an Englishman on account of the inferiority of his birth. She would never forgive my son's marrying any woman but of high rank. * * *
I will never consent to his marrying any one but a person of great wealth. He knows I can only recognize a marriage of ambition and interest, and that his name and rank require it. * * *

I refer you to Bo for the history of his aunt, the P——. She has treated him exactly as she has done all her other nephews, that is, promised and then retracted. She makes a new will every day and has quarreled with every human being on earth, and will finally leave her property to strangers. All that has been said of her is not half what she deserves,—neither hopes of legacies nor any expectation can make any one support her whims, which are so extraordinary as to make it impossible not to believe her mad. * * *

I certainly regret being separated from Bo, but parents must let their children live where their interest or taste leads them. All is sacrifice on their part. I do not expect my poor child to live where I do, although his society would be a great comfort to me. If the marriage takes place, he must live with his uncle in America. My health, and the taste I have for European society, render it quite impossible for me to live near them, as probably they will continue in Philadelphia. * * *

(To be continued.)

EDISON AND HIS INVENTIONS. I.*

THE ELECTRO-MOTOGRAPH AND ITS APPLICATIONS.

NOTHING can better illustrate the rapidity and intensity of life in the latter half of the nineteenth century than the impatience with which the American press and public have awaited the result of Mr. Edison's experiments with the electric light. The daughter of the horse-leech would contemplate with surprise the importunity with which it is demanded of an inventor that within a few months he shall turn the current of a subtle force into commercial channels, constructing and giving to the public a new illuminator requiring profound experiment and the most complicated mechanism. "What they have done," says Emerson of men of action, "commits and enforces them to do the same again;" and to this great public demand Mr. Edison's high standard of achievement has made him forever amenable. That in the case of the electric light he has not disappointed popular expectation, is perhaps not the greatest, but only the most immediately tangible, exhibition of his wonderful genius. In the present and following papers it is proposed to make observation, in detail, of the singular and interesting methods which characterize Mr. Edison's work, as exhibited by his many inventions—including not only those already well known (with the latest improvements made by the inventor up to the date of going to press), but also a number of minor importance as yet unannounced and unapplied—the incidental results of the superfluous activity of a great scientific mind.

Until within a comparatively recent time there existed great misconception of the character and surroundings of the inventor of the telephone, quadruplex, tasimeter, phonograph and the many other marvels of science. Like a newly discovered Eldorado, his seemingly inexhaustible store of wonders made him the theme of every tongue, and when one person suddenly becomes the object of general observation, Mr. Edison speedily became one of the best known but least understood of men. Perhaps no better illustration of this misconception could be given than that afforded by the press throughout this country and Europe, about the time when the phonograph, with its strange powers and properties, was given to the world. The newspaper press—animated by the same intense interest that moved the public at large, to learn more of the man who could perform such startling scientific feats—eagerly seized every story relating to the great inventor. But the material soon ran short; and then, under the plea that necessity is the mother of invention, industrious *littérateurs* began the work of drawing upon their imaginations. The hero of their labors assumed all sorts of forms. Now he was a scientific hermit, shut up in a cavern in a small New Jersey village, holding little or no intercourse with the outside world, working like an alchemist of old in the dead of night, with musty books and curious chemicals, and having for his immediate companions persons as weird and mysterious as himself. Again, he was a rollicking, careless person, highly gifted in matters scientific but deplorably ignorant in everything else,—a sort of scientific Blind Tom. Especially was he accredited with the most revolutionary ideas concerning nature. One Western journal represented him as predicting a complete overthrow of nearly all the established laws of nature; water was no longer to seek its level; the earth was speedily to assume new and startling functions in the universe; everything that had been learned concerning the character of the atmosphere was based on error; the sun itself was to be drawn upon in ways that are dark, and to be made subsidiary to innumerable tricks that are vain;—in short, all nature was to be upset.

Time, however, has in a large measure rectified all this misconception. Edison is no longer the *ignis fatuus* of science that he once was; the leading physicists of the world to day know the details of his laboratory almost as thoroughly as they know their own; his methods and systems are no longer veiled in mystery; his character and genius are understood the world over, and his correspondents may be found among the leaders of science in London, Paris, Dublin, Berlin, Vienna and St. Petersburgh.

EDISON IN THE LABORATORY.

Before entering into any detailed description of Mr. Edison's latest invention,—the electro-motograph,—which more particularly is the subject of this paper, it may not be uninteresting to take a brief glance at the surroundings of the inventor and his methods of working.

The laboratory of Mr. Edison, at Menlo Park, N. J., till within a few months, consisted of an unpretentious-looking two-story wooden building, painted white. Here the majority of his great inventions first saw light; although his quadruplex telegraph, stock-printer, and other important inventions had been perfected in his former laboratory in Newark, N. J. But the inventor was so much inconvenienced for want of room, that he has lately built a commodious structure of brick, into which has been removed all the heavy machinery. The old laboratory is now used entirely for chemical experiments. On its second floor the choicest work of the inventor is performed. Here, every day and night, surrounded by hundreds of vials of chemicals and scores of curious scientific instruments, he may be seen in his suit of blue flannel, chamelion-like with spots of acid, advising, consulting, and directing his principal assistant, Mr. Charles Batchelor, his mathematician, Mr. Francis R. Upton, and his chief machinist, Mr. John Kruza. Here are steam baths, retorts, vacuum pumps, hydraulic presses, smelting furnaces, and the various other necessary appliances.

The library of the great inventor is a compendium of the most approved works on science, and consists of nearly 2,000 volumes. A glance at the books well illustrates the character of their owner. Hundreds of them bear copious marginal notes, approving, correcting, or modifying propositions in the text, showing that their contents have been carefully read. Here we see a note to the effect that a certain statement made in the book is erroneous; or we may find a marginal explanation showing how a certain result, declared impossible of accomplishment by the writer of the book, may be obtained. The rapidity with which Mr. Edison peruses a book is remarkable. He seems to comprehend the entire contents of a page at a glance. Question him months afterward on any particular portion of the book read by him, and he will readily give all the salient features of the passages referred to.

The inventor's private office is in charge of Mr. S. L. Griffin, his private secretary, who manages the business affairs of the establishment and attends to the large correspondence. The letters received frequently number as many as 150 a day. They come from all quarters of the globe, and are in nearly every language. With French, German, Italian or Spanish epistles there is not much difficulty; but sometimes a letter comes from a Russian or a Turk, and then Mr. Griffin is put to his wits' ends to get it translated.

On the secretary's right is a large case containing about 800 pasteboard boxes, appropriately labeled with such inscriptions as "Sextuplex," "Phonograph—France," "Electric pen—South America," "Telephone—Australia," "New Zealand Correspondence," "Megaphone," etc. The patents and caveats of the inventor, which now (April, 1879) number 271, are inclosed in large wooden chests. Large volumes labeled "Experimental Researches" contain the drawings and specifications of all of Mr. Edison's inventions, together with the diagrams and descriptions of all the experiments and experimental apparatus leading to the same. Other books are kept which show the result of all experiments made by the inventor's assistants in pursuance of his instructions.

It is the duty of every person in the laboratory who is given a particular task, outside the ordinary routine, to note down the various steps in his progress, and especially to mention any phenomena he may have noticed while so working which he did not understand. By this system Mr. Edison is daily enabled to supervise every experiment made, rejecting such as were unsuccessful, correcting mistakes, and making practical application of such as meet his approbation. When it is known that thirty persons are employed in the laboratory, the untiring industry necessary to attend to all these matters can readily be comprehended. Probably no one of his assistants works so hard as Mr. Edison himself. Every morning at ten o'clock he is in the laboratory giving directions and listening to reports, and he may be found at work until near midnight every night with an intensity of interest and a continuous perseverance rarely seen.

THE PRINCIPLES OF THE ELECTRO-MOTOGRAPH.

THE latest achievement of Mr. Edison is the electro-motograph, a brief explanation of which was made in the May number of this magazine. Although it is yet in its infancy, the scope of its utility has already become far more extensive than that of any of Mr. Edison's previous inventions. Probably its most striking feature is its paradoxical power of making the human hand talk; for the hand revolves a little cylinder, and the instrument speaks as it is bidden, and when the hand stops turning, the instrument ceases to speak. At a superficial glance, this principle would seem to be the same as that of the phonograph; but in point of fact there is no essential similarity between the two inventions; they are used for entirely different purposes, and are governed by separate and distinct laws. The phonograph records and preserves the waves of sound; the electro-motograph—or, as it is called when used in connection with acoustics, the "chemical telephone"—records nothing. In the phonograph, the main principle is the indentation of tin-foil on a cylinder, by a small needle attached to a diaphragm, which is set in motion by the waves of sound. In the chemical telephone there is likewise a cylinder and a diaphragm; but with these its resemblance to the phonograph ceases. On the cylinder of the chemical telephone rests a metal arm attached to a diaphragm, and the passage of electric waves through such cylinder causes the vibration of the diaphragm, as will be more fully explained farther on. The scientific principle involved in the electro-motograph discovery is diametrically opposite to the main principle in electro-magnetism, and yet it performs in most cases exactly the same functions as electro-magnetism.

In all contrivances hitherto used for producing a mechanical movement at a long distance, the agency employed has been electro-magnetism. Take for illustration the ordinary Morse telegraph. This, as every school-boy knows, consists in the rough of a piece of soft iron around which is coiled a continuous fine wire, through which wire is passed, so to speak, a current of electricity. This current magnetizes the piece of soft iron, which thereupon is enabled to attract a second piece of iron or armature. Here, then, we have a mechanical movement, produced by energy transmitted from a distance. By means of the discovery of the principles of the electro-motograph, Mr. Edison has made it possible to produce mechanical movements at a distance without the employment of electro-magnetism. In other words, had the inventor of the telegraph never lived, and had electro-magnetism never been discovered, we might to-day accomplish the same results by means of the electro-motograph.

THE ORIGIN AND DEVELOPMENT OF THE ELECTRO-MOTOGRAPH.

THE discovery of the electro-motograph has not been the work of a day or of a year, but of six years of study and research. The germ first appeared in the year 1873, while Mr. Edison was deeply engaged in the subject of chemical telegraphy or communication at a distance by electrical discoloration of chemically prepared paper. One day, as he sat pondering over his work, he happened to take in his hand the metallic point through which, as it rested on the chemically prepared paper, the current was wont to pass. When again he closed the circuit to let the current through the paper, he held the metallic point loosely in his fingers, at the same time unintentionally allowing it to rest on the paper. His taking the metallic point in his hand was simply a change from his customary method of experimenting on the subject then under consideration. He expected no result different from that which he had previously noticed and he was therefore not a little surprised to see that every time he moved the metallic point along the paper (thus closing the electric circuit) the surface of the paper along which the point moved seemed to become exceedingly smooth. Fig. 1 represents the metallic point held in the inventor's hand and resting on the strip of chemically prepared paper.

It is one of the inventor's chief characteristics to investigate the cause of all actions he does not thoroughly understand. The most trifling deviation from established results at once commands his attention, and often he will depart for weeks at a time from the main line of experiment to ascertain the hidden reason why a certain electric impulse produced a result to-day which it did not produce under like circumstances yesterday. Sometimes these departures have resulted in important discoveries, completely overshadowing the result originally sought, as, for instance, the carbon button; while at other times he has been compelled, after weeks of study and the expenditure of perhaps thousands of dollars in experimenting, to return disappointed to the point from which he started.

On the present occasion Mr. Edison resorted to his customary practice, and for hours experimented with the metallic point. When he arose from his seat, he had established the following rule: "The passage of the electric current through this chemically prepared paper quite materially lessens the friction between the metallic point and the paper." The following day he resumed experimenting, but to his surprise the results of the previous day seemed unattainable. After spending several hours in fruitless endeavor to solve the mystery, he laid the subject aside and resumed work on the line of inquiry on which he had been engaged when the phenomenon first attracted his attention.

But he had not altogether given up the idea of fathoming the problem. Relinquishment for the time being was made necessary by reason of his other scientific engagements; but a curious note was made in his book of experimental researches.

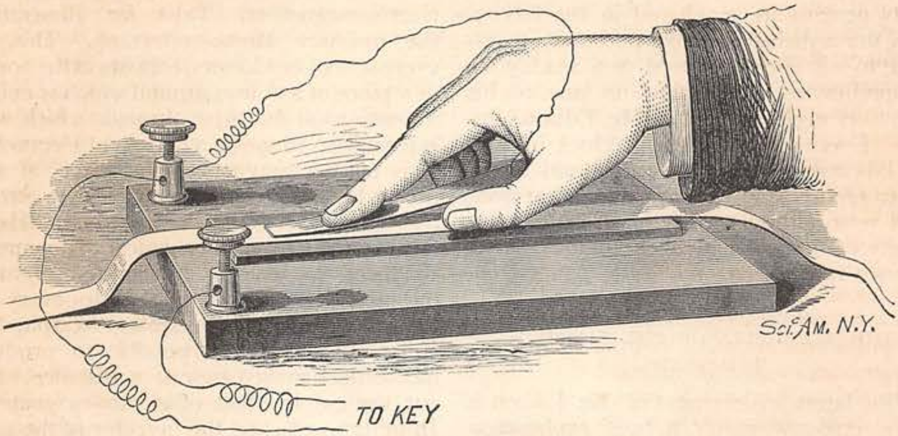

FIG. 1.—THE FIRST STAGE OF THE ELECTRO-MOTOGRAPH DISCOVERY.

Not long afterward Mr. Edison had occasion to make certain experiments in chemical telegraphy on a short or local circuit, in the progress of which he again noticed the peculiar effect of the current upon the frictional properties of the paper. It was on this occasion that the inventor conceived the plan of utilizing the discovery; but, as a preliminary measure, he set about ascertaining the reason why the electric current produced the effect it did. His investigations, however, proceeded slowly, for other matters of more immediate necessity engrossed his attention. Nothing further of consequence in the embryo electro-motograph seems to have been done until the following year (1874), when Mr. Edison called the attention of some scientific friends to the discovery. A few months later he devised an apparatus to exhibit the phenomenon, and permitted a description of the same to be published in the "Scientific American." Shortly afterward the apparatus was exhibited at a *soirée* of the Royal Society in London, where, according to the newspapers of the day, it was the object of more interest and comment than any other of the large number of scientific apparatus under inspection. After this Mr. Edison made frequent attempts to discover the first cause of the phenomenon, but without success. The results attained in his experimenting varied at different times in a manner quite unaccountable. Sometimes they were satisfactory up to a certain point, while, again, the most diligent efforts proved failures; and so it came to pass that the incipient electro-motograph was once more placed upon the list of "unfinished inventions." Two years went by and still the invention slumbered. Mr. Edison's researches in chemical telegraphy had long been completed, and nothing occurred to call to life the almost forgotten discovery of 1873. In the summer of 1876, while engaged in perfecting his speaking and musical telephone, the idea suddenly occurred to him that possibly the long-neglected discovery might be made available for the reproduction of musical sounds. The thought was an opportune one; and after a little experimenting the discovery became a valuable acquisition to musical telephony. Notes were reproduced with increased volume. Its mode of application was as follows: A large sounding-board has in its center a spring connected with the telegraph line. This spring rests upon a strip of continuous paper moistened with a chemical solution. The waves of electricity (corresponding to the sound-waves), passing through the spring and paper, cause the usual friction existing between the point of the spring and the paper to disappear as many times as there are electrical waves or impulses. The disappearance of the friction of course causes the spring to vibrate; and it in turn causes the sounding-board to vibrate, producing a musical note corresponding to the number of electrical impulses transmitted.

But the determined inventor was not satisfied with transmitting music alone. Transmission of the sound-waves of the human voice was the main object in view. And here it may be explained that the difference between musical notes and ordinary voice-waves for telephonic transmission is quite marked. The musical notes are reproduced with comparative ease, owing to the regularity of the vibrations, and also to the fact that they are more nearly of the same amplitude; while the voice-vibrations on the other hand, being of the most irregular character, require much more sensitive appliances, in order that all the sound-waves may be caught and reproduced. At this stage of the telephone's progress the electric impulses were transmitted by means of a diaphragm actuated by the voice, vibrating a platina point fastened to the center of the diaphragm and pressing at each vibration a platina-covered rubber-roller. By this means singing could readily be transmitted; but the moment the regularity of the vibrations ceased, as they did when ordinary conversation was sought to be transmitted, the telephone gave inarticulate results. The next step in the telephone's progress consisted in the introduction of "variable resistances." By means of curious mechanical contrivances the vibrations of the diaphragm were made to alter the intensity of the electric current. These variations moved the diaphragm at the other end of the line in exact unison with the transmitting diaphragm. But, important as was this improvement, the inventor was not satisfied. Next in point of time came the carbon button,—a most important discovery,—by the use of which the human voice is transmitted with marvelous accuracy a distance of many miles from the place of speaking. These various steps of progress in the telephone are here referred to, not by way of description, but only to show the condition of the telephone when the principles involved in the electro-motograph discovery were first applied to it.

Perfect as was the telephone at its last stage of development, it had one serious defect. It could not reproduce the words spoken against the diaphragm at the transmitting end of the line in anything like their original volume. The conversion, at one end of the line, of the waves of sound into electric action, and their reconversion, at the other end of the line, into sonorous vibrations, caused a double loss. Words, therefore, spoken in a loud tone of voice at one end of the line, were reproduced at the other in quite a soft tone. For commercial purposes, this made the telephone very imperfect; as, to "catch" all that was said, comparative quiet was necessary, and even then the whispering receiver could only be heard when the instrument was pressed closely against the ear. To overcome this defect, Mr. Edison called into action the discovery on which he had so long been experimenting. Up to this time, he had used chemically prepared paper as the substance upon which the electric current was to act, in order to produce at a distance a mechanical movement. He soon found that, to obtain uniform action, the employment of some other substance was imperative. Hundreds of different ones were tried in the course of experiment, until at last the choice fell upon precipitated chalk saturated with a strong solution of caustic alkali and a salt of mercury.

As at present used for telephonic purposes, the electro-motograph instrument, an interior view of which is presented in Fig. 2,

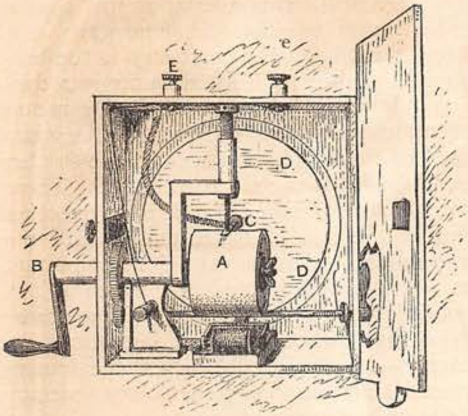

FIG. 2.—INTERIOR VIEW OF THE CHEMICAL TELEPHONE.

is constructed as follows: A is a small cylinder of precipitated chalk, two inches in length and one and one-fourth inches in diameter, saturated with the solution referred to. The cylinder is attached to a shaft which is rotated by a small crank, B. Upon the circumference of the cylinder rests, with some little pressure, a narrow strip of brass tipped with platina, C. The other end of this strip is attached to a diaphragm of mica, D D. The cylinder, A, and strip, C, are made part of the electric circuit by wires running from the screw-posts, E, e, so that the current from the line passes along the strip, C, and through the alkaline solution contained in the cylinder, A, to the shaft, and thence by the wire to the screw-post, e, to earth. When the cylinder is revolved by its handle, the friction or traction of the brass strip, C, resting on it tends to pull the diaphragm, D D, inward, in the direction of the rotation. If now, while the cylinder is being revolved, a current of electricity is sent over the line (and necessarily through the metal strip and the alkaline solution of the cylinder, they being in the circuit), the ordinary friction that exists between the metal strip, C, and the cylinder, A, disappears; and the metal slides freely on the surface of the cylinder, allowing the mica diaphragm to return to its normal position. As the lessening of the friction is in proportion to the strength of the current, the diaphragm will not be caused to return to that position by a very weak current; hence the instrument will respond to and reproduce all the minute inflections of the human voice. When no electricity is on the line, the revolving of the cylinder produces no effect other than that of keeping the diaphragm pulled inward. On the other hand, when the cylinder is at rest, a passage of the current through it does not affect the diaphragm. It is only when the cylinder is revolving that the diaphragm is caused to vibrate by the current. This principle being clear, it can readily be understood that fifty electrical impulses in one second (the cylinder being rotated) will remove the friction existing between the surface of the cylinder and the strip of brass resting on it fifty times within the second; and the diaphragm, in obedience, will make fifty vibrations within the same period of time, thus causing a sound. In other words, as the electrical impulses follow each other in regular order, corresponding to the sonorous vibrations imparted by the voice to the transmitting telephone, the alternate slipping and catching of the metal strip on the cylinder follows in the same order, causing the diaphragm to vibrate in unison with the original vibrations, and thus reproducing the words spoken into the transmitter at the other end of the line.

Fig. 3 represents a detached view of the diaphragm with the metal strip resting on

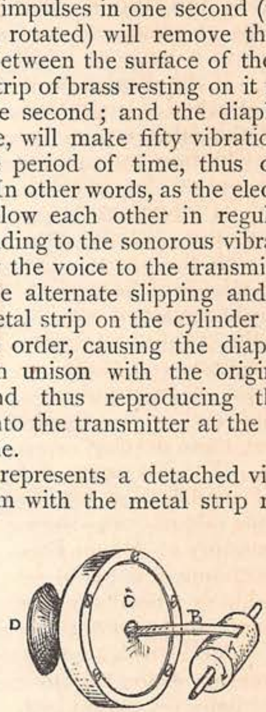

FIG. 3.—VIEW OF DIAPHRAGM AND CYLINDER OF THE CHEMICAL TELEPHONE.

the cylinder. A is the cylinder, B the metal strip, C the diaphragm, and D the mouthpiece.

To understand the principle by which the volume of transmitted vibration is amplified, or in other words the principle by which a whisper uttered in Philadelphia is converted into a shout in New York, it must be borne in mind that the amount of electric action bears no relation to the strength of the mechanical movement it generates. The movement of the cylinder is caused by a power entirely independent of the electric action, it being revolved by the hand of the listener. All that the electricity does by its passage through the strip of metal and cylinder is to destroy, to a greater or less degree, the friction that ordinarily exists between the cylinder and the strip of metal pressing upon it. And this it does with the expenditure of only a modicum of the energy that would be absorbed by an electro-magnet to obtain the same volume of sound. The electric current merely changes the state in which matter exists, and this requires an infinitely small consumption of energy. Now this strip of metal may be large or small, and may be attached to a large or small diaphragm. If the diaphragm to which it is attached is larger than the one at the other end of the line, whose vibrations transmit the electrical impulses, its swing is greater and its vibrations consequently produce sounds commensurate with the same. This local independence of the mechanical movement renders it possible to amplify the slightest vibrations at the transmitting end of the line into vibrations of great power at the receiving end, so as to make the slightest noise develop into a loud sound. To what extent this principle of amplification can be carried, time alone can show. In the laboratory at Menlo Park it is no uncommon thing to be startled suddenly with the sound of a loud voice roaring through the telephone. An investigation of its cause reveals at the transmitting end, perhaps, the errand boy, whose normal voice is a high treble. Ask him face to face why he roared so violently through the telephone and he will laughingly pipe out, "Why, sir, I only spoke as I always do—no louder than I'm speaking now, sir." For general use the chemical telephone is constructed in such a manner that the loss in power hitherto experienced by the conversion and reconversion of the sound-waves is not perceived, the sound uttered into the transmitting apparatus being reproduced exactly on the receiver. Of course, if desired the receiver may be so made that the sound is largely amplified—amplified, in fact, to such an extent that the curious spectacle may easily be presented of a person who is considerably deaf, and entirely oblivious to conversation carried on in an ordinary tone of voice in his presence, readily hearing a whisper uttered miles and miles away!

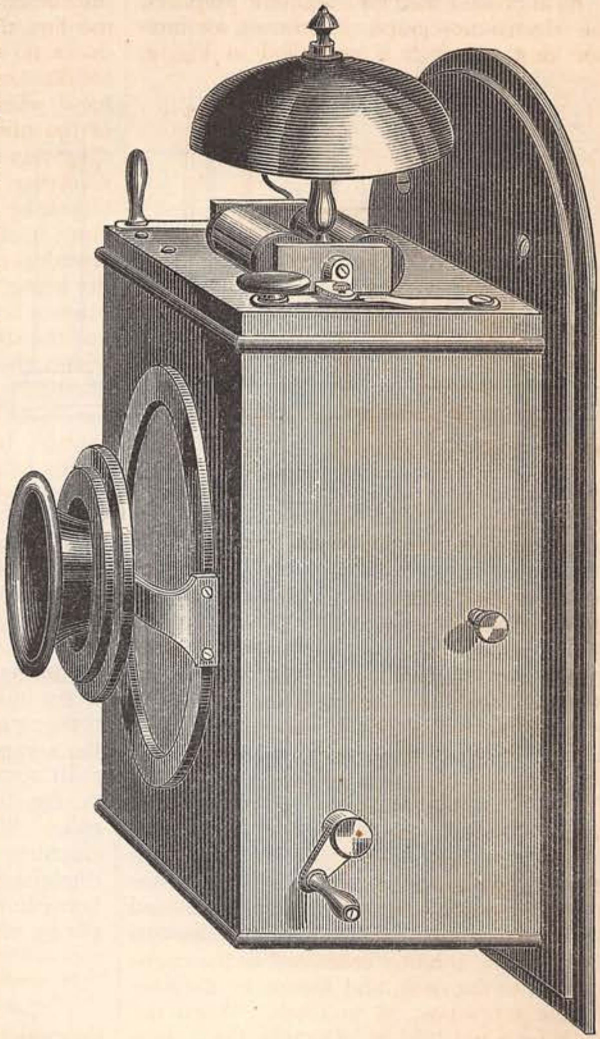

FIG. 4.—VIEW OF THE COMPLETE CHEMICAL TELEPHONE.

APPLICATION TO SIGNALING.

AMONG the other applications which Mr. Edison has already made of the discovery is one in connection with signaling at a distance by bells without the employment of electro-magnetism. Fig. 5 illustrates the method. A metal arm, B, is so arranged by connection with the upright, C, as to rest with some little pressure upon a cylinder of prepared chalk, A, chemically saturated in the manner already described. A spring, E, attached to the upright, C, tends to hold the metal arm back. The arm and chalk cylinder are now attached to the telegraph line. W, W, and made part of the electric circuit, Fastened to the metal arm is a knob, M. If, while the cylinder is revolving, a current

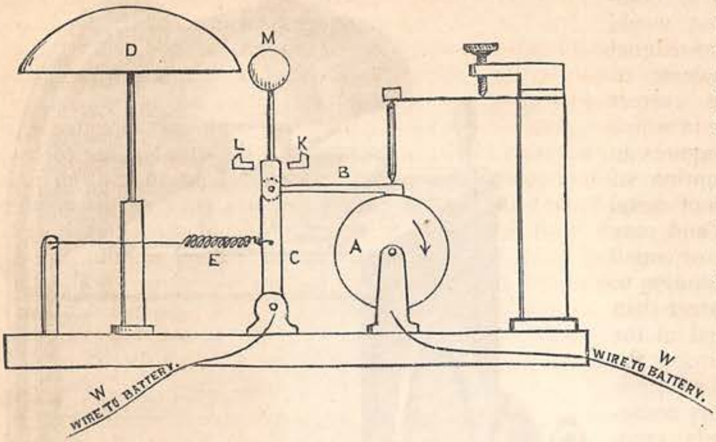

FIG. 5.—APPLICATION OF THE ELECTRO-MOTOGRAPH TO SIGNALING AT A DISTANCE.

of electricity be transmitted over the line, the friction between the metal arm, B, and the cylinder, A, is diminished and the spring, E, pulls back the arm, causing the knob to strike the bell, D. K and L are stops adjusted to regulate the movements of the upright, C.

APPLICATION TO LESSEN FRICTION.

But important as is the electro-motograph for the production of mechanical movements at a distance, its application to machinery is entitled to as much consideration by the world of science. To devise methods and appliances by which the friction incidental to machinery in motion may be reduced to a minimum has been an aim of inventors ever since machinery first became a factor in the beneficent work of lightening the labor of man and beast. That great success has attended such efforts every one familiar with machinery knows; but still the lubricating liquids and other agencies employed for the purpose, excellent though they are, leave a wide margin for improvement, for not an inconsiderable portion of the horse-power used in running machinery is wasted in overcoming the friction that exists throughout the various parts. In heavy machinery especially, this loss of power becomes an important element of consideration. By the application of the electro-motograph principle the friction is reduced to a minimum. Fig. 6 will illustrate the application to machinery. S S is an iron shaft revolving in its compartment or journal A, which latter is lined with a layer of leather, D, chemically saturated, on which rests and revolves the shaft. A current of electricity from the cell of battery, B, passes along the wire through the shaft, S S, thence through the chemical solution of the compartment or journal in which the shaft rests, and by the return wire back to the battery, thus completing the circuit. While the shaft is revolving, the electricity is performing its function of diminishing the friction that normally exists between the shaft and its journal. The simplicity of the contrivance makes it applicable to almost every mechanical movement generating friction. The locomotive puffing with its long train of cars, as well as the tired and jaded horse panting under an

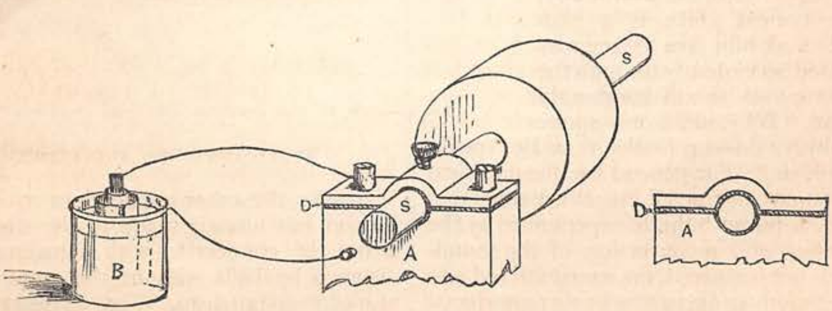

FIG. 6.—APPLICATION OF THE ELECTRO-MOTOGRAPH TO MACHINERY, TO LESSEN FRICTION.

overloaded wagon, may each, by the diminution of the friction of the axles, have its respective burden lightened.

APPLICATION TO OCEAN CABLES.

ANOTHER property of the electro-motograph, and one fully as important as any that have been referred to in the preceding pages, is its ability to increase the speed of transmission of messages over long ocean cables. The slowness of the Atlantic cable, as compared with the land lines, is the principal cause for the present high tariff for messages between this country and Europe. If the cables could be made to transmit as many messages in a given time as can be

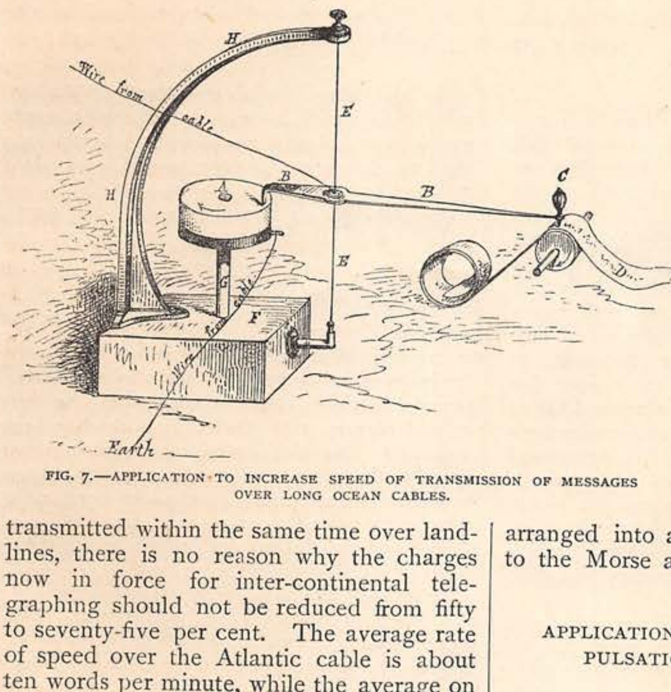

FIG. 7.—APPLICATION TO INCREASE SPEED OF TRANSMISSION OF MESSAGES OVER LONG OCEAN CABLES.

transmitted within the same time over land-lines, there is no reason why the charges now in force for inter-continental telegraphing should not be reduced from fifty to seventy-five per cent. The average rate of speed over the Atlantic cable is about ten words per minute, while the average on land-lines of this country is about twenty-two words per minute. The peculiar phenomena incidental to the transmission of electrical impulses through submarine cables of great length, such as the Atlantic cable, have made a higher rate of speed hitherto unattainable. To increase the speed of the Atlantic and other long cables to twenty-five or thirty words per minute, Mr. Edison has devised a special electro-motograph (Fig. 7). The precipitated chalk with its chemical solution is made this time in the form of a disk, A, two inches in thickness and five inches in diameter, attached by its center to a small upright post of metal, G, which rotates the disk by means of clock-work in the box, F. Resting on the disk is one end of the metal arm, B B, the other end of which contains a small pencil or stylus, C, for marking the roll of paper, D, passed under it. Through the metal arm, a few inches from the disk, is run a torsion-wire, E E, fastened at either end to small screws. The wire from the cable is connected with the metal arm, and the wire leading to earth is connected with the chemical solution in the chalk disk. The tendency of the torsion-wire, E E, is to swing to one side the metal arm, B B, but the normal friction existing between the metal arm and the disk at their point of contact overcomes this tendency, and the metal arm remains in a fixed position. If now, while the disk is being rotated, a current of electricity is sent over the cable through the wire, thence to the metal arm, B, and through the chemical solution on the disk, A, to the earth, the normal friction between the point of the metal arm and the disk is diminished, and the torsion-wire, E E, having no counteracting force, swings to one side the metallic arm, B B, and a mark is made on the roll of paper passing under the extreme right of the metal arm. These marks may be readily arranged into a code of characters similar to the Morse alphabet.

APPLICATION TO ASCERTAIN FEEBLE PULSATIONS OF THE HEART.

CONNECTED with the carbon telephone the electro-motograph may be employed to detect the feeble pulsations of the heart of a person seemingly dead. For this purpose, place over the heart a very delicate carbon receiver which is attached by wires and a cell of battery to a specially prepared electro-motograph made to amplify sound many degrees. The pulsations of the heart act upon the delicate carbon and it in turn vibrates the diaphragm of the electro-motograph upon the general principles already explained. Inasmuch as the degree of amplification of the sound-waves by the electro-motograph may be regulated to suit the necessities of the occasion simply by increasing the area of the diaphragm, it can readily be understood that the most delicate of sounds may be brought out with clearness and, what is more, with absolute accuracy. And in connection with accuracy it may be observed that the electro-motograph, as used for the purpose of amplifying sound, overcomes a defect in the microphone that has been quite a serious drawback to the usefulness of that instrument. The microphone, as is well known, amplifies sound-waves many degrees, making audible, for instance, such delicate sounds as those made by the feet of a fly passing over paper, but unfortunately, the reproduction of the sound as amplified is far from accurate. On an average, about four times out of ten the sound as amplified cannot be recognized as the original sound, the changes in its character being due to the magnetism employed, which latter interjects its own attending phenomena. All the wonderful results in the amplification of sound, attainable by the microphone may be obtained, and in a more perfect manner, by the electro-motograph.

TOPICS OF THE TIME.

Southern Civilization.

We wonder if the South knows how hard it is making it for its friends and those who would think well of its spirit and society. We know there are two Souths, but everybody does not know it. We are quite aware, and every one is likely to be so, that the South is politically a unit for its own purposes. Even in this we think Southerners make a grave mistake, as Southern solidarity will be sure to beget Northern solidarity, and the South knows what that means for them and their views of national policy. But for this we have no disposition to blame them. We understand in this quarter that the South has no great love for the national flag as such, and that "the lost cause" is still very precious to its politicians and its people. We understand this, we say, and we expect in all their dealings with national affairs only such a policy as would naturally be dictated by the circumstances in which they are placed, and the unrepentant spirit which still possesses them and on which they take their stand and boldly make their boast.

With this we do not quarrel. We expect it. It is the most natural thing in the world that we should have it; but certain events have occurred in the South of late with astounding frequency, which betray a condition of morals and society that makes every true friend of the South and every true American hang his head in shame. Murder after murder is perpetrated in high life with the coolest blood and nobody is arrested for it and nothing is done about it. Now, as we have said, we are perfectly aware that however much of a unit the South may be politically, there are socially two Souths. There is a law-loving and law-abiding South, and there is a South that is neither the one nor the other. We understand perfectly that to a great number of Southern people such a beastly murder as that of Judge Chisholm and his family is horrible. We understand that to these people such notable murders as have taken place all over the South during the last three months are a great shock and a great sorrow. The feeling finds expression in some of their best newspapers, but the trouble is that this South is utterly overawed by the other South, so that no man dares to move for the maintenance of the law and the punishment of crime. Murder is committed, and the murderer shakes his bloody hands at the law everywhere and walks the streets with entire freedom and impunity. Human life is accounted of no sacredness whatever, and law and the executors of law are held in perfect contempt. The judge upon his bench is not safe. Even the lawyer who tries a case that involves any serious personal relations takes his life in his hands when he does so. The most trivial causes seem sufficient to awaken the brutal instincts of men and to induce the extreme of violence. Fighting weapons seem to be in every man's pocket, as if he lived in a state of war, and he does not hesitate to use them on the smallest provocation.

We read of banditti in Italy who make it unsafe for a traveler who has any money to get outside the lines of ordinary travel, and we wonder at the imbecility of a government that can give him no protection, and at the low state of civilization that renders such abuses and outrages possible. We have no longer any reason to look abroad for anomalies of this sort. These Southern murders give evidence of a lawlessness and a degraded civilization much more notable than anything that can be found among the Italian wilds and mountains. They are abominable, beyond the power of an ordinary pen to characterize. There is nothing whatever to be said in apology for them. The American, when he reads of them, can only hang his head in horror and shame, and groan over the fact that such fiendish deeds can be perpetrated under his national flag without punishment, and without even the notice of those who pretend to administer the law.

desired concessions, provided trade should be opened with them. Mr. Mackenzie has also marked out a new route leading from Port St. Bartholomew to Timbuctoo, distant only 800 miles, being 1,200 miles shorter than any other route leading from the coast to Timbuctoo. This line of communication, known as the "Wadan Route," skirting the western and southern limits of El Juf, besides being so much shorter than all others, has the advantage of having forty-two excellent stations, and what is far more desirable, passes through the territory of a friendly and commercial people, who pledge themselves to further and protect the interests of trade.

Mr. Mackenzie estimates that the establishment of the station at Port St. Bartholomew will soon increase the foreign commerce of Timbuctoo from $20,000,000 to $60,000,000 per annum. So, even if the enterprise to which this is auxiliary is never carried to success, at least a new route to the center of Africa has been established.

Although the basin of El Juf has been sufficiently examined to afford assurance that its submergence will not disturb the residence or rights of any of the inhabitants of the desert, but on the contrary visit untold blessings upon the vast region which environs it, still Mr. Mackenzie deems it necessary that a thorough survey of its entire boundaries and depth should be made prior to the admission of the sea. M. de Lesseps, in his recent visit to Tunis and the adjacent desert, found that the elevation of the oases in the northern Sahara ranges from thirty to forty meters above the level of the Mediterranean, while the desert itself is considerably below sea-level. The work of exploring thoroughly so large a district as El Juf, however, can only be accomplished after the confidence and co-operation of the natives have been gained through the commercial intercourse which will spring up with the opening of the "Wadan Route."

As Mr. Mackenzie has made the preliminary arrangements for putting Port St. Bartholomew into communication with Timbuctoo, we may look for the completion of his magnificent scheme and the consequent opening of Africa to commerce and civilization at no distant day. Nor do we hope for anything less than success for the French expedition. Either of these audacious movements may by one bold stroke solve the mystery of the great continent and earn for its author the gratitude of the world of science.*

* Obligations are hereby expressed to Lieutenant-Commander Francis M. Green, U. S. N., of the Hydrographic Office, Washington, who, at the instance of Professor Spencer F. Baird, has furnished for this article valuable material relative to the French expedition.

EDISON'S INVENTIONS. II.*

THE CARBON BUTTON AND ITS OFFSPRING.

Not the least curious in the analytical study of Mr. Edison's numerous inventions is the readily observable peculiarity that the most important of them are the offspring or natural outgrowth of parent germs involving the discovery of previously hidden properties of nature, on which they depend and by which they are rendered susceptible of classification. The electro-motograph, treated of in the last paper, was an illustration in point. There the parent discovery or germ was the fact that the passage of an electric current through a substance saturated with certain chemicals diminished the friction normally existing between the surface of such substance and the electricity-conducting metal resting upon it. On this principle Mr. Edison constructed his automatic telegraph, which transmits telegrams at the rate of fifteen hundred words per minute, and devised the application to lessen the friction of machinery, the appliance for magnifying and reproducing sound electrically transmitted from a distance, and the apparatus for increasing the speed of telegraphic transmission over long ocean cables. From other beneficent scientific germs, as we shall see, he has deduced various other valuable practical applications.

This peculiarity is noticeable in the "carbon button," which is the generic title Mr. Edison has given to the various substances evincing the characteristics so strongly displayed by compressed carbon when subjected to electrical action. The basis of this, the parent discovery, is the principle that when a current of electricity is passed through a quantity of finely divided conducting matter, such as finely divided metals, conducting sulphides, oxides, graphite or carbon in its various forms, the slightest pressure on such finely divided conductor varies the strength of the electric current by diminishing the resistance offered to its passage. From this germ have sprung: 1. the transmitting telephone, 2. the micro-tasimeter or instrument for the detection of infinitesimal quantities of heat, 3. the pressure relay, 4. the carbon rheostat,—the two latter valuable acquisitions to practical telegraphy,—5. the hygrometer or instrument for detecting infinitesimal moisture, and 6. the odorometer, or instrument for detecting the presence of certain chemical vapors. And these curious properties and powers of the original discovery by no means form its limit, for Mr. Edison has already outlined other applications which give promise of much practical value.

The discovery of the property involved in the carbon button was made by Mr. Edison in the year 1873, while he was prosecuting experiments looking toward the more rapid transmission of messages over long submarine cables. To carry on his experiments properly, it was necessary to have, in small space, large resistance to the passage of the electric current, and for this purpose he pressed finely divided graphite carbon into tubes of glass, and connected many tubes together, the whole number offering a resistance to the passage of the electric current many times greater than is offered by the Atlantic cable. To these tubes contained in boxes, subsidiary apparatus was connected to imitate as near as possible all the phenomena which arise in telegraphic transmission over long cables. When the metallic ends inserted in the tubes were pressed upon the carbon or set in vibration, Mr. Edison noticed a diminution of resistance to the passage of the current; this susceptibility to pressure on the part of the carbon rendered the whole apparatus unreliable for nice experiments and it was abandoned as a failure. Here, then, we perceive the first glimmerings of light on the future telephone. The discovery of the peculiar property possessed by finely divided conductors, namely, that of having their electric resistance varied by pressure, was an accomplished fact, but its importance was unknown and unappreciated. The finely divided conductors did what Mr. Edison wanted them to do, namely, give great resistance in small space; but they did more: their great delicacy rendered uniformity of resistance almost impossible, as the slightest pressure caused variation. And so it came about that the discovery was permitted to slumber.

THE TELEPHONE.

THE succeeding steps in the history of the carbon button oblige us to follow the progress of the telephone, for the two are inseparably connected. In June, 1875, Mr. Edison began a series of experiments with a system of multiple telegraphy, having for its basis the transmission of acoustic vibrations. Among the first instruments devised by him for the purpose were a transmitter and receiver, shown in Figs. 1 and 2 respectively.

In Fig. 1, A and B are tuning-forks, placed over electro-magnets and made to vibrate a certain number of times per second. Each carries at its end a plunger or rod, C and C, which dip into the chambers of water, W and W, so that the vibrations of the plungers or rods which do not touch the conducting wires, D and D, will cause variations in the re-

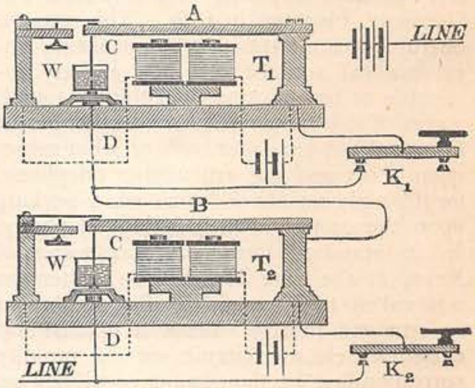

FIG. 1.—EDISON'S ACOUSTIC TRANSMITTER.

sistance, and consequently in the strength, of the current passing through the rods, C and C.

In the receiving instrument used by Mr. Edison at the same time [Fig. 2], R^1 and R^2 are telescopic tubes of metal, by the lengthening or shortening of which the column of air in either could be adjusted to vibrate in unison with the proper note of the fork whose signals were to be received by each particular instrument. An iron diaphragm was soldered to one end of these tubes, and the latter placed in such a manner as to bring the diaphragm of each respectively in front of an electro-magnet, which in action would cause them to vibrate.

The first attempt by Mr. Edison at an

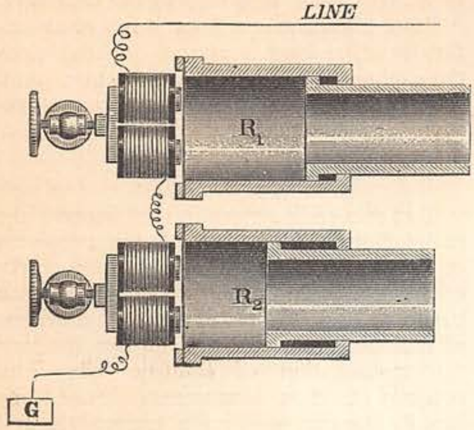

FIG. 2.—EDISON'S RESONANT RECEIVER.

articulating telephone was in July, 1875, some months before Professor Bell brought out his telephone. Previous to that time, Mr. Edison's telephonic experimenting had all been in connection with acoustic transmission other than the human voice. A short time before, he had seen a description of the telephone of Philip Reiss, of Germany, invented in 1861. This was an instrument for electrically transmitting vocal musical sounds. It was entirely incapable of transmitting the complex sound-waves of the human voice, and at its best it furnished but a meager basis of what subsequently became the articulating telephone, for it simply set Mr. Edison's mind working upon the subject of articulating telephony. In its standard form, the transmitter of Reiss, at the time Mr. Edison's attention was called to it, consisted of a diaphragm so arranged that its vibrations opened and closed an electric circuit with a rapidity corresponding to the number of vibrations. The receiving instrument consisted of a coil or helix, inclosing an iron rod and fixed on a hollow sounding-board,—being founded on Professor Page's discovery that iron bars, when magnetized by means of an electric current, become slightly elongated, and at each interruption to the passage of the current are restored to their normal length. These various elongations and shortenings of the iron bar inclosed in the helix correspond with the vibrations of the diaphragm, thereby emitting an audible sound at each change in length, such sound being magnified by the hollow sounding-box. The best result that had been obtained from this system was the reproduction at the distant end of the wire of the pitch of the sound; the intensity and quality of the sound could not be transmitted or reproduced.

One of Mr. Edison's experiments was to use a modification of the Reiss transmitter in connection with his own resonant receiver [Fig. 2]. Among the changes in the form of transmitter which he applied, was the introduction, between the points, of drops of water; but rapid decomposition of the water took place, leaving a sediment upon the platinum points, and preventing satisfactory results. On the same principle, he next applied sponge-paper and felting saturated with various solutions, and also points immersed in electrolytic cells (or cells containing water) whose conductivity was increased by the mixture of appropriate salines.

From none of these experiments, however, could he obtain satisfaction. His objective point was a telephone which would transmit the sound-waves of the human voice. He was convinced that such a result could be obtained and that its accomplishment was only a question of time and research. After much diligent labor in this direction, each step gradually paving the way for what was to come, and intensifying the determination of the inventor, he finally laid aside the line of investigation in which he had so long been engaged and branched off into another. He had proceeded far enough to learn the important fact that, for the object in view, the use of decomposable fluids was practically a waste of time.

Mr. Edison's new departure in his telephonic researches was to vary the resistance of the circuit proportionally with the amplitude of the vibrations of the diaphragm, and for this purpose he used at first a multiplicity of platinum points, springs and resistance coils, all of which were designed to be controlled by the movements of the diaphragm. None, however, gave satisfaction. The experimenting continued until the spring of 1876, when another change of plan having been made, Mr. Edison succeeded in utilizing the great resistance offered to the passage of the electric current by thin films of plumbago on white Arkansas oil-stone and on ground-glass. Here for the first time he succeeded in conveying the sound-waves of the human voice by electricity, being many articulated sentences transmitted. It was like the first sign of land after a long and dreary voyage over the ocean.

Fig. 3. shows the device employed. A metal spring, L, attached to a diaphragm, D, vibrating in a horizontal plane, has a roller on one end which rests upon a film of plumbago upon Arkansas oil-stone, S. C is a metal clamp resting also on the film and connected with the line. M is the mouth-piece. The spring, L, and clamp, C, being connected to the current, the film of plumbago becomes part of the current, and the vibrations of the spring to and from the clamp, caused by the voice spoken into the mouth-piece, vary the resistance of the current by including in the circuit more or less of the film of plumbago.

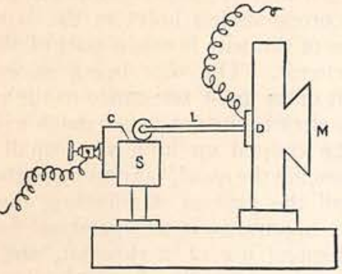

FIG. 3.—EDISON'S FIRST ARTICULATING TELEPHONE.

But encouraging as were the results of this and kindred devices, there remained great difficulties in the path of complete success, chief among them being the disturbances which the devices caused in the true vibrations of the diaphragm. Modification succeeded modification, but the difficulties still remained—to be overcome only by the carbon button.

Disappointed but not discouraged by the numerous obstacles in his path, Mr. Edison, in January, 1877, bethought him of the discovery which he had made in 1873 (as before mentioned) of the principle that under pressure the electrical conductivity of certain semi-conductors is greatly varied. It will be further remembered that the excessive delicacy of such variation was the cause of Mr. Edison having laid the discovery aside as unsuitable for application to rheostats. Taking up the principle, he now devised numerous forms of application, one of which is shown in Fig. 4. A A is a diaphragm carrying at its center a yielding spring, B, faced with platinum. C C is a stick of crude plumbago combined in proportion with dry powders and resins and held in the cup, D, and moreover adjustable by means of the screw E. When working, the plumbago was adjusted so as lightly to touch the platina on the yielding spring, B. The vibrations of the voice spoken into the mouth-piece, M, caused the platina to press upon the plumbago with a pressure corresponding to the amplitude of the vibrations, thus varying the resistance.

After conducting a long series of experiments with solid materials on the principle involved in Fig. 4, though with various modifications, Mr. Edison abandoned the solids and substituted therefor tufts of conducting fiber, consisting of floss silk coated with plumbago and other semi-conductors. One of the chief difficulties he experienced in obtaining a good articulating telephone was the too great delicacy of the apparatus; for, while giving poor articulation it showed a wonderful degree of sensitiveness to pressure, reproducing the slightest sounds in a highly magnified tone. This property of the incipient telephone, of being able to magnify sound, was often about this time the subject of much thought to Mr. Edison, who, while admiring it as a curiosity of science, was nevertheless very anxious to get it under control, since it readily magnified such delicate noises as that made by moving the finger on a piece of board, or that caused by a breath. The apparatus which utilized this property was afterward named the "microphone" by Professor Hughes of London, who investigated the subject, and made a number of curious devices for exhibiting the property. The results from the various devices tried by Mr. Edison for the purpose of reducing the delicacy of the instrument were much better, but while the volume of sound was great, the articulation was still indistinct. Besides, the instruments needed frequent adjustment to be kept in proper working order. About this time another truth dawned upon the inventor. The normal resistance of the finely divided conductors in the form then used was too

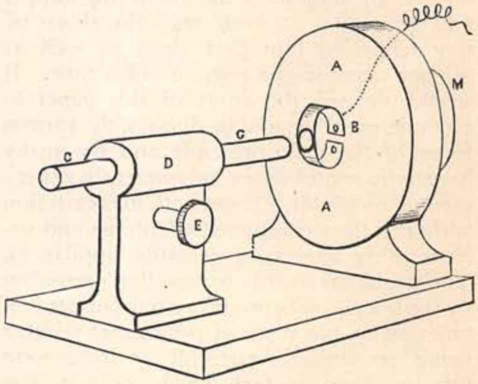

FIG. 4.—CARBON TELEPHONE.

great, and Mr. Edison readily saw that the desideratum was a form of the semi-conductor of such a character that while the normal resistance it offered to the passage of the current would be small, its essential property of varying the resistance upon slight pressure would not be impaired. With this principle in view, he constructed a transmitter having a button of the solid plumbago employed by electrotypers. From this he obtained excellent results, but the volume of sound was deficient. To improve in this line the inventor then began an exhaustive series of experiments, in search of some finely divided conducting substance, to act better in the form of a button than plumbago. In the course of such experiments he used conducting oxides, sulphides and various other partial conductors, besides finely divided metals. From all, or nearly all, articulation of an imperfect character was obtained.

Having noticed one day in the laboratory the blackened chimney of a petroleum lamp that had been smoking the night before, he was struck with the intense blackness of the soot, and impelled by curiosity, scraped off a small quantity for examination. A few weeks later, it occurred to him to mold the lamp-black in the form of a button, and try it as a conductor in connection with the incomplete telephone. The result was surprising; the articulation came clear and distinct, and the overjoyed inventor celebrated his discovery by forgetting all about his supper and remaining at work until the dawn of day reminded him that sleep as well as science demanded a portion of his time. It would exceed the limits of this paper to recount, even by passing allusion, the various forms of the main principle and the many ingenious contrivances subsequently experimented on by Mr. Edison both in connection with the then completed telephone and various other interesting scientific appliances. The world has heard conversation carried on by the telephone between persons hundreds of miles away, the voice of the distant speaker being recognized as readily as if he were face to face,—a feat which only a few years ago the most distinguished scientific men would hardly have believed possible. It has read the accounts of the sensitiveness of the tasimeter responding to the heat of distant stars, and has wondered at the marvelous power the principle displays when adapted for the amplification of sound, as in the Hughes microphone, which distinctly reproduces such faint sounds as those made by the footsteps of a fly, and makes the drawing of a breath sound like the roar of the wind in a forest.

THE CARBON RHEOSTAT.

Often in practical telegraphy it becomes necessary for the operator, especially if he be working a duplex or quadruplex wire, to throw in resistance to the passage of the electric current over the line. For this purpose rheostats are used. They consist of bobbins or coils of fine wire in a box, so arranged that by inserting small brass plugs into corresponding holes in the box, more or less of the wire is made part of the electric circuit. The wire being exceedingly fine, it offers great resistance to the passage of the electric current, hence much resistance can be cooped up in a very small space. "Balancing the quad," as practical telegraphers call the process of adjusting the quadruplex apparatus, is an operation that calls for frequent use of a rheostat, and much inconvenience results from the length of

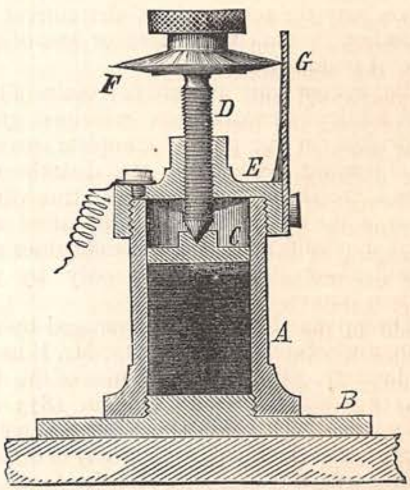

FIG. 5.—VERTICAL SECTION OF CARBON RHEOSTAT.

time consumed in its proper manipulation. To remedy this difficulty, Mr. Edison devised a "carbon rheostat," working upon the principle of semi-conductors changing their resistance under pressure,—the principle which we have just considered in his telephone.

Fig. 5 shows a vertical section of this invention. A is a hollow cylinder of vulcanite containing fifty disks of silk that have been saturated with sizing and well filled with fine plumbago and dried. These are surmounted by a plate of metal, C, which can be raised or lowered by turning the screw, D. The disks can thus be subjected to any degree of pressure, and the rheostat being placed in circuit, a corresponding resistance is thus thrown into the line. F is a circular scale attached to the screw, D, and marking off on the graduated upright, G, the quantity of pressure on the disks. The instrument has been found in telegraph offices to be of much practical value on lines where small battery power is employed.

THE MICRO-TASIMETER.

THE invention of the micro-tasimeter was due to the discovery made by Mr. Edison while experimenting on the carbon telephone that the heat of his hand threw the instrument out of order. He had noticed that almost every time he took up the telephone he found it necessary to adjust it, and as the apparatus was well made in all its parts he could not understand why such care and attention were necessary. He finally discovered that the change in adjustment was rendered necessary by the elongation of the handle of the telephone, such elongation being due to the heat from the hand of the holder. Iron handles were substituted, but the sensitiveness continued, and was accompanied with a delicate noise (audible on pressing the instrument close to the ear) that sounded like a faint metallic ringing in the distance. To this phenomenon Mr. Edison gave the name of "molecular music," attributing it to the noise made by the changing of the molecules of the metal in the expansion and contraction. Having thus learned that small quantities of heat could in this manner be detected, the inventor left the telephone for a brief time, to indulge in a little scientific by-play on the new discovery. A series of experiments evolved the fact that the best method of application was by the use of a strip of vulcanite whose sensitiveness to heat made it particularly desirable. The next step was the perfected micro-tasimeter, a vertical section of which is shown in Fig. 6.

In the vertical section, Fig. 6, A is a strip of vulcanite rubber firmly clamped at B, its lower end fitting into a slot in the metal plate, M, which rests on the carbon button, C. By wires leading from the upper plate, M, and the lower plate, P, the button is in electric circuit with a battery and delicate galvanometer (not shown in the cut). The funnel, F, serves to focus heat upon the vulcanite strip, A. Any elongation of the strip (the result of increased temperature) causes pressure upon the carbon button, C, altering the resistance to the passage of the current flowing through it to the galvanometer, which variation the galvanometer faithfully indicates by deflection of its needle. In order to ascertain the exact amount of expansion in decimals of an inch, the screw, S, seen in front of the dial, D, is turned until the deflection previously caused by the change of temperature is reproduced. The screw works a second screw, causing the vulcanite strip to descend or ascend, and the exact distance through which the rod moves is indicated by the needle, N, on the dial. The use of vulcanite as the strip is not essential; other substances, susceptible to expansion and contraction by change of temperature, may be employed, but the most satisfactory results have been obtained by the employment of vulcanite.

The first practical test of the power of the tasimeter was made by Mr. Edison on the night of July 29, 1878, at Rawlins, Wyoming Territory, whither he had gone as a member of Dr. Draper's expedition to view the eclipse of the sun. The extremely sensitive character of the tasimeter made it an object of much interest to the scientists composing the expedition, and accordingly every preparation was made to have a thorough test of its powers on the sun's corona during the few moments of totality. The night previous to the eclipse all was got in readiness for a preliminary test to insure the proper working of the instrument, and the star Arcturus was selected as the object of experiment. The tasimeter was placed on a stand firmly fixed on the earthen floor of a wooden shed at the base of a hill, and so arranged that local variations in the temperature, such for instance as that produced by the approach of a person, would affect it only at a minimum. For this purpose the apparatus was surrounded by ice in water, which kept the temperature uniform for a considerable period. A highly sensitive galvanometer, on whose needle was attached a tiny mirror of trifling weight, was included in the electric circuit with a few cells of battery and the tasimeter. Opposite the galvanometer on the floor was placed a graduated horizontal scale, behind which was a lamp which threw a ray of light through a slit in the bottom of the scale upon the tiny mirror attached to the needle of the galvanometer. The working of the apparatus was as follows: A large telescope was adjusted to the star Arcturus, the small end or eye-piece of the telescope being placed into the funnel of the tasimeter, so that the ray of light from the star was focused upon the vulcanite strip in the tasimeter. The heat from the ray of starlight thus focused affected the sensitive vulcanite, causing a

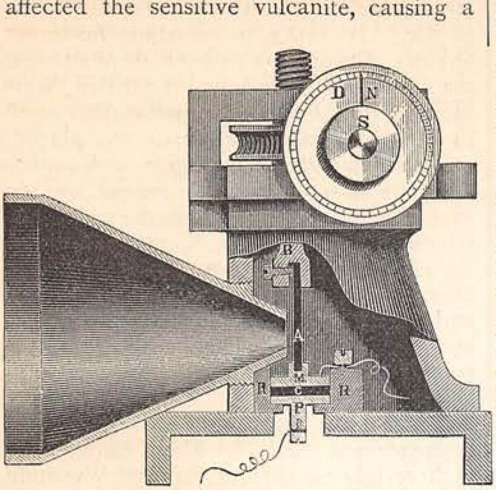

FIG. 6.—VERTICAL SECTION OF MICRO-TASIMETER.

minute elongation and a consequent pressure of the vulcanite upon the carbon button, which pressure varied the electric current passing through the button, the variation being denoted by the deflection of the galvanometer needle. Now the tiny mirror fastened to the needle of the galvanometer moved of course with it, reflecting the ray of light from the lamp before mentioned upon the graduated scale. The slightest fluctuation of the galvanometer needle caused considerable fluctuation of the ray of light on the graduated scale, so that the most delicate changes were made observable. When all was in readiness, the telescope was adjusted to the star, while Mr. Edison, on his hands and knees, eagerly watched the fine lines of the graduated scale. Several minutes passed by and no word came from the anxious inventor. The ray of light stood at zero, moving neither to right nor left, and the astronomers began to doubt the powers of the instrument. "It's strange," muttered Mr. Edison, as he watched the ray of light in its stubborn adherence to zero; "it ought to work, and I'm sure it will." Then he began examining the connections, and soon discovered the cause of the trouble: a wire had been improperly arranged. The obstacle removed, the telescope was once more adjusted to the star, and scarcely had the ray been focused when the light reflected from the mirror moved over twenty degrees of the graduated scale, a result repeated several times.

The day of the eclipse saw Mr. Edison again at his post, getting the instrument in readiness for the test on the heat of the corona. The time set by nature for the continuation of the total eclipse was two minutes and fifty seconds, beginning at 3:15 P. M., local time, and in this small interval the measurement of the corona's heat had to be taken, if at all. The success of the night previous had made all the party confident of happy results with the delicate instrument, and it was therefore with no little chagrin and disappointment that the assembled astronomers perceived the wind gradually increasing, rocking the frail structure in which the tasimeter was located, and interfering with its delicacy. By noon the gale had became a tornado, and the prospects of success were exceedingly poor. In vain Mr. Edison, assisted by a dozen stalwart workmen, propped up the little shed with boards to keep it from swaying. It was too late at that time to remove the instrument and its accompaniments to a place of greater stability, for, in less than ten minutes, the precious moments of totality would be at hand. Fortunately, however, just as all hope of a successful experiment had been abandoned, the wind suddenly subsided. Mr. Edison hastened to take advantage of the opportunity. The moon was then about seven-eighths across the face of the sun. The telescope was held in position while the inventor adjusted the delicate tasimeter. This operation consumed the precious minutes, one after another, until at last the sun was totally eclipsed; but still the tasimeter was unprepared for its task. At length, just as the chronometer indicated one-half minute more of totality, the instrument was brought into action and the heat from the sun's corona was concentrated on the delicate vulcanite and the ray of light ran clear off the graduated scale,—thus proving that this instrument is remarkably sensitive to heat and opening a wide field for future experiments in the measurement of the heat of heavenly bodies.

TO DETECT THE APPROACH OF ICEBERGS.

AN exceedingly simple, but highly useful, adaptation of the carbon button in connection with the tasimeter principle is suggested for use in vessels at sea, warning navigators of the approach of icebergs long before there is any danger of encountering them. The apparatus would consist of a carbon button in a small tube of glass, resting upon one end of a little rod of one of the substances impressionable to changes in temperature,—the whole placed in a tube or pipe attached to the bottom of the vessel in such a way that the water continually flows through it, but does not come in contact with the electrical apparatus. The carbon button could be kept in electrical connection with a galvanometer placed in the captain's office or elsewhere on the ship. The substance pressing upon the carbon button, being susceptible to changes in temperature, would contract or expand in response to the heat or cold of the water flowing around it, such expansion or contraction acting upon the carbon button and increasing or diminishing the pressure upon it, thus deflecting the needle of the galvanometer. By practice, a sea-captain would thus be enabled not only to know of the approach of icebergs, but also to tell approximately their distance. There are various other devices in this connection which, if thoroughly investigated by navigators, might be made of great service at sea.

THE PRESSURE RELAY.

IN the pressure relay, an instrument for repeating from one electric circuit into another currents of variable strengths, Mr. Edison has made another adaptation of the carbon button. In this he uses thin disks of plumbago as the finely divided substance, the more delicate lamp-black being too sensitive for the work required. Upon the disks of plumbago, A A [Fig. 7], is laid the armature, B, which is provided with a binding post, C, for clamping the local battery wire. The cores of the main line (or relay) magnet, M, the plumbago and the armature are included in a local circuit which also contains an ordinary "sounder," N, and cells of local battery. The main line magnet is inserted in the ordinary manner. The working of the instrument is as follows: when the main circuit is broken the attraction for the armature ceases and the only pressure upon the plumbago disks is that caused by the weight of the armature itself. With only this pressure the resistance of the plumbago to the passage of the local current is considerable; with this resistance in the local circuit the sounder remains open. If now the main circuit be closed, a powerful attraction takes place between the poles of the main line magnet and its armature, causing a corresponding increase in the pressure upon the plumbago disks and reducing their resistance to a fraction of what it previously had been; consequently the sounder closes. Thus far the working differs but little from the ordinary relay and sounder. But the great difference between this relay and those in common use is that it repeats from one circuit to another the relative strengths of the current in the first circuit. For example, if a weak cur-

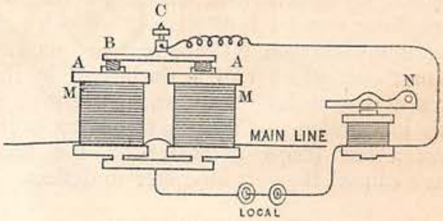

FIG. 7.—PRESSURE RELAY.

rent circulates upon the line in which a relay magnet is inserted the attraction for its armature will be small, the pressure upon the plumbago disks will be light, consequently a weak current will circulate within the second circuit; and on the contrary, if the current in the first circuit be strong, the pressure upon the plumbago disks will be increased and the current of the second circuit will be increased in proportion. No adjustment is ever necessary. With some modifications the apparatus may be used as a telephonic repeater.

THE HYGROMETER.

IN the course of his experiments on the tasimeter, Mr. Edison used a variety of substances as the strip or rod to press upon the carbon button, and among the number gelatine; and as the latter exhibited a wonderful sensitiveness to moisture, he soon set about constructing an instrument which would utilize this phenomenon. Fig. 8 shows the device for this purpose. A is a strip of gelatine, one end of which

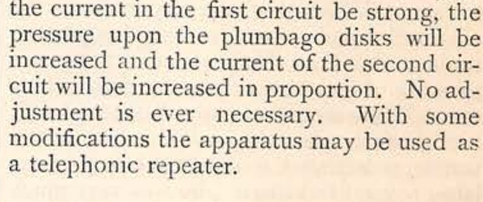

FIG. 8.—THE HYGROMETER.

presses on the carbon button, B. The latter is in electric circuit by wires from the screw posts, E and D, to the battery, F, and the galvanometer, G. The slightest moisture acts upon the sensitive gelatine strip, A, causing it to become more mobile and to vary the pressure upon the carbon button, B, thus varying the resistance of the latter to the passage of the electric current, which variation is denoted in the galvanometer, G. By this apparatus infinitesimal changes in the moisture of the atmosphere can be indicated, changes which are many thousand times less in quantity than those which can be indicated by the present barometer. Indeed, so sensitive is this instrument to the influence of moisture that a few drops of water on the floor have caused the galvanometer to deflect.

THE ODOROMETER.

A SIMILAR application of the carbon button is called by Mr. Edison "the odorometer." Having discovered that vulcanized rubber or ebonite was softened and made pliable as leather when immersed for several days in nitro-benzol or the artificial oil of almonds, the inventor began a series of experiments to ascertain whether the vapor from the chemical would not contract or elongate the rubber, and thus decrease or increase the pressure of the rubber upon the carbon button. When a strip of paper moistened with nitro-benzol was held within a foot of the tasimeter adjusted to detect the heat of the hand several feet distant, he was very much surprised to find that the galvanometer, which was in electric circuit with the tasimeter, produced a movement of the spot of light. Continuing his experiments, he ascertained that the deflection was not due to heat or to cold produced by evaporation of the chemical, but to the fact that the vapor of the chemical acted upon the rubber near by, rendering it less stiff and consequently producing a lessening of the normal pressure upon the ebonite strip. While this phenomenon was always manifested by the vapor of the nitro-benzol, the vapor from other chemicals produced no corresponding effect. Mr. Edison also found upon experiment that if strips of other materials were substituted for the ebonite or rubber strip and coated with certain substances, a deflection of the galvanometer needle always took place, provided the coating substance was soluble in the liquid whose vapors were sought to be detected. For instance, if the coating was shellac (which is soluble in alcohol) and the alcohol was held near by so that its vapor came in contact with the shellac, the needle was instantly deflected.

Fig. 9 shows the apparatus. B is the vulcanite strip coated with shellac, resting at its lower end upon the carbon button, A, which is placed in electric circuit by the wires leading from the screw-posts, D and E. The other screw-posts, X and Y, at the base of the apparatus, are connected with the battery and galvanometer (not shown in the cut). P is the pan or dish for receiving the chemical whose vapors are to be detected, and is placed at the bottom of a glass case. If alcohol is placed in the pan, its vapors ascend through the little holes on either side of the carbon button, A, and, acting upon the shellac, tend to soften it, making the strip of vulcanite which it coats less stiff and thus causing a diminution of its pressure upon the carbon button. The latter thereby acquires greater resistance to the passage of the electric current flowing through it, and the needle is at once deflected.

It will be noticed, in conclusion, that in all the foregoing applications of this principle, the inventor's object was simply to induce a mechanical pressure of some sort upon the carbon button. In the telephone this pressure comes from the sound waves; in the rheostat from the mere turning of the screw; in the tasimeter from the elongation of the vulcanite strip caused by increase of its temperature; in the pressure relay by the ordinary action of the armature, and so on. This pressure varies the electrical conductivity of the carbon button, and the varia-

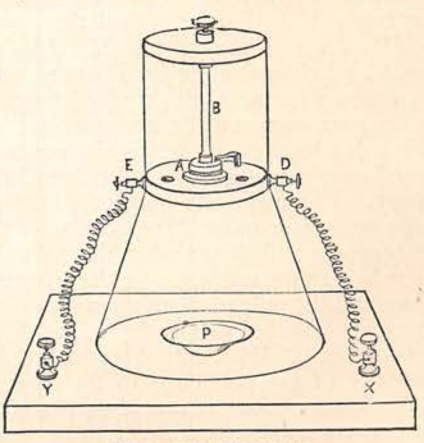

FIG. 9.—THE ODOROMETER.

tion may be indicated by the galvanometer, or in other ways. One theory of such variation is that the pressure, slight though it may be, brings closer together some of the molecules of the carbon, thus making it a more perfect conductor.

While several of these curious applications of the carbon button in their present stage of development are objects rather of scientific curiosity than of practical benefit, the telephone has become an invention of great commercial importance. Its development within the past few years has been one of surprising rapidity. In New York, Chicago and other large cities, there already exist institutions known as telephonic exchanges, by which business men are enabled without leaving their offices to converse with persons in any part of the city. By the system, a central office (called the Telephone Exchange) is connected by electric wires with the house, office, counting-room or factory of each of the subscribers, a separate wire being used for each one. Each subscriber is provided with a list of all the subscribers to the system. If at any time he desires to communicate with any one having a telephone, the subscriber calls through his telephone to the central office, which at once puts him into communication with any other subscriber. In this way merchants are enabled to transact much more business and with much less trouble than before. Lawyers, physicians, bankers, brokers, shippers, and other classes have availed themselves of the invention. In Chicago, the list of subscribers to this system already number 1,000; in New York the number is a little larger. The system is being rapidly pushed forward both in this country and in Europe, and shrewd telegraph men predict that in a few years local telephony, through the medium of telephone exchanges, will equal in magnitude, if not surpass, the great interest of the telegraph itself.

THE CONFESSION.

CAUGHT by the beams of Beauty's star,
I walk where shining summits are;
The strifes which stir the world below
I do not step aside to know.

Small need have I of scrip or store,—
My wealth lies not in golden ore;
I skim the wave whose sail expands
To waft me to enchanted lands.

I nurse a faith serene and proud;
Mixed with, I am not of, the crowd;
My galleons sail in calm and peace
Above their statelier argosies.

Mortgaged to toil, when by their side
My ways they valiantly deride;
For, him the world goes heedless by
To whom the graceful gods draw nigh.

What Raphael dreamed, what Phidias planned,
I give my days to understand;
And wrestle, undismayed, to find
The unsounded depths of Shakspere's mind.

Though balked of brilliant fame and power,
Still welcomes me the wayside flower;
For me, smiles wreathe the maiden's face,
And skies bend down to my embrace.

So, lured by Beauty's constant star,
I scale the peaks which shine afar;
What others delve for down below
I do not vex my soul to know.