

Professional Locksmith

Study Unit 4

Lock Mechanisms

DRAFT

This sneak preview of your study material has been prepared in advance of the book's actual online release.

Preview

Welcome to Study Unit 4 of your Professional Locksmith course! In your last study unit, you learned all about keys and how to identify them. Now, in this study unit, you'll begin learning about lock mechanisms in depth. A *lock mechanism* is the internal assembly of a lock that makes it work.

You'll be learning about a variety of lock mechanisms including key-operated, combination, and electric types. With the assistance of plenty of detailed diagrams and drawings, you'll be able to look at the insides of locks. You'll discover how these locks are constructed and how they work.

Then, when you've gained a solid foundation of knowledge about lock mechanisms, you'll learn what types of problems these locks are likely to have and what services locksmiths will need to perform. We'll explain how to completely disassemble and reassemble various lock mechanisms. Finally, we'll tell you how to perform simple servicing, cleaning, and lubrication on lock mechanisms.

When you complete this study unit, you'll be able to

- Name the four basic key-operated lock mechanisms
- Identify the basic types of key-operated lock mechanisms by visual inspection
- Name the principal parts of each lock type
- Explain, in simple language, how different types of lock mechanisms work
- Clean, lubricate, and perform simple maintenance on locks
- Disassemble and reassemble each type of lock as needed for servicing
- List the strong and weak points of each type of mechanism
- Explain how high security locks function
- Explain how combination entry locks work

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Lock Mechanisms

Do You Know . . .

What is the most important component of a combination lock?

What are the major parts of a padlock?

What is a *ward*?

In these pages, you'll find the answers to these and many more questions about lock mechanisms.

INTRODUCTION

What is a Lock Mechanism?

A *lock mechanism* is the assembly of parts inside a lock that makes it work. In most common locks, the locking mechanism holds or moves a latch, bolt, or shackle into the locked or unlocked position. Due to the many types of lock designs, there are many different types of locking mechanisms.

For example, a door lock contains a mechanism to operate a latch or bolt. The latch or bolt is the part that extends into the

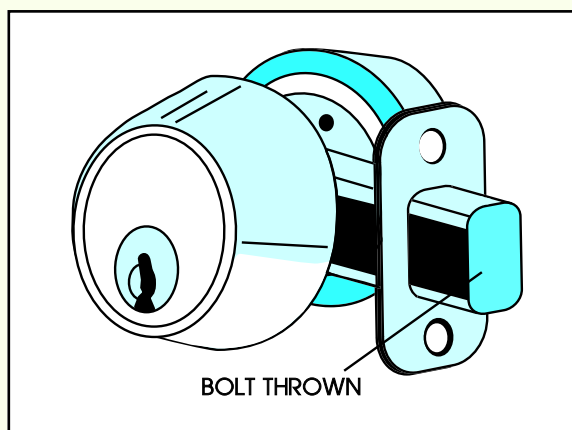
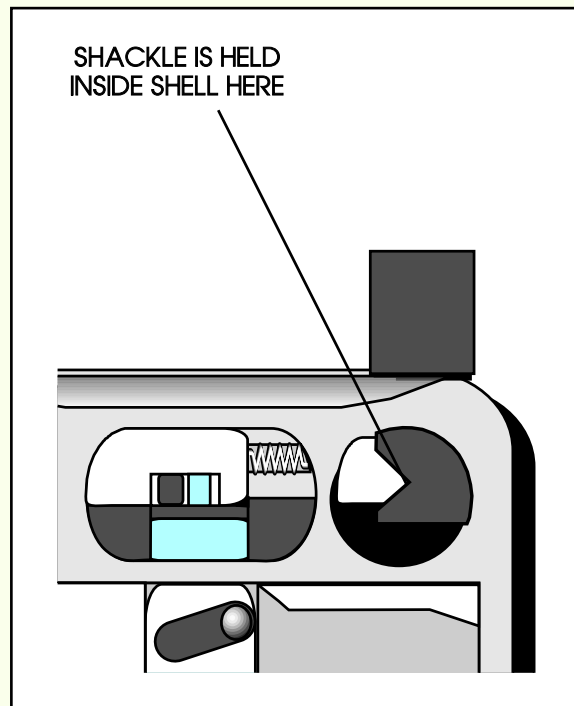


FIGURE 1—This figure shows a bolt in the “thrown” position.

strike, anchoring the door to the door frame. When the bolt is thrown, it moves into the strike and locks the door; when the bolt is retracted back out of the strike, the door is free to open (Figure 1).

FIGURE 2—A padlock mechanism holds the shackle inside the lock case or shell.



In contrast, a padlock contains a mechanism that holds the shackle in the case or shell of the lock, or that allows the shackle to release (Figure 2).

Locks vs. Lock Mechanisms

It's important for you to note the difference between a *lock* and a *lock mechanism*. The word *lock* is a general term that refers to any device installed or attached to improve security. A padlock, a door lock, a car ignition lock—all of these are *locks*. A *lock mechanism* is the inside structure of a lock. For example, a door lock could contain a warded mechanism, pin tumbler mechanism, or a disk tumbler mechanism, depending on how it was made.

For our study purposes, all lock mechanisms can be divided into three basic types: *key-operated lock mechanisms*, *combination lock mechanisms*, and *electric lock mechanisms*. In this study unit, we'll examine each of these different mechanisms in detail. We'll look at how they're constructed and how they operate; then we'll examine simple repair techniques for each type. Let's start by turning our attention to key-operated lock mechanisms.

KEY-OPERATED LOCK MECHANISMS

How Key-Operated Mechanisms Work

A *key-operated lock mechanism* is simply any type of lock that's opened and closed by inserting and turning a key. (Remember, as we discussed in Study Unit 2, not all locks are opened by a key. Some locks are opened by dialing a number combination, and some contain electrically-operated switches.) However, key-operated locks are the most common and familiar to us. Key-operated locks are found in residential doors, cars, and padlocks.

The four most common types of key-operated lock mechanisms are the *warded mechanism*, the *lever tumbler mechanism*, the *disk tumbler* or *wafer mechanism*, and the *pin tumbler mechanism*. We'll discuss each in turn now.

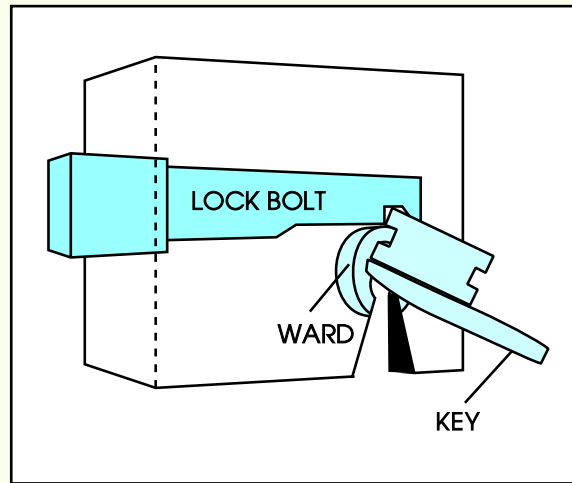
The Warded Mechanism

The word *ward* means *to guard* or *guard against*; thus, we may "ward off" a cold by taking vitamin C (or a bowl of chicken soup). Similarly, a *warden* is a prison guard. In locksmithing terms, a *ward* is a metal barrier inside a lock mechanism that prevents just any key from opening the lock. The ward ensures that only the proper key will engage the mechanism and open the lock. The "right" key contains cuts that exactly match the shape of the wards inside the lock.

The warded lock mechanism is the oldest type still in use today (it was first used by the Romans thousands of years ago). Bit keys and barrel keys are used to open warded door and cabinet locks; flat keys are used to operate warded padlocks.

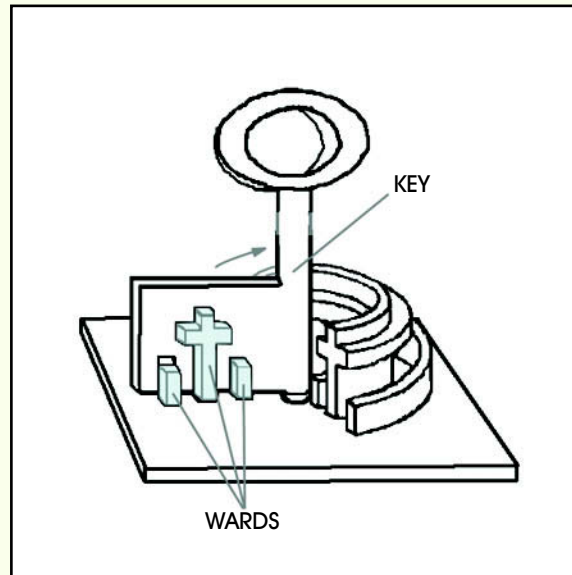
The basic principle behind the warded lock is *barrier protection*. This means that the wards create a physical barrier that must be overcome before the lock can be opened. The security of the warded mechanism comes from the type and number of wards it contains. A ward is simply a metal ridge inside the lock that creates a barrier to the lock bolt. A properly-cut key will fit around the wards and be free to turn, opening the lock.

FIGURE 3—This warded mechanism contains two wards.



A warded lock can contain any number of wards. The simplest type contains only one ward and is called a *single-warded lock*. The interior of a simple warded lock is shown in Figure 3. Note that when the key is inserted, the cut corresponds exactly to the placement of the wards. When the proper key enters the keyhole of the unlocked door, negotiates the wards, and is turned, it raises the deadbolt over the obstructions that detain it. The deadbolt enters the strike, and the door is now effectively locked.

FIGURE 4—This complex warded lock contains several wards arranged to provide extra security for the lock. Note the many cuts needed on the key to allow it to clear the wards.

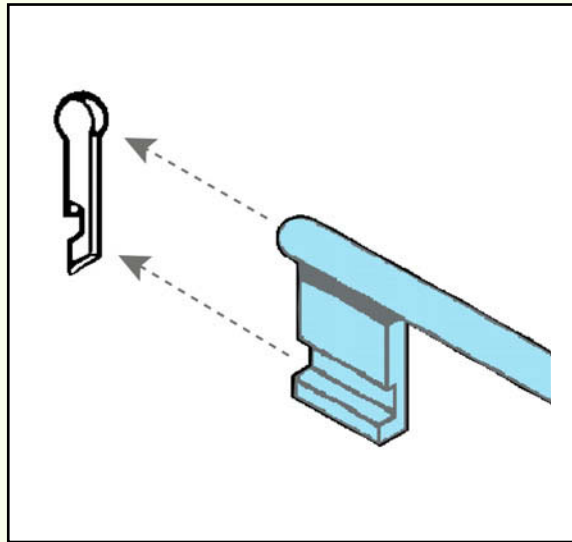


Now look at the lock interior shown in Figure 4. This lock contains several complex wards. The key for this lock was elaborately cut to “clear” the obstructions caused by the wards.

Some locks have wards on the exterior of their keyways. These wards are called

case wards. Case wards add a little security to a lock, since an additional cut must be made on a key just to allow it to slide into the keyway (Figure 5).

FIGURE 5—Case wards in the keyway of a warded lock add a little security.



A *skeleton key* is a key that has been ground down to make it very thin (Figure 6). The wards of a warded lock are easily bypassed using a skeleton key. For this reason, warded locks are not recommended in circumstances where a high degree of security is desired.

Warded Mortise Locks and Warded Rim Locks

The warded door lock in Figure 7B is called a warded *mortise lock*, because it is installed in a recess in a door called a *mortise*. By comparison, the warded *rim lock* in Figure 7A is surface-mounted *on* (rather than *in*) the door.

Figure 8 shows the interior mechanism of a typical warded rim lock. Note that the lock contains *two* bolts: a key-operated *deadbolt* and a latch bolt. The latch is operated by turning the door-knob. The latch fits securely into a strike, the metal plate recessed in the door jamb. When the latch is in place, the door will be held closed, but not locked, since no key is required to move it. When the inside latch

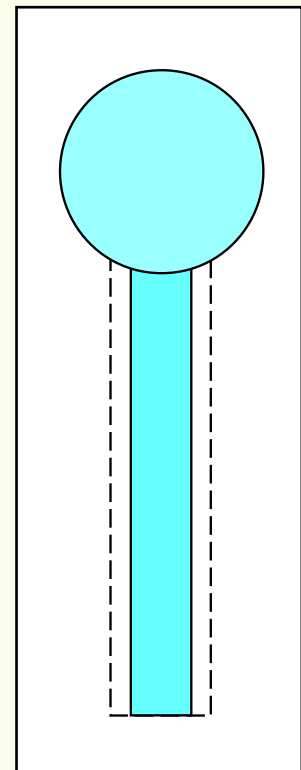
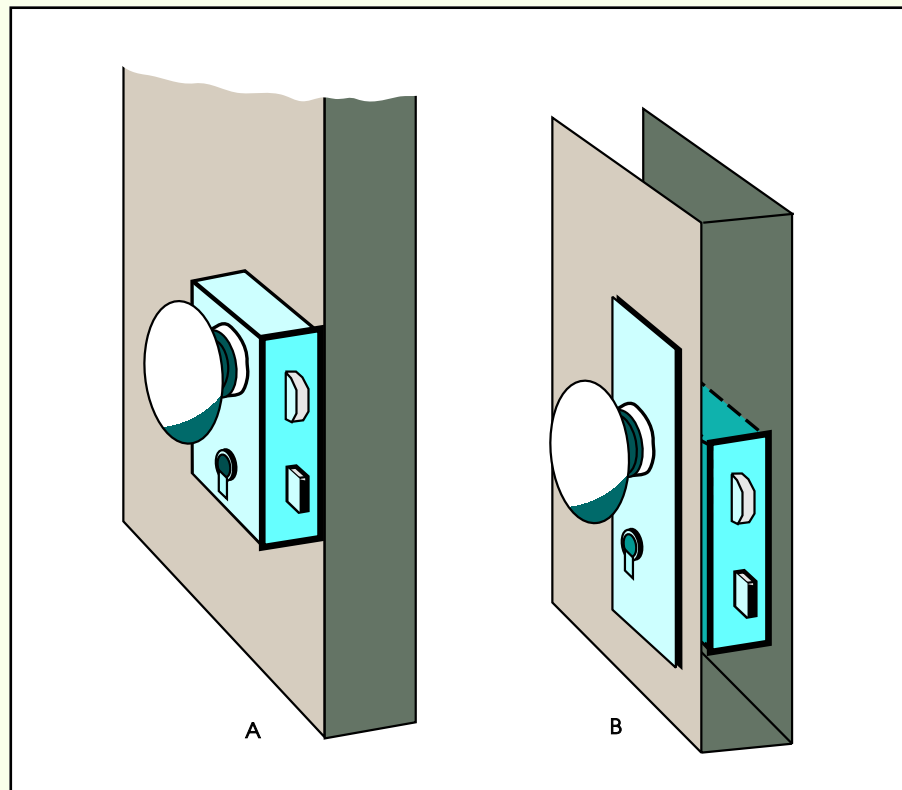


FIGURE 6—A skeleton key is designed to bypass the wards in a warded lock.

FIGURE 7—Part A of this illustration shows a warded rim lock; Part B shows a warded mortise lock.



button is pressed down, though, it does prevent the latch bolt from being released by anyone *outside* the door. The deadbolt is operated by a key or by turning a turnpiece inside the door. The door is truly locked when the deadbolt is thrown.

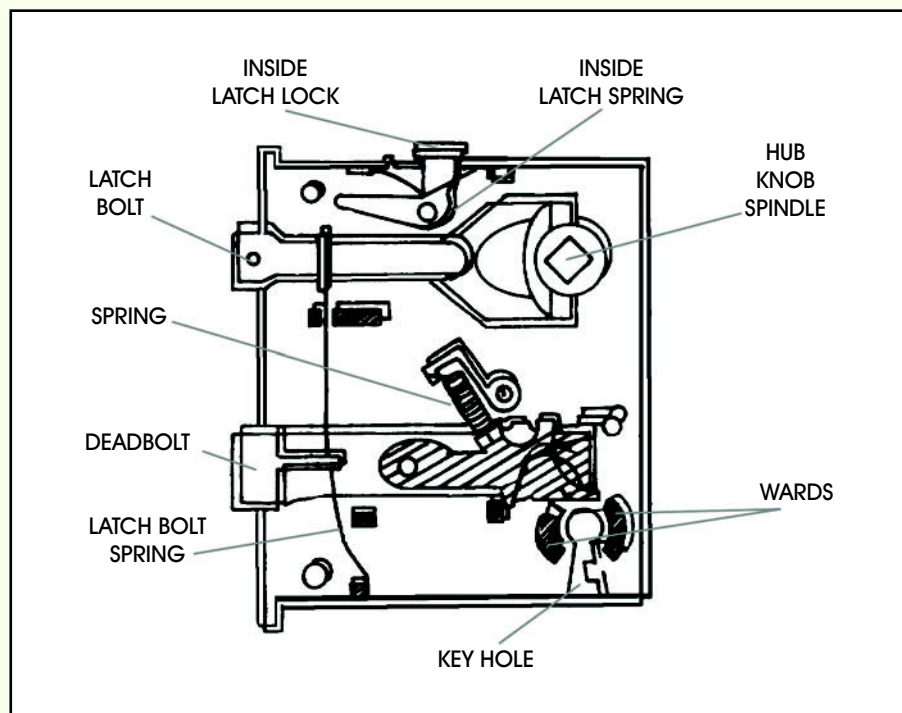


FIGURE 8—Interior of a Warded Rim Lock

Advantages and Disadvantages of the Warded Lock

Warded locks aren't generally used on today's exterior doors. They have been replaced by pin tumbler or disk tumbler locks in most cases. This is because warded locks aren't nearly as secure as pin tumbler locks (which we'll discuss shortly).

Why isn't the warded lock secure enough? Well, a lock's security depends on the following two things:

1. The complexity of its internal mechanism
2. The ease of looking into the lock to see the mechanism

In both of these cases, the warded lock offers little protection. Its mechanism is simple and the keyhole is large enough to view most of the inside of the lock. Because the keyway is so large, it's very simple to look inside the lock, bypass the wards with a pick, and release the locking mechanism to disengage the latch or bolt and open the door.

The simplest method of picking a warded lock is to use a *pick key*. Several pick keys for warded locks are illustrated in

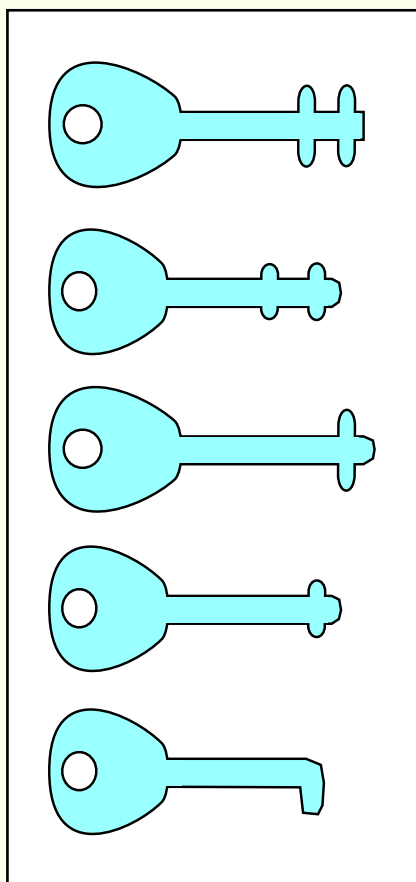


FIGURE 9—Key picks like the ones shown here are useful for opening warded locks.

Figure 9. A pick key is a specially ground and cut piece of flat steel that will fit into the keyway of a lock. A small curved projection is left near the tip of the key pick. The remainder of the key pick is quite narrow. A pick key will open all but a few warded lock types.

As you can see by the variety of ward cuts on these pick keys, it's a simple matter to select a pick key and turn it gently in the lock. If you feel an internal ward interfering with the pick key, you simply stop and try another pick key.

However, despite the relative lack of security in warded locks, note that there are circumstances when the simplicity of the warded lock is an

advantage. For example, warded padlocks are a good choice for use in wet, sandy, or dusty environments where a more complex lock would rust or jam easily.

Cleaning, Lubrication, and Repair of Warded Locks

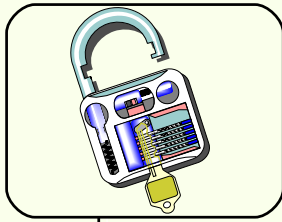
Often, a warded lock will stop working, or will work only with difficulty. Note that while it's usually easier and cheaper to replace a warded lock than repair it, a customer may want an old lock repaired anyway. This is especially true in very old homes where the owner may want to keep the warded lock for its "quaint" appearance.

You may also be called upon to repair small warded locks in antique furniture (chests, cabinets, clocks, trunks, and so on). One good suggestion is to keep any old lock parts and any old bit and barrel keys you can find (at junk shops, yard sales, and so on). Since these parts and keys aren't widely manufactured anymore, keep them on hand for repairs.

One of the most common causes of warded lock failure is the buildup of dust and debris inside the lock. Paint is one of the biggest offenders. Repeated painting of a door over the years can leave a warded lock clogged and can make it impossible to insert or turn the key.

In such a case, you'll need to open up the lock to clean it, lubricate it, or replace worn parts. The warded lock is the easiest to disassemble of all the lock types we'll look at. Simply remove the screws on the cover plate, and the "guts" are exposed. After removing the cover plate, replace any rusted or worn parts. Then, use a wire brush to clean dirt and old paint away from the affected lock parts. Unless absolutely necessary, stay away from commercial paint removers: they tend to attract lint after use.

Next, use a commercial lubricant such as WD-40 (*never* oil; we'll explain why later) to lubricate the lock. You can apply it using the spray assembly attached to the can.



Locking It Up! 1

At the end of each section in your *Professional Locksmith* texts, you'll be asked to pause and check your understanding of what you've just read by completing a *Locking It Up!* quiz. Writing the answers to these questions will help you review what you've studied so far. Please complete *Locking It Up! 1* now.

Fill in the blanks in the following statements.

1. _____ keys and _____ keys are used to open warded door and cabinet locks.
2. A _____ is the assembly of parts inside a lock that makes it work.
3. A _____ contains a mechanism that holds or releases a shackle in the case or shell of the lock.
4. A _____ is simply any type of lock that's opened and closed by inserting and turning a key.
5. The word _____ means *to guard* or *guard against*.
6. Wards on the exterior of the keyway of a lock are called _____.
7. A _____ is a key that has been ground down to bypass the wards in a warded lock.
8. A _____ lock is mounted on the surface of a door.

Check your answers with those on page 53.

The Lever Tumbler Mechanism

Figure 10 shows an exterior view of a typical *lever tumbler* lock. Lever tumbler locks are used on school lockers, cash boxes, suitcases, mailboxes, and safe-deposit boxes. The slim, flat design of the lever tumbler lock is more appropriate for these applications than a cylinder-type lock. Modern lever tumbler locks almost always use *flat keys*, although some European models are operated with bit or barrel keys. The average lever lock is only slightly more secure than the warded lock; however, the lever locks used on safe deposit boxes are very secure.

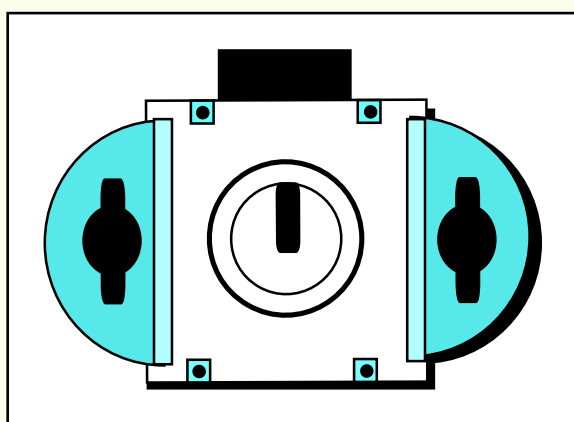


FIGURE 10—A Lever Tumbler Lock

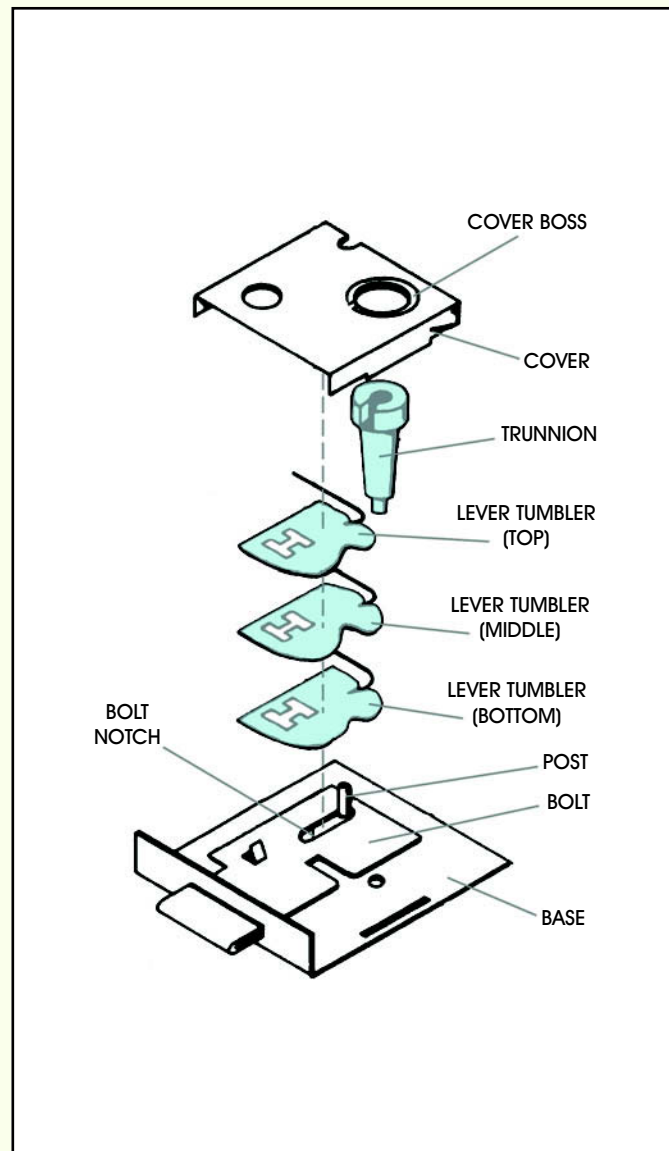
Lever tumbler locks are available in a wide range of security levels. Generally, the lever tumbler locks you will encounter will have between two and five lever tumblers within the lock. Some high-security lever tumbler locks can have

as many as sixteen lever tumblers. (The more tumblers, the more difficult it is to invade the lock.) High-security lever tumbler locks are used on some types of bank safe deposit boxes and on some types of public lockers. In this section on picking lever tumbler locks, we'll look at the medium security lever tumbler locks with two to five lever tumblers.

Now, let's look at the interior of a lever tumbler mechanism (Figure 11) to see how it operates. This lock mechanism contains three lever tumblers. Regardless of the number of tumblers, however, the operation is essentially the same in all lever tumbler locks.

Each lever tumbler is a flat metal plate held in place by spring pressure. Figure 12 shows the parts of one lever tumbler. Taking a close look at these parts will help you understand how the lever tumbler lock operates. The *lever* is the most important part of the lever lock mechanism, since its movement controls the movement of the bolt. Other important components of the lever tumbler lock are the *gate*, the *post*, and the *saddle*.

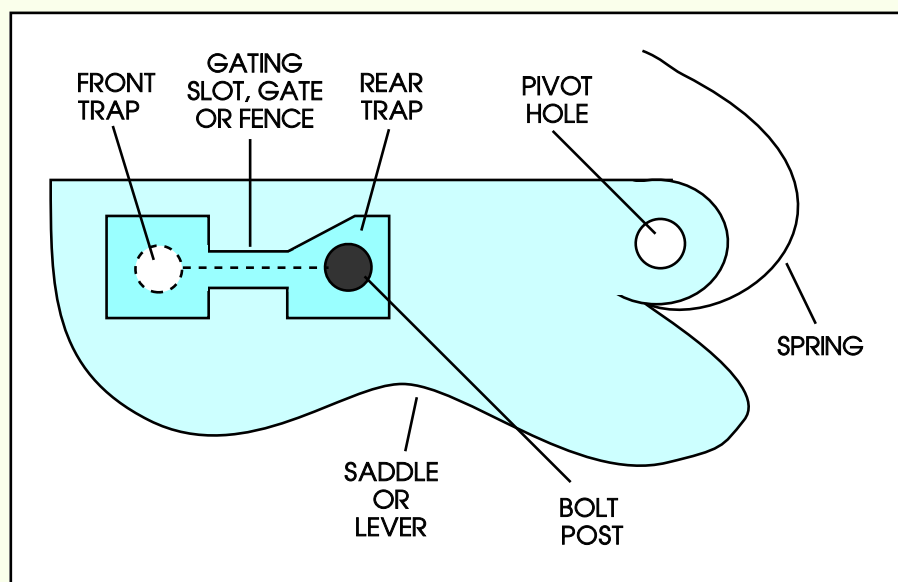
FIGURE 11—This figure shows the interior of a lever tumbler lock mechanism.



The key enters through the *cover boss* and *trunnion*. When the key is inserted, the key's cuts will engage the saddle of each lever tumbler. The saddle must be raised enough to allow the post that is attached to the bolt to slide into the rear trap. When this action occurs, the bolt will slide out of the jamb of the door, opening the door.

In some lever tumbler locks, you may see different colored levers. The color of the lever will identify the trap-to-saddle distance. Also, in some lever tumbler locks, the levers themselves will be of different thicknesses. Here the thicker the lever the greater the distance is between the bottom of the saddle and the center of the trap.

FIGURE 12—This illustration shows the parts of one lever tumbler.



Disassembly and Servicing

Lever tumbler locks that have been riveted or spot-welded are generally very inexpensive, and aren't worth the work required to disassemble and reassemble them. Instead, they should just be replaced. Other types of lever locks can be opened either by removing the cover screws or by prying the cover off, according to how the cover is attached. Carefully remove the trunnion, and then the lever tumblers *in order*. Reassemble by reversing the procedure.

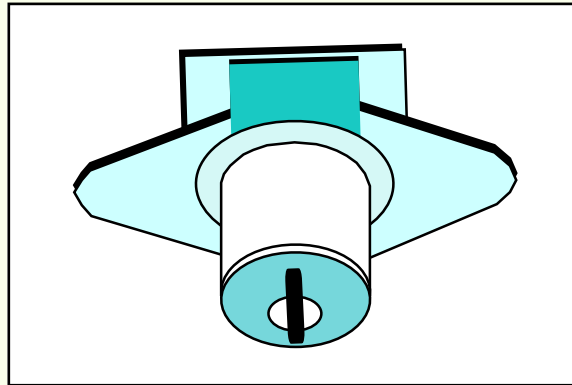
Once the lever tumblers have been removed, the exposed base and bolt can be checked for irregularities. If you find any foreign matter, remove it.

The most probable cause of trouble in a lever tumbler lock is a broken spring. To correct, remove the broken spring from the affected lever and replace it.

The Disk or Wafer Tumbler Mechanism

The disk tumbler mechanism (also called the wafer tumbler mechanism) is commonly used in automobile doors, desks and cabinets, and vending machines. Disk tumbler locks provide much better security than warded or lever tumbler locks. Note that while most disk locks are constructed the same way, their

FIGURE 13—This type of disk tumbler lock is commonly used on desks.

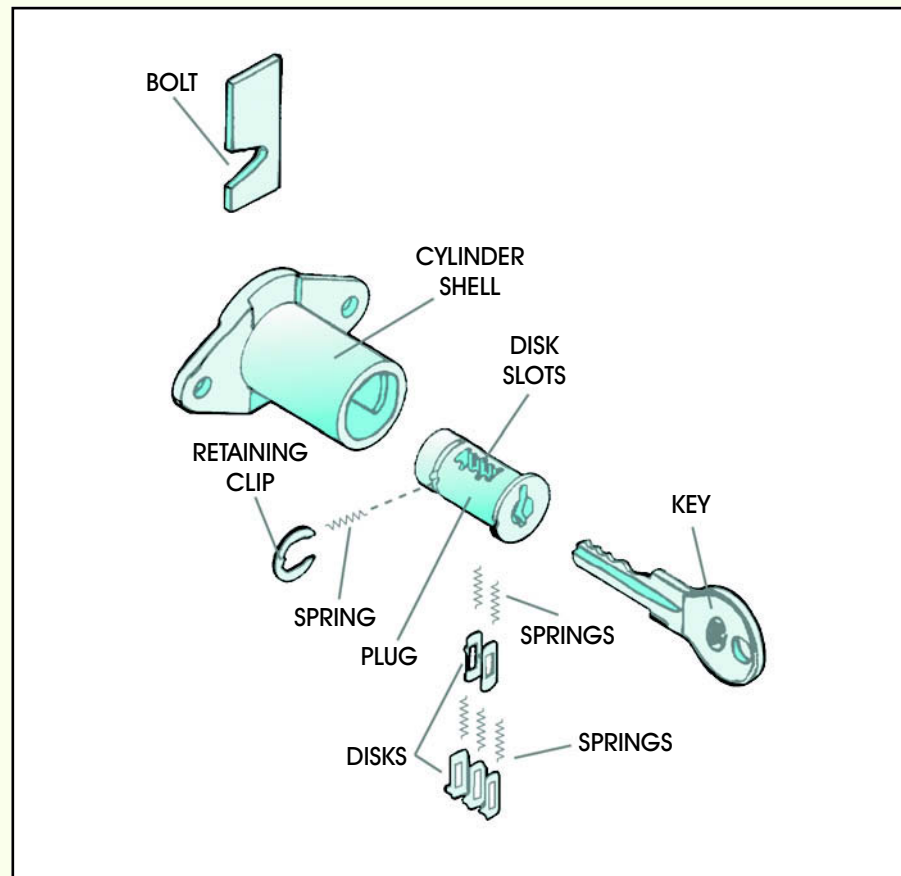


outward appearances may vary depending on what the lock is used for. Figure 13 shows a familiar example of a disk tumbler lock.

Figure 14 is an exploded drawing of the principal parts of a disk tumbler

lock. The main components of a disk tumbler lock are the *shell*, the *plug*, the *disks*, and the *springs*. Let's examine the disks first.

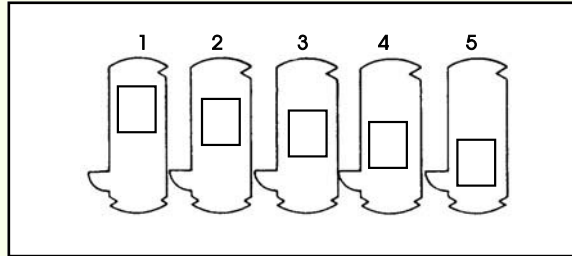
FIGURE 14—Exploded View of a Disk Tumbler Lock Mechanism



When you first think about a disk tumbler or wafer tumbler lock, you may think that the disks within the lock are circular. However, this is not the case. The disks or wafers inside these locks are small, flat, rectangular pieces of steel, each containing a slot or hole. The key will be inserted into these slots to operate the lock.

For most disk locks, the disks come in five different slot arrangements (Figure 15). The location of the slot in each disk will determine the key cut depth needed. In Figure 15, note that the position of the slot in each disk is a little different. The distance from the top of each disk varies. You may also notice that each disk has a number stamped on it. This number identifies the type of disk you're working with.

FIGURE 15—The five different sizes of discs in a disk tumbler lock are shown here.



A disk tumbler lock's *plug* will contain an arrangement of any of these five disks (any one of the disks may appear more than once, as well). While the

five disk tumblers inside the disk tumbler lock plug are the same height and width, the rectangular cuts in the disks vary in terms of their position on the disks. The key has five cuts that correspond exactly to these tumbler cuts. The arrangement of the disks forms each lock's individual combination.

The plug is held inside the shell. The shell contains an upper and a lower slot. The disks or wafers inside the plug "stick out" a little and fit into the lower slot in the shell. The disks or wafers are pressed into the slot by means of small springs. This keeps the plug from turning inside the shell when there's no key in the lock.

The disks are slotted for key entry. When the proper key is inserted into the lock, the disks are pulled away from the slot in

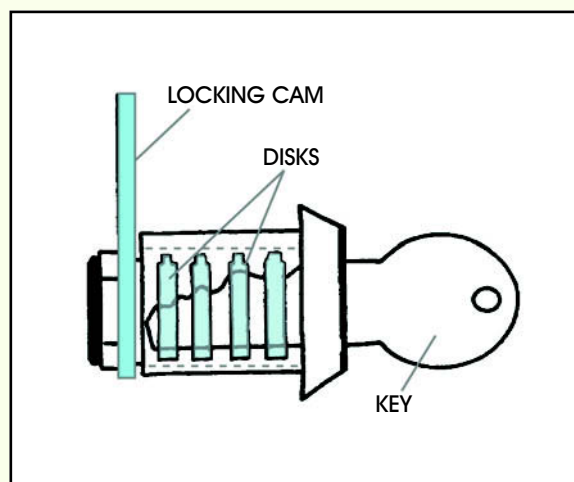


FIGURE 16—This cutaway side view shows a key inserted in a disk tumbler plug. The disks have been pulled into alignment by the key, freeing the plug to turn.

the shell and centered in the plug. This action frees the plug from the shell and allows the plug to turn with the key. Figure 16 shows a view of a key inserted in a disk lock.

If an improperly cut key is inserted into the plug, one or more of the disks

may not be lifted out of the slot in the shell. This action will prevent the plug from turning and the lock from opening.

The Side Bar Wafer Lock Mechanism

A *side bar wafer lock* is a variation of the disk tumbler lock. Side bar wafer locks provide a greater degree of security than simple disk tumbler locks because they're extremely difficult to pick. Side bar wafer locks will make up a large amount of your locksmithing work. This is because they're inexpensive, and also because they're widely used for ignition, door, and trunk or rear hatch locks for General Motors automobiles and light trucks.

The five types of wafers that you might find inside a side bar wafer lock are shown in Figure 17. The disks in a side bar wafer lock are much like those in a standard disk tumbler lock, but with one change: each disk (or wafer) has a V-shaped notch on one side. These wafers may be identified by a number (one through five) stamped on the wafer. These numbers refer to the heights of the position of the V-shaped notch.

You'll remember from our previous discussion that a regular disk lock opens when the disks disengage from a slot in the shell, allowing the plug to turn. In contrast, in a side bar wafer lock, the disks release a *side bar* that disengages from a slot in the shell.

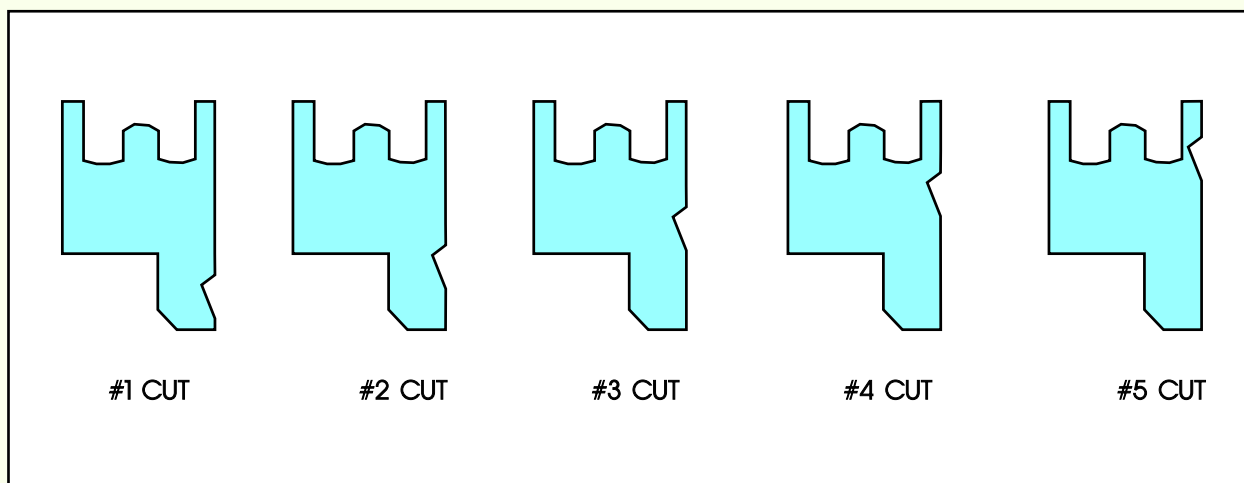
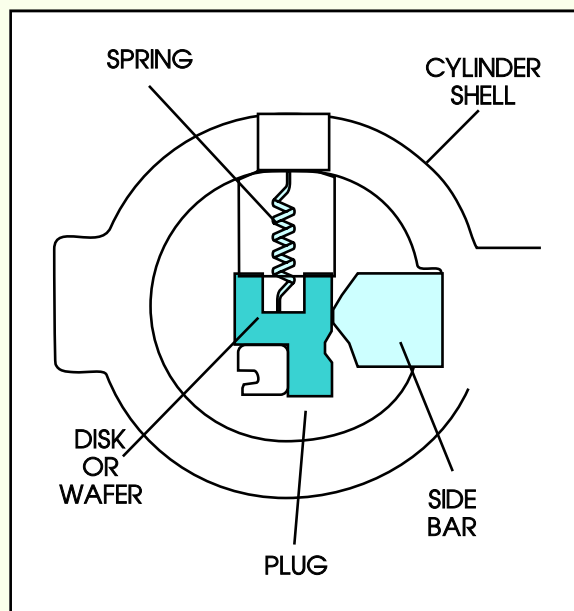


FIGURE 17—This figure shows the five types of wafers or disks you'll see inside a side bar wafer lock. Note the V-shaped notches in the sides of the wafers.

FIGURE 18—In this cutaway view of a side bar wafer lock, you can see how the disks must be aligned to allow the side bar to disengage from the shell.



When the side bar wafer mechanism is locked, the side bar extends into a special slot inside the shell; as a result, the plug is held securely in place. As the key enters the plug, the key pushes the disks upward, causing the side bar to fall into the group of V-shaped notches on the side of the disks. The side bar is now clear of the

slot, and the plug is free to turn with the key. The disks can only be aligned by the proper key. The operation of a typical side bar wafer arrangement is shown in Figure 18.

The Cam Lock Mechanism

One variation of the disk tumbler mechanism is the *cam lock* shown in Figure 19. Cam locks are used extensively on cabinet doors and desk drawers.

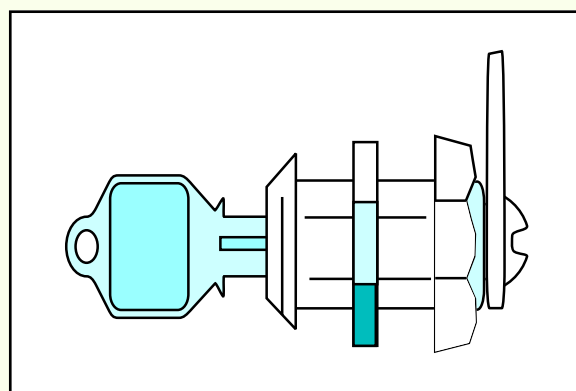


FIGURE 19—This illustration shows a typical cam lock.

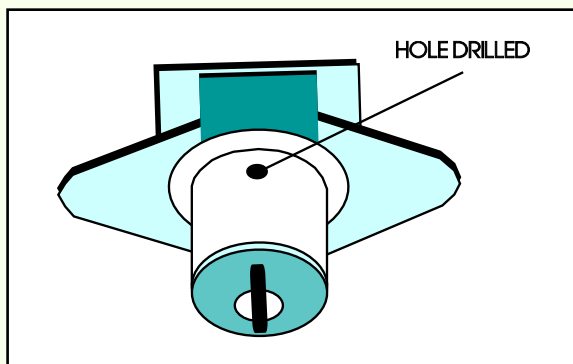
In this kind of lock, a moveable *cam* is attached to the rear of the lock. The cam is a flat piece of metal that rotates when the key is turned in the lock. The cam creates a physical barrier that prevents a door or drawer from being pulled open.

When the cam is turned into the “lock” position, the cam will hold the door or drawer in place. When the cam is turned to the “unlock” position, the door or drawer will be free to open.

Disassembly

Disk locks may need to be disassembled for cleaning, repair, or rekeying. Some disk tumbler locks are easy to take apart, others are not; it depends on the method used to hold the plug inside the shell. Some plugs are held with a screw-in retaining plate; others must be drilled to access the internal retaining clip.

FIGURE 20—A hole has been drilled in this disk tumbler lock to allow access to the retaining clip.



In the lock shown in Figure 20, a hole has been drilled in the shell to allow access to the retaining clip that holds the plug in place. On some disk tumbler locks, this hole may already be present.

To remove the plug from such a lock, insert a small tool such as a lock pick or thin awl into the drilled hole. By applying pressure, the retaining clip for the plug can be compressed. With the key located in the plug, turn the plug slowly while pulling outward. The plug should slide from the shell.

Once the plug is removed, you can begin removing the disks. The disks may lift right out, or they may need to be “pinched” to allow removal, depending on the type of lock. As each disk is removed from the lock, place it in order in a pin tray or other small container. To reassemble the lock, reload the disks into the plug. Then insert the plug into the shell, applying only as much pressure as is necessary for the end of the plug to engage the retainer clip.

Disassembling a Side Bar Wafer Lock. Since most side bar wafer locks are found in cars, you’ll need to remove it from the vehicle before you can disassemble the lock itself. In general, ignition and trunk locks are removed by driving out a retaining pin to release the lock shell. In a door lock, a special retaining clip may be used to hold the lock shell. (We’ll discuss the exact details on removing locks from automobiles in a later study unit. If you want more information now, you can consult any automotive service manual.)

To disassemble this type of lock, you will have to remove the spring and disk retainer cover. Pry upwards on the cover with

a small screwdriver and it will come free of the shell. (*Note:* Very often, this cover will be bent or distorted upon removal and require replacement after you have moved the discs. These covers are available through locksmith suppliers.)

With the cover removed, begin lifting the six internal springs from the lock with a pair of tweezers. Place these springs in your pin tray or other container.

If you were disassembling the lock for the purpose of rekeying, you would now lift the disks out of the plug and replace them as needed. Replace the springs and then insert a new spring retainer cover into the shell.

Disassembling a Cam Lock. To disassemble a cam lock, remove the nut, lock washer, and cam from the back of the lock. The core can now be pushed out with finger pressure, or eased out using the key.

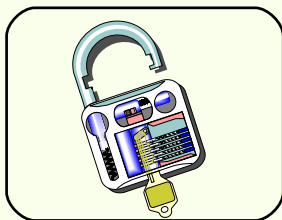
Cleaning and Lubricating

If a disk or spring has broken inside a disk tumbler lock, the lock is sometimes replaced. This is because it can be cheaper to replace a malfunctioning disk tumbler lock than to repair it. However, in many cases, a thorough cleaning and lubrication can quickly and easily correct many lock problems.

One of the first things to check when a disk tumbler lock fails is the key. When a key gets very worn, it may not lift the disks to the proper height, keeping the plug from turning. Often when a key is excessively worn, cutting a new key will correct the problem.

Many disk tumbler locks fail due to dirt or lack of lubrication (particularly car locks, which are constantly exposed to the elements). Disk tumbler plugs can be cleaned in a safe and non-flammable solvent. Spray solvents and other types of cleaning solutions are available from locksmith supply houses and hardware stores. If you wish, you can also use electrical spray cleaners such as those used on volume controls and other electronic components. A good cleaning solution should flush any dirt and dust from the lock.

It's a good idea to lightly lubricate the lock with a commercial lubricant after cleaning. Never use oil, grease, or any type of mineral- or paraffin-base lubricants. These types of lubricants will collect dust and dirt over time, and eventually turn into a paste inside the lock. This paste will cause the lock to malfunction.



Locking It Up! 2

Indicate whether each of the following statements is True or False.

- ___ 1. Modern lever tumbler locks almost always use bit keys.
- ___ 2. The disk tumbler mechanism is also called the wafer tumbler mechanism.
- ___ 3. A disk tumbler lock's springs typically contain an arrangement of five disks.
- ___ 4. Lever lock mechanisms are commonly used as ignition, door, and trunk or rear hatch locks for General Motors automobiles and light trucks.
- ___ 5. When the side bar wafer lock mechanism is locked, the side bar extends into a special slot inside the shell; as a result, the plug is held securely in place.
- ___ 6. Cam locks are used extensively on home entry doors and car ignitions.
- ___ 7. All disk tumbler locks are easy to take apart.
- ___ 8. It's generally cheaper to replace a malfunctioning disk tumbler lock than to repair it.
- ___ 9. In a disk tumbler lock, the rectangular cuts in the disks are always in the same position.
- ___ 10. Disk tumbler locks are seldom used today.

Check your answers with those on page 53.

The Pin Tumbler Mechanism

The *pin tumbler lock* is the most secure and widely used lock today. This type of lock is very popular in home entry locks, padlocks, and other types of locking devices.

A pin tumbler mechanism is contained within a device called a *cylinder*. Pin tumbler cylinders can be installed in a variety of products: in a door knob, in a door surface, or in a car ignition. While each of these locks functions differently from the outside, the pin tumbler cylinder itself always works the same way. Pin tumbler lock mechanisms are always operated with cylinder keys.

Construction

A pin tumbler cylinder contains the following parts: the plug, the keyway, the top pins, the bottom pins, and the springs. Let's start our discussion by examining these parts.

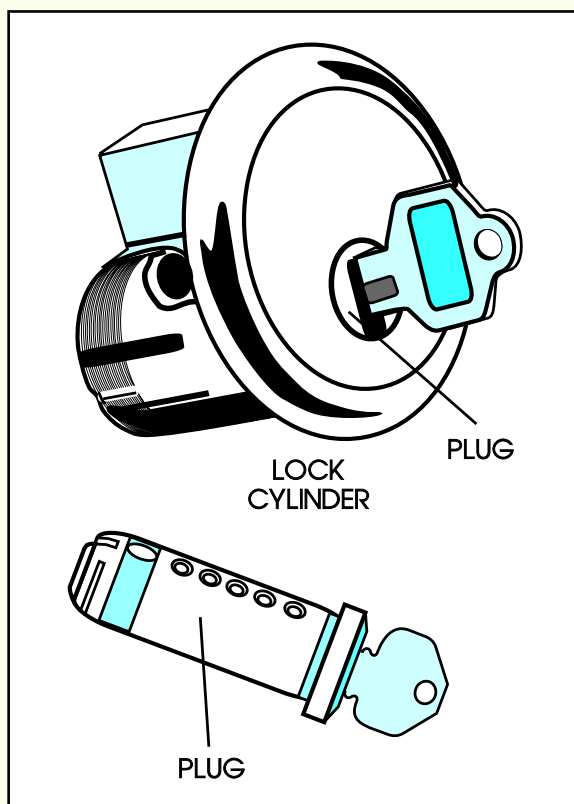
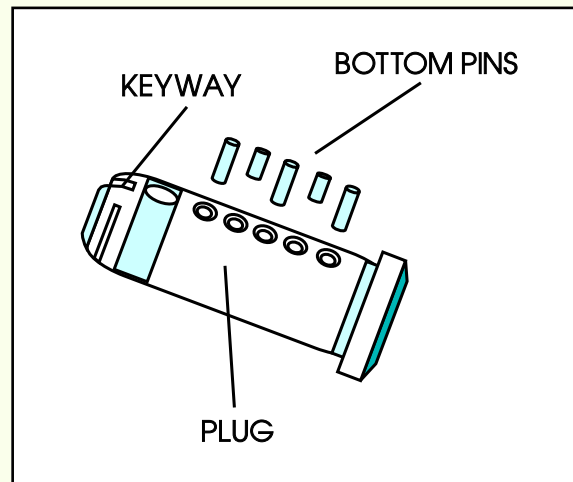


FIGURE 21—Exterior View of a Pin Tumbler Cylinder and Plug

Figure 21 shows an exterior view of a pin tumbler cylinder and a plug. The cylinder is the rounded shell that surrounds and holds the plug, which is the central assembly of the mechanism. The plug is a small “tube” that contains the *bottom pins* (Figure 22). Note the five holes that were drilled along the length of the plug, each containing a bottom pin. (Many pin tumbler mechanisms contain five pins, but

there are six- and even seven-pin arrangements.) The keyway is the opening in the plug that allows a key to be inserted.

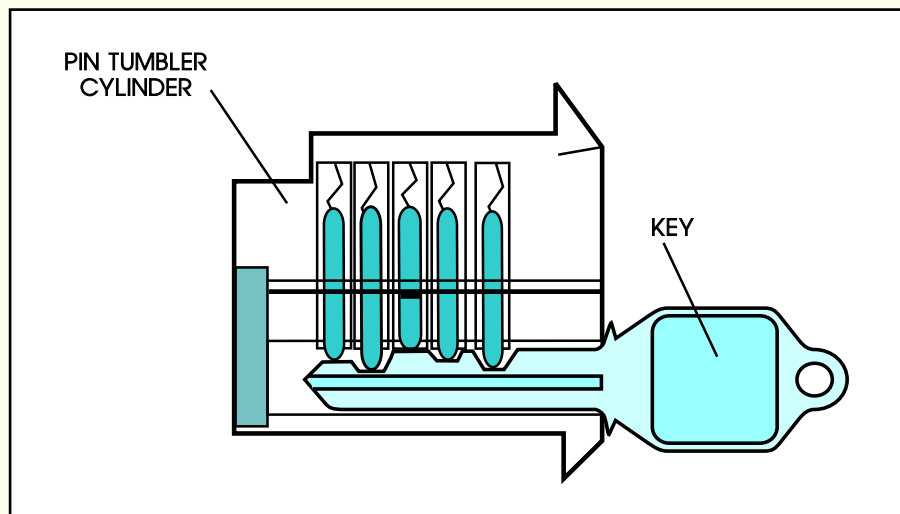
FIGURE 22—Plug and Bottom Pins



Now look at Figure 23, which shows an interior view of a pin tumbler cylinder. The visible components of the pin tumbler lock are the plug and the cylinder. This view also shows the internal components: the bottom pins, the top pins, and the springs.

Note the placement of the plug inside the cylinder. Inside the cylinder, directly above the five holes in the plug, are five more drilled holes, each containing a *top pin*. Above each top pin is a small metal spring. The *spring retainer* exerts pressure on the springs and the top pins to keep them inside the cylinder. The top pins in turn press down on the bottom pins.

FIGURE 23—Here is an interior view of a typical pin tumbler lock.



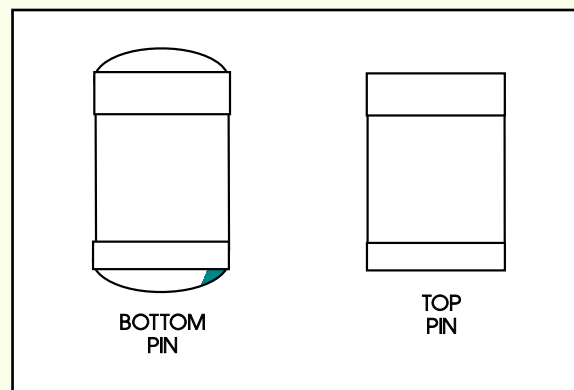
Notice that when there is no key in the plug, the top pins rest halfway between the plug and the cylinder, preventing the plug from rotating inside the cylinder. The plug is “locked” into place.

Pins and Key Cut Depths

To the average person, a *pin* may be a piece of jewelry or something to knock over in a bowling alley. To a locksmith, however, pins are very important lock components, since the movement of the pins controls the turning of the lock plug.

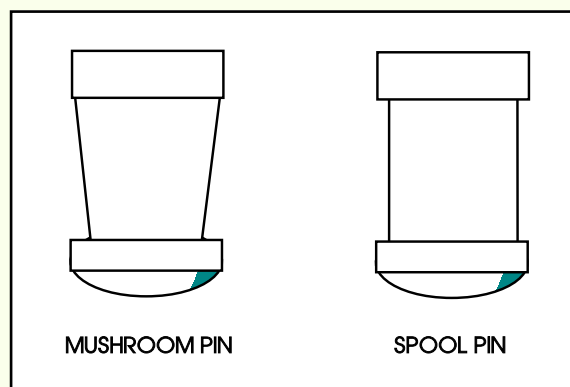
Figure 24 shows an enlarged view of a top pin and bottom pin. A top pin is flat on both ends. A bottom pin, however, is slightly “rounded” at the end to make the insertion of a key smoother.

FIGURE 24—Top Pin and Bottom Pin for a Pin Tumbler Lock



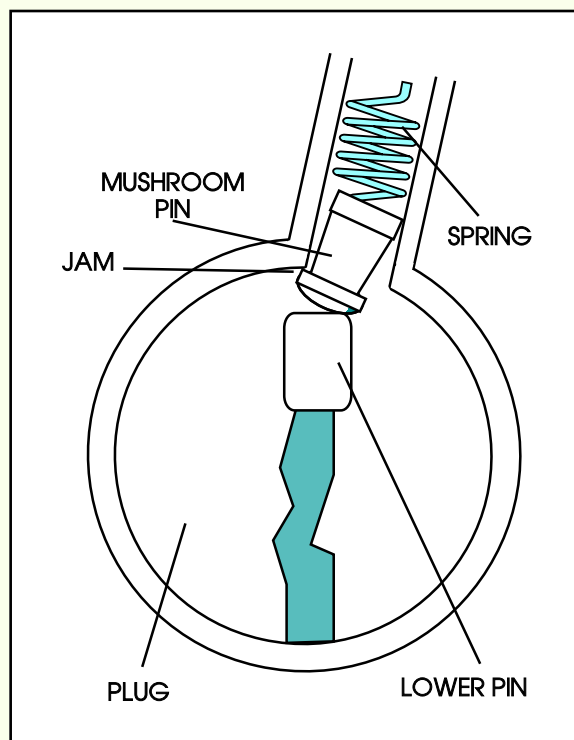
Some pin tumbler locks contain pins that make the lock harder to pick. *Anti-pick pins* are specially formed to jam inside the lock if someone tries to move them with a lockpicking tool. These pins are shaped like mushrooms or spools (Figure 25).

FIGURE 25—Anti-Pick Pins



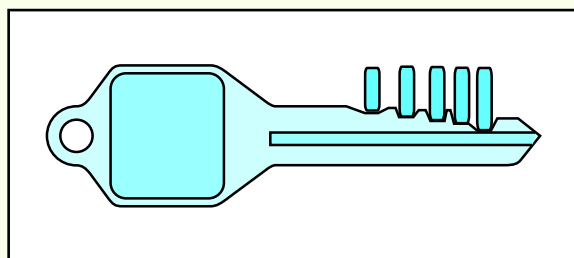
If you attempt to move anti-pick pins with a lockpick, they’ll jam between the plug and the cylinder (Figure 26).

FIGURE 26—If you attempt to lift an anti-pick pin with a lockpicking tool, the pin will jam between the plug and the cylinder.



In a pin tumbler mechanism, the length of the top pins is always the same, but the bottom pins vary in length. The length of the bottom pins must correspond exactly to the depth of the cuts in the key (Figure 27). The deeper the cut in the key, the longer the pin.

FIGURE 27—The bottom pins in a pin tumbler lock must correspond exactly to the cut depths in the key.



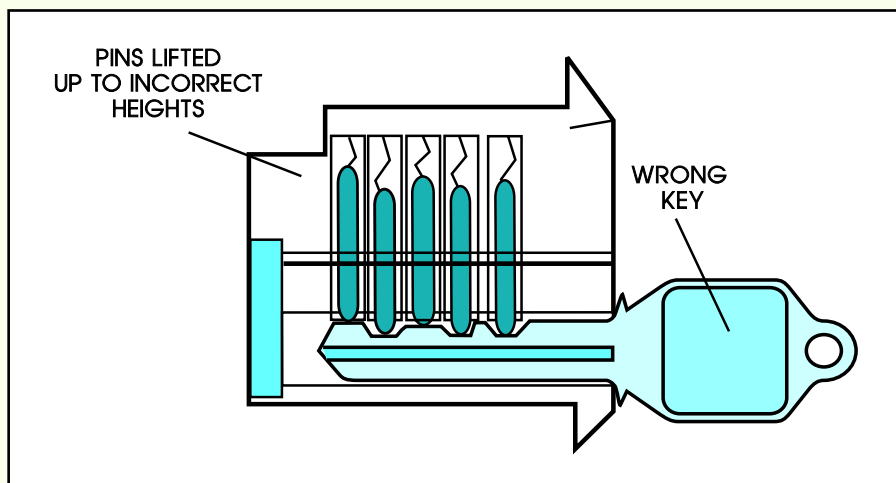
Operation

To open the pin tumbler mechanism, we need to move the bottom pins upward so that they align with the top pins. When the correct key is inserted into the plug, the bottom pins are lifted. The bottom pins press against the top pins, forcing them up into the cylinder. The bottom pins and the top pins will then line up exactly at the *shearline*. The shearline is the straight line formed between the top pins and bottom pins.

When the top and bottom pins have been aligned exactly at the shearline, the shearline is free of obstructions, and the key can be turned. When the key is turned, the plug will turn freely with it, allowing the lock to open. (Note that a very thin space exists between the plug and the cylinder. This is because if the plug were held too tightly in the cylinder, it couldn't turn to open the lock.) Refer back to Figure 23 for a visual aid to understanding this process.

Now, if the wrong key is inserted in this lock (Figure 28) the pins *would not* line up exactly at the shearline. Some of the top pins will be above the shearline, and some will be below it. This misplacement of the pins will keep the plug from turning inside the cylinder.

FIGURE 28—The wrong key was inserted in this lock, causing the pins to be misaligned at the shearline; the plug isn't free to turn.



Disassembly

Has it crossed your mind that you could make a “wrong key” fit in the lock simply by changing the heights of the bottom pins? Or, you could switch the locations of the bottom pins. If so, you’re starting to think like a locksmith! This is exactly what a locksmith does to *rekey* a lock. By changing the heights and placement of pins in the lock plug, the locksmith can make a different key operate the lock.

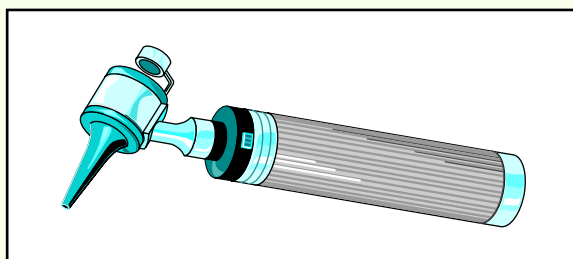
What kinds of repairs are made on a pin tumbler lock? All kinds! The pin tumbler mechanism is generally more expensive than other lock mechanisms, and it's also relatively easy to disassemble and repair. For these reasons, pin tumbler mechanisms are often repaired instead of replaced.

Typical problems with a pin tumbler lock include worn pins and worn or broken springs. Because the pin tumbler mechanism is more complex than the other mechanisms we've discussed, it's more vulnerable to dirt and grime. The small parts in a pin tumbler lock can easily "freeze up" from a buildup of dirt or a lack of lubrication. In addition, under the right weather conditions, a pin tumbler door lock can freeze from moisture intrusion or corrosion.

To perform repairs on a lock or to rekey it, you'll need to disassemble the lock. While there are many different types and sizes of pin tumbler locks, there are some general disassembly techniques that can be applied to most. (Consult the lock manufacturer's instructions for guidance whenever they're available.) Let's start by looking at a typical pin tumbler door lock.

Before you begin, note that a bright light is useful for viewing the inside of pin tumbler locks. Many locksmiths use lights called *otoscopes* to look into locks (Figure 29). (The otoscope is the same tool that a physician uses to look inside patients' ears and throats.) This light uses a halogen bulb and lens to concentrate an extremely bright beam of light into the keyway of the lock being picked.

FIGURE 29—Many locksmiths use an otoscope to view the insides of locks.



Some pin tumbler door locks are made with a *spring retainer*. The spring retainer is a small, rectangular metal cover that fits over the holes where the pins and springs are dropped into a lock plug. If the spring retainer is removed, you can gain access to the springs and the pins beneath them.

To disassemble such a lock, simply remove the spring retainer (you may need to use a pliers to "pinch" the retainer to remove it). Next, block all but one hole in the cylinder, and dump out the top and bottom pin from the one open hole. Continue this operation until all pins are removed from the lock. Set the pins in a pin tray for storage while you work on the lock. Keep the

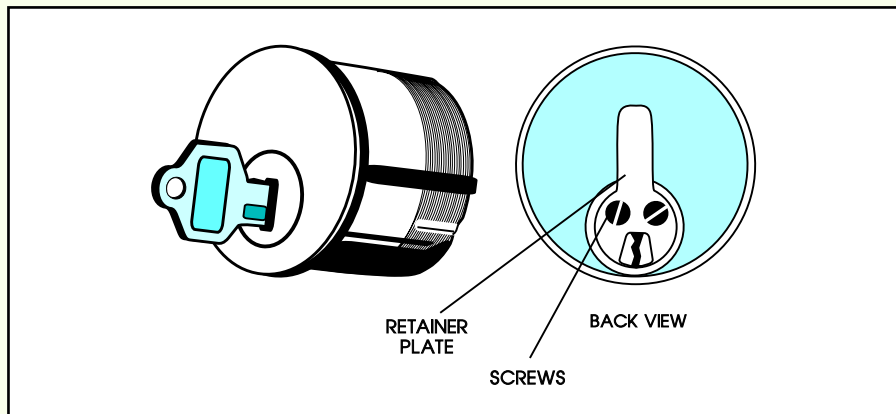
top pins together, and keep the bottom pins in the same order in which you took them out of the lock.

To reassemble the lock, replace the bottom pins in order into the plug holes. Then, replace the top pins, springs, and spring retainer. If the spring retainer was damaged during removal, replace it with a new one.

Now, let's look at a different method of disassembling a pin tumbler cylinder. Since most pin tumbler locks don't contain spring retainers, it will be necessary to use this second method in most cases.

Let's examine a pin tumbler *mortise cylinder* (Figure 30). (You may remember from an earlier study unit that a mortise cylinder is installed directly in the surface of a door.) This type of lock doesn't have a spring retainer. In order to gain access to the pins and springs inside the mechanism, it will be necessary to remove the plug from the cylinder. To remove the plug, the *retainer plate* must be removed first. The plug retainer plate is held by two small machine screws.

FIGURE 30—In this pin tumbler mortise cylinder, the plug can be removed after two screws are unscrewed from the shell, releasing the retainer plate.

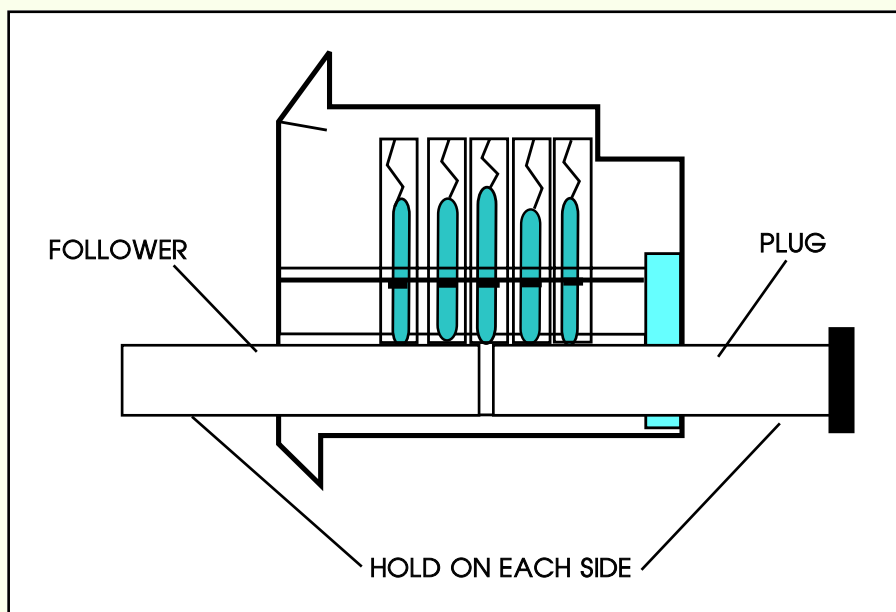


Remove the retainer plate using a small screwdriver. Now, once the retainer plate has been removed, you *could* simply insert the key, turn it one-quarter of a turn, and withdraw the plug from the lock cylinder. **BUT WAIT!** If you do that, all the top pins and springs will pop free of the lock! And, while these pins and springs *can* be replaced with a tweezers, it's not an easy job!

For this reason, the proper way to remove the plug is to use a *plug follower*. A plug follower is a wood, metal, or plastic dowel that holds the top pins and springs in place in the cylinder when you withdraw the plug. To use the follower,

simply insert the key to its full depth and turn it one-quarter of a turn. Now, place the end of the follower at the rear of the plug. Gently withdraw the plug, *and at the same time*, push in the follower. The follower will take the place of the plug while you're working on the bottom pins. The use of a plug follower is shown in Figure 31.

FIGURE 31—To properly remove a lock plug from a mortise cylinder, place a plug follower against the plug and push the plug from the shell.



With the plug out of the cylinder, the bottom pins can now be removed from the plug. Tip the plug slightly, and carefully remove the bottom pins *in order* with a tweezers. Deposit the pins in a pin tray *in order*. If you're only cleaning or lubricating the lock, you *must* return the bottom pins to their original positions in the plug; otherwise, the key won't open the lock when you put it back together! If the lock is being rekeyed, you can change the positions of the bottom pins, or replace them as necessary.

To reassemble the lock, your first task is to test the arrangement of the bottom pins in the plug. With the plug still out of the cylinder, insert the key into the plug. Check to make sure that the bottom pins are all lifted *exactly to the shearline*. If any pins fall below or stick out above the shearline, you've made an error somewhere. Rearrange the pins as necessary to get them back to their original order!

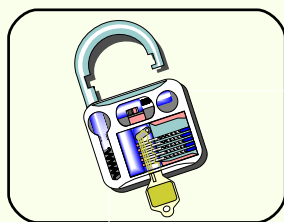
This is a very important step. If you *have* made a mistake in replacing the bottom pins, and you replace the plug in the cylinder without first checking the key, the plug could lock itself inside the cylinder. Once this happens, the original key will no longer work, and you won't be able to remove the plug again to

change the bottom pins! One option is to try to pick the lock to get it open again, which is extremely time consuming. Another option is to shim the cylinder open using a piece of shim stock. In most cases, this is faster. *Always remember to test the plug before you put it back in the cylinder!*

Once you've made sure that the key still works, you're ready to reassemble the lock cylinder. The plug is reinserted from the front of the cylinder. Place the end of the plug at the front of the cylinder so that it touches the plug follower. Then, gently press the plug into the cylinder, and *at the same time*, carefully withdraw the follower. The pins should be at a 45 degree angle to the top pins so the cylinder goes in more easily.

Servicing, Cleaning, and Repair

The disassembled parts of a pin tumbler lock may be cleaned with an application of WD-40 or a similar silicon-based solvent. In many cases, a spray cleaner (the kind used on electronic parts and components) can be used to remove dirt and grime. The parts may then be lightly lubricated with WD-40 and replaced in the lock. Never over-lubricate the parts before reassembly.



Locking It Up! 3

Indicate which of the following are True or False.

- ___ 1. A pin tumbler lock requires a special barrel key to open it.
- ___ 2. The top pins in a pin tumbler lock are all different sizes.
- ___ 3. The bottom pins in a pin tumbler lock are the same size.
- ___ 4. A plug follower is a tool used to clean a pin tumbler lock.
- ___ 5. Pin tumbler lock mechanisms can only be used in padlocks.
- ___ 6. The main parts of a pin tumbler lock are the cylinder, the plug, the top pins, the bottom pins, and the lever tumblers.
- ___ 7. The pin tumbler lock is rapidly being replaced by the warded lock.
- ___ 8. A pin tumbler lock can't be opened with a key until all the pins have been aligned along the shearline.

Check your answers with those on page 53.

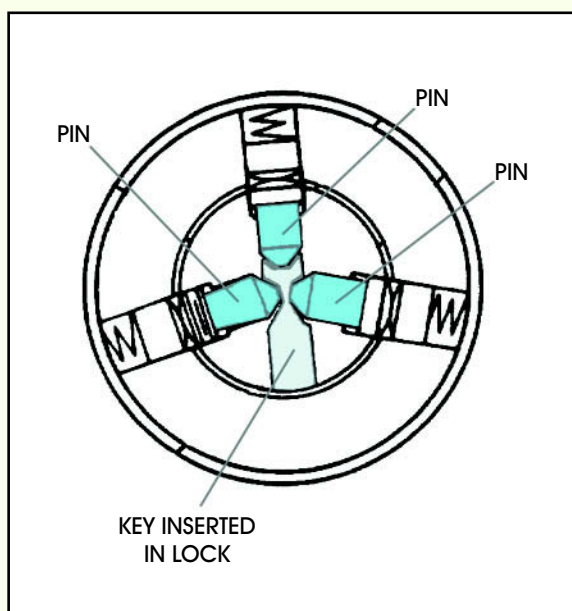
High-Security Lock Mechanisms

The term *high-security lock* can refer to any one of a variety of locking devices. High-security locks contain mechanisms that make them especially resistant to picking and forced entry. A number of lock manufacturers include a high-security line in their catalogs. Medeco Security Locks, Lori Corporation (Kaba), and Schlage Lock Company are among the best-known of the many manufacturers that do so.

Most of the high-security locks manufactured by these companies contain pin tumbler mechanisms. As such, they function basically in the same fashion as any pin tumbler lock; a key enters the plug and elevates pins of various heights to the shearline, after which the lock can be opened.

However, in a high-security lock, the pin tumbler mechanism is much more complex than in an ordinary lock. It usually

FIGURE 32—This high-security lock contains three sets of pins.



contains two or more sets of top and bottom pins. For example, in the Kaba Gemini brand high-security mechanism, the lock plug holds *three* sets of pins. The pins enter the lock cylinder at an angle, and the key must be specially cut to accept the pins at that angle. Figure 32 shows an end view of this type of mechanism.

Note the three sets of pins and the angled depressions needed in the key to make it fit in the lock. Figure 33 shows an exploded view of the lock plug. Note how the pins and springs are inserted into the plug.

Now, let's look at some other special features manufacturers put into their high-security locks.

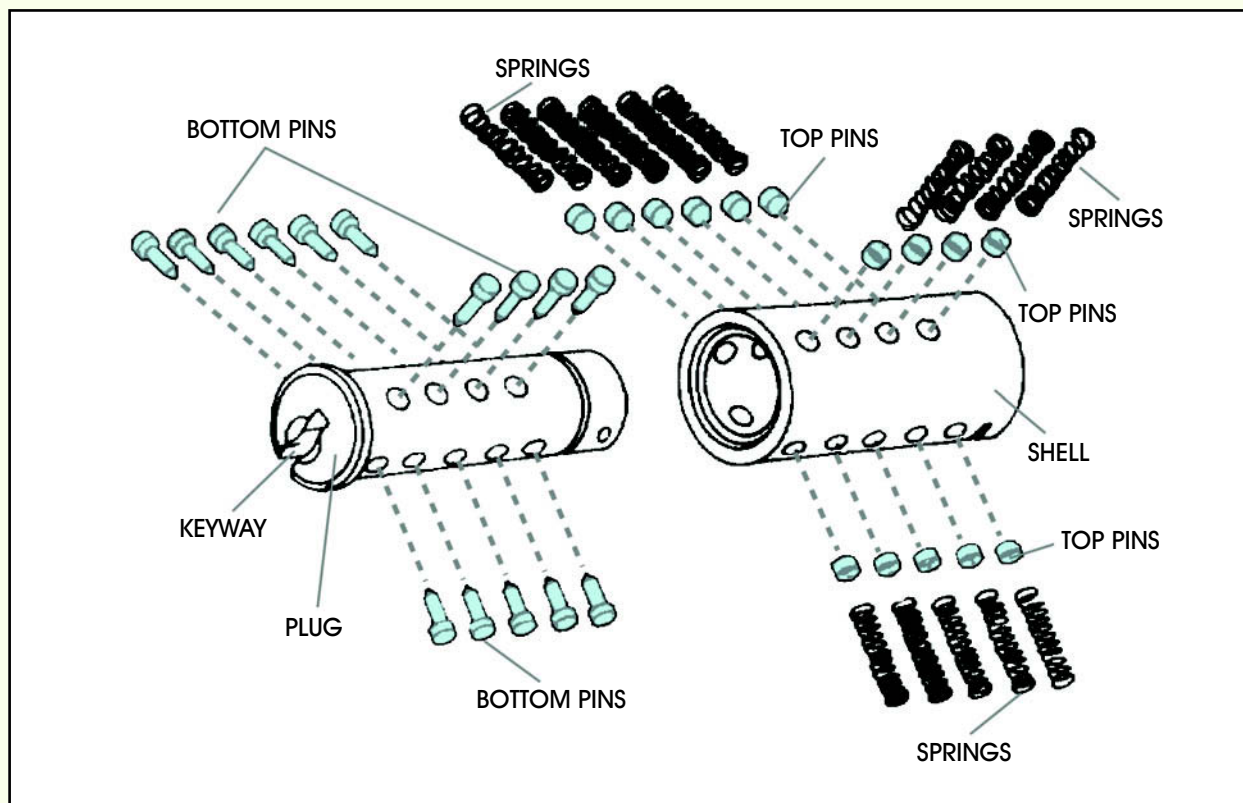
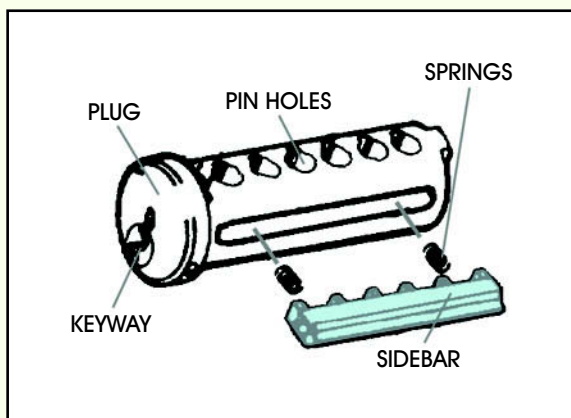


FIGURE 33—This illustration shows an exploded view of a high-security lock plug.

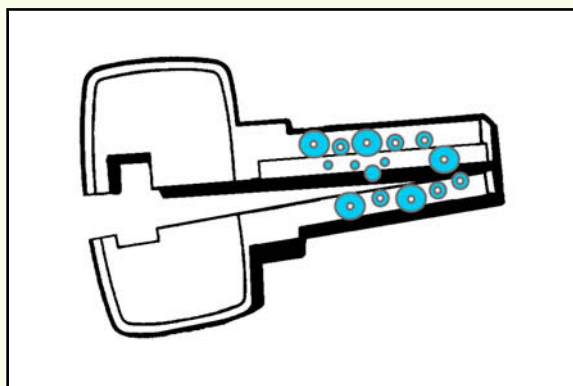
Sidebars. Medeco brand high-security locks incorporate a sidebar into the lock plug to increase security. As Figure 34 shows, the sidebar has five “legs” that correspond to five vertical slots on the facing bottom pins. When the proper key is inserted, the pins are raised to the shearline and also rotated so that the legs of the sidebar slide into the slots of the lower pins. This double action allows the plug to turn.

FIGURE 34—This type of mechanism uses a sidebar in the plug to add security.



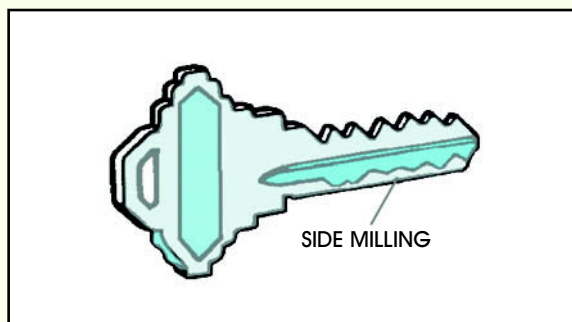
Split Keys. Some manufacturers provide a security option with their locks known as the *split key* (Figure 35). Two people are required to open the lock—each is given half of the key. When two people are needed to open a lock, unwanted single-party access to the lock is effectively ruled out.

FIGURE 35—A split key requires two people to operate it.



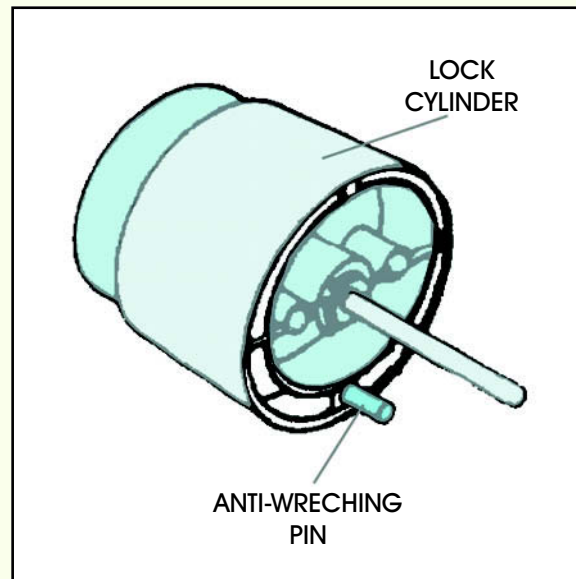
Multiple Locking Mechanisms. The Schlage company manufactures a high-security lock (the *Primus*) that contains two pin tumbler mechanisms inside. Both mechanisms are operated simultaneously by one key. However, the patented key is specially cut to operate both mechanisms. The key contains two rows of bitting (Figure 36).

FIGURE 36—This Schlage Primus key contains two rows of bitting to operate the two mechanisms inside the lock.



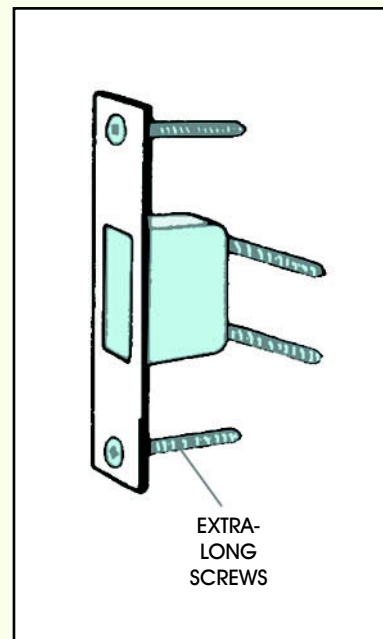
Anti-Wrenching Pins. Some lock manufacturers install *anti-wrenching pins* in their locksets (Figure 37). An anti-wrenching pin acts as an anchor embedded in the door, resisting attempts to wrench the cylinder loose.

FIGURE 37—An anti-wrenching pin anchors a lock cylinder to a door, preventing it from being wrenched or pried loose.



High-Security Strikes. One of the most popular methods of forcing entry to a home is kicking in the door. Unless the door is unusually thick or strong, the wood of the door will usually splinter around the lock and allow the burglar to get in. To prevent this, a high-security strike has extra-long screws that add strength to the door frame, making it very difficult to kick in a door.

FIGURE 38—A high-security strike has extra-long screws that add strength to the door frame.



Interchangeable Cores

Interchangeable or *removable cores* are specially-designed lock cylinders that can be removed from a door lockset without disassembling the lock or door knob. An interchangeable core is shown in Figure 39. They can easily be removed and rekeyed using a special key called a *control key*. To remove the core, the control key is inserted and turned, and the core is then withdrawn.

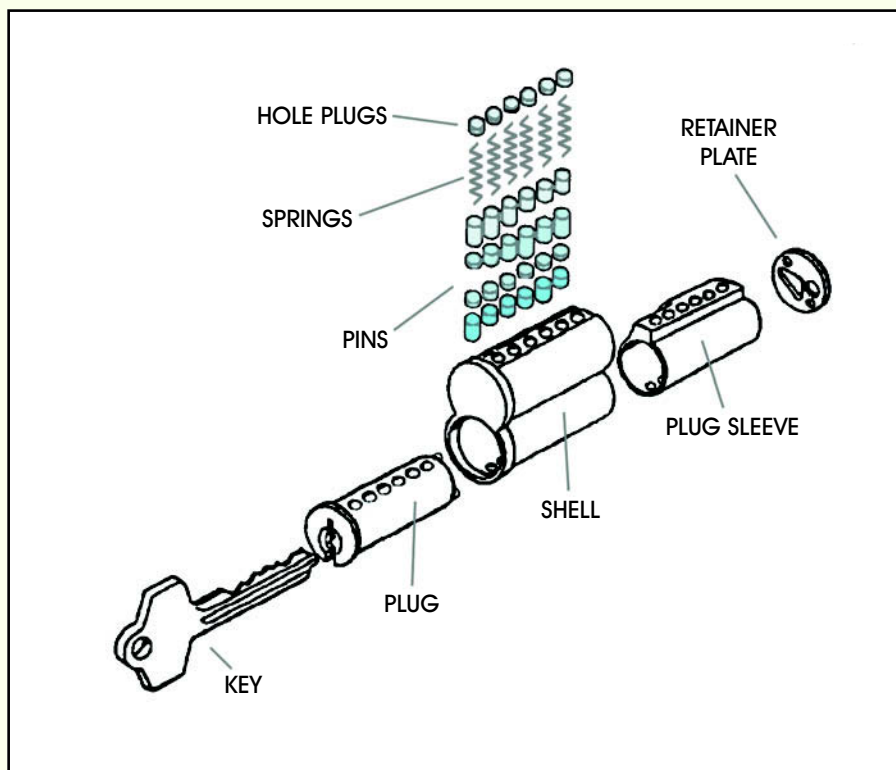


FIGURE 39—An Interchangeable Core

Most of these locks are used in commercial installations. The advantage of the interchangeable core is that if, for example, an employee loses a key to a store, the locksmith can simply remove the core, rekey it, and replace it. With another type of lock, the locksmith might have to remove the entire lock from the door to replace or rekey it, which is much more time-consuming and costly.

Key-Operated Padlocks

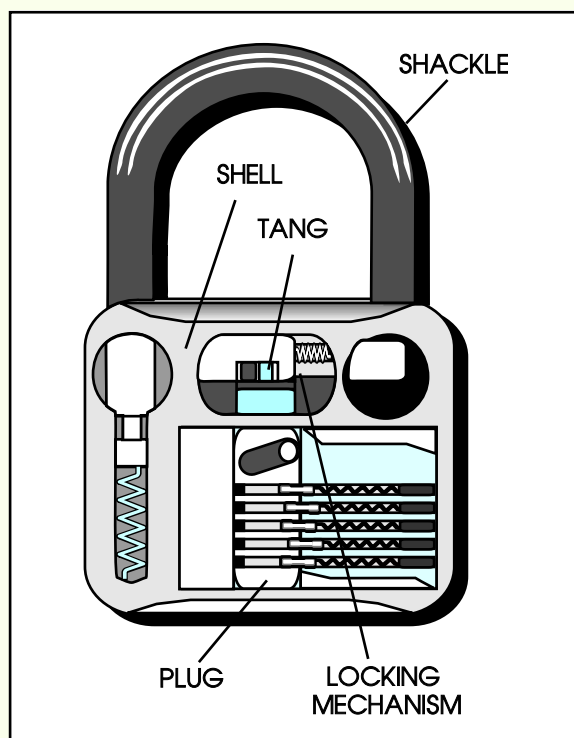
Padlocks are a familiar part of our daily lives. Many of us became familiar with padlocks as children, using them to secure

our school lockers and bicycles. Adults use padlocks to secure garages, outbuildings, toolboxes, trunks, storage units, and just about any other enclosure that offers a hasp to hang a padlock from.

There are a number of other padlock varieties. Some padlocks use a plug as a locking mechanism; the plug may hold pins, discs, or wafers. High-security padlocks are also available. These padlocks feature special laminations, as well as independent control of the two ends of the shackle.

We discussed the operation of a padlock in the Practice Exercise for Study Unit 2. Your Papaiz padlock is illustrated

FIGURE 40—Parts of a Padlock



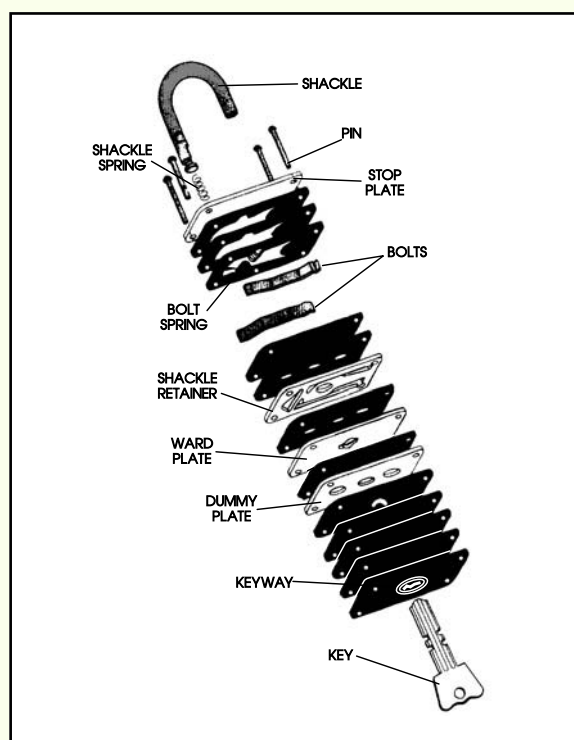
again for your reference in Figure 40. Remember that the main parts of a padlock are the shackle, the shell, and the tangs. The shackle is held in two locations by the locking mechanism near the top of the lock. The two *tangs* at the top of the plug, when rotated, cause the locking mechanism to retract. This action causes the shackle to raise under spring pressure.

No key is required to lock the padlock. Finger pressure is sufficient to return the shackle to the case, where the bolts catch the notch and secure it.

Warded Padlocks

Warded padlocks are constructed a little differently from the warded door lock, but the principle of operation is the same. A modern warded padlock is constructed from many flat layers of metal. The flat layers are then stacked up and laminated together to form the body of the lock. Small cuts are made in

FIGURE 41—Interior View of a Warded Padlock



some of the layers to create wards in the lock body. When all the layers are stacked up, the key will need to be cut to correspond to the lock's wards. An interior view of a warded padlock is shown in Figure 41.

When the correct key is inserted in a warded padlock, it passes through the *wards* and can be turned. As the key turns, it moves the bolts out of the notch and the

shackle is forced upward and out of the case by the now-relieved pressure of the shackle spring. Flat keys are used with warded padlocks.

Disassembly

Since most padlocks are inexpensive, they're more often replaced than repaired. In addition, many inexpensive padlocks (and all laminated warded padlocks) can't be disassembled at all.

Expensive heavy-duty, high-security padlocks, on the other hand, are well worth disassembly and servicing. The manufacturer's instructions will tell you how to disassemble a padlock; for example, some have special pins or rivets that must be removed to access the locking mechanism. In addition, some high-security padlocks contain interchangeable cores.

Choosing the Right Padlock

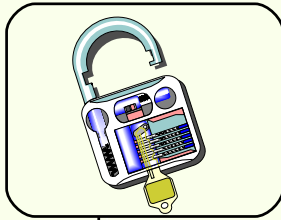
What's the best padlock to buy? As a locksmith, you'll hear that question repeatedly, and there's no easy answer. Nevertheless, since you'll be expected to come up with an answer, do so by

reviewing with the customer the following considerations: purpose, location, and frequency of use.

Purpose. What is the padlock going to be used to lock? A child's bicycle or school locker will obviously require much less security than the door to a garage or boathouse.

Location. Will the lock be used indoors or outdoors? An outdoor lock will naturally take more abuse from the weather than an indoor unit. A shed door that is covered in snow four or five months of the year presents a real problem for a cheap padlock. Urge the customer to consider any unusual circumstances due to location (moisture, sand, dust, extreme sunlight, and so on).

Frequency of Use. The price of a padlock is to a large extent dependent on its durability. If the lock is to be operated several times a day, consider a better model.



Locking It Up! 4

Fill in the blanks in each of the following statements.

1. A special key called a _____ key is used to remove an interchangeable core.
2. A _____ key requires two people to open a lock. Each person is given half of the key.
3. A special type of key that contains two rows of biting is used in the _____ lock.
4. A/an _____ acts as an anchor embedded in the door, resisting attempts to wrench the cylinder loose.
5. A high-security _____ has extra-long screws that add strength to a door frame, making it very difficult to kick in a door.
6. A/an _____ is a specially-designed lock cylinder that can be removed from a door lockset without disassembling the lock or door knob.

Check your answers with those on page 53.

COMBINATION LOCK MECHANISMS

Introduction

Let's stray away from key-operated locks for a short time and look at a lock that needs no key. This type of lock is called the *combination lock mechanism*. Combination lock mechanisms are used in many types of padlocks, door entry systems, safes, and vaults. Although combination locks differ in construction from one make and model to another, they all operate on the same basic principles.

Combination locks have a practically unlimited number of applications, from school lockers to trailer hitches to safes. They're particularly advantageous over key-operated locks in situations where several people—lab workers, industrial inspectors, high-school teachers—need access to the same equipment at random times. In a manufacturing plant, for example, six or eight workers may need to use tools or supplies that are too valuable to be left out in the open. Rather than provide each person with a key (which could be lost or stolen, requiring immediate rekeying or lock replacement), each can be given a simple three-digit combination.

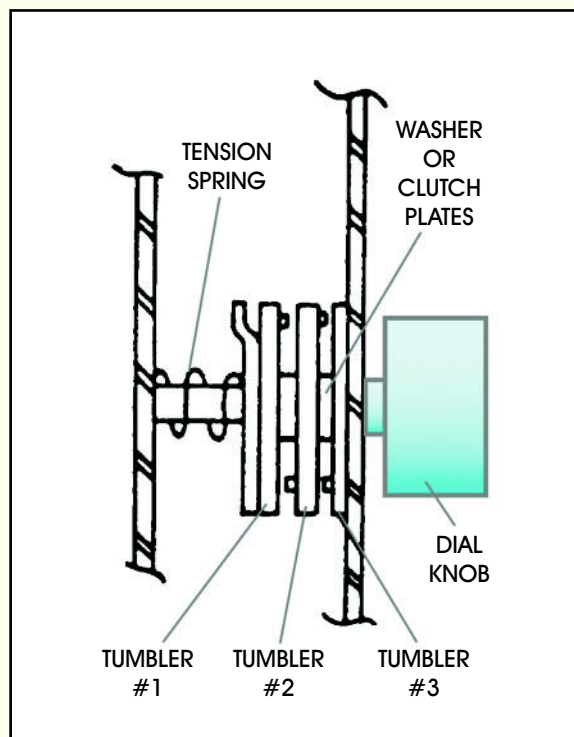
Operation

Now, let's examine the operation of the combination lock mechanism. First, the *combination* is a series of numbers (usually three numbers) that is dialed to open the lock. Typically, the combination is set at the factory. However, a locksmith can change a padlock combination at a customer's request.

Inside the lock, the main components are the *wheels* or *tumblers*. Outside, the lock has one or more *dials*. The internal components of a simple combination padlock are shown in Figure 42. This lock contains three wheels and a dial on its face.

The dial is a numbered knob on the outside of the lock which is used to dial the combination. It can be rotated to the left and

FIGURE 42—This combination lock mechanism contains three wheels and a numbered dial on its face.



right. The numbers on its face start at 0 and are read clockwise. Some locks read from 0 to 50; some read from 0 to 100. Locks with numbers up to 100 usually have a little more security than ones reading up to only 50.

When a combination lock is locked, the wheels are positioned in random relationship to each other. However, if the three wheels are moved in such a

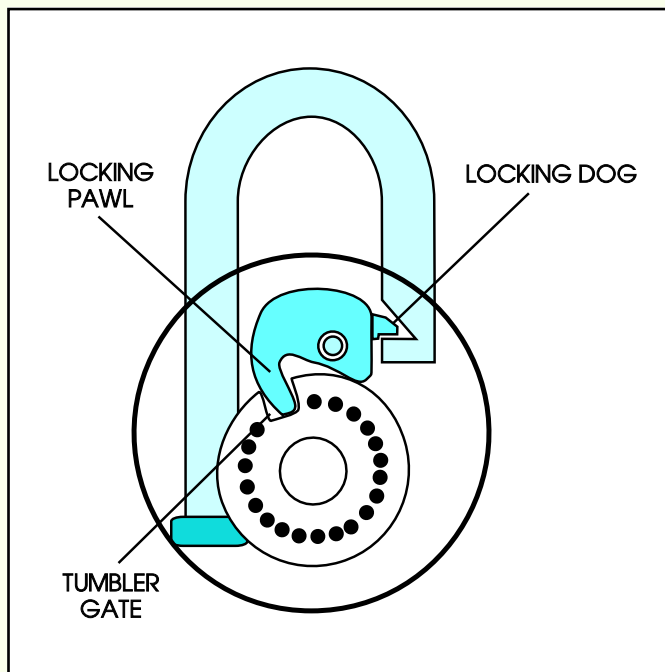
way that the wheels are caused to align, the lock mechanism will be released. To align the wheels, the dial is turned clockwise and counterclockwise to reach the numbers in the combination. As the dial is turned, the wheels inside are aligned. Each time a correct number from the combination is dialed, another wheel clicks into place. When all the numbers have been dialed, the wheels will be completely aligned, freeing the lock to open.

To see how this works in more detail, let's say we want to open a padlock with the combination 18-5-15. First, spin the dial a couple of times to clear it, and then align the zero under the arrow at the top of the dial. Next, we'd turn the dial *clockwise* two full turns, and continue to turn until number 18 is aligned under the arrow. The first wheel inside the mechanism is now set.

Next, move the dial *counterclockwise* one full turn, and stop at number 5. The first and second wheel are now aligned. Finally, turn the dial *clockwise* until number 15 is aligned under the arrow. All three wheels should now be aligned inside the mechanism, and the shackle should be free to open. In some models, the shackle will pop up out of the case, impelled by a spring; in others, you must pull down on the case to release the shackle.

If you look at a back view of the combination lock, you can see how the lock releases the shackle. Figure 43 displays this back view of the lock. Notice how the wheel has a *gate* cut into it. When the proper combination is dialed on the lock, each of the three wheels will line up with their gates open to the *locking pawl*. Since the locking pawl is free to pivot, it will enter the gates on the three tumblers and open the shackle of the lock.

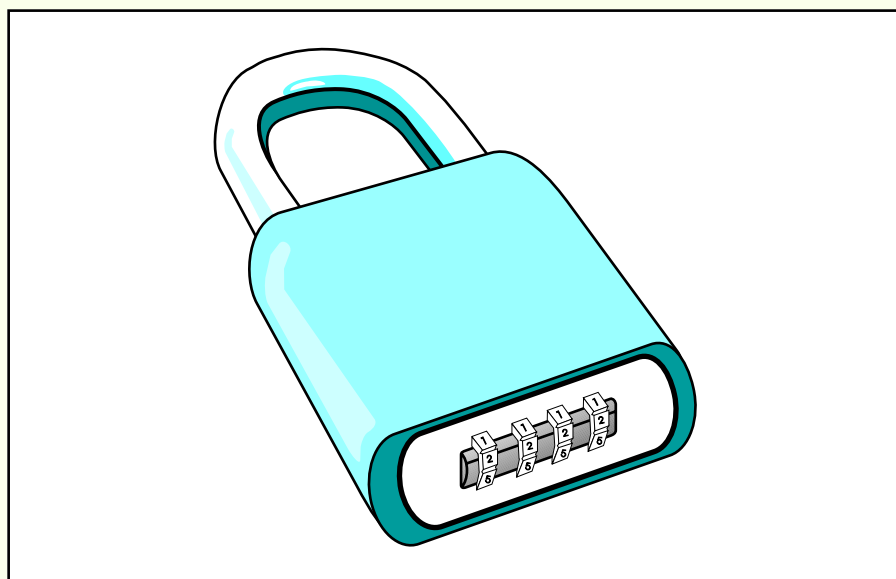
FIGURE 43—This figure shows how the gates on the wheels must align in order to free the locking mechanism.



Some combination locks carry code numbers stamped on their cases. A locksmith can discover the combination by looking up this number in one of the code books available only to professional locksmiths.

A slightly different model of combination padlock, the Sesame padlock, is shown in Figure 44. Note that this lock has four numbered dials on the bottom of the lock instead of the face. One of the most useful features of this lock is that the user can change the combination at will. To do so, a special key called a *change key* is inserted into the shackle hole, and a new four-digit combination rotated into place. *Note:* Don't confuse this combination change key with the change key of a master key system.

FIGURE 44—Sesamee Padlock



Disassembly

Most combination padlocks can't be disassembled without spending an enormous amount of time and effort to do so. If the lock is inexpensive, it's generally replaced rather than re-

paired. However, you can expect to meet customers who have lost the combination to a padlock. In such a situation, you may be able to remove the lock using bolt-cutters. Otherwise, it will be necessary to drill a small hole in the back of the lock to try to "see" the combination.

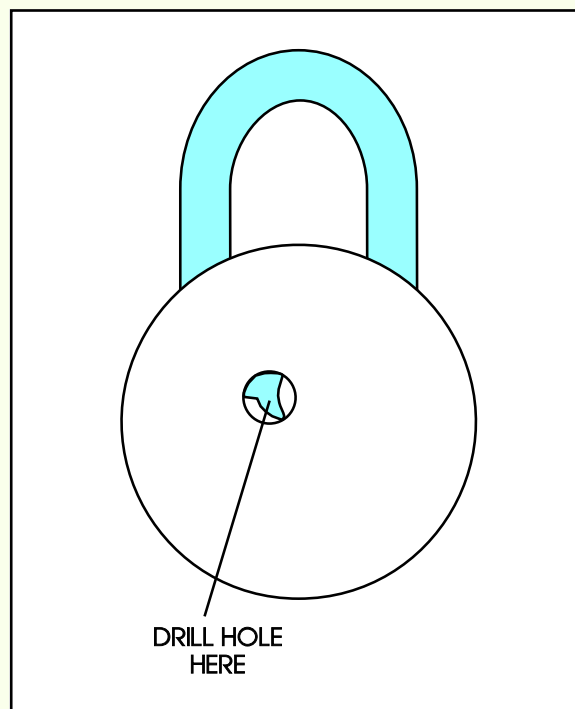


FIGURE 45—Drill a small hole as shown here to see the wheels inside a combination lock.

Drill a small ($\frac{1}{16}$ -inch) hole in the back of the padlock case. By looking inside the mecha-

nism, you can see the position at which all the wheels are aligned. Figure 45 shows where to drill the hole, which you can patch with liquid solder or liquid cement when

you're finished. The exact position of the hole might vary depending on the type and brand of lock.

Combination Entry Locks

The *pushbutton combination lock* in Figure 46 is a popular type of combination entry lock used in both home and commercial applications. These locks are especially common in hotels or other facilities where many strangers come and go at will. Instead of having to supply each person with a key, a three-number combination is supplied. The combination can be changed quickly and easily to maintain security. If desired, a security shield can be mounted around the lock face to screen it from curious eyes.

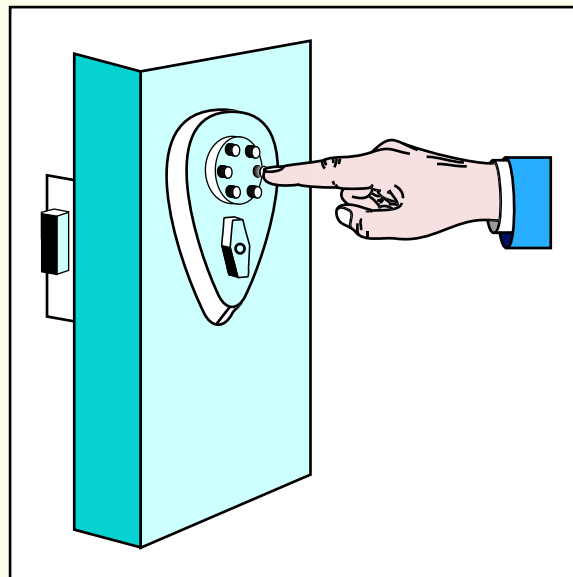


FIGURE 46—A
Pushbutton
Combination Lock

An additional advantage of the pushbutton combination entry lock is that it's easy to install. In a wooden door, two drilled holes are all that is required. For metal doors, a surface-mounted strike is provided, eliminating the need to mortise the jamb.

Now that you understand the basic operation

of the combination lock, let's take a look at another type of keyless lock, the electric lock mechanism. (*Note:* We'll be discussing the use of combination locks in much more detail later in your study unit on safes and vaults.)

ELECTRIC LOCK MECHANISMS

Applications

Electric locks are used widely by many types of businesses, hospitals, and industries. These keyless locks can be used on rear or side entries of a business to allow employees to enter and exit the building. Some homes and apartments have keyless entry systems to eliminate the need for keys.

Most modern hotels use electric locks for entry doors and/or keyless electric locks for the actual room doors. In addition, many of the hotel's interior doors may be held open using electric locks. Then, if a fire is sensed by the alarm system, these doors close to prevent the fire from spreading.

Operation

The simplest type of electric lock consists of a solenoid-type plunger that engages in a strike in the door or door jamb. When an electrical current is applied to the plunger, magnetic force pulls it out of the strike, opening the door. Another type of electric lock is operated by remote control. These are often mortised or key-in-knob locksets, and they're controlled remotely using push buttons or keyed switches. Keypad or card-reading keyless entry systems are another popular choice. Finally, the electromagnetic lock consists of a powerful electromagnet and a steel plate that can hold a door against 2,000 or more pounds of force.

In the simplest electric lock *circuit*, a single switch or pushbutton and an electric lock is used to protect one door. The power supply for this electric lock consists of a fuse and a transformer. One side of the transformer connects to the electric lock's coil, and the opposite side of the transformer connects to a pushbutton switch. When the pushbutton is pressed, the circuit is completed and the coil is energized. When the coil is energized, the coil attracts a plunger that allows the door to open.

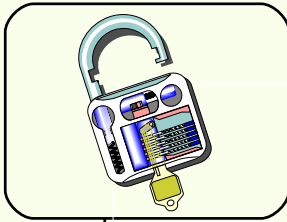
More than one electric lock can be linked to one circuit and controlled with a single switch. In such a system, both locks operate when the pushbutton is depressed. The current flow in this

circuit doubles, since two loads are connected across the power supply.

Two of the electric circuit devices we've been discussing—the transformer and the electric lock coil—use *electromagnetism* to operate. Electromagnetism is created by a magnetic field that surrounds a conductor when electric current flows through it.

The magnetic field that surrounds a wire is very small. If you could place a compass very close to the wire, you would see the needle of the compass deflect slightly. This small deflection serves no real purpose in pulling back an electric lock solenoid. However, if you loop the wire many times around a core, the magnetic fields would add together, increasing the overall field strength. The fields from the many turns of wire are concentrated in the core when the wire coil is energized. In fact, the coil has enough strength to pull the plunger out of the strike box on a typical electric door lock.

This introductory information to electric locks should be enough to familiarize you with their operation. However, note that we'll be discussing these locks (as well as *electronic security systems*) in much greater detail in a later study unit.



Locking It Up! 5

Indicate whether each of the following statements is True or False.

- 1. Only one electric lock can be connected to a circuit.
- 2. A special key called a change key is used to alter the combination of a Sesamee padlock.
- 3. The main components in a combination lock are the dials.
- 4. Once a lock's combination has been set at the factory, it can never be changed.
- 5. Pushbutton combination locks are very difficult to install and operate.
- 6. A padlock combination usually consists of three numbers.

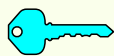
Check your answers with those on page 54.

THE KEY TO SUCCESS

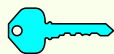
Since the beginning of this study unit, you've learned many of the important concepts and terms relating to lock mechanisms. You've learned how lock mechanisms work, in detail. You've also learned how to disassemble and service many lock mechanisms. Think about how important this valuable knowledge will be to your future career as a locksmith! You've already mastered many of the basic topics you'll need to become qualified as a professional locksmith. Be proud of your scholastic achievements, and continue to plan for your future!

Now, when you're ready, read through the *Key Points to Remember* that follow. When you've reviewed the material and feel you know it well, proceed to the examination for this study unit. Good Luck!

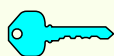
KEY POINTS TO REMEMBER



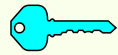
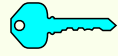
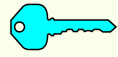
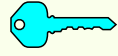
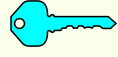
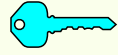

A *lock mechanism* is the assembly of parts inside a lock that makes it work. All lock mechanisms can be divided into three basic types: *key-operated lock mechanisms*, *combination lock mechanisms*, and *electric lock mechanisms*. A *key-operated lock mechanism* is simply any type of lock that's opened and closed by inserting and turning a key. Key-operated locks are found in residential doors, cars, and padlocks.


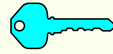


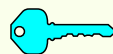
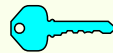


The *warded lock mechanism* is the oldest type still in use today. Bit keys and barrel keys are used to open warded door and cabinet locks. The word *ward* means *to guard* or *guard against*. In locksmithing terms, a *ward* is a metal barrier inside a lock mechanism that ensures that only the proper key will engage the mechanism and open the lock. The "right" key contains cuts that exactly match the shape of the wards inside the lock.

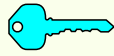


Warded locks aren't generally used on today's exterior doors. They have been replaced by pin tumbler or disk tumbler locks in most cases. This is because warded locks aren't nearly as secure as pin tumbler locks, since the warded lock has a simple mechanism and the keyhole is large enough to view most of the lock's inside.

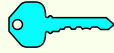
- 
- Lever tumbler lock mechanisms* are used on school lockers, cash boxes, suitcases, mailboxes, and safe-deposit boxes. The slim, flat design of the lever lock is more appropriate for these applications than a cylinder-type lock. Modern lever tumbler locks almost always use *flat keys*.
- 
- The lever tumbler mechanism may contain from one to sixteen lever tumblers, depending on the security of the lock. Each lever tumbler is a flat metal plate held in place by spring pressure. When the key is inserted, the lever tumblers are lifted and aligned inside the lock, allowing the lock to open.
- 
- The *disk tumbler mechanism* (also called the *wafer tumbler mechanism*) is commonly used in automobile doors, desks and cabinets, and vending machines. The main components of a disk tumbler lock are the *shell*, the *plug*, the *disks*, and the *springs*. The disks or wafers are small, flat, rectangular pieces of steel, each containing a slot or hole. For most disk locks, the disks come in five different slot arrangements. The location of the slot in each disk will determine the key cut depth needed.
- 
- A disk tumbler lock's *plug* will contain an arrangement of any of these five disks (any one of the disks may appear more than once, as well). The arrangement of the disks forms each lock's individual combination. The disks are slotted for key entry. When the proper key is inserted into the lock, the disks are pulled away from the lock shell and centered in the plug. This action frees the plug from the shell and allows the plug to turn with the key.
- 
- A *side bar wafer lock* is a variation of the disk tumbler lock that is widely used for ignition, door, and trunk or rear hatch locks for General Motors automobiles.
- 
- Another variation of the disk tumbler mechanism is the *cam lock*. Cam locks are used extensively on cabinet doors and desk drawers. In this kind of lock, a moveable *cam* is attached to the rear of the lock. The cam rotates when the key is turned in the lock, creating a physical barrier that prevents a door or drawer from being pulled open.
- 
- The *pin tumbler lock* is the most secure and widely used lock today. This type of lock is very popular in home entry locks, padlocks, and other types of locking devices. Pin tumbler lock mechanisms are always operated with cylinder keys. The pin tumbler mechanism is relatively easy to disassemble and repair.

- 
- A pin tumbler mechanism is contained within a device called a *cylinder*. A pin tumbler cylinder holds the plug, which is a small “tube” containing the *bottom pins*. The heights of the bottom pins correspond to the cut depths in the key. The top pins are all the same height, and rest halfway between the plug and the cylinder, preventing the plug from rotating inside the cylinder.
- 
- When the proper key is inserted in the lock, the pins are lifted to the height necessary to align them along the *shearline*, freeing the plug to turn. By changing the heights and placement of pins in the lock plug, the locksmith can make a different key to operate the lock. This process is called *rekeying*.
- 
- High-security locks* are locking devices that are especially resistant to picking and forced entry. Most high-security locks contain complex or modified pin tumbler mechanisms. For example, some high-security mechanisms hold more than one set of pins. The pins enter the lock cylinder at an angle, and the key must be specially cut to accept the pins at that angle. Some other features manufacturers add to their high-security mechanisms are sidebars, split keys, multiple locking mechanisms, anti-wrenching pins, and high-security strikes.
- 
- Interchangeable* or *removable cores* are specially-designed lock cylinders that can be removed from a door lockset without disassembling the lock or door knob. To remove the core, a special key called a *control key* is inserted and turned, and the core is then withdrawn. Most of these locks are used in commercial installations.
- 
- Padlocks are another common type of key-operated lock. Remember that the main parts of a padlock are the shackle, the shell, and the tangs. The shackle is held in two locations by the locking mechanism near the top of the lock. The two *tangs* at the top of the plug, when rotated, cause the locking mechanism to retract. This action causes the shackle to raise under spring pressure. No key is required to lock the padlock. Finger pressure is sufficient to return the shackle to the case, where the bolts catch the notch and secure it.
- 
- Another type of key-operated padlock is the *warded padlock*. A warded padlock is constructed from many flat layers of metal. The flat layers are then stacked up and laminated together to form the body of the lock. Small cuts are made in some of the layers to create wards in the lock body. When all the layers are

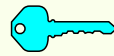
stacked up, the key will need to be cut to correspond to the lock's wards.



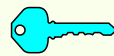
A commercial lubricant such as WD-40 (*never* oil) should be used to lubricate lock parts.



Combination lock mechanisms are used in many types of padlocks, door entry systems, safes, and vaults. The *combination* is a series of numbers that's dialed to open the lock. The dial is a numbered knob on the outside of the lock which is used to dial the combination. The dial is turned clockwise and counterclockwise to reach the numbers in the combination. As the dial is turned, the wheels inside are aligned. Each time a correct number from the combination is dialed, another wheel clicks into place. When all the numbers have been dialed, the wheels will be completely aligned, freeing the lock to open.



The *pushbutton combination lock* is a popular type of combination entry lock that is especially common in hotels or other facilities where many strangers come and go at will. Instead of having to supply each person with a key, a three-number combination is supplied. The combination can be changed quickly and easily to maintain security.



Electric locks are used by many types of businesses, hospitals, and industries. In the simplest electric lock *circuit*, a single switch or pushbutton and an electric lock is used to protect one door. The power supply for this electric lock consists of a fuse and a transformer. When a pushbutton is pressed, the circuit is completed and the coil is energized. When the coil is energized, the coil attracts a plunger that allows the door to open.

Do You Know Now . . .

Below are the answers to the questions asked at the beginning of this study unit.

What is the most important component of a combination lock?

The wheels or tumblers are the most important components of the combination lock mechanism.

What are the major parts of a padlock?

The major parts of a padlock are the shackle, the case or shell, and the tangs.

What is a *ward*?

A ward is a metal barrier inside a warded lock that obstructs any key but the proper one.

NOTES

Locking It Up! Answers

1

1. Bit, barrel
2. lock mechanism
3. padlock
4. key-operated lock mechanism
5. ward
6. case wards
7. skeleton key
8. rim

2

1. F
2. T
3. F
4. F
5. T
6. F
7. F
8. T
9. F
10. F

3

1. F
2. F
3. F
4. F
5. F
6. F
7. F
8. T

4

1. control
2. split
3. Schlage Primus
4. anti-wrenching pin
5. strike
6. interchangeable core

5

1. F
2. T
3. F
4. F
5. F
6. T



Lock Mechanisms

EXAMINATION NUMBER:

03100400

Whichever method you use in submitting your exam answers to the school, you must use the number above.

**For the quickest test results, go to
<http://www.takeexamonline.com>**

When you feel confident that you have mastered the material in this study unit, complete the following examination. Then submit only your answers to the school for grading, using one of the examination answer options described in your “Test Materials” envelope. Send your answers for this examination as soon as you complete it. Do not wait until another examination is ready.

Questions 1–20: Select the one best answer to each question.

1. A *plug follower* is used in the disassembly of

- A. a combination padlock.
- B. all disk tumbler locks.
- C. all locks made in the United States.
- D. pin tumbler locks.

2. A lock mechanism containing more than two sets of top and bottom pins would be called a

- A. high-security mechanism.
- B. wafer tumbler mechanism.
- C. combination lock.
- D. lock plug.

3. Which of the following lock mechanisms is commonly used in General Motors automobiles?
- A. Warded lock
 - B. Lever tumbler lock
 - C. Padlock
 - D. Side bar wafer lock
4. What is a *case ward*?
- A. A warded padlock
 - B. A special cut in a bit key
 - C. A ward on a lock's keyway
 - D. A lock used on a suitcase or briefcase
5. A *cam lock* is a type of
- A. high-security pin tumbler lock.
 - B. disk tumbler lock.
 - C. lever tumbler door lock.
 - D. warded padlock.
6. Where is a rim lock installed?
- A. On a briefcase or suitcase
 - B. On a safety deposit box
 - C. On the surface of an automobile door
 - D. On the surface of an entry door
7. Wheels are essential to the operation of
- A. a combination lock.
 - B. a plug follower.
 - C. a disk tumbler lock.
 - D. a warded lock.
8. An *anti-wrenching pin* is a device that
- A. is found only in warded lock mechanisms.
 - B. prevents a lock cylinder from being pulled out of a door.
 - C. prevents a lock cylinder from being picked.
 - D. protects a lock cylinder from rust and corrosion.
9. A disk tumbler lock may also be called
- A. a wafer lock.
 - B. a lever lock.
 - C. a warded lock.
 - D. a high-security lock.
10. The wards of a warded lock may be bypassed using a
- A. change key.
 - B. skeleton key.
 - C. disk tumbler.
 - D. plug follower.
11. A typical combination on a combination lock consists of a series of _____ numbers.
- A. two
 - B. three
 - C. ten
 - D. no

12. Which of the following are components of a lever tumbler mechanism?

- A. The gate, the post, and the saddle**
- B. The cover boss, the trunnion, and the ward
- C. The saddle, the top pins, and the lever
- D. The trunnion, the post, and the milling groove

13. Which of the following are components of a pin tumbler mechanism?

- A. The top pins, the trunnion, and the lever
- C. The plug, the case ward, and the bottom pins
- B. The springs, the top pins, and the wheels
- D. The top pins, the plug, and the bottom pins**

14. The top pins in a pin tumbler lock mechanism

- A. are all the same size.**
- B. are welded together.
- C. are all different sizes.
- D. correspond to the cuts in the key.

15. A warded door lock is usually opened with a

- A. cylinder key.
- B. flat key.
- C. bit or barrel key.**
- D. tubular key.

16. If you attempt to move anti-pick pins with a lockpick, they'll

- A. lift up easily to the shearline.
- B. cause the top pins and springs to pop out of the cylinder.
- C. jam between the plug and the cylinder.**
- D. cause the lockpick to become wedged inside the cylinder.

17. Which of the following lock types is generally the easiest to disassemble?

- A. Pin tumbler
- B. Lever tumbler
- C. Disk tumbler
- D. Warded**

18. When an electric lock's pushbutton is pressed, what happens?

- A. The electrical circuit is completed, and an alarm bell sounds.
- B. The coil is energized, causing a powerful magnet to hold the door shut.
- C. The electrical circuit is completed, and the door opens.**
- D. The coil attracts a plunger that locks the door.

19. Which of the following is used to service an interchangeable core?

- A. A change key
- B. A bit key
- C. A control key**
- D. A flat key

20. A combination lock will open when

- A.** all of its wheels have been properly aligned.
- B.** the first number in the combination is dialed.
- C.** all of its wards have been bypassed by the key.
- D.** a small hole is drilled in the back of its case.

COMING ATTRACTIONS

Now that you've completed Study Unit 4, your next information-packed study unit is just around the corner. Study Unit 5 is entitled *Residential Locks*, and is designed to introduce you to the many door and window locks you'll see in your career as a locksmith. The most important career topics you'll learn about are the construction and operation of door locks and the practical installation of door locks. With the help of many illustrations and easy-to-follow, step-by-step instructions, you'll learn how to install a variety of locking devices—the same locks you'll be installing profitably every day in your professional career. Enjoy your continuing studies!