TWR2000

18-Note Spring-Motor Musical Movement

A Technical Description

Autumn Rose White
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1 – General description

1.1 – Scope of the technical description

This technical description discusses the modern 18-note spring-motor musical movements that include speed regulators and use programmed cylinders as opposed to discs.

Note that while the scope of this description focuses on small musical movements, the basic mechanisms described here are applicable to larger and more complex movements.

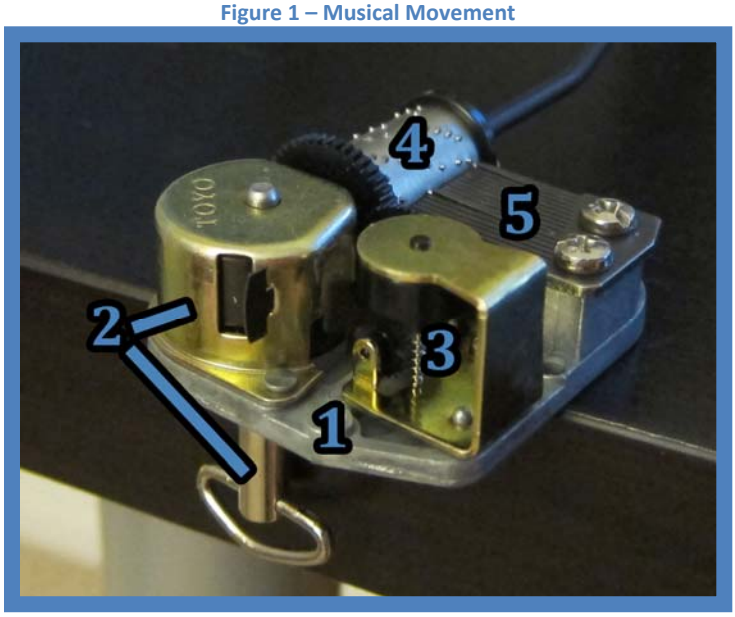
1.2 – Technical definition of a spring-motor musical movement

A spring-motor musical movement[1] is a spring-powered clockwork instrument that plays a fixed tune using a revolving cylinder set with pins to pluck the teeth of a metal comb. Typically, the manufacturer or user places the movement in a box or similar casing to amplify their sound. Manufacturers typically use these movements in jewelry boxes, children's toys, and decorative items.

Spring-motor musical movements are comprised of the following parts:

1. Base-plate
2. Spring-motor (consisting of a housing, mainspring, gear transmission system, and a key)
3. Speed regulator
4. Programmed cylinder
5. Tuned comb

Figure 1 – Musical Movement



The base-plate provides a foundation to anchor the other pieces. The spring-motor is the mechanism that stores and distributes the energy provided by the user to power the movement. The speed regulator controls the speed of the spring-motor, ensuring the music plays at an even, steady pace. The cylinder dictates the tune the music box will play. The tuned comb produces the sound of the music programmed onto the cylinder.

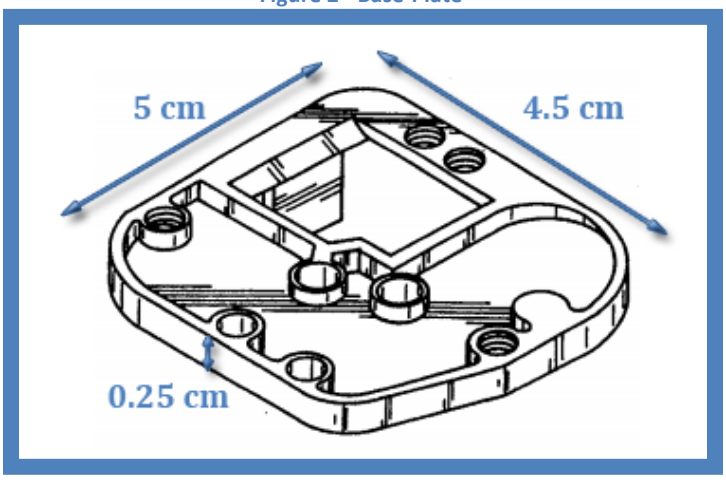
[1] The word "movement" in this context refers to a clockwork-mechanism, as opposed to the act of changing physical location or position.

2 – Main parts

2.1 – Base-plate

The base-plate (sometimes referred to as the bedplate) is a heavy piece of metal that forms the foundation of the musical movement. The base-plate is 5 cm long by 4.5 cm wide with rounded corners. It is 0.25 cm high.

Figure 2 - Base-Plate[i]

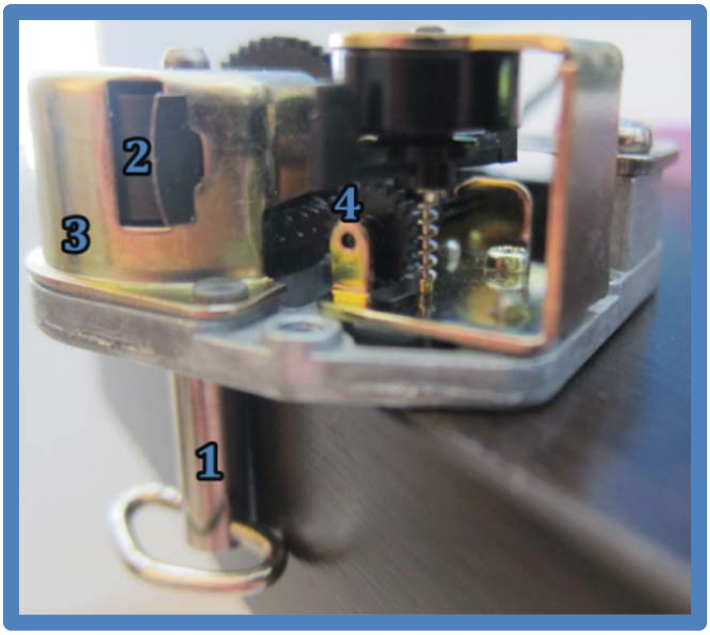


The base-plate includes a number of threaded holes for use with metal screws and dowel pins to attach the base-plate to a box or casing, and to attach the other pieces of the movement to the base-plate.

2.2 – Spring-motor

The spring-motor is the mechanism that stores and distributes the energy provided by the user to power the movement. It consists of a key (1), a mainspring (2) located within a housing (3), and a gear transmission system (4) that connects and transfers energy to all of the moving parts of the musical movement.

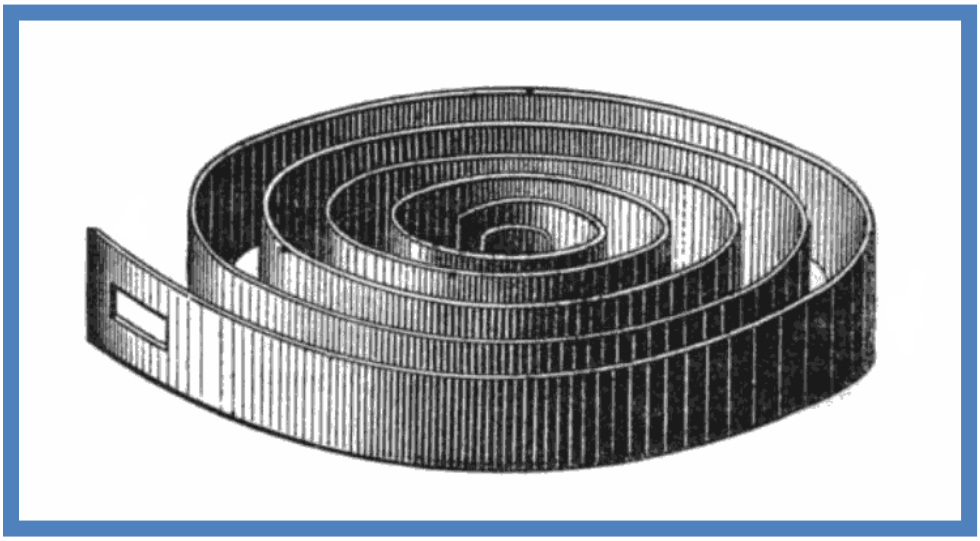
Figure 3 - Spring-Motor



1. The key is comprised of two parts – a head (the part the user can see), and an axle. The length and shape of the head and axle vary; however, they are typically made of metal. The head protrudes from the back or underside of the base-plate. If the musical movement is located in a box, the head will be located outside the box, connected to the axle through a hole drilled in the box. The axle has a threaded end onto which the manufacturer screws the head; sometimes the manufacturer uses glue to prevent the user from accidentally unscrewing the head. The axle runs through a hole in the base-plate, and connects to one end of the spring.

2. The mainspring is a flat length of metal shaped like a ribbon that stores energy when twisted, and releases it as it unwinds. It is contained within the housing. The length of the spring, which varies, dictates how long the musical movement will play.

Figure 4 - Mainspring[ii]



3. The housing is 1.5 cm high, and 2 cm wide from corner to corner (note that the outside corner of the housing is rounded; however the inside corner and the sides closest to the cylinder and speed regulator are roughly squared off to accommodate the rest of the movement). The housing can be made of either metal or plastic. The manufacturer secures it to the base-plate using dowel pins.

4. The gear transmission system is the mechanism by which the spring-motor transfers the energy of the unwinding mainspring to the speed regulator and the cylinder. It is a series of six interconnected gears, including a driving gear (at the base of the housing), a gear that rotates the cylinder (attached to the inside-end of the cylinder), a gear that rotates the speed regulator's screw shaft, and three transmission gears that connect them. The largest of the gears (the cylinder gear) is 2 cm in diameter; the smallest (one of the transmission gears) is 0.25 cm in diameter. The gears are typically made of black engineering plastic, though they are occasionally made of metal (especially in older movements). The manufacturer mounts some of the gears (e.g., the cylinder gear) on other parts of the movement, or else secures them to the base-plate via metal mounts and screws or dowel pins.

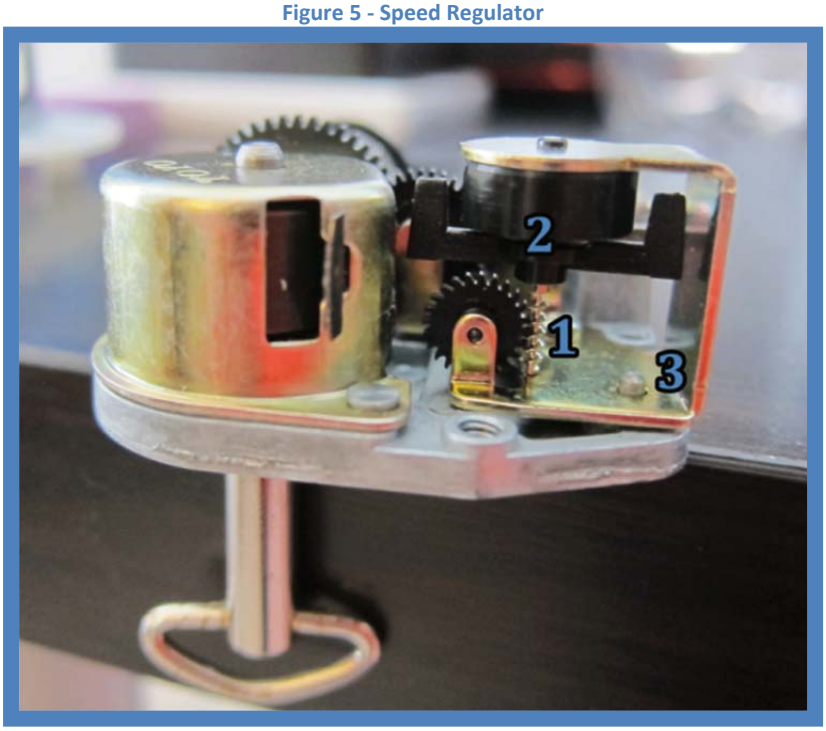
2.3 – Speed regulator

The speed regulator controls the speed of the spring-motor, ensuring the music plays at an even, steady pace. Without a speed regulator, the spring would unwind too quickly, causing the cylinder to revolve at a very high speed. This speed

would cause the pins on the cylinder to break the teeth on the comb, or to become bent over time ("stripping" the cylinder) and ruining the movement.

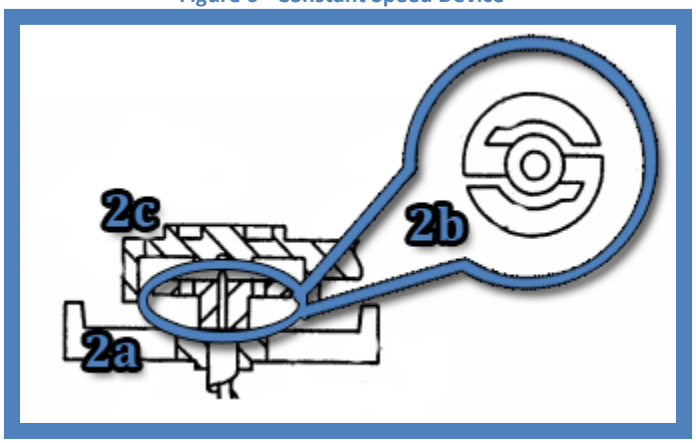
The speed regulator is comprised of a metal screw shaft (1) connected to a soft silicone constant speed device (2), and set in a metal frame that contains the entire mechanism (3). The screw shaft is 0.7 cm tall. The metal frame is 1.7 cm tall.

Figure 5 - Speed Regulator



The constant speed device consists of rotation stopper (2a), a constant speed device element (2b), and a constant speed device disc (2c). The constant speed device is 0.4 cm tall, and 1.2 cm in diameter. The rotation stopper is 1.8 cm long.

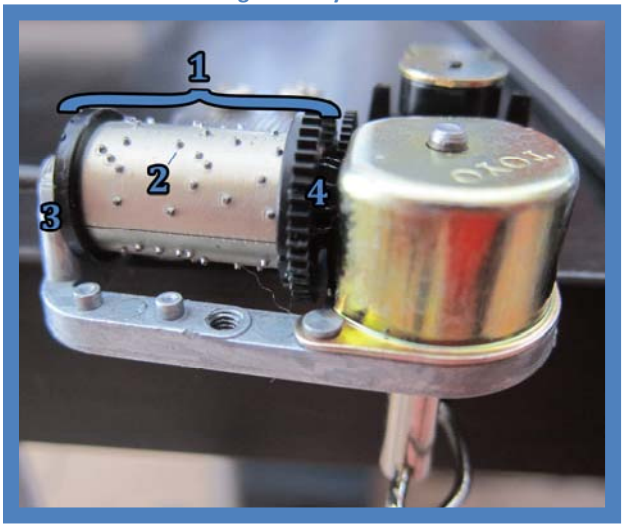
Figure 6 - Constant Speed Device[iii]



2.4 – Programmed cylinder

The cylinder (1), sometimes called a drum, is a metal cylinder that is "programmed" with a melody by setting it with small, raised metal pins (2). It is a 2.25 cm long cylinder with a 1.5 cm diameter, and can be either hollow or solid. The manufacturer mounts one end of the cylinder on the base-plate with a threaded axle or a screw (3), and connects the other to the spring-motor via a gear made of engineering plastic (4).

Figure 7 - Cylinder

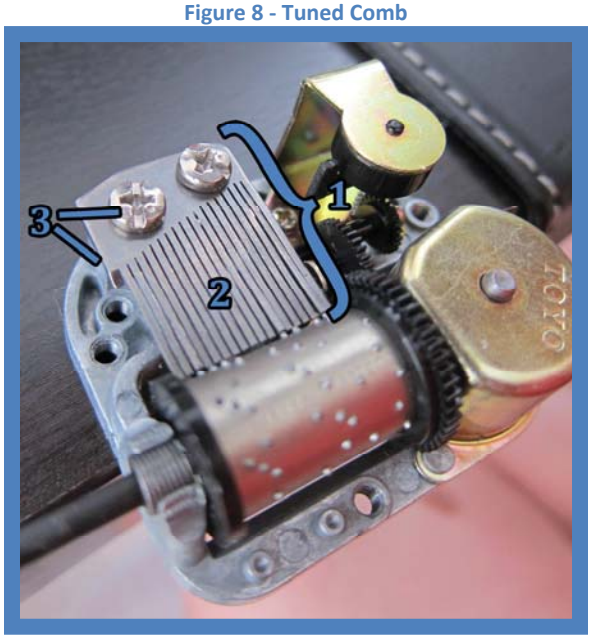


The location of an individual pin relative to the placement of the teeth of the tuned comb dictates which note the pin represents (i.e., which tooth the pin will pluck). The spacing of the pins relative to the direction of the cylinder's revolutions dictates the timing of the notes (the larger the gap between two pins in a revolution, the longer the space of time between the notes). The cylinder will only work with the specific tuned comb the manufacturer programmed it for, and will not work with others.

2.5 – Tuned comb

The tuned comb (1) is a metal instrument consisting of a set of eighteen teeth of varying lengths and thicknesses (2) designed to produce a unique and specific set of notes. The tuned comb is 2.5 cm long by 1.5 cm wide. The manufacturer fixes it to the base-plate via a metal mount and two screws (3).

Figure 8 - Tuned Comb

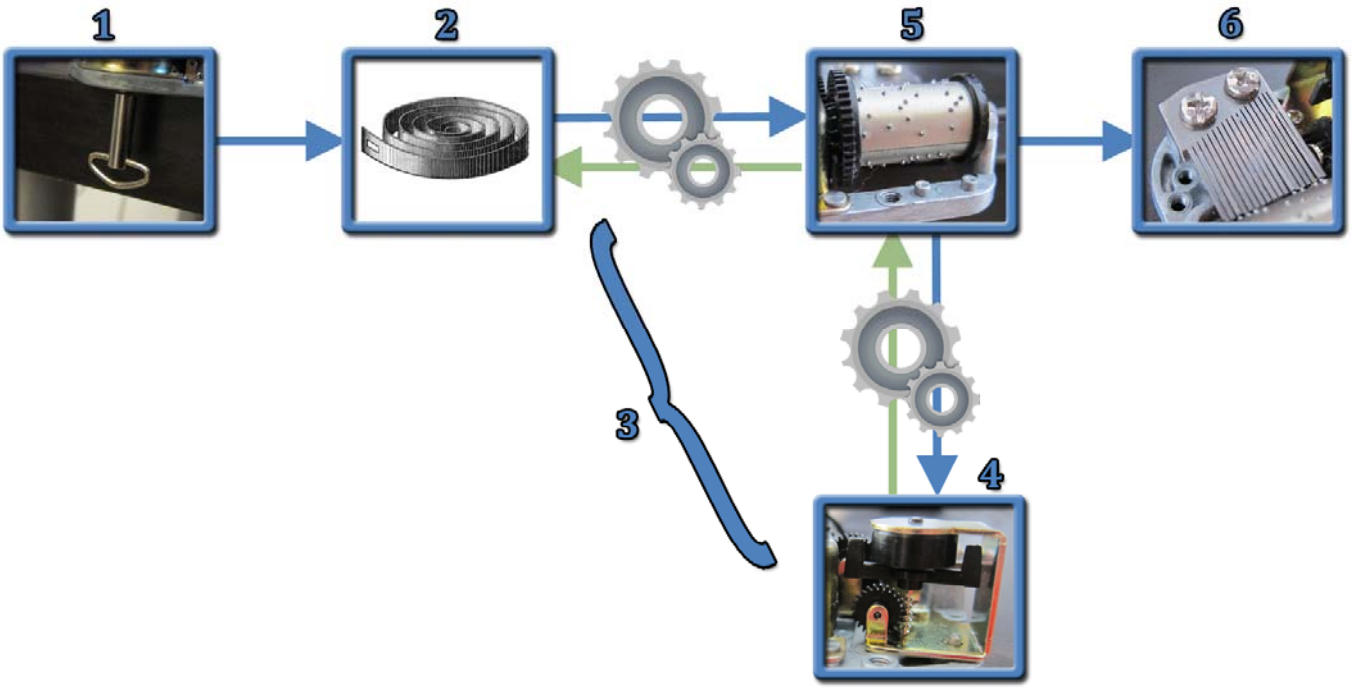


The manufacturer tunes the teeth (by varying the length and thickness of each tooth) to include only those notes necessary to play the music programmed into the companion cylinder. The tuned comb is not interchangeable with tuned combs in other musical movements – the manufacturer designed it for use with a specific cylinder.

Cycle of Operation

The following flow chart depicts the cycle of operation for an 18-note spring-motor musical movement:

Figure 9 - Cycle of Operation Flow Chart



1. The user turns the key by hand, storing potential energy in the mainspring by compressing it tightly.
2. When the user releases the key, the mainspring converts the potential energy into kinetic energy as it begins to unwind.
3. The unwinding of the spring causes the gear transmission system to turn, transferring the spring's energy to both the cylinder and the speed regulator through the turning of individual gears.
4. The turning of the gears causes the speed regulator's screw shaft to rotate, which causes the constant speed device to spin. As the constant speed device spins, centrifugal force causes the wings of the constant speed element to expand and rub against the internal sides of the constant speed disc. This rubbing creates friction, which limits the speed at which the screw shaft is able to turn. Because the same gears that rotate the screw shaft also rotate the other moving parts of the musical movement, the maximum speed of the screw shaft limits the maximum speed of the rest of the musical movement (represented in the diagram by the green arrows). In this way, the speed regulator controls the speed of the entire musical movement, and ensures the music plays at an even pace.
5. The turning of the gears also causes the cylinder to revolve (the speed of the revolutions is controlled by the speed regulator). As it turns, the raised pins on its surface pluck the teeth of the tuned comb.
6. The teeth of the tuned comb vibrate as they are plucked, emitting sound at a pitch dictated by their length and thickness, in the pattern dictated by the pins of the cylinder, creating the sound of music.

Alphabetical Bibliography

The author gathered the majority of the information contained in this technical description through study and observation of the operation of three different 18-note musical movements manufactured by Toyo, Yunsheng, and Sankyo. Unless otherwise noted, the author created the images in this description, and the images depict the Toyo musical movement.

The author used terminology from, and cross-referenced her observations against the following web pages:

BetterMusicBoxes.com
Sankyo 50 and 72 Note Music Box Design & Installation Considerations
http://www.bettermusicboxes.com/products/movements/Installation/Music-Box-Movement-Instructions.asp

Google Patents
Music Box – US 5449856 A
http://www.google.com/patents/US5449856

Music Box Attic
Learn About Music Boxes
http://www.musicboxattic.com/leabmubo.html

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History of the Music Box
http://www.themusicboxman.com/history.html

Wikipedia
Music box
http://en.wikipedia.org/wiki/Music_box

The Wikisource 1911 Encyclopedia Project
Musical Box
http://en.wikisource.org/wiki/1911_Encyclop%C3%A6dia_Britannica/Musical-box

[i] Image taken from US Patent 5,449,856, Figure 3. Measurements taken from three physical music boxes owned by the author of this technical description (manufactured by Sankyo, Toyo, and Yunsheng).
[ii] Image taken from https://en.wikipedia.org/wiki/File:Clock_Mainspring.png
[iii] Image taken from US Patent 5,449,856, Figures 4b and 4c.