length, the object being to ascertain if, by the use of petroleum or a mixture of petroleum and spirits of turpentine, steel of that degree of temper could be turned at any faster speed than with a tool used dry. The result of the experiment was that the difference, if any, was too slight to be of practical importance. A similar experiment upon a piece of soft steel demonstrated that, by the use of petroleum, no advantage in cutting speed was to be obtained. The cutting speed employed during this experiment was 37 feet per minute.

The last experiment made was upon a piece of Turton's round hammered tap steel, tempered to a clear bright blue along 4 inches of its length, the cutting speed employed being 10 feet per minute. The first cut, $\frac{1}{32}$ inch deep, was taken with a lubricant of three parts petroleum and one part spirits of turpentine, the second cut being taken dry, the result being that the tool stood a little better with the lubricant than without. It has been known for a long time that benzine, kerosene, turpentine, or any of the light volatile oils act as lubricants for cutting tools more effectively than either water or oil, their advantages being that they are more penetrating, and hence approach much more easily and freely to the cutting edge of the tool, which they therefore keep more cool. The difference in their favor is, however, not very great. A short time since, Thomas and Co., of the Freeland Tool Works, had to plane a platen for a printing press, 6 feet by 4 feet, and it was found, after one half had had a cut taken off it, that the other half was chilled so that ordinary tool steel would not touch it. Then Hobson's and Jessop's double refined steels were tried, and it was determined to throw the platen away and cast another. Finally, however, a tool made of chrome steel, $\frac{3}{4}$ by $1\frac{1}{4}$, was used, and it carried the cut across the chilled part nicely. During the last part of the cut, Mr. Thomas took a piece of rag soaked with kerosene and applied it to the tool during the back stroke of the planer, with the result that the tool retained its keenness much longer, thus agreeing with our own experiments, the cutting speed employed being in this case 14 feet per minute.

HARMONY AND DISCORD WITH OPTICAL STUDIES.

LECTURE DELIVERED AT THE STEVENS INSTITUTE OF TECHNOLOGY, BY PROFESSOR C. F. BRACKETT, OF PRINCETON, N. J.

In the previous lecture it was shown that all matter is endued with energy. Hydrogen will penetrate through a porous cell; a ball suspended by a string will continue to vibrate for a long time when set in motion. The vibrations of rods and strings were illustrated in a variety of ways. The cessation of sound in a vacuum was shown by means of a bell under a receiver, and the conduction of sound through wood by muffling a music box and connecting it with an æolian harp by means of a wooden rod.

On the present occasion, we shall consider how the vibrations thus studied may be utilized in that most glorious of all arts, music If the same note is sounded on a flute, a violin, and an accordeon, we instantly recognize to which instrument it belongs. By the same power the ear recognizes in an adjoining room the voice of a friend who has returned after a long absence, although we have not yet seen his face. The impression thus conveyed is often so precise that we would be willing to swear to his identity in a court. We see thus that tones differ, not only in loudness and pitch, but also in quality or character. The pitch of a sound by which it sounds high or low, acute or grave, is determined by the number of vibrations in a second which the sounding body makes. The loudness may be illustrated by means of a rod secured at one end; if we pull it back only a little and cause its end to describe a small arc, it will not move with as much force as if we bend it back considerably and let it fly with great velocity. The quality of sounds is due to the manner of vibrating. Instead of fastening the rod at one end only, it might be fastened at both, and then the manner of vibrating would be different. In a stretched string there are present a great many different vibrations, all of which combine to give us the impression of a musical note. When we look upon the restless ocean, we perceive at the same time huge billows surmounted by lesser waves, and perhaps delicate ripplets crowning the whole; in like manner musical notes are made up of waves of various sizes.

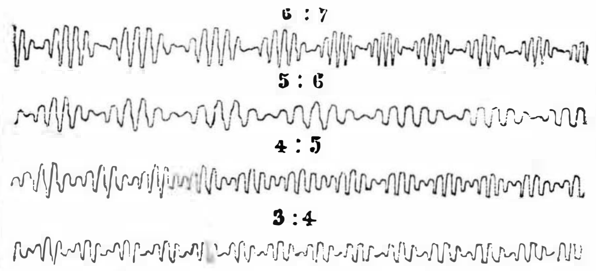
An organ pipe consists essentially of a fine edge placed in a hole; when the air passes over this edge a whistling sound like that of the wind is produced; but when a tube is placed over it, this whistling is raised to the dignity of a musical note by the vibration of the column of air contained in the tube. The same effect is produced by substituting a resonator of proper size for the tube; a sounding box developed a mere hint or ghost of the same sound. After having dissected an organ pipe in this way, another pipe already adjusted was taken, and it was shown that a second, higher sound could be produced in it by harder blowing.

A tuning fork may be set in vibration with a bow in such a manner as to emit no distinctly audible musical tone; when, however, it is held before the mouth, which is opened as though the experimenter were about to sing the corresponding note, the air in the mouth is set in vibration, and the note of the tuning fork is plainly heard. The octave of this note can be obtained in the same way. An organ tube, a resonator, or a sounding box, brought near the tuning fork, will answer the same purpose; but they must be tuned to correspond to the fork, or, in other words, they must contain the proper volume of air. Of a number of resonators on the lecture table, only one responded to the tuning fork used.

If we close the upper end of an organ pipe, a much graver note is produced. The mode of vibration of the air has been changed. When the sound wave strikes the end of the tube, it developes a nodal point, because it is not free to move further in the same direction, but is reflected back to meet the next following wave at other points. Wherever the crests of two waves or the troughs of two waves coincide, larger waves result; but where troughs and crests meet, they neutralize each other and produce nodal points. The modes of vibration are characterized by the position of these nodal points. With the same tube, for example, harder blowing will change the number and the position of the nodal points. What we are accustomed to call the pure, sweet, simple tone of the organ is really nothing of the sort; it is, in fact, a very complex form of vibration. To get a pure and simple note, we must take a tuning fork; hence, by analyzing the compound note of a musical instrument, we ought to be able to recompose it, by combining a number of tuning forks representing its components. To illustrate this, the lecturer imitated a violoncello note by means of a series of tuning forks.

The difficulty in this experiment lies in obtaining the proper relative intensities of the components.

Fig. 1.



We are not by any means dependent on the ear alone for the study of musical vibrations. They can be made apparent to the eye. If we attach a strip of paper or glass, covered with lampblack or any other fine powder, to one tuning fork and a bristle to another, we will obtain a series of compound curves by drawing the latter slowly over the blackened surface. This curve is a resultant of the two vibrations. In this way very instructive diagrams are produced with tuning forks whose vibrations have certain definite relations, such as those, for example, corresponding to the ordinary musical intervals. In Fig. 1, the ratio of 5:6 corresponds to a minor third; 4:5 to a major third; and 3:4 to a fourth. In Fig. 2 the ratio of 3:5 is that of a sixth; 5:8 of a minor sixth; and 3:2 of a fifth. Fig. 3 exhibits the result of operating with two forks whose vibrations differ more slightly in number. It represents the beating thus produced, with its alternations of intensity.

Fig. 2.

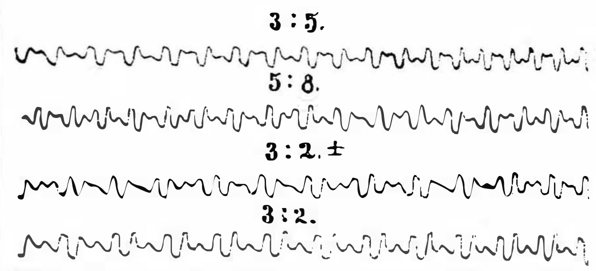
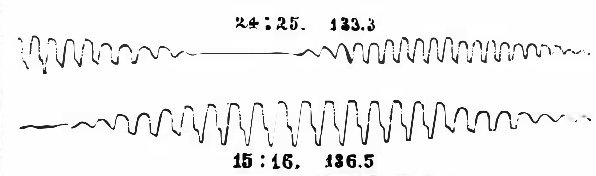


Fig. 3.



Another way of studying these resultant vibrations is by the aid of Tisley's pendulum, which consists of a marking point so arranged as to obey the motion of two pendulums swinging at right angles to each other. A variety of effects is produced by lengthening and shortening the pendulums and by varying the intensities of their motion. The result is a series of beautiful symmetrical curves represented in the accompanying engravings. Fig. 4 represents unison, where the vibrating pendulums are of equal length. Fig. 5 represents the octave, where one pendulum is twice the length of the other. Fig. 6 is the fourth, the ratio being three to four; and Fig. 7 is the fifth, having the ratio of 2 to 3. It is almost, if not quite, impossible to produce two figures exactly alike with the same arrangement of the pendulums; they will differ as much as the leaves of the same tree. Although the eye readily detects the difference between them, the sounds they represent are identical to the ear.

Fig. 4.

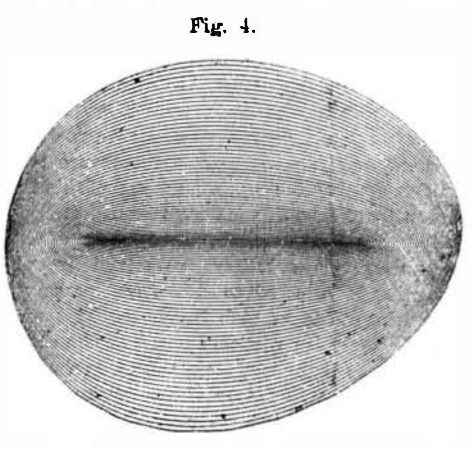
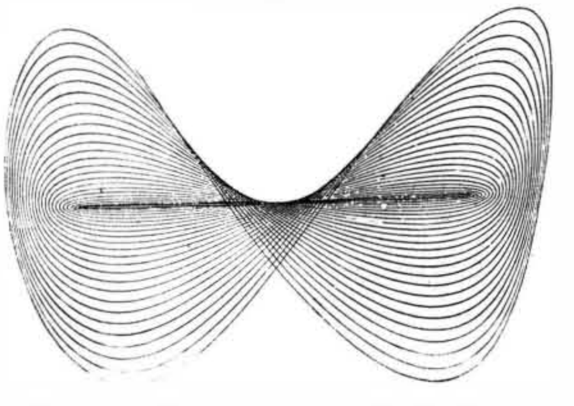


Fig. 5.



A third method of optical study is by the aid of manometric flames. The vibrations from the instrument to be studied are made to act on a piece of membrane in contact with a stream of illuminating gas feeding a jet. When the gas is lighted and the instrument sounded, the tremors of the membrane cause the flame to vibrate up and down. On revolving a mirror before the flame, the motions of the latter are spread out in the form of serrations differing with the tone. By having a number of such flames and membranes in connection with a series of resonators, composite sounds may be analyzed into their constituents.

Fig. 6.

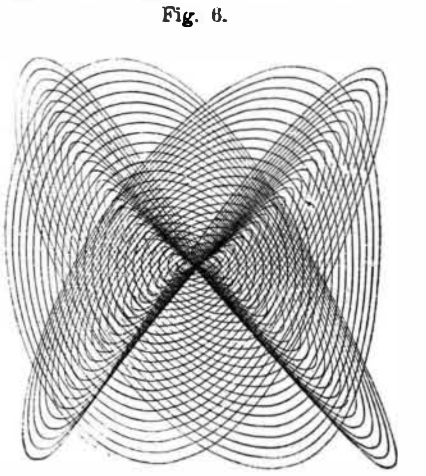
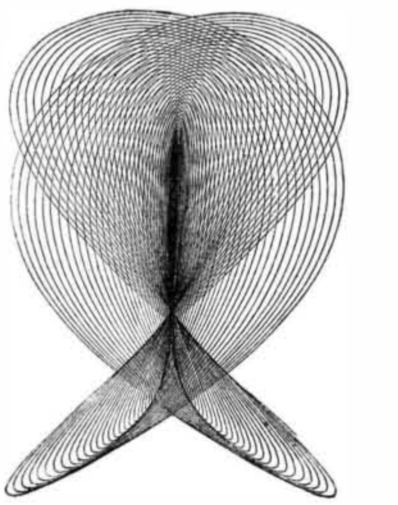


Fig. 7.



By means of these and various other apparatus too numerous to describe, even a deaf person could thoroughly study musical vibrations. They enable us to hear, as it were, with our eyes. C. F. K

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Electricity as a Transmitter of Power.

It is well known that the Gramme magneto-electric machine, which transforms mechanical force into electricity, can also be employed in inverse manner to transform electricity into mechanical force. The property may be utilized to transmit power over long distances. The motor of a factory, for example, could be connected with one machine so as to rotate the same and thus generate a current. This current, carried over distances by cables, might be communicated to another Gramme machine at the point where the power is required. The second machine, by the current, would thus be caused to revolve, and the power would be utilized as necessary.

Of course, in this double operation, there is a loss; but according to M. Magnon, who has investigated the subject experimentally, this is even less than takes place with any other mechanical disposition. If the waste of power equaled that involved in transmission by wire rope, long belts, and like means, it appears that the new plan has superior advantages, in that it does away with a large amount of shafting, belting, etc., and besides allows of power being transmitted over much longer distances than would be practicable by such devices. The details of M. Magnon's experiments, are not given, so that we are unable to review the data on which his opinion is based.