Watch 101

Amplitude: Is how big of a swing (degrees of rotation) the balance wheel moves per oscillation. Low amplitude generally means a larger problem with the power transmission causing less than needed energy to be delivered to the escapement.

Bridges: Are attached to the main plate via screws and hold wheels and other parts in place.

Barrel & Mainspring: The barrel is a large gear that contains the powerful mainspring. The mainspring, when wound, provides power to the watch.

Beat Error: Is the measurement of time between “tick” and “tock” and the comparison of the two. In a perfect world the durations are equal and so the beat error is zero.

Balance Wheel: The balance wheel receives the lateral impulses from the escape wheel and oscillates. The balance spring provides the restoring force to the balance wheel. Together, they are the regulating organ of the timepiece. The hairspring and balance wheel together are the regulating organ of the mechanical watch. This harmonic oscillator is very resistant to outside disturbances, which makes it especially suited to keeping track of time. The balance wheel and hairspring are very similar to the pendulum in a clock. The major difference is that the balance wheel and hairspring are portable, while the pendulum is not.

Crown: The crown is an external knob that allows for winding of a watch movement and setting of the time. The crown is attached to the exterior part of the winding stem.

Center Wheel: The center wheel is appropriately named as it usually is in the center of the movement. It is driven by the barrel and rotates once per hour. On the dial side of the movement, the minutes hand is attached to the center wheel via the cannon pinion.

Compensating Balance: Also known as a "compensation balance," this is a type of balance used extensively for precision watchmaking before the advent of modern, Nivarox-type balance springs. Watches before the 20th century used plain steel balance springs; these were susceptible to changes in elasticity as temperature changed, which could badly disrupt the accuracy of a watch. Watchmakers discovered that if the balance was made of two strips of brass and steel laminated together, and then two cuts made in the balance's perimeter, that the amount the balance changed in size as temperature changed, almost exactly canceled out the change in the elasticity of the balance spring.

The very first compensating balance was developed by John Harrison in the mid-18th century, for his H4 marine chronometer, and was gradually improved and simplified by later makers, including the French horologist Pierre LeRoy, and the Englishmen Thomas Earnshaw and John Arnold.

Crown Wheel: The crown wheel sits in between the winding stem and the ratchet wheel. It serves as as intermediate wheel in transferring torque from the winding of the crown to the ratchet wheel.

Cannon Pinion: The cannon pinion is the heart of the motion works. This piece is what translates the movement of the wheels on the back into the time keeping display on the front. Most commonly (there are several exceptions) this is attached to the center wheel via friction fit and it is the post that the minute hand is set on.

Click: The click holds the ratchet wheel against the force of the mainspring, allowing the watch to be wound. Its name is well suited, as the clicking noise you hear when a watch is wound is the click impacting each tooth of the ratchet wheel. Some clicks have a separate click spring that forces the click back into contact with the ratchet wheel's teeth. Others have the spring integrated into their design. Their design can vary widely, and often are a matter of movement architecture style. The first step in disassembling a movement is to let down the power of the mainspring. This action requires the click be held back from the ratchet wheel, and the winding stem let turn backwards.

Detent Escapement: With the lever escapement, this is one of the two most important types of escapements in the history of horology. The detent escapement uses a very thin blade spring with a jewel mounted on it to hold the escape wheel in place; a jewel on the balance trips the spring as it passes, which releases the escape wheel, allowing it to advance. The escape wheel then gives impulse directly to the balance and is locked again as the blade spring falls back into place.

The detent escapement has advantages over the lever in that impulse is given directly to the balance by the escape wheel, so it's very efficient and it requires no oil. Its weakness is that it can be tripped by a shock, which will allow the escape wheel to unlock when it shouldn't. In addition, it is not self-starting. For these reasons it was used most often in marine chronometers, where the fact that no oil was needed helped ensure the long-term rate stability so necessary in a navigation timekeeper; sometimes it was also used in high-precision pocket watches. Its invention is generally credited to John Arnold, around 1775.

Escape Wheel: The escape wheel is one part of the device known as the escapement. The club-shaped teeth on the escape wheel interact with the pallet fork to translate rotational motion into lateral impulses.

Escapement: The escapement is a mechanism that translates rotational energy into lateral impulses. The tick-tock sound you hear when holding a watch to your ear is from the escapement. The pallet fork locks and unlocks with the escape wheel at each vibration of the balance wheel. It is easiest to understand the escapement by imagining what would happen to a watch without one. As soon as it was wound, it would immediately unwind in an uncontrollable fashion. The escapement manages the release of power from the mainspring in a way that can be regulated by the balance wheel and hairspring.

The technical and historical development of the escapement is one of the most fascinating and in-depth areas of horology. Many different types of escapement have been invented and used over the history of the watch and clock. Today, the most prevalent is the lever escapement.

End shake: In watchmaking, the amount of vertical play a pivot has in a jewel-hole. A certain amount of end shake is necessary for smooth operation of the gear train. The amount of end shake generally decreases on wheels towards the escapement and increases on wheels towards the barrel.

Fourth Wheel: The fourth wheel rotates once per minute. In movements that display seconds in a sub-dial, the seconds hand is attached directly to the extended fourth wheel pivot on the dial side.

Frequency: The frequency is how many times a balance wheel vibrates per hour. You will commonly see this advertised with the watch. Most commonly these frequencies are 18,000, 21,600, 28,800, or 36,000. There are some very noteworthy exceptions like the Breguet 10Hz (72,000bph) and the Antoine Martin Slow Runner (3,600 bhp)

Gear Train: The gear train is responsible for transmitting torque from the barrel to the escapement. It is comprised of wheels and pinions, arranged as a multiplying gear train. In a multiplying gear train, the output rotates faster than the input. This can be thought of in terms of a bicycle; at a high gear, one revolution of the pedals results in many revolutions of the rear wheel. A byproduct of increasing output speed is a decrease in torque. Continuing the bicycle metaphor, therefore one needs to pedal much harder in the higher gears. So, in a watch gear train, the torque at the first wheel is much higher than the torque at the last. To minimize this torque loss, special care is taken to lower friction in the gear train. Sapphire jewels are used at the pivots to reduce rotational torque loss. Polished and hardened pinion leaves help reduce torque loss at the meshing of the teeth and leaves. Usually a gear train consists of four wheels. The center wheel is the first and is driven by the barrel. It is often located in the center of the movement and rotates once per hour. The second wheel is next. After the second wheel, we have the third wheel, which rotates once per minute. After the third wheel is the escape wheel.

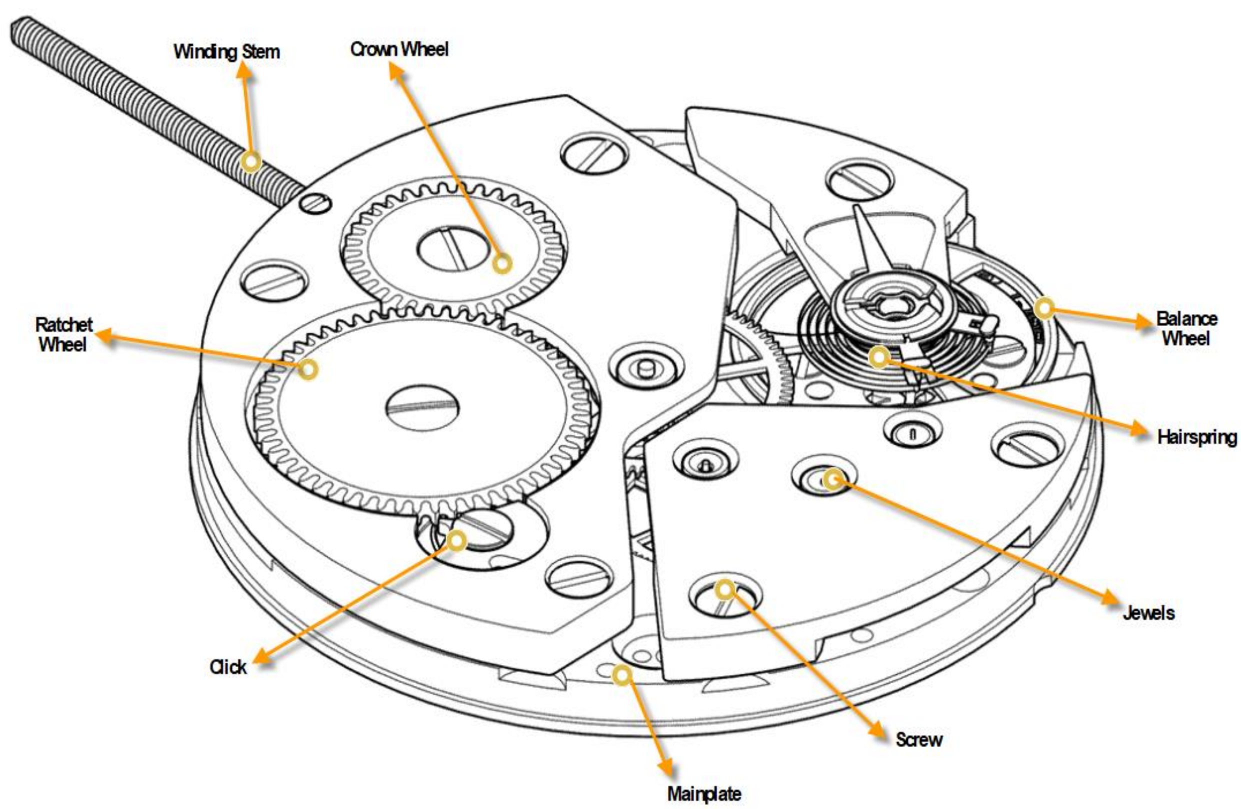
If the barrel were connected directly to the escapement, a watch would run for only a short period of time. The gear train allows the watch to run for many hours by multiplying the output rotation. The gear train is also responsible for dividing time into useful segments – hours, minutes, and seconds. Beyond its usefulness, a gear train is visually compelling because of its constant movement.

Hands: Hands are used in conjunction with a dial to indicate time. They are thin strips of metal attached to a center point of rotation.

Hairspring: The hairspring provides restoring force to the balance wheel, enabling isochronal oscillations. It is a flat spiral spring that breathes at each vibration of the balance wheel. The spring itself was originally made from steel or gold, and today is made from temperature resistant alloys or silicon. The hairspring and balance wheel together are the regulating organ of the mechanical watch. This harmonic oscillator is very resistant to outside disturbances, which makes it especially suited to keeping track of time. The balance wheel and hairspring is very similar to the pendulum in a clock. The major difference is that the balance wheel and hairspring are portable, while the pendulum is not.

Jewels: Wheels in a watch are constantly rotating while a watch is running. Wheels rotate on their pivots, which are thin posts on both ends of the pinion. This constant rotation causes friction, which in turn causes mechanical wear. To reduce friction and wear, the pivots rotate in synthetic sapphire jewels. Sapphire is used because of its hardness; only diamond is harder. Jewels are cylindrical, pierced with a hole on the flat sides. One flat side has a concave oil sink, designed to retain oil on the pivots. One jewel is pressure-fitted into the main plate, and the other into the bridge. Different pivot sizes mean each set of jewels needs a different diameter hole. A center wheel rotates once per hour and is subject to high torque levels. Because of this, the pivot diameter is large. A fourth wheel rotates once per minute and is subject to low torque levels. Because of this, a small pivot diameter is used. Shock-protecting jewel arrangements are used for balance wheels. Balance wheels have very thin pivots due to their oscillation speed. They are also very heavy, leading to increased stress on the balance pivots in the event of a shock. Shock-protecting jewels have a cap jewel mounted on a small spring to absorb the energy of any shock and protect the balance wheel pivots. Before the invention of shock-protecting jewels, broken balance staffs were a very common watch problem. Before the use of jewels, main plates and bridges were pierced directly. Without the use of jewels, the entire main plate or bridge would have to be replaced when the pivot eventually caused mechanical wear. An improvement was to use bushings, which were easily replaceable, unlike the main plate or bridge. When first introduced, jewels were natural sapphire. Today, synthetic sapphire is used. Synthetic sapphire has the advantage of being less prone to cracking. It is also much cheaper to source and produce.

Movement Side:



Keyless Works: The keyless works allows the movement to be wound and the time set via the winding stem. It allows for two (or more depending on the movement) winding stem positions that engage different gears trains in the movement.

Lever Escapement: This is the most common type of escapement, by far, found in watches today. The lever escapement is named for the small, forked lever that sits in between the escape wheel and the balance. The two jewels on the end of each tip of the fork alternately lock and unlock the escape wheel as the lever is flicked back and forth by a jewel on the balance as the balance oscillates. Each time the lever unlocks the escape wheel, the unlocked tooth slides along the receding jewel's face and this sliding force imparts impulse, through the lever, to the balance wheel, keeping it oscillating. The lever escapement is the preferred escapement for watches as it is resistant to shock and can give very high accuracy if properly set up and lubricated. Its biggest disadvantage is that it requires oil on the lever jewels where they contact the escape wheel teeth, and the rate of the watch can suffer as the oil ages. The lever escapement's invention is generally credited to the Englishman Thomas Mudge, who is thought to have made the first around 1750. With modifications, his invention is still in use today.

Motion Works: The motion works are responsible for carrying the hours and minutes hands. They are a gear train that reduces 1 hour (minutes hand) to 12 hours (hours hand). They also allow the hands to be set via the keyless works.

Movement: The complete assembled mechanism within a watch or clock that acts as the engine for telling time and any other complications.

Main plate: The main plate and bridges hold the parts of a watch movement together in a sturdy and calculated fashion. Bridges are attached to the main plate via screws. The main plate is the foundation of a movement, making up the majority of each caliber. It is traditionally the element on which the remainder of the caliber is constructed. The main plate is typically made of brass, though some high-end manufactures use German Silver (Nickel).

Pallet Fork: The pallet fork is one part of the device known as the escapement. The pallets on the pallet fork interact with the escape wheel and cause the pallet fork to move back and forth. This motion gives energy to the balance wheel, causing it to oscillate.

Ratchet Wheel: The ratchet wheel sits on top of the barrel and is attached with a screw to the barrel's arbor. When a watch is wound, the ratchet wheel turns and tightly coils the mainspring. The click holds the ratchet wheel in place, so that the mainspring cannot unwind backwards. The clicking noise you hear when winding a watch is the click tapping against each tooth of the ratchet wheel as it turns.

Rate: The rate is how accurate a watch is running, usually expressed in +/- seconds per day or s/d. Each movement has an acceptable range of variability, and a maximum deviation between extremes in all positions.

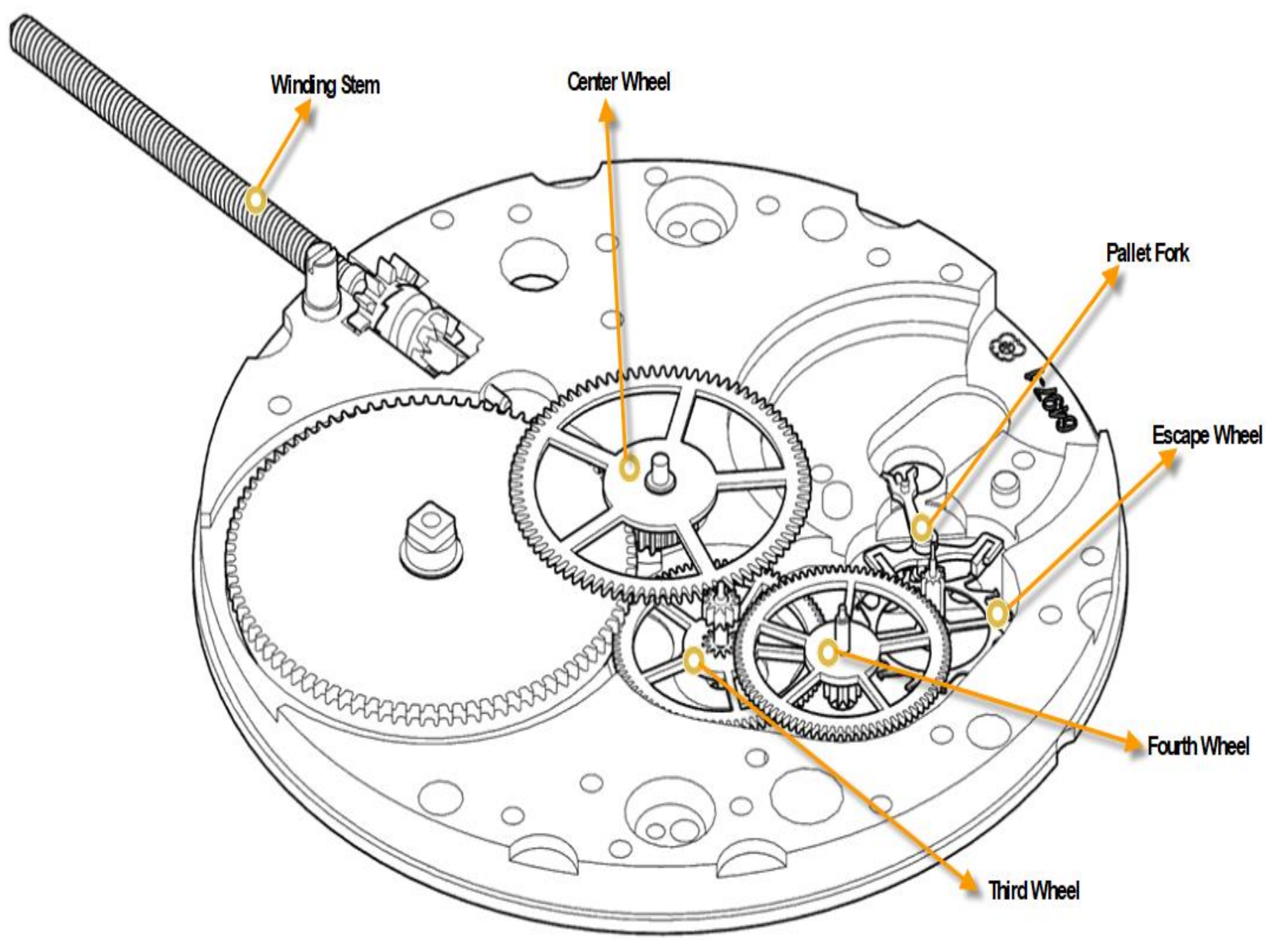
Rotor: The rotor is an eccentric weight caused to rotate by the wearer's motion. The rotation of the rotor then winds the watch.

Screw: A screw is a cylinder with a spiral thread and slotted head. Screws are used to secure two parts together in a way that is strong but easily removable. Clocks and watches predate the invention of screws. Prior to the invention, tapered pins were used to secure parts together. Removing the tapered pins was difficult and could scratch the movement. Screws are easy to place and remove and provide strong securing force. Screws are made from steel and are often seen tempered to blue with polished screw heads. The contrast between the blued screw heads and finished bridges makes for a beautiful movement.

Sideshake: In watchmaking, the amount of play a pivot has in a jewel-hole. Some very minimal side-shake is necessary in order for a gear to turn, but too much is undesirable as it can cause gear teeth to bind and stop the watch. Causes of excessive side-shake include wear to pivots due to them running in dry or poorly lubricated jewels.

Third Wheel: The third wheel sits in between the center and fourth wheels. It makes possible the large increasing gear ratio of 1 to 60 when considering the rotational speed of the center and fourth wheels.

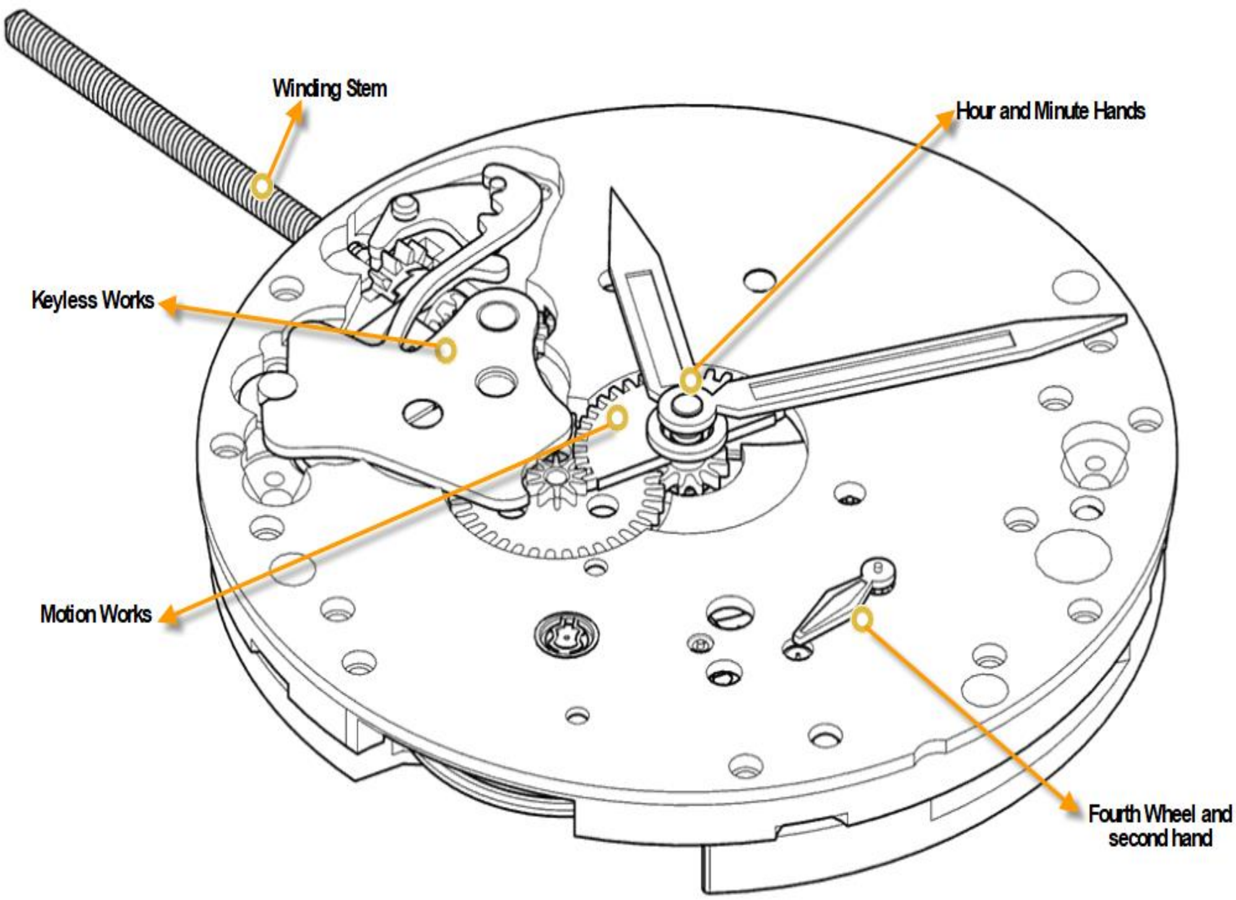
Bridges Removed:



Wheels: Wheels and pinions comprise the gear train. Wheels are large gears usually made of brass and pinions are small gears usually made of steel. They are riveted together when used in a gear train. Large gears are referred to as wheels and small gears are referred to as pinions. Pinions are almost always driven, while wheels do the driving. Wheels and pinions are manufactured separately and then riveted together. When a wheel and pinion are riveted together, the combined part is still referred to as a wheel. While a watch is running, the wheels are constantly rotating. This creates friction, which leads to mechanical wear. To keep this mechanical wear manageable and predictable, two different materials are used for the wheel and pinion. wheels are usually made from brass, and pinions from steel. Pinions also serve as the axis for rotation of the wheel, as they have pivots on both ends.

Those pivots need to be very hard, so it makes sense to manufacture pinions from steel. Because of their large diameter, wheels have spokes. These spokes reduce weight, while maintaining strength. The process of cutting those spokes is called crossing out. Sometimes, the number of spokes can be used to identify what type of wheel it is. Other times, the spokes are decorative. Pinions have a complicated manufacturing process, with many unique steps. Teeth on a pinion are called leaves. Those leaves need to be cut with a milling machine. When ready, the pinion is hardened, tempered, and polished. Pivots are cut and finally burnished before the wheel can be riveted.

Dial Side:



Winding Stem: The winding stem is the interface between the exterior and interior of a watch. Manipulation of the winding stem by turning, pulling, and pushing the crown winds and sets the mechanical movement. One end of the winding stem is threaded, where the crown is attached. The threaded side is cut to length depending on the size of the case. The other side of the winding stem has a square, which interface with the winding and setting mechanisms in the movement. The pivot on the end of the square steadies the winding stem as it turns. Manufacturing of the winding stem by hand is often a micro-mechanics exercise that watchmaking students work on.