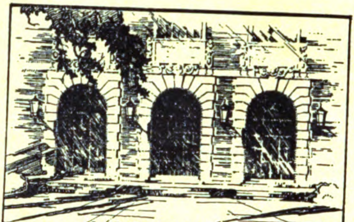
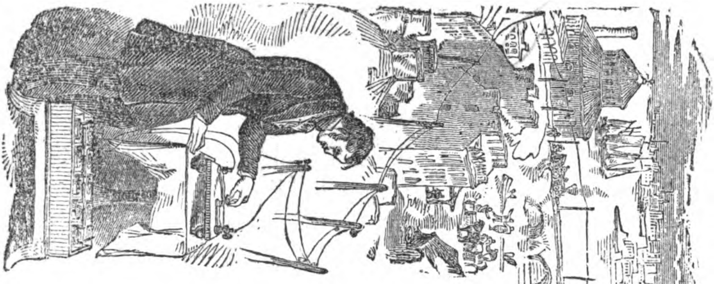
J. S. Galloway
Oxford.
April, 1855





BOOK

OF THE

TELEGRAPH.

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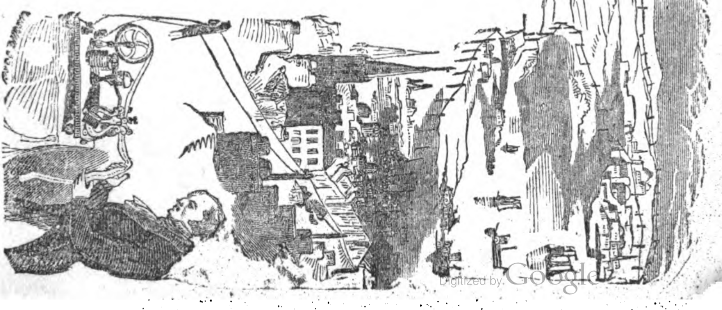


STEREOTYPED AT THE
BOSTON STEREOTYPE FOUNDRY.

BOOK OF THE TELEGRAPH.

GENERAL PRINCIPLES.

1. THE electric telegraph is the most wonderful application of that SCIENCE by which man is gradually extending his control over nature. Electricity is a very familiar agent — in the lightning, in the hair of animals, in the crackling of silk. It is also, where unseen, a central power, endowing matter with a large proportion of its chemical and mechanical properties. Electricity is, also, itself capable of assuming a variety of forms, as in the electrical machine, the galvanic battery, and the electro-magnet.

2. The telegraph is made possible by three remarkable properties or laws of electricity.

First. Electricity seeks always an equilibrium in its distribution through matter. If there is an excess in one place, it always seeks to transfer itself to another, or other places, where there is less, or a deficiency.

Second. The production of electricity, from whatever source, is always twofold, or in two directions, one surface or part of our apparatus becoming always *positive*, while another becomes *negative*; thus suggesting the idea of a gain on one side, and loss on the other, of a corresponding amount of electricity; in other words, of a *disturbance of equilibrium*. Thus the rubber and prime conductor of the electrical machine, the platina and zinc plates of the battery, and the antimony and bismuth of the thermo-electric pair, become respectively electro-positive and electro-negative, as the first condition and fact of electrical excitement.

Third. Different substances have very different conducting powers for electricity, some permitting its passage with slight resistance, while others, called *insulators*, completely bar its progress. The effect of this law, applied to the preceding ones, is to make it possible to insulate electricity in our apparatus in its two opposite conditions of positive and negative; when, by its tendency to equilibrium, a current (according to our common modes of expression) will pass from the positively excited body to the negatively excited body, by means of any conductor, as, for example, the telegraph wire, which we may please to interpose between the two.

3. The practical utility of the telegraph will depend upon the completeness of the insulation and the conduction in different parts of the apparatus, on the quantity, force, and rate of travel of the electricity employed, and the means which we have of observing and registering its passage.

4. The Leyden jar illustrates well the possible extremes of conduction and insulation which we may employ. It consists of glass, perhaps not more than

a sixteenth of an inch thick, which is coated on the outside and inside with tin foil. When charged, these coatings become excited — one electro-positive, the other electro-negative — to an intense degree. If a conductor, of a length almost without limit, be made to form a circuit connecting these, the electricity will traverse its whole extent, rather than cross the slight barrier interposed by the thickness of the glass.

5. In the galvanic battery we have the same contrast between insulation and conduction in a less degree. A platina plate may be placed at half an inch distance from a zinc plate, in an acid or saline solution; and yet the current excited will traverse a metallic conductor of hundreds of miles, disposed in a circuit so as to connect the plates, rather than cross the solution of only half an inch which intervenes. In this case, however, the obstacle to the passage of the electricity is not only, or chiefly, the bad conducting power of the solution compared with that of the wire, but an electrical relation of the liquid to the plates, which is the original occasion of the current, and which resists its passage in the opposite direction to that originally imposed upon it. Indeed, the energy of the current which flows through the long conductor is increased, rather than diminished, by approximating the plates until they are separated only by a slight film of fluid. A saline solution is a much better conductor for electricity than water; but a recent estimate of the conducting power of pure water, compared with an equal area of copper wire for galvanic electricity, places it at the enormous disproportion of one to a million.

6. Electricity, from different sources, is characterized by peculiarities which affect materially its application to the telegraph. The electricity from the common machine, by which the Leyden jar is charged, is called free electricity, and is in the same condition as lightning. It is accumulated only on the *surface* of insulated bodies; its tension is so great that it will pass off to a neighboring conductor through a considerable interval of air, thus producing the phenomenon of the spark; the quantity of its current is so small as to produce comparatively slight chemical or mechanical effects; it is insulated with difficulty, and conducted by a metal with hardly appreciable loss. In the galvanic battery, on the other hand, the current is conducted by the whole mass of the conducting material or wire; its tension, or force, may be so low as to be resisted and rapidly overcome by the best conductors, while it is insulated by almost all non-metallic substances in the solid state, such as wood. Meanwhile, its *quantity* is so great as to be capable of producing the most powerful mechanical and chemical effects. As will be mentioned hereafter, means exist of multiplying, to a certain extent, the intensity or force of the single galvanic pair, by which it becomes the most efficient means of exciting electricity for the purposes of the telegraph.

7. Another condition of the practical usefulness of the telegraph is the rate of travel of electricity, which, on examination, proves to be an almost instantaneous transfer of influence. Thus, Wheatstone determined the rate of free electricity to be 288,000 miles a

second. This would require about six minutes to traverse the space between the earth and the sun, or a somewhat shorter period than that required by light to perform the same journey. It may be observed here, that, in the transmission of messages, we are apt to consider the distance traversed by electricity as that existing between the two stations of the telegraph, whereas, it is double that distance; a *circuit*, as it is technically called, being always necessary, two conductors being required, one upon which the electricity goes out, the other upon which it returns.

8. The mode by which the rate of motion of electricity was obtained by Wheatstone is so curious, that it deserves to be described. Wheatstone caused the electricity from the common machine to pass through a long coil of insulated wire, in which were two or more breaks, across which sparks must necessarily pass. A mirror was made to revolve with immense rapidity before this coil. The reflection of the sparks was thus thrown occasionally, when the mirror was in the right position, upon a canopy above, graduated in equal divisions. The reflection of one of the sparks was found always to lag behind the other, on account of the time occupied by the electricity in passing through the intervening portion of the coil, the effect of which was multiplied by the revolving mirror. The length of the coil between the breaks, and the rate of revolution of the mirror, being known, and the distance of the reflected sparks from each other being observed, the rate of motion of the electricity was easily calculated.

9. It will be observed that this determination applies only to free electricity. The electricity of the galvanic battery, which involves in its passage a change or vibration in all the particles of the conductor, may easily have a different rate, and in the course of the brilliant experiments of the United States Coast Survey, of the last two years, it has been found that in reality its velocity is much less. It is stated by Mr. Sears C. Walker, that the rate of galvanic electricity, obtained by simultaneous observations at New York and Philadelphia, with the astronomical clock, in connection with the telegraph, and subsequently on the line between Washington and St. Louis, is approximately 18,700 miles in a second. It would, therefore, require one and one third seconds for the galvanic current to traverse a wire extending round the earth. In our ordinary telegraphic communications the time occupied by the passage of the current would be wholly imperceptible.

10. The general principles on which the electric telegraph depends have thus been considered. They involve no new facts or discoveries in science. Not only so, but, as will be seen in tracing its history, the idea of the telegraph was deduced from these principles at a very early period, and a conclusive experiment was tried before the close of the last century. The improvement which has been made by modern science, by which the telegraph has become more extensively useful and applicable, has been in the indicating or registering apparatus, by which the passage of the electricity at the distant station is noted.

11. It is evident that the power of sending a current of electricity through a wire of a hundred miles in length, however surprising, could be of no practical use unless the means existed of observing the passage of the current in distant parts of the circuit. A variety of the reactions of electricity have been employed for this purpose, which will be described hereafter in detail. The decomposition of water into its constituent gases by the passage of electricity, — the decomposition of saline solutions, in the same manner, giving rise to a change of color, — the passage of the spark across a short interval made in the circuit, — the deflection of the needle by the passage of a current of electricity in its neighborhood, — the charging of an electro-magnet, or the influence exerted upon a bar of iron in the axis of a coil, by which mechanical motion is produced, have been severally resorted to.

12. The mode of transmitting intelligible signals by this agency has always consisted in sending either a succession of instantaneous electrical impulses, or a current prolonged for some instants, measured by its effects or by its duration. A combination of these signals, according to previous arrangement, may be made to indicate all the letters of the alphabet; or even, by an ingenious contrivance, with only a single circuit, to print each letter separately.

HISTORY OF THE TELEGRAPH.

13. Soon after the discovery of the Leyden jar, in 1747, it was observed by Dr. Watson, in England, that the shock, passed through twelve thousand feet of wire, affected persons placed at either extremity, apparently at the same instant of time. The idea of the instantaneous passage of electricity was probably thus first received, and it was forced, by new observations, on the attention of all succeeding electricians. Dr. Watson also observed, in 1747, that when the current was conveyed on wires, supported on posts of baked wood, to a distance, and allowed to return through the earth, that the ground proved a good and sufficient conductor. The idea of the telegraph was naturally suggested by these experiments, and Lomond, in 1787, employed the electricity of the machine, by means of a pith ball electrometer, to communicate with a person in a different part of the same house. Should this have been the first experiment made, it is an illustration of the humble origin of many great discoveries.

14. In 1794, Reizen proposed a telegraph, employing the spark, with seventy-six wires, or thirty-six complete circuits, one for each letter and number. In 1798, Betancourt constructed a telegraph, also employing the spark, which is stated to have been in successful operation, between Madrid and Aranjuez, for twenty-six miles. This was the achievement of

the close of the last century. The difficulty of insulating free electricity made it impossible that any great results should be obtained from its use.

15. The first year of the present century produced the voltaic or galvanic battery. In 1809, Sœmmering improved this discovery by inventing a telegraph of thirty-five wires, which indicated the letters by the decomposition of water, which took place under the eye of the observer, from little pins of gold. He also caused the liberation of the gases to raise a cup attached to a lever, and thereby drop a weight on a little platform, connected with chime machinery, so as to ring a bell. In 1816, Dr. J. R. Coxe, of Philadelphia, proposed a similar decomposing apparatus, and confidently predicted the ultimate success of the telegraph. In the same year, Ronalds, in England, returned to the use of free electricity, inventing an elaborate telegraph, which was put into operation over eight miles of wire.

16. The first registering telegraph seems to have been constructed by Mr. Harrison Gray Dyar, of Long Island, in 1826, who used the decomposing power of the spark, acting upon a fillet of paper, moistened and stained with litmus, and moved by hand or clock-work. The passage of each spark from a conductor to the paper produced a discoloration, and, by different combinations of marks thus made, any signal could be transmitted and registered. This was a very important step in the history of the telegraph, and appears to be the origin of the system of telegraphic alphabets so generally used in later inventions.

17. In the telegraphs already referred to, it had been necessary to interpose the indicating apparatus in the course of the circuit; that is, to interrupt the circuit for a short space. This was obviated by the discovery of the deflection of the compass needle by Œrsted, in 1819, and the discovery of the electro-magnet by Ampere, in 1820. According to the first of these discoveries, a magnetic needle tends to place itself at right angles to a wire in its neighborhood, through which a galvanic current passes. According to the second, a piece of soft iron, placed in the axis or centre of a coil of wire, becomes a magnet during the passage of a galvanic current through the coil.

18. In 1820 and 1822, Ampere proposed and fully described the use of the deflection of a number of needles to constitute a telegraph similar to that of Wheatstone, now in operation, with a less number of circuits, in England. From this time the subject became one of frequent suggestion among philosophers. The deflective telegraph was, however, finally introduced into practice by Schilling, in Russia, at the end of 1832, by Gauss and Weber at Gottingen, in 1833, and finally, on a large scale, by Wheatstone, in England, and Steinheil, at Munich, in 1837, or soon after. The credit of the first *construction* of the galvanic telegraph belongs thus to Schilling, Steinheil, and Wheatstone, by the latter of whom, with some of his English coadjutors, many of the practical difficulties in the modes of transmitting the current were overcome.

19. The telegraph of Steinheil, which was in oper-

ation between Munich and Bogenhausen in the summer of 1837, seems to be the first *electro-magnetic* telegraph on record which employed a registering apparatus. The deflection of his needles moved little levers, carrying pen points, which marked dots or short lines on a fillet of paper moved by clock work, as had been done with common electricity previously by Dyar, and as was subsequently brought into use in this country by Professor Morse.

20. The deflective telegraph was still imperfect, each deflection of the needle requiring a very appreciable time to be accomplished. The use of the electro-magnet was the next step taken in advance. It was not until the experiments, in 1830, of Professor Joseph Henry, now secretary of the Smithsonian Institute, upon powerful electro-magnets, and the effect of long conductors, that this form of telegraph became possible; and in his first paper on the result of these experiments, he at once applied the new facts to the idea of the construction of the telegraph.

21. In 1844, the registering telegraph of Professor S. F. B. Morse, employing the electro-magnet, was introduced upon a line between Baltimore and Washington, the caveat to his patent bearing the date of October, 1837. The first suggestion of this form of telegraph is claimed to have been made by Professor Morse in 1832, and also, in its general character, by Dr. C. T. Jackson. This telegraph, together with the House telegraph, and the Bain decomposing telegraph, constitute the three systems now, for the most part, in operation in this country. They will now be

separately considered and described, together with Horn's igniting telegraph, and the axial telegraph, described in Davis's Manual of Magnetism, in 1847.

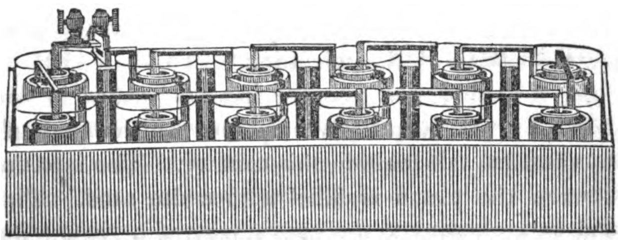
DESCRIPTION OF THE TELEGRAPH.

22. THE frontispiece shows the electric telegraph in operation. With the exception of the form of the register, which is Morse's, it may represent the general operation of any of the above telegraphs. On the left-hand side, the operator, in a city, which may be supposed to be Boston, is transmitting a message by the signal-key, on which his left hand rests. The battery is represented at his feet. The wires are seen, supported by the posts, traversing a great extent of country, including a distant town, and arriving finally at a city, which we may suppose to be New York, where the second operator is represented on the right, receiving the marked strip of paper as it passes from the register. *On this paper a mark is made every time that the distant operator on the left depresses his finger.* How is this done?

23. Fig. 1 represents a series of twelve pairs of Grove's battery, such as is generally used in connection with the telegraph. It has been said already, that, when a plate of platina and a plate of zinc are placed in an acid solution, a current tends to flow from the platina to the zinc, through any conductor which may be so disposed as to connect the two. In the figure, the galvanic series is represented, consisting

of twelve single pairs, the zinc of each of which is connected with the platina of the next. It may be

Fig. 1.



considered that a current is produced by each of these pairs, which has, however, to flow in the same direction, and fall in with all the others. Hence their intensity is multiplied twelve times. It is by this means that the resistance to the passage of the current through very long conductors is overcome. The number of pairs in the telegraph is always proportioned to the distance which the current is to traverse, fifty or more being used on a line of two hundred miles.

24. Each pair of the battery consists of a pint glass tumbler, a cylinder of zinc, a small porous cylindrical earthen ware cell within the zinc, and a platinum strip suspended within the cell from an arm belonging to the zinc of the next pair. A solution of diluted sulphuric acid is used with the zinc, outside the porous cell, and the cell itself is filled with nitric acid. The two acids are used on account of an increase of power depending on a chemical reaction. The zinc cylinder is amalgamated with mercury, to prevent its being acted upon by the acid when the

battery is not in use. A solution of sulphate of soda is sometimes added to the sulphuric acid, to assist in accomplishing the same object. This is the most powerful form of battery known, and its discovery should be spoken of as an important step in the general application of the telegraph.*

25. A battery, using copper and zinc plates in flat glass cells, has been lately employed on the lines of the chemical telegraph in this country. The interval between the plates is filled with white sand. The sand is moistened to the consistency of a paste with diluted sulphuric acid. This battery proves very constant, and, though less powerful, is much more easily managed than the Grove battery.

26. Two screw-cups will be seen rising above the battery in the cut, one of which is the positive pole or extremity of the series, the other the negative. To these the wires are attached which convey the current. These wires, as first used in the telegraph, were of copper, which is a better conductor of galvanism than iron; but the liability to accident, from their want of strength, was so great, that iron wires were substituted by Steinheil, in Germany, of a size sufficient to make up by their quantity for the poorness of their quality as conductors.

27. The wires are usually supported on posts, from which they are insulated by glass supports or knobs. They have been sometimes carried through the ground, insulated within a metallic tube.

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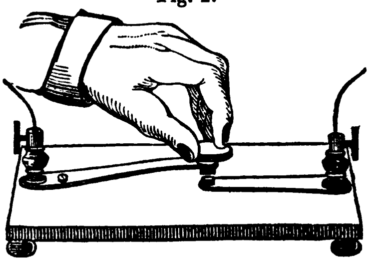
* For a more detailed account of this battery, see Davis's Manual of Magnetism.

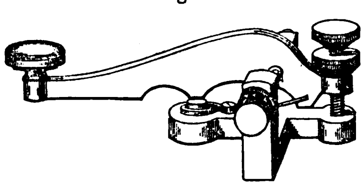
28. Fig. 2 represents the signal-key in its simple form. It is placed, when in use, in the course of the conductors or telegraphic circuit, proceeding from the battery. When the hand depresses the key, it comes in contact with the knob and metallic strip below, making connection between the two screw-cups, and completing the battery circuit. While the key is depressed, a continuous current passes; but if it be depressed, and allowed to spring immediately up, only an instantaneous wave or impulse is communicated. The use of the signal-key, in connection with the telegraph, was described by Ampere, in 1820.

Fig. 2.



29. The signal-key, in its more perfect construction, is represented in Fig. 3. It consists of a lever, mounted on a horizontal axis, with a knob of ivory for the hand at the extremity of the long arm, which is at the left in the cut. This lever is thrown up by a spring, so as to avoid contact with the button on the frame below, except when the lever is depressed for the purpose of completing the circuit. A regulating screw is seen at

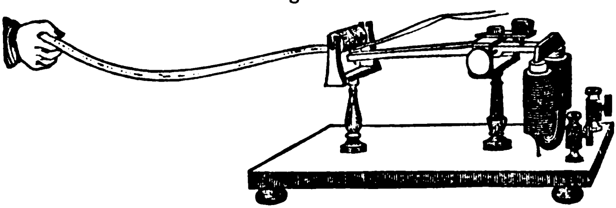
Fig. 3.



the extremity of the short arm of the lever, which graduates precisely the amount of motion of which it is at any time capable.

30. The registering part of Morse's telegraph is

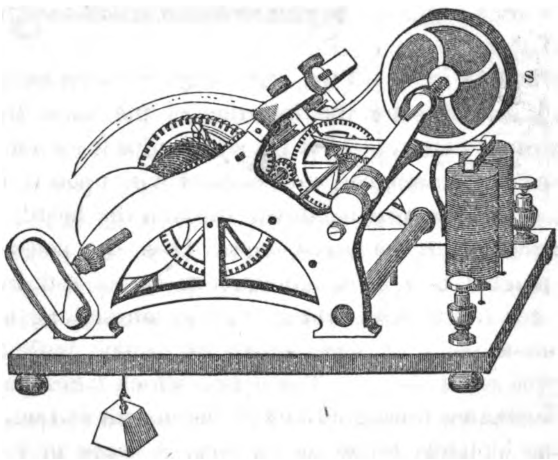
Fig. 4.



shown in Fig. 4. Two screw-cups are seen on the board, intended for the insertion of the wires from the distant battery. Next the screw-cups is seen a U-shaped electro-magnet, with coils of wire upon it, the ends of which, passing down through the board, are connected with the screw-cups. Over the poles of the magnet is a little armature, or bar of soft iron, attached to the short arm of a lever, whose long arm carries a point or style, nearly in contact with the grooved roller above. The action which takes place, on depressing the signal-key at the distant station, is, in the simplest terms, as follows: A wave of electricity is transmitted over the wire of the telegraph, arrives at the electro-magnet, and circulates through the coil of wire surrounding it. The U-shaped soft iron becomes at once a magnet, and attracts the little armature down to it. The long arm of the lever is thrown up, and marks the strip of paper passing between it and the roller. Meantime, perhaps, the distant operator has let the signal-key fly back. The current ceases, — the iron of the electro-magnet loses all its magnetism, — the armature, with the lever, is carried back by the action of a little spring, — a *dot* has been impressed upon the strip of paper. Has the distant operator held down the key? A continuous current has passed, and a *line* is marked on the paper which moves under the roller.

31. The complete registering instrument is shown

Fig. 5.



in Fig. 5. Here we have a large spool, (S,) on which the strip of paper is wound, and clock-work, with rollers, which give the strip a steady motion onwards under the style upon the lever of the electro-magnet. A bell may also be added, which is struck by its hammer on the first motion of the lever, to draw attention. There is a stop-motion sometimes used, by which the clock-work is brought to rest in a few seconds after the lĕver ceases to act, and which is released again by the first motion of the lever.

32. The following is the combination of dots and lines on the fillet of paper used by Professor Morse to indicate the different letters and numbers : —

MORSE'S TELEGRAPHIC ALPHABET.

ALPHABET.				NUMERALS.	
a	- —	*n*	— -		
b	— - - -	*o*	- -		
c	- - -	*p*	- - - - -	1	- — — -
d	— - -	*q*	- - — -	2	- - — - -
e	-	*r*	- - -	3	- - - — -
f	- — -	*s*	- - -	4	- - - - —
g	— — -	*t*	—	5	— — —
h	- - - -	*u*	- - —	6	- - - - - -
i	- -	*v*	- - - —	7	— — - -
j	— - — -	*w*	- — —	8	— - - - -
k	— - —	*x*	- — - -	9	— - - —
l	——	*y*	- - - -	0	———
m	— —	*z*	- - - -		
		&	- - - -		

33. Between each letter of a word a short space is allowed, between words a longer space, and between sentences a still longer one. Many short hand signals are also employed.

34. Where a long circuit is used, the resistance to conduction, measured by the amount of electricity which passes, is very great. The diminution of the current is most sensible when tested through the first few miles of wire, the amount which subsequently

passes appearing nearly constant for a long distance. It is not, however, sufficient, in its electro-magnetic effects, to work one of Morse's registers directly. The current, which has traversed a great length of wire, can only move the lever of the electro-magnet sufficiently to bring a platina point in contact with a little platina disk placed opposite to it, so as to complete the circuit of a local battery, which works the register with energy. This is the principle of *combination of circuits*, and constitutes the important invention of the *receiving magnet* and *relay* or *local battery*, as they are familiarly known in connection with Morse's telegraph.

35. The effect of the combination of circuits is to enable a weak or exhausted current to bring into action, and substitute for itself, a fresh and powerful one. This is an essential condition to obtaining useful mechanical results from electricity itself, where a long circuit of conductors is used, and accordingly it received the attention of early experimenters with the telegraph. This principle seems to have been first successfully applied by Professor Joseph Henry, of Princeton College, in the latter part of 1836. He was thus enabled to ring large bells at a distance, by means of a combined telegraphic and local circuit. In the early part of 1837, Wheatstone, in England,* used a combining instrument, which consisted of a magnetic needle, so arranged as to dip an arch of wire into two mercury cups, when deflected by a feeble

* London Repertory of Patent Inventions, 1839, vol. xi.

current, thus completing the circuit of a local battery, which struck a signal-bell. Davy patented in England, in 1838,* a system of combined circuits, for four different purposes connected with his telegraph. He brought into action a local circuit, 1st, to discolor or dye, by electro-decomposition, the calico on which he registered his signs; 2d, to actuate an electro-magnet regulating the motion of the calico; 3d, to direct the long or telegraphic circuit to either of two branches, by means of a receiving instrument placed at their point of meeting, and operated upon from a distance; 4th, he provided for a complete system of relays of long circuits. His instrument resembled Wheatstone's, only the contact was made by two surfaces of metal, without the use of mercury.

36. The receiving magnet used by Professor Morse is a very slight modification of his register, the platina point for completing the local circuit being substituted for the marking point. The magnet is surrounded with helices of fine wire, which multiply the effects of the feeble current, and the whole instrument is constructed with delicacy. By Morse's patent of 1840, this is applied to the combination of long circuits, or the *relay* of currents; and by his patent of 1846, it is applied to operating the register by a local or office circuit. The electro-magnet, armature and lever, constituting the chief part of both these instruments, is simply the electro-magnet of Professor Henry, described in 1831.

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* London Repertory of Patent Inventions, 1839, vol. xii.

37. In a line of telegraph of several hundred or thousand miles, any number of receiving magnets may be interspersed, as they do not interrupt the circuit. Each one of these may work a local register, and thus the same message may be recorded at a multitude of places, practically at the same moment of time. If the receiving magnet is to effect a relay of currents, the motion of its lever brings into action a powerful battery on the spot, which works the next receiving magnet in succession, and so on.

38. The use of the receiving magnet, however, for the purpose of *relay* of the galvanic force, may be dispensed with by simply increasing the number of pairs, and distributing them in groups along the line. Thus Mr. Sears C. Walker, of the Coast Survey, writes, "We have made abundant experiments on the line from Philadelphia to Louisville, a distance in the air of *nine* hundred miles, and in circuit of *eighteen* hundred miles. The performance of this long line was better than that of any of the shorter lines has hitherto been. I learn, from an authentic source, that the same success attends the work from Philadelphia to St. Louis, A DISTANCE IN CIRCUIT OF ONE TWELFTH OF THE EARTH'S CIRCUMFERENCE. The number of Grove's pint cups used is about one for every twenty miles. It is natural to conclude, from this experiment, that, if a telegraph line round the earth were practicable, *twelve hundred* Grove's pint cups, in equidistant groups of fifties, would suffice for the galvanic power for the whole line. The daily expense of acids, for maintaining this whole line, would be about five

mills per day for each cup, or six dollars per day for the whole line." * This distribution of the galvanic agency is frequently adopted in the mode of placing one half of the necessary number of pairs at each extremity of the line.

39. The conductors hitherto spoken of have been exclusively the telegraph wires. It has now, however, become a universal custom to use the earth as one half of the circuit, and thus to employ but one wire. This is accomplished by carrying a wire down at each extremity of the line, and connecting it with a metallic plate buried in the earth. The advantage consists not only in the economy of employing a single wire to each circuit, but the loss from conduction by using the earth is vastly less. Should the idea of Mr. Walker be carried so far into effect, that a telegraph wire should be carried half round the earth, and the circuit be completed by using the earth as a conductor, it is evident that the current, which always chooses a straight line, would, in returning, take the short course *through the centre of the earth.* The use of the ground circuit for the telegraph seems to be due to Professor Steinheil, of Munich.

40. In case of interruption of the telegraph wire, much ingenuity has been shown by the association of a through line and a test line, which latter communicates with a number of intermediate stations, and by means of which the place of interruption can be readily ascertained, and the injury repaired. An

* American Journal of Science and Arts, March, 1849.

interruption is shown by the increased strength, the weakness, or the suspension of the current, which each station has the means of examining, and from which the direction and nature of the accident can be inferred. When it is ascertained that the accident is between two stations, the operators from both sides have charge to repair it.

41. A great source of irregularity in the action of the telegraph, in this country, has been atmospheric electricity. The air being in different electrical states in different places, or thunder storms taking place in the course of the line, the insulated telegraph wires frequently become the medium of transfer of atmospheric electricity. The safety of the operators, and even the regular action of the electro-magnet, requires the use of conductors at the stations, which are nearly in contact with the wires, and which communicate with the earth, so as to carry off any excessive charge of electricity which might destroy the instrument, or even endanger life. Much irregularity in the action of the telegraph still exists from this cause.

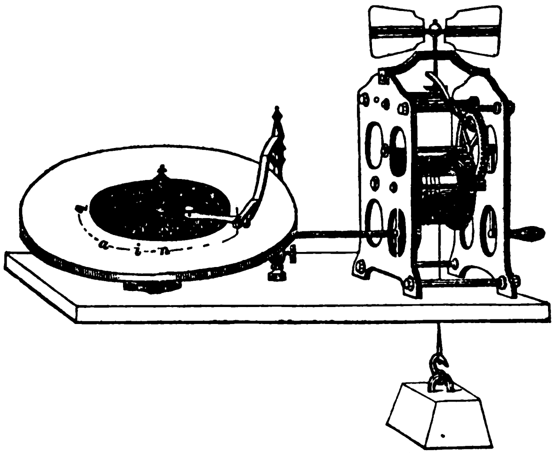
42. These facts of general application to the electric telegraph have been considered here, as many of them were first developed and applied in this country, in connection with Morse's register. This instrument, and the system connected with it, will always deserve credit for its early service in adapting the telegraph to our climate and natural resources.

43. Bain's Telegraph. — The decomposition of a saline solution, through which a galvanic current passes, has been already referred to. The telegraph

3

of Bain, represented in Fig. 6, is constructed on this principle, and is the most simple now in use. The

Fig. 6.



indication of the current takes place here without motion. The circular tablet, on which the writing is obtained, is moved by clock-work, at a uniform rate, under the wire, which constitutes the telegraphic pen. But the pen itself never stirs. It bears silently on the tablet, and as the eye observes the point of contact, now a blank space, and now a deep blue line, appears upon the retreating surface. This is the record of the intermitting current, sent over the wires from a distance.

44. In the figure, the clock-work which moves the tablet is seen on the right. Its motion is regulated by a fly-wheel above, the vanes of which can be inclined so as to present greater or less resistance to the

air. A lever or break bears upon the axle of the fly-wheel, by moving which lever the clock-work may be stopped, or allowed to go on. The circular disk, or tablet of brass, carried by the clock-work, is seen on the left of the figure, inclined towards the observer. In the centre of the disk, occupying the shaded portion, a spiral groove is cut, in which the guide to the pen travels. This guide is seen, attached at right angles to the penholder, which extends over the disk. The pen-wire is seen, held by a little clamp, descending so as to touch the tablet. This wire, of course, traces a spiral upon the outer ring of the disk's surface, exactly corresponding, in the distance of its lines, to the spiral groove within, which serves as a guide. By this beautiful contrivance, the writing is disposed in a close spiral, occupying but very little space.

45. The outer part of the surface of the disk, upon which the letters are represented in the figure, is covered with a ring of moistened and chemically prepared paper. This may be renewed or removed at pleasure. The penholder is connected with the positive wire of the telegraph, and the tablet with the negative. The circuit of conductors is completed by the moistened paper which intervenes, and which the current accordingly traverses. This paper is moistened with a solution of the yellow prussiate of potash, acidulated with nitric or sulphuric acid. The pen-wire consists of iron. When the current passes, this pen-wire is attacked by the solution, and the portion of iron dissolved unites with the prussiate of potash to form the color known as Prussian blue, which permanently stains or dyes the paper.

46. A modification in the mode of marking has been introduced in this telegraph by Mr. Rogers, of Baltimore. He substitutes a pen carrying an ink which is decomposed by the current when in contact with the brass disk, without any intervening paper. A superficial stain is produced on the metallic surface, which is easily obliterated by friction.

47. In Bain's telegraph, no receiving magnet is necessary. The current traversing the long wires is sufficient to leave its trace upon the paper. There would be a disadvantage, however, in the use of this telegraph, with a simple circuit, where it is desirable to register the same communication at a number of different places, as the interposition of the paper, moistened with a saline solution, somewhat obstructs the current. The receiving magnet and register used by Morse present a metallic conductor for the current throughout, and they can, therefore, be multiplied without serious loss. To compensate this disadvantage, a system of branch circuits at way stations has been devised, in connection with the Bain telegraph, by which communications can be received at various places at the same time. Morse's instrument requires the time taken by the motion of the armature to make each mark. The decomposition in Bain's instrument is instantaneous. This is an advantage where mechanical means are used to complete and break the circuit with great rapidity for the purpose of rapid communication.

48. An ingenious instrument to effect this object has been recently contrived. One of the circular

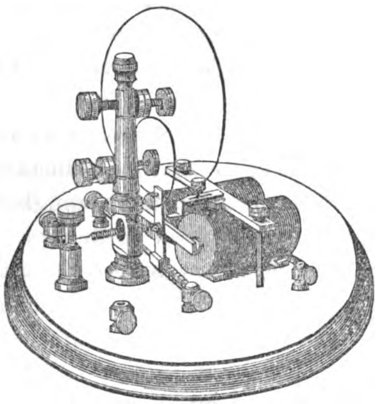
metallic disks of the register has its surface coated with wax or other composition. The lines and dots, which constitute the writing to be transmitted, are scratched through this so as to expose the metal, by the operator, previous to completing the telegraphic circuit. This writing is effected, and disposed in spirals around the disk, by simply putting a little signal-key in place of the pen-wire, and allowing the disk to revolve. The guide to the penholder, of course, carries the signal-key over the same spiral which the pen-wire would describe on the disk. The signal-key has a sharp or cutting point, which removes the wax from the disk whenever the key is depressed. The usual motion for signalizing the letters, therefore, prepares the impression of the writing, which is afterwards to be connected with the telegraph, and transmitted with speed. This transmission is effected by restoring again the pen-wire to its holder, and allowing it to follow over the track just made by the signal-key. The battery being connected, the wire completes the circuit whenever it touches the exposed metal, and breaks the circuit when it rests upon the wax. The disks at both the transmitting and receiving ends are made finally to revolve rapidly, and the message is said to be thus communicated at the rate of one thousand or more letters per minute.

49. The alphabet used by Bain is the same in principle as that employed by Dyar, Steinheil, and also by Morse, consisting of combinations of dots and lines.

50. The *call*, commonly used on the Bain lines, is

represented in Fig. 7. It consists of a U-shaped receiving magnet, placed horizontally on the board, with two helices of wire surrounding the legs. An armature, supported on an upright bar, so as to form a cross, is seen, in the figure, before the poles of the magnet. This is held back by a delicate spiral spring, graduated by a screw, which is also seen to the left. Above are two circular plates of glass. The upright bar, armed with two little knobs, to perform the part of a hammer, rises between these plates. When the armature is drawn to the magnet, it strikes one of them, and, on being drawn back, it strikes the other. As they are of different tone, the repetition of this signal at once draws attention to the register. The duty of the operator is then to set the clock-work in motion, and receive the message communicated. This instrument can be used also as a receiving magnet, by placing a platinum point on the upright bar or pendulum, and a little platinum disk immediately in front of it, so connected that the interval between the point and disk shall constitute the break in a local circuit, an additional pair of screw-cups for the attach-

Fig. 7.



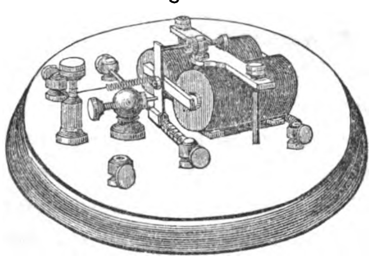
ment of which may be seen upon the base-board. When the armature approaches the electro-magnet, it closes the local circuit, and when it recedes it breaks it. This is essentially the receiving instrument of Morse and others.

51. This call is similar in purpose or principle to those used by Sœmmering in 1811, Schilling in 1831, and Henry, Steinheil, and Wheatstone in 1836 and 1837.

52. Bain's telegraph has been introduced very extensively into this country, especially in connection with the network of lines constructed throughout the south and west by the enterprise of O'Reilly.

53. The receiving magnet, in its improved form,

Fig. 8.



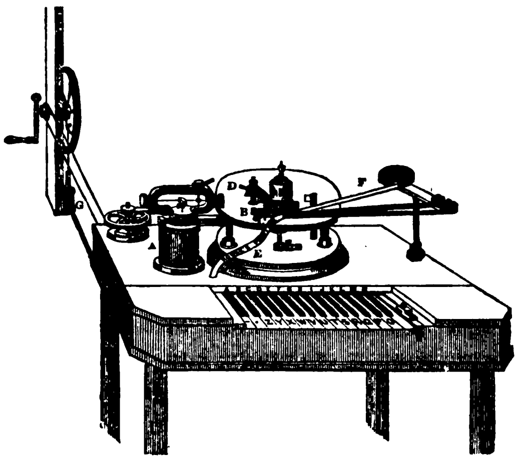
(Fig. 8,) used for the purpose of combining or connecting circuits, is closely allied in its construction to the call, and may therefore be described here, though already referred to in connection with Morse's telegraph. The armature is mounted on an upright bar, and is seen forming part of the cross just in front of the poles of the horizontal electro-magnet, surrounded with helices of fine wire. The long or telegraphic circuit is connected with these helices by means of two of the screw-cups on the board. When the current flows, the armature is attracted to the magnet, and the upright bar is brought in contact with the end of the horizontal screw, seen at the top of the instrument. This completes a local circuit, or branch circuit from the main battery, the conductors of which are connected with the instrument by means of two other screw-cups, seen on the right of the board. The points of contact of the upright bar and screw are protected from oxidation by the use of platinum.

54. House's Printing Telegraph. — This beautiful invention may be considered as one of the wonders of the age. Using but a single wire, it is yet able to select and print in order the letters of the common alphabet, with a greater rapidity than the hieroglyphic marks of Professor Morse, representing the same letters, can be produced.

55. This instrument is complicated, though all its parts are simple. We shall try to describe it so that the mode of its operation may be understood. A perspective view of the instrument is shown in Fig. 9, comprising both the transmitting and receiving apparatus. The principle by which the different letters are signalized over the wire, is the transmission of a given number of electrical impulses for each letter, by the rapid opening and closing of the circuit. This is accomplished by means of the twenty-six letter-keys, and the two keys for the dot and dash, seen in the figure. Under the key-board is a horizontal

cylinder, which is kept in revolution by turning the crank and wheel, seen at the left of the figure. At one end of this cylinder is a circuit wheel or break-

Fig. 9.



piece, having fourteen projections and fourteen spaces, on which a spring, connected with the telegraphic circuit, bears. Consequently the battery circuit is completed fourteen times, and broken fourteen times, with each revolution of the cylinder. Under each key a projection or stop is placed upon the cylinder, in such a position that, when the key is depressed, and comes in contact with it, the cylinder shall have performed such part of a revolution as to have made and broken the circuit the number of times which represents the letter corresponding to the key. The motion of the cylinder is communicated by means of slight friction, and it is accordingly arrested by depressing the key. This is the transmitting or "composing" apparatus.

56. The receiving or printing apparatus is seen behind the key-board in the figure. There is one such at each extremity of the line, to receive messages transmitted from the other extremity. But both are left constantly in the circuit, so that the operator signalizes or prints the message which he sends both at the distant end of the line and immediately before his eyes. The printing instrument, which we are examining, is, therefore, a fac-simile of the one which receives the communication at a distance from the operator at the key-board in the figure.

57. The printing apparatus consists of an upright rod-electro-magnet, enclosed in the metallic cylinder A; of a little engine, operated by condensed air, and moving an escapement at B; of a type-wheel at C; of a printing eccentric and lever, the end of which is seen at D; of a black coloring band at E; and the strip of printing paper at F F.

58. The electro-magnet consists of a compound rod of several short pieces of iron strung upon a rod of brass. This rod is enclosed in a tube of brass, attached to which, within, are several short tubes of iron, corresponding to and reacting with the pieces belonging to the axial magnet. This whole system of tubular and axial magnets is enclosed in a single helix of fine wire, connected with the telegraphic circuit. The tube is fixed, but the compound rod is movable, and attracted downwards by several coöperating

reactions when the current passes. This rod is suspended by a cross wire, which may be seen stretched across the top of the cylinder A, and acts as a spring, drawing the rod back after the current has ceased to act. A very rapid vibration of the rod is thus obtained, corresponding to the opening and closing of the circuit effected at the transmitting end of the line.

59. Connected with the wheel is a condensing pump at G, which keeps up a supply of condensed air. At the upper part of the electro-magnetic rod is a collar-valve, which changes the direction of the current of condensed air with each vibration of the rod, though these vibrations are only one sixty-fourth of an inch. The air is thus admitted to opposite sides of the cylinder of a little atmospheric engine, which, by means of its reciprocating motion, permits the action of an escapement, tooth by tooth, and the corresponding revolution of the type-wheel, which is impelled by a spring kept wound up by the manual power employed at the crank and wheel.

60. The result is, that the type-wheel, which has twenty-eight teeth, revolves just as far as the cylinder attached to the circuit-wheel, at the distant extremity of the line, has been permitted to revolve by depressing one of the keys. Each break, as well as each completion of the circuit, thus corresponds to a letter. It only requires that the instruments at both ends of the line should be set to the same letter, and then the cylinder at one extremity, and the type-wheel at the other, regulated by the pulsations of the current, will

always revolve at the same rate; and if the cylinder is stopped at any one point representing a letter, the type-wheel is stopped at the same point, and presents the type which it carries on its periphery to the strip of paper in front of it.

61. When the type-wheel stops, an eccentric, actuated also by the local power at the crank and wheel, brings the black band and paper forcibly against the type, and leaves the impression of the letter. The paper is then carried on just the distance of a letter, and is ready for another impression. Roman letters are thus printed over a long line at the rate of from one hundred and fifty to more than two hundred a minute.

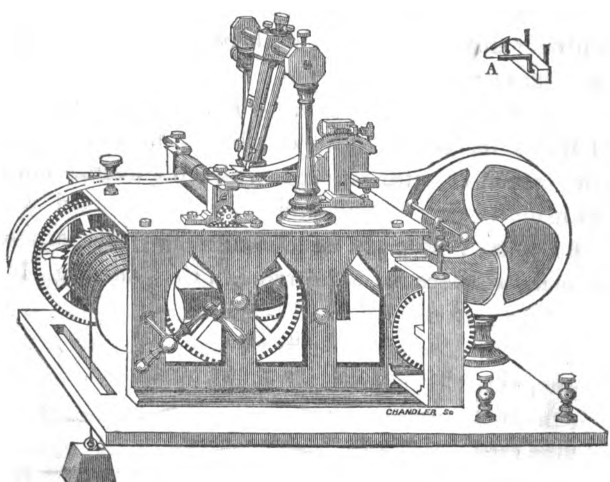
62. In the figure, the letter A will be observed at a little window above the type-wheel. This letter is on a letter-wheel, connected with the type-wheel below, so that the letters may be presented to the sight at the same time as printed; or the printing eccentric may be detached, and only the visible letters read.

63. The action of the electricity in this telegraph is merely to produce correspondence of motion in machinery at different ends of the line, in the same manner that uniformity of rate has been secured in clocks at different places regulated by the electro-telegraphic current. All the mechanical results of House's telegraph are produced by local mechanical power. For this purpose, clock-work, having a regular rate, would be preferable to manual power.

64. **Horn's Igniting Telegraph.** — The register invented by G. H. Horn employs a principle never before applied to the telegraph, namely, the heating or igniting effect of electricity. When an electrical current flows through a fine platinum wire it ignites it, or brings it to a red heat. If this wire is bent, as at A, in the figure below, so as to be in contact, for a short distance, with a moving fillet of paper, it will burn a hole through the paper when the current passes. This can be done with great rapidity, so as to represent probably a hundred linear letters per minute.

65. This instrument is shown in Fig. 10, the

Fig. 10.

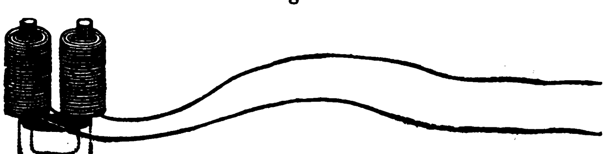


greater part of which consists of the clock-work, spool, &c., required for moving the paper. Above the clock-work are two pillars, supporting an axis, upon which is the adjustable wire-holder, the lower extremity of which is seen touching the fillet of paper. By means of the connections and insulations of the pillars, axis, and wire-holder, the platinum wire, which passes over a little slip of porcelain at the end of the wire-holder, becomes part of the circuit, with which the two screw-cups on the right of the base-board are connected. When the wire needs adjustment, the wire-holder can be turned up on its axis. The bed supporting the fillet of paper is also adjustable, so as to regulate the contact between the wire and the paper.

66. This register requires a quantity current to produce the effect of ignition, and therefore needs a receiving instrument and local battery, to be operated by the telegraphic circuit.

67. Axial Telegraph. — The axial telegraph is founded on the tendency of a bar of iron to be drawn into a coil of wire, through which a galvanic current is made to pass. This influence is increased where two coils of wire are used, surrounding the legs of a U-shaped piece of soft iron. Thus, in Fig. 11, a

Fig. 11.



piece of iron in the position of the dotted lines is immediately drawn up into the coils, upon sending a galvanic current through them. The power of this reaction is so great, that it has been successfully applied by Professor Charles G. Page, of Washington, to the propulsion of machinery on a large scale.

68. The axial telegraph is represented in a simple form in Fig. 12. The U-shaped iron rests upon a spring seen on the board. A style, attached to the iron, projects up between the coils, so as to be nearly in contact with the roller, under which the strip of paper is made to pass. A little rod or armature of iron, placed across the top of the

Fig. 12.

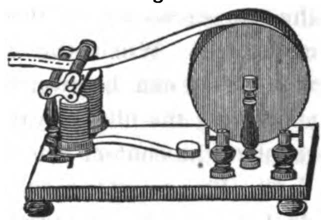
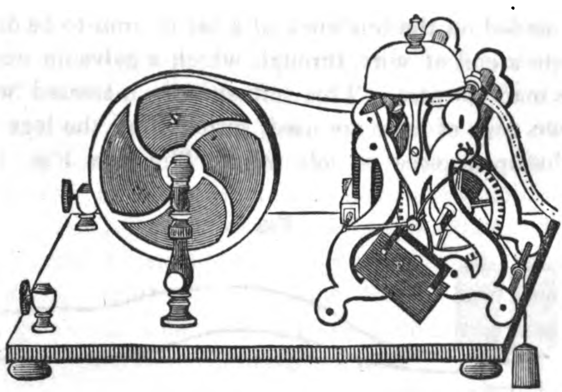


Fig. 13.



coils, causes the soft iron to move in obedience also to electro-magnetic attraction, somewhat increasing the power, but introducing a new and unnecessary principle into the reaction. The axial telegraph, in its complete form, is represented in Fig. 13, where the spool and clock-work for the movement of the paper are added.

69. The axial telegraph was described in Davis's Manual of Magnetism, in 1847. The axial motion is due to the *deflective* power of a coil, as in the telegraphs of Ampere, Steinheil, and Wheatstone, and not to electro-magnetic attraction. This instrument requires, on a long line, the intervention of a receiving instrument and short circuit.

70. The lines of telegraph are increasing so rapidly, that the length in actual use cannot be estimated at any moment with accuracy. At the commencement of 1848, it was estimated that the length of telegraph in operation in this country was about 3000 miles. At that time, Morse's register was exclusively employed, and in this estimate a portion of the lines erected by O'Reilly are included. These lines alone, constructed by the energy of a single individual, amounted, at the close of 1849, to 4000 miles in length, on which the register of Bain was for the most part used. At the end of 1850, it was estimated that the lines in operation or in progress in the United States amounted to 22,000 miles in length, 12,000 of which were operated by Morse's register, and 10,000 by the instruments of Bain and House.

71. The telegraph has been spoken of for purposes of overland communication. An important and in-

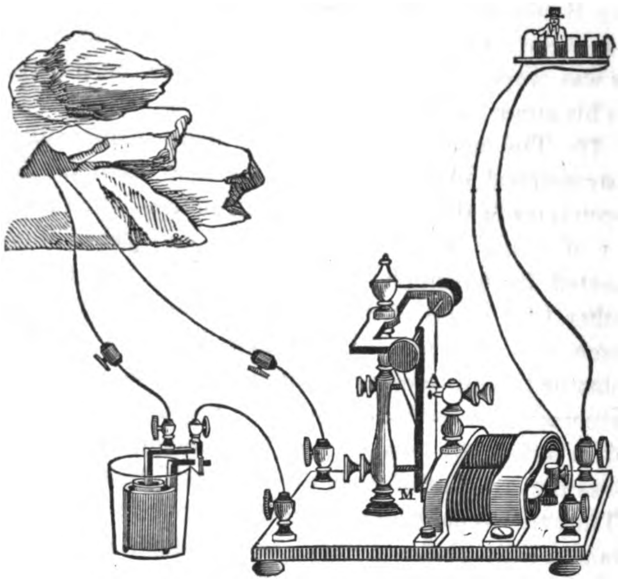
teresting branch of its application is to subfluvial and submarine intercourse. The difficulty of insulating the wires under water, has led to the expedient of carrying wires across rivers attached to masts or towers upon the banks. Insulated wires, however, have been successfully laid down under the British Channel. The communication between England and France, thus established, was afterwards accidentally interrupted. This has resulted in the additional precaution of surrounding the wires with a cable, avoiding rocky bottoms in the course of the telegraph, and making regulations for the anchorage of vessels. This system will probably insure the permanent establishment of telegraphic intercourse between those countries.

72. Various proposals have already been made to establish a telegraphic communication, between this country and Europe, under the Atlantic. The most feasible plan for such an enterprise seems to be, to sink two wires to the bottom of the ocean, several hundred miles apart throughout their course, in the expectation that a portion of the current would follow six thousand miles of wire, partially insulated, rather than cross six hundred miles of water. It will be seen that this application is very problematical, with our present means.

73. The telegraph has an application to blasting and submarine explosions. The loss of power is so great, in conveying a galvanic current by a long wire, that it is difficult to produce ignition by the current of the battery at any considerable distance. But it

is very easy to use a small telegraphic line, with a receiving magnet, which shall complete the circuit of a local battery near the spot where the effect is to be produced. This is represented by Fig. 14. An

Fig. 14.



operator is seen at a distance, with the wires extending to a receiving magnet, which is constructed on the axial principle, and serves to complete the circuit for the single cup, which is to ignite the charge in the neighboring rocks.

74. A very important use of the telegraph, which has as yet received comparatively little attention, is its application to the communication of fire alarms in

cities. The wires may be carried to every engine-house and every church bell in a city, recording the place of fire in the one, and ringing out a simultaneous alarm by chime-work on the other. This application was first brought forward in an article in the Boston Daily Advertiser, of June 3, 1845; but it has been, subsequently, several times *rediscovered.* It was proposed for adoption by the mayor of Boston, in his annual address in 1848.

75. The application of the telegraph to comparative astronomical observations is a splendid result of the operations of the American Coast Survey. The transit of a star over the meridian of two places, connected by telegraph, was notified from one to the other by a touch of the signal-key, and the time at each was observed.. The longitude could be thus obtained, with some precautions, with an ease and accuracy not before possible. A second step was then taken, by connecting the chronometer, which was the standard of time, directly with the telegraph. Thus the seconds wheel was made, by Dr. Locke, to raise a little platinum hammer, by which the circuit of the telegraph was broken once a second. By another invention, the pendulum swept through a little globule of mercury, when at its centre of oscillation, thus completing the circuit once a second. The fillet of paper of the telegraph, as it unwound from its spool, at the extreme, and also at the intermediate, stations of the line, was thus graduated accurately into seconds, represented by a line with a short break, or a break with a short line. A signal-

key was also included in the circuit, by which the observer could complete or break the circuit momentarily, so as to mark upon the same fillet the transit of the star over the wire of the telescope. A permanent and incomparably accurate record was thus made of the observation, and the instant of its time. It is estimated that the facilities of astronomical observation are increased sixty fold by this invention. In fact, it constitutes an era in modern astronomy. Though the work of the last one or two years, it has already received the tribute of the most distinguished foreign observers.

76. The electric telegraph, which has made such rapid strides, is yet in its infancy. The effect of its future extension, and of new applications, cannot be estimated. The time will soon arive, in this country when, as a means of intercourse at least, its network will spread through every village, bringing every part of our republic, between the two oceans, into the closest and most intimate relations of friendship and interest. In connection with the railroad and steamboat, it has already achieved one important national result. It has made possible, on this continent, a wide-spread empire of states, interlinked together, such as our fathers never imagined. The highest offices of the electric telegraph, in the future, are thus to be the promotion of unity, peace, and good will among men.

The Cuts are numbered in correspondence with Davis's "Manual of Magnetism," 2d Edition, where full descriptions will be found. Those lettered A, B, C, &c., are additional.

MAGNETISM.

Fig. 1.

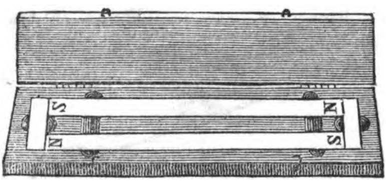


Figure 1. Two Bar Magnets and Armatures, in box.
Price $3. to 5.00.

Fig. 2.

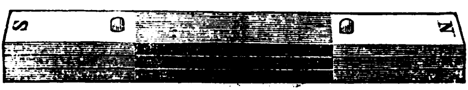


Fig. 2. Compound Bar Magnet.
Price $2.50 to 4.00.

Fig. 5.

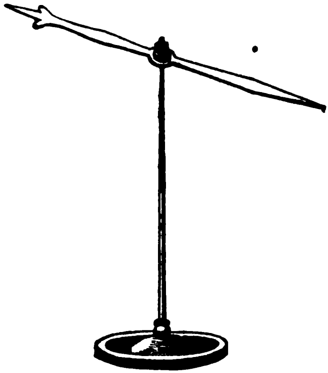


Fig. 4.

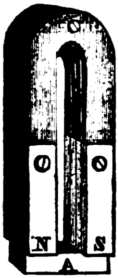


Fig. 3.

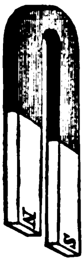
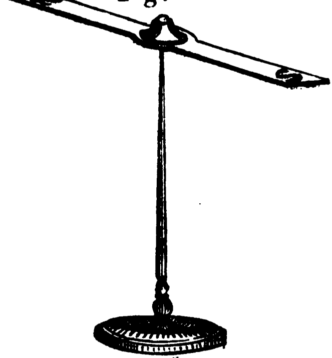


Fig. 3. U Magnet. Price 25 to 75 cents.

Fig. 4. Compound U Magnet. Price $2. to 5.00.

Fig. 5. Magnetic Needle, on brass stand.
Price 75 cts. to $1.00.

Fig. 79.



Fig, 79, Magnetic Needle, on brass stand,
Priec 75 cts. to $1.50,

Fig. 80.

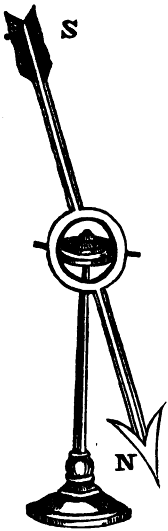


Fig. 6.

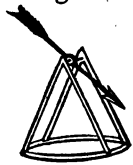


Fig. 52.

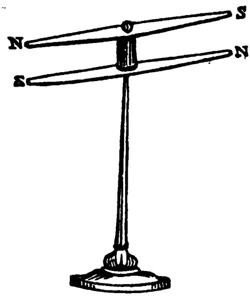


Fig. 80. Large Dipping Needle, on universal joint. Price $4. to 6.00.

Fig. 6. Small dipping Needle. Price $1. to 1.50.

Fig. 52. Astatic Needle, on stand. Price $1.50 to 2.00.

Fig. 93.

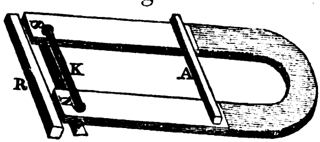


Fig. 93. Magnet, Armature and Roller. Price $1.50,

Fig. 90.

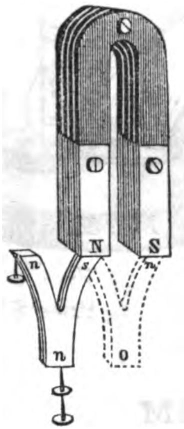


Fig. 92.

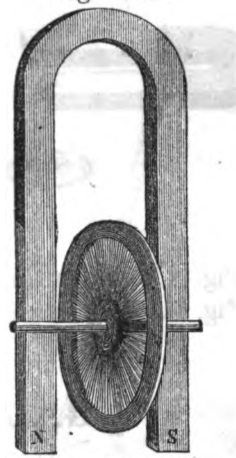


Fig. 90. Y Armature. Price 30 cents.

Fig. 92. Rolling Armature, with U Magnet. Price $2.00.

Fig. 89.

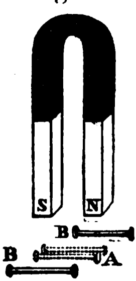


Fig. 94,

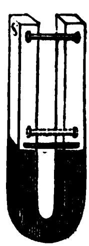


Fig. 99.

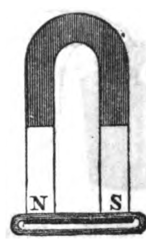


Fig. 89. U Magnet and Rolling Wires. Price $1. to 2.00.

Fig. 94. Short Rolling Wire, with U Magnet. Price $1. to 1.50.

Fig. 99. Iron Wire, (sealed up in glass tube,) with Magnet. Price 75 cents.

Fig. A.

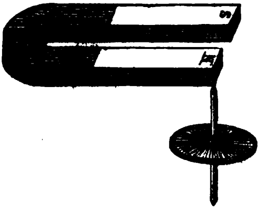


Fig. B.

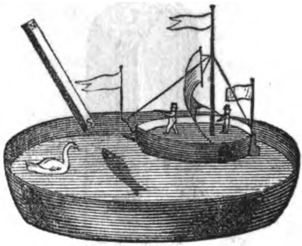


Fig. A. Magnet and Wheel. Price $2.00.
Fig. B. Ship, Swans and Fish. Price $1.50.

GALVANISM.

Fig. 9.

Fig. 12.

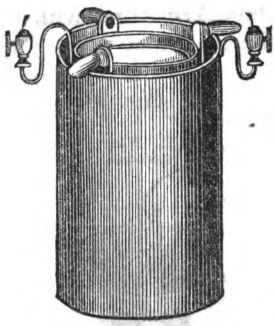


Fig. 15.

Fig. 9. Smee's Battery.
Price $1.50 to 2.00 per pair.

Fig 12. Sulphate of Copper Battery. Price for large, $7.00, medium size, $5.00, small size, $2.00.

Fig. 15. Protected Sulphate of Copper Battery.
Price $1.50 to 2.00.

Fig. 34.

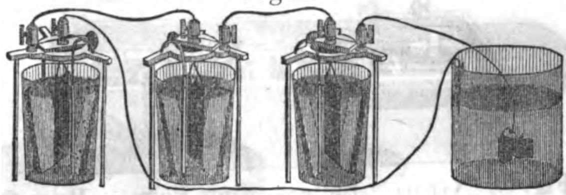


Fig. 34. Smee's Battery for Gilding and Silvering, (per pair.) Price $2.00.

Fig. 35.

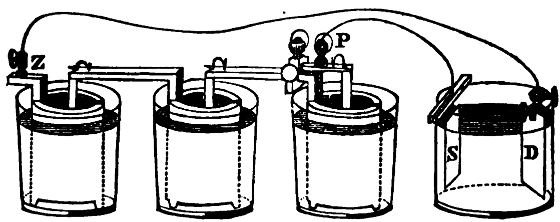


Fig. 35. Smee's Battery for Gilding. Price $2.00 per pair.

Fig. 32.

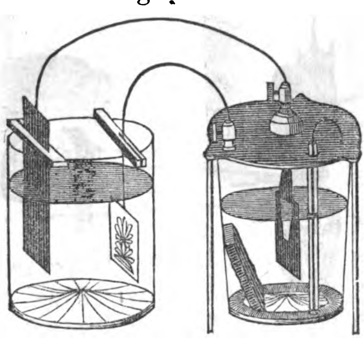


Fig. 17.

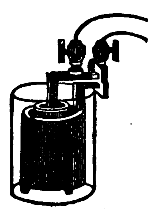


Fig. 32. Smee's Battery. Price $3. to 5.00.

Fig. 17. Grove's Battery, (single.) Price $2.00.

Fig. C.

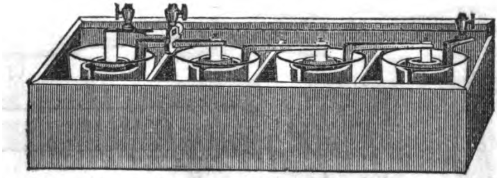


Fig. C. Grove's Battery, Four Pairs. Price $8.

Fig. 18.

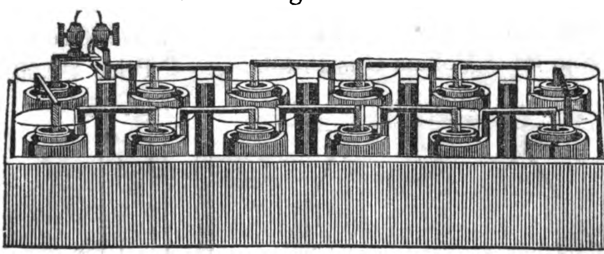


Fig. 18. Grove's Battery, in box, (per pair.)
Price $1.50, 2.00 and 2.50.

Fig. 22.

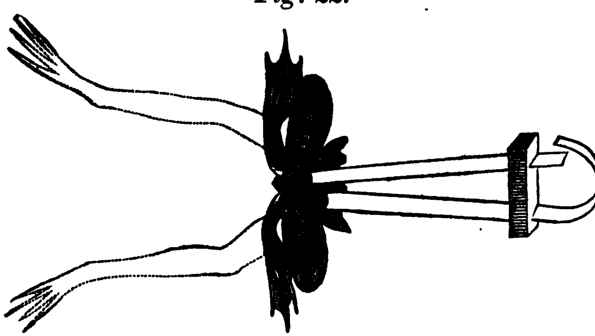


Fig. 22. Frog or Leech Battery.
Price 50 to 75 cents.

Fig. 21.

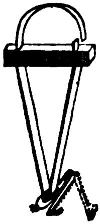


Fig. 27.

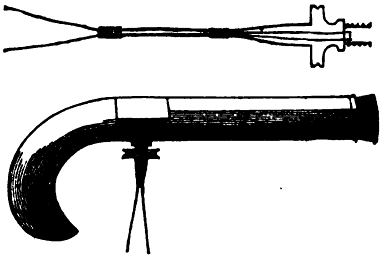


Fig. 21. Grasshopper Battery. Price 50 cents.
Fig. 27. Voltaic Gas Pistol. Price $2.50,

Fig. 25.

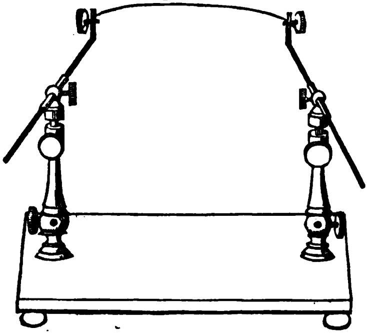


Fig. 28.

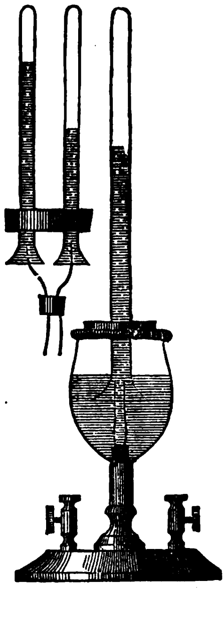


Fig. 30.

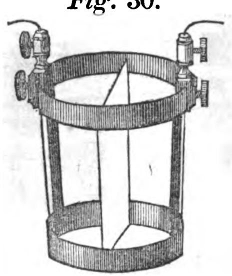


Fig. 25. Double Forceps, on Stand. Price $5.00.

Fig. 28. Decomposing Cell. Price with one gas tube, $2.50 : with two gas tubes, $3.50.

Fig. 30. Divided Tumbler, for Decompositions.
Price 2. to 3.00.

Fig. 29.

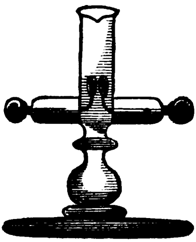


Fig. 31.

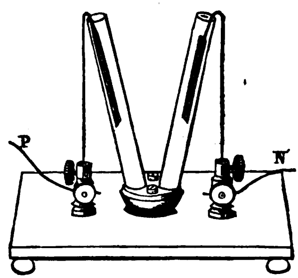


Fig. 29 Cell for delicate Decompositions.
Price $2.00 to 3.

Fig. 31. U-Tube, on stand. Price 3.50.

Fig. *D*.

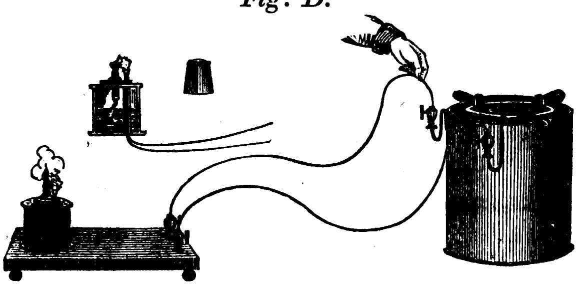


Fig. D. Galvanic Lamp.
Price, without the Battery. $2.50.

Fig. 26.

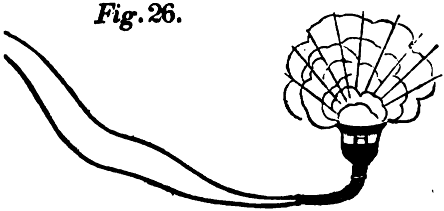


Fig. 26. Powder Cup, of glass, Price 25 cts.; of brass, 50 cents.

ELECTRO-DYNAMICS.

Fig. 159.

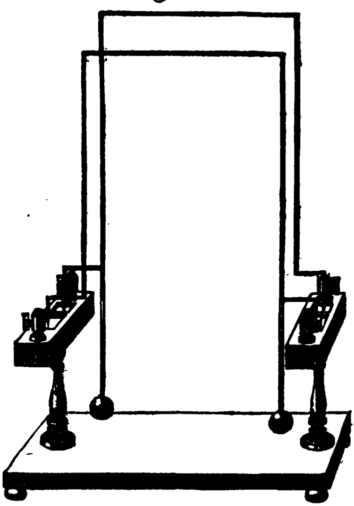


Fig. 162.

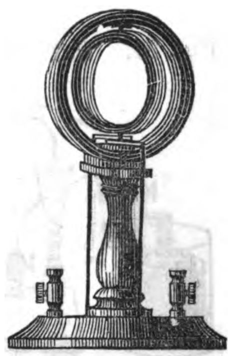


Fig. 159. Attracting and Repelling Wires. Price $3.50.

Fig. 162. Electro-Dynamic Revolving Coil. Price $6.00

Fig. 160.

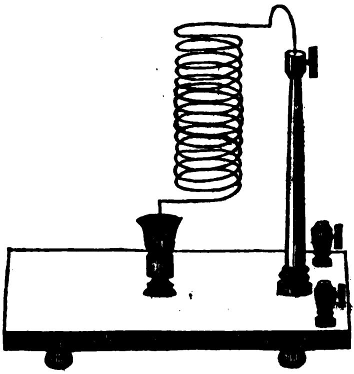


Fig. 163.

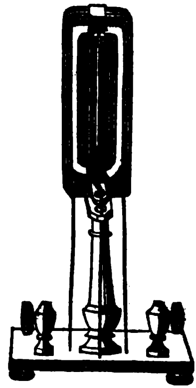


Fig. 160. Contracting Helix. Price $3.50.

Fig. 163. Electro Dynamic Revolving Rectangle. Price $7.00.

Fig. 165.

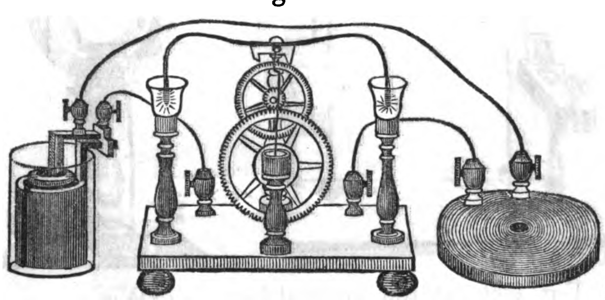


Fig. 165. Clock Work Electrotome. Price $6.00 to $7.

Fig. 167.

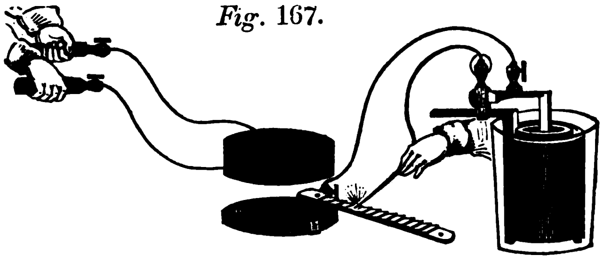


Fig. 167. Flat Spiral. Price, per lb., 75 cents to $1.00; Fine Wire Coil, per lb., $1.50.

Fig. 168.

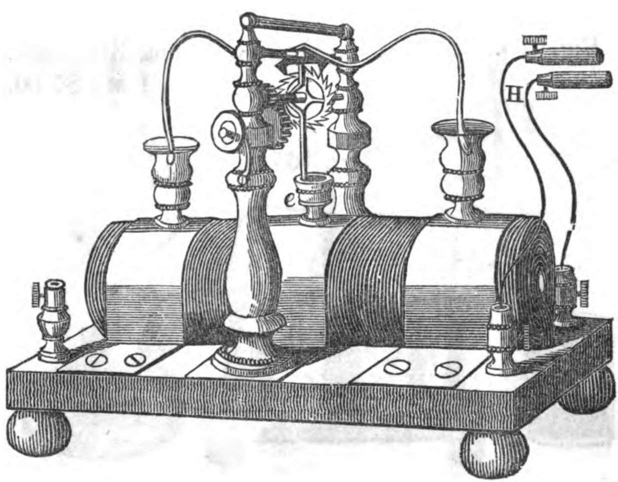


Fig. 168. Double Helix and Electrotome.
Price $20.00.

Fig. 164.

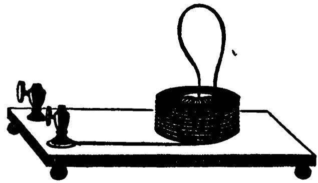


Fig. 164. Instrument for showing the rotation of Mercury. Price $4.00; with iron cup, $5.00.

ELECTRO-MAGNETISM.

Fig. 53.

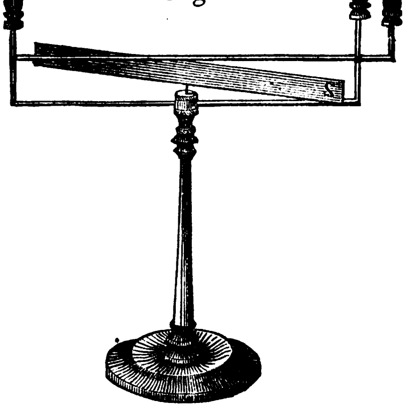


Fig. 53. Simple Galvanometer. Price $3.50.

Fig. 54.

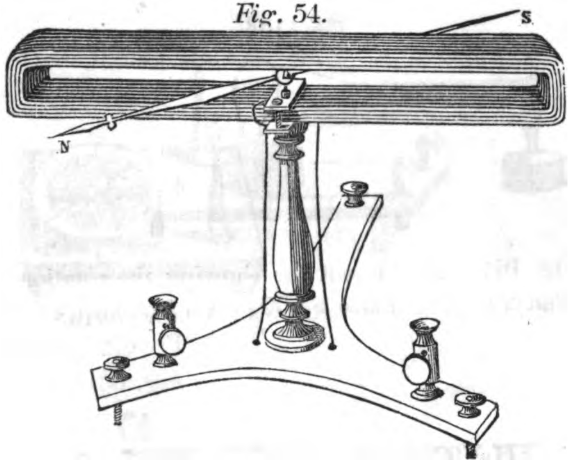


Fig. 54. Horizontal Galvanometer. Price $6.00.

Fig. 55.

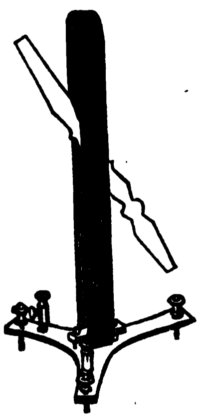


Fig. 61.

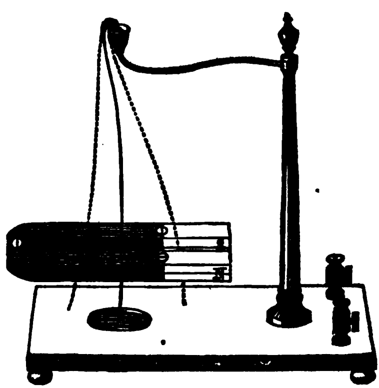


Fig. 55. Upright Galvanometer. Price $5.00.

Fig. 61. Vibrating Wire, (with magnet.) Price $5.00.

Fig. 39.

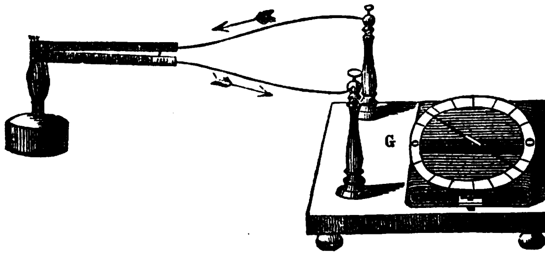
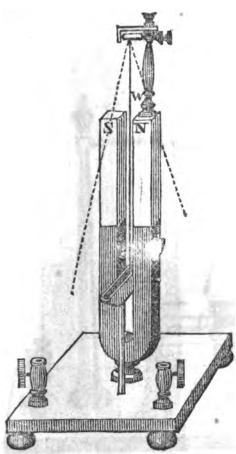


Fig. 39. Galvanometer with Astatic Needle.
Price $5. to 8.00.

Fig. 63.

Fig. 62.



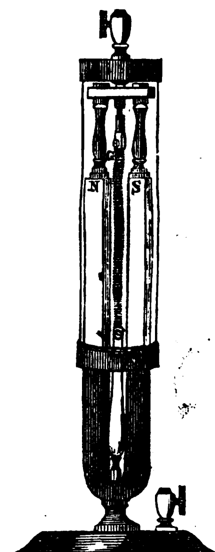


Fig. 62. Vibrating Wire, with fixed magnet.
Price $6.00.

Fig. 63. Gold Leaf Galvanoscope. Price $7.00.

2*

Fig. 57.

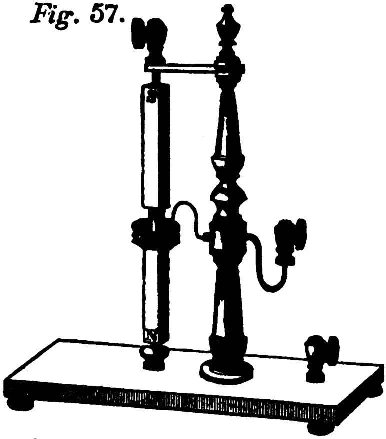


Fig. 57. Magnet revolving on its own axis. Price $6.00.

Fig. 64.

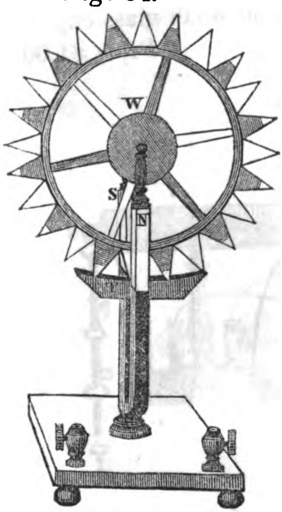


Fig. 69.

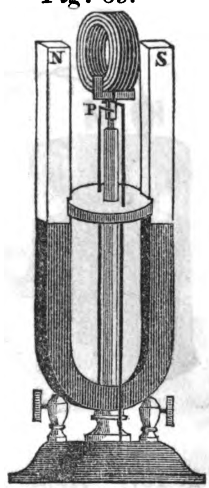


Fig. 64. Revolving Spur-Wheel. Price $5 to 8.00.

Fig. 69. Revolving Coil. Price $6.00.

Fig. 65.

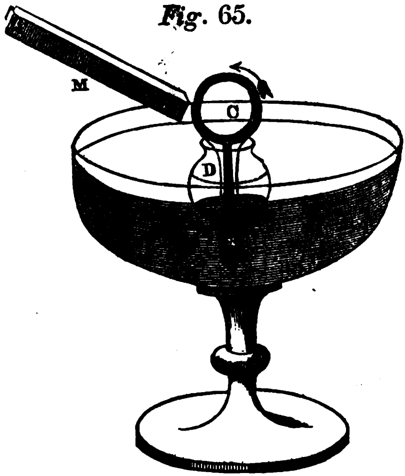


Fig. 65. De la Rive's Ring, in small glass cup.
Price $1.00.

Fig. 107.

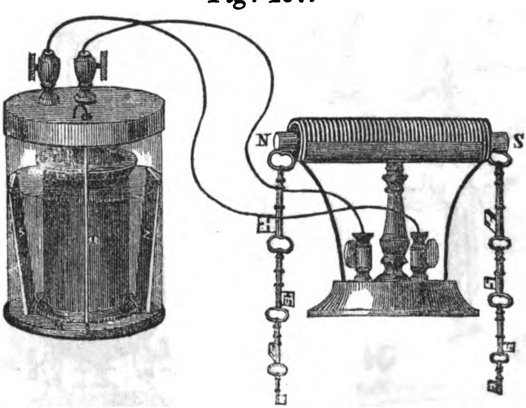


Fig. 107. Helix, on stand, (with iron bar.)
Price $2. to 2.50.

Fig. 72.

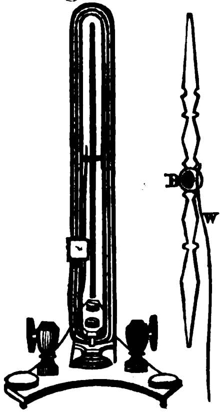


Fig. 108.

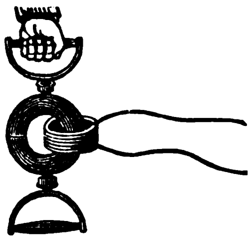


Fig. 72. Revolving Galvanometer Needle.
Price $6. to 7.00.

Fig. 108. Heliacal Ring and Semicircles, (ball and rocket joints.) Price $5.00.

Fig. 84.

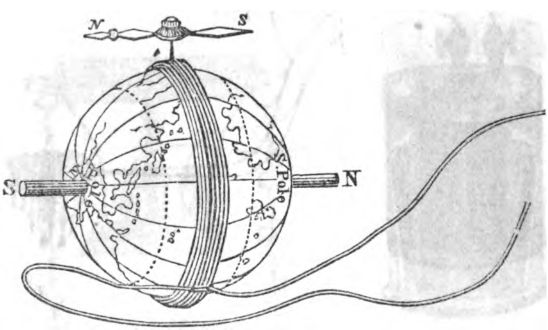


Fig. 84. Globe and Coil, with Magnetic and Dipping Needle. (*See Fig.* 6.) Price $4.00.

Fig. 109.

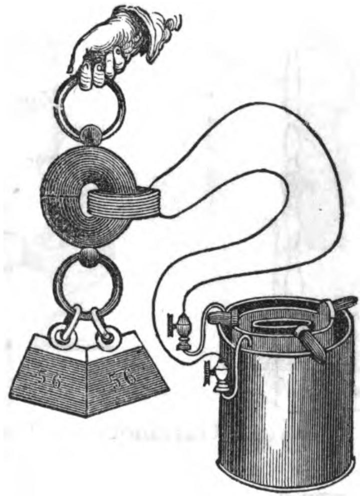


Fig. 109. Heliacal Ring and Semicircles.
Price 2.50 to $4.00.

Fig. 110.

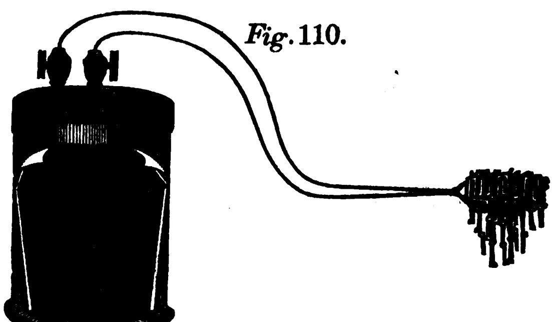


Fig. 110. Grove's Battery, (covered.)
Price $6. to 8.00.

Fig. 111.

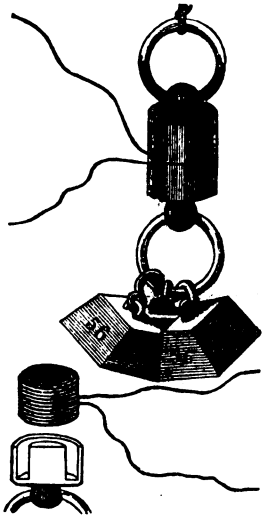


Fig. 113.

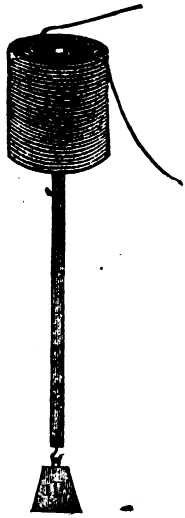


Fig. 111. Heliacal Ring and Double Cylinders.
Price $4. to 6.00.

Fig. 113. Magnetizing Helix.
Price (per lb.) $1:25 to 1.50.

Fig. 120.

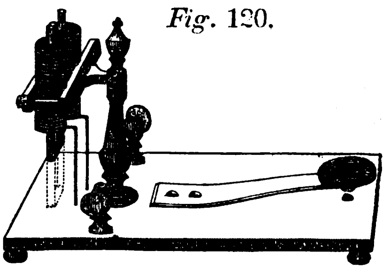


Fig. 120. Double Helix and U-shaped Bar, improved.
Price 2.50.

Fig. 112.

Fig. 129.

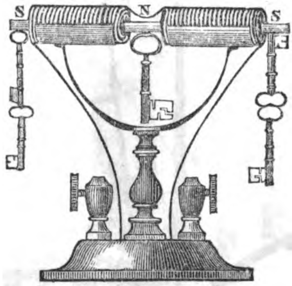


Fig. 112. Flat Spiral.

Price (per lb.) 75 cts. to $1.00.

Fig. 129. Electro-Magnet, with three poles.

Price $3.00.

Fig. 115.

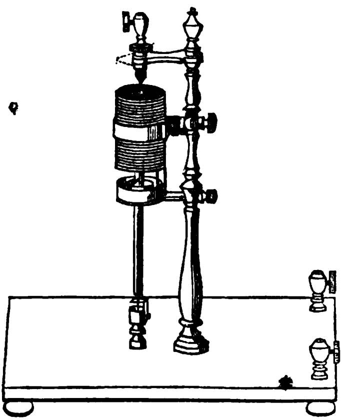


Fig. 115. Axial Revolving Bar.

Price $6. to 8.00

Fig. 116.

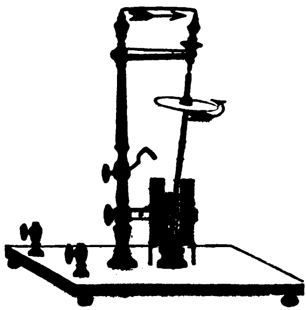
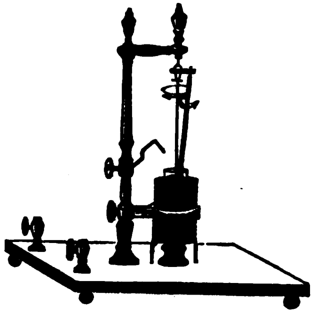


Fig. 117.



Figs. 116—117. Inclined Revolving Bar, and Bar revolving round Conductor. Price $7.00.

Fig. 122.

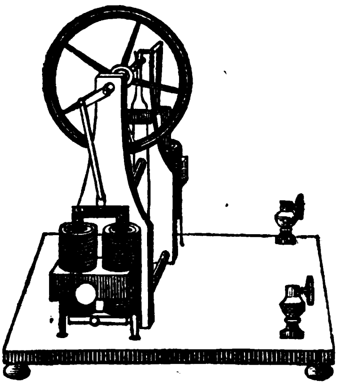


Fig. 126.

Fig. 122. Upright Axial Engine. Price **$15.00.**

Fig. 126. Small Electro-Magnet.

Price 75 cts. to **$1.00.**

Fig. 121.

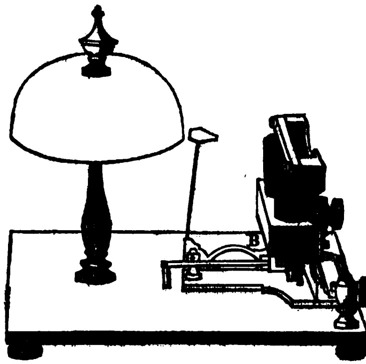


Fig. 121. Double Axial Bell Engine.

Price $8.00.

Fig. 124.

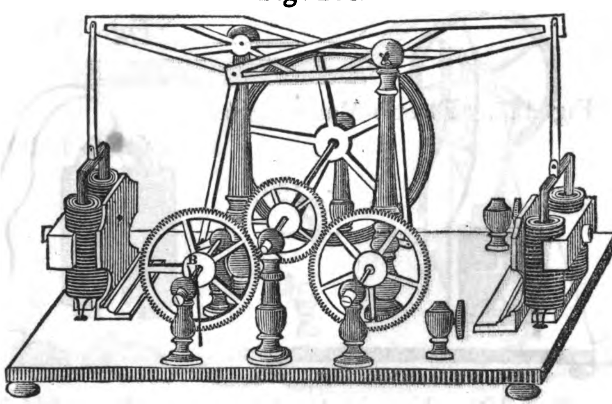


Fig. 124. Double Beam Axial Engine.

Price $15. to 18.00.

Fig. 127.

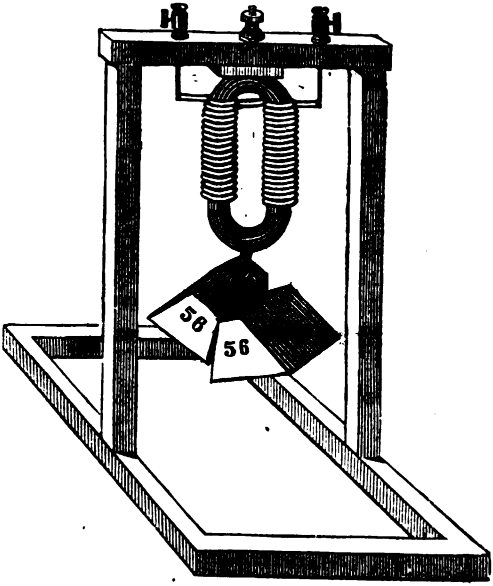


Fig. 127. Electro-Magnet in frame.

Price $8. to 12.00.

Fig. 128.

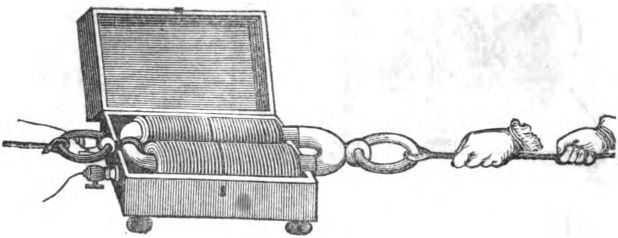


Fig. 128. Electro-Magnet, in case.

Price $10. to 25.00.

Fig. 118.

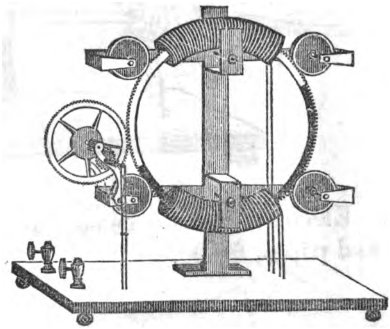


Fig. 118. Axial Revolving Circle.
Price $12. to 15.00.

Fig. 123.

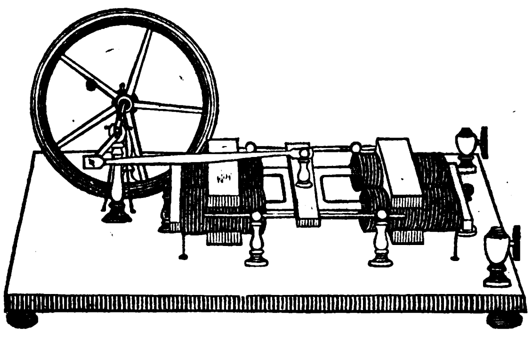


Fig. 123. Horizontal Axial Engine.
Price $18.00.

Fig. 133.

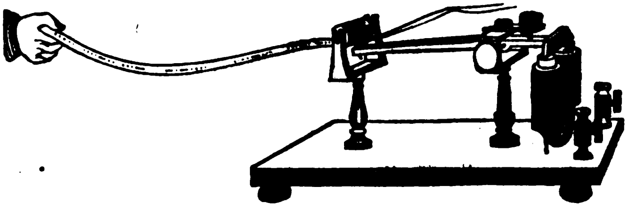


Fig. 133. Electro-Magnetic Telegraph; Price $5. With spool and paper, $8.00.

Fig. 134.

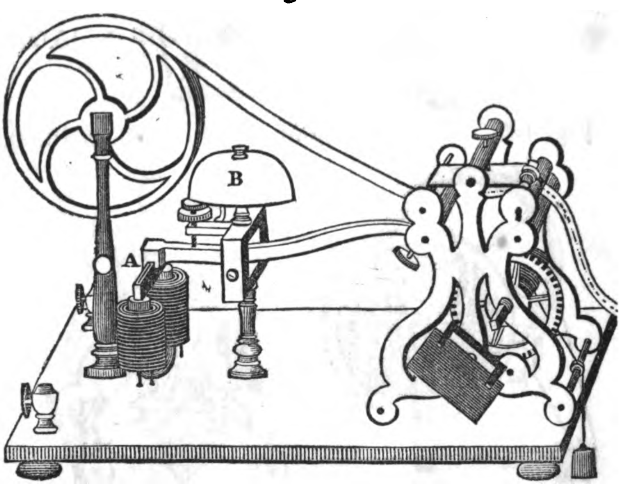


Fig. 134. Telegraph, with Clock-Work.
Price $25. to 35.00.

Fig. E.

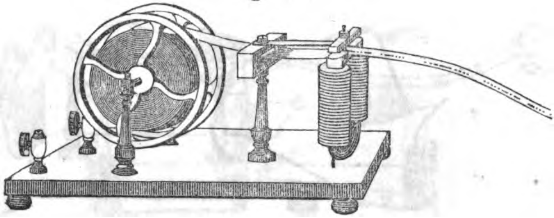


Fig. E. Telegraph Model. Price $5.00.

Fig. 137.

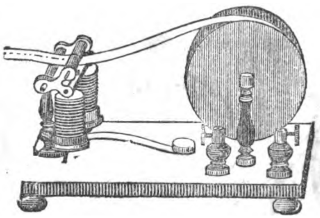


Fig. 137. Axial Telegraph. Price $6 to 10.00.

Fig. 138.

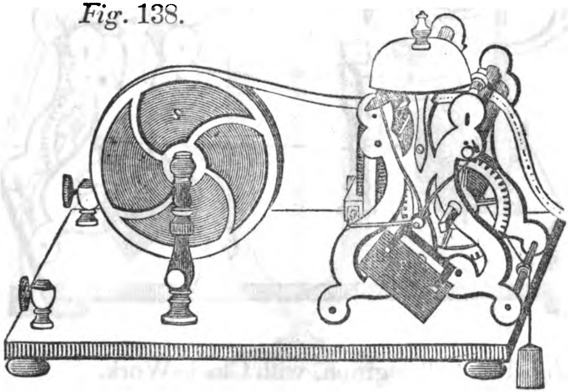


Fig. 138, Axial Telegraph, with block-work.
Price $25. to 35.00.

Fig. 135.

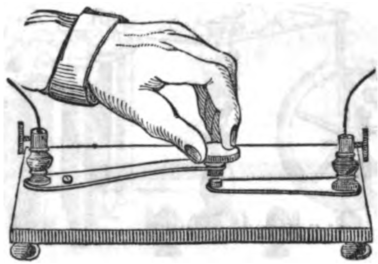


Fig. 135. Signal Key. Price $2.50.

Fig. 146.

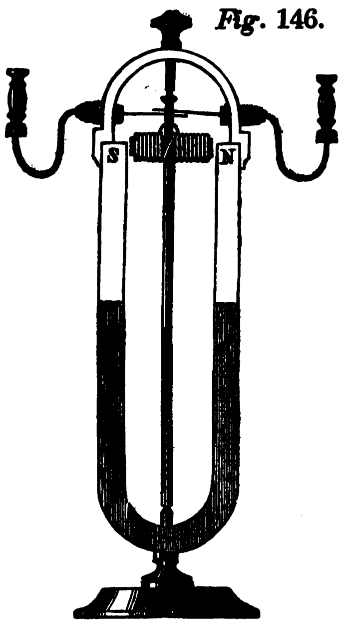


Fig. 146. Revolving Electro-Magnet.
Price $5.00.

Fig. 140.

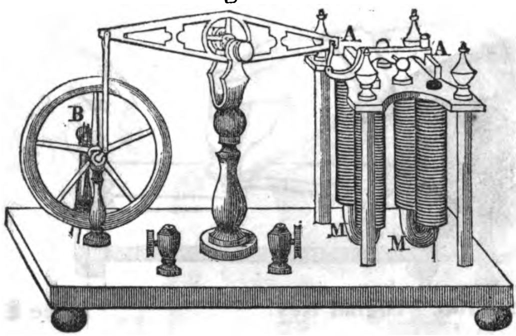


Fig. 140. Reciprocating Armature Engine.
Price $10.00.

Fig. 142.

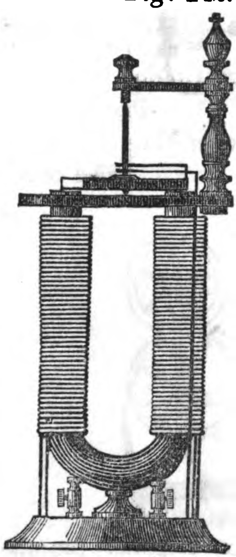


Fig. 143.

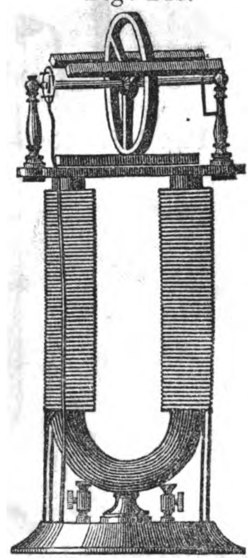


Fig. 142. Revolving Armature. Price $3.50.
Fig. 143. Revolving Armature Engine, Price $6,

Fig. 144.

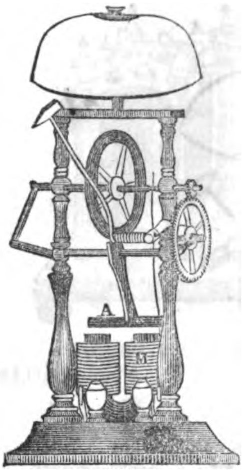


Fig. 148.

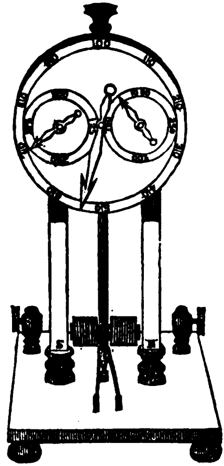


Fig. 144. Vibrating Armature Engine.
Price $10.00.

Fig. 148. Registering Revolving Magnet.
Price $8.00.

Fig. 145.

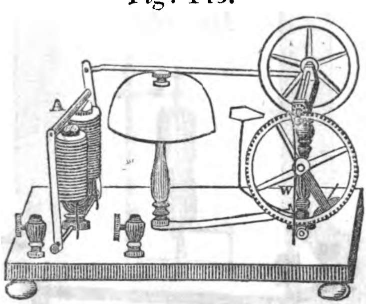


Fig. 145. Vibrating Amature Engine, (another form.)
Price $8.00.

Fig. 147.

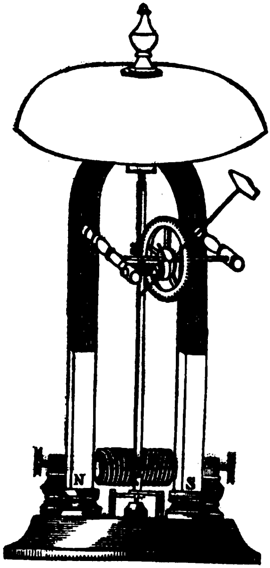


Fig. 147. Revolving Bell Engine.

Price $10.00.

Fig. 152.

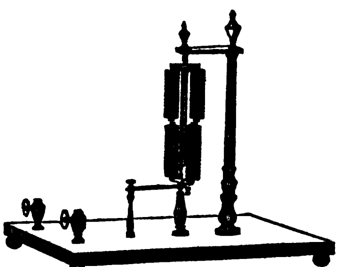


Fig. 152. Double Revolving Magnet.

Price $8.00.

Fig. 155.

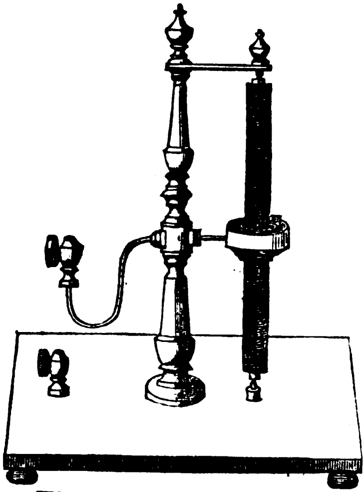


Fig. 155. Electro-Magnet, revolving on its axis. Price $7.00.

Fig. 149.

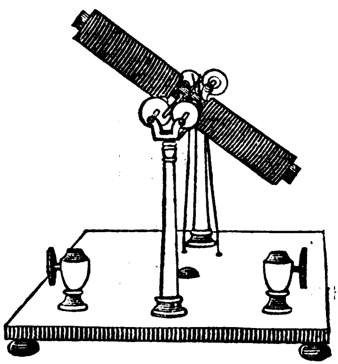


Fig. 149. Electro-Magnet, revolving by the Earth's action. Price $8.00.

MAGNETO-ELECTRICITY.

Fig. 173.

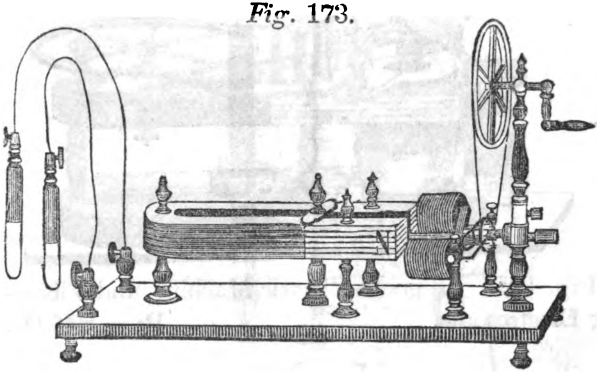


Fig. 173. Magneto-Electric Machine.
Price $30. to 35.00.

Fig. 174.

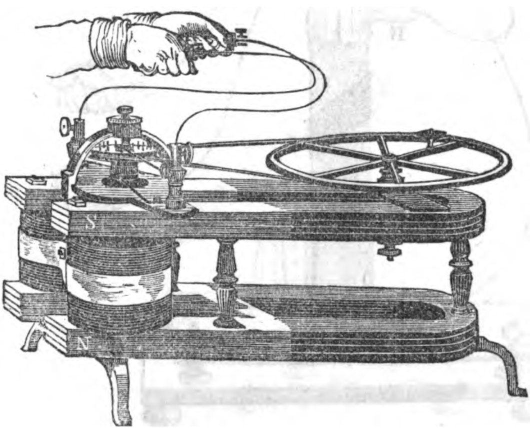


Fig. 174. Improved Magneto-Electric Machine
Price $40. to 45.00.

Fig. 175.

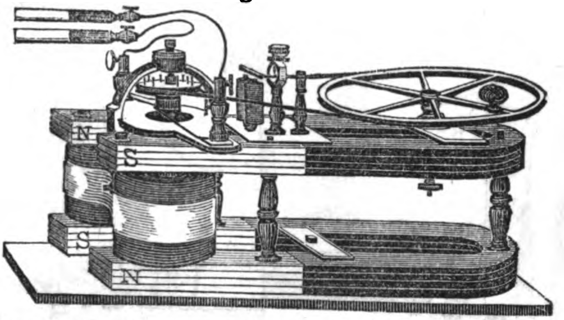


Fig. 175. Magneto-Electric Machine, and Vibrating Electrotome. Price $45.00.

Fig. 179.

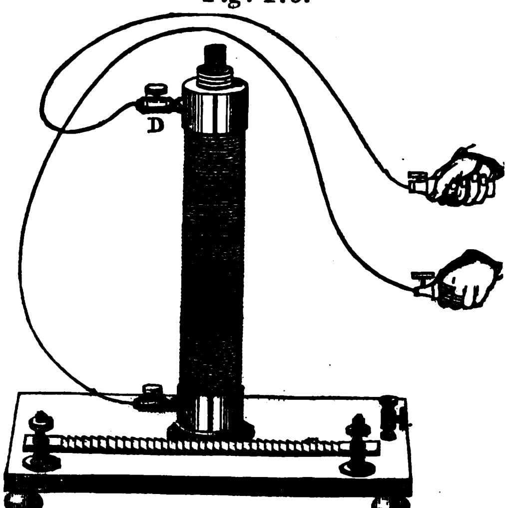


Fig. 179. Separable Helices, (with handles.) Price $10. to 12.00.

Fig. 181.

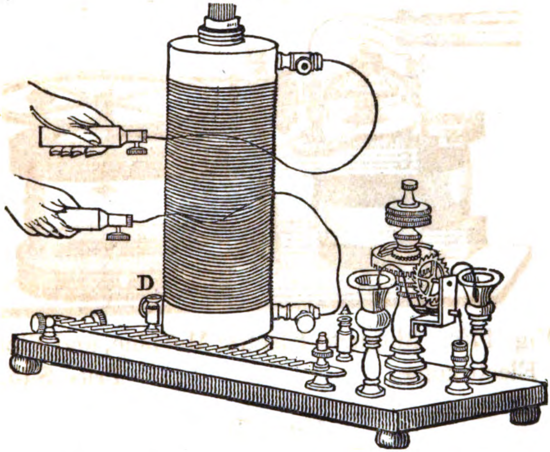


Fig. 181. Separable Helices and Clock-work Electrotome. Price $20.00.

Fig. 183.

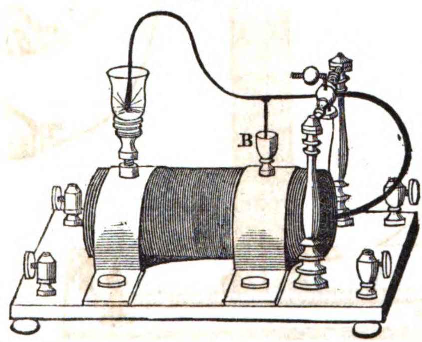


Fig. 183. Compound Magnet and Electrotome. Price $8. to 10.00.

Fig. 182.

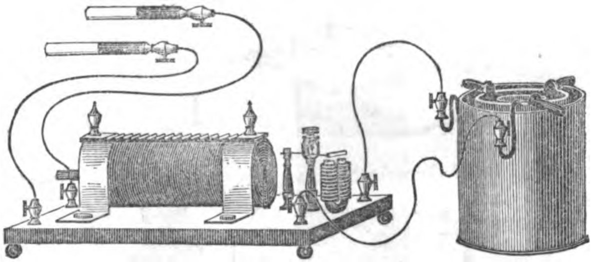
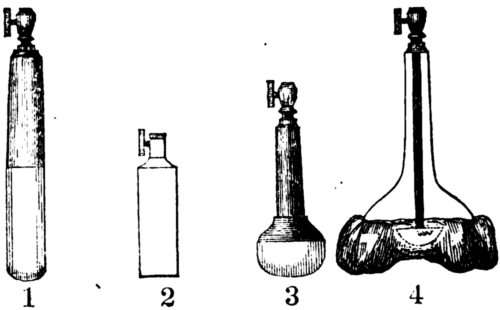


Fig. 182. Double Helix and Vibrating Electrotome, (with battery and handles.)

Price $10. to 12.00.

Fig. H.



1.	Handle, part wood, per pair.	$2.00.
2.	Handle, German silver, per pair.	$1.25.
3.	Medical Handle, silver plated, per pair.	$2.00.
4.	Sponge Handle, *large*, single.	$1.00.
	do. do. *small*, do.	75 cts.

Fig. I.

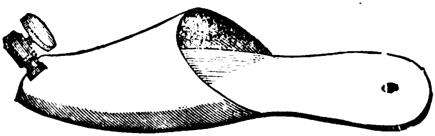


Fig. I. Galvanic Slipper, per pair. $1.25.

Fig. G.

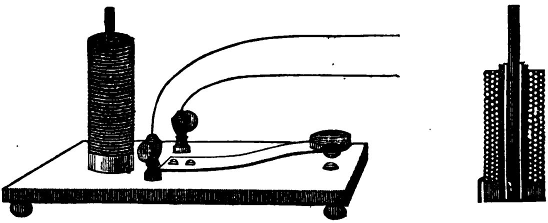


Fig. G. Apparatus for showing the Suspension of an Iron Rod by Repulsion. Price $4.00.

Fig. 184.

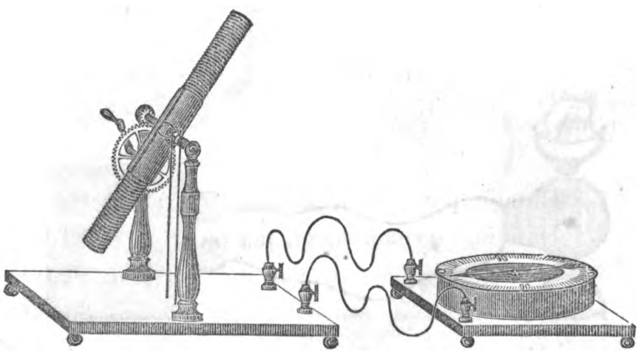


Fig. 184. Apparatus for induction of Electricity by the earth. Price $12.00.

THERMO-ELECTRICITY.

Fig. 38.

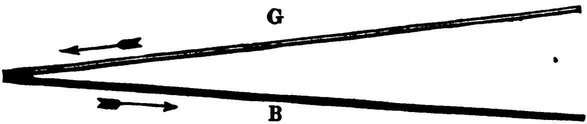


Fig. 38. Thermo-Electric Pair, (of German Silver and Brass.) Price 25 cts.

Fig. 40.

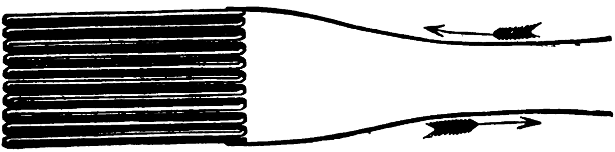


Fig. 40. Thermo-Electric Series, (10 pairs.) Price $2.00.

Fig. 41.

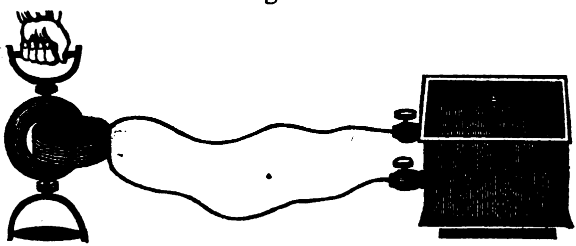


Fig. 41. Thermo-Electric Battery, (60 pairs.) Price $25.00.

Fig. 42.

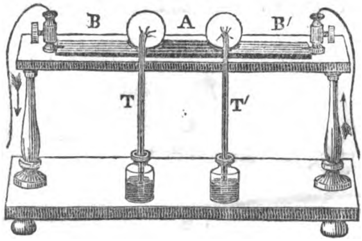
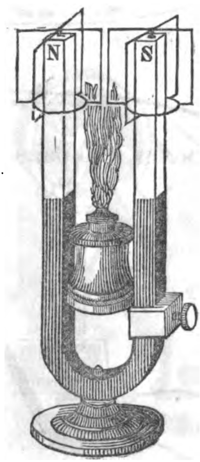


Fig. 42. Instrument for showing the production of cold and heat by Galvanism. Price $3.00.

Fig. 77.

Fig. 76.



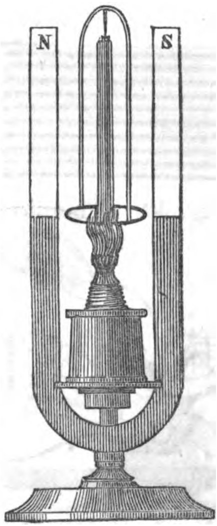


Fig. 76. Thermo-Electric Revolving Frames.
Price $6.00.

Fig. 77. Thermo-Electric Arch, between poles of a U-Magnet. Price $4.00.

Fig. F.

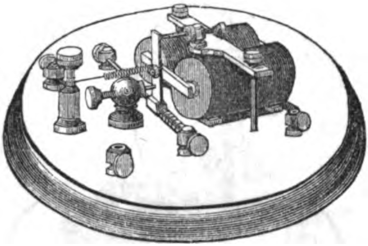


Fig. F. Receiving Magnet for the Telegraph.
Price $12.00.

Fig. G.

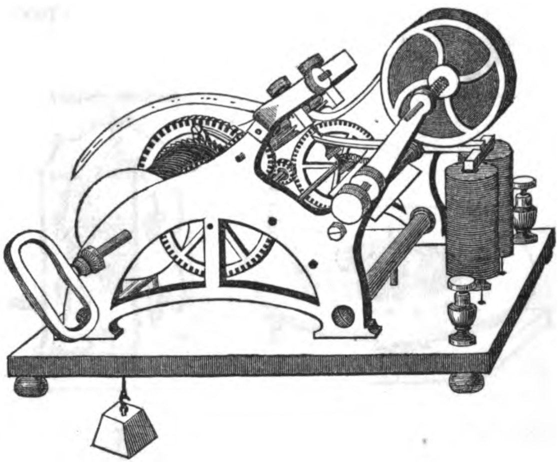


Fig G. Electro-Magnetic Telegraph, with clock work.
Price $20 to $50.

Fig. H.

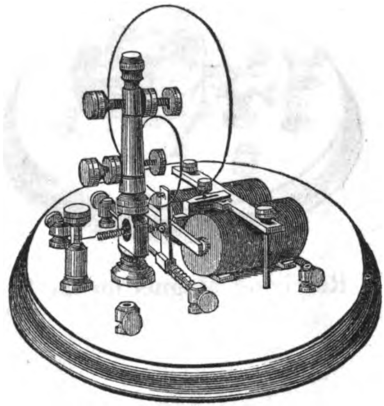


Fig. H. Telegraphic Call or Alarm.

Price $12.

Fig. I.

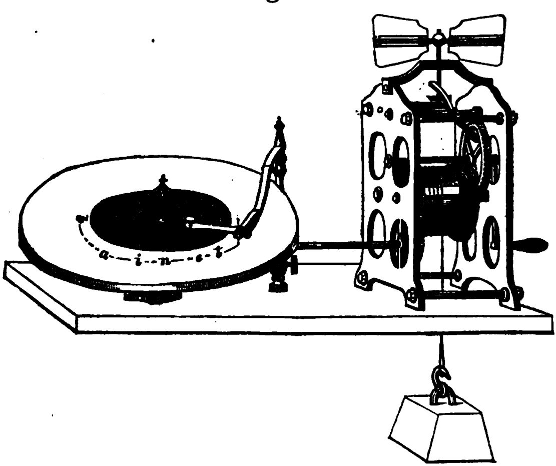


Fig. I. Bain's decomposing Telegraph.

Price $25 to $100.

Fig. J.

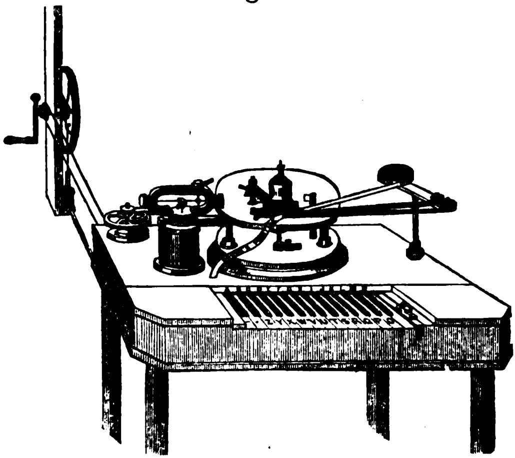


Fig. J. House's Printing Telegraph.

Fig. K.

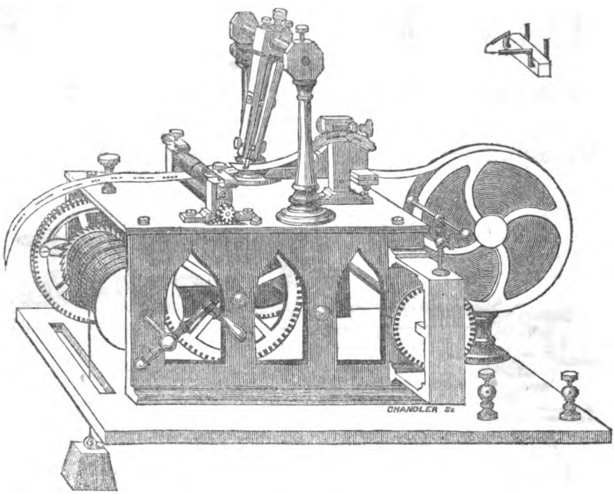


Fig. K. Horn's Igniting Telegraph.

Fig. L.

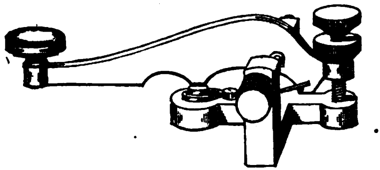


Fig. L. Signal Lever.

Price $4.50.

Fig. M.

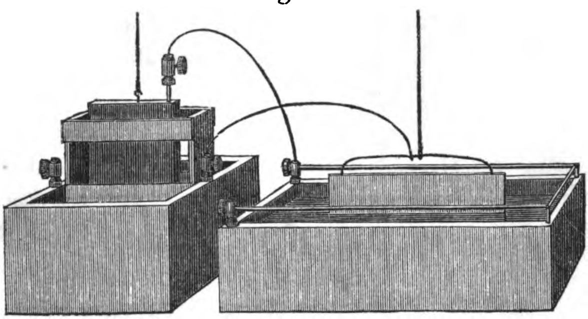


Fig. M. Electrotype Battery and Decomposing Trough. $15 to $25.

Fig. N.

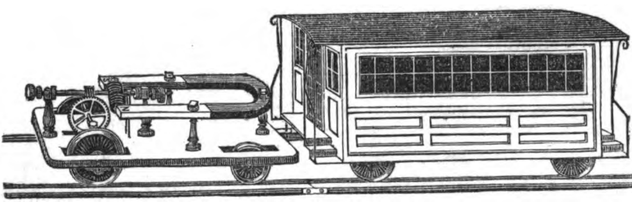


Fig. N. Electro-Magnetic Locomotive and Car. $35.00.

Fig. F.

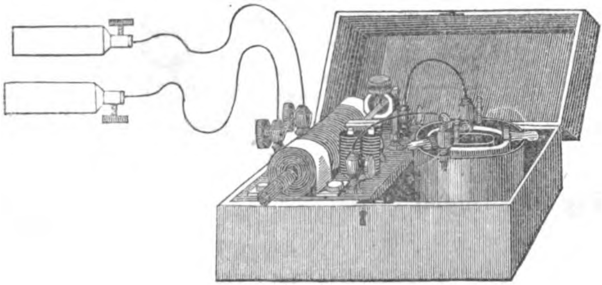


Fig. F. Box Apparatus for Medical use.
Price $10, 12, and 14.00.

Covered Copper Wire, per lb., 75 cents to $1.50.

Platinum Wire and Foil.

Fine Platinum Wire for experiments.

Porous Cells for Galvanic Batteries.

Zinc Cylinders and Plates for Batteries.

Platinum Slips for Grove's Batteries.

Apparatus for Gilding and Silvering, with instructions.

Telegraphic Apparatus for Telegraph Lines, made and repaired.

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