

tor. The diaphragm is then fastened by means of sealing wax or glue.

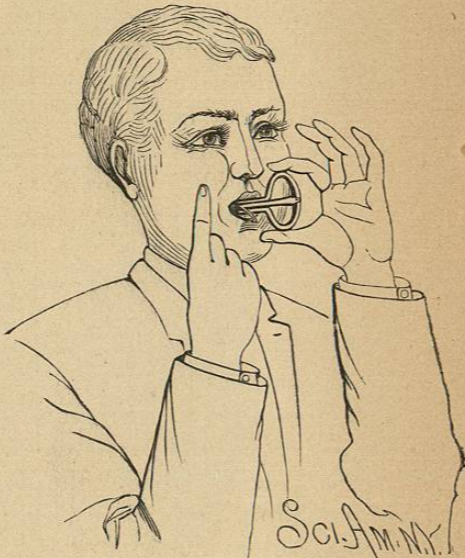
To re-enforce one of the overtones of the bell, the opposite end of the tube is gradually shortened by paring off narrow strips from its edge until it responds to the high tone which the bell is capable of giving out when bowed in a particular way. Now, by causing the bell to vibrate strongly and placing it near opposite ends of the resonator in alternation, it will be found that the deeper cavity will

FIG. 149.



The Mouth used as a Resonator.

FIG. 150.



Experiment with the Jew's Harp

respond only to the grave note of the bell, while the shallower cavity will re-enforce only the overtone to which it is tuned. In this experiment it will be found a little more convenient to have separate resonators for the different tones.

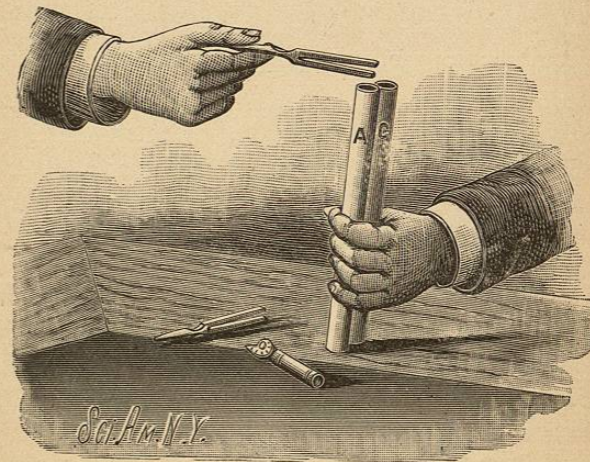
In Fig. 152 is shown an experiment which is substantially the same as that just described in connection with the bell. In this case two tuning forks, A and C, are used as sound producers, and to each fork is adapted a resonator

FIG. 151.



Bell and Resonator.

FIG. 152.



Tuning Forks and Resonant Tubes.

consisting of a paper tube about $\frac{3}{8}$ inch in diameter and 8 or 10 inches long. Each tube is tuned to the fork in connection with which it is to be used by inserting a cork and moving it until the length of the inclosed air column is such as to respond to the fork. It will be found that the A resonator will respond only to the A fork, and the C resonator will re-enforce only the sound of the C fork.

In all these cases the resonant tube or cavity corresponds in depth to about one-quarter of a wave length of the particular sound which it is adapted to re-enforce. The wave proceeding from the sounding body strikes the bottom of the resonant chamber and is reflected back in time to proceed with the other half of the wave moving in the opposite direction, greatly augmenting its volume.

The combination of two series of sound waves may be made to produce silence if the relation of the two series be such that the air condensations of one series coincide with the rarefactions of the other series. This may be demonstrated by holding a tuning fork over its appropriate resonator and turning it until the plane of vibration of the fork is at an angle of 45° with the axis of the resonating tube. By placing the fork in the same position relative to the ear, the same phenomenon may be observed without the resonator.

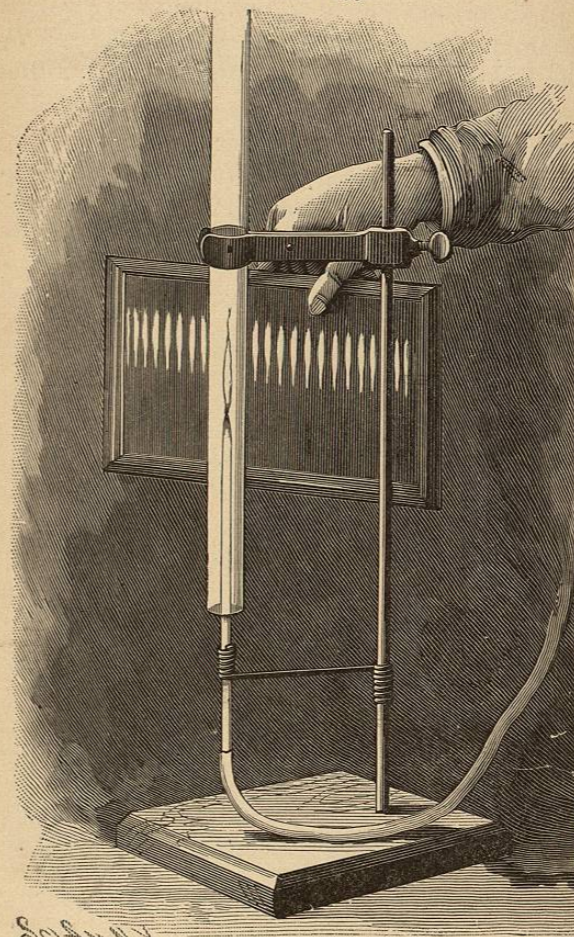
MUSICAL FLAMES.

The experiments of Tyndall and others on sounding flames are so interesting and so easily repeated with very simple appliances, that the student of physics, particularly in the department of acoustics, should not fail to repeat them. The production of musical sounds by means of flames inclosed in resonant tubes is especially easy. One form of this experiment is illustrated by Fig. 153.

For the mere production of sounds, a metal tube will answer, but for the analysis of the flame by which the sound is produced, a glass tube will be required. This tube, whether of metal or glass, may be 40 inches long and one inch internal diameter. It should be supported in a fixed vertical position in a suitable support, a filter support, for example. In a lower arm of the support is placed a glass

tube three-eighths inch in diameter, having its upper end drawn to a small circular aperture, which will allow sufficient gas to escape to form a pointed flame about $2\frac{1}{2}$ inches

FIG. 153.



Production of Sounding Flames.

in height. The tube is drawn down by heating it near one end until it softens, by continually turning it in a gas flame, then quickly removing it from the flame, and drawing it out as far as possible. By making a nick with a fine file in one

side of the tube, at a point where it is about one-sixteenth inch in diameter, the tube may be broken squarely. It may then be tried as a burner. If the flame yielded by gas at full pressure is less than two inches in length, the tube should be again broken off at a point where it is a little larger in diameter, and if the opening happens to be too large, it may be reduced by holding the extreme end of the tube in a gas flame until it partly fuses, when it will contract.

The small glass tube is connected with the gas supply, and the jet is lighted and inserted centrally in the larger tube, and moved slowly upward in the tube until a clear musical note is heard. If the flame is full size, the note will be the fundamental note of the tube. By turning off the gas so as to make the flame three-fourths to one inch high, and again inserting the burner in the tube, a point will be found between its former position and the lower end of the tube at which a tone of higher pitch will be heard. This is one of the harmonics. If the burner with the small flame be carried further upward into the tube, a point will be reached where both the fundamental and harmonic will be produced simultaneously. These tones are produced by rapidly recurring vibrations of the flame, which are rendered uniform by the vibratory period of the column of air contained in the tube.

There are two methods of analyzing these flames. One consists in simply shaking the head, or quickly rolling the eyes from side to side, thereby enabling the eye to receive the impressions of the successive flames in different positions on the retina. The other consists in viewing the image of the flame in a revolving or oscillating mirror. By holding a looking glass in the hand, opposite the flame, as shown in the engraving, and oscillating the glass, what appears to be a single flame in the tube will be shown in the mirror as a succession of flames of like form connected at their bases.

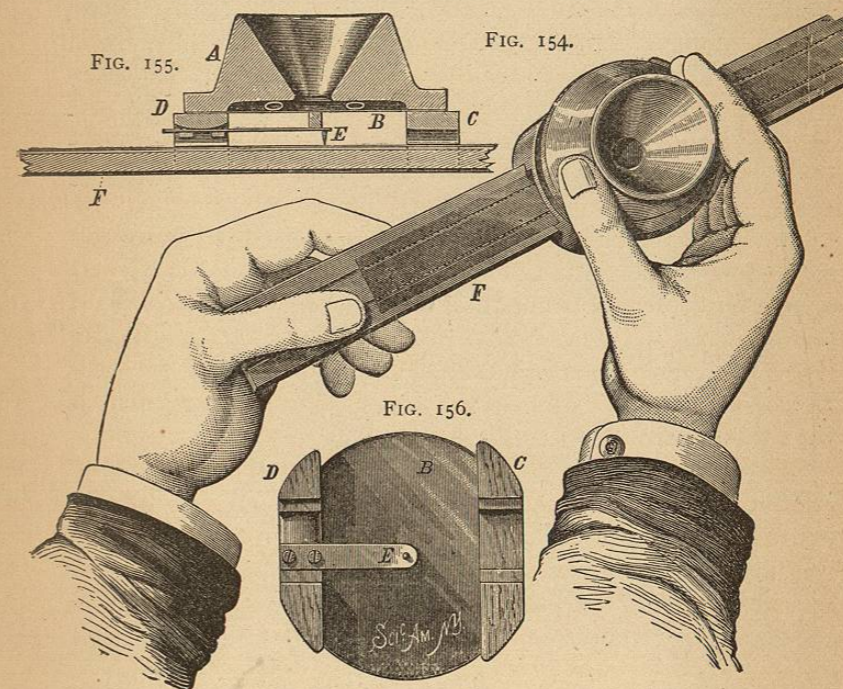
Another way of showing the periodic character of the flame consists in revolving a disk having alternating radial bands of black and white, in proximity to the tube, so that the disk is illuminated only by the light of the intermittent flame. When the disk attains a proper speed, the

intermittent illumination will cause it to appear stationary. This beautiful experiment is due to Toepler.

By employing a concave mirror instead of a plane one as described above, the image of the flame may be projected upon a screen.

A SIMPLE PHONOGRAPH.

This instrument, which is shown in perspective in Fig. 154, in section in Fig. 155, and in plan in Fig. 156, has



A Simple Phonograph.

a mouthpiece, A, to which is attached a thin ferrotype plate diaphragm, B, by means of a good quality of sealing wax or cement.

Upon the outer face of the diaphragm, and at opposite edges, there are guides, C D, for receiving the wooden strip, F. These guides present only a slight bearing surface to

the strip. The guide, D, is rounded to receive the spring, E, which is secured to it by two screws, by which also the spring is adjusted so as to bear with more or less force on the small rubber block which rests upon the center of the diaphragm.

A needle, which is sharpened like a leather sewing needle or awl, is soldered to the spring, and is located directly opposite the center of the diaphragm. The guides, C D, are placed so that the median line of the strip, F, is at one side of the needle. This strip has four slight longitudinal grooves, two on each side, which are made with an ordinary carpenter's gauge. These grooves are located so that when the strip is moved through the guides, one or the other of them will pass over the needle. A piece of beeswax is rubbed over the sides of the strip to give it an adhesive coating for receiving the foil used in recording the sounds.

The foil, which should be rather heavy, must be cut into strips wide enough to extend beyond the grooves in the wooden strip. The foil is laid on the wooden strip and bur-nished down with the thumb nail, so that it will adhere. The strip thus prepared is placed in the guides, C D, and the needle is adjusted so that it indents the foil slightly as the stick is moved along.

By talking in the mouthpiece, and at the same time moving the strip along with a smooth, steady motion, the sounds are recorded on the foil. By passing the strip again through the guides, so that the needle traverses the same groove, and applying to the mouthpiece a paper funnel or resonator, the sounds or words spoken into the instrument will be reproduced. It is even possible to record the sounds on a plain strip of wood so that they may be reproduced. The engraving is about two-thirds the actual size of the instrument.

THE PERFECTED PHONOGRAPH.

Ten years ago a young man went into the office of the *Scientific American*, and placed before the editors a small, simple machine about which very few preliminary

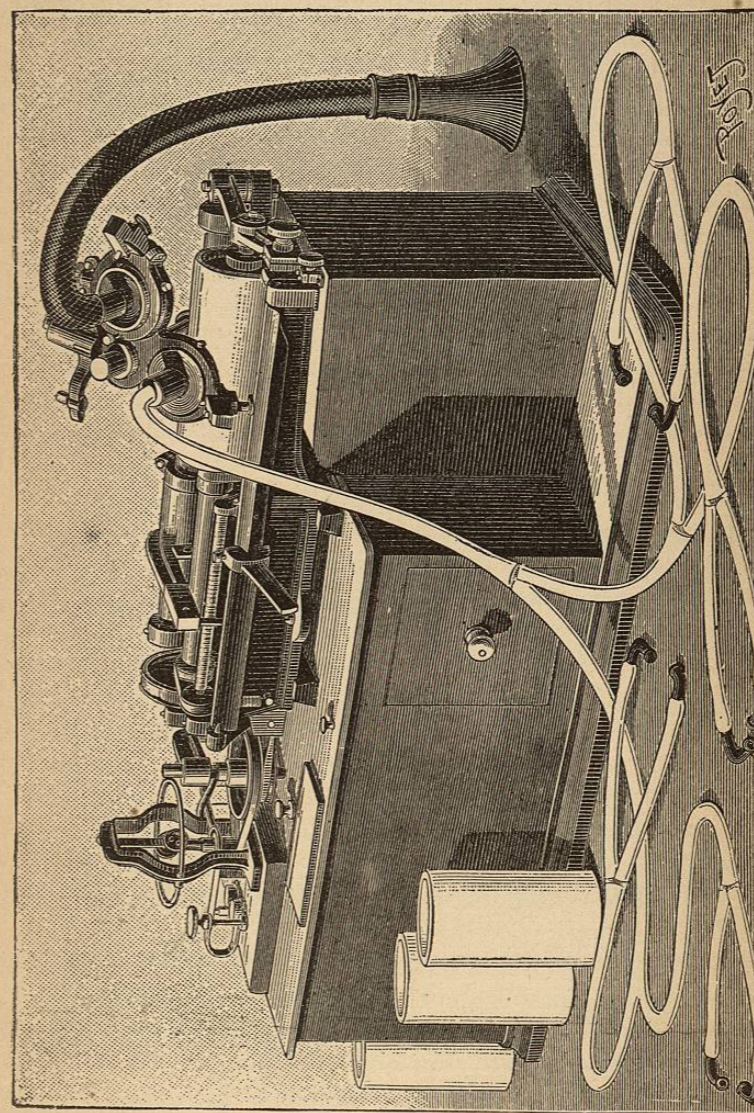


FIG. 157.

Edison's New Phonograph.