through a piece, *M*, that serves as a safeguard, and from thence reaches the wire, *L*, which passes to the station where the message is to be delivered. We see the same wire entering at the top of Fig. 302, whence the current passes through a safeguard, *M*, then into the galvanometer, from which it goes to the electro-magnet of the receiver. After passing through the electro-magnet, it passes through the wire, *T*, and is lost in the earth.

Morse's Manipulator and Receiver.

437. Morse's Manipulator is shown in Fig. 303. It consists of a wooden stand, upon which is a metallic lever, *kh*, turning about a horizontal axis. One end of this lever is raised up by a spring, *r*, and the other is traversed by a

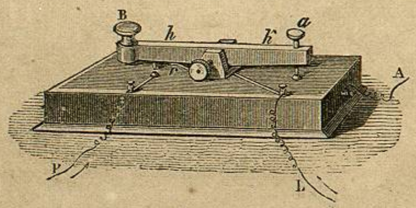

Fig. 303.

stem, *a*, which rests upon a copper button, and this in turn communicates through the stand with the wire, *A*. Fig. 303 represents the manipulator at the instant when it receives a dispatch. The current arrives by the wire, *L*, which is the wire of the line, rises into the lever, *kh*, and descends by the wire, *A*, to the receiver.

When it is desired to transmit a signal, it becomes necessary for the current from the battery, *P*, to enter the manipulator. This is not effected when the latter is disposed as in Fig. 303, for the lever, *kh*, does not touch the button in which the wire, *P*, terminates. By pressing the

(**437.**) Describe the Manipulator in detail. Its use.

button, *B*, the lever, *kh*, is lowered; a contact is established, the current passes immediately into the wire, *L*, which leads to the other station.

The Receiver, Fig. 304, is composed of an electro-magnet, *E*, which, whenever a current is transmitted, acts by attraction upon an armature of soft iron, *m*, fixed at the extremity of a lever, *mn*, and movable about an axis. At its extremity, *n*, the lever carries a point, *x*, which may be made to press against a movable fillet of paper, *ab*. When the current does not pass through the electro-magnet, the point, *x*, does not press against the fillet; but as soon as the current passes, the point is pressed against the paper, and traces upon it either a point, or a line more or less elongated,

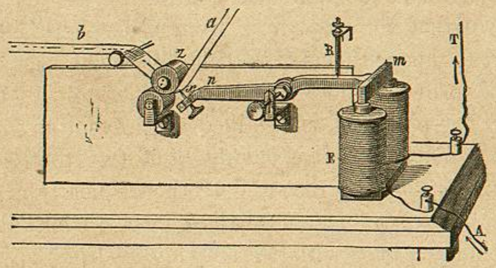

Fig. 304.

according to the length of time during which the current is uninterrupted.

The fillet of paper is kept in motion uniformly by means of a train of clock-work, *V*, which turns the cylinder, *Z* (Fig. 301). The fillet of paper moving uniformly in the direction from *a* to *b*, the operator at the other station, by pressing the button of the manipulator, and maintaining the pressure for greater or lesser periods of time, causes a succession of points and marks to be made upon the fillet at

Describe the Receiver in detail. Its use. How is the fillet of paper kept in motion? How are the letters recorded?

pleasure. These marks are, by convention, made to stand for the letters of the alphabet, as shown in the following table

MORSE'S ALPHABET.

a · —	j — · — ·	s · · ·
b — · · ·	k — · —	t —
c · · ·	l ——	u · · —
d — · ·	m — —	v · · · —
e ·	n — ·	w · ——
f · — ·	o · ·	x · — · ·
g — — ·	p · · · · ·	y · · — · ·
h · · · ·	q · · — ·	z · · · ·
i · ·	r · · ·	

It only remains to explain the PROTECTOR, *M.* Experience has shown that the wires may, from atmospheric influences, accumulate upon themselves sufficient quantities of electricity to prove troublesome to the operators of the telegraph. The piece, *M*, is destined to prevent any injurious action of this kind. It is composed of two toothed pieces of metal, disposed so that the teeth are nearly in contact. The current passes into one of these pieces, whilst the other is in communication with the earth. If, from any atmospheric change, electricity accumulates upon the wires or apparatus, it is given off by the points to the piece which is in communication with the earth, and shocks are thus avoided.

In what has been said, only a single wire, *L*, has been spoken of as running from station to station. It would seem to be necessary, in order to complete the circuit, that a second wire should be employed; such however is not the case. The employment of a second wire is avoided by connecting the two ends of the single wire with the earth. The parts *T*, Figs. 301 and 302, are for this purpose

Explain the Protector. Its use. *Why is it possible to operate a line of telegraph with a single wire?*

prolonged from the instruments till brought into free communication with the earth. The fluid then continues to circulate just as though a return wire had been used.

Velocity of Electricity.—Submarine Cables.

438. It has been found by experiment that the velocity of electricity is such as to carry a current around the earth in about a quarter of a second. For short distances, then, we may regard the transmission as instantaneous.

Since the invention of the telegraph, a complete net-work of lines has been established over both continents. Not only have thousands of miles of wires been stretched on land, but submarine wires have been laid, connecting places separated by hundreds of miles of water. Telegraphic wires connect England and Ireland, England and France, France and Algiers, and so on. Finally, an attempt has been made to connect the two continents, and although it has thus far failed to be successful, there is good reason to anticipate a complete success at no distant day. Signals and messages have been transmitted from Ireland to Newfoundland, and the possibility of the connection has thus been fully demonstrated.

Electro-Magnetic Motor.

439. Many attempts have been made, and with partial success, to employ electro-magnetism as a motor for the propulsion of machinery. JACOBI, of St. Petersburg, constructed an engine of this kind in 1838, which was capable of propelling a boat containing twelve persons. Many other machines have since been constructed, but in all cases the expense of moving them has been so great as to preclude their economical use.

Fig. 305 represents an electro-magnetic machine, constructed according to the design of M. FROMENT. It is composed of four electro-

(**438.**) What is the velocity of an electrical current? *Give an account of some of the submarine lines of telegraph.* (**439.**) Has electricity been used as a motor? *Describe* M. FROMENT'S *machine in detail.*

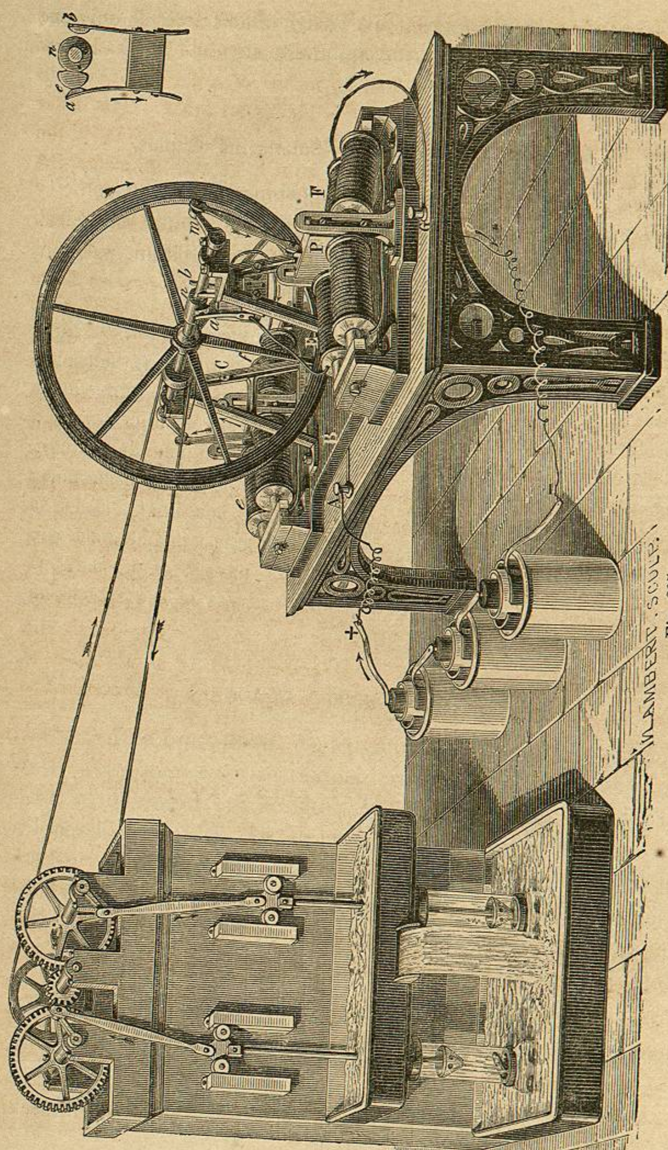

Fig. 305.

magnets, acting in pairs upon two pieces of soft iron, *P*, only one of which is seen in the figure. These pieces, attracted by the electro-magnets, *EF*, transmit the motion by means of a working-beam, to a crank, *m*, fixed at the extremity of a horizontal arbor. The latter bears an iron fly-wheel, which regulates the motion. Finally, the same arbor supports a piece of metal, *n*, of a greater diameter, the use of which will be explained presently.

The current from the battery, *P*, entering *A*, passes into a platform of cast-iron, *B*, then, through different metallic pieces, it reaches the arbor and the piece *n*. From thence the current flows alternately to the electro-magnets, *EF* and *ef*. The manner in which this alternate flow is effected, is shown in Fig. 306, which represents a section of the piece, *n*, and its accessories. Upon the piece, *n*, is a projection, *e*, called a *cam*, which in the course of one revolution touches successively two pallets, *a* and *b*; these transmit to the electro-magnets the current, whose course is indicated by the unfeathered arrows. The feathered arrows in the figure show the direction in which the parts of the machine move.

The current passing alternately into the two pallets, *a* and *b*, and thence into the systems of electro-magnets, *EF* and *ef*, the piece, *P*, is first attracted, and then a similar piece at the other extremity of the arbor of the fly-wheel is attracted, and so on. The result is a continuous rotary motion, which is transmitted by a driving-band to a train of wheels, and so on to the pumps, which it is destined to work.

III.—INDUCTION.—APPLICATION TO MEDICINE.

Induction by Currents.

440. We have seen that the electricity of the machine acts upon bodies by induction. The electricity of the battery acts in a similar manner, but only when they begin to flow and when they cease.

To show this, take two copper wires, covered with silk, and wind them side by side upon a bobbin. Then fasten the two ends of the

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Its mode of action. (**440.**) Does galvanic electricity act by induction? *How is this shown?*

first wire to the two binders, *m* and *n*, of the galvanometer, Fig. 297. Next connect one end of the second wire with one pole of a feeble galvanic battery. If the other end of the second wire be brought into contact with the second pole of the battery, at the instant of contact, the needle of the galvanometer will indicate the production of a current in the first wire, flowing in an opposite direction to that of the battery. If the contact is kept up, the flow of the induced current ceases, as is shown by the needle of the galvanometer returning to its position of rest. If the current of the battery is broken, the needle of the galvanometer is again deviated, but in a contrary direction, indicating an induced current flowing in the same direction as that of the battery.

The battery current is called the *inducing* current; the other current is called the *induced* one. These currents conform to the following laws:

1. At the instant when the inducing current begins to flow, an induced current is developed flowing in a contrary direction.

2. The inducing current continuing to flow, the induced current ceases.

3. At the instant when the inducing current ceases to flow, an induced current is developed flowing in the same direction.

Properties of Induced Currents.

441. Experiment has shown that induced currents possess all the properties of other electrical currents. Like them, they give sparks, produce violent shocks, decompose water, salts, and the like, and act upon the magnetic needle.

Induced currents are the more powerful, the longer the wires em-

What is the direction of the induced current at the instant of closing the circuit? Of breaking it? What is the inducing current? The induced one? What are the laws that govern the induced currents? (**441.**) What are the properties of induced currents?

ployed. Hence, in practice it is usual to wind the wires upon bobbins, as shown in Fig. 307.

The coil shown in Fig. 307, consists first of a cylinder of pasteboard, upon which is wound about three hundred coils of coarse copper wire. This is the inducing coil. Over it is a finer wire, making several thousand coils. These wires are not only covered with

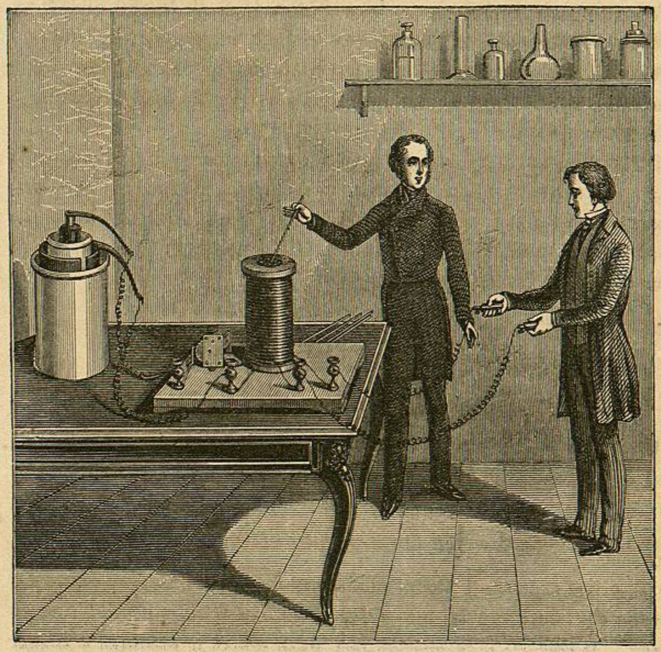

Fig. 307.

silk, but also with an insulating varnish of gumlac. At the extreme left of the stand on which the coil rests, are two binders in connection with the two poles of a battery. From one of them proceeds a plate of copper, going to a toothed wheel, moved by clockwork, and communicating with one of the ends of the inducing coil;

How are the wires wound? How insulated? How are the battery communications made?

the second binder is in communication with the other end of the same coil. The two ends of the finer wire are also connected with binders, and through them may be connected with any conductor whatever. For the purpose of administering a shock, the binders are provided with wires having copper handles, which are to be grasped, as shown in the figure.

When the instrument is in operation, the current from the battery is continually broken by means of the toothed wheel, and there results a succession of shocks, two at each interruption of the current. The shocks that arise at the beginning of the flow are almost nothing, whilst those which take place at the time of interruption are quite severe.

The force of these shocks may be graduated by introducing iron rods successively into the interior of the coil. The rods being alternately magnetized and then losing their magnetism, act upon the fine wire by induction, and augment the intensity of the shocks at the instant of breaking the current.

Physiological effects of Electrical Currents.

442. Electrical currents have been employed in the treatment of certain diseases, especially those connected with the nervous system. Electricity has a powerful action upon the animal economy, and when judiciously applied possesses considerable curative power.

Fig. 308 represents one of the many forms that have been given to the electrical apparatus, for the purpose of acting upon the human body. It consists of a wooden box, upon which is mounted a copper cylinder, inclosing a bobbin of two wires. The box has a drawer of zinc, in which is a small quantity of salt water. A plate of well calcined carbon, impregnated with nitric acid, is plunged into this solution. In a word, the combination constitutes a modified form of a BUNSEN's couple. Two copper slips communicate, the one with the zinc and the other with the carbon, conducting the current to the

How are shocks given? What arrangement is made for continually breaking the current? How may the shocks be increased? (**442.**) What application has been made to medicine? *Explain Fig. 308.*

large wire of the coil, through a piece of machinery for breaking the current. This current-breaker consists of a small plate of soft iron, attracted by an electro-magnet in the centre of the bobbin. It is attracted when the current passes, and immediately interrupts, or breaks it. The induced current is conducted by wires to two sponges

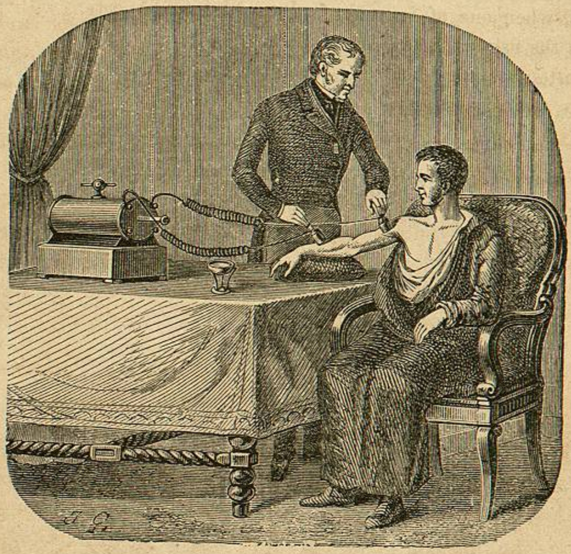

Fig. 308.

saturated with salt water, or fresh, according as it is desired to make a more or less intimate communication with the part through which the shocks are to be passed. Finally, the method of applying the shocks is shown in Fig. 308.

Electrical Fishes.

443. Certain fishes possess the power of imparting a shock that compares in intensity with that of a powerful Leyden jar. Such fishes are called electrical fishes, and are of three kinds, the most

(**443.**) *Describe the electrical fishes.*

interesting of which is the electrical eel of South America. This fish was studied by HUMBOLDT and BONPLAND, who have given a complete description of it.

The shocks given by electrical fishes are due to electricity generated in the body of the fish. MATTEUCI showed that sparks could be obtained from the fish, and also that the galvanometer is affected when one of its wires is brought into connection with the back of the fish, and the other with its belly.

In all cases the shock is voluntary, and serves as a means of defense against enemies.

To what are their shocks due? What observations were made by MATTEUCI?

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CHAPTER I.