How Things Work

ME371:ALARM CLOCK

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Introduction:

Have you ever looked inside a alarm clock,which decorates your study table, seen all the gears and springs and thought, "Wow - that's complicated!"? While clocks normally are fairly complicated, they do not have to be confusing or mysterious. In fact,learning how a mechanical alarm clock works is a very enjoyable experience.Here we try to help you understand what makes clocks tick,so the next time you look inside one you can make sense of what's happening!

Spring Alarm clocks have been used to keep time since decades and still they are fun to explore. The design aspect have also not changed dramatically since then . The Quartz clocks also use the same gear-trains.Here is the clock we will be exploring :

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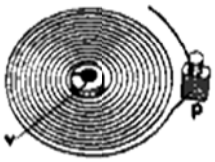
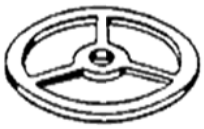
Parts:

Anchor:
The name given to the lever attached to the alarm-clock to release the escapement gear one tooth at a time.

Alarm Lever:
The lever used to restrict the alarm gear from unwinding.





Balance Spring:
The hairspring and the balance form the oscillating system. The balance spring of an clock consists of a thin and flat wire made of Nivarox.

Balance Wheel:
Part of the escapement of a mechanical clock. Oscillating device which divides the time into equal sections.

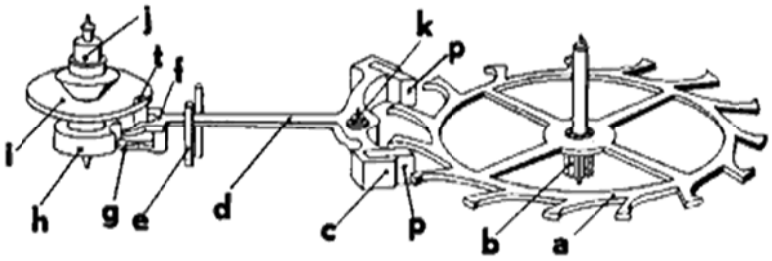
Barrel:
The barrel contains the wound-up mainspring, hooked to it at its outer end which stores the energy, assuring a power reserve of 36 to 45 hours to the clock. The mainspring is wound up manually by means of the crown.

Bridge:
Brass plate fixed on the main plate by two or more pins and screws. Between the bridge and the plate the wheels and staffs are turning.

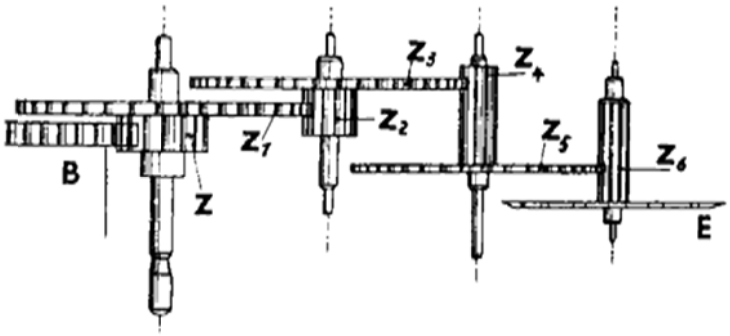
Crown:
Key to wind up and set the watch to time.

Escapement Wheel:
The escapement wheel and the lever build the escapement. It is the last wheel in the gear-train.

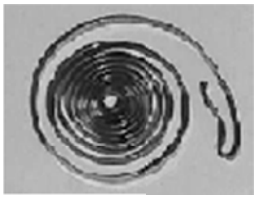
Escapement:
Mechanism built in between the gear train and balance wheel. The escapement transfers the power from the gear train in regular and even time sequences to the balance, the oscillating system.

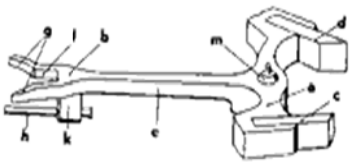


Gear Train:
The system of wheels and pinions which, from the barrel B, transmits the driving power to the escape wheel E, Z1 centre-wheel, Z3 third wheel, Z5 fourth wheel. E escape wheel. All these wheels are riveted to their respective pinions, Z2, Z4, Z6.



Mainspring:
Flat coiled spring that powers all mechanical watches.





Pallet:
Part of the lever escapement, shaped like a ship's anchor .

NOTE: Some of these figures are taken from **Oris Watch Co. Site**

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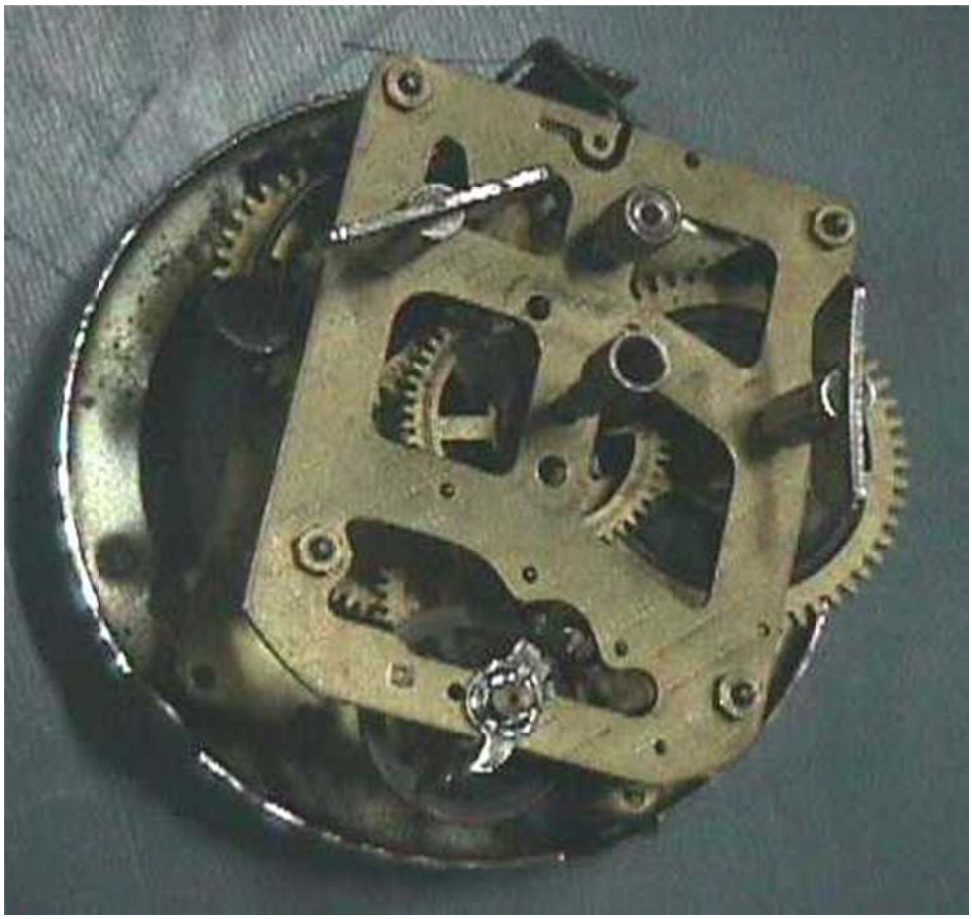
Working:

Removing the winding knobs and the back-case of your clock reveals the inside of the clock.



By removing the stand, hands, face and mounting ring, you end up with the clock mechansim itself.

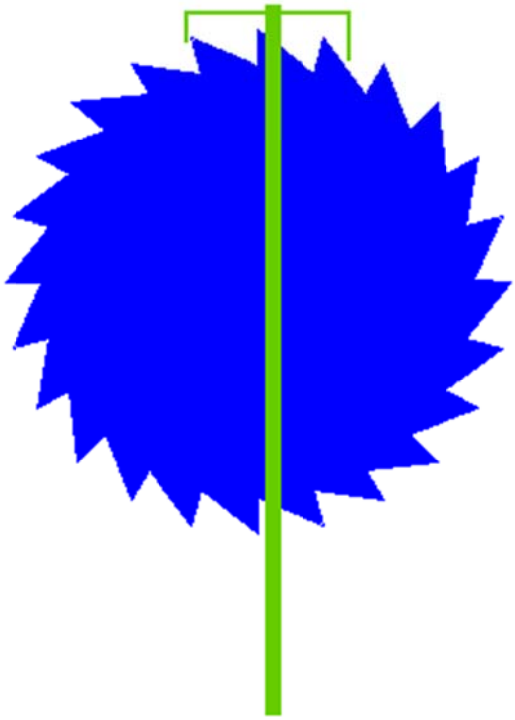
You will see the **main spring**.The basic idea behind the spring is to act as an energy storage device so that the clock can run unattended for long periods of time. The "Potential Energy" of the spring provides the driving force to run the clock . A similar but a smaller spring provides energy to the alarm . These springs have clutches to restrict the back-rotation when we are winding the main-spring using the crown.

So let's say that we wanted to use a winded main-spring to create the simplest possible clock -- a clock that has just a second hand on it. We want the second hand on this simple clock to work like a normal second hand on any clock, making one complete revolution every 60 seconds. We might try to do that simply by attaching the main-spring to a wheel and then attaching a second hand to the wheel as well. This, of course, would not work. The main-spring would always be in tension to unwind. So in this simple mechanism, releasing the spring would cause it to unwind and the wheel will rotate with a very high speed until the main-spring gets totally unwind.

Now if we put some sort of restriction on the spring and allow it to open with time---- our aim would we fulfilled.

Here an **escapement mechanism** comes into picture ----

In an escapement there is a gear with teeth of some special shape. There is also a pallet, and attached to the pallet is the **anchor** which is used to engage the teeth of the gear. The basic idea that is being demonstrated in the figure is that, for each swing of the pallet back and forth, one tooth of the gear is allowed to **escape**. For example, if the pallet is swinging toward the left and passes through the center position , then as the pallet continues toward the left the left-hand pin attached to the pallet will release its tooth. The gear will then advance one-half tooth's-width forward and hit the right-hand pin.In advancing forward and running into th pins ,the gear will make a sound ... **"tick" or "tock"** being the most common.That is where the ticking sound of a clock comes from. Also, the pallet is attached to a balance-wheel which has a balance-spring attached to its axle, which gives it a back and forth motion.



This animated GIF of the clock escapement is actually always going CCW, being blocked by one or the other teeth of the pendulum in sequence. Taken from http://www.howstuffworks.com.

One thing to keep in mind is that the pallet will not swing forever. Therefore, one additional job of the escapement gear is to impart just enough energy into the pallet to overcome friction and allow it to keep swinging. To accomplish this task, the anchor and the teeth on the escapement gear are specially shaped. The gear's teeth escape properly, and in addition the pallet is given a nudge in the right direction by the anchor each time through a swing. The nudge is the boost of energy that the pallet needs to overcome friction, so it keeps swinging.

So, let's say that we have created an escapement like this. If we gave the escapement gear 60 teeth and attached this gear directly to the spring we discussed above, and if we attach a second hand with it,we have made simple clock with a second-hand.

While accurate, this clock would have two problems that make it less-than-useful:

1. Most people typically expect a clock to have hour and minute hands as well, so this clock would be seen as lacking in that respect.
2. You would have to wind the clock again and again after some minutes. Because the spring will unwound in some time.Obviously nobody would like to do this.

To solve this problem a high ratio gear-train comes into use . This makes the main-spring to unwind in 35 to 45 hours.You can see that if you let the escapement gear itself drive another gear train with a ratio of 60:1, then you can attach the minute hand to the last gear in that train. A final train with a ratio of 12:1 would handle the hour hand.You have a clock.

Now let us see **"how the alarm works?".** Here also there is a spring which stores the energy in it. And to restrict the unwinding of the spring , there is a alarm lever which is also something like the **anchor** . This lever is controlled by another spring-lever which is always kept pressed by the alarm-gear . The alarm gear is synchrnous with the hour gear . Now when the clock strikes the time set in the alarm dial , the pin in the dial falls into a groove made on the alarm gear . This causes the alarm gear to rise ,which in turn causes spring-lever to rise

and release the alarm lever and so the spring starts unwinding. There is a gear with special teeth which meshes with the spring gear .This gear makes the alarm lever rotate to and fro , which hits the case and makes the alarming sound **"Trrrrrrrnnnnnnnnnn".**

You can see that although the gears in a clock make it look complicated,the working is fairly simple.There are 5 basic parts:

1. The spring - this provides the energy to turn the hands of the clock.
2. The weight gear train - a high-ratio gear train,transmits the motion of the spring, so that you don't have to rewind the clock very often.
3. The escapement - made up of the pallet, the anchor and the escapement gear, the escapement precisely regulates the speed at which the spring's energy is released.
4. The hand gear train - gears things down so the minute and hour hands turn at the right rates.
5. The setting mechanism - somehow disengages, slips or ratchets the gear train so the clock can be rewound and set.

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Related Links

1. How Mechanical Clocks Work
2. Glossary of Parts

Pages prepared as part of the course ME371 Hands-on lab in July-Dec 1999. **Instructors:** Amitabha Mukherjee and M.K. Muju