WORKSHEET PART #2

CONTINUE ON NEXT PAGE

CONCLUSION: SELECTION OF ACCEPTABLE REPLACEMENT SPINDLES

FROM BOTTOM OF WORKSHEET PART #1

52	**Minimum center width**
54	**Maximum center width**

FROM BOTTOM OF WORKSHEET PART #2

33.5	**Minimum axle end length**
37.5	**Maximum axle end length**

Look up in table 9-3 (page 9-20), and list below the choices that have both a center width and axle end length that fall in the ranges indicated above.

BRAND MS **CODE** 3A **CENTER WIDTH** 52 **AXLE END** 33.5

BRAND MS **CODE** 3P **CENTER WIDTH** 52 **AXLE END** 35

BRAND MS **CODE** 3N **CENTER WIDTH** 52 **AXLE END** 36

BRAND MS **CODE** 3SS **CENTER WIDTH** 52 **AXLE END** 37.5

BRAND_____ **CODE**_____ **CENTER WIDTH**_____ **AXLE END**_____

BRAND_____ **CODE**_____ **CENTER WIDTH**_____ **AXLE END**_____

WORKSHEET PART #3

USING THE JIS SPINDLE-DIMENSIONS TABLE

Table 9-3 (page 9-20) is a list of commonly available bottom-bracket spindles that are manufactured to JIS specifications. They can, in most cases, be manufactured by any number of companies but be consistent enough in design to be interchangeable despite brand differences. The numbers provided are direct from the manufacturer, not measured by Barnett Bicycle Institute. It is our experience that manufacturers sometimes do not hold very tight tolerances, so do not be surprised if a spindle does not exactly match the given numbers. Even when the JIS standardizes something, such as that a 3S spindle should measure 37.5mm on the long end, 52mm in the center, and 32mm on the short end, manufacturers may deviate dramatically; for example, a Sugino brand 3S spindle is 35mm on the short end instead of the usual 32mm.

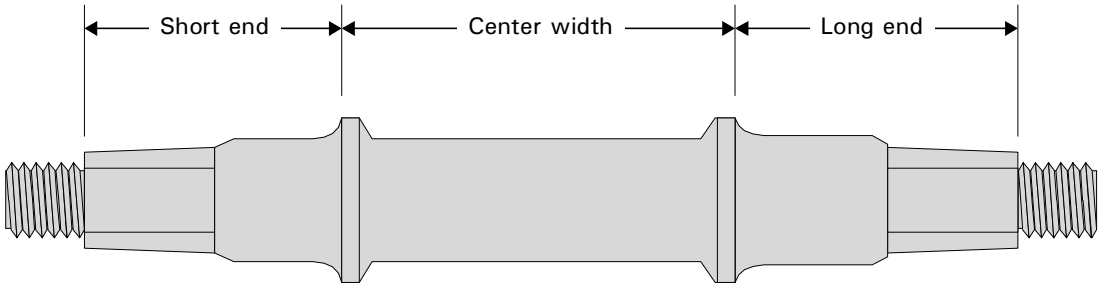
Even when a spindle measures exactly as it is supposed to, it does not mean that it will fit exactly like it is supposed to. Two spindles from two companies, or even from two batches by the same company, may both have the same long-end length, but the chainrings may end up several millimeters closer to the frame with one spindle than the other. This could be caused by variations in taper thickness. A fatter spindle will not insert as far into a crank arm as a thinner spindle. It could also be caused by differences in surface texture on the spindle flats. A smoother spindle will insert further into a crank arm than a coarser one when the crank arm is secured to both with the same torque.

This dimension table is useful only for common Asian spindles. Certain spindles, such as Shimano Dura-Ace, all Campagnolo, all other European brands, Specialized, and SunTour are so different in design that comparing measurements on one brand to measurements on another brand is meaningless. For example, a Specialized spindle marked 114-68 has a center width of 49mm. All of the spindles in the following table with a "3" in the code have a center width of 52mm. It is logical to assume that if removing the Specialized spindle and installing one of the "3" coded spindles in its place that the adjustable cup would stick out 3mm more. In fact, due to the smaller cone diameter on the "3" coded spindles, the adjustable-cup position remains virtually the same.

When interchanging spindles that are not on this list, stick with trial and error, or with spindle tables in *Sutherland's fourth* and *fifth* editions. *Sutherland's* has factored variables such as variations in and taper thickness to come up with "axle end factor" values that can be compared to each other just like the long end and short end lengths. *Sutherland's* has factored variables such as variations in cone diameter to come up with "center width factor" values, which can be compared to each other just like the center widths can be compared. The **SPINDLE-INTERCHANGEABILITY WORKSHEETS** can be used with *Sutherland's* "factors" with the following considerations. When the worksheet suggests measuring the existing center width or axle end, use the "center width factor" and the "axle end factor" in the appropriate *Sutherland's* tables. Do not mix these "factors" with actual spindle dimensions. The whole worksheet has to be done one way or the other.

The values on the following table can be used on the **SPINDLE-INTERCHANGEABILITY WORKSHEET**. When the worksheet suggests measuring an existing spindle, look up information on the existing spindle in the following table or take measurements directly from the spindle.

It is generally accepted that the long end is the right side and the short end is the left, but there is no reason that these cannot be reversed if it improves the chainring position.



JIS SPINDLE DIMENSIONS (table 9-3)

Codes	Long end (mm)	Short end (mm)	Center width (mm)
Sugino MS-68, Shimano D-3K	28.0–28.5	28.0–28.5	52
3I-B	30	29	52
3H, D-3H, 3H-B	30.5–31.0	30.5–31.0	52
3J, 3J-B, 3L, D-3L, 3L-B	32	32	52
Sugino MW-68	33.5	30.5	52
3A, D-3A, 3A-B, 3K, 3K-B	33.5	32	52
3P, D-3P, 3P-B	35	32	52
3N, 3N-B	36	32	52
3NL, D-3NL	36	34.5	52
3NN, 3NN-B	36	36	52
Sugino MT-68	37.5	29.5	52
3SS, D-3SS, 3SS-B	37.0–37.5	32	52
3S, D-3S, 3S-B	37.5	32	52
Sugino & Tange 3S	37.5	35	52
3T, D-3T, 3T-B	38.5–39.0	32	52
Sugino & Tange 3T, 3T-B	38.5–39.0	35	52
3TM-B, 3TS, D-3TS	39	37.5	52
Sugino 3U-B	40.5	32	52
3U, D-3U	40.0–40.5	35	52
Tange 3U	40	39	52
D-3XA	40.5	39	52
3X	40.5	40.5	52
Sugino 3R, 3R-B	42	32	52
3R, D-3R, 3R-B	42	35	52
Sugino 3RR-B	42	35	52
3TR-B	42	39	52
3RR-B	42	42	52
3M	43.5	35	52

Codes	Long end (mm)	Short end (mm)	Center width (mm)
Sugino MS-70	28.5	27.5	53.5
Sugino MW-70	32.5	29	53.5
Sugino MT-70	37	29.5	53.5

5H, D-5H	31	31	55
5J-B	32	32	55
5L, D-5L	32	32	55
5LL	32	32	55
D-5A	32.5	31	55
5P, D-5P	33.5–34.0	31	55
5N, 5N-B	35	32	55
D-5NL	35	33.5	55
D-5SP, 5SP-B	37.5	30.5	55
5SS, 5-SSB	37.5	32	55
5S (Sakae Royal, SR)	37	32	55
Sugino 5S-B	37.5	32	55
5S	37.5	35	55
5T, D-5T	39	35	55
Sugino 5U, 5U-B	40.5	32	55
5U, D-5U, 5U-B	40.5	35	55
5R	42	35	55

7H, D-7H	30.5	30.5	57
7L	32	30.5	57
7P-B	33.5	30.5	57
7NL, D-7NL, 7NL-B	33.5	32	57
7EL, D-7EL, 7EL-B	36.0–36.5	35.0–35.5	57
D-7S	37.5	35	57
7T-B, D-7TL	39	35	57
7R-B	42	35	57

ADUSTABLE-CUP BOTTOM-BRACKET TROUBLESHOOTING

Cause	Solution
SYMPTOM: *The bearing adjusts with a tight/loose pattern, i.e., with the adjustment completed, the spindle is tight through a portion of its rotation, and looser in another portion.*	
Bearing cups seated against misaligned shell faces.	Face bottom-bracket shell.
Low-precision parts.	Will go away with break-in if facing shell does not solve.
Bent spindle (detect by rolling on flat surface).	Replace spindle.
Cup(s) cross-threaded.	Tap shell with piloted taps.
SYMPTOM: *The spindle feels "sluggish" to rotate after completing a precision adjustment.*	
Grease is dried out.	Inspect, then overhaul.
Seal mechanism causes drag.	Lubricate seal mechanism, problem may reduce with use.
Seal mechanism is installed wrong.	Check that seal is properly mounted in groove. Try reversing orientation.
SYMPTOM: *Bearings feel "rough" after completing a precision adjustment.*	
New, low-precision parts.	Will improve with break-in.
Contamination in bearings.	Overhaul.
SYMPTOM: *Play cannot be eliminated without making the spindle very difficult to rotate.*	
Parts are worn out.	Disassemble and inspect.
Too many ball bearings.	Disassemble and inspect.
Bearing retainer reversed (evidence would be that the adjustable cup would not be inserting as far as it did originally).	Disassemble and inspect.
Seal mechanism in wrong.	Disassemble and inspect.
SYMPTOM: *A gritty or rough feeling that is not constant in location.*	
Contamination in bearings.	Overhaul.
SYMPTOM: *Adjustable cup will not reinstall to original depth.*	
Retainer in backwards.	Disassemble and inspect.
Balls out of position in cups.	Disassemble and inspect. Balls may be caught on upper lip of race.
Too many balls.	Check ball quantity and use fewer if balls are jumbled in cup.
Cup is cross threading.	Remove cup and attempt to thread straight. Disassemble and tap shell if necessary.
Ball bearings wrong size.	1/4" balls have been used where 7/32" or 3/16" are required.
SYMPTOM: *A clicking, knocking, popping sound or sensation is heard or felt from the bottom bracket after eliminating loose cranks, loose pedal mounting, loose pedal parts or bearings or loose chainwheel bolts as possible causes.*	
Loose lockring.	Tighten lockring.
Loose fixed cup.	Tighten fixed cup.
Extremely worn parts.	Disassemble and inspect.

Continued next page

ADUSTABLE-CUP BOTTOM-BRACKET TROUBLESHOOTING (continued)

Cause	Solution
SYMPTOM: *Fixed cup is loose.*	
Not properly installed (common).	Reinstall with correct Loctite and torque.
Threads have failed.	Simple and inexpensive solution is to install a cup in good condition with Loctite #RC680. This installation should be considered permanent. A more difficult and expensive solution appropriate on expensive bikes is to convert the threading to Italian if it is not already; converting threads to Italian is time-consuming, dulls the taps rapidly, and results in poor-quality threads. One other solution is to install a Mavic bottom bracket (if there is one available compatible with the crankset) because they do not use threads to install. The bottom bracket must be modified with a Mavic facing tool (see page 10-4).
SYMPTOM: *Premature wear of components.*	
Improper original lubrication or adjustment (common).	Check all factory assemblies.