

chloride of calcium. The authors use instead of the latter body chloride of magnesium, and make up a color as follows:

Thickening	5 lbs.	7 1/4 ozs.
Blue alizarine at 10 per cent.....		17 1/4 "
Acetate of chrome solution at 10 per cent.....		5 1/2 "
Chloride of magnesium, same strength		5 1/2 "
Yellow prussiate ditto.....		2 3/4 "
Glycerin.....	11	"
Thickening:		
Water	6 lbs.	9 ozs.
White starch.....		4 1/4 "
Light calcined starch.....		13 "
Olive oil.....		5 1/4 "

The addition of acetic acid to the color by way of solvent is not advantageous. The shades produced are paler and grayer.

HOW TO MAKE AN INDUCTION COIL.

By GEO. M. HOPKINS.

FARADAY discovered in 1832 that a galvanic current was capable of inducing other currents in wires near but not in contact with the conductor of the primary galvanic current; these he named *currents of induction*, or *induced currents*.

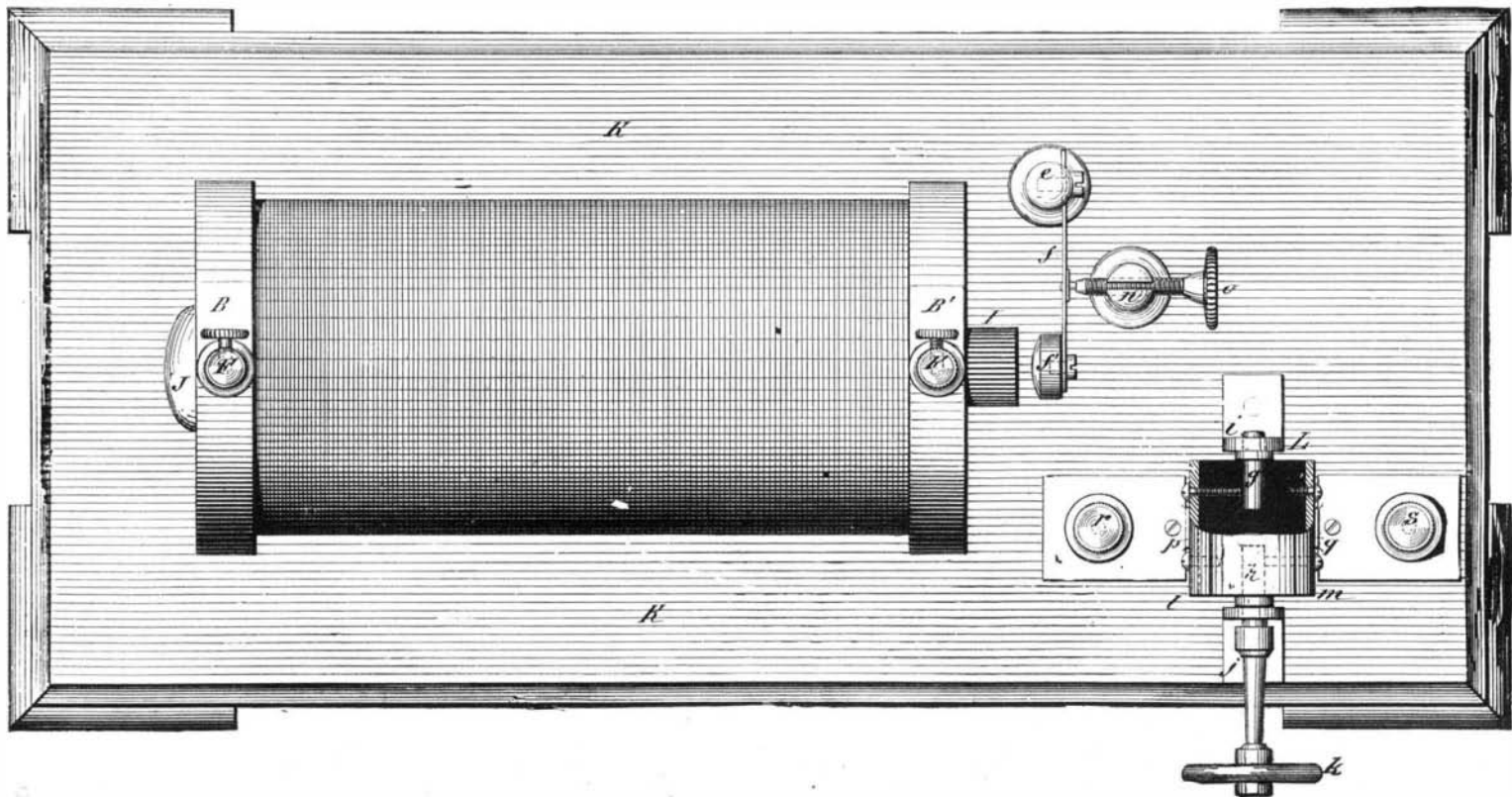
Since the discovery of Faraday, the phenomena of induction have been exhibited by many forms of apparatus; but the most striking example of inductive action is afforded by the induction coil. Prominent among makers of this instrument are Ritchie, Ruhmkorff, and Ladd. The performance of the induction coil is familiar to many of the readers of this journal; but its construction is not so well understood.

There are two methods of making an induction coil; the simpler, cheaper, and perhaps the best will be described in connection with the accompanying engravings, which, with the exception of figure 4, are exactly one half size, and may be used as working drawings from which to construct the

The primary coil must now receive four coats of moderately thick alcoholic shellac varnish; each coat being allowed to become dry before another is applied. When the primary coil has become thoroughly dry and hard, it is covered with three or four layers, D, of stout cartridge paper, which is fastened by a little gum along its outer edge. This paper covering must fit between the heads, BB', perfectly, and must be well smoothed and rounded, and varnished with shellac, taking care to cover the joints at the ends, and also to varnish the inner faces of the heads. The secondary coil, E, is wound in two sections separated by an insulating medium, G, which is applied in the manner presently to be described. The coil, E, is of No. 36 naked copper wire; the two sections being connected at H.

The winding is best done in an engine lathe, the wire being allowed to pass through a fine guide in the tool post, and the screw cutting gear of the lathe being set as for cutting a very fine thread. The different convolutions of the wire should be as near together as possible without touching. To

FIG. 1.



PLAN OF INDUCTION COIL.—HALF SIZE.

This color is printed upon cloth prepared with a fatty acid, an essential condition for success. About one part of sulpholeic acid should be used with 20 to 30 parts of water.

Steam one and a half to two hours. Wash and soap 20 minutes at 122° F. Take through boiling lime water 15 grains of quicklime per 35 fluid ounces of water. This gives a greenish blue shade, owing to the formation of a lime lake.

Wash well and soap at a boil, which restores the blue to its original purity.

Baryta and strontia produce upon blue alizarine an effect similar to that of lime. Dilute soda and potash turn the violet shade to a decided blue. Certain oxides almost insoluble, such as magnesia and oxide of zinc, act in a permanent manner upon alizarine blue when already fixed so as to modify its tone.

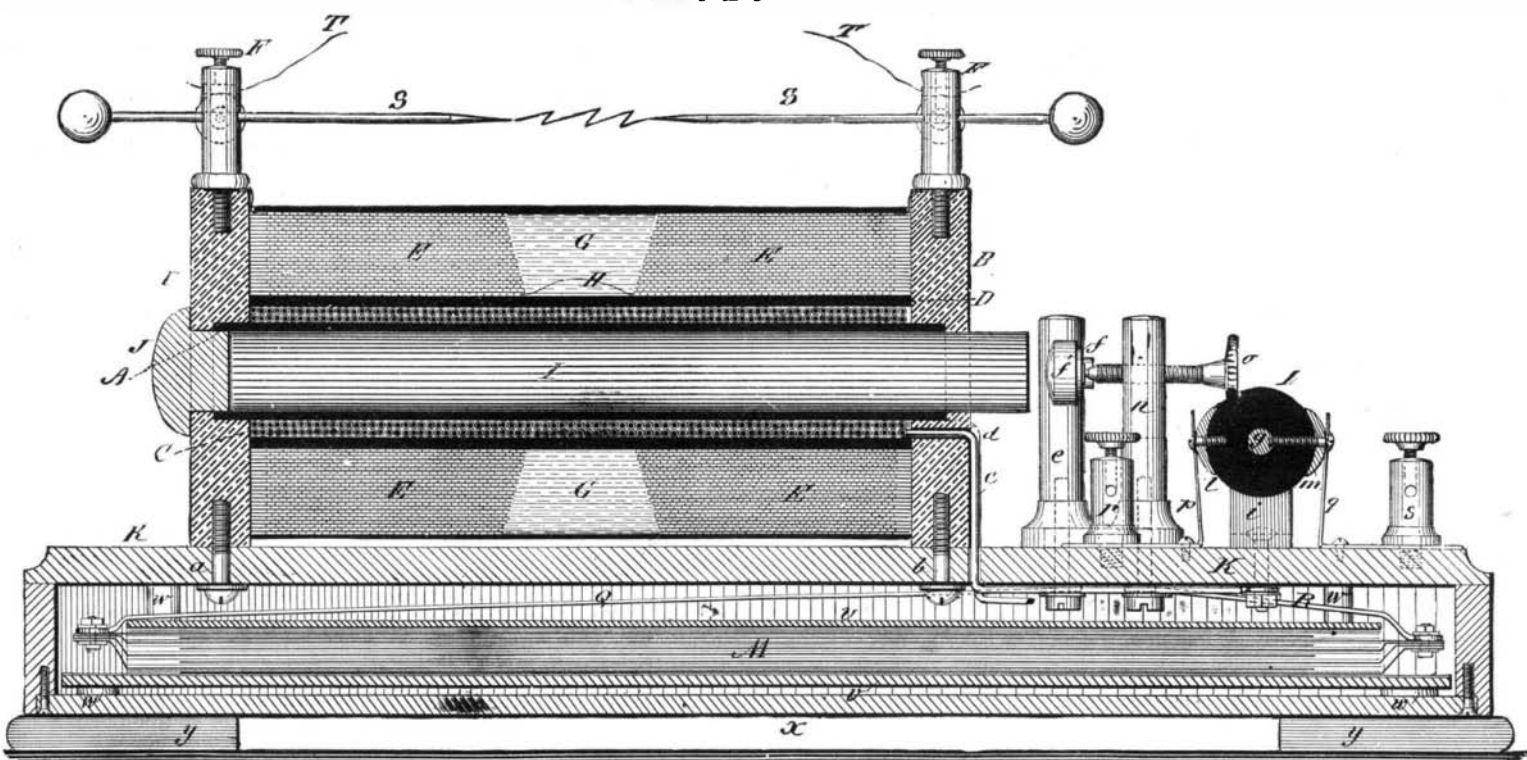
The alizarine blue fixed by our process bears chloride of lime and light. It turns certainly more gray on exposure to the sun, but its fastness is comparable to that of a vat blue. —*Bulletin de la Société Industrielle de Mulhouse.*

instrument. Figure 1 is a plan view. Figure 2 is a central, vertical longitudinal section. Figure 3 is a vertical transverse section, taken through the coil, near one end, and looking toward the commutator. Figure 4 represents the under side of the base, in plan, and the condenser, in perspective, and shows the connections.

The coil consists of two portions, the inner or primary, and the outer or secondary. The primary coil, C, consists of two layers of No. 16 cotton covered copper wire, which is wound upon a spool composed of the thin paper or wooden tube, A, and the heads, BB', which are of vulcanite, or well varnished hard wood. The tube is 7/8 inch internal diameter, and the heads have each a central hole of the same size. These holes are enlarged or counterbored to receive the ends of the tube, A, which are glued or cemented therein. In the head, B', there are two small holes near the large central hole, for the terminals, c d, of the primary coil. One of these terminals is put through the head before the winding operation is begun; the other, after the winding is finished.

accomplish the same thing in an ordinary foot lathe, a piece of quite thin brass should be bent together in a U form, and the wire should be allowed to pass through the channel thus formed; the thickness of the metal will regulate the space between the adjacent coils of wire. The winding begins at the middle, leaving the terminal, H. When one of the heads is reached, the coil or layer formed is covered with three thicknesses of common white tea paper or quite thin writing paper, the edge of which is fastened with a little gum. The winding of the fine wire is now continued toward the center of the coil; when the second layer is complete, it is covered as in the case of the first coil, when the third is wound on, and so on until it is about 3 3/8 inches in diameter. The secondary wire should not be wound close to the head, a space of about 1/8 inch should be left. After winding one of the sections of the secondary coil, the other may be proceeded with after changing ends with the spool in the lathe, so that one section may be wound as a continuation of the other. The inner terminals are connected at H, and soldered; the outer terminals are connected with

FIG. 2.



LONGITUDINAL SECTION OF INDUCTION COIL.—HALF SIZE.

the binding posts, F, which are screwed into the upper edges of the heads, BB'. For the sake of strength the outer ends of the secondary wire may be four or six sizes larger than that of the coil. The outer layers of fine wire are each partly covered with a paper band, consisting of six layers of tea paper, which is wide enough to reach from the head over about two-thirds of the coil section; the whole is then enveloped in a wrapper of stout paper, having a hole directly in the middle at the top, through which is poured melted resin to which has been added a very small quantity of beeswax.

This forms the insulating medium, G, which prevents the

some little pressure to prevent it from jarring loose by the vibrations of the spring, *f*.

The commutator, L, consists of a vulcanite cylinder on which are screwed two copper bars, *lm*, one of the screws of the bar, *l*, coming into contact with the pivot, *g*, and one of the screws of the bar, *m*, coming into contact with the pivot, *h*. The pivots, *g* and *h*, turn in posts, *ij*, which spring against the shoulders of the pivots to insure a perfect contact. The pivot, *h*, is elongated and provided with a vulcanite handle, *k*. The binding posts, *rs*, are connected by copper springs, *p* and *q*, with the copper bars on the vulcanite cylinder.

renders the wire bundle, I, magnetic; the hammer, *f'*, is attracted toward it, breaking the electrical connection at the end of the screw, *o*, when the iron wire bundle loses its magnetism, and the hammer flies back until the spring, *f*, again touches the screw, *o*, when the hammer is again attracted, and so on. When the current is broken in this manner, if the condenser be detached, there is a large spark at the end of the screw, *o*, as the extra current is discharged from the primary coil; but when the condenser is connected by the wires, Q R, with the posts, *e* and *n*, the spark is very much decreased in intensity, as the extra current is diffused in the condenser, and the strength of the secondary current is very much increased.

The binding posts, F, have each two holes and two binding screws. One set of holes receive the pointed rods, S, the other the conducting wires, T. This coil, if carefully made, will, when the current is interrupted, give a spark $1\frac{1}{2}$ inches long between the points of the two rods, S, by using two large Grenet battery cells. The current may be reversed by turning the pole changer or commutator, L, through a half revolution, and it may be stopped altogether by turning the bars, *lm*, out of contact with the springs, *p* and *q*.

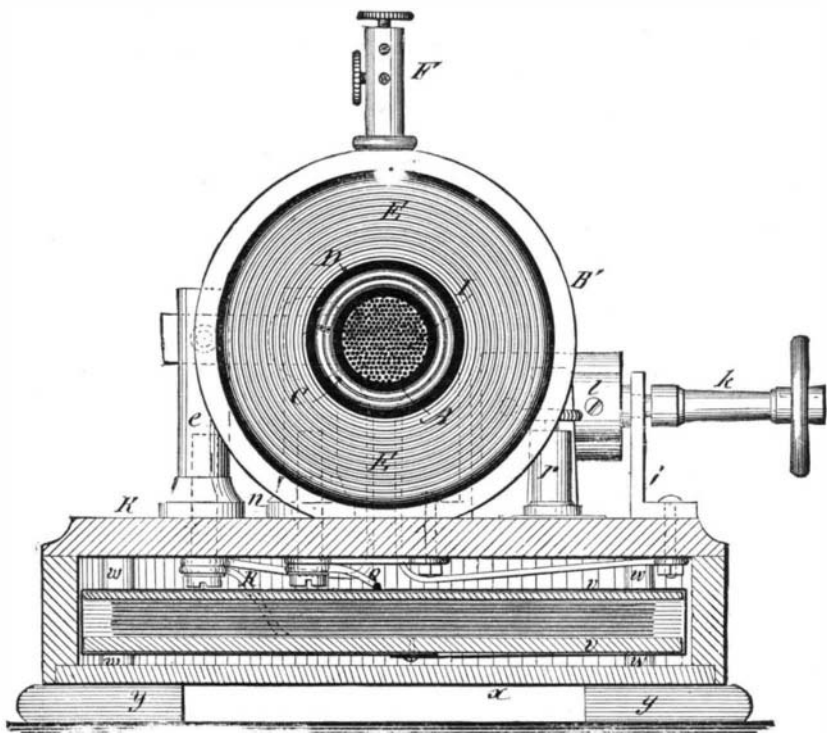
It requires nearly a pound of wire for each section of the secondary coil; but, of course, the quantity will vary somewhat with the manner of winding. By observing the proportions, given coils of other sizes may be made from these drawings.

Another method of winding, to which I shall allude only briefly, consists in winding silk covered wire entirely across the spool, and insulating each layer by a coating of shellac, and two or three thicknesses of paper coated with shellac varnish or melted paraffin. Still another method consists in making the secondary coil of very thin sections, and insulating the sections one from the other by disks of hard rubber; but the plan here given is undoubtedly the easiest, and a coil made in this manner gives good results. With it most, if not all, of the experiments usually performed with induction coils may be accomplished.

For example, it will charge a Leyden battery, decompose water, explode blasting cartridges, light gas, exhibit the phenomena of electric light in vacuo, and may be used in many very interesting experiments.

SCIENTIFIC AMERICAN SUPPLEMENT, No. 166, will contain instructions for performing a number of interesting experiments with the induction coil.

FIG. 3.



TRANSVERSE SECTION OF INDUCTION COIL.—HALF SIZE.

spark from leaping from one section of the coil to the other. After the resin cools, the thick paper is removed and a covering of smooth heavy paper is neatly put around the coil, and upon it is wound as closely together as possible common smooth finished black thread. This latter is not essential, of course, but it gives the coil an excellent appearance and forms a really good covering.

In the tube, A, is placed a bundle, I, of No. 18 soft iron wires. They should be straight and of the same length, and their outer ends especially should be exactly even. The central hole in the head, B, is stopped by a wooden plug or button, J. The base, K, consists of a wooden box, neatly made, and the size of which may be readily obtained from

In the base of the instrument is placed the condenser, M, which is composed of sheets of thin tin foil alternating in position as shown in Fig. 4. The ends of the sheets, O, projecting beyond the sheets, P, to the right, the ends of the sheets, P, projecting beyond the sheets, O, to the left. The sheets, O, are insulated from the sheets, P, by sheets of paper, N, which have been coated with shellac varnish and well dried. While the sheets, O, do not touch the sheets, P, the latter are all connected together at one end, and are in electrical connection with the wire, Q. Similarly the sheets, O, are connected with the wire, R.

A piece of pasteboard, v, is placed upon each side of the condenser thus formed, and the whole is fastened together

FIG. 4.

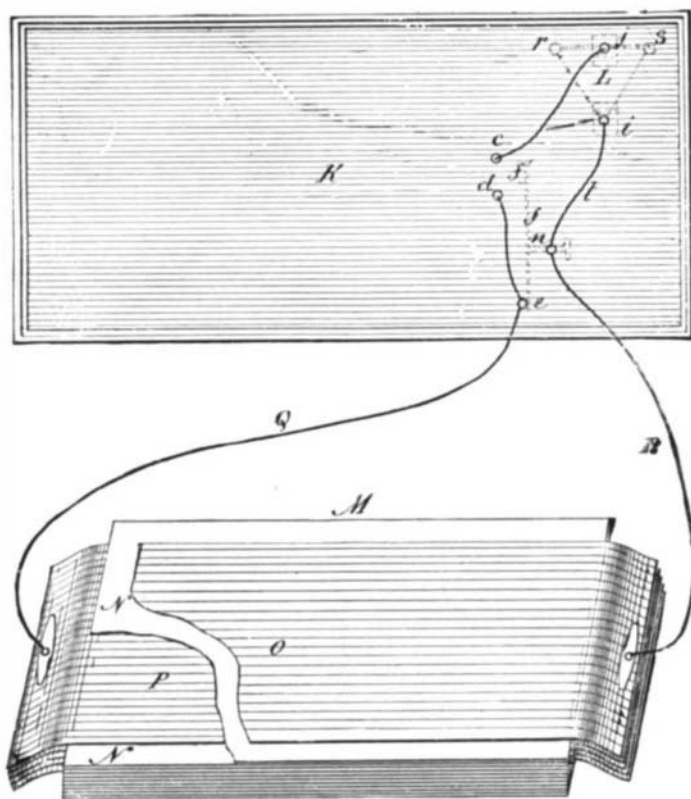


DIAGRAM OF CONNECTIONS, INDUCTION COIL.

the engravings. The coil is secured to the top of the box, a little nearer one end than the other, by two screws, *a* and *b*, which pass upward into the heads, BB'. Near the head, B, there is a brass standard, *e*, to which is secured one end of the spring, *f*, that supports the iron hammer, *f'*, exactly opposite the center of the wire bundle, I, and about $\frac{1}{4}$ inch distant from it. Opposite the middle of the spring, *f*, and $\frac{1}{2}$ inch from it, there is a post, *n*, through which passes the platinum pointed screw, *o*, which touches a small platinum plate, riveted to the center of the spring, *f*. The post, *n*, is split longitudinally, and clamps the screw, *o*, with

with tape running around it in two directions, and the condenser is held in place by bits of cork, *w*, which are pressed by the bottom, X, when it is in its place. The condenser has 40 square feet of tin foil surface. The connections are made as follows: the battery wires are connected with the binding posts, *rs*, the current passes through the springs, *p* and *q*, bars, *lm*, pivots, *g* and *h*, to the posts, *ij*. The post, *j*, is connected directly with the terminal, *c*, of the primary coil, C. The post, *i*, is connected by the wire, *t*, with the post, *n*, and the terminal, *d*, of the primary coil, is connected with the post, *e*. The battery current passing through the primary coil

ON THE MINUTE MEASUREMENTS OF MODERN SCIENCE.

By ALFRED M. MAYER.

ARTICLE XVI.

On the determination of the number of vibrations made in a second by a tuning-fork; with examples of the uses of the tuning-fork as a chronometer to mark and register minute intervals of time.

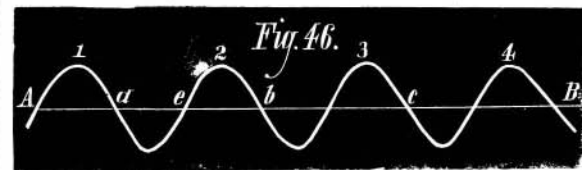
In a subsequent article I purpose to show how, with revolving mirrors, rotating disks, and tuning forks, men of science have measured the minute intervals of time occupied by electric flashes, and have found out something as to the structure and compound nature of these flashes.

To make such investigations we must first of all provide ourselves with instruments whose parts will move so quickly that they can keep pace with these sudden and violent electrical motions, and also register the very minute times during which they exist.

A tuning-fork is an excellent chronometer, and when used skillfully will accurately measure intervals of time as minute as the 1-20,000th of a second. How a tuning-fork can serve as a time keeper the reader will readily understand after making the following experiment.

Take a tuning-fork the number of whose vibrations in one second we know. Suppose that it makes exactly 500 vibrations in one second. By a vibration we understand a to and fro motion of a prong of the fork. It is thus understood in this country, in England, and Germany, but in France a vibration is a to or fro motion of a prong of the fork. Blacken a piece of window glass by moving it about in the smoke of burning camphor, or in the smoky flame of a kerosene lamp. Tip one of the prongs of the fork with a delicate point made of a triangular piece of thin copper foil. Now vibrate the fork and quickly draw the tip of foil over the smoked surface. On holding the glass up to the light you will observe that the lampblack has been brushed by the tip from off the glass, in a sinuous or wavy line, as shown in a very enlarged scale in Fig. 46.

Each vibration to and fro of the fork made a part of the trace as long as from 1 to 2, or from 2 to 3, etc., or, what is



the same, as long as from *a* to *b*, from *b* to *c*, or from *c* to *d*, measured on the axis, A B, of the curve. As the fork makes 500 of these double flexures in one second, it makes one of these double flexures (say from *a* to *b*) in the 1-500th of a second, and a single flexure (say from *a* to *e*, or from *e* to *b*) in 1-1,000th of a second. Thus it is evident that if we know the exact number of vibrations made by the fork in one second, we can use its wavy trace as a measure of the flow of time.

The velocity of rotation of a wheel measured by a tuning fork.—For an example, suppose we desire to know the velocity of rotation of the wheel of a gyroscope. Coat its disk or rim with lampblack, and touch the rotating wheel with the tip of foil on the prong of the vibrating fork. On counting the number of the flexures marked by the fork in the circumference of the wheel we have the number of thousandths of a second which the wheel took to make one revolution. Suppose we have found 25 flexures in the circumference of the wheel. This shows that the wheel made one revolution in 25-1,000ths, or 1-40th, of a second. In this very manner Dr. Thomas Young measured velocities of rotation in 1807. To this illustrious man of science is due the idea of using a tuning fork for a chronoscope, and the first published notice of this invention is found in his "Lectures on Natural Philosophy and the Mechanical Arts," London, 1807.

Evidently the knowledge of the exact number of vibrations made by the fork in one second lies at the foundation of this method of chronometry. To make this measure various methods more or less accurate have been devised.