IMITATION OF ELECTRO-PHYSIOLOGICAL APPARATUS AND ELECTRIC TUNING-FORKS BY HYDRODYNAMIC TUNING-FORKS.

The imitation by hydrodynamic way of the effects of electricity and magnetism has led me to devise an apparatus which I call a hydrodynamic tuning-fork, and which vibrates continuously under the action of a current of water, compressed air, or steam (automatically interrupted), just as electric tuning-forks do under the influence of an electric current.

The construction of this apparatus is based upon the following principles:

1. When two currents of water of opposite direction, and directly facing each other, are issuing from nozzles with thick tips or provided with small disks, there is an attraction of such currents (one of which, at least, is supposed movable) when the distance between the apertures is but a few fractions of an inch; and this attraction very quickly increases in measure as the distance diminishes.

2. If, on the contrary, the nozzles have thin tips, there is a repulsion.

3. When the currents are not exactly opposite one another, there is produced, when they meet, an axial direction that tends to bring them to a parallelism and a coincidence of axes. In all cases there may be a vibration.

Applying these results, I have had several instruments constructed that have nearly the form of the tuning-forks used in acoustics. I shall describe but one of them.

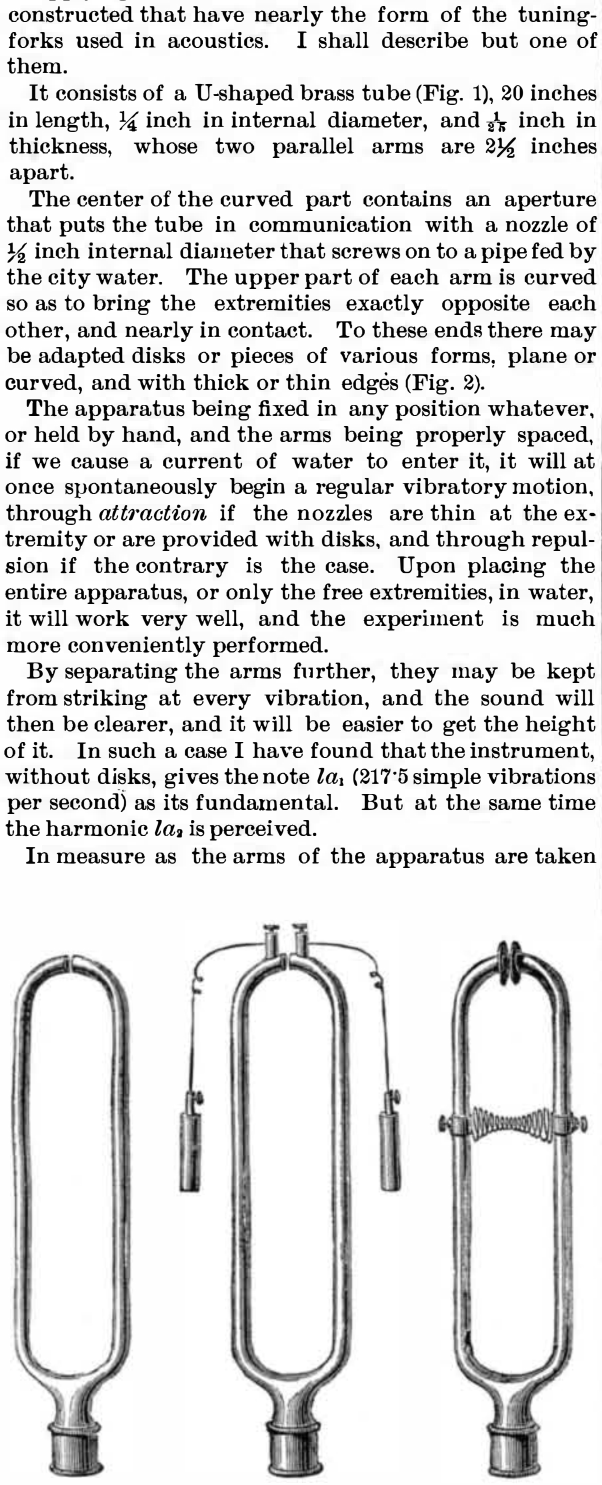
It consists of a U-shaped brass tube (Fig. 1), 20 inches in length, ¼ inch in internal diameter, and $\frac{1}{25}$ inch in thickness, whose two parallel arms are 2½ inches apart.

The center of the curved part contains an aperture that puts the tube in communication with a nozzle of ½ inch internal diameter that screws on to a pipe fed by the city water. The upper part of each arm is curved so as to bring the extremities exactly opposite each other, and nearly in contact. To these ends there may be adapted disks or pieces of various forms, plane or curved, and with thick or thin edges (Fig. 2).

The apparatus being fixed in any position whatever, or held by hand, and the arms being properly spaced, if we cause a current of water to enter it, it will at once spontaneously begin a regular vibratory motion, through *attraction* if the nozzles are thin at the extremity or are provided with disks, and through repulsion if the contrary is the case. Upon placing the entire apparatus, or only the free extremities, in water, it will work very well, and the experiment is much more conveniently performed.

By separating the arms further, they may be kept from striking at every vibration, and the sound will then be clearer, and it will be easier to get the height of it. In such a case I have found that the instrument, without disks, gives the note la_1 (217·5 simple vibrations per second) as its fundamental. But at the same time the harmonic la_2 is perceived.

In measure as the arms of the apparatus are taken



Figs. 1, 2, and 3.—HYDRODYNAMIC TUNING FORKS.

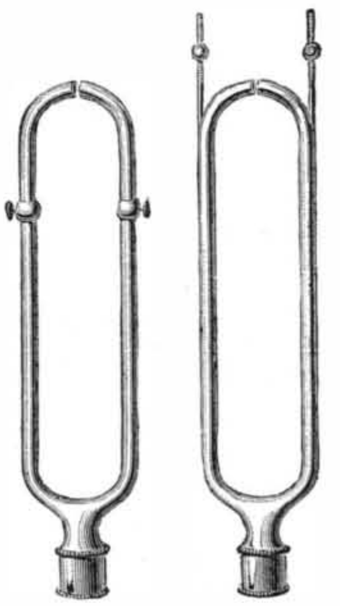
out of the water, the sound rises, and when they are entirely out of the liquid, it will have reached about a third.

In these different cases, in order to have a sound occur, it is necessary to change the regulation of the instrument; but when once it has been primed, it will continue to vibrate regularly as long as the experimental conditions are not too much modified. On compressing the arms of the apparatus with the hand or a spring, the vibratory velocity is slightly increased. On closing the cock more or less, that is to say, on diminishing not the pressure, but the quantity of water that enters within a given time, we do not perceptibly alter the vibratory velocity, but we diminish the intensity of the sound emitted, consequently the instrument tends to stop.

I doubt not that, with shorter and thicker apparatus, and a stronger current, we would obtain higher tones.

It is with the apparatus (Fig. 1) thus operating, and its extremities dipping into water, that I have noticed the very marked trembling that is felt by the hand that is holding it—a sensation entirely analogous to that which is experienced when, with both hands, a person touches the rheophores of a voltaic or induction apparatus of feeble intensity.

On attaching the arms of the apparatus to rheophores, by means of wires (Fig. 2), we obtain vibratory effects that are capable of being graduated at will, like the shocks from an electric apparatus. When the extremity of the arms of the instrument in vibration are



Figs. 4 and 5.—THE SAME, WITH REGULATORS.

touched, the figures are carried along on the same side, as they are by revolving vibrations.

On placing the pipe that leads the water into the apparatus against the ear, we hear a loud noise, like that of a torrent.

Upon holding any part of the said pipe (or, better still, one of the arms of the instrument) between the teeth, we feel an almost painful sensation, such as would be produced by an electric apparatus in which the current was interrupted.

In order to produce intenser effects, we might, instead of a single hydrodynamic tuning-fork, employ several simultaneously, either in unison or of different heights, or construct an apparatus of large dimensions actuated by so energetic a current that the contact of the hands of several persons could not arrest the vibratory motion.

With a hydrodynamic tuning-fork double the length of the one here described, and the arms of which have purposely been made crooked, there occur very strong, irregular vibrations under the influence of axial attraction. It is probable that vibrations of this nature exist (although difficult to verify) in the first apparatus, seeing the almost inevitable want of perfect coincidence between the axes of the opposite tubular extremities, without counting the longitudinal vibrations that are transmitted to the support. Ordinary tuning-forks themselves are not free from such a complexity of vibrations.

The form, dimensions, and nature of these apparatus may be modified in various ways. It would be possible, for example, to get up a form with straight arms, like ordinary tuning-forks, although it would be necessary to construct it partially of rubber, or else make it of metallic tubes of very narrowly elliptical section, or of metallic tubes grooved within.

These apparatus are all capable of likewise operating with currents of compressed air or of steam.

Thus a new relation is established between sonorous, hydrodynamic, and electric phenomena.

But there is one application of these apparatus that still further assimilates them to electrical ones, and that is that we can make the former serve for keeping up continuous vibrations in an ordinary tuning-fork, through immediate communications or through a solid intermedium. Here the current of water, interrupted automatically, replaces the electric current of electric tuning-forks.

In order to obtain such an effect, we regulate the hydrodynamic instrument by means of a spring applied to the arms, and the tension of which is varied at will, or by means of an annular or spherical slide that is to be fixed at the proper height, or by adding rods with movable balls to the arms, as in the Foucault mercurial interrupter (Fig. 5), or finally, by constructing the arms so that they will slide in and out, in order to increase or diminish the vibrating lengths according to circumstances.

As for the method of communicating the vibratory motion from one fork to the other, that can be done in several ways: (1) The two instruments being firmly fixed by their bases, an arm of the one may be connected with an arm of the other by means of a straight or helix-shaped wire. On regulating the motion of the apparatus by means of the arrangements just indicated, a synchronous motion will be communicated to the tuning-fork (Fig. 6). (2) The transmission may also be effected without an intermediate wire, by directly arranging the vibrating arms of the hydrodynamic fork on each side of those of the ordinary tuning-fork, and nearly in contact, in such a way that the discontinuous current (of compressed air) shall strike against them externally (Fig. 7). (3) The hydrodynamic instrument might also be small enough to allow its arms to be placed between those of the tuning-fork, and to act upon the latter like a spring (Fig. 8).

In order to complete what has reference to hydrodynamic tuning-forks, I shall cite one other application that may be made of them, although it is not directly connected with the comparison with which we are occupied. We might, in fact, employ the apparatus as a water meter by utilizing its regular, vibratory motion for putting a dial mechanism in motion. In order to give an idea of the operation of an apparatus of this kind, I shall cite two experiments that I have performed for the purpose of determining approximately in what ratio the discharge of water can vary when the tube is in vibration, as compared with that which takes place when the flow is free or continuous, all other conditions being the same.

It is evident that such comparative discharge may be expressed by the inverse ratio of the time that the instrument takes to fill the same vessel with water under each of the preceding conditions. Now,

1. With a converging nozzle, thin at the extremity, vibrating, it requires 2 m. 40 s. = 160 s. to fill the same vessel; non-vibrating, it requires 1 m. 40 s. = 100 s.—figures that have the ratio of 3 to 2.

2. With a cylindrical nozzle, thin at the extremity, vibrating, it requires 1 m. 30 s. = 90 s. to fill the same vessel; non-vibrating, it requires 1 m. 12 s. = 72 s.—figures that are as 5 is to 4.

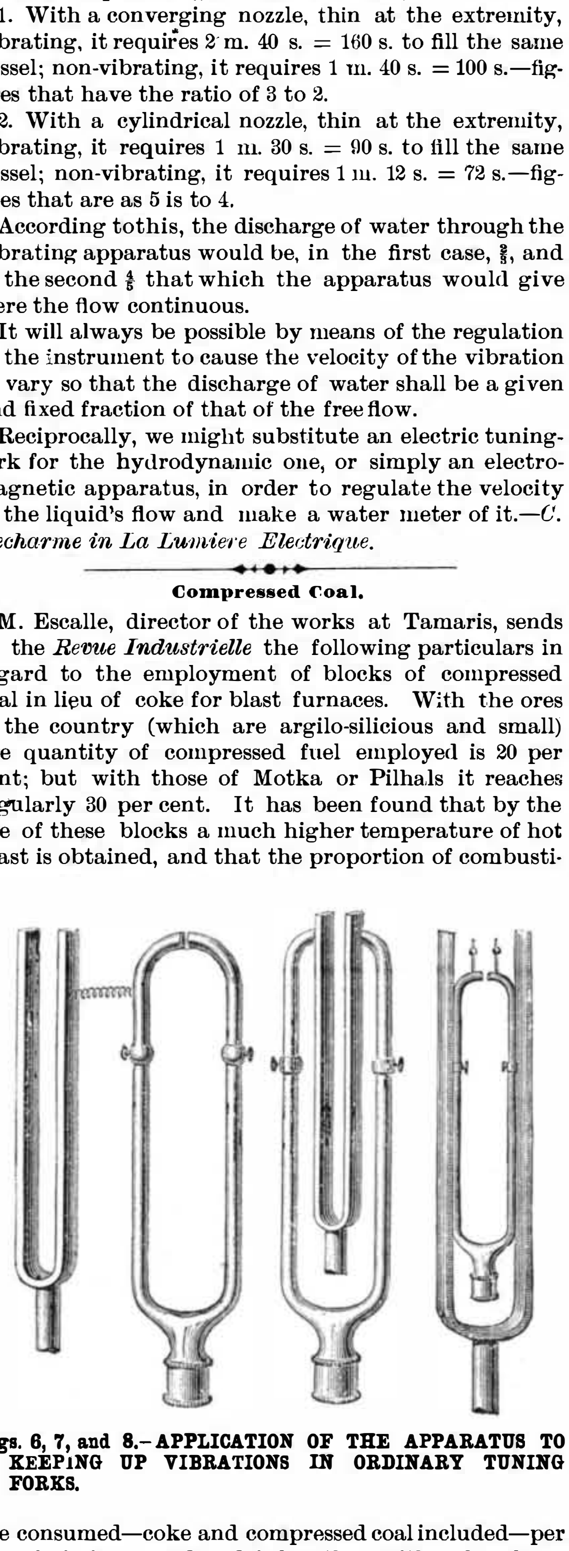
According to this, the discharge of water through the vibrating apparatus would be, in the first case, ⅔, and in the second ⅘ that which the apparatus would give were the flow continuous.

It will always be possible by means of the regulation of the instrument to cause the velocity of the vibration to vary so that the discharge of water shall be a given and fixed fraction of that of the free flow.

Reciprocally, we might substitute an electric tuning-fork for the hydrodynamic one, or simply an electro-magnetic apparatus, in order to regulate the velocity of the liquid's flow and make a water meter of it.—*C. Decharme in La Lumiere Electrique.*

Compressed Coal.

M. Escalle, director of the works at Tamaris, sends to the *Revue Industrielle* the following particulars in regard to the employment of blocks of compressed coal in lieu of coke for blast furnaces. With the ores of the country (which are argilo-silicious and small) the quantity of compressed fuel employed is 20 per cent; but with those of Motka or Pilhals it reaches regularly 30 per cent. It has been found that by the use of these blocks a much higher temperature of hot blast is obtained, and that the proportion of combusti-



Figs. 6, 7, and 8.—APPLICATION OF THE APPARATUS TO KEEPING UP VIBRATIONS IN ORDINARY TUNING FORKS.

ble consumed—coke and compressed coal included—per ton of pig iron produced is less than with coke alone. M. Escalle attributes this result to the quantity of water (1½ per cent) contained in the compressed coal blocks used by him, as well as to the nature of the volatile matters. These blocks have given, on analysis, the following results:

	By Volume.	By Weight.
CO_2	2·60	5·17
O	8·90	15·88
CO	3·50	4·43
C_2H_4	14·00	10·14
C_4H_4	48·80	63·00
H	20·20	1·82
N	2·00	2·53

The volume of gas obtained per ton of the compressed fuel was 7,620 cubic feet.