in use many years for electroplating, and in much more concentrated form than it is employed by Lenoir, without real injury.

An amalgamated silver mirror does not exhibit the yellow shade of pure silver, is far less sensitive to sulphuretted hydrogen, as two years' experience proved, and resists perfectly the action of the sun. Lenoir's process has been introduced into the mirror factory of Mangin Lesur, at Paris.—*Deutsche Industrie Zeitung.*

Correspondence.

A Singular Railway Collision.

To the Editor of the Scientific American:

In your issue of July 1 you mention and illustrate a singular collision. I notice that the *Graphic* locates the occurrence on the Northwestern Railway. Allow me to call your attention to a remarkable coincidence.

Your engraving, with but few exceptions, represents a collision that occurred on the Falls branch of the New York Central road on the morning of September 10, 1872, between the village of Albion and the city of Rochester, 2½ miles from the former place. Both trains were due at Albion at 3.45 A. M. The eastern bound train was one or two minutes late; but the train from the East not having arrived, the eastern bound train started out (having the right of way) at an unusual rate of speed. In running two miles it made up two minutes. At this juncture the engineer saw through the fog the headlight of the advancing train. He whistled down brakes, and reversed his engine. Only three brakes were set. All on both trains jumped. The engineer of the eastern bound train struck on his head, which stunned him for the moment. He sprained his wrists and bruised his face, but all the others alighted in safety. In an instant the monsters came together, hissing and seething in each other's embrace.

Unlike your illustration, they stood more nearly alike on the track, without smoke stack or bell. The tenders were driven under the rear of the engines, and everything that could be thrown from the engines under such a fearful concussion was gone. The boilers did not burst, but the engines appeared to be total wrecks. I understand, however, that one of them was rebuilt. Six cars left the track, and three more were burnt on the track. The trains were heavy freights, and a great amount of merchandise was burnt or otherwise destroyed and stolen. The loss at the time was estimated at $200,000, but I understand that this was considerably in excess of the fact. Photographers arrived too late for the prize. The engines were quickly separated, and, when disengaged, they rolled some 16 feet down the embankment. The track at the place of accident was smooth and straight.

ALEX. D. TYTLER.

Albion, N. Y.

Flax in Missouri.

To the Editor of the Scientific American:

I wish to call the attention of capitalists and inventors to an opening for them out here. I recently noticed along the road between Sedalia, Mo., and Parsons, Kan., that the farmers grew a great deal of flax, just for the seed. They do nothing with the stalk or straw. Why could not this be put to use? I always supposed that there was a great demand in this country for flax, and it looks like a great waste to let all this stand in stacks to rot or be burnt. The only reason for this that I can see is that, in thrashing out the seed, the stalks become tangled together, which may make it difficult to hackle; but our inventors could readily make some machine to overcome this difficulty. There is about 1 tun of flax straw to the acre. The crop is a regular one; many thousands of acres are cultivated every year; and after the seed is thrashed out the straw could probably be bought for a mere song.

S. E. WORRELL.

Hannibal, Mo.

[For the Scientific American.]

ANIMAL MECHANISM.

Most of the mechanical principles used in machinery have their illustrations in animal movements. Some are direct copies from Nature, but others were first contrived by man without his having consciously taken the hint from Nature, and afterwards found to be similarly used in animal mechanics. While this shows that man is created in the image of his Maker, in that the minds of each see truth and the application of principles in the same light, it also shows that man may find it greatly to his advantage to study the mechanism of animals and its applications of force, in order to learn the best means of accomplishing his ends in the mechanic arts. This may be an improvement upon the common method of working out, from the unaided brain, principles which Nature has used and displayed from the earliest time.

The shape and keel of a ship have their best models in in the form and fins of fishes, and in several species of water beetles. It was formerly supposed that it was only necessary to have the bows of a ship sharp and well proportioned; now it is found that the shape of the stern has as much to do with its ease of motion as the shape of the bow, or the way it leaves the water is as important as the way it cuts the water. Hence a boat that is made for speed is now made to taper as gradually toward the stern as toward the stem. This mechanical principle has always been in use in the fish, the water beetle, and the bird. The pectoral and anal fins of fishes answer to the keels of ships, and the tails of both fishes and birds act as rudders. The tail of a fish, in addition, acts as the propelling power, on a principle similar to that of sculling a boat or of screw propellers. Barker's reaction mill, or the force due to unbalanced pressure, is illustrated in the progressive—or rather retrogressive—movement of cuttle fishes, squids, and other cephalopod mollusks. They propel themselves backwards by forcibly ejecting water from an opening near the head.

The toggle joint, which is used in printing presses and in other machinery, has a representative in most of the hinge joints and in some others, of man and inferior animals. The pulley is used in the human body, by the cord which raises the great toe and the foot acting upon ligaments for friction wheels in the ancle; also by the digastric muscle, as it passes through a ring or loop in the muscle which is attached to the hyoid bone, serving the double purpose of raising the larynx in swallowing and of pulling down the lower jaw. The muscle which performs the oblique rolling motion of the eye also works through a loop which serves the purpose of a pulley in changing the direction of motion: as do also those attached to the knee pan.

The three classes of lever are amply illustrated in the various movements of man and other animals. The support and motion of the head upon the upper part of the spinal column illustrates a lever of the first class. The third is shown in raising the forearm by the contraction of a muscle attached a short distance below the elbow. The raising of the body upon the toes has been called a lever of the second class, in which the ball of the foot is the fulcrum, the muscle attached to the tendon of Achilles at the heel is the power, and the weight is applied at the base of the leg. There are some interesting considerations respecting the mechanical principles employed in the last case. If this is a lever of the second class, the question as to how much power is required to raise the weight of a man of ordinary size is an interesting one. On this supposition, the long arm is to the short arm as about 3 : 2; and if the power were applied outside of the body it would require 100 lbs. of power to raise 150 lbs. But as the power that raises the body is itself a part of the weight to be raised, when the muscle has contracted with the force of 100 lbs., its reaction presses downwards, upon the foot acting as a lever, with the force of 100 lbs. This reaction also has to be overcome, which adds so much to the weight of the body to be raised; and when additional force is applied to overcome the added weight, the reaction of this would necessitate still greater force, which would again increase the weight, and so on in an indefinitely decreasing series. If the reaction occurred at the end of the lever where the power is applied, of course the two would exactly balance each other, and all upward motion would be impossible. It would be like a man's trying to lift himself over the fence by his boot straps. But as this reaction occurs one third of the distance to the fulcrum, two thirds of its force at the lever's end would counterbalance it. The result seems to be possible by demonstration of the algebraic equation based on the law of the lever: that the power × the long arm = the weight × the short arm. Then x (the power) $\times 3 = (150 + \frac{2}{3}x) \times 2$; which gives 180 lbs. as the amount of power required to raise 150 lbs. and overcome the reaction of the force exerted. While in theory this seems reasonable enough, in practice the result is widely different. The principle here involved appears the same as when a man stands upon a stiff board one third of the distance from the end of the lever towards the fulcrum, placed at the opposite end, and tries to lift himself by lifting up at the lever's end. And this is practically impossible, whether the power be applied as here stated, or by means of lever and pulley arrangements, so that the power and resistance may act vertically.

The difficulties are not diminished if we consider the movements at this point as illustrations of a lever of the first class. In this case we would call the attachment of the bones of the leg to the bones of the foot the fulcrum, the power at the Achilles tendon as before, and the weight at the point where the ball of the footrests on the ground On this supposition the force of muscular contraction would tend to press down the earth; but as this is practically immovable, the result is the pushing up of the body, which is is the object most easily moved. We have a similar illustration of this application of the lever in the rowing of a boat. This would require the application of force at a greater disadvantage than in the former case, and consequently a greater strain upon the muscles performing the work. But we know that raising the body on the toes is not accompanied by any painful physical exertion by the individual, and a closer study of the anatomy of the foot shows that the work is not done by one set of muscles alone. The tendons which bend the toes downwards are, after uniting into one, made to pass by a pulley arrangement among the carpal bones, and are attached to a muscle in the calf of the leg. These tendons, being united to the end of the long arm of the lever, enable this muscle to work at an advantage, or, in other words, so that power is gained at the expense of time. But it is probable that the mechanism is even more complicated than this.

The working of the muscles employed in this movement can be illustrated and their force measured by lying on one's back and placing one foot in the loop of a rope which passes over a pulley and has a weight suspended from the other end. As the foot, acting as a lever, is made to move, it will will pull the rope and raise the weight, which may be increased till the limit of muscular power has been reached. In this experiment care must be taken that no other muscles are allowed to aid in the process.

The sliding seat in rowing is one that moves forward as the hand end of the oar is advanced, causing the knees to bend or spread. This gives a longer stroke and double purchase upon the water; for not only the muscles of the arms and trunk are brought into use, but also those of the legs This new and ingenious contrivance of mechanics, reached without the aid of Nature's suggestions, has been in use before our very eyes from the beginning of man's existence; and we needed but to study and apply the principles of animal mechanism to have employed it in practical life long ago. W. W. Wagstaffe showed, in *Nature*, a few months ago, that the shoulder illustrates the principle of the sliding seat. Besides the very free motion of the ball-and-socket joint at the shoulder, there is a forward and backward movement of six or seven inches, due to rotary motion of the clavicle upon the sternum, and also an up and down movement of about four inches, articulating at the same point, as seen in bell ringing and weight lifting, This gives an additional purchase and advantage, similar to that gained by the sliding seat.

S. H. T.

[For the Scientific American.]

TURNING HARD STEEL WITH THE AID OF PETROLEUM AS A LUBRICANT.

BY JOSHUA ROSE.

Some experiments recently made have given the following determinations:

1. That the use of either petroleum or a mixture of the same with spirits of turpentine as a lubricant for turning tools does not enable the tools to cut metal of any greater degree of hardness than can be cut by the same tool when used dry.

2. That the use of the above-named lubricant does not enable a turning tool to cut metal of any degree of hardness or temper at a faster rate of cutting speed than can be attained by the same tool when used dry.

3. That the above-named lubricant is effective, inasmuch as it will keep the cutting edge of the tool comparatively cool, and hence tend to preserve it longer than would otherwise be the case, the practical difference, however, being very slight.

4. That it is impracticable, under any of the ordinary conditions, to properly turn steel of a hardness or degree of temper greater than a deep purple bordering upon a blue.

Below will be found the details of experiments which were conducted by me at the Freeland tool works, at 360 West 34th street, New York city.

A piece of steel ¾ inches diameter and 6 inches long was made red hot and plunged endwise into clean cold water, and held submerged until quite cold. Upon inspection after immersion, the steel was found to be white all over, evidencing that the hardening was performed equally at all parts. One end of the steel was then made red hot and allowed to soften, the temper being permitted to run up at will. It was then placed in the lathe and run at a speed of 10 feet per minute. The lathe tool used was an ordinary front tool, made as hard as fire and water would make it.

A cut $\frac{1}{32}$ inch deep was started at the softened end of the steel, the feed being set at 40 revolutions to an inch. The lubricant, pure crude petroleum, was freely applied from the commencement of the cut. The tool was fed along until finally it commenced to jump, making a cracking noise, due to the excessive pressure with which the tool was forced to its cut. As soon as the cracking began, the tool became dulled and useless; and upon testing the tool with a smooth file, it was found that the file would cut the steel, where the tool cut ceased, the color of the metal being a deep brown. The tool was reground, and applied to the cut where it had left off at the first trial; but it refused to take the cut up any further. It was therefore reground and applied without any lubricant whatever, the cutting speed and feed remaining the same. It took a cut of $\frac{1}{32}$ inch in depth up to the same distance as on the first trial, leaving the cut much smoother, however, than the first one. From the fact that a file would cut the steel where it showed a temper of a brown bordering upon a yellow, it was evident that the sample of steel under operation was not of the best quality; and it was determined to make a second trial, for which a piece of Turton's hammered round tap steel was selected, its diameter being ¾ inch, and its length 6 inches. It was first hardened as hard as fire and water would make it, and then tempered so that the end was purple, the color running up an inch before the deep straw color was reached. The cutting speed was about 7 feet per minute. The tool was ground and applied to the steel where the color was a deep brown bordering on a purple. Crude petroleum was first applied, and by the application of considerable force the tool took a cut about $\frac{1}{32}$ inch deep, carrying it along about ¼ inch where the steel was of a deep brown color. The corner of a smooth file was applied to the cut where it left off, and it would just cut it under severe pressure. The tool was then reground and tried under application of two parts petroleum to one of spirits of turpentine, and then of equal parts of turpentine and petroleum; but the cut could not be carried along any further. The next operation was to try the same tool upon the same steel, but without any lubricant, and the result was that it took a cut $\frac{1}{32}$ inch deep, commencing and leaving off its cut at the same place, but requiring a trifle more power to force it to its cut.

The results so far obtained were not sufficiently encouraging to warrant any minute experiments, because the small diameter and slow rate of cutting speed were the most favorable of conditions; while the rapid destruction of the cutting capabilities of the tool was such that no practically useful effects had so far been obtained. Furthermore, the cutting, performed upon any part of the steel whose temper was greater than a blue, was neither even or smooth; and it was a certainty that no finishing tool could be made to stand, whatever the lubricant employed.

The next operation was to make a test upon a piece of steel tempered to a deep purple for about an inch along its

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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, ¾ by 1¼, 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.

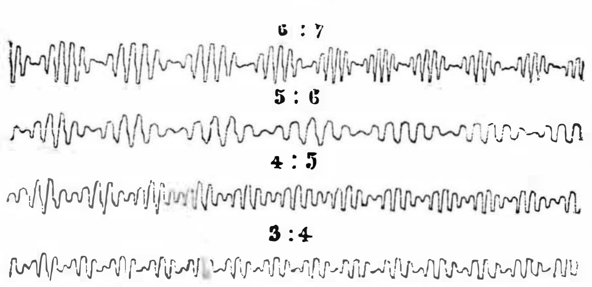
An organ pipe consists essentially of a fine edge placed in a hole; when the air passes over this edge a whistling sound like that of the wind is produced; but when a tube is placed over it, this whistling is raised to the dignity of a musical note by the vibration of the column of air contained in the 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.

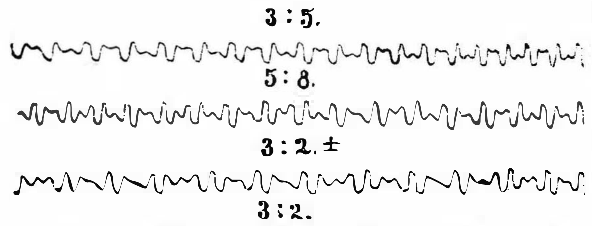
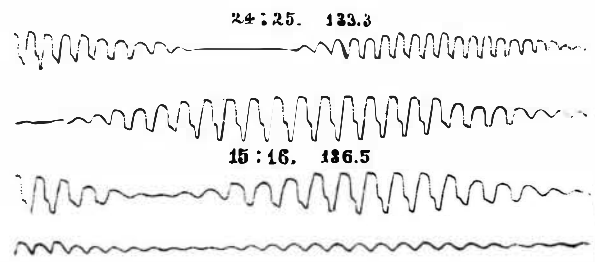
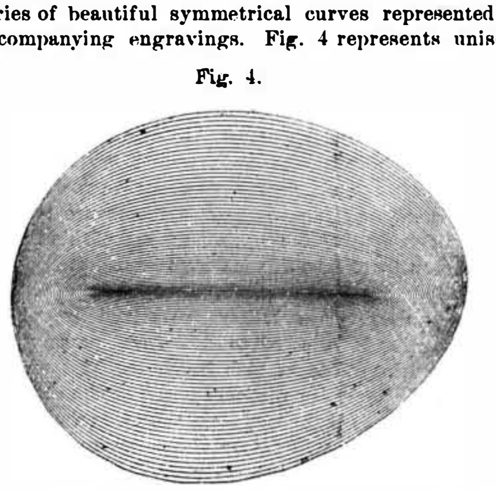


Fig. 3.



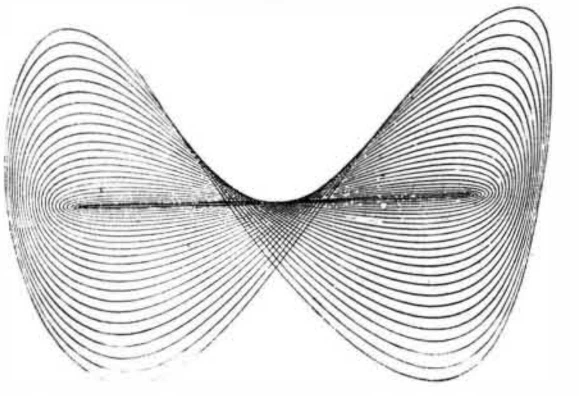
Another way of studying these resultant vibrations is by the aid of Tisley's pendulum, which consists of a marking point so arranged as to obey the motion of two pendulums swinging at right angles to each other. A variety of effects is produced by lengthening and shortening the pendulums and by varying the intensities of their motion. The result is a series of beautiful symmetrical curves represented in the accompanying engravings. Fig. 4 represents unison,

Fig. 4.



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. 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.

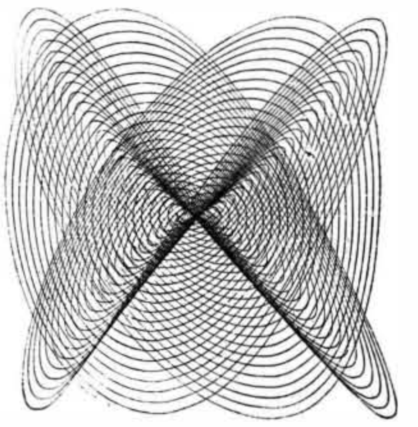
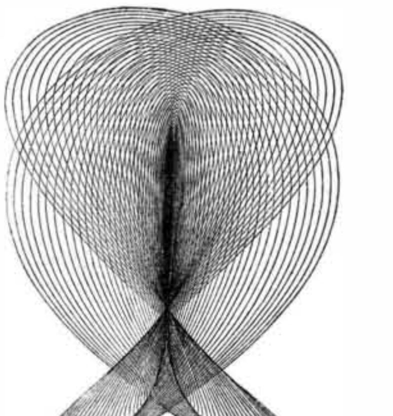


Fig. 7.



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

* * *

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.

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