CHAPTER VIII.

SOUND.

The student of acoustics need not go beyond the realm of toys for much of his experimental apparatus. The various toy musical instruments are capable of illustrating many of the phenomena of sound very satisfactorily, if not quite as well as some of the more pretentious apparatus.

Sound is a sensation of the ear, and is produced by sonorous vibrations of the air. It may be in the nature of a mere noise, due to irregular vibrations, like the noise of a wagon on the street, or it may be a sharp crack or explosion, like the cracking of a whip or like the sound produced by the collision of solid bodies. The clappers, or bones, with which all boys are familiar, are an example of a class of toys which create sound by concussion, and the succession of sounds produced by the clappers are irregular, and clearly distinct from musical sounds.

FIG. 117.

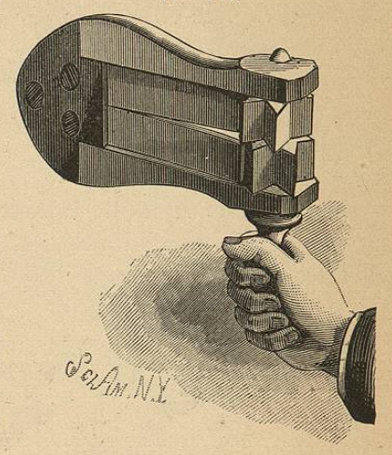
Clappers.

A succession of such sounds, although occurring with considerable frequency and perfect regularity, will not become musical until made with sufficient rapidity to bring them within the perception of the ear as a practically continuous sound. The rattle, or cricket, produces a regular but unmusical sound.

The wooden springs of the cricket snap from one ratchet tooth to another, as the body of the cricket is rapidly swung around, making a series of regular taps, which, taken all

together, make a terrific noise, having none of the characteristics of musical sounds. That a musical sound may be made by a series of taps is illustrated by the buzz, a toy consisting of a disk of tin having notched edges and provided with two holes on diametrically opposite sides of the center, and furnished with an endless cord passing through the holes. The disk is rotated by pulling in opposite directions on the twisted endless cord, allowing the disk to twist the cord in the reverse direction, then again pulling the cord, and so on.

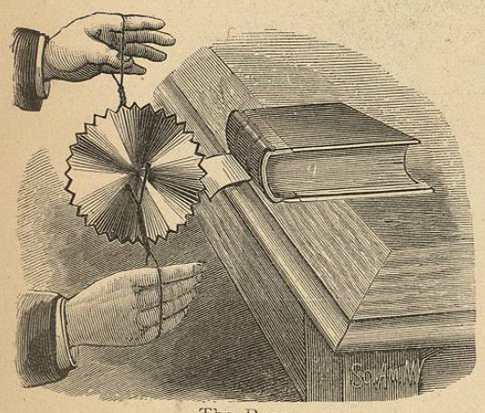
FIG. 118.



The Cricket, or Rattle.

If, while the disk is revolving rapidly, its periphery is brought into light contact with the edge of a piece of paper, the successive taps of the teeth of the disk upon the paper produce a shrill musical sound, which varies in pitch according to the speed of the disk. Such a disk mounted on a shaft and revolved rapidly is known as Savart's wheel.*

FIG. 119.



The Buzz.

It is ascertained by these experiments that regular vibrations of sufficient frequency produce musical sounds, and that concussions, irregular vibrations, and regular vibrations having a

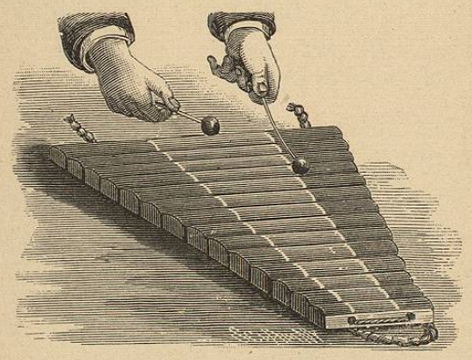
*See chapter on experiments with the scientific top.

slow rate, produce only noises. It has been determined that the lowest note appreciable by the ear is produced by sixteen complete vibrations per second, and the highest by 24,000 complete vibrations per second.

VIBRATING RODS.

The zylophone and metallophone are examples of musical instruments employing free vibrating rods supported at their nodes. The zylophone consists of a series of wooden rods of different lengths, bored transversely at their nodes, or points of least vibration, and strung together on cords. The instrument may either be suspended by the cords or

FIG. 120.



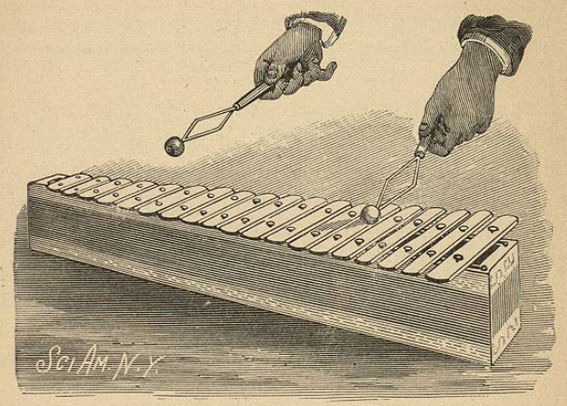
The Zylophone.

laid upon loosely twisted cords situated at the nodes. By passing the small spherical wooden mallet accompanying the instrument over the wooden rods, very agreeable liquid musical tones are produced by the vibration of the rods, and when the rods are struck by the mallet they yield tones which are very pure, but not prolonged.

The cheaper forms of zylophone are tuned by slitting the rods transversely at their centers on the under side, by means of a saw, to a depth required to give them the flexibility necessary to the production of the desired tones. The rods are divided by the nodes into three vibrating parts,

the parts between the nodal points and the ends being nearly one-half of the distance between the nodes.

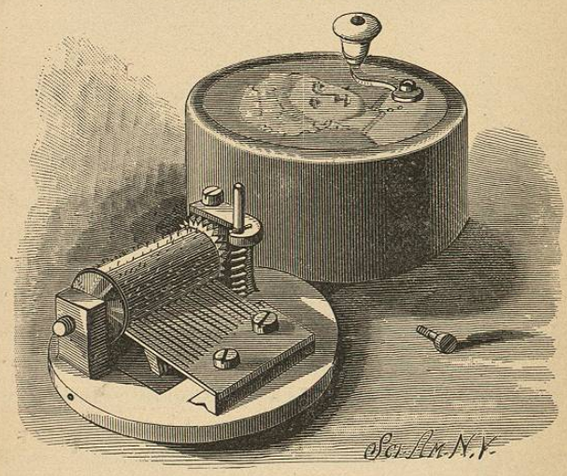
FIG. 121.



The Metallophone.

The metallophone is similar in form to the zylophone, but, as its name suggests, the vibrating bars are made of metal—

FIG. 122.



Music Box.

hardened steel. The bars rest at their nodes on soft woolen cords, secured to the upper edges of a resonator forming

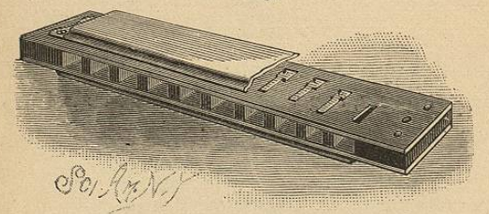
the support of the entire series of bars. The resonator is tapered both as to width and depth, and serves to greatly increase the volume of sound, although it does not act as a perfect resonator for each bar.

When a bar is struck, its downward movement produces an air wave which moves downward, strikes the bottom of the resonator, and is reflected upward in time to re-enforce the outwardly moving air wave produced by the upward bending of the bar.

The metallophone yields sweet tones which are quite different in quality from those produced by the vibration of wooden bars.

The music box furnishes an example of the class of instruments in which musical sounds are produced by the vibra-

FIG. 123.



Mouth Organ, or Harmonica.

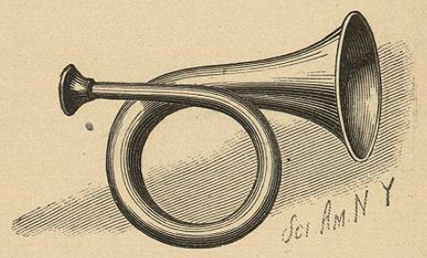
tion of free reeds or tongues rigidly held at one end and free to vibrate at the other end. The tongues of the music box are made by slitting the edge of a steel plate, forming a comb, which is arranged with its teeth projecting into the paths of the pins of the cylinder, which are distributed around and along the cylinder in the order necessary to secure the required succession of tones. The engagement of one of the pins of the cylinder with one of the tongues raises the tongue, which, when liberated, yields the note due to its position in the comb.

The tongues are tuned by filing or scraping them at their free or fixed ends, or by loading them at their free ends. In this instrument the sonorous vibrations are produced by the tongue, which itself has the desired pitch.

REEDS.

In reed instruments the sounds emitted by the reeds are greatly strengthened by resonance. The mouth organ or harmonica is a familiar example of a simple reed instrument without accurately adjusted resonators.

FIG. 124.



The Bugle.

When reeds are employed in connection with resonating pipes, as in the case of the reed pipes of an organ, the pipe synchronizes with the reed, and re-enforces the sound. When the reed is very stiff, it commands the vibrations of the air column, and when it is very flexible, it is controlled by the air column.

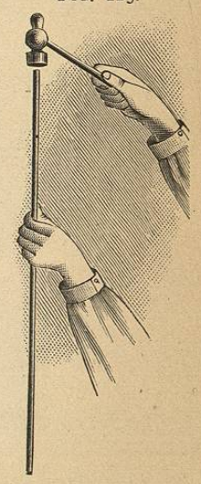
The horn is a reed instrument in which the lips act as reeds, and the tapering tube serves as a resonator.

LONGITUDINAL VIBRATION OF RODS.

The foregoing are examples of the transverse vibration of rods. The annexed figures illustrate apparatus in which the longitudinal vibration of rods is shown.

By grasping a steel rod at the center between the thumb and finger, each of its two ends being free, and striking it upon the end with a hammer, the rod can be made to yield a sound of very high pitch. By holding one end firmly in a vise, and skillfully rubbing the rod, by pulling it

FIG. 125.

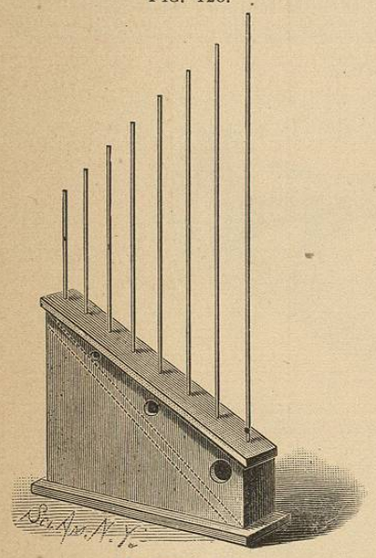


Longitudinal Vibration of a Steel Rod.

between the fingers with a cloth or piece of leather covered with powdered resin, a note an octave lower will be emitted.

Marloye's harp, shown in Fig. 126, depends upon the longitudinal vibration of rods. This instrument consists of a number of pin rods of different lengths inserted in a sounding box or solid block of wood, and tuned by cutting them off at such lengths as to cause them to yield the notes of the diatonic scale. The instrument is played by rubbing the rods lengthwise by the thumb and finger covered with powdered resin. The sounds produced by the instrument resemble those of a flute.

FIG. 126.

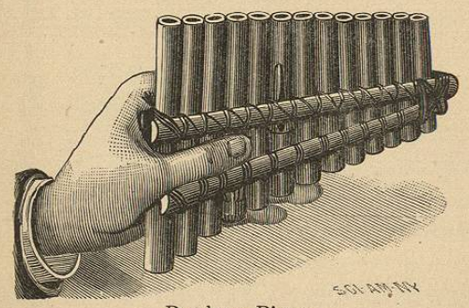


Marloye's Harp.

PIPES.

The ancient Pandean pipes present an example of an instrument formed of a series of stopped pipes of different lengths. These pipes

FIG. 127.

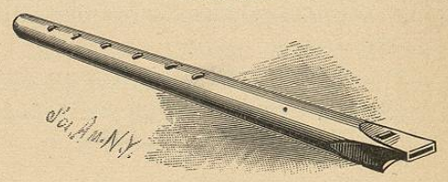


Pandean Pipes.

are tuned by moving the corks by which their lower ends are stopped, and the air is agitated by blowing across the

end of the tubes. The flageolet is an open pipe in which the air is set in vibration by blowing a thin sheet of air through the slit of the mouthpiece against the thin edge of the opposite side of the embouchure. The rate of the fluttering produced by the air striking upon the thin edge is determined by the length of the pipe of the instrument, the length being varied to produce the different notes, by open-

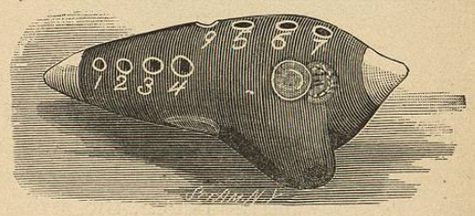
FIG. 128.



Flageolet.

ing or closing the finger holes. By comparing the flageolet with the Pandean pipes, it is found that for a given note the open flageolet pipe must be about twice as long as the Pan pipe. When all the finger holes of the flageolet are closed, it is then a simple open pipe, like an organ pipe, and, if compared with the Pan pipe yielding the same note, it is found to be just twice as long as the closed pipe. If, while

FIG. 129.



Ocorina.

the holes are closed, the open end of the flageolet pipe be stopped, the instrument will yield a note an octave lower if the blowing be very gentle. These experiments show that the note produced by a stopped pipe is an octave below the note yielded by an open pipe of the same length, and the same as that obtained from an open pipe of double the length.

The ocorina is a curious modern instrument, of much

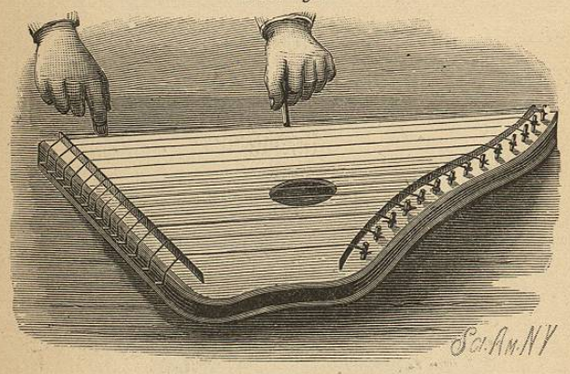
the same nature as the flageolet. It is, however, a stopped pipe, and shows how tones are modified by form and material, the latter being clay. It produces a mellow tone, something like that of a flute.

STRINGED INSTRUMENTS.

The zither, now made in the form of an inexpensive and really serviceable toy, originated in the Tyrol. It consists of a trapezoidal sounding board, provided with bridges, and having 24 wire strings.

Its tones are harp-like, and with it a proficient player can produce agreeable music. Much of the nature of the

FIG. 130.



Zither.

vibration of strings may be exhibited by means of this instrument. On damping one of the strings by placing the finger or a pencil lightly against its center, and vibrating the string, at the same time removing the pencil, the string will yield a note which is an octave higher than its fundamental note.

By examining the string closely, it will be ascertained that at the center there is apparently no vibration, while between the center and the ends it vibrates. The place of least vibration at the center of the string is the node, and between the node and the ends of the strings are the venters. It will thus be seen that the string is practically divided into two equal vibrating segments, each of which produces

a note an octave higher than that of the open string. That the note is an octave higher than the fundamental note may be determined by comparing it with the note of the string which is an octave above in the scale of the zither.

By damping the string at the end of one-fourth of its length, the remaining portion of the string divides itself into three ventral segments, with two nodes between.

The division of the string into nodes and venters occurs whenever the string is vibrated, and all of the notes other than the fundamental are known as harmonics, and impart to the sound of the string its quality.

By tuning the first two strings in unison, the vibration of one string by sympathy with the other string may be shown.

CONDUCTION OF SOUND.

The string telephone, although not a musical instrument, nor even a sound producer, exhibits an interesting feature in the conduction of sounds. It consists of two short tubes or mouthpieces, each covered at one end with a taut parchment diaphragm, the two diaphragms being connected with a stout thread. By stretching the thread so as to render it taut, a conversation may be carried on over quite a long distance, by talking in one instrument and listening at the other. The vibration of one diaphragm, due to the impact of sound waves, is transmitted to the other diaphragm by the thread.

FIG. 131.

String Telephone.

In the toys illustrated we have a representative of the Savart's wheel in the buzz; of the pipe organ in the Pan pipes, the flageolet, and the mouth organ; of band instruments in the bugle; and of the piano, harp, and other stringed instruments in the zither.