EDISON AND HIS INVENTIONS.

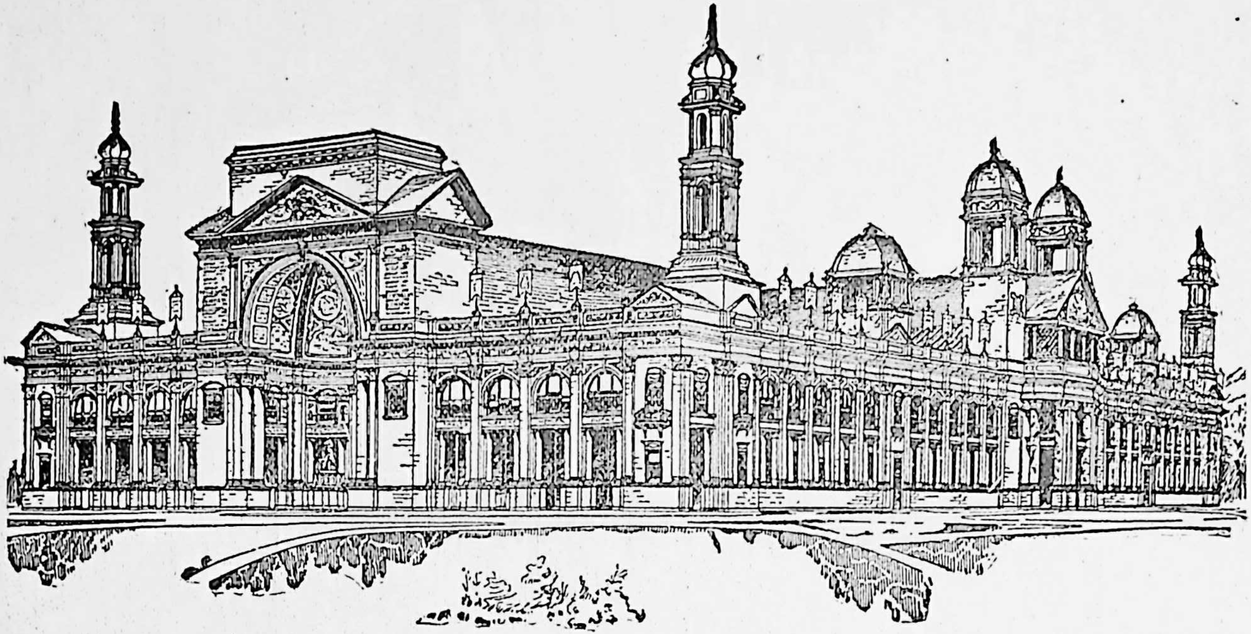
THE UNION NEWS EDITION COMPANY.

Price 50 cts.

EDISON AND HIS INVENTIONS

WITH COMPLETE

ELECTRICAL DICTIONARY.



THE ELECTRICAL BUILDING.


Thomas A. Edison

EDISON

AND

HIS INVENTIONS

INCLUDING THE MANY

INCIDENTS, ANECDOTES, AND INTERESTING PARTICULARS CONNECTED WITH THE EARLY AND LATE LIFE OF THE GREAT INVENTOR.

ALSO

FULL EXPLANATIONS OF THE NEWLY PERFECTED PHONOGRAPH, TELEPHONE, TASIMETER, ELECTRIC LIGHT, AND ALL HIS PRINCIPAL DISCOVERIES, WITH COPIOUS ILLUSTRATIONS.

"T. A. E. never had any boy-hood days; his early amusements were steam engines and mechanical forces."

—*SAMUEL EDISON, (concerning his son.)*

Edited by

J. B. McCLURE, M. A.

CHICAGO:

RHODES AND MC CLURE PUBLISHING CO.

1896.

PREFACE

In the fractional moment of the world's history, like its own self, Electrical Science has suddenly flashed into general utility, and is now rapidly lifting, not only the veritable darkness from the earth, but everywhere in home and office, field and mine, on land and sea, is demonstrating a scope of usefulness commensurate with the loftiest aspirations of man.

Very circumscribed must be the mind, and decidedly limited the vision of him who can take no interest now in both the actual and possible verities of Electricity.

Its position is one of popular supremacy, from which its blessings fall upon the day, no less than the night, and from which the weary spaces and even time itself, seem to flee away. What it really *is*, no one knows; but what it is actually *doing* this book clearly tells in its sketch life of Thomas Alva Edison, the self-made electric king of the nineteenth century. So numerous are his inventions in every department of this wonderful science, and so fully are they described in this volume—and generally by Mr. Edison himself—that a careful perusal leaves little or nothing else to be known of what is practical, just now, in this marvellously interesting field.

Connected with the life of such a person, there is always an array of incident and anecdote in which a generous public manifest a keen interest that enlightens and entertains. It has been our aim, also, in this volume, to present the many stories and remarkable experiences of his early and later life that make up the wonderful history of Mr. Edison.

Twelve years ago the first edition of this work was issued. The world was intensely expectant then as to what Edison might discover along the line of the mystic science; many doubted, some laughed, and a few scientists who should have known better, scoffed and said, "No, it is impossible." This was a period of great struggle with Mr. Edison, and yet not without hope. No one knows this better than the great inventor himself. But where are the scoffers now? And what the stupendous array of facts? Into his Electric Light alone has gone $25,000,000, with more to follow! to say nothing of his many other inventions, one of which, and the latest, his perfected Phonograph, he is said recently to have sold for a "cool million" of dollars. Verily the laborer is worthy of his reward.

There can be no doubt, Electricity "has come to stay." Its mission is "business." And we shall probably yet see the "lightning all round the horizon." Mr. Edison still "has the floor." Let us listen.

We retain, unchanged, the full details of Edison's early struggles with the Electric Light and Phonograph —all the more interesting now—and add the full particulars of his great success in these departments; also a chapter on "Menlo Park" and its noble Edisonian band of workers in days of yore has not been altered.

The reader will find quite an extended Electrical Dictionary at the close of this volume that fully explains the many newly coined words and phrases required in this new and rapidly enlarging field, which are not found in Webster's Unabridged, and which constitute, as a whole, an interesting and instructive epitome of practical Electricity.

We acknowledge our obligations, in the preparation of this work, to Samuel Edison, Esq.—father of the inventor—of Port Huron, Mich. ; Messrs. Edison, Batchelor, Griffin, and other well known and industrious and faithful associates of Mr. Edison.

At the great Paris Exposition of 1889—we should add —Mr. Edison received the highest honors, official and social. His numerous exhibits were the greatest wonder of all, unless it was his personal self.

At the World's Columbian Exposition, in Chicago, 1893, the hand of Edison was everywhere visible and his name enrolled with the great scientists of the earth.

At the Mid-winter Exposition of California at San Francisco, 1894, Edison still continues to astonish the world with his Electric Light, Phonograph and other inventions.

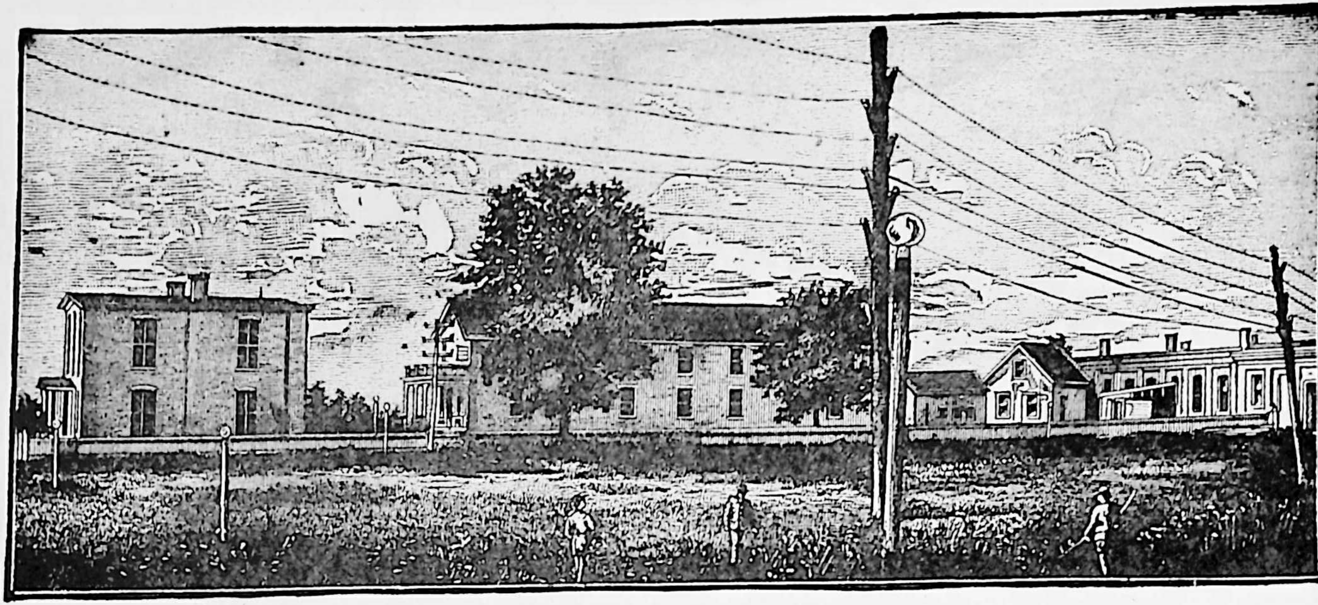
Mr. Edison has recently perfected and made practical his Kinetograph, an instrument by which every gesture of a speaker is photographed, while at the same time his words are recorded by the phonograph, all of which is reproduced by the kinetograph. The effect upon the hearer is that ihe figure on the screen is doing the talking.

Let us hope that the life of the great electrician may be long spared and his inventions continue to multiply and bless mankind. And let us also trust that a busy world may still continue to appreciate and justly honor the great inventor and benefactor.

J. B. McCLURE.

CONTENTS.

ILLUSTRATIONS



"MENLO PARK"—THE BIRTHPLACE OF THE INCANDESCENT LIGHT.

EDISON AND HIS INVENTIONS.

Our Age and Its Hero.

"'Of what use is it?" said the skeptic to Franklin, doubting the value of his identification of lightning and electricity.

"Of what use is a child?" said the philosopher, adding "It may become a man."

Evidently, this "man with the kite" saw the coming possibilities of the "subtle fluid," but it is hardly possible that he dreamed of its ultimate widespread general utility. "We put it now," says Professor Gray, "to all sorts of uses. We make it carry our messages, drive our engine, ring our door bell, and scare the burglar. We take it as a medicine, light our gas, see by it, hear from it, talk with it, and now we are beginning to teach it to write. If Job lived in this age, and the question was put to him as of old, 'Canst thou send lightnings, that they may go and say unto thee, 'Here we are?" he could say, 'Yes;' and they can be made to say it in the vernacular." "A friend of mine says in verse," adds the professor:

"Time was when one must hold his ear
Close to a whispering voice to hear—
Like deaf men, nigh and nigher;
But now from town to town he talks,
And puts his nose into a box
And whispers through a wire.

"In olden times along the street
A glimmering lantern led our feet
When on a midnight stroll;
But now we snatch, when night comes nigh,
A piece of lightning from the sky
And stick it on a pole."

Yes, the "child has become a man," noble, honest, useful, good and great. It has had a singularly long period of infancy, but a decidedly brief boyhood. As Samuel Edison says of his son, the great inventor, so has it been with electricity: "T. A. E. never had any boyhood days; his early amusements were steam engines and mechanical forces." "Those of us who are just across the meridian of life," says Gray, "can remember the first telegraph wire that was strung in this country. To-day it is difficult to find a corner of the earth so remote as to be out of sight of one. You will find them even in the bottom of the seas and oceans. The last twenty years have seen more advance in the science of electricity than all the 6,000 historic years preceding. More is discovered in one day now than in a thousand years of the middle ages, so that, literally, 'a day is a thousand years.'"

Inventions multiply with increasing rapidity, and discoveries flash as lightnings over the land. We cannot, if we would, shut our eyes to the results.

Intimately associated with this progress, and foremost in the ranks, is Thomas Alva Edison, the acknowledged leader in "applied electricity," a veritable "captain of industries," whose multiplied and multiplying useful electrical mechanisms have become to men of thought, the wonder of the world.

Since the first Edison dynamo was built, for the unfortunate steamer "Jeannette," which now lies with it in the cold depths of the Artic Ocean, over one hundred and fifty central stations, and nearly two thousand isolated plants, with a capacity of more than one million, five hundred thousand lamps, have been iustalled in America alone, to supply the Edison incandescent electric light, aggregating an expenditure of many millions of dollars. Other plants are to follow, one of which, the great Auditorium Building in Chicago, is the largest isolated plant in the world, containing eight thousand, six hundred lights. And all this, in the line of only one great purpose of the Edison discoveries, the electric light, involving, however, about one thousand separate patents!

Verily, these facts demonstrate not only the genius, but the persistent energy and dominant determination of Mr. Edison, to subordinate the occult forces of the mystic science to his end and aims, and also verify his remarkable words, uttered some eight years ago only, concerning the "commercial evolution of electricity," amid the laughs and jeers of many, and exciting great criticism at the time, when he said: "Two years of experience proves beyond a doubt that the electric light for household purposes can be produced and sold."

Professor Barker may well say, as he has, of Mr. Edison, that "He is a man of Herculean suggestiveness; not only the greatest inventor of the age, but a discoverer as well; for, when he cannot find material with properties he requires, he reaches far out into the regions of the unknown, and brings back captive the requisites of his inventions."

Recently, at a concert in the Crystal Palace, London, Edison's new phonograph recorded perfectly a performance of Handel's music, reporting with perfect accuracy the sublime strains of the "Israel in Egypt," and which can now be repeated at any time and place with the phonogram and a " a reproducer."

By Edison's automatic system one thousand words per minute are possible over a single wire; by his quadruplex, four distinct and different messages pass over the wire at the same time; by his phonograph all shades of sound are preserved and may at any time be reproduced; by his carbon telephone all shades of sound pass over the long wires to be distinctly heard many miles away; and by his electric light, night, with its darkness, is disappearing from the arena of civilization. Thus the wide world, every day, by this great man, is being brought into closer proximity, with its facilities for communication, business, social life and pleasures, almost infinitely augmented.

Well may a leading journal of this country remark: "There can be no doubt that Mr. Edison, the inventor of the phonograph, is one of the mcst remarkable men of the present century. His improvements in telegraphic apparatus, and in the working of the telephone, seem almost to have exhausted the possibilities of electricity. In like manner the discovery of the phonograph and the application of its principles in the ærophone, by which the volume of sound is so amplified and intensified as to be made audible at a distance of several miles, seem to have stretched the laws of sound to their utmost limit. We are inclined to regard him as one of the wonders of the world. While Huxley, Tyndall, Spencer and other theorists talk and speculate, he quietly produces accomplished facts, and, with his marvelous inventions, is pushing the whole world ahead in its march to the highest civilization, making life more and more enjoyable."

Personal Description.

OF MEDIUM SIZE—FINE LOOKING, COMPANIONABLE, UNOSTENTATIOUS—GREAT ENERGY, PERSEVERANCE—AN INTERESTING ANECDOTE.

Mr. Edison is a very pleasant looking man, of the average size, five feet ten inches high, fair complexion, with dark hair considerably silvered, and wonderfully piercing gray eyes. The latter are almost veritable electric lights, and when engaged in deep thought their look is intense, indicative of decided penetration and acute analysis. His features are well outlined in the engraving we present, and show him to be a man remarkably adapted to his line of labor.

He is now forty years of age. His residence is at Llewellyn Park, Orange, N. J., where he has a fine home, with all the pleasant surroundings that a magnificent country seat requires. He lost his first wife several years since, the indulgent mother of two dear children, "Dot" and "Dash." Some two years ago he married Miss Minnie Miller, the daughter of the well known manufacturer and capitalist of that name residing at Akron, Ohio. A third child has come upon the stage, who is the "little one" of this pleasant family of five, and is the "baby" elsewhere mentioned in this volume, the record of whose varied vociferations Mr. Edison is said statedly to be recording with his wonderful phonograph, just to show it after a while when it has grown to young womanhood how it could and did, without a doubt, chirrup, cry and laugh during the infantile period.

It is here, also, at Orange, that Mr. Edison has located his newest, best and very extensive laboratory, which is fully equipped with every possible convenience for turning out his many and remarkable inventions. It is in this immense establishment, completed at great expense, and manned by a noble body of faithful, intelligent and competent assistants, many of whom were at Newark and Menlo Park, that Mr. Edison is quite at home and fully master of the situation.

When in this vast workshop, the great inventor is too studious to care much for his dress and general make-up. On such occasions he appears, like other hard-working men, often the "worse for wear," with acid-stained garments, dusty eye-brows, discolored hands and dishevelled hair. Uunder such circumstances he has been correctly noted by reporters as "considering time too valuable to waste on personal decoration," his boots often "not blackened," and his hair appearing as if "cut by himself." But at the proper time and place, when a better appearance is requisite, he is always equal to the occasion, being "clean shaven," handsomely attired in the most approved style, wearing a number seven and seven-eights silk hat, and is every whit a noble-looking man.

Mr. Edison is social by nature, and very companionable to those who enjoy his confidence. He loves to converse with those interested in his inventions, and particularly so if his discoveries are comprehended. His geniality has made for him a host of friends, and gathered about him a band of workers, some of whom have been with him for many years. In his family he is affectionate and generous, a kind husband and indulgent father, caring little for the ordinary mannerisms of life, and always reaching the point by the nearest road. Withal he has a well defined vein of humor that is always seen at the right time, and that not infrequently assumes the aspect of a joke. Thus he occasionally threatens to adjust an invention of some kind to his gate at the factory that will deter visitors from entering, perchance knock them down, but the gate yet swings harmlessly and hosts of visitors pass in and out.

His personal tastes are very simple, and he is thoroughly unostentatious. When invited some time since to a dinner at Delmonico's, he satisfied himself with a piece of pie and cup of tea, greatly to the astonishment of his host, who wished to do "the handsome thing." On one occasion when tendered a public dinner, he declined, stating that "one hundred thousand dollars would not tempt him to sit through two hours of personal glorification." Personal notoriety he dislikes, and aptly says "a man is to be measured by what he does, and not by what is said of him."

His habits are peculiar, consequent upon his intense devotion to discovery. When in the throes of invention, he scarcely sleeps at all, and is equally as irregular concerning his eating. "Speaking of his early work in Newark," says Mr. Johnson, a co-laborer, "he averaged eighteen hours a day." Says the same gentleman: "I have worked with him for three consecutive months, all day and all night, except catching a little sleep between six and nine o'clock in the morning." At Newark, on the occasion of the apparent failure of the printing machine he had taken a contract to furnish, he went up into the loft of his factory with five assistants, and declared he would not come down till it worked. It took sixty hours of continuous labor" but it worked, and then he slept for thirty. His perseverance, patience, endurance, determination and industry are very remarkable, and perhaps without parallel. The routine of his day, it is well said, "is a routine of grand processes and ennobling ideas."

The following story fairly illustrates the scope of Mr. Edison's labor in reaching a single point: In the development of the automatic telegraph it became necessary to have a solution that would give a chemically prepared paper upon which the characters could be recorded at a speed greater than two hundred words a minute. There were numcrous solutions in French books, but none of them enabled him to exceed that rate. But he had invented a machine that would exceed it, and must have the paper to match the machine. "I came in one night," says Mr. Johnson. "and there sat Edison with a pile of chemisteries and chemical books that were five feet high when they stood on the floor and laid one upon the other. He had ordered them from New York, London and Paris. He studied them night and day. He ate at his desk and slept in his chair. In six weeks he had gone through the books, written a volume of abstracts, made two thousand experiments on the formulas and had produced a solution —the only one in the world—that would do the very thing he wanted done,—record over two hundred words a minute on a wire two hundred and fifty miles long. He has since succeeded in recording thirty-one hundred words a minute."

Edison's Monument to Electricity.

THE NEW LABORATORY AT LLEWELLYN PARK, ORANGE, N. J.

The finest and most complete laboratory, doubtless, to be found in the world, Mr. Edison has just erected at Llewellyn Park, Orange, N. J., where he and his faithful and competent assistants now spend their time in "*turn-*

ing out inventions, with two one hundred and fifty horse-power engines back of them." "The Electrical Review," in describing this establishment, says:

"He has not merely a laboratory of unequalled extent, but he has a storehouse of everything, a perfectly equipped machine shop, capable of turning out the heaviest as well as the most delicate kinds of work, with workmen of the highest skill in every department; a veritable central station, adapted to furnish any desired current for experiments; a chemical laboratory of the most complete description; a scientific library of enormous proportions; and in short, he has a modernized Aladdin's Lamp, by whose aid every wish almost can be at his bidding converted into an accomplished fact."

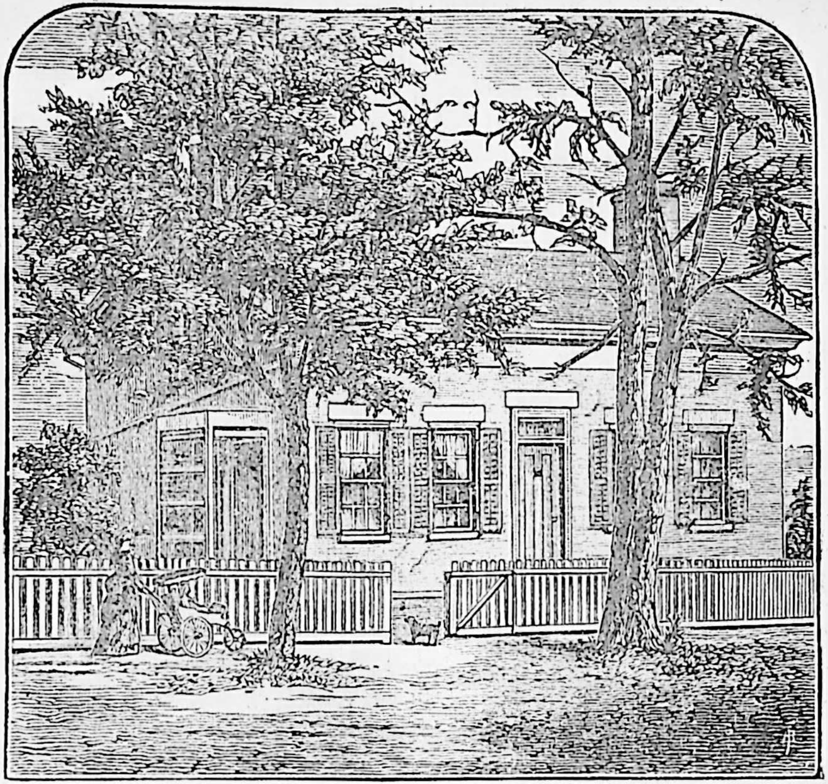
In the chemical department of this institution there is to be found samples of every element and compound, known and unknown, in the world, in quantities to meet the wants of the inventor for experimental purposes, even the teeth, fur, skins, etc. of animals, and leaves, grasses, wood, etc., from every clime.

The library is also a magnificent affair. It is a spacious, high-ceild room, with three tiers of alcoves and two balconies around the room, all finished elaborately in hard wood, and will hold about 100,000 volumes. Though not quite filled, it will soon be, at the rate of stocking now going on. Tables and writing desks are conveniently arranged, and any given subject can be quickly studied up in comfortable chairs, under a strong light and the pleasant surroundings of Turkish rugs and exotic plants. Electric lamps are everywhere, ready to be lighted at will, both here in the library and in every part of the buildings.

The lecture room is devoted to lectures by various members of Mr. Edison's staff, and these are given on regular occasions. A raised platform, with experimental tables and blackboards for illustrations, occupies the center of one of the sides, and at the walls are the terminals from the distant dynamos and batteries ready to supply current for all sorts of experiments or demonstrations.

Altogether, the laboratory has not its equal in the world. Mr. Edison has personally selected his assistants and workmen, the requirement being the highest intelligence and skill; and it may be safely said that nowhere else can be found a corps of officers and workmen combining the intellectual knowledge and mechanical expertness here drawn together.

The laboratory, the fulfilment of the unexpressed hopes of the genial inventor for years past, would seem to be one of his greatest achievements; but he himself considers as his greatest work the establishment and successful operation of the great central station in Pearl street, New York City. The task was undertaken at a time when absolutely nothing had been done from which example could be taken. There were no finger posts, no beaten paths, nothing but a wilderness of darkness and obscurity. Everything had to be invented, the dynamos, regulators, indicators, distributing mains and feeders, house-wiring devices, meters, lamps, holders and a myriad of minor details. Yet these were all devised, put in practical form, applied, the great network switched in, brushes applied, steam raised, the engines started and thousands of lamps started into illuminated life, and, not the least extraordinary part of it, from that moment to the present, there has not been a single cessation of current in the mains. Truly it was a great work, and one which has become a conspicuous mile post on the wayside of electrical history.



House in which Edison was born—*Photographed by C.H. Kellogg.*

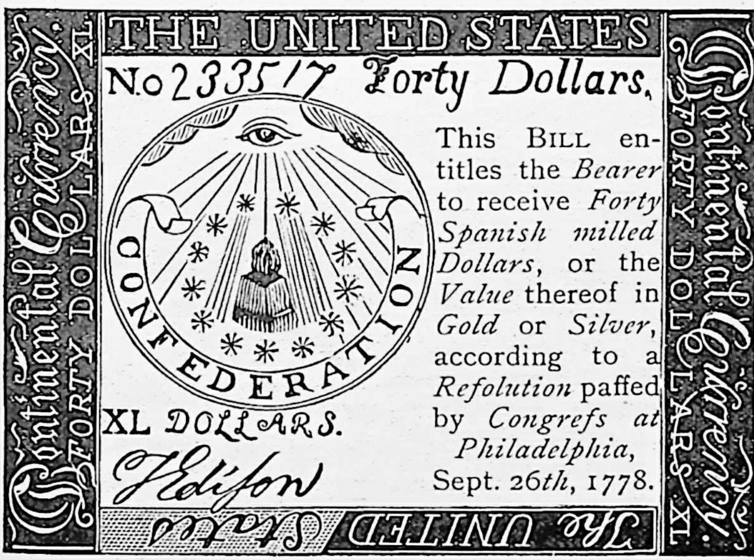
Edison's Early Life.

His Nativity—Childish Amusements—His Ancestry Mrs. Nancy Elliott Edison—Removal to Port Huron—Edison's Happy Home—Early Education.

The first seven years of young Edison's early life were spent in Milan, Erie County, Ohio, where he was born February 11th, 1847. At this time Milan was a young, ambitious and prosperous town of three thousand inhabitants, located on the Huron River, at the head of navigation, ten miles from Lake Erie. It was the center of an extensive trade in grain, cooperage, ship-building, etc., that continued prosperously until the completion of the Lake Shore Railway, a few miles South. when its business rapidly declined, and Milan almost ceased to exist. Its name, however, is now immortal, for it will always be known as the birth-place of Thomas Alva Edison. It is quite befitting that America should furnish the greatest of inventors, and equally so, that a central State, like Ohio, should include his village of nativity. Edison may be said to be the "product" of a free country, and appropriately heads the longest list of great inventors that history anywhere exhibits. And we are glad to say, like the ancient Roman, who always asserted with emphasis his Roman citizenship, that Edison, too, rejoices in the fact that he is "an American citizen." He is proud of his native land.

Milan, with its little river, surrounding hills and grand old forests, salubrious clime and busy industries, proved an excellent basis of physical life for young Thomas. He was fond of the ramble and young adventure, and often indulged in innocent play on the banks of the Huron. He is said to have delighted in the construction of little plank roads, the excavation of little caves, and such like original pursuits. He never lacked for subjects, thus revealing "the dominant power" very early in life. From the first, he was a chubby, rosy faced, laughing boy. He is said to have known all the songs of the canal-men before he was five years old, and "lisped in homely numbers, 'Oh, for a life on the raging canawl,' ere he had fairly learned his alphabet." But his great heritage at Milan was the love and tender solicitude of his parents. He had a careful, watchful father and a loving mother, to whom, Thomas Edison owes much, if not nearly all, that has made him great.

His ancestry on the paternal side can be traced back two hundred years, when they were extensive and prosperous millers in Holland. In 1730 a few members of the family emigrated to America.



Thomas Edison, great grandfather of Thomas Alva, was a prominent bank officer on Manhattan Island during the Revolution, and his name appears on the continental money. His signature is shown in the engraving on a continental note, now over one hundred years old. He died in the one hundred and second year of his age. The race is remarkable for its longevity. Thomas Alva's grandfather lived to be one hundred and three years old.

His father, Samuel Edison, is now living, aged eighty-four, in perfect health, and able to attend to all the details of an active business life. He is six feet two inches high, and in 1868 it is said, "outjumped two hundred and sixty men belonging to a regiment of soldiers stationed at Fort Gratiot, Mich."

He was born August 16th, 1804, in the town of Digby, county of Annapolis, Nova Scotia. For a short time, and when quite young, he resided at Newark, N. J., and subsevuently, at the age of seven, removed to the township of Bayham, Upper Canada. He married Miss Nancy Elliot, an accomplished lady of Vienna, Canada, and came west in 1837, locating at Detroit, Mich., where he resided one year, and then moved to Milan, Ohio, and afterwards returned to Michigan in 1854. In his younger days he learned the tailor's trade, but subsequently entered commercial life, engaging in an extensive lumber business and afterwards becoming a produce merchant, in all which he has been sufficiently successful to amply provide the comforts of a happy home. He has always been in good circumstances and was deeply interested in the home education of his son, paying him a fixed price for every book he read to encourage him in the work.

Mrs. Nancy Elliott Edison, mother of T. A. Edison,

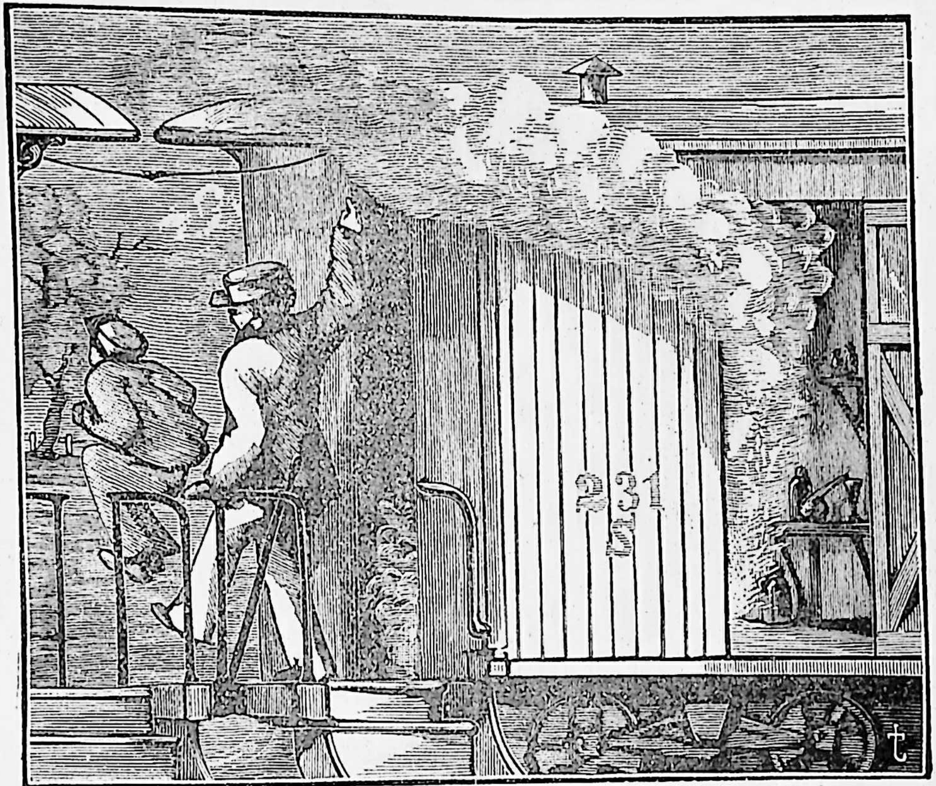
Samuel Edison. Mrs. Nancy E. Edison.

Parents of Thomas A. Edison.

was born in Chenango County, N. Y., January 10th, 1810. She was of Scotch and English parentage, and highly educated. For several years she was a successful and popular teacher in a Canadian High School. She died April 9th, 1871, but her memory is still dear to a long list of associates, many of whom speak of her as a Martha Washington. She was a fine looking, cultured, well educated lady, endowed with great social powers, and beloved by a large circle of friends. For her son Thomas she always had the most tender affection.

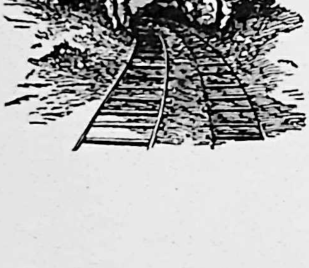
Wm. P. Edison, a brother of Thomas A., is a prominent business man iu Port Huron, Mich., where he has resided for the last thirty-five years. Samuel Edison, the father, is also a resident of the same city. A sister, Mrs. Homer Page, is a resident of Milan, Ohio. This is the extent of the family.

At the age of seven young Edison and his parents removed from Milan to Port Huron, Michigan, where his father still resides. He soon became reconciled to his new home, and was the same cheerful lad on the shores of the "narrow sea" that he had been on the banks of the little river. The family residence at Port Huron was among the largest and finest in that region of country, being a very roomy, good old fashioned white frame building, located in the center of an extensive grove, and attached to which was an observatory giving a glorious outlook over the broad river and distant hills. How far this remarkably pleasant home contributed in laying the mental and moral foundations of the great inventor is a matter of mere conjecture. Here, however, he lived, studying more or less for several years, at his mother's side, who by her great natural qualifications for such a work and by a mother's immeasurable love taught him, not only the "fundamental branches," but what is better. the *love* and *purpose* of knowledge. There existed an unusual and superlative affection between the mother and her son. She seemed to love his very presence, and for this reason, young Thomas was taught at home, where he might constantly add to the parental pleasures. It can be easily seen how Thomas Edison under such benign and potent influences became a well instructed, and we may add, a well educated boy; for he was taught the presence, power and possibilities of human resources, and what he himself might ultimately accomplish if "faithful to the end;" that the wide world was one great, broad field of activities, and that nature was brimmed with law, order, the beautiful and good. His mother taught him not only "his alphabet, spelling, reading, writing and arithmetic," but also the great object of all learning. She was careful to implant the love of learning and fire the young mind with a burning desire to know more of the "great beyond." In this she succeeded to a degree commensurate with her efforts, for at the age of ten, young Alva's mind was an electric thunder-storm rushing through the fields of truth. At this age he had read the "Penny Encyclopediæ," "Hume's History of England," "History of the Reformation," "Gibbon's Rome," Sears' "History of the World," several works on chemistry and other scientific books. He read them all with the utmost fidelity, never skipping a word or formola. It is this wonderful habit of concentration, fired with the determination to reach "the point," that has led him to accomplish so many astonishing results. It is true that it must always remain a curious fact that such a man as Mr. Edison should never have



Young Edison's Mishap and Ejectment from the Train.

attended the schools, that his name, now so great, was never enrolled in any college calendar, and that in fact he never "went to school" more than two months in all his life. But may we not, yea, do we not, see again, for the thousandth time, the power and possibilities of a mother's love and labor, in training the child in the way it should go? Was not his home, after all, his university? And was it not a good one, well officered, and well adapted to accomplish the real work? It is said his mother was a fine reader, and often read aloud to the family. Oh, how easy, in this way, to enkindle an interest, aud impart the information that gives life to the young soul. Again we can trace the "beginnings" of another great life to a mother's love. This was the "main battery" that has sent out, and still sends its silent influence over the long line of Edison's life. It is a divine adjustment, Heaven's grand discovery for man, this mother's love! Though gone these many years, it is said Mr. Edison still greatly reveres his mother's name, and delights as her child, to "rise up and call her blessed."

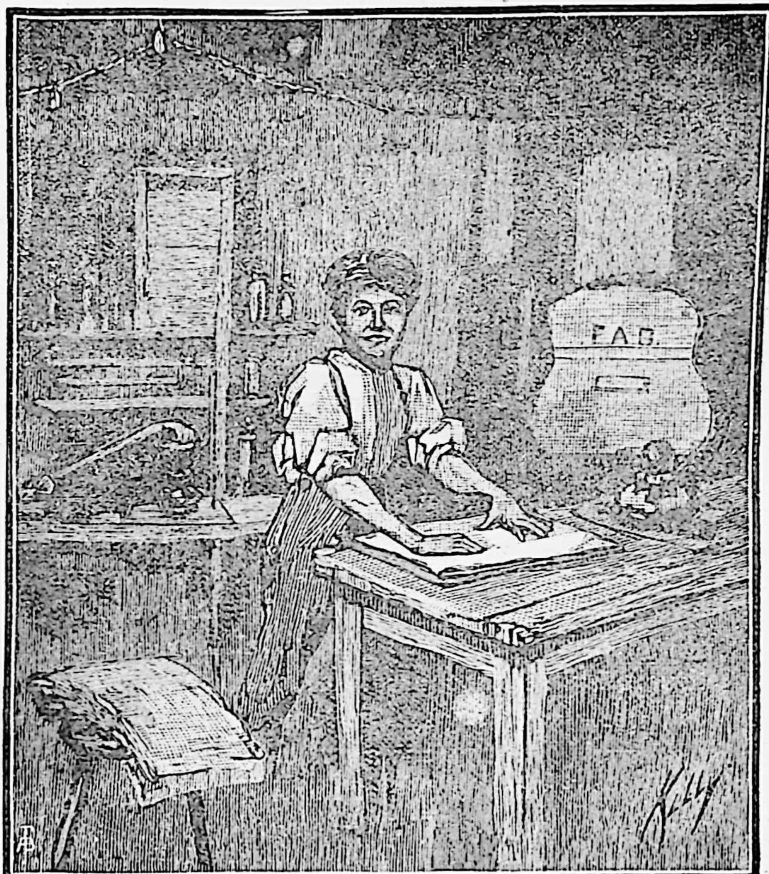


Edison as "Train Boy."

HIS SUCCESS IN SELLING APPLES, TOYS, PERIODICALS, ETC., ON THE TRAIN—HOW HE USED THE TELEGRAPH—HE STARTS A NEWSPAPER—THE EDISON DUPLEX—HIS LABORATORY ON WHEELS—A GREAT MISHAP—YOUNG EDISON PITCHED OFF THE TRAIN.

Young Edison began public life at the age of twelve as train boy on the Grand Trunk Railroad, between Port Huron and Detroit, a position selected by his father, because it afforded his son an opportunity to learn many important lessons in practical life, to earn something of a livelihood, and to enjoy, still, the pleasure of spending many a pleasant evening at home, at the Port Huron end of the line. In this new vocation, young Thomas was a "decided success." He sold figs, apples, toys, magazines, newspapers, and the entire inventory of things that make up the miscellaneous merchandize of the train boy. His business rapidly increased, and in a little while he was compelled to employ as many as four assistants. For the purpose of enlarging his business, and thus demonstrating his early genius for invention, he soon hit upon the novel plan of telegraphing in advance of his train the head-lines of the war news columns, which were properly bulletined at the stations, and which caused his papers to "go off" at almost electric speed. His periodicals were purchased principally at the Detroit end from John Lanigan, now of Chicago, who remembers him as an "honest boy," who did a "cash business," but when "time" was desired, it was always given, and the "liabilities" were promptly met. His average daily earnings during the four years in which he continued in this work were something over one dollar, aggregating the neat sum of nearly two thousand dollars, all of which he turned over to his beloved parents. His habits of study and love for reading followed him into the new field, and led him in his early visits to Detroit to unite with the library association of that place. He undertook the herculean task of reading every volume in that extensive collection. Commencing at the bottom shelf, he actually read through a line of books fifteen feet in length, omitting no volume, nor skipping any part of a single book. The dusty list included, among others, Newton's "Principia," Ure's Scientific Dictionaries, Burton's "Anatomy of Melancholy," etc. After completing fifteen feet of the mammoth project, he gave up the job and thereafter delected more congenial material. He was an occasional reader of poetry and fiction. Victor Hugo was among his favorite authors. The "Les Miserables," he read a dozen times, and has reviewed it perhaps as many times since. He regards the "Toilers of the Sea," by the same author, as a wonderful production. His memory is remarkably retentive, and from his vast field of research he has always been able to make extensive extracts, and can usually refer direct to the book and page for any information or fact needed for experiment and research. So extensive and thorough has been his earnest reading, that it is difficult to mention any subject about which he knows nothing.

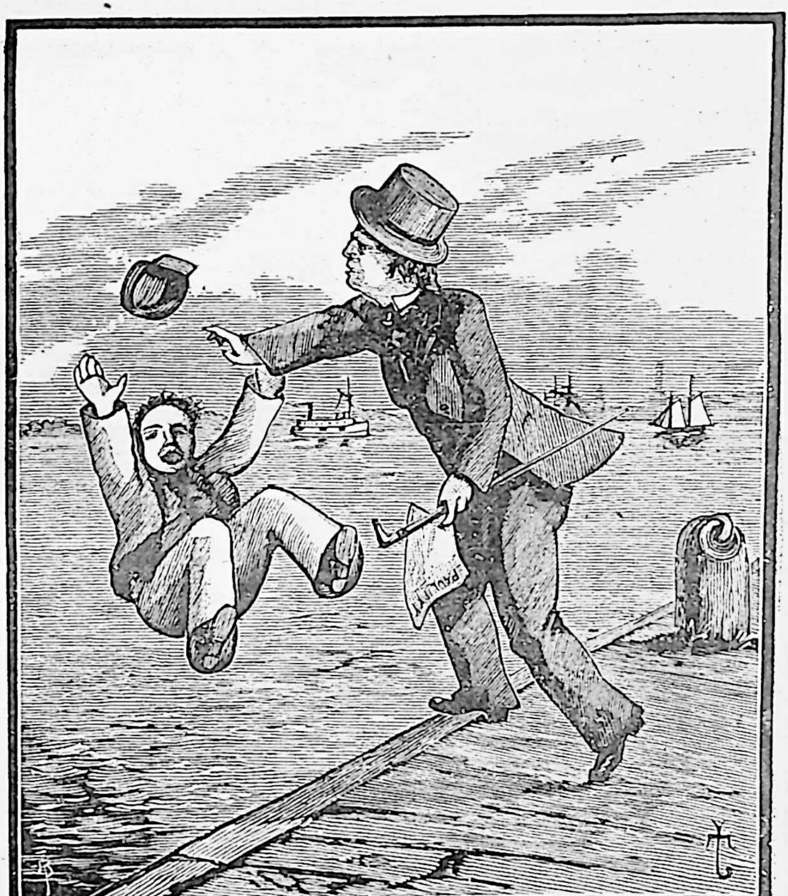
While disposing of his papers it soon occurred to young Edison, which is another demonstration of his inventive resources, that he might as well get up a paper of his



Printing The Grand Trunk Herald on the Train.

own. Attached to the train was a springless freight car having a room set apart for smoking purposes, but which was so poorly ventilated and otherwise dilapidated that passengers seldom entered it. This was selected as the head center of his first grand enterprise. Three hundred pounds of type were purchased from the Detroit *Free Press*, and very soon Edison was the editor and publisher of a little paper, twelve by sixteen inches, issued weekly, entitled *The "Grand Trunk Herald;"* the columns of which were devoted to railway gossip, changes, accidents and general information. It was printed in the most primitive style, on one side only, the impressions being made by the pressure of the hand. It sold for three cents a copy, and reached a circulation of several hundred. On one occasion it came under the eye of the celebrated English engineer, George Stephenson, builder of the great tubular bridge at Montreal, who at once ordered an extra edition for his own use. It numbered among its contributors many worthy railroad men, and became quite celebrated as the only journal in the world printed on a railway train. Among its contemporaries in which it received favorable mention, was numbered the London *Times*. Edison was highly delighted with the new enterprise, and became in fact, a little Ben. Franklin, whose early history in this line, and ultimate success as an influential man doubtless greatly inspired the young editor of the *Herald*.

Parallel with this novel enterprise and in the same old abandoned freight car, Thomas Alva was prosecuting another and entirely different line of labor. From the very start he was a self-exhibition of the duplex system, which long afterwards appeared through his manipulations, in telegraphy. He procured a work on chemistry—Freseniu's Qualitative Analysis—purchased a supply of chemicals on the instalment plan, obtained some retort stands from the men in the railroad shops in exchange for papers, and opened a laboratory. This was his first effort in the great world of chemical law. He saw at once the wonderful and varied attributes of material things; the endless existing affinities, and occult power and possibilities of the elements. It was a new world in which he stood entranced. Aud from that time, on to the present, he has never ceased to delve into the subtle influence and mysteries of chemical science. The laboratory of the abandoned smoking car and the laboratory on the hill at Menlo Park are in the same series. The real difference is simply a matter of wheels, which persisted in carrying the former at the rate of thirty miles an hour, jostling and bumping and otherwise seriously interfering with the young chemist's experiments, while the latter stands stock-still at Menlo Park, and allows the distant whispers to jingle against the carbon button, or permits the heat from the North Star whose light has been forty-seven years in reaching the earth at the rate of one hundred and eighty-four thousand miles per second, to quietly register itself on the scale of the tasimeter. Nevertheless, this difference of wheels ultimately proved a serious matter for young Edison. In this rudely constructed laboratory there was a bottle of phosphorus, from which one day the water had evaporated, and which an extra jolt of the springless car tumbled to the floor. A scene of confusion, of course, followed. The car was ignited and a conflagration was imminent. The conductor rushed hurriedly,



Edison Pitched into the River.

and we may add madly, to the scene of conflict and with difficulty extinguished the flames. In his rashness, and to make it absolutely certain that such an event could not possibly occur again, he unceremoniouly threw overboard, not only the chemicals of the entire laboratory, but also the printing establishment, and closed the fearful drama by soundly boxing young Edison's ears, and hurriedly ejecting him from the blazing train. What has become of this impetuous gentleman, we do not know. Perhaps he is endeavoring to atone for his work as the gentlemanly conductor of the excursion trains, which, now and then, to accommodate scientists, friends and the curious, run from Boston to Menlo Park. Sad as was the event, it did not, however, discourage the young chemist and editor. He doubtless realized the importance of fire-proof smoking cars, and, if he had felt more amiable, at the time, towards railway officials, might have invented one, but in lieu of this, and with a better knowledge of phosphorus and human nature, he gathered up his scattered materials and located in what he deemed a much safer plaee, the basement of his father's residence at Port Huron. Here, as opportunity afforded, he continued his experiments in chemistry, and, in time, issued another petite journal entitled "*Paul Pry*," which was more afher the regular plan of a newspaper, and every way an improvement on the "*Herald*."

It had a host of contributors and a long list of subscribers. But alas for all sublunary affairs. It was not long before an article from a contributor appeared in the columns of this newspaper which, though Edison persistently claimed was not within the bounds of the legally libelous, yet have great offence to a subscriber who at once sought the editor in chief, and finding him on the margin of the St. Clair, deliberately picked him up and pitched him into the river. It was an unexpected and hasty plunge bath, entirely involuntary on the part of young Thomas, but from which he soon emerged, safe and sound, with the conviction, however, not soon forgotten, that the life of an editor is environed with no inconsiderable degree of danger. In the former great mishap fire was the essential factor ; in the latter it was water ! Thus early in life, and in a peculiar manner, was the great inventor baptized with the two great elements. Nor was it an ordinary "sprinkle" either ; in both instances it was a rousing "immersion !"

Mr. Edison occasionally refers to this train boy period of his life, and always with much humor. When asked one day if he belonged to the class of train boys "who sell figs in boxes with bottoms half an inch thick ?" he responded with a merry twinkle, "If I recollect right the bottoms of my boxes were a good inch." A daguerreotype of his train boy epoch is yet extant, which represents the great inventor as a chubby faced boy in glazed cap and, with a bundle of papers under his arm. His lips are wreathed in smiles, and altogether he presents the appearance of a contented and happy little fellow. Such a life had, of course, its ups and downs, but after all, it was a profitable schooling for young Edison. Besides, during the four years he continued in this work he was always in daily reach of home, where his sorrows as well as joys were promptly shared by those who could easily and gladly impart the essential lesson. The easy manner in which he disposed of his limited stock of merchandize, the use of the telegraph to aid in the disposal of his papers, the successful issuing of a weekly paper, the laboratory with its varied experiments, and the wonderful amount of solid reading that pervaded all, clearly demonstrate that Mr. Edison at this age was not only a most extraordinary "train boy," but also a remarkable genius. The spirit of invention was upon him. The click of the "sounder" was audible, and the "message" of his coming greatness was on its way.

Early Reminiscences.

Mr. Samuel Edison states that his son, T. A. E., never had any "boyhood days" in the common acceptation of that term.—From the first his inclinations were in the direction of machinery, and amusements, with steam engines and various mechanisms. It is not surprising therefore to find him at an early age perfecting, on a small scale, a working engine. When on the Grand Trunk line he frequently rode with the engineer that he might learn something about the mysteries of a locomotive, and on one occasion, to demonstrate his proficiency, while the engineer was asleep, ran a train nearly the entire trip, with the only mishap of pumping too great a quantity of water into the boiler, which being thrown from the smoke-stack deluged the engine with filth. Occasionally, as he had opportunity, he would visit the railroad machine shops, where he always manifested the greatest interest in examining the machinery.

He was always careful with his little laboratory and would not allow his things to be tampered with by any one. To insure better safety he labeled every bottle in the establishment "poison."

When excited, young Thomas was slow to cool down. The sequel to the dreadful cold water catastrophe, was that the name of the person—J. H. B. of Port Huron—who threw him into the river, was studiously kept out of the columns of *Paul Pry.* If Thomas had not been a good swimmer, that occasion might have been far more serious than it was.

Edison's sister tells a good story of his childhood: "He tried to sit on eggs," she said. "What do you mean?" inquired the listener. "Why, he was about six years old, I should think, and he found out how the goose was sitting, and then saw what the surprising result was. One day we missed him, called, sent messengers, and couldn't find him anywhere. By and by, don't you think, father found him curled up in a nest he had made in the barn and filled with goose eggs and hen's eggs,—actually sitting on the eggs and trying to hatch them."

The Young Electrician.

HE BUYS A BOOK ON ELECTRICITY—EXTEMPORIZES A SHORT LINE—THE TOM-CAT ELECTRICAL-BATTERY—A DARING FEAT IN FRONT OF A LOCOMOTIVE—THE YOUNG SON OF THUNDER GETTING DOWN TO BUSINESS—ANECDOTES.

Edison's interest in telegraphy dates from the time when, as train boy, he sent the head lines of the news columns over the wires in advance of his trains to be bulletined at the stations. In this novel and successful plan he saw at once the great advantages of the telegraph system, and made up his mind that he would very soon know more about it. He immediately purchased a standard work on the electric telegraph, and began its careful persual. Every day led him farther out into the exciting wonders of electrical science. He was pleased, delighted and amazed. A new world was discovered, marvelous and grand. An apocryphal power silently stole out from the acidulated metals and leaped two thousand miles per second. It laughed at space and time. There were things it seemed to love and things it hated, things to which it clung and things it would not touch. Now like the light of the sun, then silent and dark, yet ever moving, and exerting its strange incomprehensible force. Easily could he see the cup, the copper, zinc and acid, and could hear the click of the soundar; but from whence and how comes this influence? That was the question. He studies the chemistries of the battery, and delves farther into his work on electricity. He concedes the wonders, but exclaimes "what I know not now, I may know hereafter."

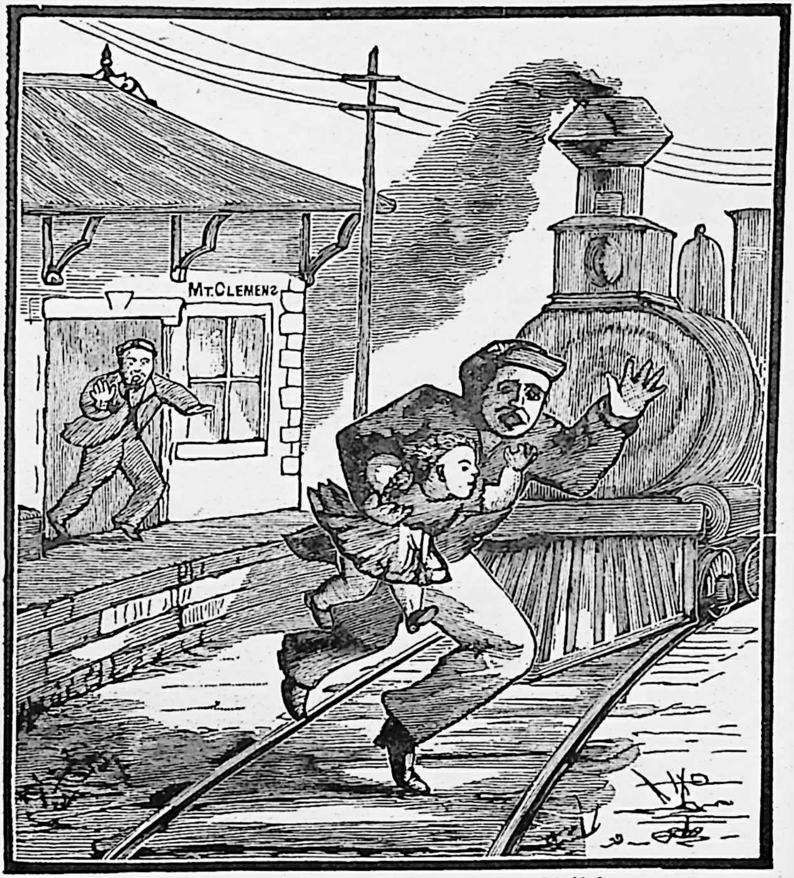
It is under the conviction of this final exclamation that young Edison passes from the more theoretical into practical telegraphy. A short line is extemporized, connecting his new basement office at home with the residence of his young assistant, James Ward, also of Port Huron. In its construction they used common stove pipe wire, insulated with bottles placed on nails driven into trees, and crossed under an exposed road by means of a piece of an abandoned cable captured from the Detroit river. The magnets used in connection with this primitive line were made of old wire wound with rags for insulation, while a piece of spring brass formed the all important key. It is said that these two young aspiring electricians, now the proprietors of a "short line" and evidently in high glee, "were somewhat mixed as to the relative value of dynamic and static electricity for telegraphic purposes and the first attempt to generate a current was by means of a couple of huge cats rubbed vigorously at each end of the line at an appointed time." The only success attending this novel and gigantic effort was the complete and hurried riddance of the two great cats which, under the pressure of the moment, lit out at lightning speed and were never heard of afterwards. Had the "ground wire" in this case been properly adjusted, that is wound securely about the necks of the feline batteries, this unexpected phenomenon might have been avoided, and better success have followed.

Mr. Reid in his "Memorial Volume," referring to this incident, says:

"He had seen sparks emitted from a cat's back. Judging that there must be good battery where the indications were so strong, he inserted a tom-cat in the circuit, using the fore and hind feet as electrodes. The connections, after some resistance, having been duly made, he tried to start an induced current by rubbing the cat's back, the incensed feline meanwhile giving him some forced telephone lessons, and in other ways objecting to his electrocratical operations. The experiment however was not without success. A tremendous local current and perfect electric arc was produced, but it would not work the line, and was abandoned. The experiment illustrated the humor of the man."

Had young Thomas and James demonstrated the feasibility of cats for electrical purposes they would doubtless have received the homage of mankind. Long after this amusing event, Mr. Edison was forcibly reminded of the great leap made by his cat on this occasion, when he discovered what he believed then and still believes, to be a "new kind of electricity," which is capable of causing a spark "to leap twenty feet in the clear air" without effecting in the least manner the galvanometer.

Soon after this experiment, in nowise discouraged, some old telegraph instruments and battery materials were purchased and a successful short line was established, which at that time was quite an achievement, it being among the first of the kind ever inaugurated. In a boylike way his aspirations seemed now crowned with success. He was not only an electrician, but had constructed a telegraph line of which he was at once Superintendent, proprietor and operator. Whether he posted up his "Rules and Regulations," scheduled his "rate" and forwarded night messages at half price, etc., is not known,



Young Edison Rescuing a Child.

but it is quite likely something of this kind was done. All this however was but a high order of boyish sport; a toying with heaven's lightning, and yet beneath it is the impulse to more real and grand achievements.

The quadruplex, electro-motograph, phonograph, telephone, etc., were all in germinal form and within microscopic range. At the end of the "short line," sat the young son of thunder, with a hand upon a rustic and slow moving key, that was destined to fashion another and better line and mechanism that should pick up three thousand and one hundred full words in a single minute!

Soon after this an event occurred that proved a turning point in Edison's life. It was a daring, but successful effort made to rescue the life of a little child. J. A. Mackenzie, station agent and operator at Mt. Clemens, near Port Huron, had a dear little boy only two years old, which one day crept on the track just in front of a rushing train. A moment more and its mangled form would have been quivering in the dust. Young Edison saw the impending danger. He flew to the rescue and at the point of his own life, rescued the child. It was a noble deed, and out of gratitude, the father, volunteered to teach young Edison how to become an operator.

This offer was gladly accepted and thereafter Thomas Alva, after reaching Port Huron would return by freight train to Mt. Clemens in order to learn, at night, the lessons that were to perfect him in his newly chosen and interesting employment.

A warm friendship existed from the first, between Mr. Mackenzie, the teacher, and young Edison, the pupil. which to this day continues, though we believe now, Mr. Edison is the teacher. It was with Mr. Mackenzie and at Menlo Park that Mr. Edison, only a few day's since, perpetrated a little Pleasantry.

"Look here," says Edison, "I am able to send a message from New York to Boston without any wire at all."

That is impossible, says Mackenzie.

Oh, no! says Edison. Its a new invention.

Well, how is it done, Al! says Mack.

By sealing it up and *sending by Mail!!*

The old gentleman laughed heartily at the joke.

Morse Alphabet.

A	B	C	D	E	F	G
- —	— - - -	- - -	— - -	-	- — -	— — -
H	I	J	K	L	M	N
- - - -	- -	— - — -	— - —	———	— —	— -
O	P	Q	R	S	T	U
- -	- - - - -	- - — -	- - -	- - -	—	- - —
V	W	X	Y	Z	&	
- - - —	- — —	- — - -	- - - -	- - - -	- - - -	

NUMERALS.

1	2	3	4	5
- — — -	- - — - -	- - - — -	- - - - —	— — —
6	7	8	9	0
- - - - - -	— — - -	— - - - -	— - - —	———

PUNCTUATION MARKS.

Period.	Comma.	Semi-colon.	Quotation.
- - — — - -	- — - —	- — - — -	- — - — - — - —
Parenthesis.	Interrogation.	Italics.	Paragraph.
— — - —	— - - — -	— - - - —	— — — —
Exclamation.			
— — — -			

The Young Operator.

His Engagement at Port Huron—Resigns—Goes to Stratford—Rigs an Ingenious Machine—Telegraphing By Steam.

Edison was yet a boy, being only fifteen years of age. But in five months after he began taking lessons of Mr. Mackenzie at Mt. Clemens, he was sufficiently advanced in the art of sending messages to procure employment in the telegraph office at Port Huron. The salary was $25.00 per month, with the understanding that he should have extra pay for extra work. The office was in a jewelry store and, as usual, Edison indulged in his mechanical inclinations. He worked, however, very industriously at the key, night and day, that he might improve himself as an operator.

After six months of hard labor, on finding his pay for extra work, withheld, he at once resigned, and left Port Huron, for Stratford, Canada, where he engaged as night operator. Here he applied his ingenuity in a novel way, which shows at least, how fertile must have been the young-operator's brain. The operators were required to report "six" every half hour to the Circuit Manager. Young Thomas instead of reporting, in person, rigged a wheel with Morse characters cut in the circumference in such a way that when turned by a crank it would write the figure "six" and sign his office call. The watchman turned his wheel while Edison slept.

His stay at this point was brief. One night the dispatcher sent an order to hold a train. Edison repeated back the message before showing it to the conductor. When he ran out for the purpose the train had pulled off from the side-track and was gone. When the dispatcher was notified, the opposing train was beyond reach. Fortunately the two trains met on a straight track and no accident happened. The railroad Superintendent sent for Edison and so frightened him with threats of imprisonment that, without getting his wardrobe, he started for home, and was greatly delighted to reach his native land.

His ready ingenuity was shown in an early instance of facile adaptation of the processes of his new profession to novel circumstances. One day an ice-jam broke the cable between Port Huron in Michigan and Sarnia on the Canada side and stopped communications. The river is a mile and a half wide. It was impassible and no present means existed of repairing it. Young Edison jumped upon a locomotive and seized the valve controlling the whiste. He had an idea that the scream of the whistle might be broken into long and short notes, corresponding to the dots and dashes of telegraphing.

The whistle sounded over the waters: Toot, toot, toot, toot—tooot—toooooot—toooooot—toot-toot—toot-toot.

"*Halloo!* Sarnia! Do you get me?"

"Do you hear what I say?"

No answer.

"Do you hear what I say, Sarnia?"

A third, fourth and fifth time the message went across without response, but finally the idea was caught by an operator on the other side; answering toots came cheerfully back, and the connection was again established. This novel incident was a feather in young Edison's cap and his praises were sounded abroad.

He spent a few weeks at Port Huron in study, but operators were in demand, and he obtained a situation at Adrian, Mich. Here he had a small shop and a few tools, where his sparl time was used in repairing instruments and making such experiments as he had the means to accomplish. It was then a peculiarity of the Morse telegraph system that only one message at a time could be sent on a wire. On one occasion when he had some message from the Superintendent he insisted on taking the line from all comers. The superintendent of Telegraph lived in the same town und had an instrument in his house. Hearing the tussel on the wire, he rushed to the office, pounced upon young Edison, and discharged him for violation of rules. He, however, at once found a position as night operator in Fort Wayne where he made rapid progress in his work and in two months was engaged at Indianapolis.

The Young Inventor and Operator.

INVENTS AN INSTRUMENT—TELLS THE BOYS TO "RUSH HIM"—FIDELITY REWARDED—BECOMES A FIRST CLASS OPERATOR.

While operating at Indianapolis, young Edison invented his first successful telegraph instrument. It was an automatic repeater which transferred the writing from one telegraph line into another line without the medium of a sending or receiving operator. It was considered an important achievement for one so young and is described in a recent work on telegraphy, as "probably the most simple and ingenious arrangement of connections for a repeater known, and has been found to work well in practice. It is especially good and convenient where it is necessary to fit up a repeater, in an emergency, with ordinary office instruments."

Edison's ambition as an operator was, like that of most operators, to be able to take what is called "press report." To accomplish this end he practiced at night incessantly and was finally awarded a trial, but finding himself making too many "breaks," or interrogations, he adjusted two more recording registers, one to receive and the other to repeat the embossed writing at slower speed, so it could be copied. When this new arrangement was properly adjusted, young Edison felt very secure and at once announced to the sending operator to "rush him." This gave him a brief reputation as a receiving operator, but, alas for the press reports, they came in too slowly, which caused complaint and he was suspended from the work and afterwards transferred to Cincinnati.

Here he worked a day wire and continued to practice at night, always "subbing" for the night men whenever he could get the privilege. His fidelity and industry were finally rewarded in this city and in the following manner.

After he had been in Cincinnati three months a delegation of Cleveland operators came down to organize a branch of the Telegraphers' Union, which resulted in a great strike among the operators. They struck the office in the evening, and the whole force, with one exception, went off on a gigantic spree. Edison came round as usual to practice, and finding the office so nearly deserted took the press report to the best of his ability, and worked through the night, clearing up business. The following day he was rewarded by an increase of salary, from $65 to $105 per month, and was given the Louisville wire, one of the most desirable in the office. Mr. R. Martin, known among the craft as "Bob Martin," one of the fastest senders in the country, worked the Louisville end, and from the experience here acquired, Edison dates his ability as a first-class operator.

Young Edison's ambition, however, was not at rest when he found that he could jingle the key as rapidly as Bob Martin. Beyond this were higher aims of which Bob never dreamed and, which so wholly absorbed Edison's mind that it not unfrequently was the cause of apparent neglect in what, to the average mind, seemed very essential. He had already invented his automatic repeater, but he saw other principles possible to be utilized and these occupied his mind. He cared little for dress and was willing to work at all hours, night or day, but he would not relinquish his efforts to solve what appeared to his companions, utter impossibilities. These efforts were rewarded by the production of a remarkable steam engine and the discovery of his duplex transmission basis.

So intensely did these points occupy his mind and so positive was he of duplex transmission and other possibilities of great importance in telegraphy, and which long ago he has made practical, that his companions dubbed him with the title of "luny," or crazy man, a name which clung to him for years. But other good men had been served in the same manner and he was not discouraged. Notwithstanding this insulting title

Edison had the good will of his associates. He continued his extensive research and reading, and as opportunity afforded, indulged in such experiments as tended to demonstrate his convictions in electrical science.

Edison's Ups and Downs.

THE INVENTOR VS. THE OPERATOR—THUNDER ALL ROUUD THE HORIZON—FOOTING IT IN TENNESSEE—OFF FOR SOUTH AMERICA—"RUN" ON A BANK—INCIDENTS.—

In 1864, young Edison went to Memphis where he obtained a more remunerative salary. But his associates were dissolute and imposed upon his good nature to such an extent that the work he did was enormous. Abstemious himself almost to stoicism, he freely loaned his money to his companions or expended it in the purchase of books and apparatus. While here, and still but a boy of seventeen, he made and put into operation his automatic repeater, so that Louisville and New Orleans could work direct, thus saving the work of one operator and receiving a compliment for his ingenuity.

The idea of duplex transmission had taken possession of him, and he was perpetually advocating and experimenting to accomplish it. These efforts were looked upon with disfavor by the management, and in the changes resulting upon the transfer of the lines from the Government to the Telegraph Company Edison was dismissed.

Being without money, and having transportation to Decatur only, he walked to Nashville, where William Foley, an operator in the same predicament, was found, and they traveled together to Louisville. Edison had only a linen suit, and on arriving at Louisville he found the weather extremely chilly. He hunted up a friend who loaned him money for his immediate need. Foley's reputation, it is said was too bad to obtain a situation for himself, but he recommended Edison, who obtained work. For this service Edison supported Foley till he could get employment.

Edison describes the Louisville office at this time as a fearful place. Rats in great numbers kept the operator company at night. The discipline was lax in all things except the quality and promptness of work. Edison was reqired to take reports on a line worked on the blind side of a repeater, where he had no chance to break. This required skill, and he attained to a rare perfection by the most careful study of names, markets, and general information.

The line was old and in poor condition, being subject to many interruptions and changes. To assist in his work, Edison was in the habit of arranging three sets of instruments, each with a different adjustment, so that whether the circuit was strong or weak, or no matter how rapid the change, he was able to receive the signals accurately. He remained in Louisville for nearly two yeass and then, owing to glowing reports which he had heard, made up his mind he would go to South America.

Economy was now rigid, and funds sufficient, were soon amassed for the grand departure. In connection with two of his associates, Messrs. Keen & Warren, they finally started for the southern clime via New Orleans. On arriving at the latter place, the vessel upon which they were to ship had fortunately sailed. By a fortuitous circumstance, Edison fell in with a Spaniard who had traveled all around the world. He told the young adventurer that of all the countries he had ever visited, the United States was the best, having the most desirable government, institutions, climate, and people. This wholesome advice shook Edison's determination, and in connection with his disappointment, and delay, he resolved to go home. So he returned to Port Huron, via the Gulf and Atlantic States. After a pleasant visit among his relatives and friends Edison returned to Louisville, where he was again employed as an operator.

He now began work with renewed vigor and determination, saving his daily earnings to invest in additions to his library, apparatus, printing office and shop. New life was infused into all these departments and in a short time he had prepared a volume on electricity which he proposed to issue from his own office, but the undertaking was too great for his limited facilities.

He went into a most elaborate series of experiments, as was his custom when investigating any subject, to determine the most rapid and best-adapted style of penmanship for an operator's use. He finally fixed upon a slightly back-hand, with regular round characters, isolating the letters from each other, and without shading. This beautiful penmanship he became able to produce at the speed of forty-five words per minute, which is the extreme limit of a Morse operator's ability to transmit. A specimen of his penmanship is seen in Mr. Edison's autograph in the frontis-piece. Edison's description of the habits of his associate operators at this time is amusing in the extreme. Often when he went home from his work in the small hours of the morning he would find three of the boys on his bed with their boots, where they had crawled after an evening's dissipation. He would gently haul them out and deposit them on the floor, while he turned in to sleep.

During young Edison's stay in Louisville the telegraph office was removed to a building, fitted up with improved fixtures. The instruments, which in the old office were portable, in the new, were fastened down to tables and strict orders were issued from the proper authorities not to move a single instrument. This order not only interfered with Edison's convenience in taking reports, but also seriously discommoded him in his experiments. He could not desist, and three sets of instruments were readjusted, so as to aid him in taking reports, and on one occasion he took every instrument out of the office for the purpose of trying an experiment.

Directly beneath the new telegraph office were elegantly furnished banking rooms, the private office of which was under the battery room. This was richly carpeted. One night in trying to abstract some sulphuric acid for experimental purposes he tipped over the whole carboy. The acid ran through the floor and ceiling and fell upon the brussels and furniture below doing great damage. This proved the climax of endurance and Edison was at once discharged.

Bidding good bye to Louisville and with some regrets for the damage done the bank furniture, Mr. Edison went immediately to Cincinnati where he obtained employment as a "report" operator. This was his second visit to this point. During his former stay he built an ingenious little steam engine and arranged his first duplex instruments. His second stay in Cincinnati was less popular on account of his continued experiments. He would get excused from duty, and take a bee-line to the Mechanics' Library, where his entire day and evening would be spent reading the most ponderous electrical and scientific works. He remained in Cincinnati only a short time, and returned home to Port Huron.

Thus young Edison went the "grand rounds." "It would be gratuitously malicious," sure enough, "to note so many queer mishaps, if they were thought to show a want of conscientiousness. They seem to have been the result of an uncontrollable impulse. His inventions were calling him with a sort of siren voice and under the charm he was deaf and semi-callous to everything else.'

Edison Telegraphing by Steam.

Young Edison in Boston.

DEPARTS FOR THE "HUB"—SNOW BOUND—HIS RECEPTION—JOKE ON THE COCKROACHES—INVENTIONS—THE GIRLS—

Sooner or later "coming greatness" is apt to touch at Boston. Boston is a great city—the hub etc. Moody went to Boston. It was there he received that celebrated letter from his sister, charging him to beware of pickpockets, when, alas, he hadn't a nickel in the world. Of course young Edison went to Boston. He had a warm personal friend in the telegraph office in that city, M. F. Adams, who was anxions he should come and was ready to receive him. An expert was wanted in the Boston office to work a heavy New York wire. Several candidates had failed as the New York end was worked by the "York and Erie" operators, who, as a class, had the reputation of writing anything but the "Morse" alphabet. G. F. Milliken, the manager, offered the situation to Edison by telegraph, and he accepted.

He started via the Grand Trunk, but the train was snowed in for two days near the bluffs of the St. Lawrence by a violent storm. The passengers nearly perished with cold and hunger. All resources for fuel and food were exhausted; a delegation was sent out to hunt for relief. They were gone so long another expedition was about starting in search of them, when they returned and reported a hotel not far distant where cigars were one cent apiece, and whiskey three cents a glass, and board fifty cents a day. A shout of relief went up from the crowded cars, and they were soon comfortably housed till the storm was over. Edison finally reached Boston all right. His reception at the telegraph office by the young operators was not as cordial as it might have been, owing, no doubt, to jealousy. The table at which he had been placed was in the centre of the room, located there, it is said, for the better enjoyment of his discomfiture. He noticed the arrangement, and says he would have died rather than make a break.

He arrived in Boston in 1868, and in the person of Mr. Milliken found the first superior officer who could appreciate his character. Mr. Milliken was an accomplished gentleman, a thorough master of his profession, and an inventor of merit. He proved a faithful friend of Mr. Edison and in the secret excitement under which he seemed to labor, recognized the fire of genius. Edison's stay in Boston was congenial. There is a vein of humor running through his character, and he played a practical joke on the cockroaches which infested the office in great numbers.

He placed some narrow strips of tin-foil on the wall connecting them with the wires from a powerful battery. Then he placed food on them in an attractive manner to tempt them. When these clammy individuals passed from one foil to the other they completed the battery connection, and with a flash were cremated, to the delight of the spectators. Edison started a shop in Boston, and gave all his spare time to it. He invented a dial instrument for private line use, and put several into practical operation. He made a chemical vote recording apparatus, but failed to get it adopted by a Massachusetts Legislature. He commenced his experiments on vibratory telegraph apparatus, and made trial tests between Boston and Portland. He matured his first private line printer, and put eight into practical operation. From lack of means to pay for quotations his venture was not successful, and he sold out. This patent subsequently came into possession of the Gold and Stock Telegraph Company, and was considered to have a base or foundation value upon which many subsequent improvements were built.

At one time he was invited to explain the operation of the telegraph to what he supposed was a girl's school. He forgot the appointment, and when found was putting up a line on a house-top. He went directly from his work, and was much abashed to find himself ushered into the presence of a room full of finely dressed young ladies. He was actually timid in ladies' presence, but his subject was understood, and the occasion passed pleasantly. He was introduced to a number of young ladies, who always recognized him on the street, much to the astonishment of his fellow-operators not in the secret.

Edison in New York.

PENNILESS AND HUNGRY—THE SUPREME MOMENT—BRAINS—HIS GREAT SUCCESS.

Before his arrival in New York, in 1870, Mr. Edison, assisted by Mr. F. L. Pope, patent adviser of the Western Union Telegraph Company, made a trial experiment of his duplex system, which though not fully satisfactory, was sufficiently convincing to engender absolute faith in its ultimate success. He then went to New York. The story of his arrival, remarkable experience, and the supreme moment of final success, in this city, is narrated by one of his most intimate friends as follows: When Mr. Edison arrived in New York from Boston, where he was employed as an operator in the Western Union Telegraph office, he was absolutely penniless. He was unsuccessful in procuring work in any of the Tetegraph offices, and there is no doubt he suffered not only for food, but for clothes while he tramped the streets on the look out for a job. After three weeks of unavailing effort, he by chance stepped into the office of the "Laws Gold Reporting Telegraph Co." The instrument which reported the gold market was out of order, and Mr. Laws the inventor of the system (George Laws, now of St. Louis, Mo.) was in despair, when Mr. Edison told him he thought he could make it work, and was given an opportunity. In a few moments, the instrument was working as usual, and Mr. Edison had a situation. This, it may may be said, was the start towards the name which he has since earned. From that time to the present date he has made by his own efforts and expended, the sum of nearly five hundred thousand dollars.

The Indicator Company at once employed Mr. Edison to fill a responsible position and his discouragements were at an end. He immediately began the work of improving the Indicator and very soon invented his Gold Printer. His next advance was a co-partnership with Messrs Pope & Ashley and the introduction of the Pope & Edison Printer. A private line system was put in active operation, but was soon disposed of to the Gold and Stock Company.

From this time on, T. A. Edison has been known and appreciated. His success was like the opening of a flower, the result of long and stupendous preparations, but blooming, at last, in a single day. For many years he has been retained in the service of the Gold and Stock Company and the Western Union Telegraph Company at a large salary, they having the first option to purchase his inventions pertaining to telegraphy at prices agreed upon in each case. His inventions pertaining to the Gold and Stock Telegraph room replaced the old apparatus, and that system is interwoven with his inventions and improvements.

Mr. Edison's final triumph is a matter of general congratulation, not only because his patient labors and long and dubious industries merited reward, but for the grand field it opened from which the world has received some of its best inventions. It has also its distinctive and impressive lessons. Perseverance conquers. Indomitable will is power. Ideas are everything. Deaf to all derision, determined, though often disappointed, decided, though often discharged, Edison went "right along" until the glad hours came.

Edison in Newark.

Soon after the intimate relationship was formed between Mr. Edison and the Gold and Stock Company he removed to Newark, New Jersey, where he established an immense electrical manufacturing establishment in which he employed over three hundred men. It was divided into three large shops and two laboratories. Electrical experiments were now the order of the day and Mr. Edison, at this time, claimed to be the busiest man in America. It was his grand opportunity. There was nothing to impede. Everything urged him on. His inventions multiplied, and soon he was described by the United States patent commissioner as "the young man who kept the path to the Patent Office hot with his footsteps." At one time he had forty-five distinct inventions and improvements under way.

An idea of his determination and persistence can be gained from the following incident: He had been given an order for $30,000 worth of improved printers. The sample instrument had worked an experimental circuit, but the first instruments for practical use proved a failure. In vain he sought to remedy the defect, till finally, taking four or five of his best men, he went to the top floor of his factory, remarking that they would never come down till the printer worked. They labored continuously for sixty hours, and he was so fortunate as to discover the fault, and made the printers operate perfectly at an expense of $5,000. Such severe and protracted labors are common with him. He says after going without sleep more than the ordinary hours he becomes nervous, and the ideas flow in upon him with great rapidity. His sleep after these efforts is correspondingly long, sometimes lasting thirty to thirty-six hours. He knows no such division as day and night in his labors, and, when the inspiration is upon him, pursues the investigation and experiment to the end.

It is doubtful whether there has ever lived just such another character as Mr, Edison, whose time and energies have been given so devotedly and successfully to the discovery of practical inventions.

Edison's Courtship and Marriage.

Edison was now master of the situation. He was the king of inventors, and far removed from dangers originating with superintendents, conductors, and such like dignitaries. Yet it cannot be said that he was "perfectly secure." In another direction, entirely different, new influences were silently operating that soon demonstrated the young inventor to be not wholly invulnerable. It was trivial at first, but gradually became a serious matter. He was evidently within the influence of a peculiar magnetic battery, which he could not fully control. To get beyond the magic power was impossible. The sequel to all this was his marriage in 1873 to Miss Mary Stillwell, of Newark, N. J. The medallion on the new silver dollar is pronounced an excellent profile likeness of Mrs. Edison. The story of his love and marriage is briefly told as follows:

When he was experimenting, some years ago, with the little automatic telegraph system, he perfected a contrivance for producing perforations in paper by means of a key-board. Among the young women whom he employed to manipulate these machines, with a view to testing their capacity for speed, was a rather demure young person who attended to her work and never raised her eyes to the incipient genius. One day Edison stood observing her as she drove down one key after another with her plump fingers, until, growing nervous under his prolonged stare, she dropped her hands idly in her lap, and looked up helplessly into his face. A genial smile overspread Edison's face, and he presently inquired rather abruptly:

"What do you think of me, little girl? Do you like me?"

"Why, Mr. Edison, you frighten me. I—that is—I——"

"Don't be in any hurry about telling me. It doesn't matter much, unless you would like to marry me."

The young woman was disposed to laugh, but Edison went on:

"Oh, I mean it. Don t be in a rush, though. Think it over; talk to your mother about it, and let me know soon as convenient—Tuesday say. How will Tuesday suit you, next week Tuesday, I mean?"

Edison's shop was at Newark in those days, and one night a friend of his, employed in the main office of the Western Union Telegraph Company, in New York, returning home by the last train, saw a light in Edison's private laboratory, and climbed the stairs to find his friend in one of his characteristic stupors, half awake and half dozing over some intricate point in electrical science which was baffling him.

"Halloo Tom?" cried the visitor cheerily, "what are you doing here this late? Aren't you going home?"

"What time is it?" inquired Edison, sleepily rubbing his eyes and stretching like a lion suddenly aroused.

"Midnight easy enough. Come along."

"Is that so?" returned Edison in a dreamy sort of a way. "By George. I *must* go home, then. I was *married* to-day."

Marriage was an old story with him—he had been wedded to electrical hobbies for years. But, in spite of his seeming indifference on "the most eventful day" in his life, he makes a good husband, and the pretty little woman of the perforating machine smilingly rules domestic destinies at Menlo Park, and proudly looks across the fields where chimneys rise and her husband still works on the problems that made him a truant on his wedding day. A swarm of children pluck her gown to share their mother's smile, and lay in wait to climb into their father's lap and muss his hair with as great a relish as if he were not the greatest genius of his time. The pet names of two of these little ones are "Dot" and "Dash,"—after the characters in the Morse alphabet—and a third, only three months old, is called William Leslie. Dot's real name is Mary Estelle, and Dash's, Thomas Alva Edison, Jr.

In Menlo Park.

In his arduous labors at Newark, Mr. Edison was subject to constant annoyance arising from the great tax upon his powers, curiosity seekers, etc., which finally causd him to dispose of his expensive machinery and seek a more retired spot, where he could quietly put into practical shape, his grand ideas connected with various mechanisms. He accordingly removed with his family, in 1876, to Menlo Park, a retired place, on the line of the New York & Philadelphia railroad, two miles north of Metuchin and twenty-four miles from New York. At this point Mr. Edison then erected and fitted up the most extensive laboratory in the world. Mr. Reid in his Memorial Volume pronounces it "one of the amplest laboratories and the finest array of assisting machinery to be found in connection with scientific inquiry."

Mr. Edison has very recently enlarged his facilities for his line of business by completing a workshop one hundred by thirty-five feet—about the same size of the old one—which is fitted up in the best possible manner with appropriate machinery. The engine in the new building is an eighty horse power, built by Charles Browne and Co., and said to be one of the finest and best made engines in the United States. The boiler is of the latest pattern, sectional, while the lathes, punches, drills, planers, milling machines, etc., are from the best makers.

The experimental apparatus is the very finest and has been obtained by Mr. Edison at an expense of $100,000,00. The facilities for "*getting out an invention*" are far superior to any other laboratory in the world. It is not an uncommon thing for Mr. Edison to make an invention in the morning, and before night receive the working model for the same, from the hands of his chief assistant. It is in this stupendous and splendid laboratory that the great professional inventor is now at work, day and night, astonishing the civilized world by the character and number of his discoveries. The interior of this wonderful establishment is described in detail in an earlier chapter of this volume.

In every well regulated institution of this character there are always a number of faithful co-workers who merit the highest commendations. Mr. Charles Batchelor, who is Mr. Edison's chief assistant, has been with him for the last nine years and has helped him to perfect all his inventions. He is a gentleman of superior ability and integrity. Under his supervision, Mr. Edison keeps eleven of the most skillful machinists and instrument makers to be found in the country—some of whom have been employed for years—and a corps of laboratory assistants.

Professor McIntyre, an accomplished scholar and noted chemist, with two assistants are kept constantly engaged on original research under Mr. Edison's own special direction. The inventor's extensive correspondence is attended to by Mr. L. S. Griffin, his private secretary, a life long friend and former telegraph manager. He also attends to financial and confidential matters. William Carman is book-keeper, and Mr. John Kreuzi master machinist. To all of these faithful co-laborers Mr. Edison pays stated wages in the usual manner, except Mr. Batchelor, to whom he gives an interest in the inventions when perfected.

The analysis of labor is so perfect that the whole establishment moves along like clock-work. Each workman is interested in the success of every important invention and, it is said, does not care so much for the exact hours of his labors, as is generally done in extensive manufactories. Edison is seen frequently among his men, genial and jovial, but moving through all as the grand master spirit, which he is.

Edison's Principal Inventions.

In his new and extensive factory at Llewellyn Park, Orange County, N. J., Mr. Edison, with a large corps of competent assistants, is constantly busy in "turning out inventions," as was done in Newark and Menlo Park. Among the principal inventions in the catalogue are the following:

The new and perfected Phonograph, including the Receiver and Reproducer.

New Edison Dynamo.

Incandescent House Lamp.

Incandescent Municipal Lamp.

Pyro-Magnetic Dynamo.

Ground Detector.

Junction Box and Safety Catch.

Train Telegraphic Apparatus.

Mimeograph.

Improved Phonoplex.

Sea Telephone.

Button Repeater.

Gold and Stock Printer.

Private Line Printer.

Automatic Telegraph.

Etheric Force (a new discovery.)

Electric Pen and Press.

Duplex Telegraph.

Domestic Telegraph System.

Electro-Motograph (a new discovery.)

The Acoustic Telegraph.

The Carbon Speaking Telephone.

The Pressure Relay (a new discovery.)

The Megophone.

The Aerophone.

The Tasimeter, or "Minute Heat Measure."

Harmonic Engine.
Multiplying Copying Ink.
Vocal Engine.
The Sonorous Voltameter.
Subdivision of the Electric Light.
Mining Apparatus for Separating Ores, Etc., Etc.

At present he is improving the Phonograph; Electric Light; process for separating gold and silver from ores; the Telephone, etc., etc.

A single invention is sometimes covered by from fifteen to twenty or more patents, the patent laws not allowing one patent to cover all the essential points. Edison's stock telegraph instrument is covered by forty patents; his quadruplex telegraph by eleven; and his automatic system of telegraphy by forty-six.

Mr. Edison's electric light system alone is operated under about one thousand patents!

Mr. Edison patents his inventions in Europe as well as in this country. The following story from him illustrates how quickly it may be done:

"I made a discovery at four o'clock in the afternoon. I got a wire from here (Menlo Park) to Plainfield, where my solicitor lives, and brought him into the telegraph office at that place. I wired him my discovery. He drew up the specifications on the spot, and about nine o'clock that night cabled an application for a patent to London. Before I was out of bed the next morning I received word from London that my application had been filed in the English patent office. The application was filed at noon, and I received my information about seven in the morning, five hours before the filing. The difference between London and New York time explains the thing."

The Quadruplex.

A WONDERFUL INVENTION—FOUR DIFFERENT MESSAGES SENT AT SAME TIME OVER A SINGLE WIRE—HOW IT IS DONE.

If we were writing a volume on science, under this caption we should give a page to the wonders of electricity. But this is not our aim and therefore the reader must simply accept it as a wonderful fact that by Edison's quadruplex system, four separate and distinct messages, two in each direction, may pass simultaneously over a single wire. Mr. Reid well remarks in his "Memorial Volume," that "the chief product of Mr. Edison's genius has been the quadruplex system of telegraphy, by which already the equivalent of fifty thousand miles of wire have been added to the capacity of the lines of the Western Union Telegraph Company." If Mr. Edison had perfected no other mechanism, this alone would rank him among the greatest of public benefactors.

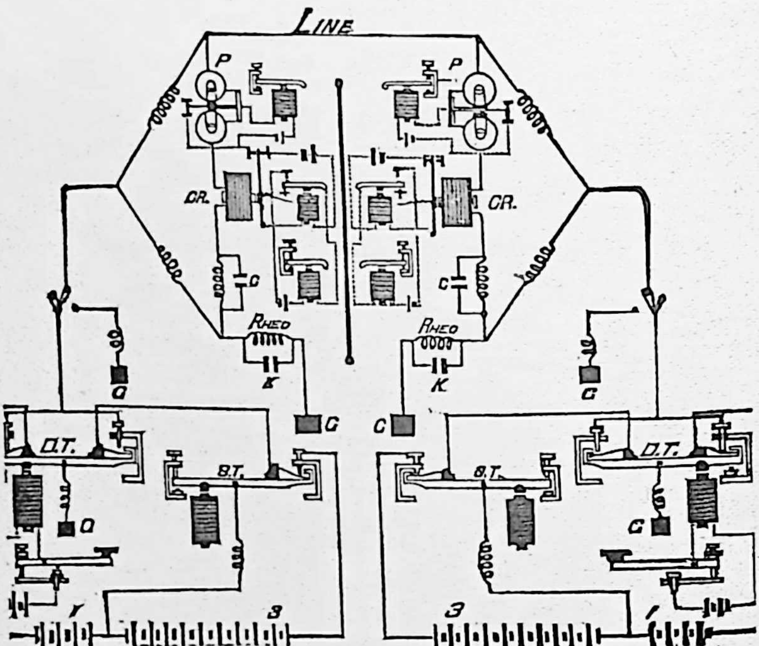
It was duriug the summer of 1874, at Newark, N. J., while engaged in conjunction with Mr. Prescott, of New York, in experimenting upon Stearns' duplex apparatus with a view of introducing certain modifications that Mr. Edison discovered the basis of the quadruplex system.

The distinguishing feature of this method of telegraphy consists in combining at two terminal stations, two distinct and unlike methods of single transmission, in such a manner that they may be carried on independently upon the same wire, and at the same time, without interfering with each other. One of these methods of single transmission is known as the double current system, and the other is the single current or open circuit system.

In the double current system the battery remains constantly in connection with the line at the sending stations, its polarity being completely reversed at the beginning, and at the end of every signal, without breaking the circuit. The receiving relay is provided with a polarized or permanently magnetic armature, but has no adjusting spring, and its action depends solely upon the reversal or polarity upon the line, without reference to the strength of the current.

In the single current system, the transmission is effected by increasing and decreasing the current, while the relay may have a neutral soft iron armature, provided with a retracting spring. A more desirable form, however, for long circuits, is that of the polarized relay, especially adopted to prevent interferences from the reversals sent into the line to operate the double current system. The action, therefore in this system, depends solely upon the strength of the current, its polarity being a matter of indifference.

By making use of these two methods, viz., polarity and strength, combined with the duplex principle of simultaneous transmission in opposite directions, four sets of instruments may be operated at the same time, on the same wire.



The Quadruplex. D T, Double Transmitter; S T, Second or Single Transmitter; P, Polarized Relay; C R, Common Relay; C, Condenser; G, Ground. 1 and 3 Batteries.

Phonograph in Operation.

The Phonograph.

THE EDISON AND FABER "TALKING MACHINES"—PHONOGRAPH FULLY EXPLAINED—ITS FIDELITY IN RE-PRODUCING SOUND—WHAT WE MAY EXPECT FROM IT.

No invention in the world's history has engendered more curiosity than the Phonograph. And yet of all, it may be considered among the most simple as well as singular. Efforts were made long ago to produce a "talking machine," but they were attended with no great degree of success. The organs of speech were well imitated by excellent mechanisms and vibrations were produced which gave out a sound similar to the human voice, but it was after all only a species of the pipe organ, and too complicated and expensive to be of any practical value. By an entirely different principle, in which the vibrations of the voice are communicated at once upon a metalic surface, becoming thereby fixed, as so many indentations representing exactly the words spoken, Mr. Edison has developed a simple mechanism that reproduces with wonderful exactness the human voice in all its possible variations.

Professor Faber, in developing his machine, worked at the source of articulate sounds, and built up an artificial organ of speech, whose parts, as nearly as possible, perform the same functions as corresponding organs in our vocal apparatus. A vibrating ivory reed, of variable pitch, forms its vocal chords. There is an oral cavity whose size and shape can be rapidly changed by depressing the keys on a key-board. A rubber tongue and lips make the consonants; a little windmill, turning in its throat, rolls the letter *r*, and a tube is attached to its nose when it speaks French. This is the anatomy of Faber's wonderful piece of mechanism.

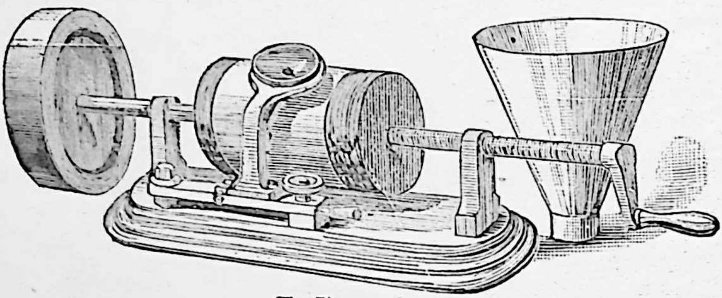
Faber attacked the problem on its physiological side. Quite differently works Mr. Edison: he attacks the problem, not at the source of origin of the vibrations which make articulate speech: but considering these vibrations as already made, it matters not how, he makes these vibrations impress themselves on a sheet of metallic foil, and then reproduces from these impressions the sonorous vibrations which made them.

Faber solved the problem by reproducing the mechanical *causes* of the vibrations making voice and speech; Edison solved it by taking the mechanical *effects* of these vibrations. Faber reproduced the movements of our vocal organs; Edison reproduced the motions which the drum-skin of the ear has when this organ is acted on by the vibrations *caused* by the movements of the vocal organs.

The simplicity of Mr. Edison's mechanism and its fidelity in reproducing sound, enthrone the phonograph as king in the realm of wonderful inventions. Geo. B. Prescott, a friend of Mr. Edison, and electrician of the Western Union Telegraph Company at New York says that "certainly, within a dozen years, some of the great singers will be induced to sing into the ear of the phonograph, and the stereotyped cylinders thence obtained will be put into the hand organs of the streets, and we shall hear the actual voice of Christine Nilsson or Miss Cary ground out at every corner. In public exhibitions, also, we shall have reproductions of the sounds of nature, and of noises familiar and unfamiliar. Nothing will be easier than to catch the sounds of the waves on the beach, the roar of Niagara, the discords of the street, the voice of animals, the puffing and rush of the railroad, the rolling thunder, or even the tumult of a battle."

"In its simplest form, the speaking phonograph" says Mr. Prescott, "consists of a mounted diaphragm, so arranged as to operate a small steel stylus or needle point, placed just below and opposite its center, and a brass cylinder, six or more inches long by three or four in diameter, which is mounted on a horizontal axis extending each way beyond its ends for a distance about equal to its own length. A spiral groove is cut in the circumference of the cylinder, from one end to the other, each spiral of the groove being separated from its neighbor by about one-tenth of an inch. The shaft or axis is also cut by a screw thread corresponding to the spiral groove of the cylinder, and works in screw bearings, consequently when the cylinder is caused to revolve, by means of a crank that is fitted to the axis for this purpose, it receives a forward or backward movement of about one-tenth of an inch for every turn of the same, the direction, of course, depending upon the way the crank is turned. The diaphragm is supported by an upright casting capable of adjustment, and so arranged that it may be removed altogether when necessary. When in use, however, it is clamped in a fixed position above or in front of the cylinder, thus bringing the stylus always opposite the groove as the cylinder is turned. A small, flat spring attached to the casting extends underneath the diaphragm as far as its center and carries the stylus, and between the diaphragm and spring a small piece of india rubber is placed to modify the action, it having been found that better results are obtained by this means than when the stylus is rigidly attached to the diaphragm itself.

The action of the apparatus will now be readily understood from what follows. The cylinder is first very smoothly covered with tin-foil, and the diaphragm securely fastened in place by clamping its support to the base of the instrument. When this has been properly done, the stylus should lightly press against that part of the foil over the groove. The crank is now turned, while, at the same time, some one speaks into the mouth-piece of the instrument, which will cause the diaphragm to vibrate, and as the vibrations of the latter correspond with the movements of the air producing them, the soft and yielding foil will



The Phonograph.

become marked along the line of the groove by a series of indentations of different depths, varying with the amplitude of the vibrations of the diaphragm; or, in other words, with the inflections or modulations of the speaker's voice. These inflections may therefore be looked upon as a sort of visible speech, which, in fact, they really are. If now the diaphragm is removed, by loosening the clamp, and the cylinder then turned back to the starting point, we have only to replace the diaphragm and turn in the same direction as at first, to hear repeated all that has been spoken into the mouth-piece of the apparatus; the stylus, by this means, being caused to traverse its former path, and consequently, rising and falling with the depressions in the foil, its motion is communicated to the diaphragm, and thence through the intervening air to the ear, where the sensation of sound is produced.

As the faithful reproduction of a sound is in reality nothing more than a reproduction of similar aucoustic vibrations in a given time, it at once becomes evident that the cylinder should be made to revolve with absolute uniformity at all times, otherwise a difference more or less marked between the original sound and the reproduction will become manifest. To secure this uniformity of motion, and produce a practically working machine for recording speeches, vocal and instrumental music, and perfectly reproducing the same, the inventor has devised an apparatus in which a plate replaces the cylinder. This plate which is ten inches in diameter, has a volute spiral groove cut in its surface on both sides from its center to within one inch of its outer edge; an arm guided by the spiral upon the under side of the plate carries a diaphragm and mouthpiece at its extreme end. If the arm be placed near the center of the plate and the latter rotated, the motion will cause the arm to follow the spiral outward to the edge. A spring and train of wheel-work regulated by a friction governor serves to give uniform motion to the plate. The sheet upon which the record is made is of tin-foil. This is fastened to a paper frame, made by cutting a nine-inch disk from a square piece of paper of the same dimensions as the plate. Four pins upon the plate pass through corresponding eyelet-holes punched in the four corners of the paper, when the latter is laid upon it, and thus secure accurate registration while a clamping-frame hinged to the plate, fastens the foil and its paper frame securely to the latter. The mechanism is so arranged that the plate may be started and stopped instantly or its motion reversed at will, thus giving the greatest convenience to both speaker and copyist.

The sheet of tin-foil or other plastic material receiving the impressions of sound, may be stereotyped or electrotyped so as to be multiplied and made durable; or the cylinder may be made of material plastic when used, and hardening afterward. Thin sheets of *papier mache*, or of various substances which soften by heat would be of this character. Having provided thus for the durability of the phonograph plate, it will be very easy to make it separable from the cylinder producing it, and attaching it to a corresponding cylinder anywhere and at any time. There will doubtless be a standard of diameter and pitch of screw for phonograph cylinders. Friends at a distance will then send to each other phonograph letters, which will talk at any time in the friend's voice when put upon the instrument. How startling also it will be to reproduce and hear at pleasure the voice of the dead! All of these things are to be common, every-day experiences within a few years.

Possibilities of the Phonograph.

A SHORT HAND REPORTER—ELOCUTIONIST—OPERA SINGER—TEACHER OF LANGUAGES—ITS MEDICAL POSSIBILITIES.

In speaking of the various purposes for which the phonograph may be utilized, Mr. Edison says:

"*First.*—For dictating it will take the place of short-hand reporters, as thus: A man who has many letters to write will talk them to the phonograph, and send the sheets directly to his correspondents, who will lay them on the phonograph and hear what they have to say. Such letters as go to people who have no phonographs will be copied from the machine by the office boy.

"*Second.*—For reading. A first-class elocutionist will read one of Dickens' novels into the phonograph. It can all be printed on a sheet ten inches square, and these can be multiplied by the million copies by a cheap process of electrotyping. These sheets will be sold for, say, twenty-five cents. A man is tired, and his wife's eyes are failing, and so they sit around and hear the phonograph read from this sheet the whole novel with all the expression of a first-class reader. See? A company for printing these is already organized in New York.

"*Third.*—It will sing in the very voice of Patti and Kellogg, so that every family can have an opera any evening.

"*Fourth.*—It may be used as a musical composer. When singing some favorite airs backward it hits some lovely airs, and

I believe a musician could get one popular melody every day by experimenting in that way.

"*Fifth.*—It may be used to read to inmates of blind asylums, or to the ignorant, who have never learned to read.

"*Sixth.*—It may be used to teach languages, and I have already sold the right to use it to teach children the alphabet. Suppose Stanley had had one and thus obtained for the world all the dialects of Central Africa!

"*Seventh.*—It will be used to make toys talk. A company has already organized to make speaking dolls. They will speak in a little girl's voice and will never lose the gift any more than a little girl.

"*Eighth.*—It will be used by actors to learn the right readings of passages. In fact, its utility will be endless."

A leading medical journal asserts that the phonograph opens up a vista of medical possibilities delightful to contemplate: Who can fail to make the nice distinctions between every form of bronchial and pulmonary rale, percussion, succussion, and friction sounds, surgical crepitus, fætal and placental murmurs, and arterial and aneurismal bruit, when each can be produced at will, amplified to any desired extent, in the study, the ampitheatre, the office, and the hospital? The lecturer of the future will teach more effectively with this instrument than by the mouth. The phonograph will record the frequency and charcteristics of respiratory and muscular movements, decide as to the age and sex of the fætus in utero, and differentiate pneumonia from phthisis. It will reproduce the sob of hysteria, the sigh of melancholia, the singultus of collapse, the cry of the puerperal women in the different stages of labor. It will interpret for the speechless infant, the moans and cries of tubercular meningitis, ear-ache, and intestinal colic. It will furnish the ring of whooping-cough and the hack of the consumptive. It will be an expert in insanity, distinguishing between the laugh of the maniac and the drivel of the idiot. It will classify dysphasic derangements, such as ataxic, amnesic, paraphasic and phataphasic aphasia.

6

It will recount, in the voice and words of the patient, the agonies of neuralgia and renal calculus, and the horrors of delirium tremens. It will give the burden of the story of the old lady who recounts all the ills of her ancestors before proceeding to the era of her own. More than this, it will accomplish this feat in the ante-room, while the physician is supposed to be busying himself with his last patient.

Last, but not least, it will simultaneously furnish to the medical philosopher the grateful praises and promises of him who is convalescent from dangerous illness, together with the chilling accents, in which, later, the doctor is told that he must wait for his remuneration till the butcher and the baker have been paid.

The Phonograph's Arrival "Out West."

It Visits Chicago—Is Interviewed by a Reporter—A Modern Miracle—How It Talked—What It Had To Say.

While the phonograph is a great traveler, and has already visited most of the civilized world, conversing with kings and queens, and attending great expositions, etc., yet its trip out West will always remain among the most remarkable of its earliest adventures. Wherever exhibited, it proved an object of the greatest interest. Its arrival in Chicago was heralded as the "Modern Miracle," and the whole occasion is described by an intelligent spectator as follows:

The phonograph has come. It was interviewed this morning. The creature was found screwed up in a box and manifested no unruly tendencies. It does not stand on its hind legs at the sight of visitors, and is apparently perfectly safe for children to approach and even handle, but there is no denying that it does perform some most remarkable capers. At these the Western public will soon be accorded the privilege of wondering with open-mouthed amazement. The instrument, or instruments—for there are three of them—are in the possession of Mr. Geo. H. Bliss, General Manager of the Western Electric Manufacturing

Company, a friend of Edison, the inventor, who has been awarded the privilege of exhibiting the modern miracle in Illinois. They arrived yesterday afternoon, and were enclosed in an apartment of the Methodist Church Block, from which it was deemed probable that they would be unable to effect an escape. They are the very first of their genus that have ever been brought to this part of the country, and, of course, their keeper is very careful of them.

This morning, when the cover was carefully removed from the box, the reporter drew near and cautiously looked in, but immediately started back, expecting the thing to jump.

"Don't be afraid," said Mr. Bliss; "it won't bite."

Whereupon Mr. Chase, a friend of Mr. Bliss, and the reporter were sufficiently re-assured to allow Mr. Bliss to remove the machine from its lair, and place it on the table. An inspection of it, conducted with increasing boldness, as it was observed to be entirely harmless, served to show that it consisted of an iron cylinder, about five inches in diameter and six in length, into which was cut an ordinary screw-thread, running from end to end. This cylinder was swung on an axle, projecting at each end about the length of the cylinder, and also circled by a screw thread corresponding to that on the cylinder. To the end of the axle was attached a small crank, by means of which the cylinder could be revolved, so as to work end-for-end on the axle-supports. The mouth-piece is a small round disk of thin tin, having a concave surface calculated to catch the sound, supported by a moveable rest, so that it can be swung close to or away from the cylinder. Fixed to the under side of this mouth-piece, by means of cement, is a minute chisel-shaped needle which, when the rest is brought close to the cylinder, would impinge into the screw-thread thereon. This was the simple contrivance. Now in order to make it speak, all that was necessary was to wind the cylinder with a piece of smooth tin foil, fastening the ends of the sheet with cement. The crank is then turned so that the cylinder is run clear to one end of the frame, and the mouth-piece is brought close to the cylinder, the little needle being very nicely adjusted against the tin foil. Then, as the words are spoken into the mouth-piece, the cylinder is slowly revolved; the plate to which the needle is attached vibrates to correspond with the voices and the needle gently indents the tin foil, striking each indentation into the groove of the screw so that it is clear cut and visible, though very small. The speaking having been concluded, the mouth-piece is swung away, and the cylinder is screwed back to where it began. A large tin funnel is then attached to the mouth-piece, which is swung back to the cylinder. This funnel is designed to garner and send out the sounds as they come from the instrument; the crank is turned, and, as the cylinder moves back over its former course, the little needle strikes into the indentations first made, thus vibrating the tin plate of the mouth-piece precisely as it was vibrated by the voice and—lo and behold, the creature speaks! That is all there is to it. Its voice is a little metallic, but a listener can recognize a friend's eccentricity of speech. The instrument receives a tenor or treble voice much more readily than a bass. Last evening the instrument, interviewed this morning, was put into operation in the auditorium of the First Methodist Church.

"Hurrah for Grant!" screamed Mr. Bliss, forgetful of the antiquity of that sentiment.

"Hurrah for Grant!" returned the instrument: but somebody had laughed at Mr. Bliss' patriotic exclamation. So the machine laughed while getting out the sentence, in such a manner as would not have sounded really flattering to the ex-President.

It repeated with the real spirit and twang such expressions as "What d'ye soye?" "Does yer mother know yer out?" and numberless other Americanisms, and, at length, after the company had been speaking very loud, under the impression that the thing had to be very emphatically addressed, the little daughter of the sexton of the church was brought into requisition. As it happened, she was bashful and could only be gotten to speak very low. But she repeated "Mary Had a Little Lamb," and presently the instrument ground out the familiar lines. The poem being encored, Mr. Bliss' clerk essayed to say it, but the man at the crank turned the cylinder with increasing speed, so that when the verses were returned, the tones went scaling up in rapidly ascending pitch, until at last, like Elaine's wailings, it "scaled high on the last line"—awful high. In the frequent repetitions of this idyl, it was not observed that the instrument ever once attempted any of the numerous parodies which have been perpetrated, but every time adhered to the true words and meter, from which it may be inferred that it will be a truthful recorder.

Phonographic Records under the Microscope.

HOW THE LETTERS LOOK—BELIEVED BY EDISON TO BE LEGIBLE—THE DEEPEST INDENTATIONS MADE BY CONSONANTS.

Microscopic examination of the indentations made in the tin foil by the phonograph when spoken to, shows that each letter has a definite form, though there is a great variation, resulting from the intensity and difference of voice. Long E (or ay) on the tin foil looks like two indian clubs with the handles together. The same general resemblance is observed in E short except that as in A short, the volume of sound being less, the intensity is less, or (what is the measure of intensity) the path of the needle-point is shorter, and it seldom entirely clears the foil, the consequence being a continuous groove of irregular, but normally irregular width.

I long and I short are much alike in general form, as also are O long and O short, the coupling of the pairs of the latter being the most striking feature. U long and U short best show the difference in shape produced by less intensities, the short being drawn out, and more acicular.

OI is very interesting. The dipthong consists of short O and short I, and the very molds which characterize their sounds are to be observed.

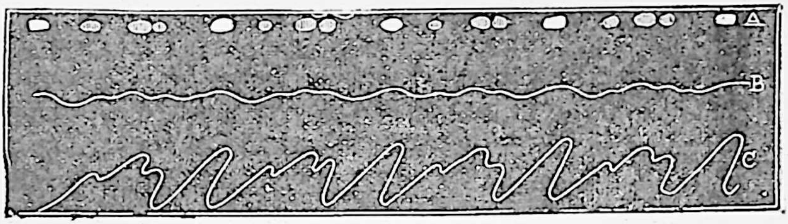
OW presents a composite character, but its derivation has not yet been made out. Evidently each letter has a definite form.

It has been a question of serious consideration and one of great importance with Mr. Edison whether the indentations in the tin foil could be read with the eye. Want of time has kept him from making extensive experiments, but he is of the opinion that careful study will enable experts to decipher the characters. Profs. Fleming Jenkin and M. Ewing, of the University of Glasgow, Scotland, have spent much time in examining the phonographic records, and have been partially successful in their attempts to read them. The method employed by the Professors was to repeat each of the vowel and consonant sounds a number of times, and then examine the record to determine if the indentation had any regular or characteristic shapes which would serve to identify the sounds. The result shows that the record of any single sound repeated is very irregular—one series of indentation differing widely from another. It was claimed, however, that despite this irregularity the record of any one sound could be distinguished from that of another sound.

Mr. Edison has repeated some of the experiments made by Profs. Jenkin and Ewing. Knowing beforehand what sounds had produced the records, he could tell the sounds by the indentations and also count the number of times a sound had been repeated. He found it impossible, however, to recognize similar sounds which had been repeated to the phonograph by another person. The shapes of the indentations were found by experiments to differ for the same sound, according to the speed with which the cylinder of the phonograph was turned, the force with which the sound was uttered, and the distance of the mouth from the diaphragm. Even by placing his hand against his cheek while repeating the sound, Mr. Edison says he can change the shape of the phonetic characters. The depest indentations are made by consonant sounds, on account of the explosive force with which these sounds are uttered. Words beginning with P can be recognized more easily than any others by the deep indentations which begin the records. One difficulty in recognizing records of words is found in the length of these records.

The clearness of the phonograph's articulation, Mr. Edison says, depends considerable upon the size and shape of the opening in the mouth-piece. When words are spoken against the whole diaphragm, the hissing sounds, as in shall, fleece, etc., are lost. These sounds are rendered clearly, when the hole is small and provided with sharp edges, or when made in the form of a slot surrounded by artificial teeth.

Besides tinfoil, other metals have been used. Impressions have been made upon sheets of copper, and even upon soft iron. With the copper foil the instrument spoke with sufficient force to be heard at a distance of two hundred and seventy-five feet in the open air.



Phonographic Records under the Microscope.

In the above engraving, the dotted line A, represents the appearance to the eye of the impressions made on the foil when the sound of *a* in *bat* is sung against the iron plate of the phonograph.

B, is a magnified profile of these impressions on smoked glass obtained by using a form of pantagraph.

C, gives the appearance of Konig's flame when the same sound is sung quite close to its membrane.

It will be seen that the profile of the impressions made on the phonograph, and the contours of the flames of Konig, when vibrated by the same compound sound bear a close resemblance.

The Phonograph Supreme at Home.

A Western journal jocosely remarks that the phonograph will be a source of comfort and consolation to long suffering wives whose husbands are in the habit of staying out late at night and returning in the small hours to wrestle with the key-hole, and eventually go to bed with their boots on. To get even with these wretches, the poor woman has to sit up and await their coming in order to more effectually free her mind. Having her phonograph, she can speak a vigorous lecture into it, and, fixing the clock-work so that it will go off at the time she knows he will return, she can compose herself to sleep, confident that her representative will do her work with the necessary vigor and emphasis, and that the victim will have to endure it. He may raise the window and pitch the phonograph into the street, but the machine will none the less have its say out, and in this case will have the immediate neighbors for listeners. For the curtain lecture business the phonograph will be of great advantage, as it can be set to go off at any specified time, like an alarm clock. A woman specially gifted in invective and sarcasm, and having a good flow of speech, could do a thriving business by supplying plates to those of her sex less gifted in the science of combing down recreant spouses and reducing them to a state of pliability and won't-do-so-any-more. Many family jars might be pleasantly adjusted by the phonograph. The husband and wife could scold it out into their instruments, and leave them on the bureau for the housemaid to take out into the back-yard, where they could splutter at each other without doing any harm. Right at this point, however, there is a startling possibility. Mr. Edison's ærophone is only a colossal telephone that conveys sound for ten miles. The alarming capabilities of such an instrument are apparent when the reader contemplates an irate woman, whose husband is out later than he ought to be, in possession of a voice ten miles long and as big as a small clap of thunder. The clock strikes twelve, one, two; the whole city is wrapped in silence, when suddenly a voice cries through the startled air, awakening every one from sleep, "John Henry Jones, you come home right off, or you'll catch it." Such developments of the domestic discipline are among the alarming possibilities of Mr. Edison's inventions.

"Uncle Remus" and the Phonograph.

"Unc. Remus," asked a tall, awkward looking negro who was one of a crowd surrounding the old man in front of James' Bank, "W'at's dis 'ere wat dey calls de fongraf—dis 'ere inst'u-ment wa't kin holler 'roun like little chillum in de back yard?"

"I ain't seed um," said Uncle Remus, feeling in his pocket for a fresh chew of tobacco. "I ain't seed um, but I hear talk on um. Miss Sally wuz a readin' in de papers las' Chuesday, an' she say dat it's a mighty big whatyoumaycallem."

"A mighty big which?" asked one of the crowd.

"A mighty big whatshisname," answered Uncle Remus. "I wuzzent up dar close to whar Miss Sa'ah was reedin' but I kinder geddered it in dat it wuz one er dese 'ere whathisnamzes w'at holler inter one year an' it comes out at de odder. Hit's mighty funny unto me how dese folks kin go an' prognosticate dere ekoes intu one er dese yer i'on boxes, an' dar hit'll stay ontwell de man comes 'long an' turns de handle an' lets de fuss come pilin' out. Bimeby dey'll get ter makin' shore-nuff people, an' den dere'll be a racket 'roun here.—Dey tells me dat it goes off like one er dese 'ere torpedoes."

"You hear dat, don't you?" said said one or two of the younger negroes.

"Dat's w'at dey tells me," continued Uncle Remus.—"Dat's w'at dey sez. Hit's one er dese yer kinder w'atsiznames dat sasses back when you hollers at it"

"W'at dey fix um up for den?" asked one of the practical negroes.

"Dat's w'at I want er know," said Uncle Remus contempla-tively. "But dat's w'at Miss Sally was reedin' in de paper. All you gotter do is holler at de box, an' dar's no remarks. Dey goes in, an' dar dey are tooken, an' dar dey hangs on twell you shake de box, an' den dey drops out des er dese yere fishes w'at you git from Savannah, an' you ain't got time fer ter look at dere gills needer."

Moses and the Toddygraph.

"Officer Warlow bring up Moses in the bulrushes," said Justice Bixby.

The officer brought up a seed-cucumbery looking individual, and placed him at the railing.

"The officer found you last night," said the Judge, lying in the bullrushes round the Union Square fountain, dead drunk. What have you to say?"

Well, Judge, I'll tell you how it was," said the prisoner, I'm an inventor."

"Of what?" asked his honor.

"Of the toddygraph."

"What's that?"

"Why, you wind a cylinder with tinfoil," said the prisoner, "and drop into a liquor-saloon and take a drink. You have the cylinder under your coat, and when the bar-keeper ain't looking, you breathe on the tinfoil; when you get out you turn a crank, and repeat the drink as often as you please."

"A very dangerous invention," said his honor.

"By no means," said the prisoner, "for it ruins the landlord's business. One drink will last a week."

"Yes," said his Honor, "but it kills the imbiber."

"But if there were no landlords there would be no imbibers," said the prisoner.

"That may be so; but what has all this to do with your being found drunk in a public park?"

"I'll tell you. Last night I was testing a new machine, and I think—I won't be positive—but I think I turned the crank just once too often"

"Very well," said his Honor, "I will send you up for ten days." As you tarry in classic Blackwell, I advise you to turn your inventive genius to something more useful. Invent a dinnergraph, for instance, so that a poor man can repeat a square meal often. Millions yet unborn will bless you, and your name will go down to posterity along with Peter Cooper and Florence Nightingale."

How the "Phonograph Man" is said to Amuse Himself.

A Cincinnati gentleman is responsible for the following:

Edison, the phonograph man, is wretched unless he invents half a dozen things every day. He does it just for amusement when regular business isn't pressing. The other day he went out for a little stroll and he thought out a plan for walking on one leg so as to rest the other, before he had gone a square.

He hailed a milk-wagon and told the driver of a little invention that had popped through his head just that moment for delivering milk without getting out of his wagon or even stopping his horses. A simple force-pump, with hose attached, worked by the foot, would do the business. Milk-men who dislike to halt for anything in their mad career, because it prevents them running over as many children as they might otherwise do, would appreciate this improvement. Edison isn't sure but that sausage and pig's feet could be delivered in the same way.

He stepped into a hotel office, and, observing the humiliations which guests encountered in seeking to obtain information from the high-toned clerk, he sat down in the reading-room, and in five minutes had invented a hotel clerk to work by machinery, warranted to stand behind the counter any length of time desired, and answer all questions with promptness, correctness, and suavity—diamond pin, and hair parted in the middle, if desired.

Lounging into the billiard-room, he was struck with the need-less amout of cushions required to each table. Quick as lightning he thought of a better and more economical plan—cushion the balls! He immediately pulled out a postal card and wrote to Washington applying for a patent.

When Edison started to go out he had to pass the barber-shop of the hotel, and, as he did so, he sighed to think that, with all his genius and creative imagination, he could never hope to equal the knight of the razor as a talking machine. This saddened him so that he went home and invented no more that day.

How the Phonograph Frightened a Preacher.

One of the most amusing anecdotes in relation to Mr. Edison and the phonograph is told in connection with a well known divine who was very skeptical concerning the capabilities of the wonderful instrument and who, it seems, had a vague suspicion that either Mr. Edison or some one of his assistants, was palming off some first class ventriloquism under the assumed name of the marvelous. Such a remarkable case as this one was likely to be, Mr. Edison thought demanded special attention and so a plate of tin foil was properly doctored for the divine, to suit the emergency.

Sure enough his incredulity was manifested at the proper time. He wanted to talk into the mouthpiece himself and see if his own words would be recorded and repeated. So down he sat and gravely repeated a verse of scripture to the phonograph.—The readjusment was made and to his utter astonishment it came back from the instrument as follows:

He that cometh from above is above all; (who are you, anyhow?) he that is of the earth (Oh, pshaw, give us a rest,) is earthly, and speaketh of the (Look here, you can't preach, go home) earth, etc. The startled divine was lost in amazement, but repeated experiments convinced him that the phonograph was all right.

How the Phonograph was Discovered by Mr. Edison.

The phonograph was discovered—to use Mr. Edison's language—"by the merest accident." "I was singing," says he, "to the mouthpiece of a telephone, when the vibrations of the wire sent the fine steel point into my finger. That set me to thinking. If I could record the actions of the point, and then send the point over the same surface afterwards, I saw no reason why the thing would not talk.

I tried the experiment, first on a strip of telegraph paper, and found that the point made an alphabet. I shouted the word "Halloo! Halloo!" into the mouthpiece, ran the paper back over the steel point and *heard a faint Halloo! Halloo!* in return! I determined to make a machine that would work accurately, and gave my assistants instructions, telling them what I had discovered.

They laughed at me. I bet fifteen cigars with one of my assistants, Mr. Adams, that the thing would work the first time without a break, and won them. That's the whole story. The discovery came through the pricking of a finger."

Mr. Edison related this story of the phonograph's origin to a company of interested listeners at Menlo Park, as given above, and then turning to the instrument he shouted out in the mouthpiece:

> " Nineteen years in the Bastile!
> I scratched a name upon the wall,
> And that name was Robert Landry.
> Parlez vous Francais ? Si habla Espanol,
> Sprechen sie Deutsch ?"

And the words were repeated, followed by the air of "Old Uncle Ned," which he had sung.

Edison Joking with the Phonograph.

The matrix, after having been used to record one conversation or poem as the case may be, will also admit of another being superinduced, but they will, of course, be reported in a very jumbling manner. In this way Mr. Edison and his assistants frequently created much amusement for the listeners.

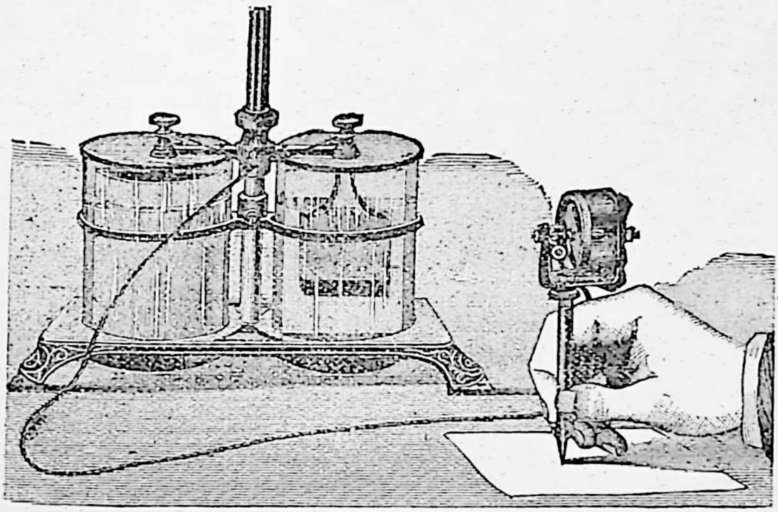
On one occasion the affecting words of the first verse of "Bingen on the Rhine" were made by the phonograph to be reported as follows:

A soldier of the legion lay dying in algiers,
—— —— "Oh, shut up!" —— —— "Oh, bag your head!"
There was lack of woman's nursing, there was
—— —— —— "Oh, give us a rest!" —— —— ——
lack of woman's tears.
—— —— —— — "Dry up!"
But a comrade stood beside him while his life
—— —— —— — "Oh, what are you giving us!" ———"Oh,
blood ebbed away,
cheese it!"
And bent with pitying glances to hear what he
—— —— —— "Oh, you can't read poetry!" —— —— "Let
might say.
up!"
The dying soldier faltered, and he took that com
—— —— —— —— "Police! Police!" —— —— —— "Po-
rade's hand,
lice!"
And he said, "I shall never see my own, my
—— —— —— —— "Oh, put him out!" —— —— "Oh cork
native land."
yourself!"

It is impossible to describe the ludicrousness of the effect. Mr. Edison himself laughed like a boy.

Edison's Electric Pen.

Mr. Edison has taught the lightning to write in more ways than by chemistry. Perhaps his most simple, and still very ingenious, method is by means of the electric pen, over sixty thousand of which are now in use throughout the country. The electricity in this case causes a perforating needle point to move up and down within a pencil shaped holder at very great rapidity. This holder is manipulated the same as if it were a pen or pencil, and as it moves rapidly over the surface of the paper the needle point, by its intensely rapid movement perforates the pa-



Edison's Electric Pen.

per sufficiently to produce a perfect stencil of what has been written.—When the electric writing is completed, the sheet of paper is put into a duplicating press and copies made therefrom in any numbers required. The perforations are so numerous and so nearly together, that when the ink is pressed through them upon the surface of the duplicate sheet, they seem to form a continuous line making the writing easily legible, provided of course, the electric instrument which makes the stencil is guided by a good penman. The battery, line, pen, and working principle of this novel invention are shown in the engraving here given.

The Electro-Motograph.

A CURIOUS INSTRUMENT—HOW IT WORKS—FOUR HUNDRED MOVES IN ONE SECOND!

Among the most singular of Mr. Edison's discoveries is the fact that certain chemical salts lose their functional properties when subjected to the action of an electric current. On this as a basis of action he has devised a telegraphic system in which the ordinary relay magnet is wholly unnecessary. This he called the Electro-motograph. In the language of Mr. Prescott, "it was the substitution of friction aud ante friction for the presence of magnetism in the relay. It was remarkable also, in that it could be worked by an almost infinitessimal current." Its rapidity of action is more than ten-fold greater than any magnet hitherto constructed, which renders it the only known apparatus that can repeat or translate, from one circuit to another, the signals of high speed telegraph systems.

The working principle of the instrument is explained as follows: A drum, rotated by clock work, carries slowly forward a slip of paper moistened with a solution of potassic hydrate.—Immediately over this drum is a circuit closing lever which moves freely upward and sideways. Upon the extreme end of the lever is a screw having a lead point, which is held firmly against the surface of the chemical paper by the tension of a spring. Near the end of the lever is a platina pointed extension projecting upwards, its extreme end playing between a limiting screw and a platina-pointing screw opposite. The local connections, or second line wire are made in the usual manner. There is also a sounder and a local battery. The zinc pole of the main battery is connected with the lead point screw, while the other pole is connected through the key to the drum. The action is as follows: The pressure with which the lead point is held upon the chemicalpaper causes great friction and locks the point, as it were, to the paper, and the rotating drum carries the lever forward to the limiting screw, the local circuit and main line being broken. If one or two turns only be given the spring which draws the lever back, the friction will still be sufficient to detain the lever in contact with the drum, but the moment the key is closed, the passage of the current produces an unknown and peculiar action upon the lead point and chemical paper, and the *almost total annihilation of the normal friction*, when, of course, the spring draws the lever back and closes the local circuit or second main line as the case may be, and continues there as long as the current passes; but when the current is broken by the key the *normal friction returns instantaneously*, and the continuously moving drum and paper carries the lever forward again to the limiting screw, or stop, breaking the secondary circuit.

The genius of the instrument is in the chemical paper, which in some strange manner loses its frictional properties when subjected to a current of electricity. By means of signals transmitted from perforated paper, Mr. Edison succeeded in applying it as a repeater, and transmitted fourteen hundred words from one circuit into another in one minute, which requires at least *four hundred full and perfect movements of the lever each second!*

Modifications of this apparatus have been devised by the inventor, which enables it to work with positive and negative currents, thus dispensing with the adjusting springs. From the fact that this instrument requires but small battery power and is remarkably sensitive to feeble currents, and can be used to record very delicate signals without electro-magnets, it is extremely probable that it will be the basis of new discoveries, among which is the solution of the problem of fast working through long sub-marine cables. "Important results," says Mr. Prescott "are to follow this discovery."

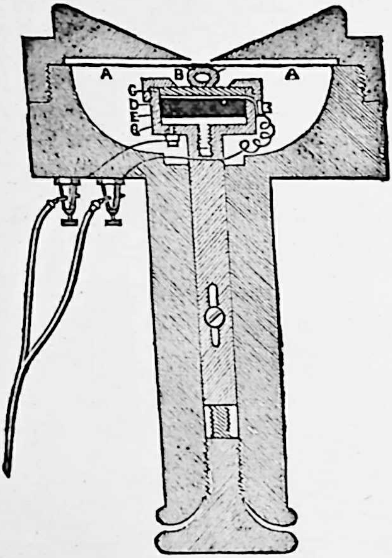


Fig. 1.

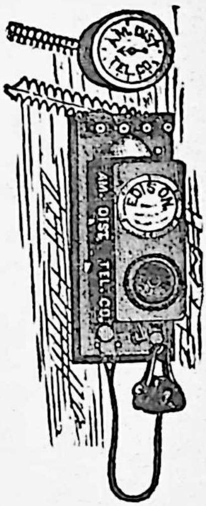


Fig. 2.

Fig. 1. Carbon Telephone—Interior. A A, Iron Diaphragm; B, India Rubber; C, Ivory; D, Platina Plate; E, Carbon Disk; G, Platina Screw. Fig. 2. Exterior View of Edison's Telephone.

The Telephone.

EDISON'S OWN ACCOUNT OF HIS DISCOVERY OF THE CARBON TELEPHONE—AN INTERESTING HISTORY—HIS EXPLANATION OF THE WONDERFUL INSTRUMENT—ILLUSTRATED BY NUMEROUS ENGRAVINGS—IT TALKS OVER A WIRE 720 MILES LONG—HIS OTHER TELEPHONES.

"My first attempt at constructing an articulating telephone," says Mr. Edison, "was made with the Reiss transmitter and one of my resonant receivers, and my experiments in this direction, which continued until the production of my present carbon telephone, cover many thousand pages of manuscript. I shall, however, describe here only a few of the more important ones.

In one of the first experiments I included a simplified Reiss transmitter, having a platinum screw facing the diaphragm, in a circuit containing twenty cells of battery and the resonant receiver, and then placed a drop of water between the points; the results, however, when the apparatus was in action, were unsatisfactory—rapid decomposition of the water took place and a deposit of sediment was left on the platinum. I afterwards used disks attached both to the diaphragm and to the screw, with several drops of water placed between and held there by capillary attraction, but rapid decomposition of the water, which was impure, continued, and the words came out at the receiver very much confused. Various acidulated solutions were then tried, but the confused sounds and decompositions were the only results obtained.

With distilled water I could get nothing, probably because, at that time, I used very thick iron diaphragms, as I have since obtained good results; or, possibly, it was because the ear was not yet educated for this duty, and therefore I did not know what to look for. If this was the case, it furnishes a good illustration of the fact observed by Professor Mayer, that we often fail to distinguish weak sounds in certain cases when we do not know what to expect.

Sponge, paper and felting, saturated with various solutions, were also used between the disks, and knife edges were substituted for the latter with no better results. Points immersed in electrolytic cells were also tried, and the experiments with various solutions, devices, etc., continued until February, 1876, when I abandoned the decomposable fluids and endeavored to vary the resistance of the circuit proportionately with the amplitude of vibration of the diaphragm by the use of a multiplicity of platinum points, springs and resistance coils—all of which were designed to be controlled by the movements of the diaphragm, but none of the devices were successful.

In the spring of 1876, and during the ensuing summer, I endeavored to utilize the great resistance of thin films of plumbago and white Arkansas oil stone, on ground glass, and it was here that I first succeeded in conveying over wires many articulated sentences. Springs attached to the diaphragm and numerous other devices were made to cut in and out of circuit more or less of the plumbago film, but the disturbances which the devices themselves caused in the true vibrations of the diaphragm prevented the realization of any practical results. One of my assistants, however, continued the experiments without interruption until January, 1877, when I applied the peculiar property which semi-conductors have of varying their resistance with pressure, a fact discovered by myself in 1873, while constructing some rheostats for artificial cables, in which were employed powdered carbon, plumbago and other materials, in glass tubes.

For the purpose of making this application, I constructed an apparatus provided with a diaphragm carrying at its centre a yielding spring, which was faced with platinum, and in front of this I placed, in a cup secured to an adjusting screw, sticks of crude plumbago, combined in various proportions with dry powders, resins, etc. By this means I succeeded in producing a telephone which gave great volume of sound, but its articulation was rather poor; when once familiar with its peculiar sound, however, one experienced but little difficulty in understanding ordinary conversation.

After conducting a long series of experiments with solid materials, I finally abandoned them all and substituted therefor tufts of conducting fibre, consisting of floss silk coated with plumbago and other semi-conductors. The results were then very much better, but while the volume of sound was still great, the articulation was not so clear as that of the magneto telephone of Prof. Bell. The instrument, besides, required very frequent adjustment, which constituted an objectionable feature.

Upon investigation, the difference of resistance produced by the varying pressure upon the semi-conductor was found to be exceedingly small, and it occurred to me that as so small a change in a circuit of large resistance was only a small factor, in the primary circuit of an induction coil, where a slight change of resistance would be an important factor, it would thus enable me to obtain decidedly better results at once. The experiment, however, failed, owing to the great resistance of the semi-conductors then used.

After further experimenting in various directions, I was led to believe, if I could by any means reduce the normal resistance of the semi-conductor to a few ohms, and still effect a difference in its resistance by the pressure due to the vibrating diaphragm, that I could use it in the primary circuit of an induction coil.—Having arrived at this conclusion, I constructed a transmitter in which a button of some semi-conducting substance was placed between two platinum disks, in a kind of cup or small containing vessel. Electrical connection between the button and disks was maintained by the slight pressure of a piece of rubber tubing, ¼ inch in diameter and ½ inch long, which was secured to the diaphragm, and also made to rest against the outside disk. The vibrations of the diaphragm were thus able to produce the requisite pressure on the the platinum disk, and thereby vary the resistance of the button included in primary circuit of the induction coil.

At first a button of solid plumbago, such as is employed by electrotypers, was used, and the results obtained were considered excellent, everything transmitted coming out moderately distinct, but the volume of sound was no greater than that of the magneto telephone.

In order, therefore, to obtain disks or buttons, which, with a low normal resistance, could also be made, by a slight pressure, to vary greatly in this respect, I at once tried a great variety of substances, such as conducting oxides, sulphides and other partial conductors, among which was a small quantity of lampblack that had been taken from a smoking petroleum lamp and preserved as a curiosity on account of its intense black color.

A small disk made of this substance, when placed in the telephone, gave splendid results, the articulation being distinct, and the volume of sound several times greater than with telephones worked on the magneto principle. It was soon found upon investigation, that the resistance of the disk could be varied from three hundred ohms to the fractional part of a single ohm by pressure alone, and that the best results were obtained when the resistance of the primary coil, in which the carbon disk was included, was six-tenths of an ohm, and the normal resistance of the disk itself three ohms.

Mr. Henry Bentley, President of the Local Telegraph Company, at Philadelphia, who has made an exhaustive series of experiments with a complete set of this apparatus upon the wires of the Western Union Telegraph Company, has actually succeeded in working with it over a wire of 720 miles in length, and has found it a practicable instrument upon wires of 100 to 200 miles in length, notwithstanding the fact that the latter were placed upon poles with numerous other wires, which occasioned sufficiently powerful induced currents in them to entirely destroy the articulation of the magneto telephone. I also learn that he has found the instrument practicable, when included in a Morse circuit, with a battery of eight or ten stations provided with the ordinary Morse apparatus; and that several way stations could exchange business telephonically upon a wire which was being worked with a quadruplex without disturbing the latter, and notwithstanding, also, the action of the powerful reversed currents of the quadruplex on the diaphragms of the receiver. It would thus seem as though the volume of sound produced by the voice with this apparatus more than compensates for the noise caused by such actions.

While engaged in experimenting with my telephone for the purpose of ascertaining whether it might not be possible to dispense with the rubber tube which connected the diaphragm with the rheostatic disk, and was objectionable on account of its tendency to become flattened by continued vibrations, and thus necessitate the readjustment of the instrument, I discovered that my principle, unlike all other acoustical devices for the transmission of speech, did not require any vibration of the diaphragm—that, in fact, the sound waves could be transformed into electrical pulsations without the movement of any intervening mechanism.

The manner in which I arrived at this result was as follows:—I first substituted a spiral spring of about a quarter inch in length, containing four turns of wire, for the rubber tube which connected the diaphragm with the disks. I found, however, that this spring gave out a musical tone, which interfered somewhat with the effects produced by the voice; but, in the hope of overcoming the defect, I kept on substituting spiral springs of thicker wire, and as I did so I found that the articulation became both clearer and louder. At last I substituted a solid substance for the springs that had gradually been made more and more inelastic, and then I obtained very marked improvements in the results. It then occurred to me that the whole question was one of pressure only, and that it was not necessary that the diaphragm should vibrate at all. I consequently put in a heavy diaphragm, one and three quarter inches in diameter and one sixteenth inch thick, and fastened the carbon disk and plate tightly together, so that the latter showed no vibration with the loudest tones. Upon testing it I found my surmises verified;—the articulation was perfect, and the volume of sound so great that conversation carried on in a whisper three feet from the telephone was clearly heard and understood at the other end of the line. This, therefore, is the arrangement I have adopted in my present form of apparatus, which I call the carbon telephone, to distinguish it from others.

The accessories and connections of this apparatus for long circuits are shown in Fig. 3. A is an induction coil, whose primary wire, P, having a resistance of several ohms, is placed around the secondary, instead of within it as in the usual manner of construction. The secondary coil, *s*, of finer wire, has a resistance of from 150 to 200 ohms, according to the degree of tension required; and the receiving telephone, R. consists simply of a magnet, coil, and diaphragm. One pole of the magnet is connected to the outer edge of the diaphragm, and the other, which, carries the wire bobbin of about 77 ohms resistance, and is included in the main line, is placed just opposite its center.

"P R. is the signaling relay, the lever of which, when actuated by the current from a distant station on the line in which the instrument is included, closes a local circuit containing the vibrating call bell, B, and thus gives warning when speaking communication is desired.

"Besides serving to operate the call bell, the local battery, E, is also used for sending the call signal. S is a switch, the lever of which, when placed at *o*, between *m*, and *n*, disconnects the, transmitter, T, and local battery, E, from the coil, A, and in this position leaves this polarized relay, P R, free to respond to currents from the distant station. When this station is wanted, how-

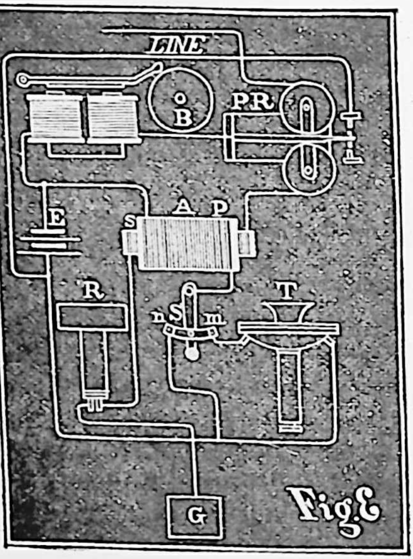


Fig. 3; Telephone Apparatus.

ever, the lever, S, is turned to the left on *n*, and depressed several times in rapid succession. The current from the local battery, by this means, is made to pass through the primary coil of A, and thus for each make and brake of the circuit induces powerful currents in the secondary, *s*, which pass into the line and actuate the distant call bell.

"When the call signals have been exchanged, both terminal stations place their switches to the right on *m*, and thus introduce the carbon transmitter into their respective circuits. The changes of pressure produced by speaking against the diaphragm of either transmitter, then serve, as already shown, to vary the resistance of the carbon, and thus produce corresponding variations in the induced currents, which, acting through the receiving instrument, reproduce at the distant station whatever has been spoken into the transmitting instrument.

For lines of moderate lengths, say from one to thirty miles, another arrangement, shown in Fig. 4, may be used advantageously.

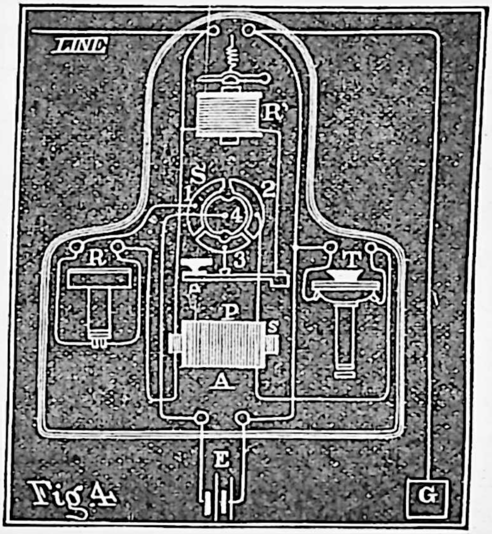


Fig. 4; Telephone Apparatus, with Switch.

ously. The induction coil, key, battery, and receiving and transmitting telephones, are lettered the same as in the previous engraving, and are similar in every respect to the apparatus there shown; the switch, S, however, differs somewhat in construction from the one already described, but is made to serve a similar purpose. When a plug is inserted between 3 and 4 the relay or sounder, R,' battery E, and key, K, only are included in the main line circuit, and this is the normal arrangement of the apparatus for signaling purposes. The battery, usually about three cells of the Daniell form, serves also both for a local and main battery. When a plug is inserted between 1, 2, and 4, the apparatus is available for telephonic communication.

I have also found, on lines of from one to twenty miles in length, that the ordinary call can be dispensed with, and a simplified arrangement substituted. This latter consists simply of the ordinary receiving telephone, upon the diaphram of which a free lever, L, is made to rest, as shown in Fig. 5. When the induced currents from the distant station act upon the receiver, R, the diaphgram of the latter is thrown into vibration, but by itself is capable of giving only a comparatively weak sound; with the lever resting upon its center, however, a sharp, pene-

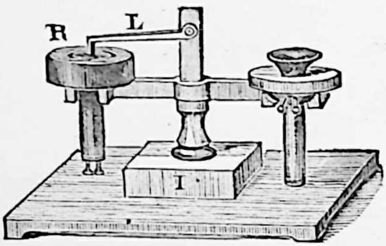


Fig. 5; Lever Signal.

trating noise is produced by the constant and rapid rebounds of the lever, which thus answers very well for calling purposes at stations where there is comparatively but little noise.

Among the various other methods for signalling purposes which I have experimented with, I may mention the sounding of a note, by the voice, in a small Reiss's telephone; the employment of a self-vibrating reed in the local circuit; and a break wheel with many cogs, so arranged as to interrupt the circuit when set in motion.

I have also used direct and induced currents to release clock work, and thus operate a call, and in some of my earlier acoustic experiments tuning forks were used, whose vibrations in front of magnets caused electrical currents to be generated in the coils surrounding the latter.

By the further action of these currents on similar forks at a distant station, bells were caused to be rung, and signals thus given. Fig. 6 shows an arrangement of this kind. A and R

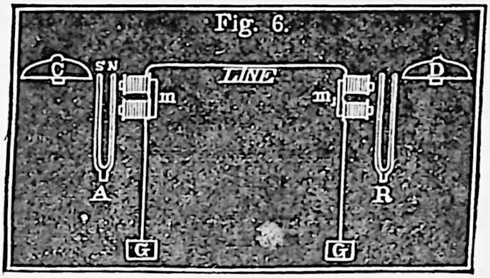


Fig. 6; Tuning Fork Signal.

are two magnetized tuning forks, having the same rate of vibration and placed at two terminal stations. Electro-magnets *m* and m^1 are placed opposite one of the prongs of the forks at each station, while a bell, C or D, stands opposite to the other. The coils of the magnet are connected respectively to the line wire and to earth. When one of the forks is set in vibration by a starting key provided for the purpose, the currents produced by the approach of one of its magnetized prongs towards the

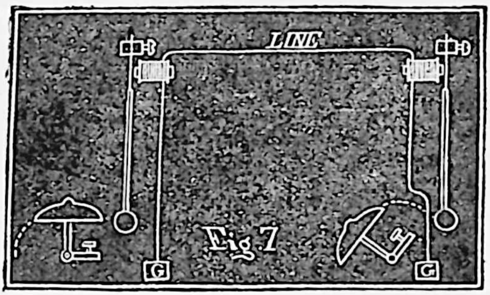


Fig. 7; Pendulum Signal.

magnet, and its recession therefrom, pass into the line and to the further stations where their action soon causes the second fork to vibrate with constantly increasing amplitude, until the bell is struck and the signal given.

For telephonic calls the call bells are so arranged that the one opposite to the fork, which generates the currents, is thrown out of the way of the latter's vibrations.

Another call apparatus which I have used, is represented in Fig. 7. In this arrangement two small magnetic pendulums, whose rates of vibration are the same, are placed in front of separate electro-magnets, the helices of which join in the main line circuit. When one of the pendulums is put in motion, the currents generated by its forward and backward swings in front of the electro-magnet pass into the line, and at the opposite terminal, acting through the helix there, cause the second pendulum to vibrate in unison with the former.

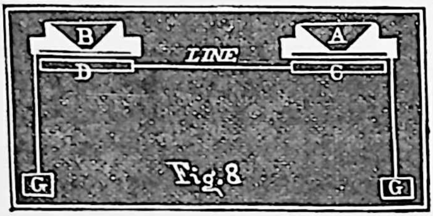


Fig. 8; Electrophons Telephone.

Fig. 8 shows a form of electrophorus telephone which acts by the approach of the diaphragm contained in A or B towards, or its recession from, a highly charged electrophorus, C or D. The vibrations of the transmitting diaphragm cause a disturbance of the charge at both ends of the line, and thus give rise to faint sounds. Perfect insulation, however, is necessary, and either apparatus can be used both for transmitting and receiving, but the results are necessarily very weak.

Another form of electro-static telephone is shown in Fig. 9.—In this arrangement Deluc piles of some 20,000 disks each are contained in glass tubes, A and B., and conveniently mounted on glass, wood, or metal stands. The diaphragms, which are in electrical connection with the earth, are also placed opposite to one pole of each of the piles, while the opposite poles are joined together by the line conductor. Any vibration of either diaphragm is thus capable of disturbing the electrical condition of the neighboring disks, the same as in the electrophorus telephones; and consequently the vibrations, when produced by the voice in one instrument, will give rise to corresponding elec-

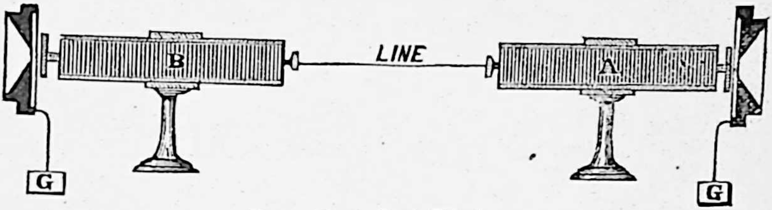


Fig. 9; Electro-Static Telephone.

trical changes in the other, and thereby reproduce in it what has been spoken into the mouthpiece of the former.

With this arrangement fair results may be obtained, and it is not necessary that the insulation should be so perfect as for the electrophorus apparatus.

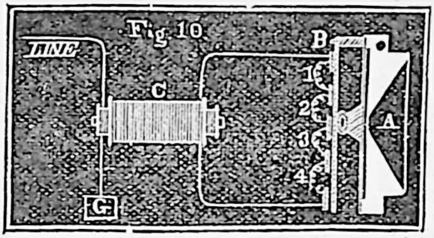


Fig. 10; Electro-Mechanical Telephone.

Fig. 10 shows a form of electro-mechanical telephone, by means of which I attempted to transmit electrical impulses of various strength so as to reproduce spoken words at a distance. Small resistance coils (1, 2, 3, etc.) were so arranged with connecting springs near a platinum faced lever, B, in connection with the diaphragm in A, that any movement of the latter caused one or more of the coils to be cut in or out of the primary circuit of an induction coil, C, the number, of course, varying with the amplitude of the vibrating diaphragm. Induced currents corresponding in strength with the variations of resistance were thus sent into the line, and could then be made to act upon an ordinary receiving telephone. By arranging the springs in a sunflower pattern about a circular lever, articulate sentences have been transmitted by this method, but the results were very harsh and disagreeable.

Fig. 11 shows a form of the water telephone, in which a double cell was used so as to afford considerable variation of resistance for the very slight movements of the diaphragm. The action of the apparatus will readily be understood from the en-

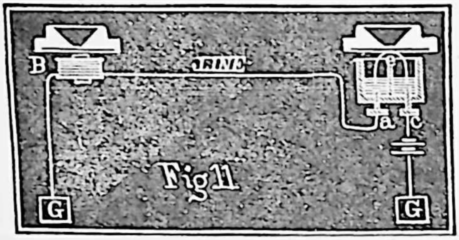


Fig. 11; Water Telephone.

graving, where a wire in the form of the letter U is shown, with the bend attached to the diaphragm, and its ends dipping into the separate cells, and thus made to form part of the circuit when the line is joined to the instrument at *a* and *c*.

I am now conducting experiments with a thermo-electric telephone, which gives some promise of becoming serviceable. In this arrangement a sensitive thermo-pile is placed in front of a diaphragm of vulcanite at each end of a line wire, in the circuit of which are included low resistance receiving instruments. The principle upon which the apparatus works depends upon the change of temperature produced in the vibrating diaphragm, which I have found is much lower as the latter moves forward, and is also correspondingly increased on the return movement.

Sound waves are thus converted into heat waves of similar characteristic variations, and I am in hopes that I may ultimately be able, by the use of more sensitive thermo-piles, to transform these heat waves into electrical currents of sufficient strength to produce a practical telephone on this novel principle.

Before concluding, I must mention an interesting fact connected with telephonic transmission, which was discovered during some of my experiments with the magneto-telephone, and which is this, that a copper disk may be substituted for the iron diaphragm now universally used. The same fact, I believe, has also been announced by Mr. W. H. Preece, to the Physical Society at London.

If a piece of copper, say one sixteenth of an inch thick and three fourths of an inch in diameter, is secured to the center of a vulcanite diaphragm, the effect becomes quite marked, and the apparatus is even more sensitive than when the entire diaphragm is of copper. The cause of the sound is due, no doubt, to the production of very weak electrical currents in the copper disk.

It will be seen from this description by Mr. Edison that the carbon telephone was not the work of a single day but of years, in which he labored with singular patience and tenacity. The genius of the instrument is the carbon button. This is the all essential factor, not only in the telephone, but in the tasimeter, and other inventions of Mr. Edison. It ranks among the grandest discoveries of the nineteenth century. With the appliances already completed it is possible that a thunder-clap might be made to roll around the world, and in the near future, greater results will certainly come to pass. By this same marvelous button in the tasimeter, the heat of a telescopic star is definitely registered, and yet the nearest fixed star is over thirty trillions of miles distant from the earth. If not the philosopher's stone, it is certainly next to it, in its wonderful facilities for transformations.

Mr. Edison has very recently invented a new telephone receiver, in which no magnet is used. It is based upon the the principle of the electro-motograph, described elsewhere in this volume. By this new receiver the volume of the message transmitted is increased so as to be heard distinctly fifteen feet from the instrument. It is expected this new invention will render possible conversation through the Atlantic cable, and that between the large cities throughout the country this will be a daily occurrence. He is also introducing a "double transmitter."

Testing Edison's Telephone.

A Little Chat, Intermingled with Whispers, Between Persons 210 Miles Apart—An Innocent Joke Perpetrated on Mr. Firman—Complete Success of the Carbon Telephone.

A thorough and satisfactory test of Edison's Telephone was made January 5th, 1879, over a wire of the Western Union Telegraph company between Indianapolis and Chicago. The wire runs along the I. C. & L. Railroad to Lafayette; thence along the N. A. & C. Railroad to Wanatah; thence along the P. Ft. W. & C. Railroad to Chicago, being about two hundred and ten miles in length. When the reporter, whose account we here give, entered the Superintendent's rooms at the Indianapolis end, the experiment had already begun and almost the first thing he heard was the operator at that end, speaking in the telephone, saying: "Here comes a *Journal* man. Wait till I give him a receiver, so he can hear you."

Another receiving telephone was attached and handed to the visitor, when the operator said, "Now, Mr. Wilson, at Chicago, I want to introduce Mr. Blank, of the *Journal*, at Indianapolis. Speak to him. He is listening. Be careful how you talk, he is liable to print it."

Instantly came back, clear and distinct, as if spoken through a tube from an adjoining room, "Good morning, Mr. Blank. I hope you are very well. Are you able to understand me?"

"Perfectly," was the reply; "and I can hardly believe you are so far away."

"If you were acquainted with my voice, so as to recognize it, your belief would be strengthened."

"Yes, very likely. I can see that if I were acquainted with your voice, I could easily recognize it. Have you ever talked this far before?"

"Oh, yes, we had a chat with your Indianapolis friends two or three Sundays ago, which was very satisfactory. We even exchanged whispers that day. Let's try it now. Listen closely."

A whisper sound was heard. When notified that ten would be counted it was readily recognized in a whisper.

Mr. Smith, of the W. U. T. Company, then stepped to the instrument and spoke to Mr. Wilson, at Chicago.

"Good morning, Charlie."

"Good morning, Mr. Smith."

"You know me, do you?"

"Why, of course I do. Pretty cold morning, this."

"Pretty cool here; we are getting used to it though. The wire works nicely, don't it?"

"Yes, indeed, couldn't ask anything better.

"Say, Charlie?"

"Well."

"Have you a wire over to the Telephone Exchange?"

"Yes, sir."

"See if you can find Mr. Firman at his office or his house, and connect that wire to this."

"All right. Guess I can find him in a few minutes."

"Just say that some one wants to speak with him, but don't say who or where."

"All right; we'll have some fun with the gentleman if I can find him. I'll call you; look out for me."

"All right."

Mr. Firman is the General Manager of the Telephone Exchange and American District Telegraph Company in Chicago. After waiting perhaps three minutes, Mr. Wilson's voice was heard:

"Mr. Firman's at home. I'm going to connect you. Speak to him. Now!"

"Halloo, Firman!"

"Halloo, yourself! What do you want?"

"Well, I wanted to say good morning, but you seem a little bit crusty, so I won't."

"Well, I take it all back. I'm glad to see you. How are you, any how? When did you come to town?"

"Guess you don't know who you are talking to."

"I'm talking to Wiley Smith, or I'm very much mistaken."

"You are right. Thought I would beat you this time."

"Oh, no! my telephone experience has enabled me to recall familiar voices without many mistakes now. Where are you stopping?"

"What do you mean?"

"Why, where are you stopping?—what hotel?"

"I don't need to stop at a hotel. I have a home, wife, and children—why should I go to a hotel?"

"Well, now, where are you?"

"I'm in Mr. Wallack's office."

"At Indianapolis?"

"Yes."

"Thunder you are."

"Yes; I was talking to Charlie Wilson, and got him to connect you without posting you."

"That's good enough. Why, I get you splendidly; No trouble at all."

Mr. Firman and Mr. Smith then talked quite a while about instruments, batteries, and such things. The conversation with Mr. Firman concluded with a description of a novel business meeting:

"Firman, I want you to tell a gentleman here, who is listening, about that Director's meeting you told me of the last time I saw you."

"Certainly. We had a Director's meeting of our Company. At the hour appointed we lacked three of a quorum. Of course, they all have telephone wires to their houses, by means of which we learned they could not be present. It was suggested, and carried out, that the meeting be held by telephone. The wires were connected so all could hear anything said. The gentleman who had prepared the resolution we wanted to consider read it from his house; the President asked each how he should vote, and receiving their replies declared the resolution adopted, and ordered the Secretary to record it. Several lawyers who have heard of it gave it as their opinion that the meeting was a legal one. If that's all, I will ask to be excused; my wife wants to go to church."

"All right; remember us in your prayers."

"Contract is too large."

"You can go now."

Wonderful Olfactory Powers of the Telephone (?)

When the telephone line connecting the water works at the foot of Chicago Avenue with the new water works at Twenty-second street and Ashland Avenue was completed, Mr. Creiger, chief engineer of the Chicago Avenue establishment—who by the way is something of a wag—desiring to test the new telephone adjustment called up the institution at the other end of the line. On receiving a prompt answer, Mr. Creiger said:

"Is that you, John?"

"Yes," said John.

C. "How do you feel this afternoon, John?"

J. "Very well, I thank you."

C. "Been eating onions, aint you, John?"

J. (Turning round to an operator near by says): "Thunder! I knew we could talk through this thing, but I didn't know before that a feller could *smell* through it!"

As a matter of fact John *had* eaten heartily of onions that day for dinner, and for the time being was thoroughly convinced of this new attribute of the telephone.

A Canada gentleman stepped into a friend's office in Chicago, one day, just in time to hear the closing words of a telephone conversation between the Chicago man and another party.

"Oh, Shut up," says the Chicago man, "I can smell your breath. Don't smoke any more of those blamed poor cigars when I am talking to you."

"Great Caesar!" says the Canada friend, "You can't *smell* through that thing can you?"

C. M. "Oh, yes, splendidly." (C. M. who had been smoking, quietly puffs into the telephone,) "If you don't believe it just come and try it yourself."

C. F. (Stepping up to the telephone) "Halloo."

"Halloo," (By distant party.)

C. F. (Applies nasal organ) "I'll declare! you can smell his breath, can't you? I wouldn't have believed it."

Burdette and Edison Testing the Spanktrophone!

Burdette, of the Burlington *Hawkeye*, perpetrates the following in the interest of "transmission of sound(?)"

We remember meeting Mr. Edison, some years ago, when he was most deeply absorbed in his experiments relating to the conductibility of sound through the various mediums, and had a long and interesting conversation with him upon that subject.—We conversed upon the well-known fact that the same medium of transmission has different properties at different times. We both cited instances in which a man forty-three years old, though using his utmost strength of lung and voice, could not shout loud enough, at 6:30 in the morning, to awaken a boy nine years old just on the other side of a lath and plaster partition, while at 11 o'clock that night the same boy would hear a low whistle on the sidewalk, through three doors and two flights of stairs, and would spring instantly out of a sound sleep in response to it. It was a belief of Mr. Edison's at that time, that sound could be made to travel as rapidly as feeling, and to test the matter he had invented a delicate machine called the spanktrophone, which he was just about trying when we met him.—We were greatly interested in the machine and readily agreed to assist in the experiment. By the aid of Mr. Edison and a street-car nickel, we enticed into the laboratory a boy about 7 years old. After many times reassuring him and promising him solemnly that he would not be hurt, we got the machine attached to him, and the great inventor laid the boy across his knees in the most approved old-fashioned Solomonic method. On a disc of the machine delicate indices were to record, one the exact time of the sound of the spank, the other the exact second the boy howled. The boy was a little suspicious at this point of the experiment, and with his head partly turned, was glaring fearfully at the inventor. Mr. Edison raised his hand. A piercing howl rent the air, followed by a sharp concussion like the snapping of a musket cap, and when we examined the dial plate of the machine, infallible science proudly demonstrated that the boy howled sixty-eight seconds before he was slapped. The boy went down stairs in three strides, with an injured look upon his fearful face. Mr. Edison threw the machine out of the window after the urchin, and we felt that it was no time to intrude upon the sorrows of a great soul, writhing under a humiliating sense of failure. We have never met Mr. Edison since, but we have always thought he didn't know much about boys, or he would know how utterly unreliable the best of them would be for a scientific experiment.

Eli Perkins and Mr. Edison.

In the course of human events, Eli Perkins would naturally meet with Mr. Edison. On one occasion, according to E. P.'s version, the interview was as follows:

It pains me to hear of so many people being burned on account of elevators, and defective flues. To-day Prof. Edison and I laid a plan before the Fire Inspectors which, if carried out, will remedy the evil.

When I called on Prof. Edison at Menlo Park, he was engaged on a new experiment. He was trying to abstract the heat from the fire, so as to leave the fire perfectly harmless, while the heat could be carried away in flour-barrels to be used for cooking. Then the professor tried experiments in concentrating water to be used in the engines in case of drought. The latter experiment proved eminently successful. Twelve barrels of water were boiled over the stove, and evaporated down to and this was sealed in a small phial, to be diluted and to put out fires in cases of drought, or in cases where no Croton water can be had. In some cases the water was evaporated and concentrated till it became a fine dry powder. This fine, dry powder, the Professor tells me, can be carried around in the pockets of the firemen. and be blown upon the fires through tin horns,—that is, it is to extinguish the fire in a horn.

I examined the Professor's pulverized water with great interest, took a horn—in my hands—and proceeded to elucidate to him my plan for constructing fire-proof flues. I told him that, to make fire-proof flues, the holes of the flues should be constructed of solid cast-iron, or some other non-combustible material, and then cold corrugated iron, without any apertures, should be poured around them.

"Wonderful!" exclaimed Prof. Edison in a breath; "but where will you place those flues, Mr. Perkins?"

"My idea," I replied, drawing a diagram on the wall-paper with a piece of charcoal, "is to have these flues in every instance located in the adjoining house."

"Magnificent! but how about the elevator?" asked the Professor.

"Why, after putting them in the next house, too, I'd seal them up water-tight, and fill them with Croton, and then let them freeze. Then I'd turn them bottom side up, and, if they catch fire, the flames will only draw down into the cellar."

Prof. Edison said he thought, my invention would eventually supersede the telephone and do away entirely with the necessity of the Keely motor!!

Satisfactory Evidence.

One day, just before a thunder-storm, a man stepped into a telegraph office and requested the privilege of talking through the telephone with his wife, who was visiting the Manager's wife at a distant telegraph station. The Assistant manager granted the request, and the man began operations. He couldn't be prevailed upon to believe that it was really his wife who was talking to him, and she so many miles away. He finally asked her to say or do something known to themselves only, that he might be convinced that it was she. Just then a rambling streak of lightning came on the wires, hitting the husband on the head, when he jumped to his feet and exclaimed: "Oh-o-oh dear!—I am satisfied; all correct; It's her!"

Dawdles Tries the Telephone.

Mr. Bassingbal, city merchant, enjoys the luxury of a private wire. He was ecstatic over his wonderful telephone and in describing it to a special friend one day said:

"Oh, it's magnificent; very convenient! I can converse with Mrs. B. just as if I was in my own drawing room. Stop; I'll tell her you are here. (Speaks through the telephone.)

"Dawdles is here—just come from Paris—looking so well—desires to be," etc., etc. "Now take the receiver, Mr. D., and you'll hear her voice distinctly"

Dawdles. "Weally!" (Dawdles takes it and adjusts to his ear.)

The voice. "For goodness sake, don't bring that insufferable noodle home to dine!"

The Telephone and the Doctors.

A novel use of the Telephone is shown in the following instance, related by a physician of Chicago.

"I attended a family on the North Side near Lincoln Park. The other evening about 11 p. m. they 'called' me through the telephone, saying: "Our baby is taken suddenly ill,---we fear croup, — can you prescribe without coming over?' I said 'We will see.' Has the child fever? What is its temperature? In a few moments came the answer, 'Temperature 103,—skin hot and dry.' (They have a clinical thermometer.) 'Is the breathing quick?' 'No, but it is labored. He coughs all the time. 'Bring the child as near as possible to the 'receiver,' and let me hear him cough. In a moment there came with startling distinctness to my ear the shrill, crowing, unmistakable cough as characteristic of croup! I directed them to hold the child there till he cried. In a minute or two I heard the cry,—not natural, but hoarse, still further verifying my diagnosis. Knowing that they possessed a chest of medicines, I directed them to give aconite and sanguinaria in rapid alternation, and make certain applications to the throat. The answer came, 'we have aconite, but no sanguinaria.'

"Well, Doctor, what could you do in such a dilemma?

"Fortunately there is a druggist within a few blocks, who on inquiry at the central office, I ascertained possesses a telephone. It was not the work of five minutes to call him up, and direct him to send to No. — on X street a prescription containing the required sanguinaria. It was put up, delivered, and administered inside of half an hour, and the whole transaction, consultation and all, did not extend over that time.

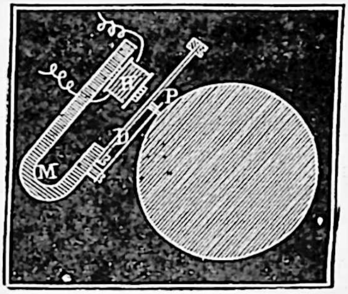
The wonderful fidelity with which the telephone transmits the peculiarities of the human voice and all other sounds is marvelous. I can distinguish the laugh of each member of a family, and even any variation from the natural voice of those with whom I am acquainted. Also the nasal voice which accompanies catarrh, as any variety of cough.

"The telephone of the future will enable us to recognize conditions of morbid states in patients who are miles away, as well as if they were sitting in our offices. With a microphone attachment, we may be able to hear the beating of the heart, and any of its abnormal sounds, and possibly, to record the tracings of the pulse, to hear abnormal sounds occurring during respiration, and perhaps count the number of respirations per minute.

The Telephonograph.

COMBINATION OF THE TELEPHONE AND PHONOGRAPH.

Mr. Edison has devised a new instrument that combines the telepone and phonograph, which he calls the Teleponograph. It is a simple combination of the two instruments as shown in the accompanying diagram. The drum of the phonograph is shown in section. The diaphragm, instead of being vibrated by



The Telephonograph.

the voice, is vibrated by the currents which traverse the helix H, and which originate at a distant station. The object of this new instrument is to obtain a record of what is said at the distant office, which can be converted into sound when desired. The instrument gives additional significance to the phonograph.

Edison's "Baby."

Among the many instruments which Mr. Edison has constructed, he has perhaps been more enthusiastic over this than all others. For some time after its invention it was his custom to exhibit this with great pride. On one occasion when showing a company of friends through the Labratory at Menlo Park, he remarked as they came to the Phonogragh: "I have invented a great many machines, but this," said he, (patting the phonograph) is *my baby*, and I expect it to grow up and be a big fellow and support me in my old age."

The Megaphone.

This is among Mr. Edison's latest discoveries, and has a curious origin. "Strange as it may seem," says Mr. Edison, "it came to life through the mistake of a reporter." To use his own words, "a reporter came to see my phonograph and went back and got it mixed up in his paper. He stated that I had got up a machine to make partially deaf people hear. The item was extensively copied, but I thought nothing more of it until after a while I found myself receiving letters from all over the country asking about it. I answered some, saying it was a mistake, but they kept piling in upon me until I was getting them at the rate of twenty and thirty a day. Then I began thinking about the matter and began experimenting. One day while at work on it I heard some one loudly singing 'Mary Had a Little Lamb.' I looked around, nobody was near me and nobody was singing.—Then I discovered that the singer was one of my young men, who, in a distant corner of the room, was softly singing to himself. The instrument had magnified the sound, and I heard it distinctly, although I'm pretty deaf, while others in the room had not heard a whisper. That was the first of the megaphone."

No electricity is used in this instrument. It is a peculiarly constructed ear trumpet. For use in the open air it is made very large and consists of two great ear-trumpets and a speaking trumpet; mounted together upon a tripod. Two persons provided with this instrument are enabled to converse in the ordinary tones of voice some miles apart.

A smaller instrument is made for deaf persons, which is portable and adjustable, similar to an opera glass, by means of which a whisper is heard through the largest hall. While on a recent visit to Chicago, Mr. Edison, in view of his own deafness, facetiously remarked to a friend that he ought to have had one of these instruments with him, and in the same strain described the trumpet as one that was unnecessary to "bawl into!"

Mr. Edison is now improving the megaphone, and states that he will use electricity in its construction which will require a small battery. It will doubtless prove a blessing to deaf persons.

The Sonorous Voltameter.

This high-sounding-titled instrument is amusingly described by Mr. Edison, to a friend, as follows:

"Have you seen the Sonorous Voltameter yet?" said Mr. E. to his friend.

The friend admitted that the sonorus voltameter was as yet outside the pale of his scientific education, and asked for light on the subject.

Mr. Edison doffed his hat; and by a dexterous throw landed it on a table several feet away. Then he took paper and pencil and drew a sonorous voltameter.

"There she is," he exclaimed, joyfully, as he put on the finishing touches to a complex arrangement of wires, batteries, tubes, and funnels.

"What is she good for," inquired the friend, adopting the inventor's metaphor and gazing on the unintelligible combination.

"First-class arrangement. Tells of the strength of telegraph batteries right to a dot. It makes you hear their strength. This end of the wire, you see, makes the oxygen, and this end hydrogen. The bubbles rise and make a noise, which is magnified by the funnel. These glass tubes indicate the intensity of the current by degrees, and the funnel indicates the same by sound. You take your watch and count the number of ticks caused by the bubbles per second. Thus you know how strong your battery is. Just try it some time.

The astonished companion promised that the first time he found a battery lying around without any owner he would clap on a sonorous voltameter and find out all about it.

Edison Joking his Friends.

Mr. Edison is fond of joking with his intimate friends. In the presence of a company of these one day at Melno Park, and just as they were drawing on their great coats preparatory to departure, Mr. Edison astounded the party by gravely announcing as follows:

"Gentlemen, I am now about to tell you something that will astonish all the electricians in the world. I am prepared to send a current of electricity from here to Philadelphia without any wire.

Down came the great coats in a hurry.

"Why Al, (his second name is Alva, and many of his friends call him Al,) that's impossible," said a friend, who was an old telegraph operator.

"Oh, no," answered Mr. Edison. "It can be done, and I know it. It is the result of a recent discovery."

"How," inquired several at once.

"Store it up in a condenser and send it there by express," was the reply. "Now don't give it away to the newspaper men."

Ha, Ha, Ho, Ho, just so, you're right, said his friend.

Down in the Gold Mines.

During his trip to the Rocky Mountains Mr. Edison visited a number of the gold mines. It was soon reported that he had discovered a method of finding gold without digging for it.— This, he pronounced a misstatement, and says:

What I did get up was a simple contrivance for ascertaining the quantity of ore in any given place once gold is struck. It is a very simple thing and absolutely reliable.

"The ore is surrounded by a bed or bank of conducting material. For instance, in the mines which I examined that material was clay. The quantity of clay is an indication of the quantity of ore. When ore is struck thousands are often expended in drilling for more, when in reality the vein is completely exhausted. The contrivance I suggested enables the miner to know whether or not the vein is exhausted. I simply make a ground connection and run a wire through a battery and instrument. Now, I take the other end of the wire down the shaft and connect it with the clay or other conducting material surrounding the ore. If the clay bank is extensive the connection is a good one, and the current of electricity flows freely;—but if the clay bank is small in area a poor connection is formed. By adopting a unit of measurement the area can be told almost to the square foot.

Edison's Anecdote of the Rocky Mountain Scouts.

Mr. Edison made an extensive trip to the Mocky Mountains in July, 1878, to test his tasimeter on the sun's corona during a total eclipse of that luminary. While there, he went off buffalo hunting, which gave occurrence to the following little story, in the presence of a few friends, after his return to Menlo Park:

"That Western country is a great country," his face beaming as he thought of his recent vacation. "Those scouts out there are wonderful fellows. One of them tracked us on one occasion over a distance of eighty miles, and all that he had to guide him was tobacco juice."

"Tobacco juice! How in the world could tobacco juice guide a man?" asked one of his friends.

"It happened in this way. A cable dispatch came for me at Rawlins, but I had gone out hunting with a party of thirteen, some of whom were old Western hunters. Word was cabled back that the message could not be delivered, as our whereabouts were unknown. Soon an answer came to send out a scout in search of us. The scout traveled for three days over the wildest sort of country, with nothing to guide him but tobacco juice, which the hunters of our party, who were inveterate chewers, left behind. Once he lost the trail and was for hours in doubt, but he again got it. Sharp fellows, those scouts."

The Tasimeter or Thermopile.

An Insirument that Measures the Heat of the Stars —How it is Done—Full Account of Its Discovery.

This is a new invention by Mr. Edison for measuring to an astonishing exactness a very low degree of heat. It is so sensitive in its operating facilities that it registers the heat from the fixed stars and will no doubt, from this fact, prove a great adjunct in the science of astronomy. It also registers with equal precision the presence of moisture. It ranks among the most wonderful of Mr. Edison's many inventions and is described in his own language as follows:

"It consists of a carbon button placed between two metalic plates. A current of electricity is passed through one plate, then through the carbon, and through the other plate. A piece of hard rubber or of gelatine is so supported as to press against these plates. The whole is then placed in connection with a galvanometer and an electric battery. Heat causes the strip of hard rubber to expand and press the plates closer together on the carbon, allows more current to pass through, and deflects the needle of the galvanometer. Cold decreases the pressure.—Moisture near the strip of the gelatine can be measured in the same way by increasing or decreasing the pressure and accordingly deflecting the needle. By means of this apparatus or one combined with sensitive electrical galvanometers it is possible to measure the millionth part of a degree Fahrenheit. Infinitesimal changes in the moisture of the atmosphere can be indicated in the same way,—changes which are a hundred thousand times less in quantity than those that can be indicated by the present barometer. It will thus foretell a storm much more readily.—The carbon button I have in this instrument is of lampblack burned from rigolene. I discovered about two years ago that carbon of various forms, such as plumbago, graphite, gas retort carbon, and lampblack, when molded in buttons, decreased the resistance to the passage of the electrical current by pressure.

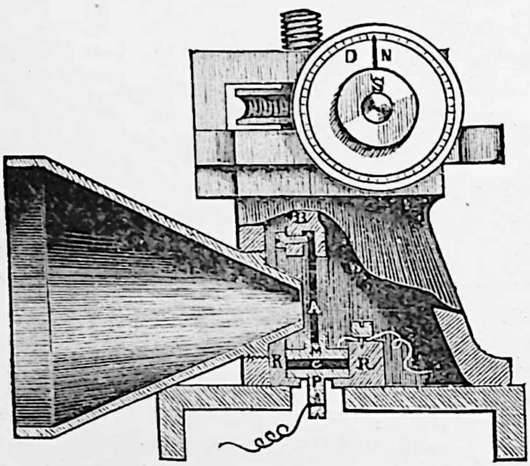
This is part of the apparatus of the carbon telephone and microphone.

The Tasimeter was discovered by Mr. Edison in the following manner: During his investigations, which resulted in the invention of his carbon telephone, Mr. Edison found that carbon was subject to expansion and contraction under conditions of electric influence and pressure that made it the most sensitive substance within reach of the scientist. Applying this discovery to the measurement of heat, he found that by using even an ordinary electronemer, the pressure on the carbon disk caused by the expansion of any substance acted on by even the lowest degree of heat reacted so as to govern the movements of the balanced needle over a finely graduated scale. This invention he has been long engaged in perfecting. He was invited by Prof. Langley, of Pittsburg, to adapt it for measuring the heat of stellar spectra. This he has succeeded in accomplishing, with such wonderful success that he is now able to measure the heat of even the telescopic stars. By focussing the heat rays of these distant bodies so as to concentrate them on the substance pressing on the carbon button, he is enabled to measure accurately their relative and actual heats. In this way it is not improbable astronomical researches as to the distance of the stars from the earth, may be measured by their degrees of heat acting on the thermopile. The condition of moisture can also be determined by its effect on a bar of gelatine substituted for the hard rubber used for measuring heat. Indeed so sensitive to the influence of moisture is this delicate instrument, that a little water spilled on the ground in the same room with the instrument, or even, as Mr. Edison asserts, spitting on the floor will be indicated by the the movement of the the balanced-needle.

The Tasimeter and the Stars.

EXPLANATION—TEST—THE HEAT OF ARCTURUS REGISTERED.

The value of the tasimeter lies in its ability to detect the smallest variation in temperature. This is accomplished indirectly. The change of temperature causes expansion or contraction of a rod of vulcanite, which changes the resistance of an electric circuit by varying the pressure it exerts upon a carbon-button included in the circuit. During the eclipse of July 29, 1878, it was thoroughly tested by Mr. Edison, and dem-demonstrated the existence of heat in the corona.



The Tasimeter.

The instrument, as used on that occasion by Mr. Edison is shown in section in the engraving, which affords an insight into its construction and mode of operation. The subtance where expansion is to be measured is shown at A. It is firmly clamped at B, its lower end fitting into a slot in the metal plate M, which rests upon the carbon-button, C. The latter is in an electric circuit, which includes a delicate galvanometer. Any variation in the length of the rod changes the pressure upon the carbon, and alters the resistance of the circuit. This causes a deflection of the galvanometer-needle—a movement in one direction denoting expansion of A, while an opposite motion signifies contraction. To avoid any deflection which might arise from change in strength of battery, the tasimeter is inserted in an arm of the Wheatstone bridge.

In order to ascertain the exact amount of expansion in decimals of an inch, the screw, S, seen in front of the dial, is turned until the deflection previously caused by the change of temperature is reproduced. This screw works a second screw, causing the rod to ascend or descend, and the exact distance through which the rod moves is indicated by the needle, N, on the dial.

This novel instrument was completed only two days before Mr. Edison went West in July, 1878, to experiment on the sun's corona. It was set up immediately on his arrival at Rawlins, but he found great difficulty in fully adjusting so delicate an instrument. This, he however, finally effected by new and ingenious devices, which he designates "fractional balancing." In order to form some idea of the delicacy of the apparatus when thus adjusted to measure the smallest amount of heat, "the tasimeter," says Mr. Edison, "being attached to the telescope, the image of the star Arcturus was brought on the vulcanized rubber. The spot of light from the galvanometer *moved to the side of heat!*"

After some minor adjustments, five uniform and successful deflections were obtained with the instrument, as the light of the star was allowed to fall on the vulcanite to produce the deflection, or was screened off to allow of a return to zero." The tasimeter on this occasion was placed in a double tin case, with water at the temperature of the air between each case. This case was secured to a Dollond telescope of four inches aperture.

Testing the Tasimeter on the Sun's Corona.

This wonderful invention was tested by Mr. Edison at Rawlins, Wyoming Territory, on the sun's corona during the total eclipse of July 29th 1878. Though attended with much labor and difficulties the demonstration was successful. A graphic description of the first great trial of the tasimeter appeared at the time in a New York journal, from which we give the following extract:

But a new evll soon became manifest. A strong wind began blowing the frail pine structures used for observatories. These commenced to rock. Edison's observatory, which, in its normal condition, is a hen-house, was particularly susceptible. He hurried toward it only to find his sensitively-adjusted apparatus in an extreme state of commotion. Every vibration threw the tasimeter into a new condition of adjustment. To remedy the evil was far from easy, as the time was then so short and precious it was too late to remove the apparatus, and seemingly impossible to break the force of the wind, which was gradually increas-into a tornado. Hatless and coatless he ran to a neighboring lumber-yard, and in a moment a dozen stalwart men were carrying boards with which to prop up the structure and erect a temporary fence at its side. This completed, the chronometer indicated half-past one o'clock.

At thirteen minutes past 2 the moon began to make her first appearance between the sun and earth. Again Edison adjusted his tasimeter, but only to find that the gale continued to sway his projecting telescope so violently that a satisfactory result was almost impossible. A rigging of wire and ropes soon partially overcame the difficulty, and once more the instruments were ready for work. In a few moments there came Dr. Draper and the announcement, "There she goes," and the crowd of spectators immediately leveled their smoked glasses at the sun. The moon had just made her appearance.

At half-past 1 p. m. one quarter of the sun's disc was darkened with slow but steady pace. The progress of the moon continued. In the observatory of Dr. Draper the fall of a pin could be heard; outside almost equal quiet reigned. The only place of disorder was in that frail structure of Edison's. Notwithstanding his efforts the wind continued to give him trouble. In vain he adjusted and readjusted. At 3 o'clock three-quarters ot the sun's disc was obscured, and darkness began to fall upon the surrounding region. The hills around were all alive with people watching for the moment of totality. In Dr. Draper's observatory everything was proceeding excellently. The force of the wind had been broken. Edison's difficulty seemed to increase as the precious moments of total eclipse drew near. At five minutes past 3 o'clock, the sun's disc was seven-eighths covered, and the country around was shrouded in a pale grayish light, resembling early dawn.

At a quarter past 3 darkness was upon the face of the earth. The few moments for which the astronomers had traveled thousands of miles had arrived. Still Edison's tasimeter was out of adjustment. All the other instruments were in excellent working order. Totality had brought with it a marked cessation in the force of the wind. Edison worked assiduously, but the tasimeter would not come to a proper condition. At last, just as the chronometer indicated that but one minute remained of total eclipse, he succeeded in concentrating the light from the corona upon the small opening of the instrument. Instantly the fire ray of light on his graduating scale swept along to the right, clearing its boundaries. Edison was overjoyed. The experiment has shown the existence of about fifteen times more heat in the corona than that obtained from the star Arcturus the previous night.

Edison's tasimeter showed its power to measure the corona's heat. It, however, was adjusted ten times too sensitively. Never having used it before for a similar purpose, he had no means of telling the degree of sensitiveness necessary. The heat from the corona threw the ray of light entirely off the scale, and before he could make the second test the eclipse had passed away. The experiment demonstrated that, compared to some of the fixed stars, the corona's heat was much greater.

Basis of the Tasimeter.

The tasimeter is a modification of the micro-tasimeter which is the outcome of Mr. Edison's experiments with his carbon telephone. Having experimented with diaphragms of various thicknesses, he ascertained that the best results were secured by using the thicker diaphragms. At this stage he experienced a new difficulty. So sensitive was the carbon button to the changes of condition, that the expansion of the rubber telephone handle rendered the instrument inarticulate, and finally inoperative. Iron handles were substituted with a similar result, but with the additional feature of musical and creaky tones distinctly audible in the receiving instrument. These sounds Mr. Edison attributes to the movement of the molecules of iron among themselves during expansion. He calls them "molecular music." To avoid these disturbances in the telephone, the handle was dispensed with; but it had done a great service in revealing the extreme sensitiveness of the carbon button, and this discovery opened the way for the invention of this new and wonderful instrument.

The micro-tasimeter is represented in perspective in fig, 12, in section in fig. 13, and the plan upon which it is arranged in the electric circuit is shown in fig. 14.

The instrument consists essentially in a rigid iron frame for holding the carbon button, which is placed between two platinum surfaces, one of which is fixed and the other moveable, and in a device for holding the object to be tested, so that the pressure resulting from the expansion of the object acts upon the carbon button.

Two stout posts A, B, project from the rigid base piece, C. A vulcanite disc D, is secured to the post A, by the platinum-headed screw E, the head of which rests in the bottom of a shallow circular cavity in the centre of the disc. In this cavity, and in contact with the head of the screw E, the carbon button F, is placed. Upon the outer face of the button there is a disc of platinum foil, which is in electrical communication with the battery. A metalic cup G, is placed in contact with the platinum disc to receive one end of the strip of whatever material is employed to operate the instrument.

The post B, is about four inches from the post A, and contains

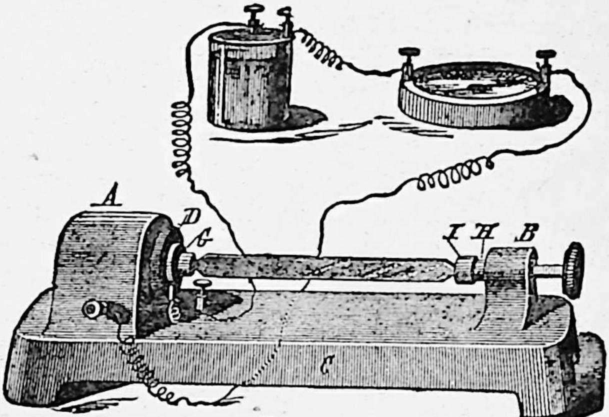
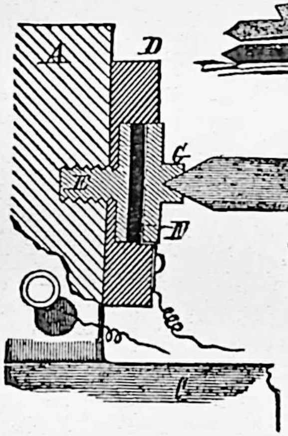


Fig. 12.



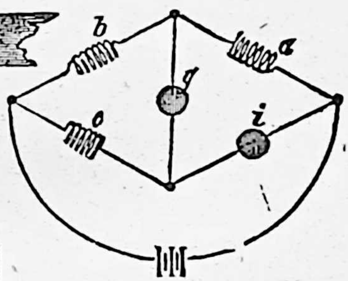


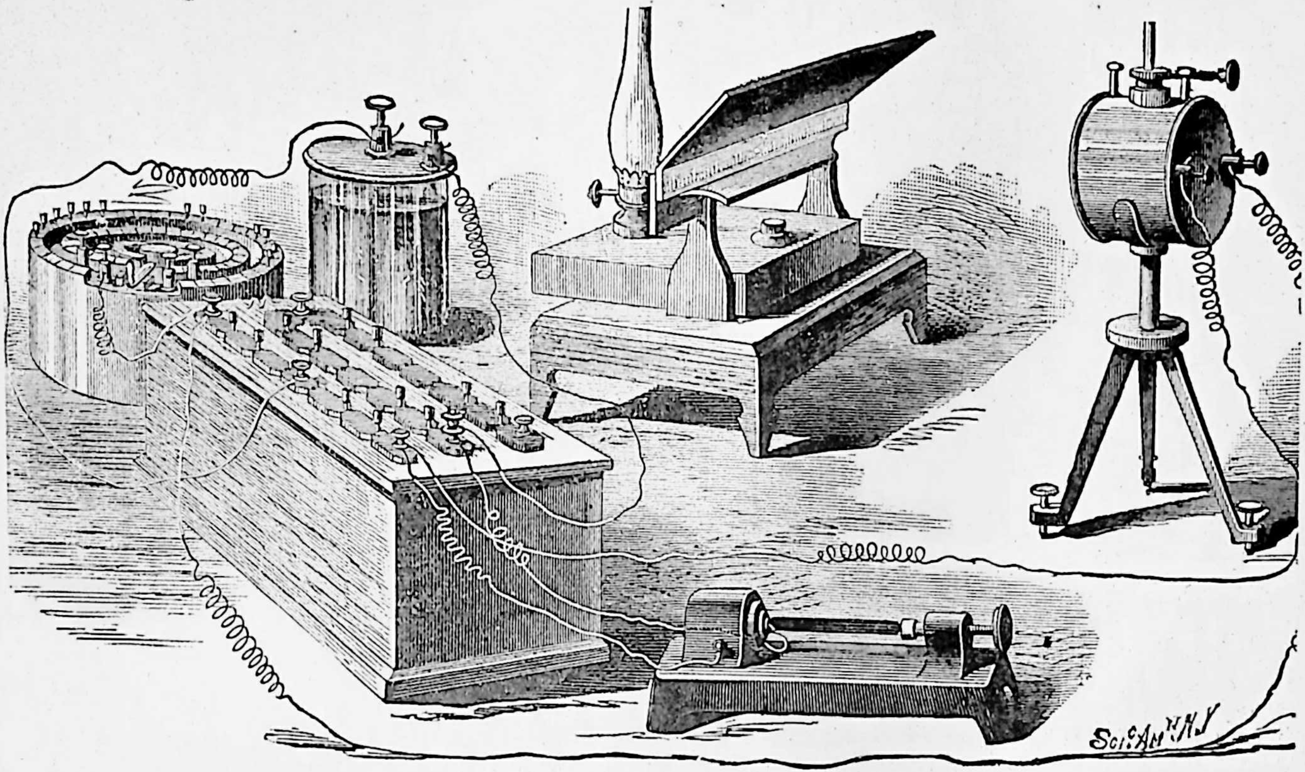
Fig 13. Fig. 14.

a screw-acted follower H, that carries a cup I, between which and the cup G, is placed a strip of any substance whose expansibility it is desired to exhibit. The post A, is in electrical communication with a galvanometer, and the galvanometer is connected with the battery. The strip of the substance to be tested is put under a small initial pressure, which deflects the galvanometer needle a few degrees from the needle point. When the needle comes to rest, its position is noted. The slightest subsequent expansion or contraction of the strip will be indicated by the movement of the galvanometer needle. A thin strip of hard rubber, placed in the instrument, exhibits extreme sensitiveness, being expanded by heat from the hand, so as to move through several degrees the needle of a very ordinary galvanometer, which is not effected in the slightest degree by a thermopile facing and near a red hot iron. The hand, in this experiment, is held a few inches from the rubber strip. A strip of mica is sensibly affected by the heat of the hand, and a strip of gelatin, placed in the instrument, is instantly expanded by moisture from a dampened piece of paper held two or three inches away.

For these experiments the instrument is arranged as in fig. 12, but for more delicate operations it is connected with a Thomson's reflecting galvanometer, and the current is regulated by a Wheatstone's bridge and a rheostat, so that the reistance on both sides of the galvanometer is equal, and the light-pencil from the reflector falls on 0° of the scale. The principle of this arrangement is illustrated by the diagram, fig. 14. Here the galvanometer is at *g*, and the instrument which is at *i*, is adjusted, say, for example, to ten ohms resistance. At *a*, *b*, and *c*, the resistance is the same. An increase or diminution of the pressure on the carbon button by an infinitesimal expansion or contraction of the substance under test is indicated on the scale of the galvanometer.

The carbon button may be compared to a valve, for, when it is compressed in the slightest degree, its electrical conductivity is increased, and when it is allowed to expand it partly loses its conducting power.

For measuring the heat of the stars, etc., this instrument is slightly modified so as to admit the light or heat at G, to the carbon button F. Mr. Edison proposes to apply the principle of this instrument to delicate thermometers, barometers, hygrometers, etc., and ultimately to weigh the light of the sun.



EDISON'S MICRO-TASIMETER.

Pressure Relay.

In this novel and useful instrument Mr. Edison takes the advantage of the remarkable property which plumbago possesses of decreasing its resistance enormously under slight pressure. Thin discs of plumbago are placed upon the cupped poles of an electro-magnet—as shown in Fig. 15; p. 135—the coils of which have several hundred ohms resistance. Upon the discs of plumbago is laid the armature which is provided with a binding post for clamping the local battery wire.

The core of the magnet, the plumbago discs, and the armature are included in a local circuit, which also contains an ordinary sounder and several cells of bichromate battery. The relay magnet is inserted in the main line in the usual manner. The operation is as follows: When the main circuit is opened the attraction for the armature ceases, and the only pressure upon the plumbago discs is due to the weight of the armature itself. With this pressure only the resistance of the plumbago to the passage of the local current amounts to several hundred ohms; with this resistance in the local circuit the sounder remains open. If now the main circuit be closed, a powerful attraction is set up between the poles of the relay magnet and its armature, causing a great increase in the pressure upon the plumbago discs, and reducing its resistance from several hundred to several ohms, consequently the sounder closes. So far the result differs but little from the ordinary relay and sounder. But the great difference between this relay and those in common use, and its value, rests upon the fact that it repeats or translates from one circuit into another, the relative strengths of the first circuit. For instance, if a weak current circulates upon the line in which the relay magnet is inserted, the attraction for its armature will be small, the pressure upon the plumbago discs 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 discs will be increased, and in proportion will the current in the second circuit be increased

No adjustment is ever required. It is probably the only device yet invented which will allow of the translation of signals of *variable strengths*, from one circuit into another, by the use of batteries in the ordinary manner.—This apparatus was designed by Mr. Edison for repeating the acoustical vibrations of variable strengths in his speaking telegraph.

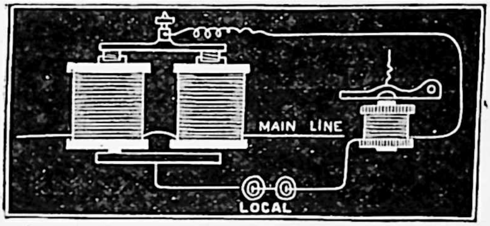


Fig. 15; Pressure Relay.

The Carbon Rheostat.

A NEW AND VALUABLE INSTRUMENT—BALANCING THE ELECTRICAL CURRENT—HOW IT IS DONE.

In quadruplex telegraphy it is vital to the working of the system to perfectly balance the electrical current.

The common method of doing this is to employ a rheostat containing a great length of resistance wire, more or less of which may be thrown into or cut out of the electrical circuit by inserting or withdrawing plugs or keys. This operation often requires thirty minutes or more of time that is or might be very valuable.

To remedy this difficulty Mr. Edison has devised the instrument represented in the engraving, Fig. 16 being a perspective view and Fig. 17 a vertical section.

A hollow vulcanite cylinder, A, is screwed on a boss on the brass plate, B. Fifty discs—cut from a piece of silk that has been saturated with sizing and well filled with fine plumbago and dried—are placed upon the boss of the plate, B, and are surmounted by a plate, C, having a central conical cavity in its upper surface. A pointed screw, D, passes through the cap, E, at the top of the cylinder, A, and projects into the conical cavity in the plate C. The screw is provided with a disc, F, having a knife edge periphery, which extends to the scale, and serves as an index to show the degree of compression to which the silk discs are subjected.

The instrument is placed in the circuit by connecting the cap, E, with one end of the battery wire and the plate, B, with the other end.

The principle of the instrument is identical with Mr. Edison's carbon telephone. The compression of the series of discs increases conductivity: a diminution of pressure increases the resistance. Any degree of resistance within the scope of the instrument may be had hy turning the screw one way or the other.

In this instrument the resistance may be varied from 400 to 6,000 ohms, and any amount of resistance may be had by increasing the number of silk discs.

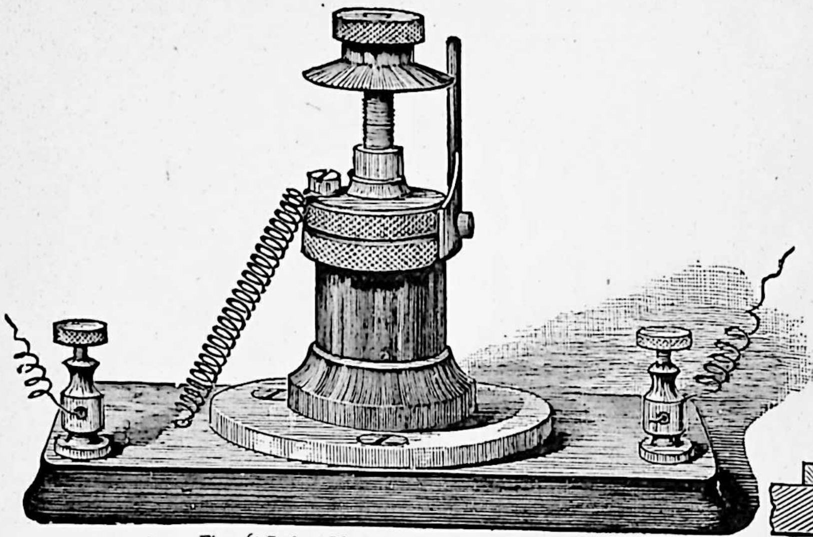


Fig. 16; Carbon Rheostat (in perspective.)

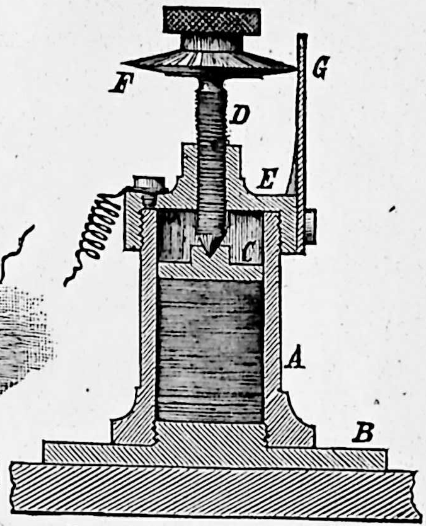


Fig. 17; Carbon Rheostat (in section.)

The Aerophone.

The great object of this instrument is to increase the loudness of spoken words, without impairing the distinctness of articulation. The working of the mechanism is as follows:

The magnified sound proceeds from a large diaphragm, which

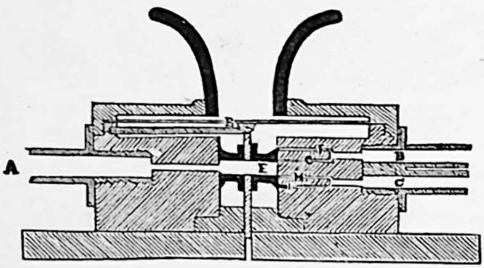


Fig. 18; Aerophone, (1.)

is vibrated by steam or condensed air. The source of power is controlled by the motion of a second diaphragm, vibrating under the influence of the sound to be magnified. There are, therefore, three distinct parts to the instrument: First, a source of power—steam or compressed air; second, an instrument to control the power; and third, a diaphragm vibrating under the

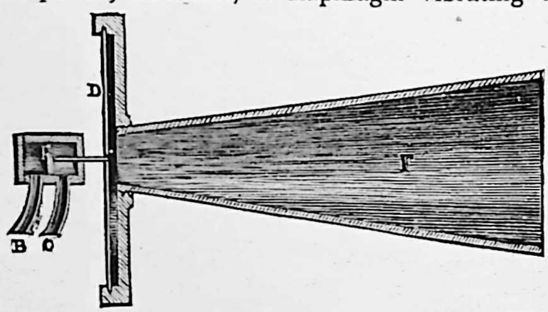


Fig. 19; Aerophone, (2.)

influence of the power. The first of these is usually compressed air, supplied from a tank. It is necessary that it should be of constant pressure.

The second is shown in section in Fig. 18, and consists of a diaphragm and mouth-piece, like those used in the telephone.

A hollow cylinder is attached by a rod to the center of the diaphragm. The cylinder, and its chamber, E, will therefore, vibrate with the diaphragm. A downward movement lets the chamber communicate with the outlet, H, an upward movement with the outlet, G. The compressed air enters at A, and fills the chamber, which, in its normal position, has no outlet. Every downward vibration of the diaphragm will thus condense the air in the pipe, C, at the same time allowing the air in B to escape *via* F. An upward movement condenses the air in C, but opens I.

The third and last part is shown in Fig. 19. It consists of a cylinder, and piston, P, like that employed in an ordinary engine. The piston-rod is attached to the center of a large diaphragm D. The pipes C and B, are continuations of those designated in Fig. 18, by the same letters. The pipe C, communicates with one chamber of the cylinder, and B with the other. The piston, moving under the influence of the compresssed air, moves also the diaphragm, its vibrations being, in number and duration, identical with those of the diaphragm in the mouth-piece.

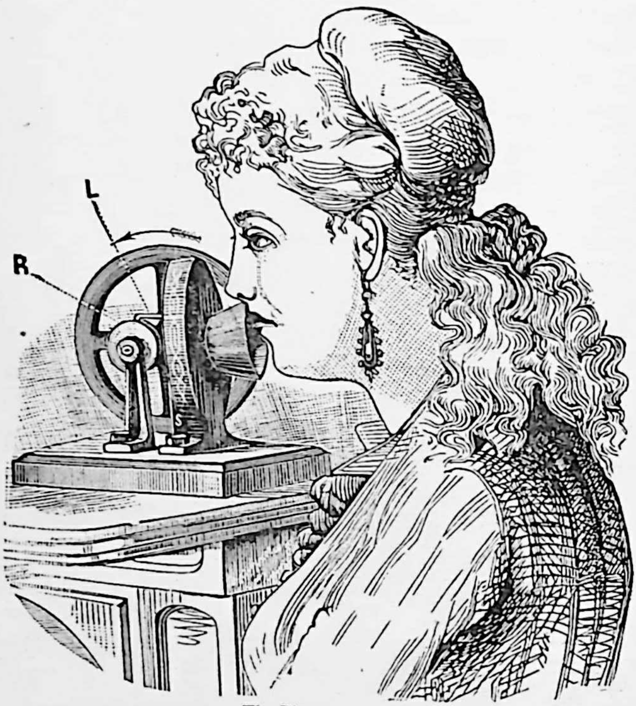
The loudness of the sound emitted through the directing tube, F, is dependent on the size of the diaphragm and the power which moves it. The former of them is made very large, and the latter can be increased to many hundred pounds' pressure.

With this instrument a locomotive may be made to call out the stations; steamships can converse at sea; light-houses may thunder the notes of danger far over the deep, and by a single machine, as Mr. Edison says, "the Declaration of Independence may be read so that every citizen in any one of our large cities may hear it."

Edison's Phonometer.

SOUND POWER—A MECHANISM RUN BY THE HUMAN VOICE—HOW DISCOVERED AND HOW IT IS DONE.

This is a very ingenious and novel piece of mechanism, noted for the singular fact, that when spoken or sung *at*, (or into,) res. ponds immediately by causing a wheel to revolve, but is deaf to all other influences. No amount of blowing will start the wheel;



The Phonometer.

only by the aid of sound can it be set in motion. In his telephone and phonograph researches Mr. Edison discovered that the vibrations of the vocal chords were capable of producing considerable dynamic effect. Acting on this hint, he began experiments on a phonometer, or instrument for measuring the mechanical force of sound waves produced by the human voice.

In the course of these experiments he coustructed the machine shown in the accompanying engraving, which exhibits the dynamic force of the voice.

The machine has a diaphragm and mouth-piece similar to a phonograph. A spring which is secured to the bed piece rests on a piece of rubber tubing placed against the diaphragm. This spring carries a pawl L, that acts on a ratchet or roughened wheel R, on the fly-wheel shaft. A sound made in the mouth-piece creates vibrations in the diaphragm; the vibrations of the diaphragm move the spring and pawl with the same impulses, and as the pawl thus moves back and forth on the ratchet wheel, it is made to revolve. It revolves with considerable power: for it requires a surprising amount of pressure on the fly-wheel shaft to stop the machine while a continuous sound is made in the mouth-piece. Mr. Edison says there is no difficulty in making the machine bore a hole through a board.

The various purposes which this exeedingly ingenious and novel instrument may yet be called upon to accomplish, of course are mere conjectures, but if confined to the measurement of sound force only, it is a valauble discovery, for in this deparment it may find many important applications.

Edison's Harmonic Engine.

PUMPING WATER WITH A TUNING FORK—A SINGULAR MACHINE—HOW IT WORKS.

Until recently, electricity as a motive power has been a comparative failure as ninety per cent. of the battery was

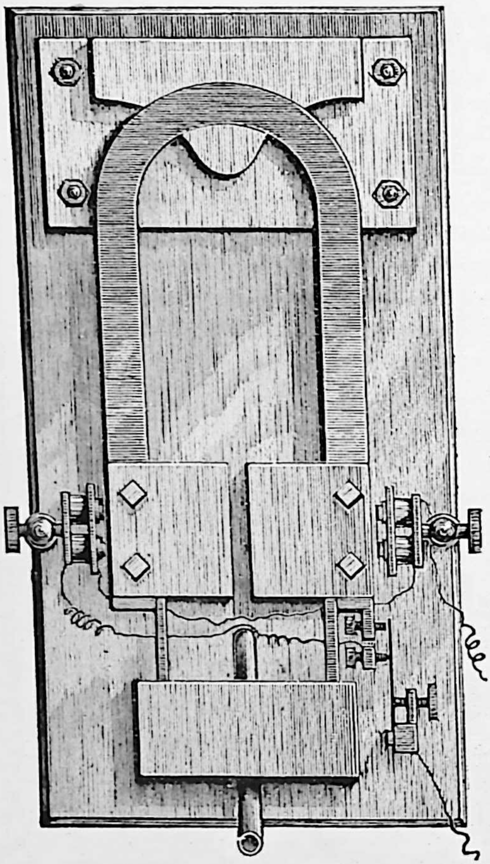


Fig. 20; Harmonic Engine.

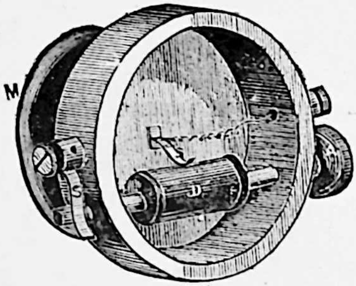
wasted. Mr. Edison has devised a novel electrical machine which he calls the Harmonic Engine, in which ninety per cent. of the power is realized. With two small electro-magnets and three or four small battery cells, sufficient power is generated to drive a sewing machine or pump water for household purposes.

This engine, which is shown in Fig. 20, consists of a fork which is two feet and a half long, made of two inch square steel. The curved part of the fork is firmly keyed in a solid casting which is bolted to a suitable foundation, and to each arm of the fork is secured a thirty-five pound weight. Outside of and near the end of each arm is placed a very small electro-magnet. These magnets are connected with each other, and with a commutator that is operated by one of the arms. The arms make thirty-five vibrations per second, the amplitude of which is one-eighth of an inch. Small arms extend from the fork arms into a box containing a miniature pump having two pistons, one piston being attached to each arm. Each stroke of the pump raises a very small quantity of water, but this is compensated for by the rapidity of the strokes. Mr. Edison proposes to compress air with the harmonic engine, and use it as a motive agent for propelling sewing machines and other light machinery. The power must be taken from the fork arms so as not to affect the synchronism of their vibrations, otherwise this novel engine will not operate. It appears to be considerably in advance of other electric engines, and through its agency electricity may yet become a valuable motive power.

When we remember that this engine is capable of causing the arms to make seventy or more combined strokes per second, and that each stroke can be made to pump a few drops of water, it is readily seen that as now constructed, the harmonic engine is of no inconsiderable value.

Edison's Motograph Receiver.

Mr. Edison has quite recently applied to his telephone, the principle of his electro-motograph. It is called the "Motograph Receiver," and is described as follows:



The Motograph Receiver.

A diaphragm of mica four inches in diameter is held in a suitable framework. A hand crank or screw at A, rotates a chalk cylinder D, (previously impregnated with the chemical solution,) with a continuous forward motion directly outward from the face of the diaphragm. One end of a metal bar is fastened to the center of the diaphragm and the other end rests upon the chalk cylinder, being held down very firmly by a spring. The circuit is made from this metal bar, through the chalk cylinder to the base. As the cylinder is rotated either by hand or other power the friction between the metal bar and the chalk cylinder is very considerable. and the diaphragm is drawn or bowed outward toward the cylinder. This operation is purely mechanical and local. When the electric waves are transmitted from the distant station by the speaker (who uses Edison's carbon transmitter) over the wire to the receiver, each wave as it passes through the chalk cyilinder.effects by electro-chemical decomposition more or less neutralization of the friction between the bar and the cylinder, according as the wave may be a strong or weak one. The resultant effect of each wave is the freeing of the diaphragm, permitting it to gain its normal position. Thus a series of electric waves, with the alternate space between, effects a vibration of the diaphragm in perfect accord with the voice of the speaker.

Etheric Force.

Sometime since Mr. Edison and his assistants were experimenting with a vibrator magnet, consisting of a bar of Stubb's steel, fastened at one end and made to vibrate by means of a magnet, when they noticed a spark coming from the core of the magnet. They had often noticed the same phenomenon in connection with telegraphic relays and other electrical instruments, and had always supposed it to be due to inductive electricity. On this occasion the spark was so bright that they suspected something more than mere induction. On testing the apparatus they found that, by touching any portion of the vibrator or magnet with a piece of metal, they got "the spark!"

They then connected a wire to the end of the vibrating rod—the wire leading nowhere—and got a spark by touching the wire with a piece of iron. Still more remarkable, a spark was got on turning the wire back on itself and touching any point of the wire with its free end! These strange phenomena, in which the sparks as exhibited seem to antagonize the known laws of electrical science, led Mr. Edison to believe he had discovered a *new force.* He accordingly, after repeated experimentation, named his discovery "Etheric Force."

It differs from electricity, especially inductive electricity, to which its sparks were at first attributed—in that its sparks are different in appearance and effect. They scintillate, and require actual contact of the points at which they appear. It differs from electricity in general in its entire independence of polarity. It does not require insulation. It will not charge a Leyden jar. It has no effect upon electroscopes or galvanometers. It fails to affect chemical compounds which are extremely sensitive to electricity. This discovery called forth considerable criticism.

Edison says: I suggest that as I have freely laid myself open to criticism by presuming to believe in the capacity of Nature to supply a new form of energy, which presumption rests upon experiment, it is but fair that my critics should back up their assertions by experiment, and give me an equal chance as a critic."

The Electric Light.

THE AGES SLOW TO LEARN—EDISON'S LIGHT VS. JABLOCHKOFF'S, ET AL.—SUBDIVISION OF THE FLUID—PLATINUM AND IRIDIUM ESSENTIAL FACTORS—HOW THE LIGHT APPEARED TO A VISITOR—CARBON CANDLE.

Electric light, though it has been flashing from the clouds from the remotest ages of creation, and is in fact older than the hills, has not until within a recent date been considered of any practical utility. Job, and Ben. Franklin, each in his day, saw this light, but they never dreamed that it was ultimately to illumine great cities. Like almost every other real good in the physical realm, this, too, has had its long period of inappreciation and non-comprehension. One would have supposed that the rousing thunders, Heaven's great aerophone, that accompanies every exhibibition of this light, would have long ago, awakened the world itself to a realization of the fact that the electric light might be utilized. But it has not been so. Coal, even—to say nothing of coal gas—is a modern discovery. So are potatoes and "love apples," so far as their essential values are concerned. The ages are slow to learn. And even now there are sage philosophers who stoutly aver that Mr. Edison will never succeed with his electric light. Probably it is better to exercise even this much thought about a new subject and so assert, than not to think anything whatever about the matter. So they thought and asserted about the quadruplex, and other of his inventions, and yet they came along. It will be seen in another part of this volume that Mr. Edison, while engaged on duplex transmission, was called a lunatic, and yet this came out all right, and he now talks of a sextuplex. His quadruplex system, says the President of the Western Union Telegraph Company in his last report, "saved the Company five hundred thousand dollars yearly in construction." Splendid insanity this, which can accomplish such stupendous results financially from a single invention!

The general public wish Mr. Edison all possible success in this new line of investigation, and doubtless believe it is only a question of time when the electric light will be no longer confined to flashes in the clouds. The logical position is one of confident expectation. We must wait and see. As a matter of fact, Mr. Edison, thus far, has comprehended the subject of electricity sufficiently to introduce into this country more telegraphic instruments than any other man, and there are more of them earning money to-day than of any other man's inventions. All this is encouraging, to say the least.

But Mr. Edison has already accomplished very much of what is to be done in securing the electric light. The "subdivision" is a virtual fact. Only the details necessary to render it easily and safely manipulated remain. And to these points he is giving his patient attention and energy. So far as he has gone in the great work, it should be noted, that his method radically differs from all others. While Jablochkoff, Sawyer, Werdermann, Wallace, Jenkins, and others consume carbon, more or less, in their methods of electrical illumination, Mr. Edison's is one of incandescence. They use the carbon candle, which has not, thus far, allowed the subdivision of the electric fluid to any great extent; he uses a metalic compound which admits of almost an infinite subdivision, and which is not consumed.

When an electrical current from a battery meets with resistance to its passage, the electricity is directly converted into heat. If a thin wire be placed in the circuit the temperature of the wire rapidly rises; and it has long been known that the amount of heat thus generated is directly proportional to the electric resistance of the wire. Now the resistance depends, among other things, on the nature of the metal; those metals which are good conductors, such as silver, offering much less resistance than those which are bad conductors such as platinum, which from its low electric conductivity, or what amounts to the same thing, from its high resistance—is peculiarly fitted for exhibiting incandescence. A chain made of alternate links of platinum and silver, when placed in a circuit would show the platinum links in a state of white heat. The resistance which a platinum or other wire offers to the current is related not only to the nature of the metal, but also to the thickness of the wire. Reduce the thickness and the resistance is immediately increased. Again, the heating effect is closely connected with the strength of the current. Hence a powerful current sent through a thin platinum wire immediately renders it incandescent (white heat.)

Mr. Edison's electric light is produced by incandescence.—The conductor, which is made incandescent by the electrical current passing through it, is a small, curiously shaped apparatus, consisting of a high alloy of platinum and iridium, which cannot be melted at 5,000 degrees Fahrenheit. A sufficient quantity of this metal is placed in each burner to give a light equal to that of a gas jet. Devices of exceeding simplicity, and, as repeated experiments have proved, of equal reliability, are connected with the lamp. They surmount the apparent impossibility of regulating the strength of the light. This lamp, when placed in the electric circuit in which a strong current circulates, is absolutely independent of the strength of the current. This Mr. Edison considers one of the vital features of the invention. Thus, if the regulator is set so that the light gives only, say, ten candle power, no increase in the strenth of the current will increase its brilliancy.

Each light is independent of all others in the circuit. A thousand may be fed from the same conductor, and the extinguishing of all but one will have on that one Mr. Edison claims, no perceptible effect. Each lamp in the circuit, by means of the regulator—a description of which latter the inventor for the present withholds—is allowed to draw from the central station just sufficient current to supply itself. In lighting by incandescence the light is obtained by the resistance which the conductor in the lamp offers to the passage of the electric current. Hence any other resistance exterior to the lamp used therewith to regulate it requires a current in proportion to its resistance although it gives no light. One of the main features of Edison's invention consists in having all the resistance outside of the main conductor produce light, consequently there is maximum economy. The lamp devised by Mr. Edison is not merely a coil of incandescent metal, but a very peculiar arrangement of such metal whereby (by means of a discovery of his in connection with radiant energy) a much weaker current is made to generate a given light than if a given spiral were used, and the considerable loss due to the division of the light is compensated for.

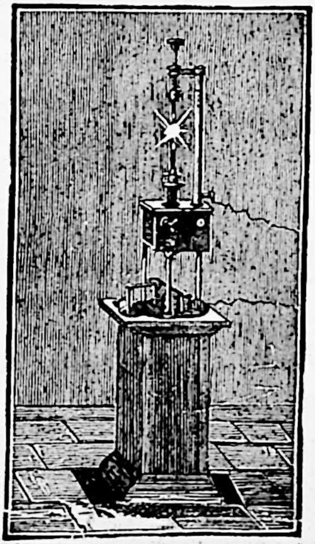
In the Jablokoff method of electrical illumination, now used to a limited extent in Europe, the carbon candle, so called, consists of two rods or needles of carbon placed side by side, and kept insulated from each other, by a layer of plaster paris. They are each one-eighth of an inch in diameter and ten inches long, and are firmly fixed into metal sockets, to which wires are led and the conductor of the machine is made. When new, the tops of the two sticks only are joined by a small bit of carbon. One of these will ordinarily burn from an hour and a quarter to an hour and a half. Four of them are usually adjusted together under a large opal glass globe which subdues the dazzling brilliancy of the light, though at a loss of about one half of the illuminating power of the naked candle. As one of these candles burns down, the current is shifted to the next, and so on until the four are consumed. So that, at the outside, the lamps would continue burning six hours, when the set of four candles has to be replaced by others. By sending the current of electricity alternately through the two rods, thereby changing the poles, the carbons are kept uniform in length and the light more steady.

It has been acknowledged by nearly all electricians that lighting by incandescence, especially incandescence of a metalic wire, offers less obstacles to the division of the electric light than by any other method, and Mr. Edison believes it to be the only reliable method, because the light-giving metal is an electrical "constant" whose resistance can always be known and depended upon,—a condition which is exceedingly essential when many hundreds of lights must be supplied from one conductor. In the case of the electric are between carbon rods, the resistance varies at every instant, not only from changes in the strength of the current, but from impurities in the carbon, from air-currents, and from many other causes. On this account Mr. Edison claims that factors so variable coming in play in hundreds of lamps make it impossible to calculate the strength of the current or size of the conductors. It would be as difficult supplying gas from one main where each burner varied from excessive limits with the rapidity of lightning. Besides in the case of carbon points many hundreds reacting on each other cause such an unsteadiness in the light as to be unbearable. Lighting by incandescence Mr. Edison claims is free from any of these defects.

In the course of his experiments on the electric light Mr. Edison made the discovery that he could, by a certain combination in the form of the metal used in his lamp secure sufficient light from the electricity generated from a one cell battery to enable him to read by. The cell used was an ordinary one of Daniell's battery. To his surprise—for he hardly expected such a result—the metal soon became a dull red, and, after several other changes, he succeeded in obtaining a glow which made it not at all difficult to read by the room being kept dark. Several of the labratory hands examined the phenomenon with curiosity. It served to demonstrate to Mr. Edison that he had hit upon the form of metal to produce the best result.

Another new feature in the system of the light as a whole is his improvement on dynamo machine specifications, for a patent for which Mr. Edison has only just applied.

A visitor at Menlo Park describes this light as follows: Mr. Edison exhibited an electric generating machine. It was what is known as the Wallace Machine. A knot of magnets ran around the cylinder, facing each other. and wires were attached to it. The great inventor slipped a belt over the machine, and the engine used in his manufactory began to turn the cylinder. He touched the point of the wire on a small piece of metal near the window casing, and there was a flash of blinding white light. It was repeated at each touch. "There is your steam power turned into an electric light," he said, There was the light, clear, cold and beautiful. The intense brightness was gone, and there was nothing irritating to the eye. The mechanism was so simple and perfect that it explained itself. The strip of platinum that acted as a burner *did not burn.* It was incandescent. It threw off a light pure and white, and it was set in a gallows-like frame; but it glowed with the phosphorescent effulgence of the star Altair. You could trace the veins in your hands and the spots and lines upon your finger nails by its brightness. All the surplns electricity had been turned off, and the platinum shone with a mellow radiance through the small glass globe that surrounded it. A turn of the screw and its brightness became dazzling, or reduced itself to the faintest glimmer of a glow-worm. It seemed perfect.



Electric Light

Edison's Explanation of His Electric Light.

HOW THE ELECTRICITY IS GENERATED—HOW THE LIGHT IS PRODUCED.

The electro-magnetic machine for producing the electricity for Edison's electric light, is described by the great inventor in his specifications, as follows:

"It has long been known that if two electro-magnets, or an electro-magnet and a permanent magnet, be drawn apart or caused to pass by each other, electric currents will be set up in the helix of the electro-magnet. It has also been known that vibrating bodies, such as a tuning-fork or a reed, can be kept in vibration by the exercise of but little power. I avail of these two known forces, and combine them in such a manner as to obtain a powerful electric current by the expenditure of a small mechanical force. In Fig. 23 of the drawing, a tuning fork, *a2*, is represented as firmly attached to a stand, *b2*. This fork is preferably of two prongs, but only one might be employed upon the principle of a musical reed. The vibrating bar or fork may be two meters long, more or less, and heavy in proportion. It has its regular rate of vibration like a tuning fork, and the mechanism that keeps it in vibration is to move in harmony. A crank and revolving shaft, or other suitable mechanism, may be employed, but I prefer a small air, gas, or water engine, applied to each end of the fork. The cylinder *a1* contains a piston and a rod, *b1*, that is connected to the end of the bar, and steam, gas, water or other fluid under pressure acts within the cylinder, being admitted first to one side of the piston and then the other by a suitable valve; the valve and directing rod, *c2*, are shown for this purpose. The bar of fork, *a2*, may be a permanent magnet or an electro-magnet, or else it is provided with permanent or electro-magnets. I have shown an electro-magnet, *c1*, upon each prong of the fork—there may be two or more on each—and opposed to these are the cores of the electro-magnets *d*. Hence as the fork is vibrated a current is set up in the helix of each electro-magnet, *d*, in one direction as the cores approach each other, and in the opposite direction as they recede. This

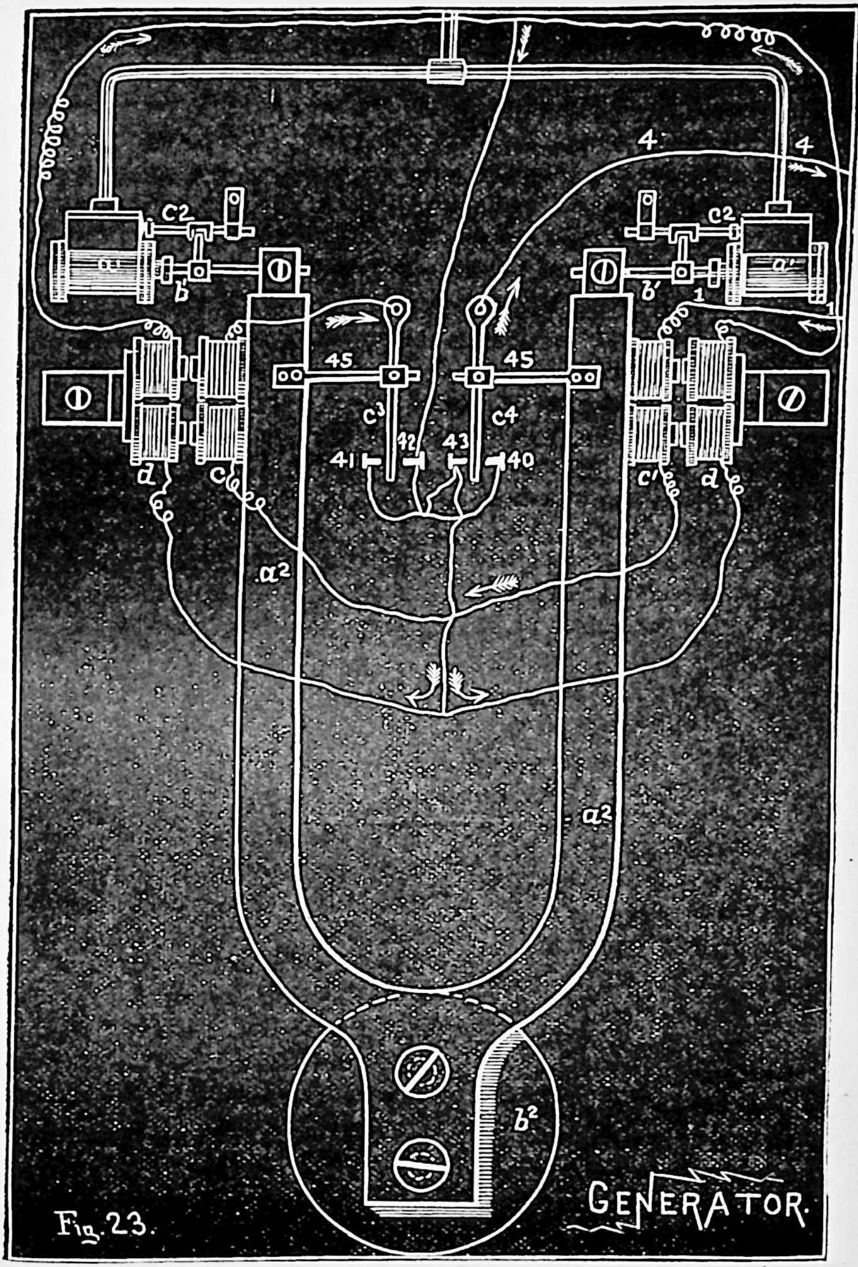


Fig. 23.

alternate current is available for electric lights, but if it is desired to convert the current into one of continuity in the same direction a commutator is employed, operated by the vibrations of the fork to change the circuit connections each vibration, and thereby make the pulsation continuous on the line of one polarity. A portion of the current thus generated may pass through the helixes of the electro-magnets, *c1*, to intensify the same to the maximum power and the remainder of the current is employed for any desired electrical operation wherever available. I, however, use the same, especially with my electric lights, but I remark that electricity for such lights may be developed by any suitable apparatus. I have represented commutator springs or levers, *c3*, *c4*, operated by rods that slide through the levers, *c3*, *c4*. and by friction move them. When the prongs, *a2*, *a2*, are moving from each other the contact of levers, *c3*, *c4*, will be with the screws, 40, 41, and the current will be from line 1, through *c1* to *c*, thence to *c3* to 41, 43, and to circuit of electro-magnets, *d d*, and from *d d* by 42 to 40 *c4*, and line as indicated by the arrows. When the prongs, *a2*, *a2*, are vibrating towards each other the circuit will be through *c1*, *c*, *c3*, 42, in the reverse direction through the circuit and magnets, *d d*, back to 43, and by *c4*, to line."

Fig. 24 shows the Edison lamp, which is thus described by the inventor:

"Platinum and other materials that can only be fused at a very high temperature have been employed in electric lights; but there is risk of such light-giving substance melting under the electric energy. This portion of my invention relates to the regulation of the electric current, so as to prevent the same becoming so intense as to injure the incandescent material. The current regulation is primarily effected by the heat itself, and is automatic. In Fig. 24 I have shown the light producing body as a spiral, *a*, connected to the posts, *b c*, and within the glass cylinder, *g*. This cylinder has a cap, *l*, and stands upon a base, *m*, and for convenience a colum, *n*, and a stand, of any suitable character may be employed.

I remark further, it is preferable to have the light within a case or globe, and that various materials may be employed, such as alum water, between concentric cylinders, to lessen radiation, retain the heat, and lessen the electric energy required; or colored or opalescent glass, or solutions that reduce the refrangibility

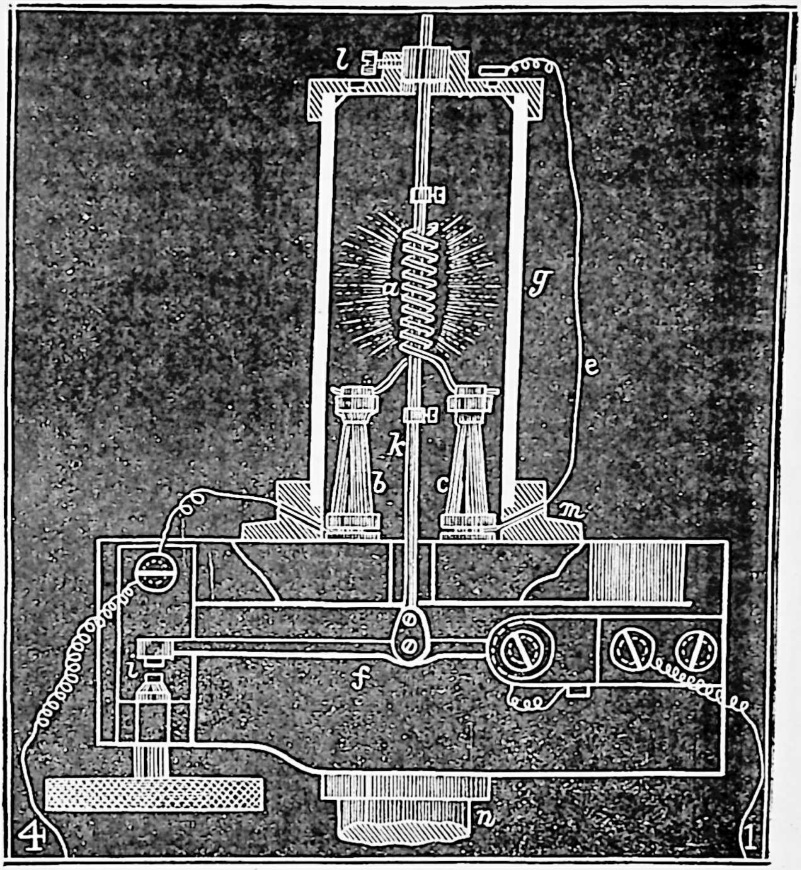


Fig. 24; Edison's Electric Light.

of the light, such as sulphate of quinine, may be employed to moderate the light, and the light may either be in the atmosphere or in a vacuum.

The electric circuit, Fig. 24, passes by line 1 to the lever, *f* thence by a wire or rod, *k*, cap *l*, wire, *e*, to post, *c*, through the double spiral, *a*, to the post, *b*, and by a metallic connection or wire to line 4, and so on through the electric circuit. (Lines 1 and 4, are the same in both figures.) The light is developed at *a*. The rod, *k*, will expand in proportion to the heat of the coil, or in proportion to the heat developed by the passage of the current through the fine wire, *k*, and, if the heat becomes dangerously high, injury to the apparatus is prevented by the expansion of rod, *k*, moving the lever, *f*, to close the circuit at *i* and short circuit or shunt a portion of the current from the coil, *a*, and reducing its temperature; this operation is automatic, and forms the principal feature of my invention, because it effectually preserves the apparatus from injury. The current need not pass through the wire or rod, *k*, as the expansion thereof by the radiated heat from the coil, *a*, will operate the lever, *f*, but the movement is not so prompt. It is to be understood that in all cases the action of the short current through the light-giving substance and the circuit-closing devices play up and down at the contact point, maintaining uniformity of brilliancy of light."

Concerning this wonderful invention, Mr. Edison further states: "Electric light coils may be put in a secondary circuit containing cells, with plates in a conducting liquid; and a lever is vibrated by an electro-magnet or by clock-work. When the lever is in contact the current from line 1 passes through the electro-magnet and cells, but when the contact ceases the line is closed, but a local circuit is made through the coils and second battery; the discharge of the second battery *gives the light*, and the movement is so rapid that the light appears continuous." Thus it will be seen that Mr. Edison is making sure and steady progress with his electric light, which when finally completed, must rank with the grandest of all human inventions. His knowledge of the general subject, in which he has no superior in the world, his great inventive genius, his untiring industry, personal interest, and the success already attained, augur almost the absolute certainty that the electric light will soon be a household blessing.

FURTHER EXPERIMENTS.

Edison's New and Perfected Electric Light—Simplicity Simplified —Making Little Suns Out of Burnt Paper.

Incredible as it may appear, Mr. Edison's new and perfected electric light is produced from a little piece of burnt paper, that a single breath of air would blow away. Through this little strip of paper is passed an electric current, and the result is a bright, beautiful light like the mellow sunset of an Italian autumn. Mr. Edison makes this little piece of paper more infusible than platinum, more durable than granite. And this involves no complicated process.

The paper is merely baked in an oven, until all its elements have passed away except its carbon framework. The latter is then placed in a glass globe, connected with the wires leading to the electricity producing machine, and the air exhausted from the globe. Then the apparatus is ready to give out a light that produces no deleterious gases, no smoke, no offensive odors—a light without flame, without danger—requiring no matches to ignite, giving out but little heat, vitiating no air, and free from all flickering; a light that is a little globe of sunshine, a veritable Aladdin's lamp.

In the preceding pages which treat of the electric light, we have the steps taken by Mr. Edison, that led him through a maze of experiments up to his "platinum burner," which he supposed, for a time, would prove permanently successful. It was found, however, that platinum, when exposed to a high degree of heat for any considerable time became crystallized, a condition unfavorable for illumination. He therefore made a new departure, the steps of which are shown in the following pages, and which led him to his present Carbon Lamp.

After various experiments he hit upon the unique idea of making the platinum give the light as it were by proxy. By means of a reflector he concentrated the heat rays of the platinum upon a piece of zircon, causing the latter to become luminous. Figure 25 shows the apparatus; a, is a mass of non-conducting material, b, is an air space, c, is a polished reflector of copper, coated with gold, d, is a platinum iridium spiral, which becomes heated by the passage of the electric current through it; e, is a thin piece of zircon that receives the heat rays thrown off by the reflector c, which heat rays bring up the zircon e, to vivid incandescence, making it give out a light much more brilliant than the light of the platinum spiral, d. With this form Mr. Edison tried numerous experiments, and from time to time made many alterations and improvements, but eventually the apparatus was placed in the category of non-successors.

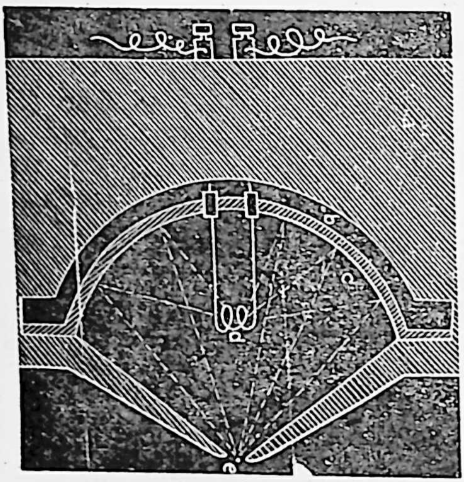


Fig. 25, Zircon Burner.

Realizing from the first the necessity of the light-giving substance offering much resistance to the passage of the electric current, a necessity in extensive subdivision of the light, the inventor throughout his experiments kept a close watch for substances and forms that gave suitable resistance. In figure 26 is shown a form of lamp disconnected from the regulating apparatus, which largely embodied the above requirement, and for a time gave good results. A, is a spiral of carbon with two large ends, B, e, connecting with the wires leading to the machine for generating the current. This device was tried for several weeks, but did not as a whole give satisfaction

Branching off from the line of investigation he had been previously following, Mr. Edison at this time began experimenting with a view to having the light produced locally, *i. e.*, arranging for each householder to become his own manufacturer of light, thus dispensing with mains and central stations. The apparatus which he used for this purpose is shown in figure 27. R, is an induction coil, such as are used by showmen at fairs and other places, when they give electric shocks to inquiring sight-seers at so much per shock. It is operated by two cells of battery B, and wires lead from it to the glass tubing T, from which the air has previously been extracted, and the passage of the electric current through the tubing gives out a light. This plan is analogous to what is known as the Geisler tube arrangement, the difference being in the tube and the extreme smallness of the bore, and also in the degree of vacuum produced. Mr. Edison succeeded by this arrangement in obtaining a light of several candle power, with a moderately powerful induction coil. The light, however, was not the one sought after so persistently by the inventor, and so it took its place in that part of the laboratory occupied by inventions not in use.

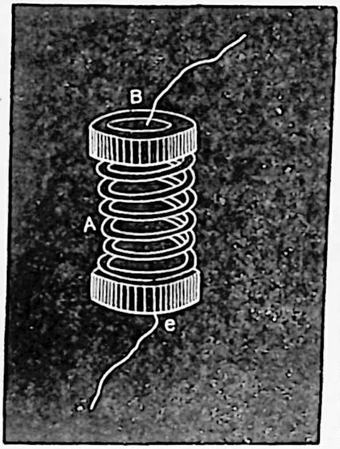


Fig. 26, Carbon Spiral.

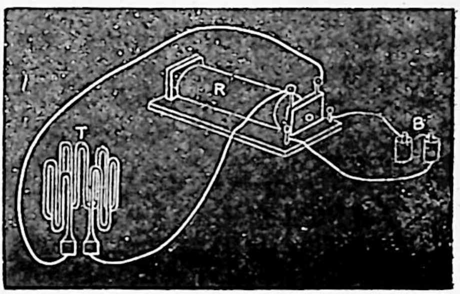


Fig. 27, Local Lamp.

Once more Mr. Edison made a departure. He molded powdered metallic oxides in the form of sticks, and subjected them to a very high temperature. In this connection he obtained very fine results from the native alloy of osmium iridium called bridosmine, which alloy he used in the form of a powder inclosed in a tube of zircon. The electric current passing through the same brought it to a beautiful incandescence.

The inventor's next important move was the adoption of carbon in connection with platinum as the substance to be made incandescent. He caused a slender rod of carbon to rest upon another of platinum, the inferiority of contact between the two at their point of meeting producing a resistance to the passage of the electric current and causing the carbon to become highly incandescent while the platinum attained only a dull red heat. The carbon rod was kept pressing upon the platinum by a weight ingeniously arranged. A dozen or more forms of this lamp were made, but after all the inventor was obliged to return to platinum as the substance most suited, all things considered, for being made incandescent. For two months he worked at platinum, day and night, only to find that platinum, as he had previously been using it, was worthless for incandescent lighting. To many experimenters this would have proved a discouragement perhaps fatal, but it had the effect only of increasing Edison's determination, and, after scores of new experiments, he arrived at the true causes of the defects, and hastened to apply the remedy. "I have found," he writes, "that when wires or sheet platinum, iridium, or other metallic conductors of electricity, that fuse at a high temperature, are exposed to a high temperature near their melting point in air for several hours, by passing a current of electricity through them, and then are allowed to cool, the metal is found to be ruptured, and under the microscope there are revealed myriads of cracks in various directions, many of which reach nearly to the center of the wire. I have also discovered that, contrary to the received notion, platinum or platinum and iridium alloy, loses weight when exposed to the heat of a candle; that even heated air causes it to lose weight; that the loss is so great a hydrogen flame is tinged green. After a time the metal falls to pieces; hence wire or sheets of platinum or platinum and iridium alloy, as now known in commerce, are useless for giving light by incandescence: 1. Because the loss of weight makes it expensive and unreliable, and causes the burner to be rapidly destroyed. 2. Because its electrical resistance changes by loss in weight, and its light-giving power for the total surface is greatly reduced by the cracks and ruptures. The melting point also is determined by the weakest spot of the metal.

"By my invention or discovery I am able to prevent the deterioration of the platinum or its alloy by cutting off or intercepting the atmospheric action. A spiral wire or other forms of platinum is placed in a glass tube or bulb, with the wire near its ends passing through and sealed in the glass, and the air is exhausted from the glass. The platinum wires of the spiral are then connected to a magneto-electric machine or battery, the current of which can be controlled by the addition of resistance. Sufficient current is allowed to pass through the wire to bring it to about 150 degrees Fahrenheit. It is then allowed to remain at this temperature ten or fifteen minutes. While thus heated, both the air and gases confined in the metal are expelled by the heat or withdrawn by the vacuum action.

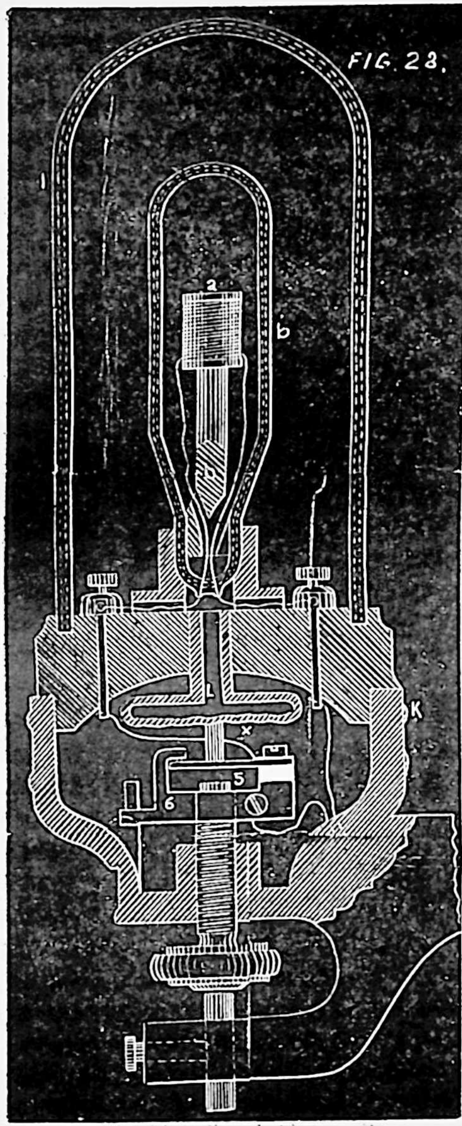
"While this air or the gases are passing out of the metal the mercury pump is kept continually working.

"After the expiration of about fifteen minutes, the current passing through the metal is augmented so that its temperature will be about 300 degrees Fahrenheit, and it is allowed to remain at this temperature for another ten or fifteen minutes.

"The mercury pump is to be worked continuously, and the temperature of the spiral raised at intervals of ten or fifteen minutes, until it attains vivid incandescence and the glass is contracted where it has passed to the pump and melted together, so that the wire is in a perfect vacuum, and in a state heretofore unknown, for it may have its temperature raised to a most dazzling incandescence, emitting a light of twenty-five standard candles, whereas, before treatment, the same radiating surface gave a light of only about three standard candles. The wires, after being thus free from gasses, are found to have a polish exceeding that of silver, and obtainable by no other means. No cracks can be seen even after the spiral has been raised suddenly to incandescence many times by the current, and the most delicate balance fails to show any loss of weight in the wire even after it is burning for many hours continuously. I have further discovered that if an alloy of platinum and iridium coated with the oxide of magnesium and subjected to the vacuum process described, a combination takes place between the metal and the oxide, giving the former remarkable properties. With a spiral having a radiating surface of three-sixteenths of an inch, light equal to that given by forty standard candles may be obtained, whereas, the same spiral, not coated by any process, would melt before giving a light of four candles.

"The effect of the oxide of magnesium is to harden the wire to a surprising extent, and render it more refractory. A spiral made of this wire is elastic and springy when at high incandescence. I have found that chemically pure iron and nickel, drawn in wires and subjected to the vacuum process, may be made to give a light equaling that of platinum in the open-air. Carbon sticks also may be freed from air in this manner, and be brought to a temperature where the carbon becomes pasty, and on cooling it is homogeneous and hard."

About this time another truth dawned upon the inventor, viz., that economy in the production of light from incandescence demanded that the incandescence substance offer a very great resistance to the passage of the electric current. Concerning this the inventor writes: "It is essential to reverse the present practice of having lamps of but one or two ohms (electrical units) resistance, and construct lamps which,



when giving their proper light, shall have, at least, 200 ohms resistance."

The lamp, at this stage is shown in figure 28. a, is the burner, or incandescent platinum, in the shape of a bobbin, supported within the vacuum tube b, by a rod d, of the same material as the bobbin ; the vacuum tube b, is sustained by the case K, and around said tube b, is a glass globe, I ; within the case K, is a flexible metallic aneroid chamber, L, that opens into the glass case I, so that the air, when expanded by heat, can pass into the aneroid chamber and give motion to the flexible diaphragm, X, and parts connected therewith.

When the current circulating around the bobbin a, becomes too intense, the air within the glass case I is expanded, and presses the diaphragm X and the pin upon the spring 5, and separates said spring from the block 6, and breaks the circuit to the burner. The temperature within the globe I, lowers immediately, and the parts return to their normal position, closing the circuit through the burner to 5 and 6. This opening and closing of the circuit is but momentary, and the uniform brilliancy of the light is not affected.

The lamp, after these latter improvements, was in quite a satisfactory condition, and the inventor contemplated with much gratification, the near conclusion of his labors. One by one he had overcome the many difficulties that lay in his path. He had brought up platinum as a substance for illumination from a state of comparative worthlessness to one well nigh perfection. He had succeeded, by a curious combination and improvement in air pumps, in obtaining a vacuum of nearly one-millionth of an atmosphere, and he had perfected a generator, or electricity producing machine (for all the time he had been working at lamps he was also experimenting in magneto-electric machines) that gave out some 90 per cent in electricity of the energy it received from the driving engine. In a word, all the serious obstacles toward the success of incandescent electric lighting he believed had melted away, and there remained but a comparatively few minor details to be arranged before his laboratory was to be thrown open for public inspection, and the light given to the world for better or for worse.

There occurred, however, at this juncture a discovery that materially changed the system and gave a rapid stride toward the perfect electric lamp. Sitting one night in his laboratory, reflecting on some of the unfinished details, Edison began abstractedly rolling between his fingers a piece of compressed lamp black mixed with tar, for use in his telephone. For several minutes his thoughts continued far away, his fingers, in the meantime, mechanically rolling out the little piece of tarred lamp black until it had become a slender filament. Happening to glance at it, the idea occurred to him that it might give good results as a burner if made incandescent. A few minutes later the experiment was tried, and to the inventor's gratification, satisfactory, although no surprising results were obtained.

Further experiments were made with other forms and compositions of the substance, each experiment demonstrating that at last the inventor was upon the right track. A spool of cotton thread lay on the table in the laboratory. The inventor cut off a small piece, put it in a groove between two clamps of iron and placed the latter in the furnace. The satisfactory light obtained from the tarred lamp black had convinced him that filaments of carbon of a texture not previously used in electric lighting were the hidden agents to make a thorough success of incandescent lighting, and it was with this view that he sought to test the carbon remains of a cotton thread. At the expiration of an hour he removed the iron mold containing the thread from the furnace and took out the delicate carbon frame-work of the thread, all that was left of it after its fiery ordeal.

This slender filament he placed in a globe, and connected it with the wires leading to the machine generating the electric current. Then he extracted the air from the globe and turned on the electricity. Presto! a beautiful light greeted his eyes. He turns on more current, expecting the fragile filament instantly to fuse. But no; the only change is a more brilliant light. He turns on more current, and still more, but the delicate thread remains the same. Then, with characteristic impetuosity, and wondering and marvelling at the strength of the little filament, he turns on the full power of his machine, and eagerly watches the consequence. For a minute or more the slender thread seems to struggle with the intense heat passing through it—heat that would melt the diamond itself. Then at last it succombs, and all is darkness.

The powerful current had broken it in twain, but not before it had emitted a light of several gas jets. Eagerly the inventor hastened to examine under the microscope this curious filament, apparently so delicate, but in reality much more infusible than platinum, so long considered one of the most infusible of metals. The microscope showed the surface of the filament to be highly polished, and its parts interwoven with each other.

It was also noticed that the filament had attained a remarkable degree of hardness compared with its fragile character before it was subjected to the action of the current. Night and day, with scarcely rest enough to eat a hasty meal or catch a brief repose, the inventor kept up his experiments, and from carbonizing pieces of thread he went to splinters of wood, straw, paper, and many other substances never before used for that purpose. The results of his experiments showed that the substance best adapted for carbonization and the giving out of incandescent light was paper, preferably thick like cardboard, but giving good results even when very thin. The beautiful character of the illumination, and the steadiness, reliability, and non-infusibility of the carbon filament, were not the only elements incident to the new discovery that brought joy to the heart of Edison. There was a further element not the less necessary because of its being hidden, the element of a proper and uniform resistance to the passage of the electric current.

The inventor's efforts to obtain this element had been by far the most laborious of any in the history of his work from the time he undertook the task, and without it absolute success to electric incandescent illumination could not be predicated, even though all the other necessary properties were present in the fullest degree.

Passing over the scores of experiments made since the discovery that the carbon frame-work of a little piece of paper or thread was the best substance possible for incandescent lighting, we come to consider the way in which the same is prepared at the present time in the laboratory.

With a suitable punch there is cut from a piece of "Bristol" card-board a strip of the same, in the shape of a miniature horse-shoe, about two inches in length and one eighth of an inch in width. A number of these strips are laid flatwise in a wrought-iron mold about the size of the hand and separated from each other by tissue paper. The mold is then covered and placed in an oven, where it is gradually raised to a temperature of about 600 degrees Fahrenheit. This allows the volatile portions of the paper to pass away. The mold is then placed in a furnace and heated almost to a white heat, and then removed and allowed to cool gradually. On opening the mold the charred remains of the little horse-shoe card-board are found. It must be taken out with the greatest care, else it will fall to pieces. After being removed from the mold it is placed in a little globe and attached to the wires leading to the generating machine. The globe is then connected with an air-pump, and the latter is at once set to work extracting the air. After the air has been extracted the globe is sealed, and the lamp is ready for use. Figure 29 shows the lamp com-

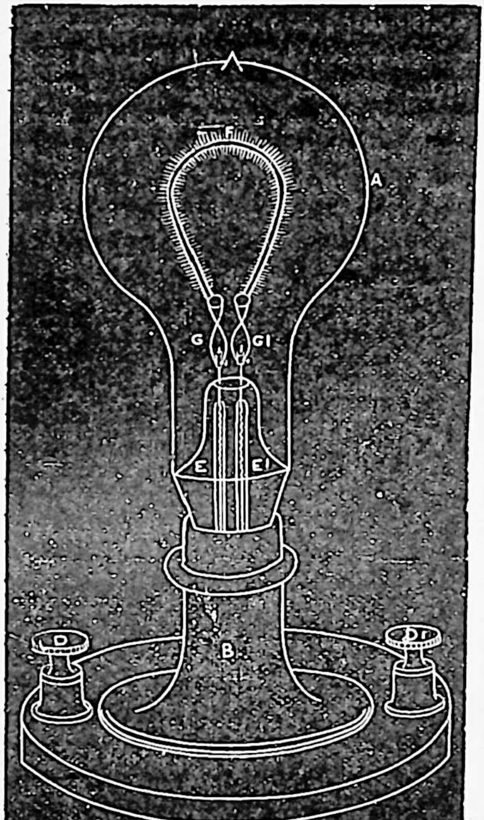


Fig. 29, Electric Lamp.

plete. A, is a glass globe, from which the air has been extracted, resting on a stand, B. F, is a little carbon filament connected by fine platinum wires (G, G 1) to the wires (E, E 1) leading to the screw-posts (D, D 1), and thence to the generating machine. The current entering at D, passes up the wire (E) to the platinum clamp (G), thence through the carbon filament F, to G 1 down the wire E 1 to the screw-post D 1, thence to the generating machine. It will be noticed by reference to the complete lamp in figure 29 that it has no complex regulating apparatus, such as characterized the inventor's earlier labors. All the work he did on regulators was practically wasted, for he has lately realized that they were not at all necessary, no more so than a fifth wheel is to a coach.

The electric energy can be regulated with entire reliability at the central station, just as the pressure of gas is now regulated. By his system of connecting the wires the extinguishment of certain of the burners affect the others no more than the extinguishment of the same number of gas-burners affect those drawing their supply from the same main. The simplicity of the completed lamps seem certainly to have arrived at the highest point, and Edison asserts that it is scarcely possible to simplify it more. The entire cost of construction is not more than twenty-five cents.

The lamp shown in figure 29 is a table lamp. For chandeliers it consists of only the vacuum, globe, and the carbon filament attached to the chandelier, and connected to the wires leading to the generating machine in a central station, perhaps a half a mile away, the wires being run through the gas pipes, so that in reality the only change necessary to turn a gas jet into an electric lamp is to run the wires through the gas pipes. take off the jet, and screw the electric lamp in the latter's place. Although the plans have not been fully consummated for general illumination, the outline of the probable system to be adopted is the locating of a central station in large cities in such a manner that each station will supply an area of about one third of a mile.

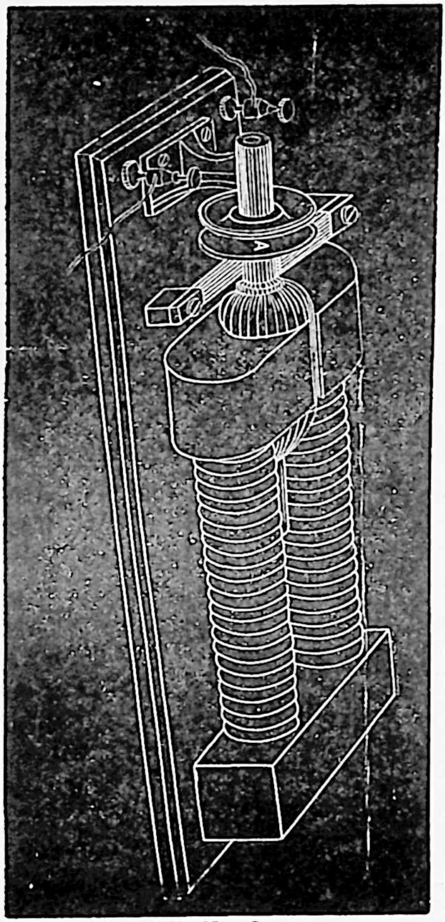


Fig. 30, The New Generator.

In each station there will be, it is contemplated, one or two engines of immense power, which will drive several generating machines, each generating machine supplying about fifty lamps.

Mr. Edison's first experiment in machines for generating the electric current did not meet with success. His primal apparatus was in the form of a large tuning fork, constructed in such a way that its ends vibrated with great rapidity before the poles of a large magnet. These vibrations could be produced with comparatively little power. Several weeks of practice proved, however, that the machine was not practical, and it was laid aside.

Then followed a number of other forms, leading up gradually to the one at present used. Bearing in mind the principle common to all magneto-electric machines, viz., that the current is produced by the rotation of magnets near each other, it will not be difficult to understand in a general way how his machine operates. It is called the Faradic machine, in honor of Faraday, and is composed of two upright iron columns, three feet high and eight inches in diameter, wound with coarse wire, and resting upon the bases which form its magnetic poles. This part of the apparatus is called the field of force magnet. Fixed on an axle so as to freely revolve between the poles is a cylindrical armature of wood, wound parallel to its axes with fine iron wire. When this cylinder or armature is made to revolve rapidly between the magnetic poles, by means of a belt driven by an engine, there is generated in the wire surrounding the armature strong currents of electricity, which are carried off by the wires to the electric lamps.

By constructing the machine in the form shown in figure 30, there is obtained an electric motor capable of performing light work, such as running sewing machines and pumping water. It forms part of the inventor's system, and may be used either with or without the electric light.

To run an ordinary sewing machine it requires only as much electricity as is necessary to give out one electric light of the strength of a common gas jet. To put it in operation on a sewing machine the housewife has merely to attach it by a little belt at A, with the wheel of the sewing machine and turn on the electricity by touching a little knob conveniently attached. The cost is the same as if she were burning one electric light.

The apparatus for measuring the amount of electricity used by each householder is a simple contrivance, consisting of an electrolytic cell and a small coil of wire appropriately arranged in a box, the latter being of about one half the size of an ordinary gas meter, and, like a gas meter, it may be placed in any part of the house. The measurement is obtained by the deposit of copper particles on a little plate in the electrolytic cell, each deposit being caused by the electric current passing through the cell. At the end of any period, say one month, the plate is taken by the inspector to the central office, where the copper deposit is weighed, and the amount of electricity consumed determined by a simple calculation.

The New Edison Dynamo.

A WONDERFUL MECHANISM FOR GENERATING ELECTRICITY.

The new Edison Dynamo is a singular and somewhat complicated mechanism, which, by the very rapid revolution of an armature, properly adjusted to a magnetic field, generates electricity. Apparently this electricity comes from the atmosphere, or from without the dynamo in some mysterious manner, not yet fully understood. In the Edison

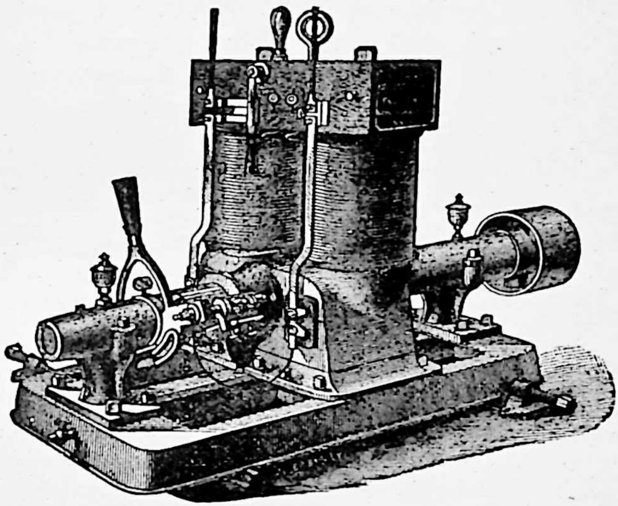


Fig. 31; Edison Dynamo.

Dynamo, we have a strong, compact, durable, safe and economical mechanism, made in different sizes, and now in use in every part of the world where the electric light is used. The essential parts, common to all dynamos, as well as to Mr. Edison's, are:

1. An iron body constituting the magnetic limbs, or field. This is always wrapped over a certain portion of its length with insulated copper wire, and its purpose is to produce

between its ends or polar surfaces, a region or field of magnetic force.

2. An armature, which consists of a series of coils of copper wire, generally wound upon a subdivided mass of iron, and capable of revolution about an axis in such a way as to make each coil pass successively before the polar surfaces of the magnetic limbs. This is always so placed that it helps, with the magnets, to form a nearly closed magnetic circuit of iron.

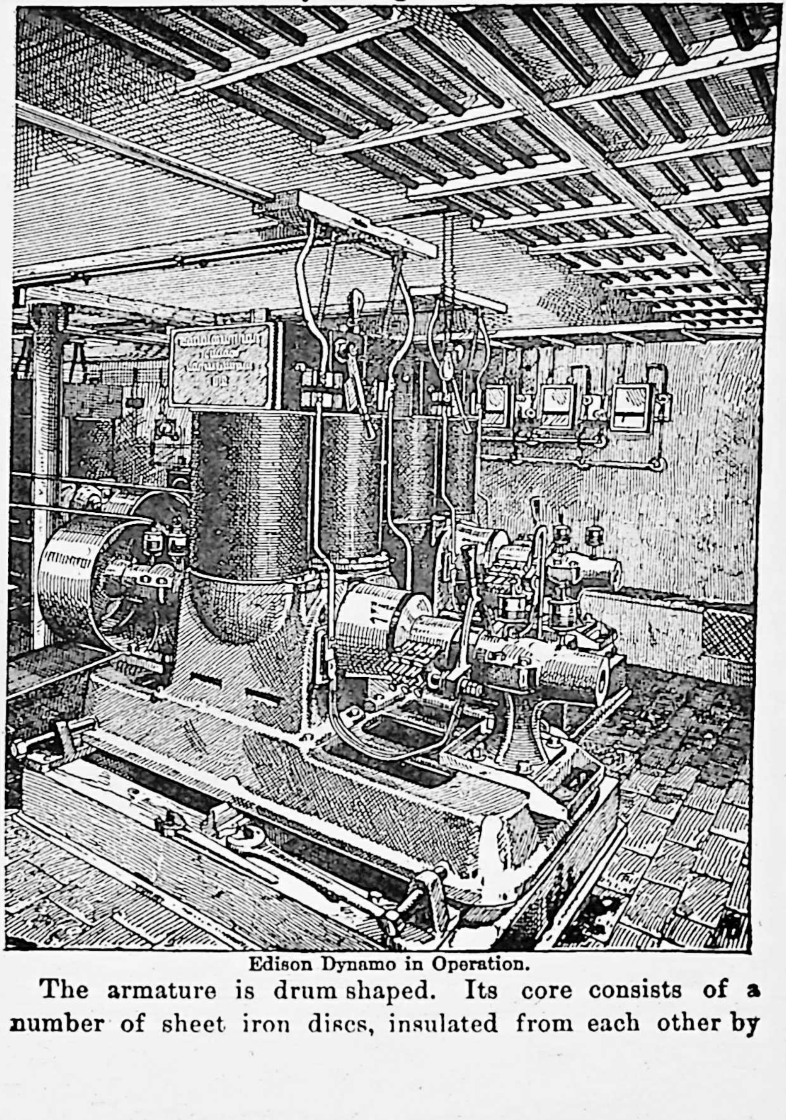
3. A commutator, which is merely the ends of the armature coils brought to one side, and which, revolving with the armature, effects a change in the direction of the currents formed alternately plus and minus.

4. Several brushes, or collectors, usually two in number, consisting of pieces of metal which press upon the segments of the commutator, and which are in metallic communication with the terminals of the machine.

In general, the armature revolves between the poles of the electro magnet; but in some machines, notably those intended to furnish alternate currents, the armature is stationary, and the magnet coils, themselves, revolve.

The wonderful light-generating dynamo and apparatus constructed by Mr. Edison, when complete and in operation, consists of a regulating box, armature, commutator, brush, armature revolving from left to right, armature revolving from right to left, brush holder, brush-holder with attachment to rocker arm, babbitt shell for journal, safety cut-out, safety plug for cut-out, switch, lamp, and lamp attached to key socket.

The field magnets of the new Edison Dynamo consist of vertical cylinders, as shown in the engraving, with large wrought iron cores, resting on massive cast-iron pole pieces which nearly enclose the armature. The extreme length of core found in the older styles have been reduced, and the diameter correspondingly increased, so as to preserve the massiveness, a feature which, in both cores and pole pieces, it is claimed, increases the magnetic intensity of the field and lessens the liability to magnetic saturation of the iron.



Edison Dynamo in Operation.

The armature is drum shaped. Its core consists of a number of sheet iron discs, insulated from each other by tissue paper, and mounted on an iron shaft, but insulated from it by an interior cylinder of *lignum vitæ*, while an external covering insulates it from the coils. These consist of cotton-covered copper wire stretched longitudinally, and grouped together in parallel, twelve wires, more or less, in a group; all the groups being so connected as to form a continuous closed circuit. These groups are arranged in concentric, and are of the same number as the segments of the commutator, the ends of the wires in each group being attached to arms connecting with the commutator segments; a spiral arrangement being adopted in making the connections between the straight portions of the wire and the arms. The object of grouping is to secure flexibility for winding by the use of small wire, and low electric resistance by having several wires in parallel, the effect as to resistance being practically the same as if the several wires were combined in one. At the ends the wires are insulated from the core by discs of vulcanized fibre, with projecting teeth. The discs of the core are bolted together by insulated rods, and the coils are confined by brass bands surrounding the armature. The bar armature, formerly used in the Edison Dynamo, has been abandoned.

The brushes are composed of several layers of copper wires combined with flat copper strips, two layers of wire being placed between each two strips, an arrangement which is claimed to give a very perfect connection, and to prevent sparking by furnishing numerous points of contact, the copper strips confining the wire, and making the brush more compact.

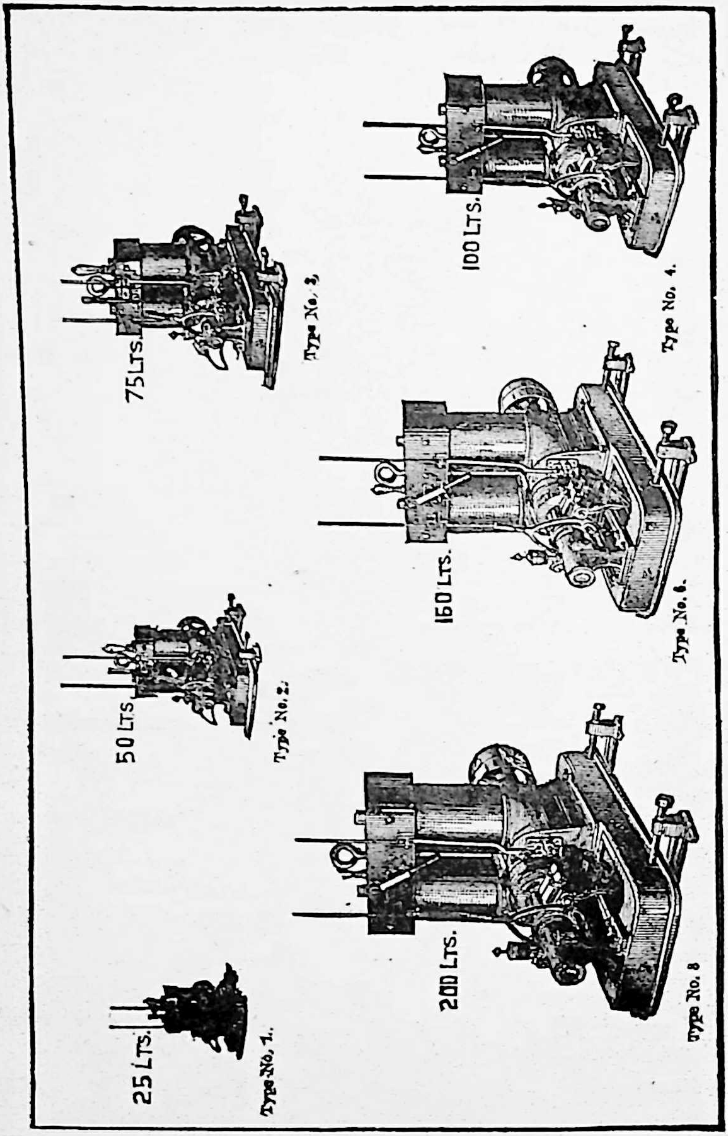
HOW TO PUT THE DYNAMO IN OPERATION.

To put the dynamo in operation we first fill the oil-cups and set the feed, then start the armature and bring it to full speed, when we place the brushes on the commutator. We next close the field-circuit by placing the plug in the regulator, and then close the main switch on the dynamo. As soon as the current is developed we adjust the candle-power of the lamps by the regulator until the indicator points to zero, and also adjust the brushes to prevent any sparking. In stopping the dynamo, we follow the above rules in their reverse order.

The dynamo should always run with no sparks at the brushes, and should be kept scrupulously clean; no water should be allowed near the machine, nor should any oil-cans, wrenches, and other tools be left near, as they are liable to be attracted by the magnets and drawn into the machinery. All contact surfaces should be kept bright and clean and firmly screwed up.

The machine should carry only its normal load, and should never be overloaded. When the dynamo is in operation and the load is increased or decreased to a considerable extent, the brush-holder yoke will sometimes need an occasional adjustment backward or forward in the line of rotation, in order that the current may be taken off at the point of high electro-motive force, at which point there is no sparking. This point often varies in different dynamos, but is usually at an acute angle from the horizontal diameter; for a light load it will be on, or slightly over, the line of horizontal diameter; as the load increases it will travel toward the line of perpendicular diameter.

Switches or circuit-breakers should always have their contact surfaces clean, and must make firm contact when the circuit is closed. Safety plugs should be carefully inspected, occasionally cleaned, and firmly screwed in place. When a safety-plug requires renewing we first trip the switch controlling its circuit, then remove the old plug, replace it by the new one of the proper capacity, and then turn on the current.


25 LTS.
Type No. 1.
50 LTS.
Type No. 2.
75 LTS.
Type No. 3.
200 LTS.
Type No. 8
160 LTS.
Type No. 6.
100 LTS.
Type No. 4.

GENERAL INSTRUCTIONS CONCERNING THE DYNAMO.

The machine must be set in a clean, dry place on a firm foundation. The speed must be constant and regular, and the belts tight and free from slipping. The journal-bearings must have a regular and constant supply of good, clean and medium heavy lubricating oil. The oil should be filtered.

The bearing at commutator end will generally be warmer than at the pully end, but neither bearing should feel exceedingly warm to the hand. If too hot, loosen the cap a little. If excessively hot, use a small quantity of fine plumbago mixed with oil, and cool off with cold water or ice. When the machine is stopped, remove the pillow block, and clean and scrape the bearing.

The commutator must always present a clean, polished surface free from scratches. If accidentally scratched, the commutator can be polished with very fine sandpaper, moistened with a drop of oil. Never use emery paper or cloth. The commutator is in its best condition when it presents a rather dark glazed surface. The commutator must never be allowed to have flat spots; always keep its circumference perfectly true. Do not attempt to oil or fit while running with current on, or brushes in operation. The brushes must always be firmly fastened in the holders, and must be so adjusted, when the armature is not running, that they rest on the commutator at exactly diametrically opposite points; the bevel end of the brush must conform accurately to the curve of the cummutator. The brush-holder should be occasionally moved laterly to allow brushes to wear the commutator evenly.

The pressure of the brushes on the commutator must be sufficient to keep them close to its surface, but not so heavy as to cause them to scour or cut the commutator.

Do not let the brushes become saturated with oil. They can be cleaned by washing them in benzine. The brushes must be so adjusted in the holders that when they have their correct bearing on the commutator, the thumb-screws which govern the tension-spring will have full range of action. When the armature is at rest, the brushes should be lifted from the commutator, and held away by the small clips on the brush-holder provided for this purpose.

Strangers witnessing the wonders of a dynamo in motion should be exceedingly careful not to approach too near the machine, as a slip or fall within its reach might occasion instant death; watches also, when brought too near, if not demagnetized, are apt to be ruined. It should be said in reference to the Edison system of electric lighting, and to its great credit, that it is constructed in all its details, with reference not only to the best possible light, but also to personal safety under every and all circumstances.

When Mr. Edison went to work at the electric dynamo, too much had been done already to admit of his doing much pioneer work. His great mission has been to perfect, and this, too, where so many brilliant and burning intellects had been directed into the same field. His labors were directed to removing from the dynamo all surplus wire not useful for purposes of generation; to avoiding unnecessary internal resistance in the machine, and the consequent excessive accumulation of heat, etc. In a word, Edison's share in perfecting the electric light process involved the most minute investigations into and comparison between the experiments of all preceding inventors, combined with a genius for rapid invention and facile advance in every line of electric skill, which should utilize and save all of value which each had done. This he has done so effectually, that the very words, "Electric Light," must stand forever as closely associated with the name of Edison as is gravitation with Newton, or the telescope with Galileo.

ELECTRIC MOTOR.

We may add in this connection that an electric motor is nothing more or less, virtually, than a "dynamo reversed," where the electricity is brought by the conducting line into the magnetic field of the motor and causes the armature to revolve, and thus renders the electric forces available for practical purposes in running machinery, street cars, etc., etc. A stationary dynamo, run by steam power, generates the electricity, and this electricity is carried by the conducting wire to the electric motor on the street car, or down into a mine, or wherever it is wanted, and entering the motor, furnishes the requisite power.

The modus operandi of the motor has been described as a current flowing around the magnet, and instantly the nearest armature section, feeling the impulse of attraction, will rush forward toward the point of contact. But directly on its approach the finger reaches a non-conducting section and the current ceases. The deluded armature, no longer under the influence of attraction, flies onward impelled by its own momentum, and allows the joke to be played on the next armature section coming up from below. As soon as the connecting finger touches another conducting section, this second armature repeats the effort of its predecessors with equal, but with no better success, and, after failure, relinquishes the field for the next. And so the play goes on, until the wheel, continually gathering momemtum from momentum, flies like the revolving saw, and is strong enough to turn ponderous machinery, or lifts tons upon tons.

Edison's Pyro-Magnetic Dynamo.

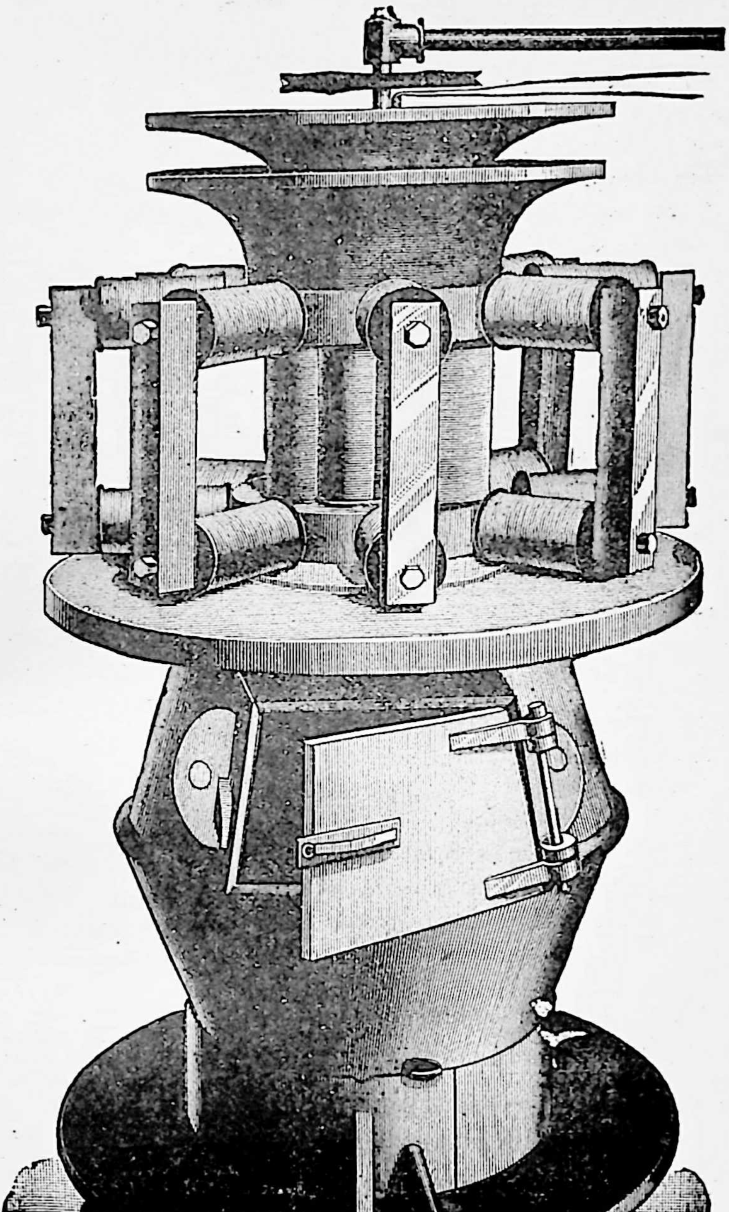
A MECHANISM GENERATING ELECTRIC ENERGY BY HEAT FROM A STOVE.

The Edison Pyro-Magnetic Dynamo is designed to produce electric energy from fuel, and may be used in connection with the wood or coal heating stoves and furnaces that heat our dwellings In a paper prepared by Mr. Edison on this new invention he says: "To do this, has long occupied the close attention of inventors. Could the enormous energy latent in coal be made to appear as electric energy with reasonable economy, the mechanical methods of the entire world be would revolutionized, and another grand step of progress would be taken.

"Quite recently Lord Rayleigh concluded that from a copper iron couple a conversion of not more than one-three-hundredths of the coal energy could be hoped. As a heat engine, therefore, the thermo cell can have no higher efficiency than Carnot's reversible engine. Another line of investigation suggested itself.

"It has long been known that the magnetism of metals has been markedly affected by heat. Nickel loses its power of being magnetized at 400°, iron at a cherry-red heat, and cobalt at a white heat. Whenever a magnetic field varies its strength in the vicinity of a conductor, a current is generated in that conductor; so it occurred to the inventor, that by placing an iron core in a magnetic circuit, and by varying the magnetizability of that core by varying its temperature, it would be possible to generate a current in a coil of wire surrounding the core. This idea constitutes the essential features of the new generator, which therefore is called the 'Pyro-Magnetic Generator of Electricity.'

"The principle was first applied to the construction of a simple form of electric engine, a pyro-magnetic motor." This consisted of a permanent magnet, having a bundle of small tubes made of thin iron placed between its poles, and



Edison's Pyro-Magnetic Dynamo.

capable of rotation about an axis perpendicular to the plane of the magnet. By suitable means hot air passes through these tubes, so as to raise them to redness. By a flat screen placed across this bundle of tubes, and covering half of them, access of the heated air tc these tubes is prevented. When this screen is so adjusted that its ends are equidistant from the two legs of the magnet, the bundle of tubes will not rotate, since the cooler and magnetic portions beneath the screen will be equidistant from the poles. If the screen be turned about the axis of rotation, so that one of its ends is nearer one of the poles, and the other nearer the other, then rotation of the bundle will ensue.

"The first motor constructed on this principle was heated by two small Bunsen burners, and it developed about 700 *foot pounds* a minute. A second and larger motor is now finished which will weigh about 1,500 pounds, and is expected to develop about three-horse power. In both these machines electro-magnets are used in place of permanent magnets, the current to energize them being derived from an external source. In the larger machine the air for combustion is forced through the tubes to cool them, and then is forced into the furnace at a high temperature.

"The construction of a machine of sufficient size to demonstrate the feasibility of producing continuous currents on a large scale was at once begun and has since been completed. The new machine consists of eight elements, each the equivalent of the device already described, arranged radially around a common center. The machine is placed upon the top of any suitable furnace, fed by a blast, so that the products of combustion are forced up through the armature in turn. The potential difference developed by this dynamo depends upon the number of turns of wire on the armature coils, the temperature difference in working, the rate of temperature variation, and the proximity of the maximum point of effect.

"The results thus far obtained lead to the conclusion that the economy of the production of electric energy from fuel, by the pyro-magnetic dynamo, will be at least equal to, and probably greater than any of the methods in present use. But the actual output of the dynamo would be less than that of an ordinary dynamo of the same weight. Since, however, the new dynamo will not interfere with using the excess of energy of the coal for warming the house itself, and since there is no attendance required to keep it running, it would seem to have already a large field of usefulness for it. By using the regenerative principle in connection with it great improvement may be made in its capacity."

EDISON ON STORAGE BATTERIES.

The storage battery, says Edison, is one of those peculiar things which appeal to the imagination, and no more perfect thing could be desired by stock swindlers than that very selfsame thing. In 1879 I took up that question and devised a system of placing storage batteries in houses connected to mains and charging them in the day time, to be discharged in the evening and nights to run incandescent lamps. I had the thing patented in 1879, but there is nothing in it. I rung all the changes on it. My plates were prepared like Plante's. The method of preparing them for charging is more tedious, but it is better than that of Faure, after preparation. The first storage battery was sent from France by Faure to Sir William Thompson, who was at first astounded by it. He was asked to endorse it, consented and took a retainer; but on investigation he became convinced that there was nothing in it, and returned the retainer to the French Company. The more he investigated the more he found out the fallacy of the whole business.

Scientifically the thing is all right, but commercially as absolute a failure as one can imagine. You can store it and hold it; but it is gradually lost and will all go in time. Its efficiency, after a certain number of charges have been sustained, begins to diminish, and its capacity and efficiency both diminish after a certain time in use, necessitating an increased number of batteries to maintain a constant output.

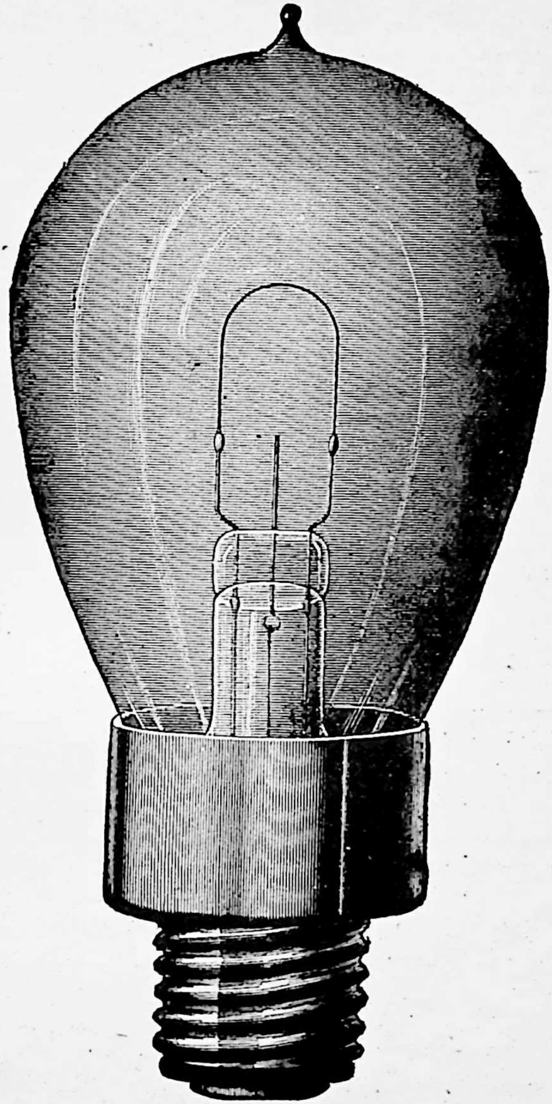
There is a natural law working against the storage battery, and that is, that finely divided lead decomposes water. It is said that when Sir William Thompson had his attention called to this fact he "threw up the sponge." All metals are fuel. When oxidized they are ashes, and it takes energy to put them back again into metalic form, when it is again fuel.

The Edison Municipal Lamp.

AN INCANDESCENT LIGHT FOR OUTSIDE ILLUMINATION.

The Municipal Lamp is an incandescent light designed for outside lighting, on streets, alleys, courts, in mines, caves, and for small towns or suburban districts, etc. It is also equally as well adapted for lighting railroad yards, platforms, tunnels and bridges. The lamps are placed on wires, somewhat similar to the arc lights, and are operated from a central station, and are therefore all lighted at the same moment, or extinguished.

The Municipal Lamp is of low resistance, with thick substantial carbon, the length of the loop determining the candle-power and the E. M. F. required. Hence as a 15-candle lamp has a carbon of the same cross-section as one of 50 candles, it requires the same current, the difference being simply in the volts absorbed. This gives a remarkable flexibility to the system, the only requisite in calculation being that the total candle-power in each of the various circuits shall conform approximately to a given standard, which standard is found by a determination of the most economical percentage of loss in the conductor in each particular instance.



The Edison Municipal Incandescent Lamp.

The lamps thus far used have required about three amperes, and have been of the same standard of efficiency as the high resistance lamps used in the three-wire system. Their life has been very long, reaching in multitudes of cases from 1,500 to 3,000 hours, with only slight blackening of the bulb before breaking. The standard of distribution for this lamp has been, 640 candles for each circuit.

A second type is made, allowing of a greater number on a wire, the current being four amperes, an increase of one-third, while the pressure per lamp is reduced somewhat in excess of that proportion, thus raising the standard of efficiency, and securing 1,000 candles on each circuit of 1,000 volts. This effects a considerable reduction in costs of conductors and station appliances in a large system, and also reduces the percentage of change in current when a lamp breaks.

It gives a clean, clear, steady and brilliant light. Lamps of various degrees of candle-power may be used on the same circuit to meet the varying requirements of locality, and should any lamp in the circuit be broken, it is so arranged that the other lamps continue to illuminate, and notice of the broken lamp is instantly given at the central station.

The standard street hood adopted for the Municipal, after a great number of experiments, has a metallic frame and top, with an inverted conical reflector of opal glass, which "lights up" in a very efficient manner. It contains a socket and cut-out of exceedingly simple construction, which, in case the safety device in the lamp itself should fail, operates to complete a shunt around the terminals, and also to maintain the continuity of the circuit when a lamp is removed, either intentionally or by accident. The method of re-adjustment when a new lamp is placed is such as to compel an inspection of the mechanism to insure continued reliability.

An ornamental form of hood is made entirely of opal shades, and is well adapted to hotel piazzas, railroad approaches, private grounds and other special locations.

An exceedingly important attachment to every Municipal hood when suspended from either an iron or wooden post or other support in the open air, is an insulator which makes it impossible for the wires, cross-arm or frame of the hood to become grounded at this point. The standard form contains a hard-rubber device, which, with a metallic coupling in which it is encased, makes a "double petticoat" insulator, capable of standing any mechanical strain which may be put upon it in practice.

When used apart from the ordinary street connection, a special socket with non-conducting shell is supplied, which also serves as a perfect cut-out for every lamp. A special flexible cord is necessary in using this system, which, as a matter of convenience and special precaution against accident, is connected at the ceiling with a simple and ornamental receptacle.

The station apparatus necessary to operate each circuit is placed on a separate base, and a number of these sections, ranged on proper supports, allowing of free access from the rear, form a compact switch-board, preventing liability of leakage, and rendering it easy to connect each circuit with any one of several dynamos.

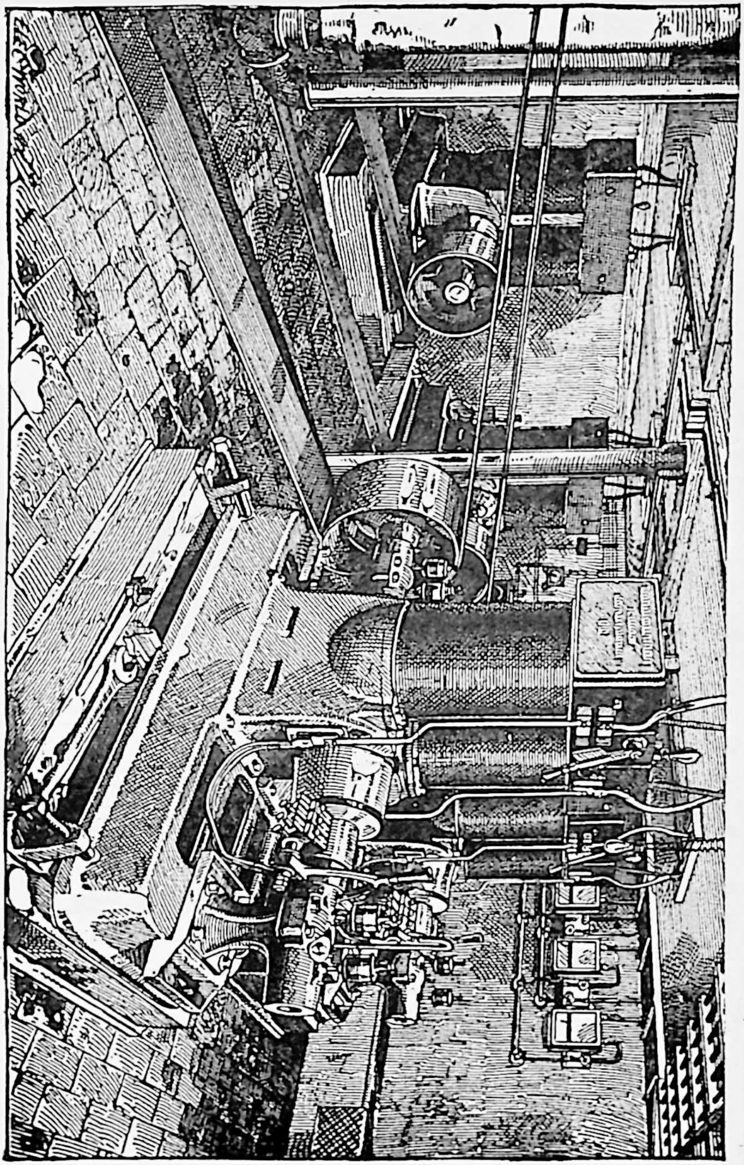
EDISON'S NEW CUT-OUT.—AN INGENIOUS MECHANISM TO PREVENT A LONG LINE OF LAMPS FROM BECOMING SUDDENLY EXTINGUISHED.

In the Edison Municipal System of incandescent lighting, incandescent lamps of low resistance are placed in series on long circuits and fed with a constant current from dynamos giving an E. M. F. as high as 1,200 volts. With the incandescent lamps in series it is evidently necessary to provide a means by which the circuit is maintained continuous in the case of a lamp giving out, and various automatic cut-outs have been designed for this purpose. After experimenting for a long time for the purpose of obtaining a device which should be absolutely certain in its action, Mr. Edison at last hit upon a very simple and ingenious arrangement which is embodied entirely with the lamp so that no external cut-out is required.

The new Municipal Lamp as now constructed, has a platinum wire extending upwards a short distance between the two sides of the carbon horse-shoe. This third wire passes down through the stem of the lamp outside of the vacuum, and is joined to fine iron wire holding a spring in tension. When the lamp breaks an arc is formed at the positive end of the carbon, and the current divides between the negative terminal and the central wire, the arc being attracted by the pointed end. The current thus diverted is sufficient to melt instantly the iron wire, thus liberating the spring under tension, which forces down a plug that short circuits the lamp, and extinguishes the arc. This novel form of cut-out is perfect in its operation and avoids all the difficulties encountered in the older forms.

THE EDISON ELECTRIC LIGHT PLANT IN THE ROOKERY BUILDING IN CHICAGO, ONE OF THE LARGEST ISOLATED PLANTS IN THE WORLD.

The new Rookery Building in Chicago, which is eleven stories in height, and is considered the largest and finest office building in the world, is lighted by the Edison system. The plant is said to be one of the largest in the country, and consists of four No. 20 Edison Dynamos, each having the capacity to operate 800, 16-candle lamps, or a total capacity of 3,200, 16-candle lamps. The building is wired for 4,000, 16-candle lamps. All the wiring of the building is concealed and has water-proof insulation. The dynamos are operated from a counter-shaft which can be driven from either one of two engines, of which one is of 50, and the other 250 horse power capacity. The engines are of the Hamilton Corliss type. The insulation of the wires of the building

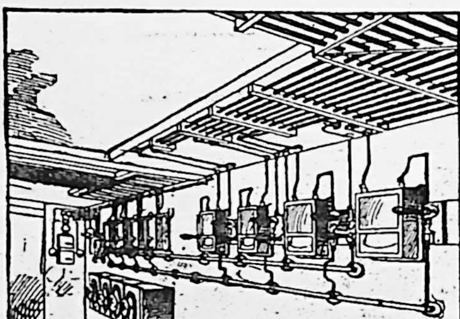


Edison Electric Light Dynamo Room in Rookery Building, Chicago.

is very high, each circuit having passed an inspection requiring an insulating resistance of one megohm.

The arrangement of the system of conductors is such that the variation of pressure does not exceed one half of one per cent throughout the entire building, which is wired on the two-wire system. An amperemeter is placed in circuit with each dynamo to show the amount of current it is supplying. The machine wires lead to a set of omnibus bars, from which are laid four feeders, upon each of which is placed an amperemeter to show the amount of current being delivered by that feeder to the system.

The device for placing different dynamos in circuit is very complete, it being impossible to notice any effect whatever upon the light or any of the instruments, or in the operation of the dynamos, where a machine is added to, or taken away from, the system. The new Edison lamps of 110 volts are used throughout the building, requiring .46 of an ampere for a 16-candle lamp. The cut-outs in the building are all made of porcelain; and are grouped at four different points on each floor in handsome cabinets built for the purpose, which are set in the walls, so that they are not in any way conspicuous. The court is lighted by several groups or bunches of lamps, consisting of from ten to thirty lights in a group, the fixtures being of a handsome design. This very large and successful electric plant was installed by Messrs. Leonard and Izard of Chicago.



Amperemeters and Regulator Boxes.

Edison's High Economy Converter System.

Mr. Edison says of this: "In systems wherein a number of converters are used, the difficulty arises that, although the whole or the greater number of the lamps supplied are in circuit and using current only during about four hours out of twenty-four, the converters themselves are using current during the whole day. There is a loss of from seven to twelve per cent., according to the construction in each converter, and this loss goes on all the time, whether all the lamps are in circuit or only a very few of them, so that the removal of lamps does not cause a corresponding reduction in the amount of current required in the system. It will be seen that this detracts enormously from the economy of the system, since, though only a few lamps may be in use, it is necessary to always keep the generation of current at a sufficient amount to supply the loss in all the converters. In some cases the current used in the converters—which of course is a dead loss to those operating the plant—will be equal in amount to that sold to the consumers. Evidently this results in a great diminuition of the profits of the business.

"I propose to remedy this by so arranging the system that only so many converters will be in circuit at any time, as are required to supply the lamps or translating devices actually in use, providing the converters, or certain of them, with switches, whereby their primary and secondary circuits may be opened or closed, as desired, and thus any desired number of the converters may be removed from, or maintained in connection with, the system, according to the amount of current required to be used at any time. I prefer to employ switches controlled from the central station, whereby any particular switch may be operated without affecting the others, though they are all controlled by the same circuit."

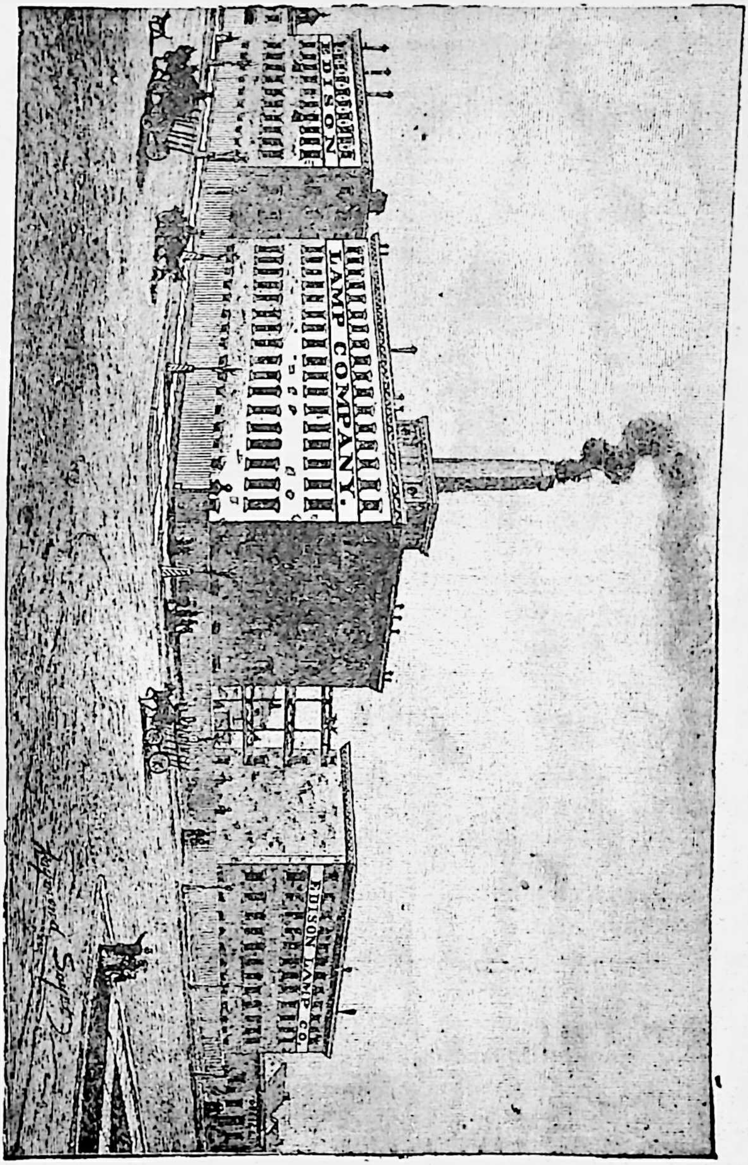
The Incandescent House Lamp.

The Edison Ho se Lamp.

There are in fact only two kinds of electric light: one known as the arc light and the other as the incandescent. The arc light is produced by an intense current of electricity through two separate carbon points. At the points where the two carbon rods come together the current of electricity passes from one point to the other and produces an arc, which might be called "pure lightning," and which consumes the carbons. This makes the intense light which dazzles the eye, and by the light of which a photograph may be taken. Davy produced the arc light in 1810, using charcoal inclosed in a vacuum. Foucault followed in 1844, using carbon from the retorts of gasworks, which is much harder and less easily consumed. As early as 1844–45 the Place de la Concorde, Paris, was lighted by an arc light fitted up by Delenil. In 1858 Jobart proposed to make use of small carbon in a vacuum, and in the same year F. Moleyns, of Cheltenham, patented his lamp, and in 1859 Dumoncel experimented with carbon filaments of cork, sheepskin, etc.

The incandescent light is produced by a current of electricity passing through a filament of carbon, in a vacuum, and the carbon is heated to a white heat which gives out the light. These carbon filaments will endure for months, but in fact, they are slowly consumed, and like the arc lights, are replenished.

Edison's first incandescent light was made by using fine platinum wire. He now uses bamboo fibre, which is first by machinery divided into fibres of about one millimeter in diameter and twelve centimeters in length.



The Edison Lamp Company's Factory, Newark, N.J.

Edison Building, Chicago.

LOCATION OF THE EDISON ELECTRIC LIGHT PLANT.

The electrical plant in the Edison Building, Chicago, on Adams, near LaSalle Street, was planned and supervised by W. S. Andrews, who has made it as perfect as the present stage of this business will admit. It is known as the "Central Station." The full capacity is thirty-six dynamos, which can operate about 50,000 lamps of sixteen candle-power each, aggregating 800,000 candles. The electric current was turned on the underground conductors, August 6, 1888, and thousands of bright lights in the many stores, offices and other places, attest its great success.

The ground floor is devoted to the company's offices, store-rooms, and a very capacious boiler and engine department. The second floor contains the dynamos, located over the engine room, additional boilers, and the motors, situated over the offices. On the west side of this floor are the feeder equalizers, ampere-meters, pressure indicators, safety-catches and main conductors, all of which occupy the entire length of the room, 103 feet. The Chicago Edison Company sell electricity to the public through the meter, so that each consumer pays only for what he actually uses. This electricity may also be used for power, as well as light. In this way great steam-engines, representing almost unlimited ability, generate, by the aid of the dynamos in a local plant, a prodigious volume of electricity, which, through underground conductors, becomes, for miles in every direction, available for illumination and power.

Thus has Mr. Edison demonstrated his assertions made four years ago under the caption "The Commercial Evolution of Electricity," and which excited much criticism at the time, that "Two years' experience proves, beyond a doubt, that the electric light, for household purposes, can be produced and sold in competition with gas."

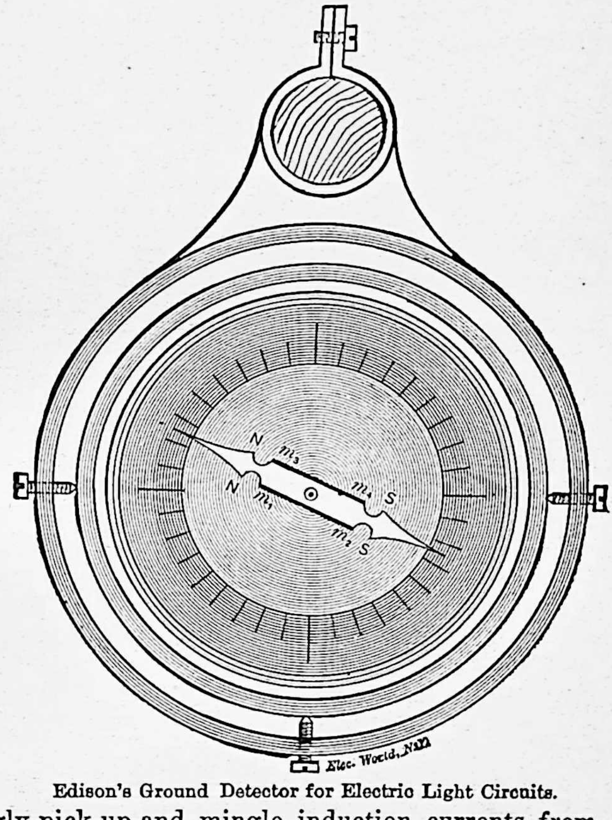
EDISON BUILDING.

Edison's Ground Detector For Electric Light Circuits.

A MECHANISM FOR LOCATING THE "BREAK" IN AN UNDERGROUND WIRE.

The object of this mechanism is to determine the exact location of any defect or break in an underground wire, carrying or intended to carry an electric current. The difficulty of locating the position of a "ground" in electric light circuits varies directly, other things being equal, with the weight or cross-section of the main. In other words, an error in the determination, which would represent a displacement of the "ground" from the true position to the extent of 10 feet in mains whose sectional area is 5,000 circular *mils*, would, under similar circumstances, induce an error of 200 feet in mains of 100,000 circular *mils* cross section. It consequently follows that in most cases of grounds in mains of considerable size the location of the fault cannot be carried out practically to anything approaching the degree of accuracy that it would be desirous to attain.

Thus while a localization to the limit of one hundredth of an *ohm* accuracy generally requires considerable time, care, experience and calculation, such an error would involve a displacement of 100 feet in mains of 100,000, and of 200 feet in mains of 200,000 circular *mils* section. The consequence is that in all such cases the slow process of digging and disconnection has to be resorted to, first by ascertaining between which pair of safety catch boxes the ground lies, then by sinking a hole in that half-section, next in the quarter-section, and so on until the final tube is arrived at. Much time and labor would, therefore, be saved if some practical method could be devised of detecting directly from the surface-level the position of the fault in the wire. The telephone has been tried, and is still sometimes employed in connection with an induction coil carried over the pipe line while the current from a few cells of battery is passed through the mains of that section; but the success attained by this method has not been very great, partly from the great delicacy of the telephone, which is liable to con-



Edison's Ground Detector for Electric Light Circuits.

fusingly pick up and mingle induction currents from other neighboring conductors, and partly from other causes.

With the object of solving the problem more satisfactorily, Mr. Edison instituted at his laboratory, experiments which have resulted in the use of a device which materially economizes the time and labor expended in the subdividing sectional process. The principal employed has been nothing more than the deflection of an ordinary magnetic needle by the magnetic force of a current passing beneath it. The extent to which this principle can be adopted—that is to say, the limit of the ground resistance, which can, under ordinary circumstances, be so detected from the street above, is easily capable of estimation.

Experiment seems to show that the iron pipe enclosing the main does not reduce the deflection produced by the current to any serious extent. Consequently it might be expected if a compass needle were carried above the surface over the mains and a periodic current of seven or more amperes were sent regularly through the grounded main, free at the distant end, then the deflection of the needle from its position of rest (under weak artificial control) parallel to the pipes, would serve to indicate that the ground was still ahead of the observer; while the cessation of the current would indicate that the ground had been passed and that the current had left the main.

Mr. Edison's instrument for thus detecting the location of the fault, and which he calls his "Ground Detector," consists of a compass box swung on gimbals containing two light, strongly magnetized needles, *m* 1, *m* 2, *m* 3, *m* 4, as shown in the figure, rigidly connected by a thin aluminium strip that also serves as a pointer over a graduated dial. By this means the moment of inertia of the needles and pointer is small and its movements are quick. The whole is clamped at the lower end of a stick held in the hand. A small controlling magnet to bring the needle parallel to the line of tubes has generally to be carried on a clamp above the needle or laid on the ground near to it.

Edison's Method of Regulating the Current.

In regulating the current of electricity that goes out from a generating station to light up this or that street, block, etc., Mr. Edison's method consists in interposing in the shunt circuit, in which the field magnets are placed, an adjustable resistance. When the number of lamps in the circuit is increased, resistance is thrown out of the field circuit. Similarly, when the speed increases, resistance is thrown into the field circuit, and taken out when this diminishes. The electro motive force can thus be kept practically constant, whatever the changes may be in the working circuit. At central stations, the shifting of these resistances is done by hand, but their manipulation is effected automatically in separate plants of moderate size, such as those designed for lighting workshops, large buildings, etc. The difficulties of an automatic regulation of very large plants, such as those operated from a central station, are considerable, and Mr. Edison has always preferred to have a mode of regulation as free as possible from mishaps.

This field resistance is varied in accordance with the indications of a galvanometer placed in a Wheatstone bridge. An incandescent lamp is placed on one side of the bridge and the variable resistance of the bridge adjusted so that the galvanometer needle stands at zero, when the lamp is giving its natural light. As the resistance of the incandescent carbon filament varies with its temperature, any change in the current following through the lamps, will immediately destroy the balance of the bridge and cause the needle to move in one direction or the other, according as the lamp rises or falls in candle-power. Resistance is then introduced into, or thrown out of the field circuit until the needle returns to its natural position. These resistances, which consist of coils of German-silver wire, are readily manipulated by the attendant by means of a switch.

It might be supposed that this duty on the part of the attendant would require constant watchfulness, but this is far from being the case.

In any extensive distribution of the electric light, the variation in the demand for current is a calculable one, and the greater the number of consumers, the more easily the amount and time of these variations can be foreseen.

The Edison Meters.

The Edison Meter has two cells, the indications of one serving as a check upon the other, in both of which are zincs, which are in the circuit, and, consequently, gradually consumed. Only a fraction of the current passes through, and the consumption of the zinc is small. These plates are weighed statedly, and from this weight the amount of electricity consumed is reckoned. As the resistance of the cell varies with its temperature, it is kept constant by a lamp automatically lit or extinguished, as the temperature falls or rises. This is done by an expansion bar closing and breaking the circuit of the lamp.

In Edison's automatic registering meter, there are two cells placed side by side, constructed so that the cell itself forms one plate, the other being hung in the liquid from the same scale beam. The electrical connections are so that the current goes from the plate forming the jar to that suspended plate, which is raised in one cell, and from the lowered suspended plate to the enclosing jar in the other cell. The raised plate is consequently gaining in weight and the lowered, losing. When the raised plate becomes the heavier of the two, it descends, and the current is reversed. There is, therefore, a successive gain and loss of weight by the suspended plates, which causes the scale beam to periodically oscillate, each movement of which acts upon a registering apparatus, resembling the dial of a gas-meter. The dial shows, not the amount of electricity in electrical measure, but the equivalent of the amount of gas necessary to give the light furnished.

Edison Junction Box and Safety Catch.

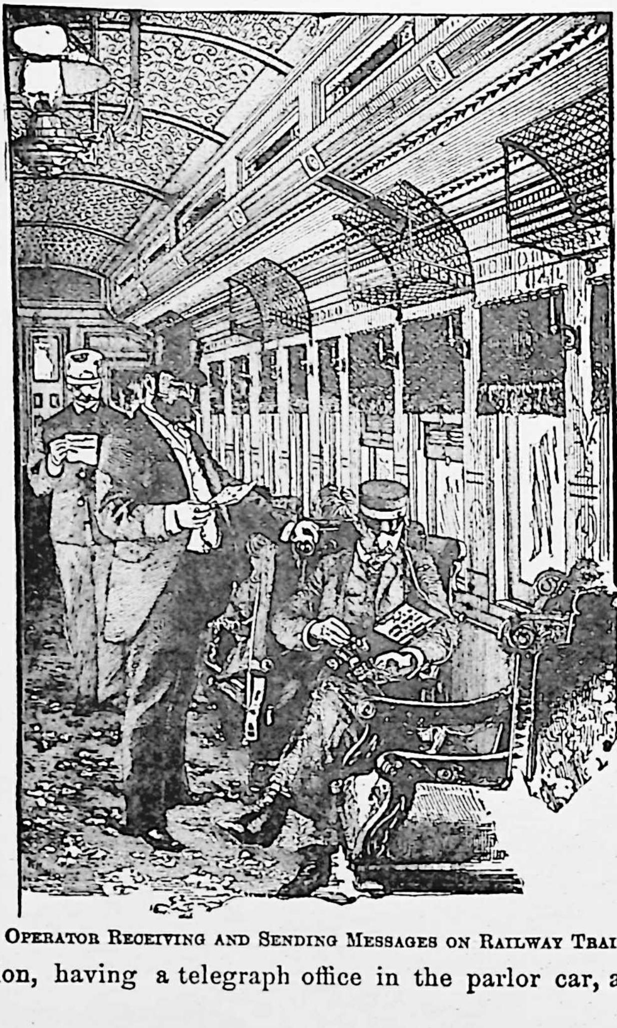
In large cities the mains, in which are the copper insulated wires, are laid about two feet under the ground, and are arranged so that they form a net-work throughout the whole district, constituting, in fact, a gigantic sieve, of which the blocks are the meshes, and these are joined together at the corners by means of Junction Boxes. The main junction boxes are constructed by means of curved metal arms, adapted for expansion and contraction. Similar, though smaller, boxes serve for the connection of house conductors with the mains. In these two boxes a wire is interposed in the branch circuit which constitutes the safety-catch, and which is made of fusible metal, designed to cut off the current, if by accident it should become too strong to injure the lamps, or to cause, in the conducting wires, a dangerous heating. These boxes also enable the circuit, in case of accident, to be interrupted at the necessary point, so as to isolate parts of the circuit that may be inaccessible, while the remainder is still supplied.

The interior conductor for houses is made of copper wires wrapped in a casing of cotton rendered incombustible, and if desirable, may be covered with silk. In the path of these wires, Mr. Edison also places little safety-plates, thus multiplying his usual precautions so that a fire is not possible through any irregularity of current.

Train Telegraphy.

HOW A TELEGRAM MAY BE SENT OR RECEIVED FROM A RAPIDLY MOVING TRAIN.

The system of telegraphing on the train while in rapid



OPERATOR RECEIVING AND SENDING MESSAGES ON RAILWAY TRAIN.

motion, having a telegraph office in the parlor car, and all over the world, is due to Mr. Edison. In the first equipment—on the Lehigh Valley Railroad—the inductive receiver on the car consisted of a coil of many turns of wire wound round the car, and the line conductor was an insulated wire laid along the track. While this system left little to be desired, it involved some expense which is avoided by the method used at present.

This consists in the employment of the roof of the car, where such is available, as a static receiver, and the line is an ordinary wire strung upon short poles near the track. The roof of the car, by the present system, is in most cases, available, and a car can be equipped ready for work in a remarkably short time. All that is necessary is the attach-

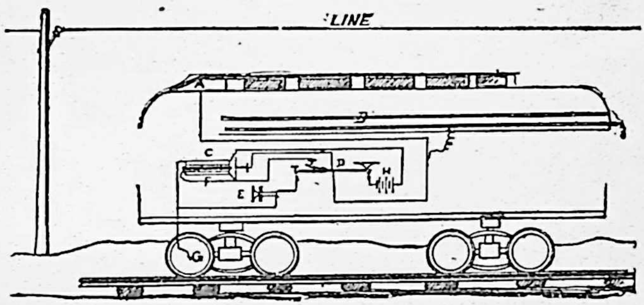


FIG. 33. SHOWING SYSTEM OF TELEGRAPHY FROM A CAR WHILE THE TRAIN IS IN RAPID MOTION.

ment of a wire to the roof, another to the swivel plate of a car track for a ground, and the insertion of the instruments in the circuits thus formed. A short pole telegraph line extends along side of the railroad track at a distance of eight or ten feet, the poles being much smaller than the ordinary telegraph poles and from ten to sixteen feet high. At their top is placed an ordinary porcelain insulator, strung upon which is a single galvanized telegraph wire. Whenever practicable, the metal roof of the car is employed as the inductive receiver of the car, but where no metal roof exists an iron or brass rod or tube, half an inch in diameter, is employed, placed under the lines of the car. From the roof the wire passes to the instruments, and then to the wheels of the car.

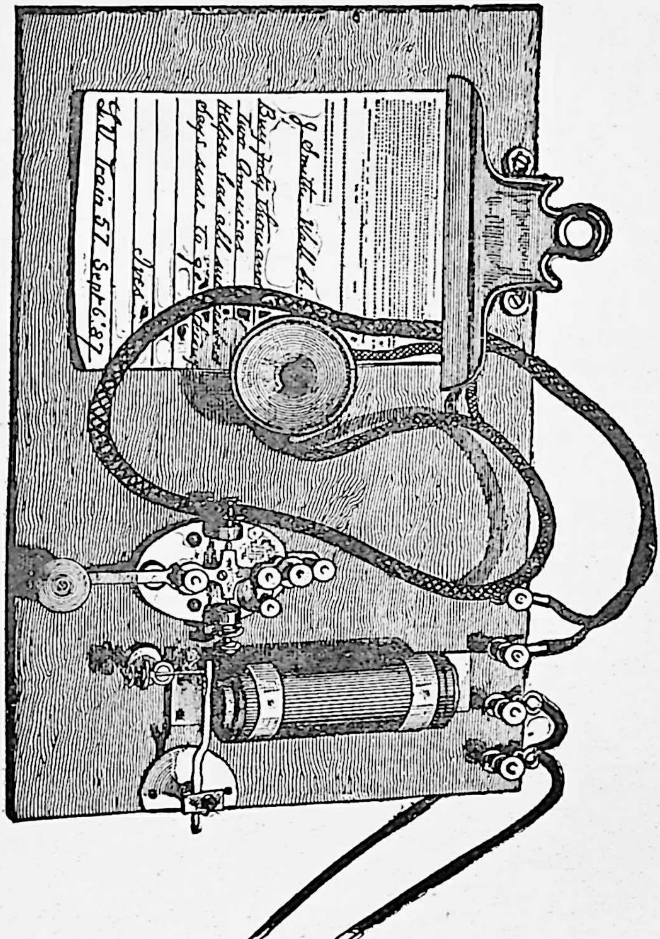
The diagram, Fig. 33, shows the arrangement. The roof A or bar B are connected to the secondary C of an induction coil The primary of the coil is connected to the front contacts of the double pointed key D, in which is also included the battery H, and a buzzer arrangement opposite the core of the coil, for transmitting a series of impulses to the line whenever it is closed. When the key is upon the front contact also, the extra contact shown at the top of the key closes the secondary circuit and allows the charges to be sent into the roof. When the key is on its back contact, both its secondary and primary coils are cut out, the charge from the roof passing by the wire directly to the key and thence through the telephone to the earth."

The operator's equipment is quite simple, and consists merely of a small tablet to which the key, the coil and the buzzer are attached, and just with sufficient top surface to hold a telegraph blank conveniently.

The battery employed is enclosed in a box and can be placed beside the operator, if it is desired. The operator is supported by head gear as shown in figure. A battery of twelve small cells is employed in circuit with the primary of the induction coil, although it is said that two cells can do the work. The primary and secondary of the induction coil are respectively about 35 and 250 *ohms*.

The arrangement at the terminal station, so far as the induction circuits and instruments are concerned, is indentical with that on the car; but in addition there is supplied a

Morse arrangement by means of which the line can be used



OPERATOR'S TRAIN TELEGRAPHING APPARATUS.

for the transmission of ordinary Morse business. The circuit is made continuous for the induction system by means of a condenser which transmits the impulses when the Morse key is open.

On a trial trip on the Lehigh Valley Railroad a large number of messages were sent and received without the slightest delay of any kind. One of the striking demonstrations of the wide application of the system was the sending of a dispatch, on this occasion, from the rapidly moving train, to John Pender, of London, England, *via* the Atlantic Cable.

The Edison Mimeograph.

The Mimeograph, invented and carefully perfected by Mr. Edison, is an ingenious apparatus for duplicating, or manifolding letters, circulars, etc., without any trouble, and with rapidity. Three thousand copies may be made from one writing or stencil, no previous practice being required. The manner of making the stencil or first writing is very simple. A sheet of thin, sensitive paper is laid over a finely grooved steel plate, the corrugations of which are so close as to be nearly imperceptible. The writing on the stencil sheet is done with a smooth steel stylus, which is about the size of a well-sharpened lead pencil. The paper is perforated from the under side, leaving the stylus free to roam at the will of the writer; the corrugation on the plate affording just enough resistance to the stylus to prevent slipping and make the writing easy and natural. After the stencil is completed it is placed in a suitable frame and copies made to any number desired by passing an ink roller over the surface—a process so well-known as to need no further explanation. In this way music, sketching, mechanical drawings, maps, architectural drawings, and in fact, anything that can be done with a lead pencil, can be done by the mimeograph process.

Edison's Improved Phonoplex.

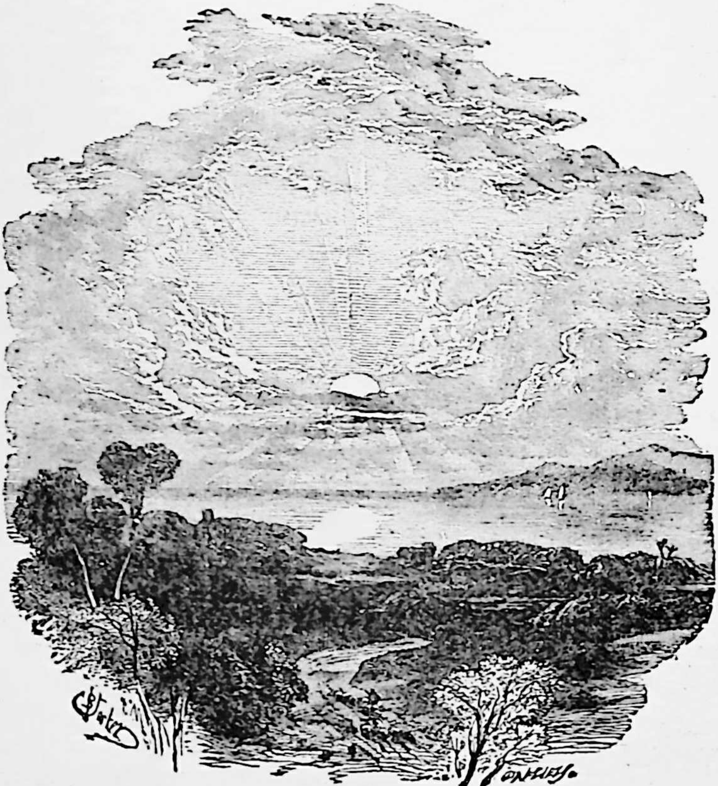
In the Edison duplex or "Phonoplex" now in use, the difficulties of duplexing to intermediate or way stations is overcome by adding to the ordinary Morse instruments another which responds to rapid induction impulses, such as those given by a spark or induction coil. The system has been still further improved by Mr. Edison, so that it may now be used as a triplex, or equivalent to three independent circuits. This is accomplished by adding to the apparatus just described, a second form of induction apparatus; but instead of transmitting and receiving Morse's signals by simple induction impulses of considerable strength, as does the simple induction apparatus, this third apparatus employs rapidly occurring induction waves or vibrations which form a musical note, this note being transmitted into dots and dashes for producing Morse's harmonic signals, and thus the "Phonoplex" system becomes a success.

The Sea Telephone.

HOW SHIPS MAY TALK ON THE OCEAN.

Mr. Edison, who has expended over $2,000,000 in experiments, is wide-awake to the possibility of inter-ship communication at sea. His experiments on this device have been confined mainly on the waters of the Caloosahatchie, where he has succeeded in conveying intelligible messages a distance of one mile. The principle on which he will endeavor to perfect this instrument is the remarkable facility afforded by water for the transmission of sound. Divers in the ocean have heard the swash of a steamer's wheels when fifteen miles away, and Mr Edison believes he can transmit his messages from ship to ship a distance of at least seven miles.

He proposes, after he has perfected his apparatus, to have the large ocean steamers equipped with a steam-whistle



The Sea.

device, worked by keys somewhat similar to a telegraph instrument, and transmitters after the telephone fashion. Under the water-line of each steamer will be a sounder connected with the captain's cabin by a thin transmitting wire running through a tube. When the captain of one vessel wants to signal another he will sit down at his key-board, turn the steam on his whistle, manipulate the keys, and send his message out into the waves that break against the sounder. This sound will pass unbroken from wave to wave until it runs up against the sounder of any vessel that may be within reach of the volume of sound.

As soon as the sound waves strike the sound of the hull of the vessel within reach, the message will run over the electric wire to the captain's cabin, where it will ring an electric bell. An attendant will then take down the message as it comes from the water, by means of keys.

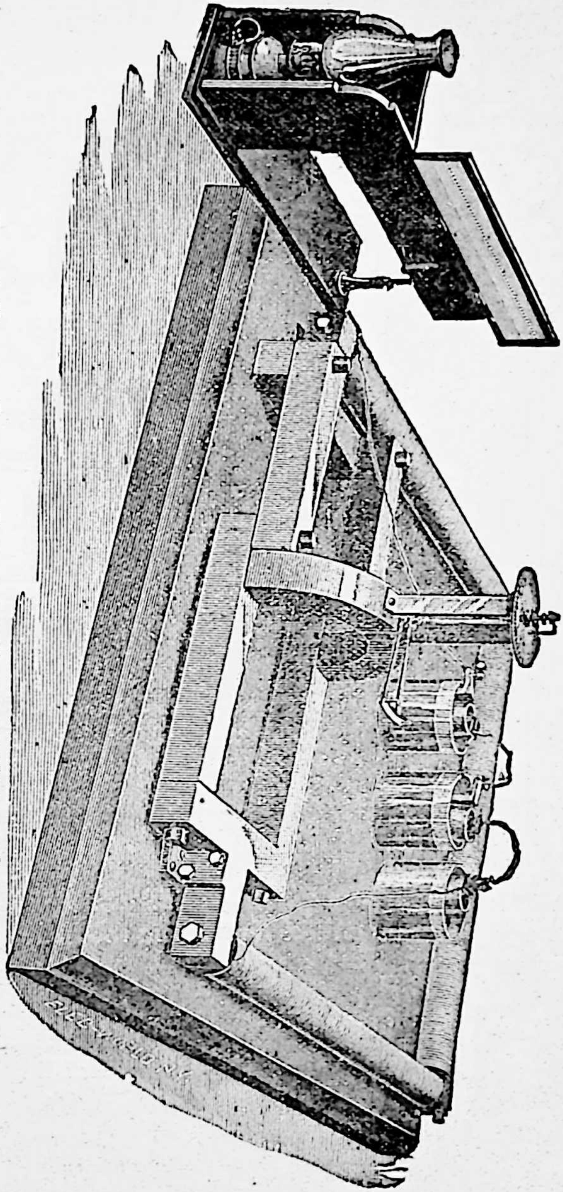
After the message has been received the captain can swing his vessel around and continue the message through seven miles more of water in the same direction until it strikes another vessel, when the operation may be again repeated until the breadth of the ocean space has been crossed.

The Edison Bridge for Measuring Magnetic Conductivity.

"Perhaps no electric measuring instrument," says Mr. Edison, "has proved more useful in practice, especially if we consider the various forms which it has assumed, than the device contrived by Christie, and commonly known as 'Wheatstone's Bridge'. It was with a belief that a similar instrument could be constructed which should perform the same service for magnetic measurements that the experiments were made, the results of which I have the honor now to present.

"The Wheatstone Bridge is based upon the fact that if two points of different electric potentials are united by two conducting paths, the fall of potentials along these paths is absolutely the same, provided, that these paths are absolutely alike electrically. Consequently, if two points equidistant from the place of higher potential be connected together, no current will flow through the connecting wire. So by analogy, if two points be maintained at a constant difference of magnetic potential the fall of potentials from one to the other, through two or more paths, will be absolutely uniform in all, provided these paths be magnetically identical. Hence, at any points equidistant from a given terminal the magnetic potential is the same, and these points could be without differential action upon a magnetic pole.

"The magnetic bridge may be constructed in the form of a rhomb, the typical form of the Wheatstone Bridge. For this purpose the four sides are made of the purest Norway iron, as soft as possible and thoroughly annealed. To the acute angles of the rhomb are connected the two poles of a long U-shaped electro-magnet, whose function is to develop the desired magnetic potential difference at these points. Connected to the two obtuse angles and projecting inward are two bars of Norway iron, similar in section to those



EDISON'S MAGNETIC BRIDGE, OR BALANCE FOR MEASURING MAGNETIC CONDUCTIVITY.

forming the sides. Their inner ends, which are hollowed out, approach to within about a half inch of each other. Between these ends a stirrup is suspended by means of a silk fibre, which stirrup carries a short needle, consisting of a thin tube of hardened steel, well magnetized. To the stirrup is attached either a pointer moving over a graduated arc, or better, a mirror, by means of which the defection can be read in the usual way with a lampstand and scale.

"In the instrument now in use in my laboratory, the magnetic bridge is in the form of a rectangle, as shown in the engraving, the ends or poles of the electro-magnet being connected to the middle of the short sides, while the bars which pass inward to the needle are joined to the middle of the longer sides. The four halves of these longer sides constitute the sides of the bridge. The two at one end of the rectangle are fixed, the two at the other end are movable. The two bars which pass inward to the needle are curved so as to form a semicircle standing above the plane of the rectangle. The needle itself is similar in construction to that above described, but is suspended by a wire attached to a torsion head.

"It will be readily seen that when the electro-magnet is charged, a constant difference of magnetic potential is maintained at the two ends of the rectangle, so that if the four bars constituting the sides of the bridge are magnetically identical, there will be no difference of magnetic potential between the ends of the bars which pass to the needle, and hence there will be no deflection. But if one of the movable bars be loosened, the needle is at once deflected, and in a direction depending upon the side the bar occupies. If the bar is entirely removed the deflection is a maximum, of course. And if it be replaced by another bar differing in cross-section, in quality of iron or any other way which affects the magnetic conductivity through the bridge, the deflection shows at once the amount of difference between that bar and the original one taken as a standard. The instrument is extraordinarily delicate, and the principal difficulties encountered in using it have arisen in the attempt to preserve this delicacy, while, at the same time, the range of the apparatus is maintained.

"The magnetic bridge was devised for the purpose of testing readily the quality of the iron purchased for the construction of dynamos. Very great variations are observed in irons supposed, commercially, to be of the same quality. Consequently the potential difference developed by a dynamo having field cores of such iron can never be exactly calculated. But by comparing the iron which is to be thus used in the magnetic bridge, its exact value for dynamo purposes may be determined, and the constants of the generator thus accurately calculated in advance.

"But this bridge, it would seem, will be equally useful for testing iron and steel for other purposes. By its means not only may the character and quality of the metal be ascertained in terms of any desired standard, but flaws in the interior of a bar, such as a car axle, may be discovered at once.

"Constructed with sufficient care and attention to details, the magnetic bridge may, without doubt, be made a most valuable instrument of precision for the furtherance of scientific research. The theory of its action is extremely simple, and it is the exact counterpart of an ordinary Wheatstone Bridge, constructed for measuring low resistance and immersed in salt water, since now whatever is true electrically of the one is true magnetically of the other. Not only may the laws of magnetic conductivity be investigated by means of this balance for all paramagnetic and diamagnetic bodies, but the variation of this conductivity under the action of various physical agencies, such as heat, pressure, strain, etc., may be determined."

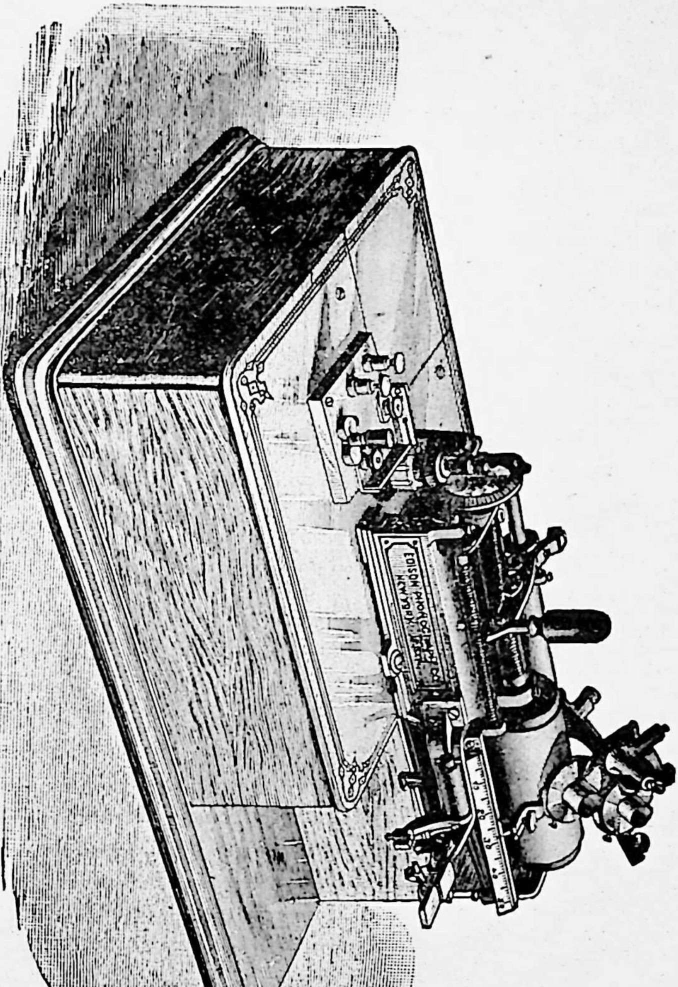
Edison's New Phonograph.

AN INSTRUMENT THAT IS ONE OF THE WONDERS OF THE WORLD FULLY EXPLAINED IN EDISON'S OWN WORDS.
ITS GREAT FUTURE.

The phonograph, as first completed by Mr. Edison in 1878, is fully explained elsewhere in this volume, with illustrations and extended remarks, as may be seen on pages 75 and 94, inclusive. The essential principles of this old instrument have been preserved in the new one, and so many additional valuable improvements have been made, that the newly perfected phonograph is now one of the genuine wonders of the world. In a recent statement in the *North American Review*, Mr. Edison has given us a very interesting account of both the old and new phonograph, from which we make the following extracts that fully explain, in Mr. Edison's own language, the new phonograph.

"Since the time of Lucretius, the movements of atoms have been invested with an intense interest for philosophers and scientific students, and the wave-motions of light, heat and sound have engaged, with a constantly increasing degree of importance, the attention of modern investigators. When we consider the relation of these motions to mathematics and to music, the conception of Pythagoras that number and harmony constituted the principle of Universe does not seem to be very far out of the way.

"In the phonograph we find an illustration of the truth that human speech is governed by the laws of number, harmony and rhythm. And by means of these laws, we are able to register all sorts of sound and all articulate utterance—even to the slightest shades and variations of the voice—in lines or dots which are an absolute equivalent for the emission of sound by the lips; so that, through this contrivance, we can cause these lines and dots to give forth again the voice, of music, and



EDISON'S NEW AND PERFECTED PHONOGRAPH.

all other sounds recorded by them, whether audible or *inaudible*. For it is a very extraordinary fact that, while the deepest tone that our ears are capable of recognizing is one containing 16 vibrations of sound a second, the phonograph will record 10 vibrations or less, and can then raise the pitch until we hear a reproduction from them. Similarly, vibrations above the highest rate audible to the ear can be recorded on the phonograph and then reproduced by lowering the pitch, until we actually hear the record of those inaudible pulsations.

"To make the general idea of the recording of sound more clear, let me remark one or two points. We have all been struck by the precision with which even the faintest seawaves impress upon the surface of a beach the fine, sinuous line which is formed by the rippling edge of their advance. Almost as familiar is the fact that grains of sand sprinkled on a smooth surface of glass or wood, on or near a piano, sift themselves into various lines and curves according to vibrations of the melody played on the piano-keys. These things indicate how easily the particles of solid matter may receive an imparted motion, or take an impression, from delicate liquid waves, air waves, or waves of sound. Yet, well known though these phenomena are, they apparently never suggested, until within a few years, that the sound-waves set going by a human voice might be so directed as to trace an impression upon some solid substance, with a nicety equal to that in the tide in recording its flow upon a sand beach.

"My own discovery that this could be done came to me almost accidentally while I was busy with experiments having a different object in view. I was engaged upon a machine intended to repeat Morse characters, which were recorded on paper by indentations that transferred their message to another circuit automatically, when passed under a tracing-point connecting with a circuit-closing apparatus. In manipulating this machine I found that when the cylinder carrying the indented paper was turned with great swiftness, it gave off a humming noise from the indentations—a musical, rhythmic sound, resembling that of human talk heard indistinctly.

"This led me to try fitting a diaphragm to the machine, which would receive the vibrations or sound-waves made by my voice when I talked to it, and register these vibrations upon an impressible material placed on the cylinder. The material selected for immediate use was paraffined paper, and the results obtained were excellent. The indentations on the cylinder, when rapidly revolved, caused a repetition of the original vibrations to reach the ear through a recorder, just as if the machine itself were speaking. I saw at once that the problem of registering human speech, so that it could be repeated by mechanical means as often as might be desired, was solved.

"It may be of interest, here, to contrast briefly the perfected phonograph with the mere exhibition models shown all over the world, in 1878. Those models were large, heavy machines which purposely sacrificed distinctness of articulation, in order to secure a loud tone which could be heard in a large room when emitted through a funnel-shaped transmitter. Tin-foil was used as the material on which the indentations were to be made. The cylinders were revolved by hand, or by clock-work; and there were numerous other details of construction which differed from those of the instrument as now completed. At that time I had made various designs for a special kind of electric motor, differing from all others, to run the machine, in place of clock-work; and the phonograph, as we now manufacture it, is provided with such a motor, which turns the cylinder noiselessly, uniformly and easily.

"Instead of tin-foil, I now use a cylinder of wax fo receiving the record of sound-pulsations, as in the original experiments. One diaphragm (the 'recorder') receives these pulsations, which are incised on the wax, in exceedingly fine lines, hardly visible to the naked eye, by means of a small point pressing against the wax. A turning-tool attachment, near this recording diaphragm, pares off the surface of the wax, removing any record which may previously have been left there, and smoothing the way for whatever you wish to speak into the 'recorder.' When you have finished speaking, two simple motions bring the reproducing diaphragm into place directly over the wax; and this diaphragm, provided with a very delicate but durable needle, takes up and reproduces the vibrations registered in the fine lines of indentations, bringing them to the ear by means of a tube.

"Sometimes, indeed, one can hear the recorded words as they are thrown off by the needle from the revolving cylinder, without using a tube at all, and by simply putting the ear close to the wax. The adjustments of these receiving and transmitting diaphragms, known as the 'recorder' and the 'reproducer,' are very exact, but very easily arranged. And a machine, once adjusted after being set up, will run well with very little attention or re-adjustment for a long period of time. The battery, also, conveniently placed in a box under the desk which holds the instrument, will last for six weeks or more, according to use, without renewal. A scale and indicator running the whole length of the cylinder, in front, enable you to observe at what point you began talking so that the reproducer may be set at that point on the wax as soon as you wish to take off the record."

Another very handy attachment supplies a key for suspending the reproduction of sounds when it is going on too rapidly for the copyist, who is writing it out. A second key when pressed down will run the reproducer back so as to repeat anything which has not been clearly understood, and this may be done any desired number of times. A single wax cylinder, or blank, may be used for fifteen or twenty successive records before it is worn out. But if the record is to be kept, the wax blank must not be talked upon again, and is simply slipped off from the metal cylinder and filed away for future reference. It may be fitted on to the cylinder again at any time, and will at once utter whatever has been registered on it. One of these wax blanks will repeat its contents thousands of times with undiminished clearness. Further, we are able to multiply to any extent, at slight cost, phonographic copies of the blank, after the talking, or music, or other sounds, have been put upon it once.

It is curious to reflect that the Assyrians and the Babylonians, 2,500 years ago, chose baked clay cylinders, inscribed with cunei-form characters, as their medium for perpetuating records; while this recent result of modern science, the phonograph, uses cylinders of wax for a similar purpose, but with the great and progressive difference that our wax cylinders speak for themselves, and will not have to wait dumbly for centuries to be deciphered, like the famous Kileh-Shergat cylinder, by a Rawlinson or a Layard. With our facilities, a sovereign, a statesman, or a historian, can inscribe his words on a phonograph blank, which will then be multiplied a thousand-fold; each multiple copy will repeat the sounds of his voice thousands of times; and so, by reserving the copies and using them in relays, his utterance can be transmitted to posterity, centuries afterwards, as freshly and forcible as if those later generations heard his living accents.

Instrumental and vocal music—solos, duets, quartets, quintets, etc., can be recorded on the perfected phonograph with startling completeness and precision. How interesting it will be to future generations to learn from the phonograph exactly how Rubinstein played a composition on the piano; and what a priceless possession it would have been to us could we have Gen. Grant's memorable words, "Let us have peace," inscribed on the phonograph for perpetual reproduct-on in his own intonations! We are in a position to obtain results of this sort by the present phonograph, from the wave-motions of sound; so that it seems to me we realize here the "poetry of motion" in a new sense, combined with the *science* of motion.

In my article ten years ago, I enumerated among the uses to which the phonograph would be applied: 1. Letter writing and all kinds of dictation without the aid of a stenographer. 2. Phonographic books, which would speak to blind people without effort on their part. 3. The teaching of elocution. 4. Reproduction of music. 5. The "Family Record"—a registry of sayings, reminiscences, etc., by members of a family, in their own voices, and of the last words of dying persons. 6. Music boxes and toys. 7. Clocks that should announce in articulate speech the time for going home, going to meals, etc. 8. The perservation of languages, by exact reproduction of the manner of pronouncing. 9. Educational purposes; such as preserving the explanations made by a teacher, so that the pupil can refer to them at any moment, and spelling or other lessons placed upon the phonograph for convenience in committing to memory. 10. Connection with the telephone, so as to make that invention an auxiliary in the transmission of per manent and invaluable records, instead of being the recipient of momentary and fleeting communications.

Every one of these uses the perfected phonograph is now ready to carry out. I may add that, through the facility with which it stores up and reproduces music of all sort, or whistling and recitations, it can be employed to furnish constant amusement to invalids, or to social assemblies, at receptions, dinners, etc. Any one sitting in his room alone may order an assorted supply of wax cylinders inscribed with songs, poems, piano or violin music, short stories or anecdotes or dialect pieces, and, by putting them on his phonograph, he can listen to them as originally sung or recited by authors, vocalists and actors, or elocutionists. The variety of entertainment he thus commands, at trifling expense and without moving from his chair, is practically unlimited. Music by a band, in fact, whole operas, can be stored up on the cylinders, and the voice of Patti singing in England can thus be heard again on this side of the ocean, or preserved for future generations.

On four cylinders eight inches long, with a diameter of five, I can put the whole of "Nicholas Nickleby" in phonogram form. In teaching the correct pronunciation of English, and especially of foreign languages, the phonograph as it stands seems to be beyond comparison, for no system of phonetic spelling can convey to the pupil the pronunciation of a good English, French, German or Spanish speaker so well as a machine that reproduces his utterances even more exactly than a human imitator could.

The speeches of orators, the discourses of clergymen, can be had "on tap" in every house that owns a phonograph. It would not be very surprising if, a few years hence, phonographic newspaper bulletins should be issued on wax cylinders. Even now, so soon as the phonograph comes into general use, newspaper reporters and correspondents can talk their matter into the phonograph, either in the editorial office or at some distant point, by a telephone wire connected with a phonograph in the composing-room, so that the communication may be set up in type without any preliminary of writing it out in long hand.

The wax cylinders can be sent through the mails in little boxes which I have prepared for that purpose, and then put upon another phonograph at a distant point, to be listened to by a friend or business correspondent. To obviate the difficulty caused by the friend's not having a phonograph of his own, pay stations will be established, to which any one may take the phonogram that he has received, have it placed on the instrument, and the contents recited to him from the machine, as well as copied out at the same moment by a type-writer. Thus the phonograph will be at the service of every one who can command a few cents for the fee. And which of us would not rather pay something extra in order to hear a dear friend's or relative's voice speaking to us from the other side of the earth?

Authors can register their fleeting ideas and brief notes on the phonograph at any hour of day or night, without waiting to find pen, ink, or paper, and in much less time than it would take to write out even the shortest memoranda. They can also publish their novels or essays exclusively in phonogram form, so as to talk to their readers personally; and in this way they can protect their works from being stolen by means of defective copyright laws. Musical composers, in improvising compositions, will be able to have them recorded instantaneously on the phonograph.

For the present it has been decided to make all the phonographs of uniform size; so that a record put upon the machine in New York may be placed on another machine of the same pattern in China, and speak exactly as it was spoken to on this continent. Each wax blank will receive from 800 to 1,000 words; and, of course, several blanks may be used for one document, if needed. This uniform size and pattern make the thing perfectly practicable in offices which have business connections all over the globe. My private secretary to-day speaks all letters into a phonograph, from which they are taken off by a type-writer or ordinary long-hand-writer, with an immense saving of time and trouble. Persons having a large correspondence can talk all their letters into the phonograph in a very short time, and leave them to be listened to and copied by an assistant, without the delay involved in stenography or the trouble of going over and correcting the copyist's work, which is almost inevitable under the conditions of dictation now prevailing.

Furthermore, two business men, conferring together, can talk into the recorder by means of a double transmitting tube, with perfect privacy, and yet obtain upon the cylinder an unimpeachable transcript of their conversation in their own voices, with every break and pause, every hesitation or confident affirmation, every partial suggestion or particular explanation, infallibly set down in the wax. They can then have this conversation written out or typed by a secretary for future reference; or can, if they prefer, have it multiple-copied by our mechanical process. In this way many misunderstandings may be avoided. Interesting philosophic or literary discussions and dialogues may be recorded in the same way. In fact, the phonograph will do, and does at this moment accomplish, the same thing in respect of conversation which instantaneous photography does for moving objects; that is, it will present whatever it records with a minute accuracy unattained by any other means.

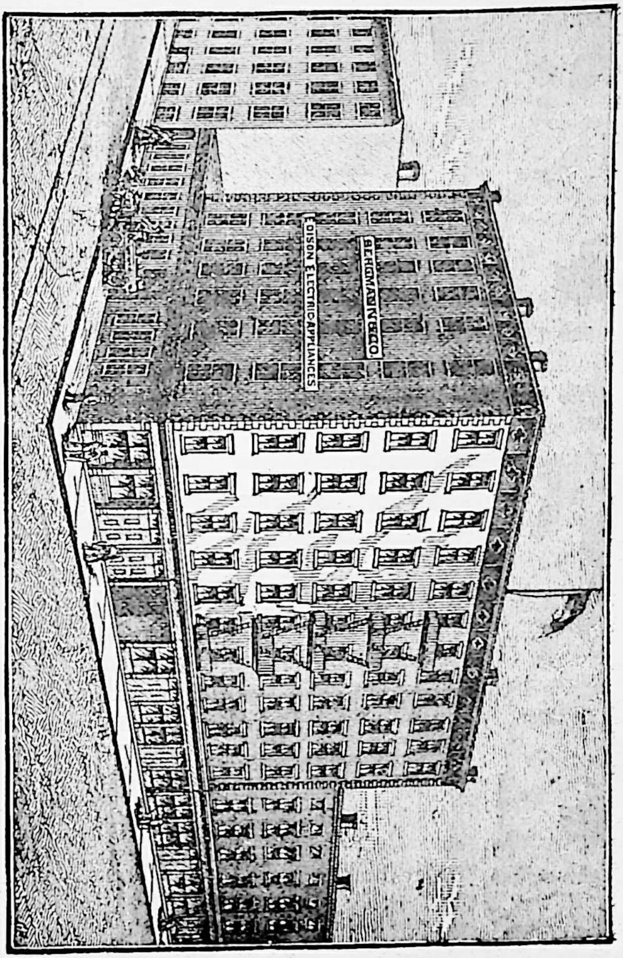
The most skillful observers, listeners and realistic novelists, or even stenographers, cannot reproduce a conversation exactly as it occurred. The account they give is more or less generalized. But the phonograph receives, and then transmits to our ears again, every least thing that was said—exactly *as* it was said—with the faultless fidelity of an instantaneous photograph. We shall now for the first time know what conversation really is; just as we have learned, only within a few years, through the instantaneous photograph, what attitudes are taken by the horse in motion.

Letters of introduction may be spoken onto a phonograph blank, without any of the formality of address and phraseology now customary, or the trouble of folding, enveloping and addressing a written communication. In fact, all correspondence will be greatly simplified and wisely abbreviated by the use of phonograms. A telephone subscriber can place at his telephone a phonogram which will announce to the exchange, whenever he is called up, that he has left the office and will return at a certain time.

Similarly, one man calling at the office of another and not finding him, will talk into the phonograph anything he wishes to say. This saves the trouble of writing a note, and obviates the uncertainty of giving to clerk, office-boy or servant, an oral message that may be forgotten or incorrectly delivered. Hotels and clubs will, naturally, find this function of the phonograph extremely servicable; and their guests and patrons will avail themselves of phonograms constantly. The accuracy of interviews with newspaper reporters will also be determined, no doubt, by phonographic record. And travelers in vestibule trains will be glad to use phonograph blanks in place of letter paper and telegraph blanks, owing to the difficulty of writing while on a rapidly moving train.

It must be borne in mind that I am not talking now of things which may be made possible in the future. I did my predicting ten years ago; and the functions above mentioned are those which the present perfected phonograph is able to fulfill at this moment. To use the phonograph, a little instruction and practice are needed, but much less than the type-writer requires and hardly more than the training needed for the operation of a sewing-machine.

Various other uses for which the phonograph is now fully ripe might be mentioned; but I do not want to give to these memoranda the character of a catalogue. Enough has been



MANUFACTORY OF EDISON'S ELECTRICAL APPLIANCES, NEW YORK.

said, I think, to indicate that the phonograph, unlike children, should be "seen" *and* "heard." It is no longer in a state of infancy. It may be still in its childhood; but it is destined to a vigorous maturity. The phonograph, in one sense, knows more than we do ourselves, for it will retain a perfect mechanical memory of many things which we may forget, even though we have said them. It will become an important factor in education; and it will teach us to be careful what we say—for it imparts to us the gift of hearing ourselves as others hear us—exerting thus a decidedly moral influence by making men brief, businesslike and straightforward, cultivating improved manners, and uniting distant friends and associates by direct vocal communication.

The Phonograph and Music.

Mr. Edison's newly perfected phonograph, by its musical achievements, cannot fail to interest all music lovers, and especially those musicians who long to know the exact peculiarities of time and rhythm adopted by the great composers in conducting their own works. Had Beethoven possessed a phonograph, the musical world would not be left to the uncertainties of metronomic indications which we may interpret wrongly, and which at best are but feeble suggestions; while Mozart, who had not even a metronome, might have saved his admirers many a squabble by giving the exact fashion in which he wished his symphonies to be played. According to all accounts, the phonograph will give the true time of a piece of music, no matter how constant or how delicate the variations.

There seems to be no reason to doubt that it will give a fair echo of a musical performance. All musicians will see at once of what immense value even an accurate echo, in time and tune, may be. It will give the student the phrasing of great soloists—something which no expression marks can convey. Future generations will be able to learn, if they care to know, exactly how Rubinstein "phrased" the "Emperor" concerto, or with what mannerisms Mme. Patti sang "Home, Sweet Home"; they will be able to compare the manner in which one famous conductor led the masterpieces of musical art with the conception of his rivals; and will know infinitely more about the music of to-day than we know of the music of our ancestors. Finally, the old gentleman, slightly deaf, who insists that there is no such music nowadays as was to be heard in his youth, will be brought to book almost literally, and be confounded with phonographic proofs to the contrary.

The Funny Side of the Phonograph as Seen by Col. Knox.

"The phonograph," says the Colonel, "will soon be 'in our midst.' The inventor says that it is perfected and is being manufactured for sale. When we get one we shall merely have to talk to it, and it will record every articulate sound; then at any time in the future we shall have only to turn the handle of the thing and it will reproduce the words, the tone and the accent exactly as received from us.

"Possibly the instrument may be developed until vest-pocket phonographs are made, and we can all carry them around with us and collect the flashes of folly and whisperings of wisdom expressed to us by our friends and acquaintances. There will be advantages and disadvantages in this. The autograph pest will throw away his album and buy a phonograph. He will come around and present the muzzle of the instrument to you and request you to load it up with a few remarks to be preserved, so that they may be fired off at future generations. The opera singer will be asked to warble a carol into its lungs, and the statesman to fill its throttle with his views on the political problems of the hour, and these will be duplicated, as a woodcut or steel engraving is, and amateur phonographers will make private collections of all sorts of sounds, from the hoarse toot of a foghorn to the soft sibilant swish of an unripe picnic kiss, and will reproduce them at will.

"And Mrs. Jones will set the trigger of her phono when Jones comes home at 2 A. M., and, pursuing him around the room, will capture every lie he tells and every hiccough he hics, and even the noise he makes falling over his feet, and at the breakfast table next morning she will turn it loose on him and paralyze him with his own abbreviated words and tangled language of the night before, and he will be much embarrassed thereat.

"Again there is the reporter; he will use it, and when you tell him that you are 'not a candidate, and would not, under any circumstances, accept the nomination if tended,' he will file away your remarks until you deny that you ever uttered them, and then, from his inside pocket, he will draw forth his phonograph and you will wish you had bought a time lock for your mouth.

"Pity, isn't it, that the phonograph was not invented a few thousand years ago, because if it had, down through the corridors of time might have reverberated the echoes of the great events of the past, and we of to-day could have taken our phonos out on the back stoop in the long summer evening and listen to the roar of the lions in Daniel's den, the sound of Nero's fiddle and the clatter of the Roman Empire as she fell.

"If this wonderful instrument is possible why may it not be possible to invent a machine that will take our unvoiced thoughts as we think them, and record them in some way so that they may be afterward transferred to paper? What vagaries of thought the thinkograph would reveal—what delirium tremens of imaginings would it disclose! In cold type they would astonish even the thinker."

The Doll Baby Phonograph

Edison's phonograph has resulted in a patent for a combined doll and phonograph, issued May 22, 1888, that promises to be a very interesting and profitable application of the principles of that wonderful device. It is a child's doll, in which a small phonograph is fixed, that makes it quite practicable as a toy. And as it can be put to so many useful purposes as a kindergarten apparatus, etc., it would seem to be something more than a toy. It at once suggests a great variety of very useful applications of the phonograph for the pleasure, as well as the instruction, of the little folks, who would, through its medium, be placed in command of an automatic story-teller, and have Jack, the Giant-Killer, and all the other phantasmagoria of childhood, brought to their attention in the most vivid and interesting manner.

A Story of Edison—Hurrying up the Phonograph.

As illustrating the versatility and fecundity of Mr. Edison, the inventor, Mr. Edward H. Johnson, of the Edison Light Company, tells the following little story: "I was traveling," says he, "through the west for Edison, giving exhibitions of, and lectures on, the telephone. Edison had previously told me in a casual way that he believed he could make a talking machine, and he meant to do it some day. In a burst of enthusiasm at Buffalo, I boasted that the wizard would astonish them still more as soon as he could find time to perfect his talking machine. The audience went wild over the announcement, and it was some minutes before I could proceed with my lecture. At its conclusion I was besieged and congratulated by an eager crowd, who extorted from me a promise that I would hurry up that talking machine and exhibit it first in Buffalo.

"I abandoned the remainder of my trip, packed my grip sack and started for Newark that night. All the way home I was wondering whether I hadn't bit off more than I could chew."

"Tom," says I, as soon as I could reach him, "you must let everything else go, and finish that talking machine without delay. The people are crazy over it. I made a bluff at them in Buffalo, and the whole audience called me down."

"All right," said Edison, unconcernedly.

"In three days he received from New York the metal cylinder, and before nightfall the phonograph was an accomplished fact."

Edison Experimenting with the Baby and the Phonograph.

It is facetiously remarked of Mr. Edison that he has experimented extensively with a phonograph and his new baby at home. He found that when the baby crowed with glee, the crow was registered perfectly on the phonograph; when it got mad and yelled, its piercing screams were irrevocably recorded on the same machine. That phonograph is now a receptacle of every known noise peculiar to babyhood. It is Mr. Edison's intention to take a record of the strength of baby's lungs every three months. "I will preserve the record," says he, "until the child becomes a young lady. Then the phonograph can be operated for her benefit, and she can see for herself just what kind of a baby she was, and won't have to take her mother's and the nurse's words for it."

Edison's Opinion of the Patent Law.

A PLAIN, PUNGENT STATEMENT FOR CONGRESSMEN.

"I always thought," said Mr. Edison, recently, on the subject of the Patent Law, "that my original patent of twelve years ago covered the essential features of the phonograph so completely as to give me a monopoly of the perfected instrument whenever I, or any one else, should find time to finish it. Within the last few years, however, I have become extremely skeptical as to the value of any patent, and so long as our patent law remains in its present iniquitous shape, I shall try to do without patents.

"The present law is a constant temptation to rascals, and virtually offers a premium on rascality. Under it the infringer of a patent is not interfered with until the real owner can show that he has the monopoly of the device in question. This process may take years, during which the infringer, who has money and audacity enough to secure another man's invention, can go on and perhaps wear the rightful owner's life out by litigation and annoyance. I have had so much of this sort of thing within the last five years, that I have almost made up my mind never to take out another patent until the law is changed. The burden of proof is now put entirely on the man who holds the patent instead of the man who wishes to infringe it, whereas it ought to be all the other way.

"There is scarcely an invention of importance made within the last generation, which has not been disputed upon frivolous grounds, and the inventor put to all sorts of annoyance. In my own case, I am sure that no matter what I may patent, some one will come up as soon as the patent is seen to have any value, and shows by dozens of witnesses, if necessary, that he is the rightful owner of the invention.

"If I patent to-morrow a process for making good flour at a cost of two cents a barrel, the publication of my patent would bring out about ten men who could prove that they did that sort of thing years ago, and that I had no right to a patent.

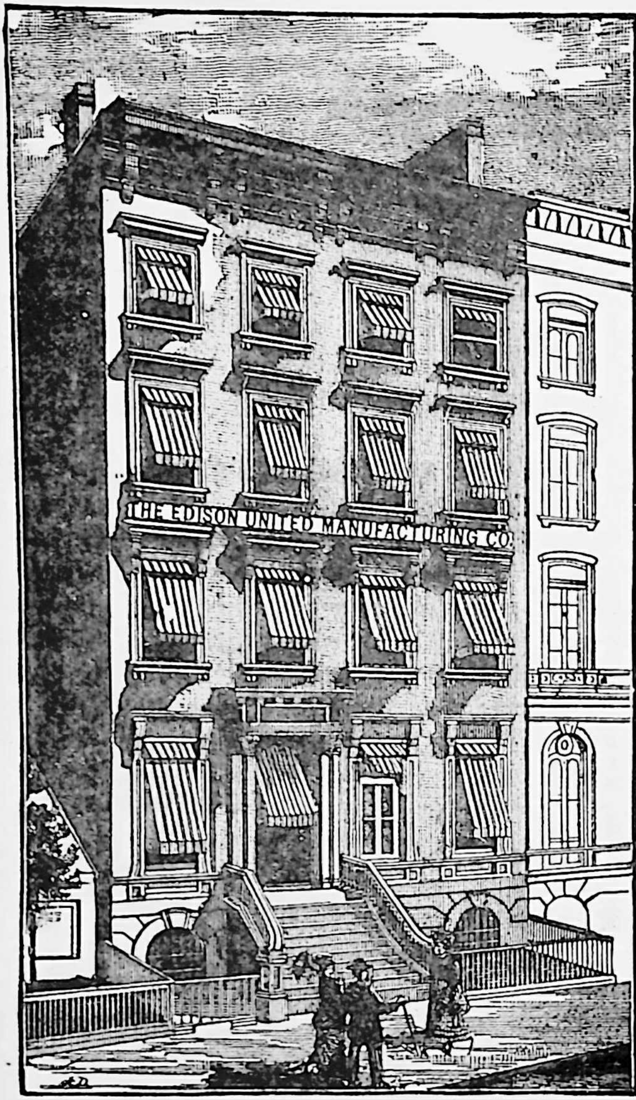
"In the case of my dynamos, I have patents by the score, and yet when a great firm of machinists want to go into the business of making dynamos, they coolly appropriate one hundred of my inventions, and laugh at my claims as patentee. To litigate the matter to the end, if there was any end in sight, would cost hundreds of thousands of dollars, and put me in hot water for years to come. I am an inventor and not a lawyer, and I hate litigation. If patents are going to give me nothing but law-suits, I don't want any more of them.

"In case of the phonograph these Washington people have had the decency to come here to Orange and ask for my permission to manufacture and sell their devices; they wanted a license, which I refused to give them. Having no license, they go to work at once and proclaim the worthlessness of all patents upon the phonograph except their own; they have got some patents for twisting a screw to the right instead of the left, etc. I really can't say what our first steps will be, and I leave all those matters to the lawyers, who enjoy that sort of business. Certainly if the phonograph turns out to be the great success that I expect for it, there will be a dozen infringements upon the market within the next six months, and the lawyers will have their hands full.

"I am so thoroughly convinced of the uselesseness of patents, that one of the objects in building my present laboratory is to search for trade secrets that require no patents, and may be sources of profit until some one else discovers them. There are scores and scores of such secret processes, which are enormously profitable and which are not claimed right and left, just because they are secrets. Some of them are used in this country, but most of them, chiefly chemical, are held in Europe. Methods of dyeing, of working certain fabrics, etc., pay millions every year to those who know the secret processes employed."

"I have already found one chemical device which promises to pay me handsomely, and the patent office will never hear anything about it. To apply for a patent would simply invite a lot of rogues to share with me, or, what is more likely, to take all the profits. I am rather curious to see what is to be done when the phonograph comes out. The patent has only five years to run, and, evidently, if men with millions behind them jump into the manufacture upon a large scale, the patent may run out before my claim to the fundamental device is allowed.

The reader must not infer that Mr. Edison has been deprived of all his just rights and dues in the patent business generally. By no means. He occupies one of the very finest estates in the vicinity of New York City, and, as has been remarked, "if he is not twice a millionaire, it can be for no other reason than that, like too many of us, he has found it less easy to keep money than it is to get it." In addition to this he has now sold out his phonograph to a large and competent company for a "cool million" which must very materially augment his bank account.



OFFICES AND SHOW ROOMS OF THE EDISON UNITED MANUFACTURING COMPANY, NEW YORK.

ELECTRICAL DICTIONARY AND EXPLANATIONS.

The very rapid development of electricity in its wide scope of general and useful application in art, science and human progress in this country and throughout the civilized world, which necessarily requires the coining of many new words and phrases that even a "Webster" cannot keep pace therewith, has rendered this Electrical Dictionary and explanation of terms a necessity, which will not only greatly aid the reader in pursuing electrical literature generally, but, perhaps, supplement his knowledge of this wonderful science and help him to keep abreast of this "Electric Age."

Absolute Unit—"That force which, acting upon a mass of one gramme for one second, is able to give it a velocity of one centimeter per second." It is called the "absolute unit," because, in fact, one gramme is the unit of mass, one centimeter, the unit of length, and one second, the unit of time. It is also known as the "C. G. S. unit," adopted at the Paris Congress of Scientists in 1882, and made on that occasion the basis of electrical measurements. The exact amount of force requisite to move one gramme one centimeter in one second, is a most important point to fix in the mind, for it is the basis of the mathematics of electricity, and the "absolute unit" to which all other units are referred or adjusted. Its symbols are C. G. S., the C. representing Centimeter (space), G. Gramme (mass), and S. Second (time). A centimeter is about 2-5 of an inch, and a gramme is nearly 15½ grains.

Accelaration—The rate of change of velocity.

Accumulator—An apparatus for receiving and retaining large quantities of electricity.

Amalgam—A compound of mercury with another metal; used in coating electric plates.

Ampere—The practical unit of current strength, or "flow of current," named after Ampere. It is equal to the current produced in a circuit of one ohm resistance by a difference of potential of one volt. Its value is 1-10 that of the C. G. S. or absolute unit of strength.

Amperemeter.—A mechanism for measuring the current strength, or flow of the current.

Anions—The products of electrolysis which appear at the anode.

Anode—The electrode in connection with the pole (metal, platinum, carbon, etc.) of the *battery* or *cell.*

Annunciators—An electric mechanism for calling or signalling purposes.

Arc Light—The light produced by the electric current at the ends of two carbon sticks placed in easy contact. The friction engendered by the short leap of the current heats the carbon points to a temperature of from five thousand to eight thousand degrees, thus causing them to give off a brilliant light. The bombardment of the carbon particles intensifies the heat and really adds to the whiteness of the light. The pure electric arc is of a violet blue color and not white. The positive carbon, or the one from which the current leaps to cross the break is heated to a higher degree than the negative,, or lower carbon, which receives the current, and is consumed more rapidly. It burns down in the ordinary arc light about one-and-a-half inches per hour, while the negative carbon is consumed at about half that rate.

Armature—The revolving fixture of the dynamo, consisting of a core of iron, wrapped with coils of copper wire, which revolves rapidly between the poles of the magnet, but does not touch these poles. The current produced flows in opposite directions as they pass the poles in succession, but by means of the commutator they are made to flow in one and the same direction.

Armature Core—The soft iron portion or core of the armature.

Artificial Magnets—Bodies in which magnetism is artificially induced.

Attraction and Repulsion—Properties of the magnet and electro-magnet. Like poles repel and unlike, attract. The intensity of this attraction or repulsion varies in the inverse ratio of the square of the distance; that is, if the distance of the pole is doubled, the force with which they attract or repel each other is reduced to one-quarter of the previous amount; if trebled, to one-ninth, and so on. This attraction and repulsion which so signally characterizes the magnet, is the foundation and essential factor in nearly all forms of electrical mechanism.

Automatic—Self-operating; electricity is prolific in automatic mechanism.

Axial Line—The line joining the poles; the lines at right angles to it is called the equatorial.

B. A. Unit—The standard fixed upon by the British Association as the unit of electrical resistance, and is the same as the *ohm*. It is approximately equal to in resistance to a wire of pure copper 250 feet long, and the one twentieth of an inch in diameter.

Bar Magnet—An artificial permanent magnet in the form of a straight bar; a magnet composed of several straight bars joined together, side by side, is called a compound bar magnet.

Battery—One or more cells which are provided with the proper solution and plates, connected together, which generates electricity by chemical action.

Bec-Carcel—The French unit of light, taken from the light of a Carcel lamp, and is equal to 9.5 British standard candles, or 7.6 German candles.

Brake-Shoes—Electric brakes for operating electric motors, etc.

Break.—A complete disconnection, which occurs when the circuit is open. It may be caused by a broken ground wire, defective battery, open key, broken line wire, etc.

Calorie—The unit of heat, which in the C. G. S. system is the gramme degree. Its mechanical equivalent is equal to 42,000,000 ergs (the unit of work.)

Candle Power—The British unit of light is the light of a spermaceti candle ⅞ of an inch in diameter, burning 120 grains per hour (six candles weigh one pound); the German unit is the light of a paraffine candle 20 millimeters in diameter, burning with a flame five centimeters high.

Carbons.—The "sticks" used in the carbon arc light lamp. They are made of powdered cake 15 parts, lamp black 4 parts, and special syrup 8 parts, mixed with water and molded and dried in a crucible.

Cathode—The electrode in connection with pole (metal, zinc, etc.) of the *cell* or *battery*.

Cations—The products of electrolysis which appear at the cathode.

Centimeter—The fundamental unit of length; equal to 0.3937 inch in length, and nominally represents the one thousand-millionth part of a quadrant of the earth.

Circular Mil—The practical unit of wire gauge, which is a wire the one-thousandth of an inch in diameter, usually written as so many *mils.*

Closed Circuit.—A complete circuit; connected and unbroken, so that the electric energy "flows" all around, which it could not do if the line were broken.

Commutator—An instrument whose use is to change the direction in which the current flows through the primary circuit, and, of necessity, to change the direction of that in the secondary circuit also.

Condenser—An instrument to add to the current traversing the primary wire, and consequently to increase the force of the secondary discharge. It consists of a number of plates of tin-foil, separated by sheets of varnished or rosinized paper; the alternate tin-foil plates being attached together, thus forming two separate insulated series. One series of the plates is connected with the pillar of the contact-breaker that carries the platinum screw, and the other series with the block that holds the vibrating spring. These plates do not form a part of the battery circuit, but are, as it were, lateral expansions of that circuit, on each side of the contact-breaker. The insulating sheets thus have their electrical condition disturbed, and when the battery is interrupted the plates return to their normal state, and in so doing increase the action of current circulating in the primary wire.

Conductors—Substances that possess the property of allowing electricity to diffuse itself freely and readily through them.

Constant of a Galvanometer—The deflection of the galvanometer, obtained through a standard resistance by a standard battery. As explained by Kempe, it is the "product of the deflection in degrees and the resistance in ohms when multiplied together."

Contact-Breaker—A vibrator by which the electric current can be made and broken with great rapidity.

Crater—A term used to express the hollowing out of the upper (positive) carbon in the arc lamp. The upper carbon burns hollow, and the lower, cone shape.

Cross—Where one wire crosses another and interferes with the line, often caused by wind, branches of trees, etc.

Dead Earth.—A term used when the line at any point touches the ground, or some good conductor in contact with the earth. This is also called a "ground."

Diamagetic—Substances which are repelled by the magnet. Bismuth, antimony, zinc, etc., are diamagnetic. It is found that the magnetism of two iron particles lying in the line of magnetization is increased by their mutual action, but on the contrary, the diamagnetism of two bismuth particles lying in this direction is *diminished* by their mutual actions.

Dielectric—The insulating substance which separates two conducting surfaces and thereby enables them to sustain opposite electrical states. All insulators are dielectrics.

Dip—The "dip" of any telegraph line wire is the *sag* between the poles; the dip of the magnetic needle is the vertical angle of the needle with the horizon; the tendency to point downwards.

Difference of Potential—The difference of potential between any two points expresses the amount of work which each unit of electricity could do on its journey if it could all be utilized to do work instead of having to overcome the resistance of the circuit. The place *from* which the positive electricity tends to move is assumed to be of higher potential than the other.

Duplex Telegraphy—Sending two messages over the same wire at the same time.

Dynamo—A machine for converting mechanical into electric energy; or a machine that generates electricity. When a piece of soft iron is brought near a magnet, it, too, becomes a magnet. If, for instance, a common nail has its point brought near the north pole of a magnet, the head of the nail will at once become a north pole and its point a south pole. If the position of the nail is reversed, the magnetism will remain the same as relates to the magnet, but not to the nail. The nail may be said to have turned round on its magnetism. If, now, this nail should have a small shaft through it perpendicular to its axis, and mounted so as to be revolved with rapidity while in this position, the magnetism in the nail would change at each turn, the end nearest the magnet always being a south pole. This is called a change of polarity. Now, if on this nail a fine coil of insulated wire be placed, and the outside and inside ends connected together, a strong pulsation of electricity will take place in the wire of the coil at each half turn. When the ends of the wire are separated and brought down to the shaft, so that the current may be taken off through a commutator, or stationary conductor, we have a complete *little dynamo*, which only needs enlarging to produce an electric light. The effect, however, would be very much increased if we bent the nail in the form of a ring, with a shaft secured into it like the shaft in a wheelbarrow wheel, and the coil divided up into twenty or more sections, each section ending in an independent copper strip in the commutator. Another improvement would result from revolving it between two magnets of opposite polarity, or between the opposite poles of a horse-shoe magnet. It will be seen the magnetic principle of attraction and repulsion is the essential factor of the dynamo.

Dyne—The unit of force; called the absolute unit, and also the C. G. S. unit.

Electric Bells—Bells rung by the electric current. There are "single stroke," "vibrating or trembling," and other kinds of electric bells, manipulated by push buttons, cranks, etc., and all operating upon the principle of making and breaking the circuit, or the action of the electro-magnet.

Electric Candle—Where two carbon sticks are placed upright, parallel to each other and separated by a thin insulator, and which burn from the top down like a candle; an invention of Jablochkoff, in 1876.

Electric Circuit.—The entire path of the electric current, including the battery itself and the conducting medium which unites its poles.

Electric Current—A current of electric fluid traversing a closed circuit over conductors, or passing by means of conductors from one body to another which is in a different electrical state. Its symbol is C. Machines are constructed to give *continuous* currents and *alternating* currents.

Electricity—"A form of motion; energy charged in a special manner upon ordinary matter and developing special relations among its molecules. It is not *material*, or fluid, nor is it a special force." (Sprague.) It is, however, treated as if it *were* a fluid, because it is more easily understood when so considered; hence we speak of the "flow of current," etc. The fluid theory was held by nearly all the older electricians, and even to-day we cannot talk or write about it in a manner to be comprehended except as we treat it as a fluid having current, etc.; and to all intents and purposes it acts as if it *were a fluid.* According to the fluid theory, there were two kinds of fluids, each very subtle, rare, quite imponderable, and consisting of particles that repel each other. Benjamin Franklin believed in only *one* fluid, the particles of which mutually repel each other. What was called vitreous electricity, Franklin called positive electricity, and the resinous he called negative. Professor Pepper of the Royal Polytechnic Institute, London, said long ago that "the same wave theory which accounts for heat and light will doubtless ultimately be applied to electricity, which may be only some remarkable vibratory state of the ether pervading all matter and space;" "and this opinion," he adds, "was held forty years before Galvani, by Sultzer, who first experimented with pieces of silver and lead. By placing them on opposite sides of the tongue, and then bringing the two in contact, he noticed a peculiar metallic taste, like vitriol." The American school of electricians, which is decidedly practical in its ideas, perhaps more generally considers electricity a "form of energy" having its peculiar attributes, back of which they have not as yet cared to go. As a matter of fact, electricity is evolved in any disturbance of molecular equilibrium, whether from a chemical, physical or mechanical cause. Lockwood defines electricity as "one of those peculiar forces of nature as universal in its effects as its kindred forces, light and heat, and is in many respects analogous to them. Scientists, at present, consider electricity to be a particular form of energy which causes the infinitesimal particles to alter their positions in regard to one another."

Electro-Chronograph—A mechanism for noting time by means of electricity; an electric clock.

Electrodes—The terminals of the poles of the battery or cell which excite the current, and which are in contact with the electrolyte or solution.

Electro-Dynamics.—Having reference to electricity *in motion*. Its phenomena as classified by Faraday are: Evolution of heat, magnetism, chemical decomposition (electrolysis), physiological phenomena and the spark.

Electrolysis—The decomposition of bodies by means of the electrical current, their elements being set free.

Electrolytes—Bodies that may be decomposed directly by the electric current, their elements being set free.

Electrolyzation—The process of decomposition by means of an electric current.

Electro-Magnet—A mass of soft iron, usually in the form of a bar, rendered temporarily magnetic by being placed within a coil of wire through which a current of electricity is passing.

Electro-Magnetism—Magnetism produced by means of electricity.

Electrometer—A mechanism for measuring the quantity or intensity of electricity.

Electro-motive Force—The force, or pressure, which electric energy is capable of exerting by virtue of a difference of electric potential between the body in which it is accumulated and some other body. It is also defined as "the force which sets the current moving around a closed circuit," and is often called the "*electrical pressure.*" As with water, the higher the level the greater is the pressure and power, so with electricity, the higher the electric level or potential the greater the pressure, or electro-motive force. The force or pressure is exerted by the energy itself, the body in which it is accumulated, or by which it is transmitted, being only a passive medium. It is a very singular fact that a loose, dangling wire will conduct from a dynamo a force which at the distant end, miles away, will run a motor of many horse power. The question is, What is this subtle influence that so occultly and curiously operates? We may define, but alas, no one can yet explain. Let us hope that "Time will tell." The symbol of electro-motive force is E. M. F., sometimes written only E., and its practical unit is the "volt," which is 100,000,000 "absolute," or C. G. S. units. The E. M. F. of a Daniell cell is about one volt.

Electroscope—An instrument for showing electrical excitation, or the presence of electricity, the simplest being that of two delicately suspended pith balls.

Electrophorus—A mechanism for exciting electricity and repeating the charge indefinitely by induction.

Electroplate—The process of covering with a coat of metal by means of electrolysis.

Electro-positive—Of such a nature relative to some other associated body or bodies as to tend to the negative pole of a voltaic battery, while the associated body tends to the positive pole. The converse of this is the *electro negative.*

Electro-statics—That which pertains to statical electricity.

Electro-therapeutics—Electricity in relation to disease; now recognized as a vaiuable element in the healing art.

Electro-tint—Etching by means of electricity; where a picture is drawn on a metallic plate with some materials that resist the fluids of the battery, so that in electrotyping, the parts not covered by the varnish receive a deposition of metal and produce the required copy in intaglio.

Electrotype—The process of copying metals, engravings, etc., and of making stereotype plates by means of electric deposition; or the art of producing *copies* in metal of any object by means of the action of electricity. Engravings, book pages set in type, and composition work generally, may be accurately and permanently copied by this process with a metal surface, which is usually copper. This art was introduced in 1838, by Prof. Jacobi, of St. Petersburg, and also, about the same time, by Thomas Spencer, of Liverpool, who demonstrated its practical utility. A printer by the name of Jordan also aided in its development.

E. M. F.—Is said to "signify that property of any source of electricity by which it tends to do work by transferring electricity from one point to another." The E. M. F. of a battery is the power which it has of overcoming resistance. It increases in direct proportion to the number of cells employed. It is often written with only an E. instead of E. M. F. which letters indicate Electro-Motive Force.

Energy—A body is said to possess *energy* when it is capable of doing work, either in consequence of the motion with which it is endowed or its position. A ball fired upward possesses the power of doing work on account of its motion. This energy from motion is called Kinetic energy. At the top of its flight the energy of the ball is not lost, but is transformed. The ball now has energy due its position, and will be able to do the same work in falling as in rising. As long as the ball is supported in its elevated position its energy is *potential*, and may be called upon to do its work when desired. Thus the separated elements of a chemical compound just as truly possess energy of *position* as an elevated body. Allow them to unite and their potential energy passes into Kinetic energy, and the work of separation is returned in that of chemical combination. What the projected ball loses in Kinetic energy, it has gained exactly in potential energy. Considering the universe as a whole, we find a like condition of things. The sum of the energy due to the position of things is always equal to the sum of the energy due to motion. This is the "conservation of energy," or, as it is often called, "the conservation of the forces."

Erg—The unit of work (adopted by the Paris Congress.) There is in one foot-pound 13,563,000 ergs; and in one English horse-power, 7,460,000,000 ergs. The unit of work is therefore the 1-13,563,000 of a foot-pound.

Escape—The loss of a *portion* of the current on the main line is called an "escape," caused by defective insulation, etc.

Farad—The practical unit of capacity, named in honor of the celebrated Faraday. The capacity is determined by dividing the quantity of the charge by its potential. This unit is equal to $1\text{-}10^{-9}$ of the C. G. S. unit of capacity. As this is large, the microfarad is commonly used in practice, which is the one millionth part of a farad.

Ferro-magnetic—Iron and similar bodies which are attracted by the magnet.

Foot-pound—The work required to raise one pound one foot.

Force—That which produces motion or change of motion in a body. The unit of force is that force which, acting for one second on a mass of one gramme, gives to it a velocity of one centimeter per second. This is the "absolute unit."

Galvanic Battery—Two dissimilar substances or metallic surfaces, both being conductors of electricity, immersed in a jar of acidulated water or other exciting fluid that will act more energetically on one than the other, and connected on the outside with a wire. The materials most suitable are carbon, platinum, gold, silver, copper, iron, tin, lead, zinc;

and the exciting fluids are sulphuric and nitric acids, bi-chromate of potash, sulphate of copper, etc. The ordinary battery is made with copper and zinc plates inserted in a jar filled with sulphuric acid, the plates being connected by a wire, which forms the circuit of current. It is the chemical action in connection with the plates that generates the electricity.

Galvanometer—An instrument for indicating or measuring the quantity of electricity, and for detecting, indicating or measuring the currents of electricity. The principle is that of attraction and repulsion produced by the current on a magnet that carries a little mirror which reflects a lamp light ray on a screen or dial. Of course, the slightest current will move the magnet, and the slightest movement of the magnet and mirror throws the reflected ray backward or forward on the screen.

Gastroscope—An electric apparatus used by physicians for exploring the interior of the stomach. A little incandescent lamp is adjusted and inserted and then the current turned on.

Gramme—The fundamental unit of mass, and is equal to 15.432 grains, and represents the mass of a cubic centimeter of water at 4° C. Mass is the quantity of matter in a body.

Ground Wire—The terminal wire of a line that may run into the ground or be attached to gas or water pipes, etc., and to which also are attached the lightening arresters. They are also used, when the line is impaired or broken, for testing to ascertain the point of current interruption.

Horse-power—The power required to raise 550 lbs. one foot high in one second, or 33,000 lbs. in one minute.

Horse-shoe Magnet—A permanent magnet bent in the form of the letter U, which brings the two opposite poles near together.

Incandescent—That which is heated to a white heat.

Incandescent Light—The light produced by the electric current overcoming the resistance offered by a filament of carbon, and raising it to a temperature sufficient to render it luminous. This filament is placed in a glass bulb from which the air has been exhausted, and therefore cannot burn. In fact, the carbon filament of the incandascent light is simply heated to a white heat by the current in a vacuum.

Induction of Electricity—Developing electricity in a body by the inflnence of other electricity in its neighborhood.

Induction of Magnetism—Developing magnetic properties in a body by the influence of a magnet.

Insulation—Prevention of the escape of electricity; glass, ebonite and silk are among the insulating substances.

Insulators—Substances that do not allow electricity to diffuse itself through them.

Intensity of Magnetization—The intensity of magnetization of a magnetic particle is the ratio of its magnetic movement to its volume.

Intermittent Cross—Where the wires are too slack between the poles so that they often touch each other and interfere with sending of messages.

Joint Resistance—The resistance of two or more independent branches of a circuit considered and treated as one.

Joule—The electrical unit of work, as proposed by Sir William Siemens. It is equivalent to the volt-coulomb, and to 10^{-7} ergs. It represents the work done in one second in a circuit of one ohm resistance by a current of one ampere.

Kinetic Energy—The work a body can do by virtue of its *motion*.

Leclanche Battery—A popular electric battery using zinc and carbon plates, and a solution of salamoniac.

Leyden Jar—A device for the accumulation of electricity, consisting of a glass jar coated inside and outside with tinfoil, except a few inches at the top.

Local Action—The name given to the chemical action in the battery, whether the circuit is closed or open.

Loop—A wire which branches out from the main line to some other point and returns to the main line again at or near the point where it left it.

Magnet—A body that exhibits magnetic properties, such as attraction, repulsion, polarity, etc.

Magnetic Induction—See Induction of Magnetism.

Magnetic Moment—The product of the length of a uniformly and longitudinally magnetized bar magnet into thc strength of its positive pole.

Magnetic Needle—A light and slender magnet mounted upon a center of motion so as to allow it to traverse freely.

Magnetic Polarization—In speaking of the state of the particles of a magnet as magnetic polarization, we imply that each of the smallest parts into which a magnet may be divided has certain properties related to a definite direction through the particle, called its axis of magnetization, and that the properties related to one end of this axis are oppositeto the properties related to the other end. The properties which we attribute to the particle are the same kind which we observe in the complete magnet. In other words, each particle is a perfect magnet; their poles all point in the same way, *i e.*, in a line of the axis of magnetization.

Magnetism—The peculiar properties of attraction, repulsion, polarity and induction possessed under certain conditions by iron and some of its compounds; also nickel, cobalt, etc. The name is supposed to be derived from Magesia, the place where lodestone (the natural magnet) was first found by the Greeks.

Magneto Bell—A polarized relay, with its armature extended into a hammer which vibrates between two bells.

Magneto-Electricity—Electricity produced by the influence of magnetism.

Magnetometer—An instrument for measuring the magnetizing power of galvanic currents.

Mass—The quantity of matter in a body.

Megafarad—One million farads.

Megavolt—One million volts.

Megohm—One million ohms.

Metronome—An instrument which serves to measure time in music.

Microfarad—One millionth of a farad.

Microvolt—One millionth of a volt.

Microhm—One millionth of an ohm.

Microphone—An electrical instrument by which minute sounds, like those of a fly walking, may be magnified so as to be distinctly audible. Its action is due to the disturbance of electric contacts, and in reality it is a telephone transmitter.

Mil—One thousandth of an inch.

Mili-ampere—The thousandth part of an ampere. The electric currents employed in telegraphy vary from 4 to 250 mili-amperes, the latter being the approximate current strength flowing in an ordinary local sounder circuit; currents utilized in electric lighting vary between one and fifty amperes.

Momentum—The quantity of motion in a body, which is measured by the product of the velocity of the body into the mass.

Motor—A machine for converting electrical into mechanical energy. All electric motors owe their motion to the attractions and repulsions caused by the actions of electro-magnets.

Multiplex Telegraphy—Sending a number of messages over the same wire at the same time.

Natural Magnets—Lodestones (a certain kind of iron ore.)

Non-Conductors—Substances that do not allow electricity to pass through them, such as glass, gutta-percha, ebonite, etc., and which therefore are used in making insulators. Dry air and ebonite are among the best non-conductors, and silver is the best conductor.

Ohm—The practical electric unit of resistance, named in honor of Ohm, who first suggested the method of measuring electrical resistance. It is equal to 10^9 C. G. S. or absolute units, or the resistance of a pure copper wire one mili-meter in diameter and forty-eight meters long. "Roughly speaking," says Prescott, "one thousand ohms is equal to seventy miles of well constructed line." The ohm has been derived from the relation between a current, the mechanical force it exerts on a magnet, the distance of the magnet, and its strength.

Ohms Law—"Current:= $\frac{\text{Electro Motive Force}}{\text{Resistance}}$ or $C=\frac{E}{R}$." Ohms Law was promulgated by Dr. G. S. Ohm of Nuremberg, Germany, as early as 1827, and is the basis of all electrical measurements. According to this law we have the E. M. F. divided by the current, aud the E. M. F. equals the current multiplied by the resistance.

Paramagnetic—Magnetic; opposed to diamagnetic. Bodies which are repelled by the magnet, such as bismuth, antimony, lead, tin, mercury, gold, silver, zinc, copper, water, sulphnr, sugar, etc., are diamagnetic; but iron, nickel, cobalt, chromium, manganese, platinum, etc., are attracted by the magnet and are called magnetic, or paramagnetic.

Permanent Magnet—A magnet formed of hardened steel that retains its magnetic properties.

Photometer—An instrument for measuring the intensity of light. In Rumford's photometer the shadows of an opaque rod are thrown from the two lights and compared on white screen.

Photometry—Measuring light. The intensity of light on unit surface is inversely as the square of the distance from the source.

Photophore—A peculiar form of an incandescent lamp used by physicians in exploring the cavities of the ear, nose, larynx, etc.

Plug Switch—Two or more brass plates, with holes drilled between them, so that by the insertion of a metal plug any two or more plates, with the circuits attached to them, may be connected together.

Polarity—The directive force of a magnet, which always comes to rest with the same pole pointing north.

Polarization—The electric re-action at the poles of a cell, and is of the nature of a counter electro motive force. It is in overcoming this polarization force that we are enabled to store electricity.

Poles—The extremities of a magnet; one of which is called the north pole, because it points north, and the other the south pole, the symbols of which are N. and S.

Poles of a Battery—The terms applied to that part of the plates that is without the exciting fluid of a battery, *i e.*, not immersed in it; one of which is positive, and the other negative. The immersed portions of the plates are the positive and negative *elements* of a battery, and they are always the reverse of the poles, so that each plate of a battery has opposite terms applied to it, one part being called positive, and the other negative, as it is in, or out of, the acid solution. The binding screws and wire attachments are included as a part of the plate outside of the liquid. In a zinc and copper battery the zinc in the solution is the *positive plate*, but the wire leading from it is the *negative pole*, while the copper is the *negative plate*, but the wire proceeding from it is the *positive pole*. The electric action begins at the zinc plate, passes through the liquid to the copper plate and *out* of the liquid, and thence over the wire and back to the zinc plate.

Potential—A term used to represent the energy which a body may possess to do work. Thus a weight has gravity potential; a furnace has heat potential; and electricity in this manner is said to have electric potential. A difference of potential is analogous to a difference of level of water, and just as work must be done in raising water from the lower to the higher level, so work mustbe done in raising electricity from the lower to the higher electric level. The water, in falling, is able to perform the work done in lifting it, and so the electricity is able to do that which was done in raising it to the higher potential. The greater the difference in water level, the greater is the "head" of water and the water power; and the greater the diflerence of electric potential, the greater is the electric energy. And just as water cannot flow "up stream," or on a dead level, but must always flow down stream, so it is with electricity; the current is toward the lower potential, and with an equal potential, at each end of a wire (level), there is no current possible.

Potential Energy—The work a body can do by virtue of its *position*.

Primary Current—The main current or direct current from the battery; that which induces the secondary current.

Quadruplex Telegraphy—Sending four messages over the same wire at the same time.

Quantity—The amount of electricity present in a body. All the most remarkable effects of the current of electricity, such as electrolysis, combustion of metals, the deflection of the galvanometer, the production of magnetism, etc., are dependent on the quantity of electricity passing. Its symbol is Q.

Receiver—That by which a telephone message is received, and which we apply to the ear.

Recorder—The mecanism that records, or takes down the message spoken into a phonograph, so named by Mr. Edison.

Rheostat—An instrument used for the purpose of varying at will the amount of resistance in a circuit.

Rheotrope—An arrangement for reversing the current and often called the reverser, or commutator.

Regulator—The mechanism of an arc lamp by means of which the two carbons are kept at the proper distanee apart.

Relay—An instrument included in the line circuit at each station, which acts by the influence of the electric currents on the main line to bring into play a battery, called the local battery, at the receiving station, and by closing the circuit of such local battery, to work a sounder or register with much greater strenght than it could be worked by the main line current, which is weakened by the distance which it has to travel and by leakage due to imperfect insulation.

Repeaters—A peculiar arrangement of instruments and wires whereby the relay, sounder, or register of one circuit is caused to open and close another circuit, thus repeating or duplicating the signals sent out on the first circuit.

Reproducer—The mechanism that reproduces the message spoken into a phonogragh. So named by Mr. Edison, its inventor.

Residual Charge—If a Leyden jar be fully charged, allowed to stand some time, and then discharged, it will be found to re-charge itself to a small extent. This is called the residual charge.

Residual Magnetism—When a current is conveyed through the coil of the electro magnet the soft iron core is strongly magnetized; and when the circuit is broken, or ceases to flow, demagnetization instantly takes place, but unless the iron is very soft and pure, a certain amount of the magnetism remains in the iron, and this is called residual magnetism.

Resistance—The obstruction to the passage of electricity by the *substance* of the circuit through which it passes. Silver is among the substances that offers the least resistance, and gutta-percha the most. Silver is, therefore, one of the best conductors, and gutta-percha one of the best insulators. Its symbol is R.

Resistance of Battery—The battery is a conductor of electricity as well as a *producer*, and is a part of the circuit, and, therefore, bears its proportion of the resistance of the circuit. It is also called "internal resistance of the battery."

Second—The fundamental unit of time, and is equal to the time of one swing of a pendulum making 86,164.09

swings in a sideral day, or the 1-86,400 part of a mean solar day. A mean solar day is 24 hours.

Secondary Batteries—Batteries, which are acted upon by an external source of electricity in such a manner that they acquire the power to give out an electric current opposite in direction to that of the external source by which they were influenced. The cells of a secondary battery contain plates of the same kind of metal, usually lead.

Secondary Currents—The momentary waves of electricity excited by electro-dynamic induction in a conductor conveying a current, or in a neighboring one. The wave which accompanies the *closing* of the circuit is termed the *initial secondary*, and flows in the opposite direction to the inducting current; the other, which follows the *opening* of the circuit, is called the *terminal secondary*, and flows in the same direction as the current which induced it.

Shunt—A contrivance for leading by another route a part of the current, which, as a whole, may be too powerful for the immediate purpose. In this manner it diverts a definite portion of current aside.

Solenoid—An insulated copper wire bent in the form of a spiral, and having its ends bent backwards along the axis to the middle point and then bent upwards at right angles between two coils of the spiral. The typical solenoid of Ampere consists of an arrangement of circular (spiral) currents of infinitely small radius, placed side by side, so that the planes of all the circles are perpendicular to the line passing through their centers, which line is called the axis of the solenoid.

Sounder—That which exactly reproduces the movements of a telegraph key at the other end of the circuit, and by which the operator "takes" the message.

Specific Cravity—The ratio of the heaviness of a given substance to the heaviness of pure water, at a standard temperature, which in Britain is 62° Fahr.

Spring Jack—A device for easily inserting any loop into a line circuit, and is operated in conjunction with a wedge-connector.

Switch—An apparatus for the convenient intercharge of circuits, usually called a switch-board.

Tangent—A straight line which touches at any one point the circumference of a given circle.

Terrestrial Magnetism—The earth is a magnet, possessing a total magnetic power compared with that of a saturated steel bar of one pound in weight (according to Goss) as 8,464,000,000,000,000,000,000 to 1; which, supposing the magnetic force to be uniformly distributed, would be about six of such bars to every cubic yard.

Thermo-electricity—Electricity developed by the agency of heat.

Transmitter—That through which a telephone message is sent, or into which we speak in sending a message.

Typed—Written out in type letters by a type-writer.

Type-writer—A mechanism for writing in type letters; one who operates the type-writer.

Unit—The base of any system of measurement; as of length, which is the *foot*, and that of capacity, the gallon, etc. And as electricity has properties, it therefore has units. The unit of electro-motive force is called the *volt;* the unit of resistance, *ohm;* the unit of current streugth, *ampere;* the unit of capacity, *farad*, and the unit of quantity, *coulomb*.

Unit of Force—The force which, acting upon a mass of one gramme for one second, moves it one centimeter. It was adopted by the International Congress of Physicists, at Paris, in 1882, in connection with a "system of units," known as the centimeter-gramme-second, or C. G. S. System, so named from the units of length, mass and time. This Congress gave the name *Dyne* to the unit of force. It is also called "the absolute unit," and is the basis from which the electrical system of measurement is derived. Its symbols are C. G. S.

Unit of Heat—(English). The amount of heat required to raise one pound of water from 60° Fahr. to 61°.

Unit of Light—(English). The light of a spermaceti candle $\frac{7}{8}$ inch in diameter, burning 120 grains per hour. Six candles weigh one pound; (german) the light of a paraffine candle, 20 millimeters in diameter, burning with a flame 5 centimeters high.

Velocity—The *rate* of motion; electricity travels 288,000 miles per second.

Volt—The practical unit of electro-motive force or potential, named in honor of the Italian physicist, Volta, the original inventor of the primary battery. It is equivalent to 100,000,000 C. G. S., or absolute units of potential. The E. M. F. of one of Daniel's cells is equal to 1.08 Volt.

Voltaic or Galvanic Electricity—The name given to electricity evolved by chemical action; so called in honor of Volta and Galvani, two Italian philosophers. This is also called *Dynamical*, or *Current* electricity.

Watt—The electrical unit of power, as proposed by Sir William Siemens. It is equivalent to the volt-amperes. One English horse-power is equal to 746 volt-amperes.

Wheatstone Bridge—An electric bridge apparatus, including a rheostat and galvanometer with two keys, one to make and break the battery circuit, and the other to make and break the bridge wire circuit, forming a system of measurement of circuits whereby a galvanometer can be most advantageously employed.

Work—When a body is moved against any force opposing its motion, *work* is done, and its amount depends on the intensity of the force, and the distance through which it is overcome. Thus, if we lift a pound-weight one foot high against the force of gravity, we perform a definite amount of work. If we lift it twice as high we double the work, and so is work done in overcoming any force, such as the molecular forces of chemical attraction, magnetic force, etc., and the amount of this work is always expressed by the product of the force by the distance through which it is overcome. Work is, therefore, *the measure of the expenditure of energy*, or the transformation of energy from one form to another, and has reference solely to the amount of effort necessary to accomplish a given result, independent of time. Its symbol is W.

SYNOPSIS OF THE PRACTICAL ELECTRICAL UNITS.

Unit of	Symbol of	Name of Unit.	Derivation.	Value in C. G. S. Units.
E. M. F..	E.	Volt....	Ampere x ohm	10^{8}
Resistance	R.	Ohm ...	Volt ÷ ampere	10^{9}
Current ..	C.	Ampere	Volt ÷ ohm	10^{-1}
Quantity..	Q.	Coulomb	Amp. per second	10^{-1}
Capacity..	K.	Farad ..	Coulomb ÷ Volt	10^{-9}
Capacity..	K.	Micro-Farad ..	1 millionth farad	10^{-15}
Power....	P.	Watt...	Volt x ampere	10^{7}
Work, Heat, } ..	W.	Joule...	Volt x Coulomb Amp. x sec x ohm	10^{7} 10^{7}

Table of Weight.

	Grains Troy.	Pounds Avoirdupois.
1 Milligramme.......	0.015	....
1 Centigramme	0.154	....
1 Decigramme.......	1.543	....
1 Gramme	15,432	....
1 Killogramme.......	15,432.348	2.2046
2 Killogrammes......	....	4.4092
3 Killogrammes......	....	6.6138

7,000 grains Troy make one pound Avoirdupois.
1 Liter is 35.275 fluid ounces, or 1,764 pints.
1 Cubic Centimeter is .0610 cubic inches.
1 Liter is equal to 61.024 cubic inches.

Table of Lineal Measure.

	Inches.	Feet.	Yards.
1 Millimeter..........	0.39	....	....
1 Centimeter.........	0.393	....	....
1 Decimeter..........	3.937	....	....
1 Meter..............	39.370	3.280	1.093
1 Kilometer..........	39,370.790	3,280.899	1,093.633.

Relative Conductivities.

Each substance named conducts better than the one that follows it. No conductor is perfect.

Silver.
Copper.
Gold.
Zinc.
Platinum.
Iron.
Tin.
Lead.
Mercury.
Carbon.
Acids.
Saline Solutions.
Rarefied air.
Melting ice.
Distilled water.
Stone.
Dry ice.
Dry wood.
Porcelain.
Dry paper.
Wool.
Silk.
Glass.
Sealing wax.
Sulphur.
Resin.
Gutta-Percha.
India-Rubber.
Shellac.
Paraffine.
Ebonite.
Dry air.

Some Curious Features of Electricity and Magnetism.

The magnet, in the exercise of its attraction upon any substance, is equally attracted by that substance. There is no single or one-sided attraction, it is absolutely dualistic. The magnet seems to get back exactly what it gives and the substance gives exactly what it gets, but there is no attraction without its apparent exchange. All this is equally true with the electro-magnet. Commercially, the magnet operates on the *ad valorem* basis; its consideration in every transaction is an exact equivalent, or there is no trade; and morally, it invariably observes the golden rule, and does precisely as done by. There is a great deal of philosophy in a magnet.

When one kind of electricity is produced, there is always as much of the opposite kind produced. This is dualism again. Electricity does not like to be "alone;" in fact it never *is* alone, but invariably has its companion; it is two or none.

Electricity and magnetism, though in many respects similar, in many are dissimilar. Electricity likes to travel. Magnetism is decidedly averse to this. Electricity will go around the world eleven times in a second and enjoy it; magnetism cannot be induced to leave the house under any consideration whatever. Electricity is a rover, but magnetism is always at home.

A piece of green wood is a good conductor; let it be heated and dried, it becomes a non-conductor or insulator; let it be baked to charcoal, it becomes a good conductor again; burn it to ashes, and it becomes once more an insulator. The principal element in wood is carbon.

The current generated in a magneto-telephone is estimated by De la Rue not to exceed that which would be produced by one Daniell cell in a circuit of copper wire four millimeters in diameter, and of a length sufficient to go two hundred and ninety times around the earth.

The tenacity of a copper wire is diminished after an electric current has for sometime passed through it. In an iron wire the tenacity, in the same circumstances, increases.

The conducting power of carbon is much lower than the metals. Instead of decreasing, as in the metals, with a rise of temperature, it *increases!* With the metals, heat destroys the conducting power; with carbon it seems to produce it. Carbon is a very singular element in connection with electricity.

According to Faraday, so small a quantity of electricity is stored in a Leyden jar that the decomposition of a single grain of water required 800,000 discharges of his large Leyden battery! Static electricity is great in intensity, but of small quantity.

Electricity produces magnetism and magnetism produces electricity.

Wheatstone, after much industry with very delicate instruments, made up his mind that electricity has a velocity of 288,000 miles per second. Light travels 184,000 miles per second, and sound 1,140 feet in the same time!

Sulzyer, of Berlin, in 1762, is believed to have been the first who noticed the peculiar taste occasioned by a pieee of silver and a piece of lead when placed in contact with each other and with the tongue. Professor Siemens has remarked that we may yet be able, in some way, to produce food by electricify. He intimates that this is quite probable in certain departments.

When called upon to give his opinion concerning the nature of electricity, Faraday gave utterance to the following: "There was a time when I thought I knew something about the matter; but the longer I live, and the more carefully I study the subject, the more convinced I am of my total ignorance of the nature of electricity."

ELECTRIC SCIENCE FACTS.

Dropping a steel magnet or vibrating it in other ways diminishes its magnetism.

It is said that steel containing 12 per cent. of manganese cannot be magnetized.

Flames and currents of very hot air are good conductors of electricity. An electrified body placed near a flame soon loses its charge.

In charging a secondary battery the charging electro-motive force should not exceed the electro-motive force of the battery more than 5 per cent.

Lightning has an electro-motive force of 3,500,000 volts and a current of 14,000,000 amperes. The duration of the discharge of lightning is 1-20,000 of a second.

The resistance of copper rises about 0.21 per cent. for each degree of Fah. or about 0.38 for each degree Cent.

A lightning-rod is the seat of a continuous current so long as the earth at its base and the air at its apex are of different potentials.

The rate of transmission on Atlantic cables is eighteen words of five letters each per minute. With the "duplex" this rate of transmission is nearly doubled.

The effect of age and strong currents on German silver is to render it brittle. A similar change takes place in an alloy of gold and silver.

To obtain the number of turns of wire in an electro-magnet multiply the thickness of the coils by the length and divide by the diameter of the wire squared.

A test for the porosity of porous cells consists in filling the cell with clean water and taking the per cent. of leakage. The correct amount of leakage is 15 per cent. in twenty-four hours.

If the air had been as good a conductor of electricity as copper, says Prof. Alfred Daniell we would probably never have known anything about electricity, for our attention would never have been directed to any electrical phenomena.

A perfect vacuum is a perfect insulator. It is possible to exhaust a tube so perfectly that no electric machine can send a spark through the vacuous space, even when the space is only one contimeter.

For resistance coils, for moderately heavy currents, hoop iron, bent into zigzag shape, answers very well. One yard of hoop iron, $\frac{1}{2}$ inch wide and 1-32 inch thick, measures about 1-100 of an ohm; consequently 100 yards will be required to measure an ohm.

The voltage of a secondary battery must always be equal to or slightly in excess of the voltage of the lamp to be burned. For example, a twenty volt lamp will require ten secondary cells, but ten cells will supply more than twenty lamps.

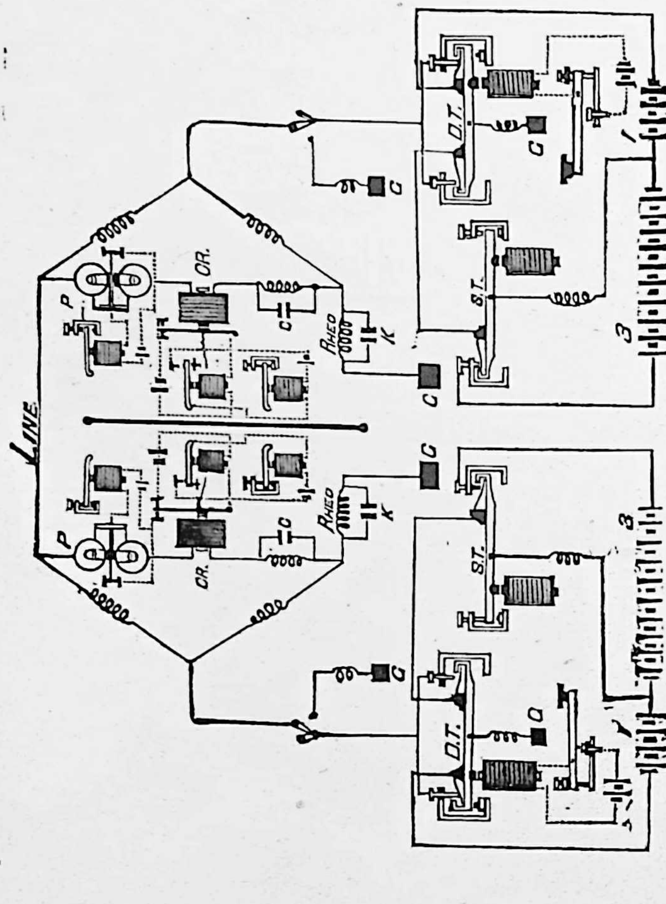
Compression of air increases its dielectric strength. Cailletet found that dry air compressed to a pressure of forty or fifty atmospheres resisted the passage through it of a spark from a powerful induction coil, while the discharge points were only 0.05 centimeter apart.

An accumulator with seventeen plates, 10x12 inches, is reckoned, in horse-power hours, equal to about one horse-power hour. Taking this as a basis it will require six cells for one horse-power for six hours, or thirty cells for five horse-power for the same length of time.

Recapitulation of Diagrams

ILLUSTRATING

EDISON'S INVENTIONS.



The Quadruplex.

D T, Double Transmitter; S T, Second or Single Transmitter; P, Polarized Relay; C R, Common Relay; C, Condenser; G, Ground; 1 and 3 Batteries.

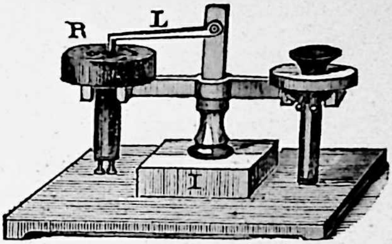


Fig. 5; Lever Signal.

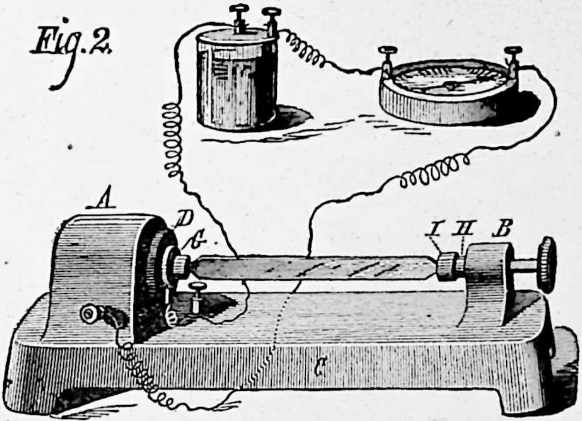
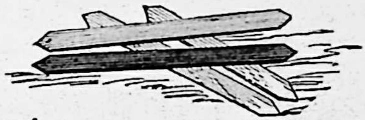
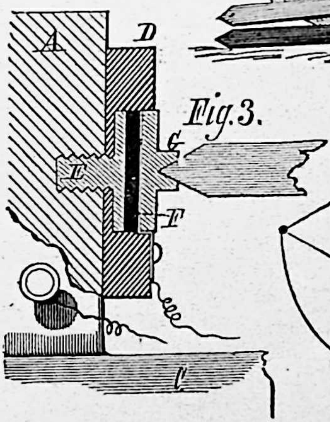


Fig. 12; Micro-Tasimeter in perspective.





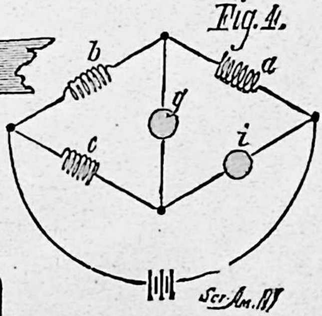


Fig. 13; Micro-Tasimeter in section.

Fig. 14; Micro-Tasimeter in circuit.

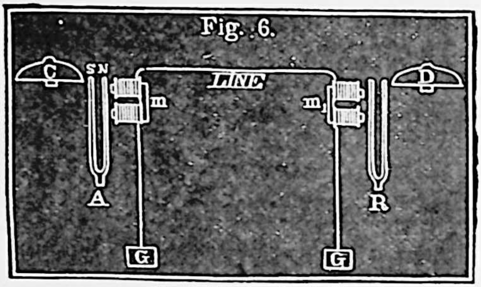


Fig. 6; Tuning Fork Signal.

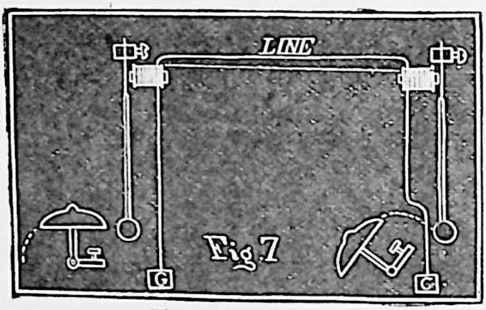


Fig. 7; Pendulum Signal.

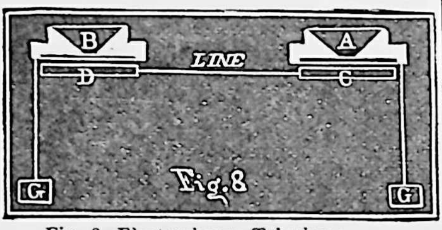


Fig. 8; Electrophorus Telephone.

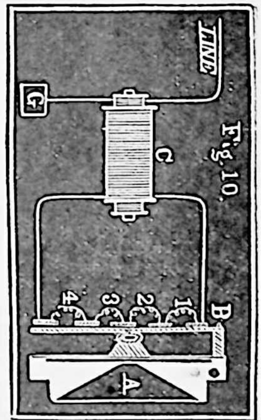


Fig. 10; Electro-Mechanica Telephone.

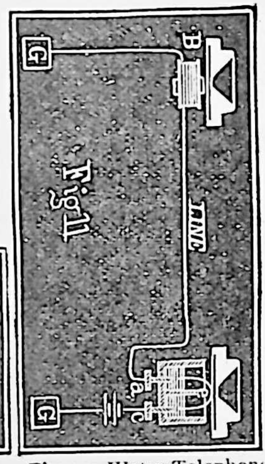


Fig. 11; Water Telephone

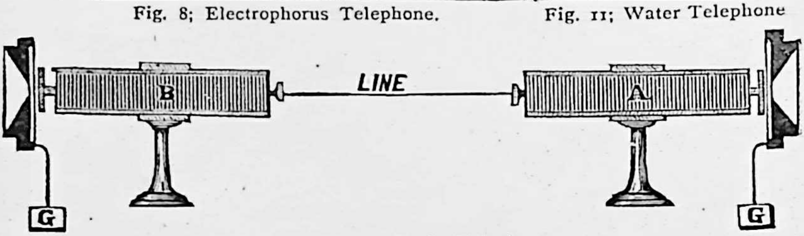
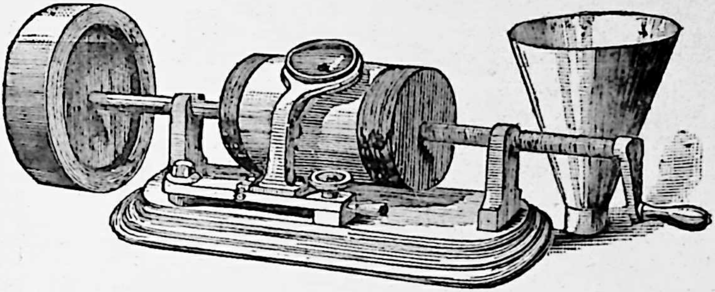


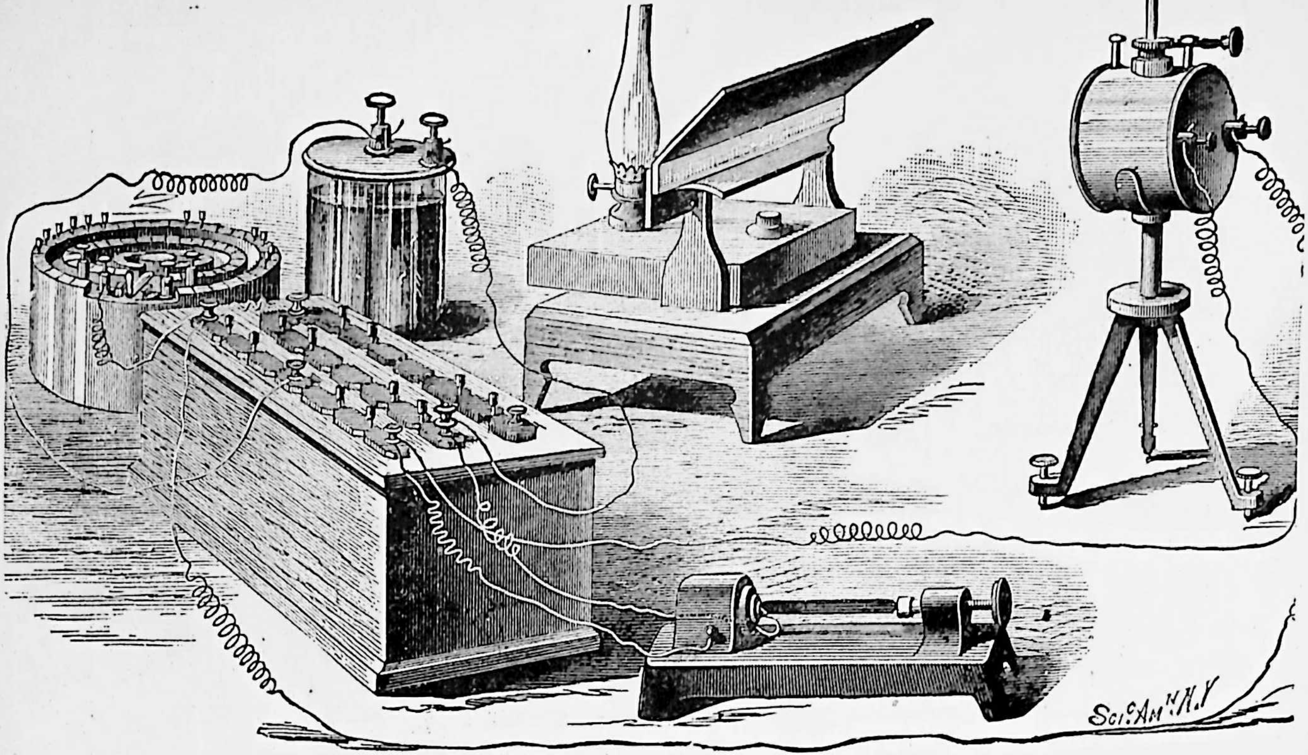
Fig. 9; Electro-Static Telephone.



The Phonograph.

The Phonograph in operation.

Phonographic Records under the Microscop.



EDISON'S MICRO-TASIMETER.

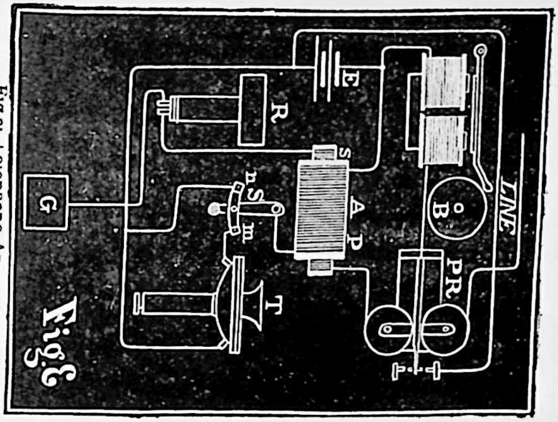
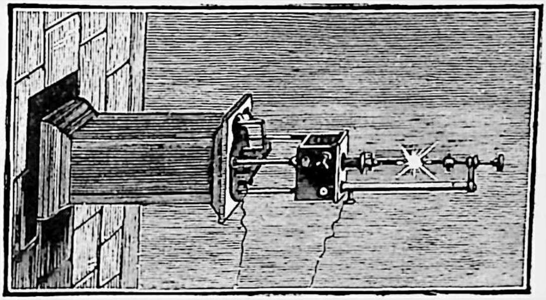


Fig 3: Telephone Apparatus.



Electric Light.

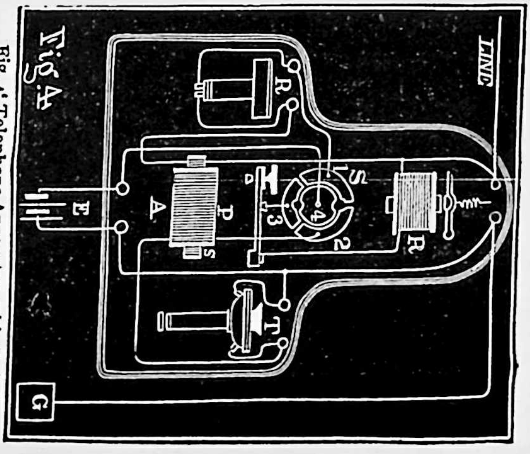
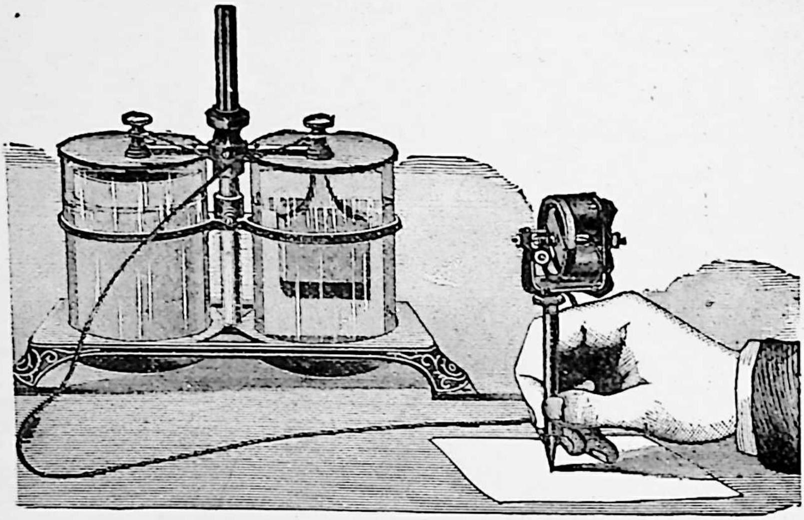


Fig. 4: Telephone Apparatus, with Switch.



Edison's Electric Pen.

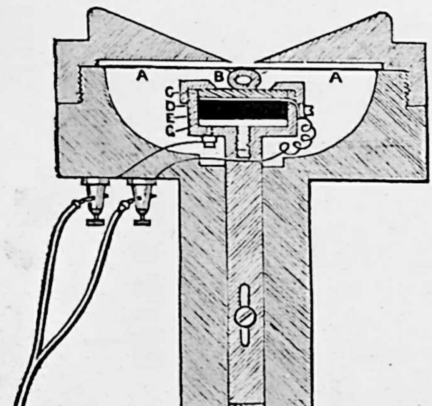


Fig. 1.

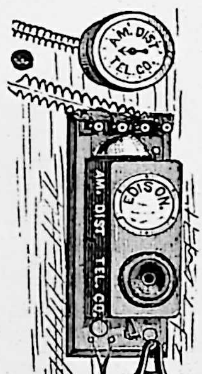
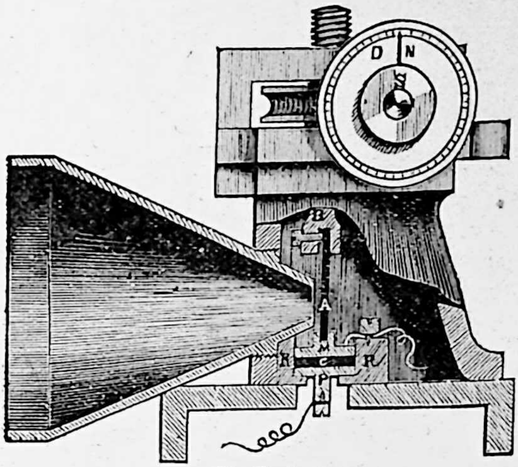


Fig. 2.

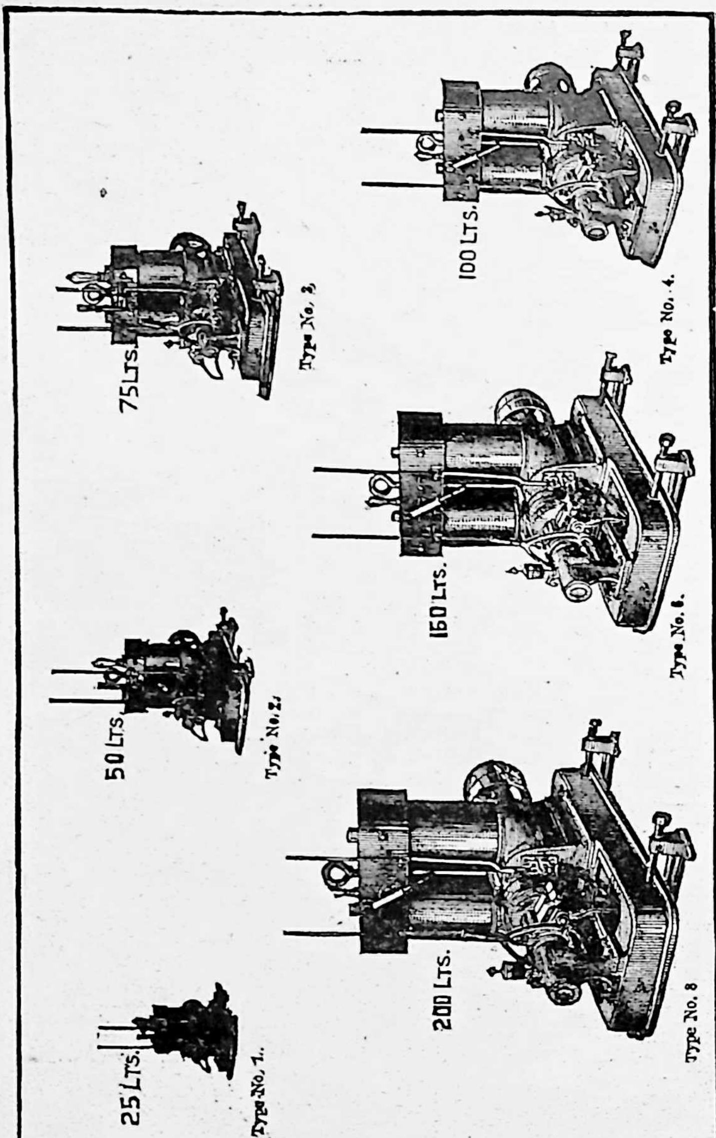
Fig. 1. Carbon Telephone—Interior. AA, Iron Diaphragm; B, India Rubber; C, Ivory; D, Platina Plate; E, Carbon Disk; G, Platina Screw.

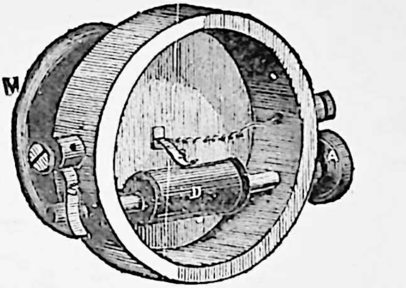
Fig. 2. Exterior View of Edison's Telephone.



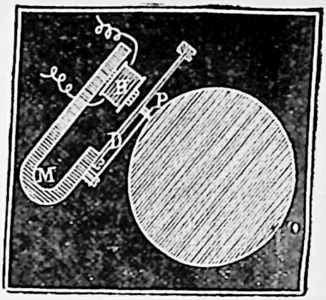
The Tasimeter.

The Phonometer.

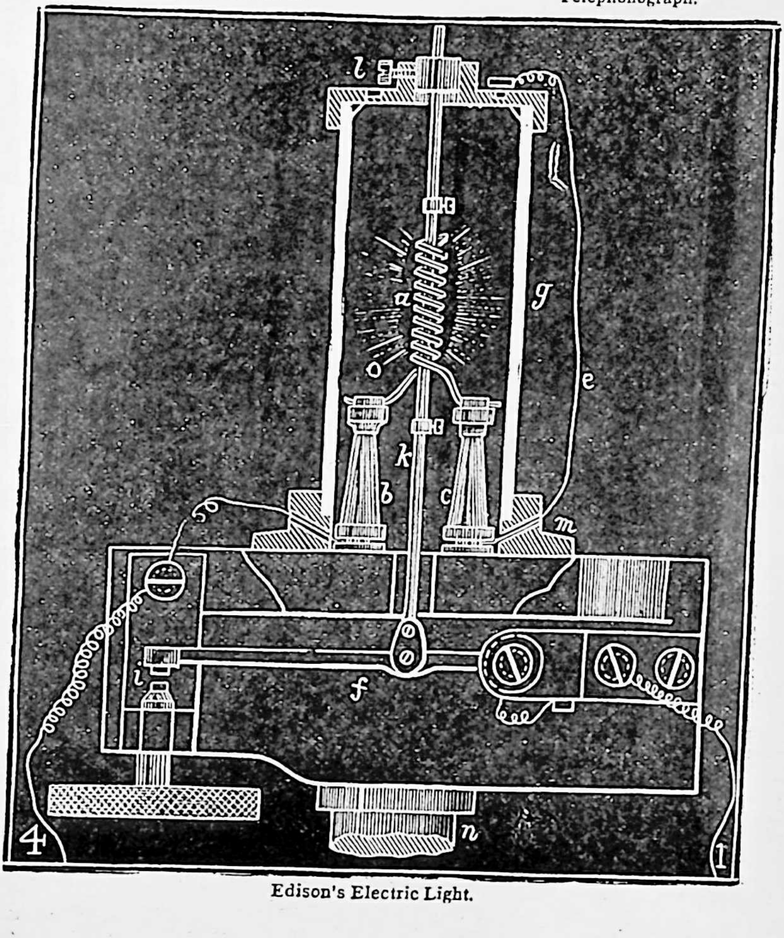

25 LTS.
Type No. 1.
50 LTS.
Type No. 2.
75 LTS.
Type No. 3.
100 LTS.
Type No. 4.
150 LTS.
Type No. 6.
200 LTS.
Type No. 8



M etograph Receiver.



Telephonograph.



Edison's Electric Light.

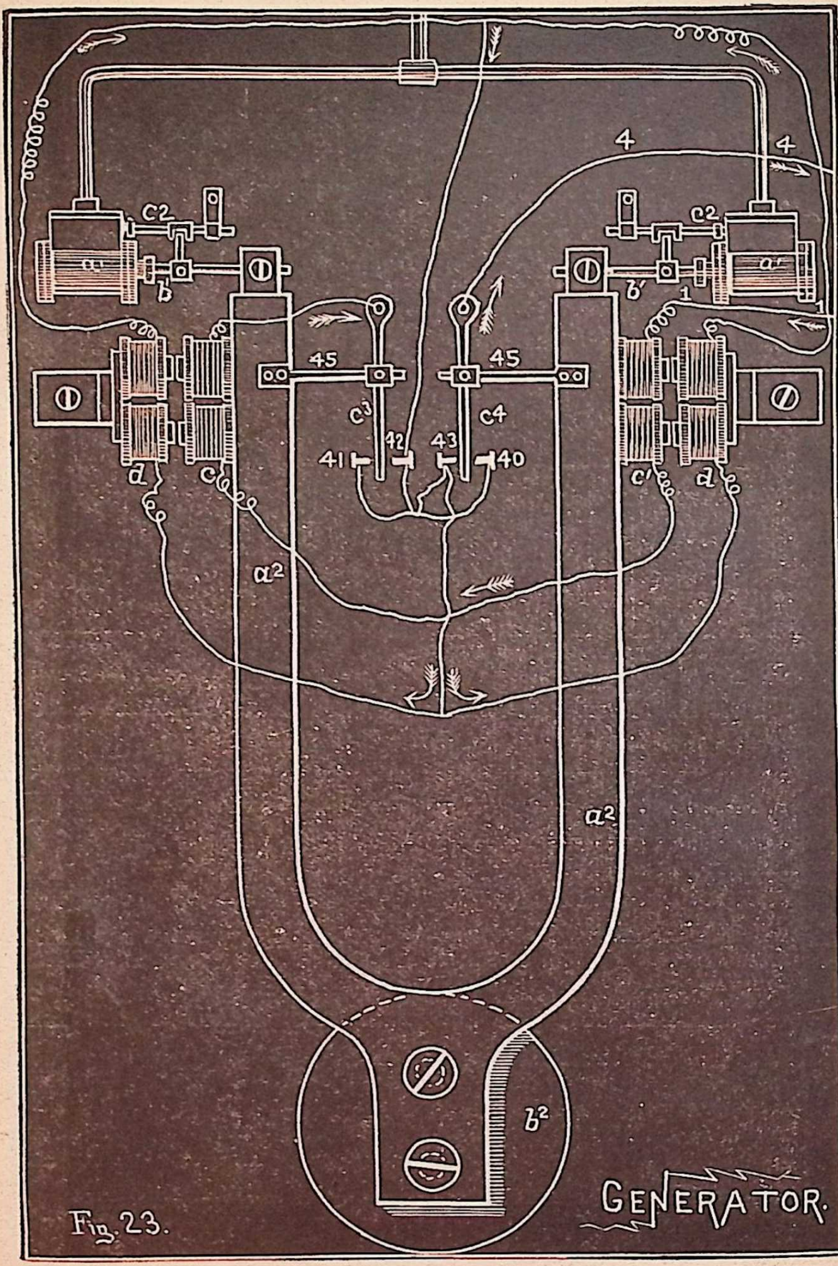
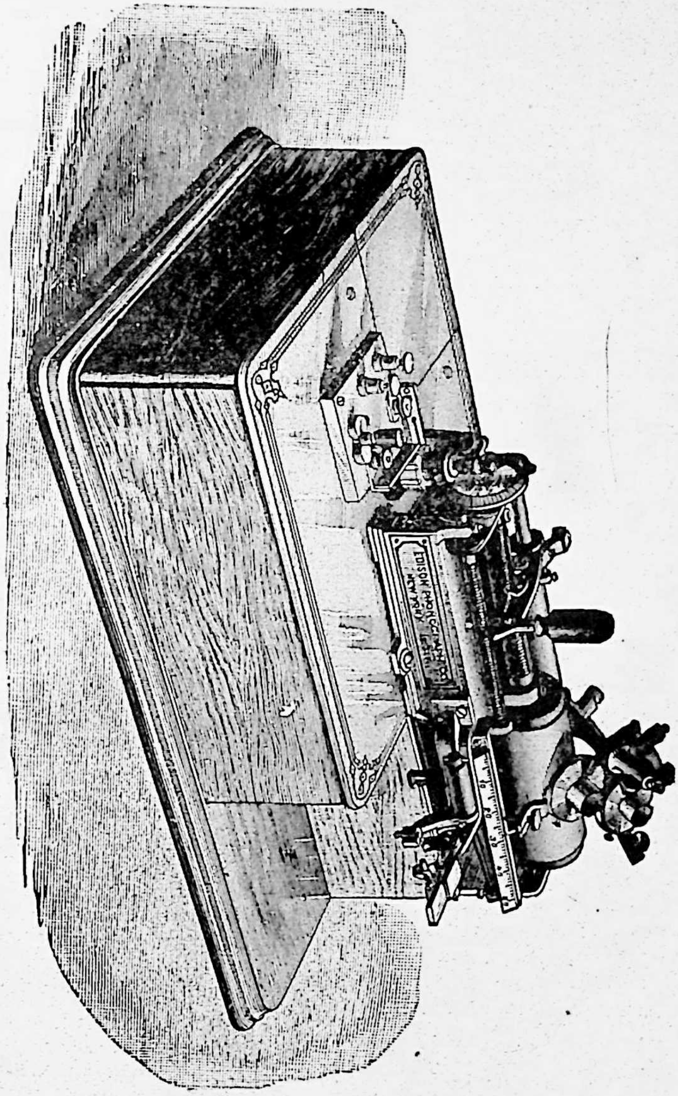


Fig. 23.



Edison's New and Perfected Phonograph.

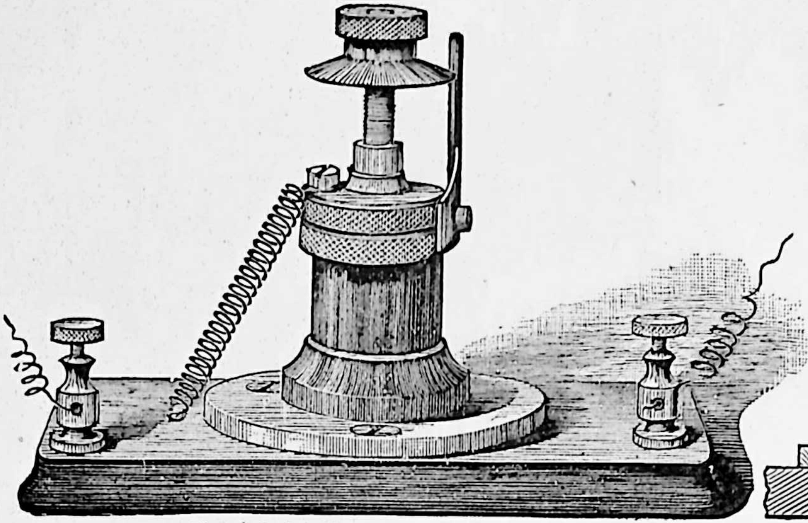


Fig. 16; Carbon Rheostat (in perspective.)

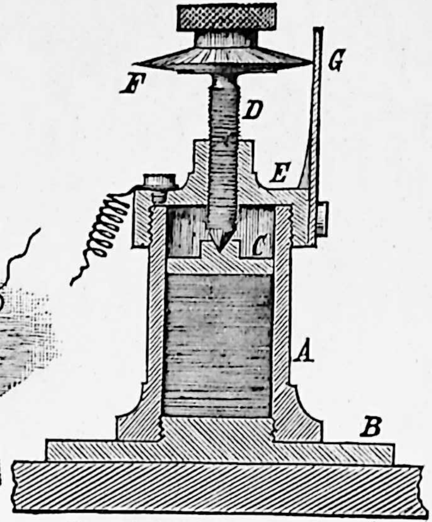
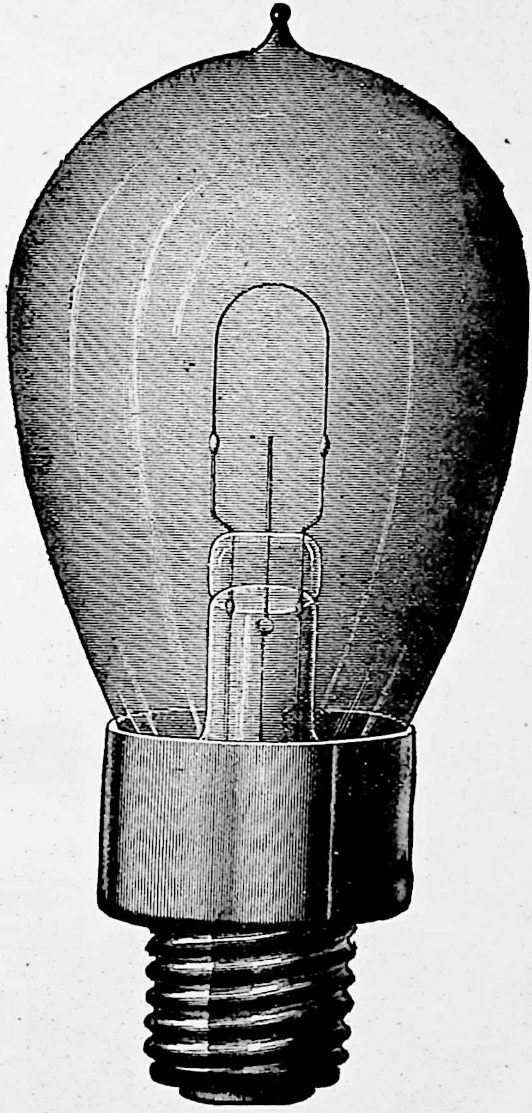
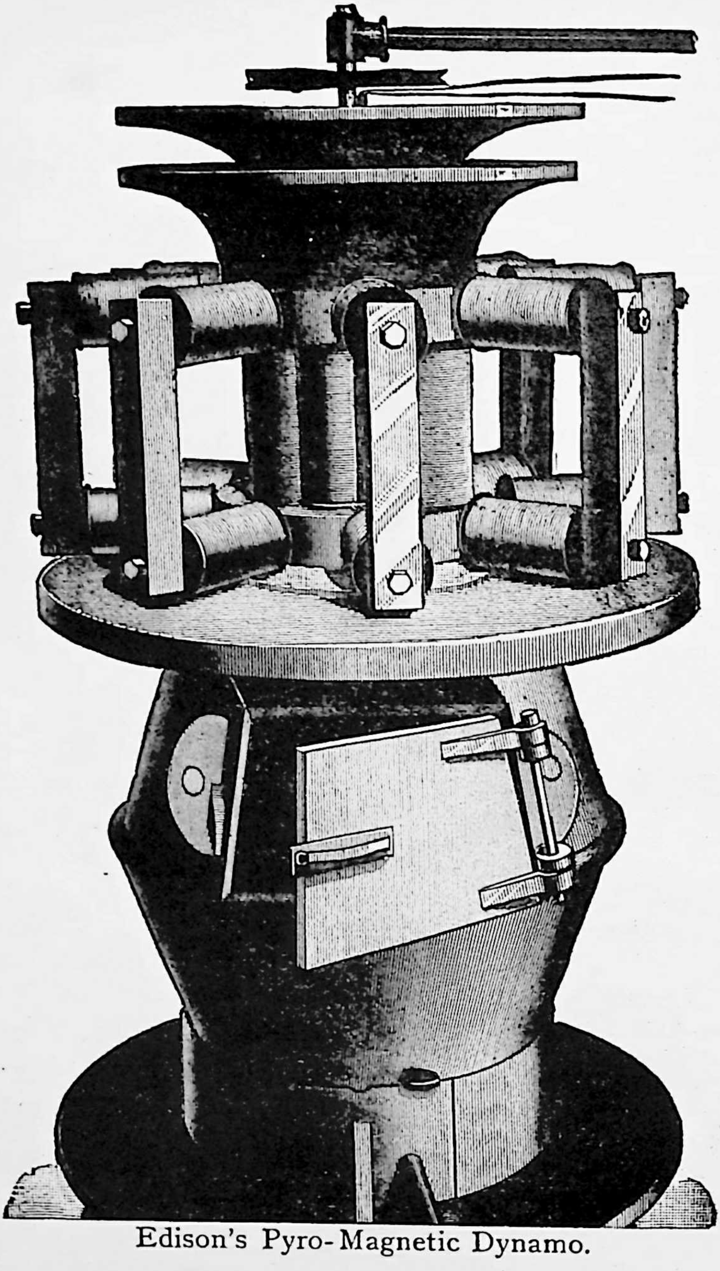


Fig. 17; Carbon Rheostat (in section.)



The Edison Municipal Incandescent Lamp.



Edison's Pyro-Magnetic Dynamo.

PUBLISHED BY

RHODES & McCLURE PUBLISHING CO.

93 Washington Street, . CHICAGO.

All handsomely bound in the best English and American cloths, with full silver embossed side and back stamp; uniform in style of binding. Together making a handsome library, or, separately, making handsome center table volumes.

Price, $1.00 each. Sent postpaid.

ABRAHAM LINCOLN'S STORIES AND SPEECHES; in one volume, complete; new 1895 edition; handsomely illustrated; 473 pages. Containing the many witty, pointed and unequalled stories as told by Mr. Lincoln, including Early life [illegible]; Professional life stories; White House and War stories; also presenting the full text of the popular Speeches of Mr. Lincoln on the great questions of the age, including his "First Political Speech;" "Rail Splitting Speech;" 'Great Debate with Douglas;" and his Wonderful Speech at Gettysburg; etc., etc.; and including his two great Inaugurals, with many grand illustrations. An instructive and valuable Book,

MOODY'S ANECDOTES; 210 pages. Containing several hundred interesting stories, told by the great evangelist, D. L. Moody, in his wonderful work in Europe and America. Hundreds of thousands of copies have been sold. Illustrated with excellent engravings of Messrs. Moody, Sankey, Whittle and Bliss. "A book of anecdotes which have thrilled hundreds of thousands."—*Pittsburg Banner.*

SAM JONES' SERMONS, Vol. I; 346 pages. SAM JONES' SERMONS, Vol. II; 340 pages. Sam Jones is pronounced "one of the most sensational preachers in the world, and yet among the most effective." His sermons are characterized by clearness, point and great common sense, including "hits" that ring like guns. Printed in large type, and illustrated with engravings of Sam Jones and Sam Small; complete in two volumes.

SAM JONES' ANECDOTES; 300 pages. An exceedingly interesting and entertaining volume, containing the many telling and effective stories told by Mr. Jones in his sermons. They strike in all directions, and always impart good moral lessons that cannot be misunderstood. Adapted for the young and old. A book which everybody can enjoy.

MISTAKES OF INGERSOLL; and His Answers complete; newly revised popular (1895) edition; illustrated; 482 pages. Containing the full replies of Prof. Swing, Judge Black, J. Munro Gibson, D. D., Chaplain McCabe, Bishop Cheney, Dr. Thomas, Dr. Maclauglan, Dr. Goodwin and other eminent Scholars, to Ingersoll's Lectures on the "Mistakes of Moses," "Skulls," "What Shall We Do to be Saved?" and "Thomas Paine," to which is appended in full these Ingersoll lectures and his replies. A fair presentation of the full discussion.

GREAT SPEECHES OF COL. R. G. INGERSOLL; complete; newly revised (1895) edition; 409 pages. Containing the many eloquent, timely, practical speeches of this most gifted orator and statesman; including his recent matchless 'Eulogy on Abraham Lincoln"; "Speech on the Declaration of Independence"; "To the Farmers on Farming"; "Funeral Oration at his Brother's Grave," etc., etc.; fully and handsomely illustrated.

Standard Publications, $1.00 each, bound in Cloth.

WIT, WISDOM AND ELOQUENCE OF COL. R. G. INGERSOLL; newly revised popular (1895) edition; illustrated; 336 pages. Containing the remarkable Witticisms, terse, pungent and sarcastic sayings, and eloquent extracts on popular themes, from Ingersoll's Speeches; a very entertaining volume.

GEMS OF TRUTH AND BEAUTY; 300 pages. A choice selection of wise, eloquent extracts, from Talmage, Beecher, Moody, Spurgeon, Guthrie and Parker, forming a volume that keenly interests. A good gift and center table book. Illustrated.

TEN YEARS A COW-BOY; 471 pages. A full and vivid description of frontier life, including romance, adventure, and all the varied experiences incident to a life on the plains as cow-boy, stock owner, rancher, etc., together with articles on cattle and sheep raising, how to make money, description of the plains, etc., etc. Copiously illustrated.

FORBIDDEN FRUIT; 310 pages. A truthful, instructive, pleasing and poetical presentation of Biblical stories, history and gospel truth; fully and handsomely illustrated from the world-renowned artist Gustav Dore; by E. U, Cook; the whole forming an exceedingly interesting and entertaining poetical Bible. One of the handsomest volumes ever issued in Chicago.

GEMS OF POETRY; 407 pages; finely illustrated. Contains a very choice and varied selection of our most popular, beautiful and time-honored poems, written by the poets of all ages and climes. A magnificent gift book for a friend; a splendid book for the holidays; appropriate for a birthday or wedding present; a fine center table book, interesting to all.

THE FIRST MORTGAGE. A finely written and fully and most elegantly illustrated volume of 300 pages, in which all trials, difficulties and sorrows of life are represented as the result of a mortgage. How this mortgage is finally and fully cancelled. A book at once entertaining and elevating.

EVILS OF THE CITIES; By T. DeWitt Talmage, D. D.; 530 pages. The author, in company with the proper detectives, visited many of the most vile and wicked places in New York City and Brooklyn, ostensibly looking for a thief, but in reality taking notes for a series of discourses published in this volume, which contains a full and graphic description of what he saw and the lessons drawn therefrom. The Doctor has also extended his observations to the "Summer Resorts," "Watering Places," Races, etc., etc , all of which are popularized from his standpoint in this volume. Handsomely illustrated and decidedly interesting.

TALMAGE IN THE HOLY LAND; 322 pages. The Palestine Sermons of T. DeWitt Talmage, delivered during his tour of the Holy Land. Including graphic descriptions of Sacred Places, Vivid Delineations of Gospel Truths, interesting local reminiscences, etc., etc., by his visit to the many places made sacred by the personal presence of Jesus Christ, and the great pens of Biblical characters and writers. Copiously illustrated.

Standard Library, 25 Cent Edition.

BEN-ONI; OR, A TALE OF THE FOURTH CENTURY; by Douglas Vernon 330 pages. A book of love and romance, in which the fidelity of the beautiful Princess Serapta for the worthy Prince Ben-Oni remains unshaken amid all temptations and intrigues which so signally characterized the age of Constantine. A decidedly readable book.

THE WORLD'S EULOGIES ON PRESIDNET GARFIELD; 254 pages. This volume contains some of the most eloquent and pathetic words that have ever fallen from the lips of man, called forth by the life and death of one whose career, from the Cabin to the White House, forms the brightest pages in human history.

EVERY-DAY COOK BOOK AND ENCYCLOPEDIA of Practical Receipts for Family Use; by Miss E. Neill. Economical, reliable and excellent. 324 pages.

NAZER. A novel of the Passions, Love, Hate, Truth, Hypocrisy, Wit and Despair personified. By Col. John A. Joyce.

LET 'ER GO GALLAGHER OF TEXAS. A story of the adventures of a Texan, not only on the plains but in the larger cities. By A. Nestor Gallagher.

A TRAMP'S ADVENTURES. Containing the wonderful adventures of an adventurous tramp from boyhood to the grave. Illustrated.

HIT AND MISS; OR, THE MYSTERY OF NELLIE CLARE. By A. Stewart Manly. 428 pages. Contains the wonderful history and life struggles of a girl, kidnapped when a child; left to battle the cold world by herself; thrilling incidents and adventures of her life with final triumph. A story that will hold and interest the reader from beginning to end.

OKLAHOMA BOOMER'S LIFE; 358 pages. Contains full account of the adventures of a boomer determined to settle in this country before the proclamation opening it for a settlement; his adventures with the Indians, cowboys and soldiers; also, full description of this beautiful land.

CHICAGO: History, Stories and Strangers' Guide; 400 pages.

ENTERTAINING ANECDOTES; 240 pages. From all available sources.

THE WORLD'S WIT AND WITS; 340 pages. Sketches from Mark Twain and others.

PHIL JOHNSON'S LIFE ON THE PLAINS; 358 pages.

TWO THOUSAND JOKES AND JESTS: 446 pages.

MR. MEESON'S WILL. A novel, by H. Rider Haggard.

STORIES AND SKETCHES OF GEN. GRANT, at Home, Abroad, in Peace and in War; 8vo., 247 pages; illustrated.

Many children who are now being educated by signs, have sufficient hearing to be taught with the Audiphone articulate speech instead. Truly yours.

Paris France
Dec 1st 1880

R. S. Rhodes

WORLD

Jan 18/96

Edison speaks from the past

Century-old recording carries voice of genius

By Ted Anthony
The Associated Press

WEST ORANGE, New Jersey

Through the scratchy crackle of a decaying wax cylinder comes a muffled yet vigorous voice — an ethereal message left by the inventor whose genius allowed history's sounds to endure.

He talks of global adventures, of trips on boats and trains to far-flung lands, of technologies barely thought possible.

Thomas Edison, whose phonograph allowed astonished men and women to speak to posterity for the first time, has managed to reach from the 19th century and surprise people with his creation yet again.

A previously unknown 1888 cylinder found at the museum that was once his laboratory contains the oldest rendering of his voice known to exist. It reveals an Edison far different from later, more familiar recordings.

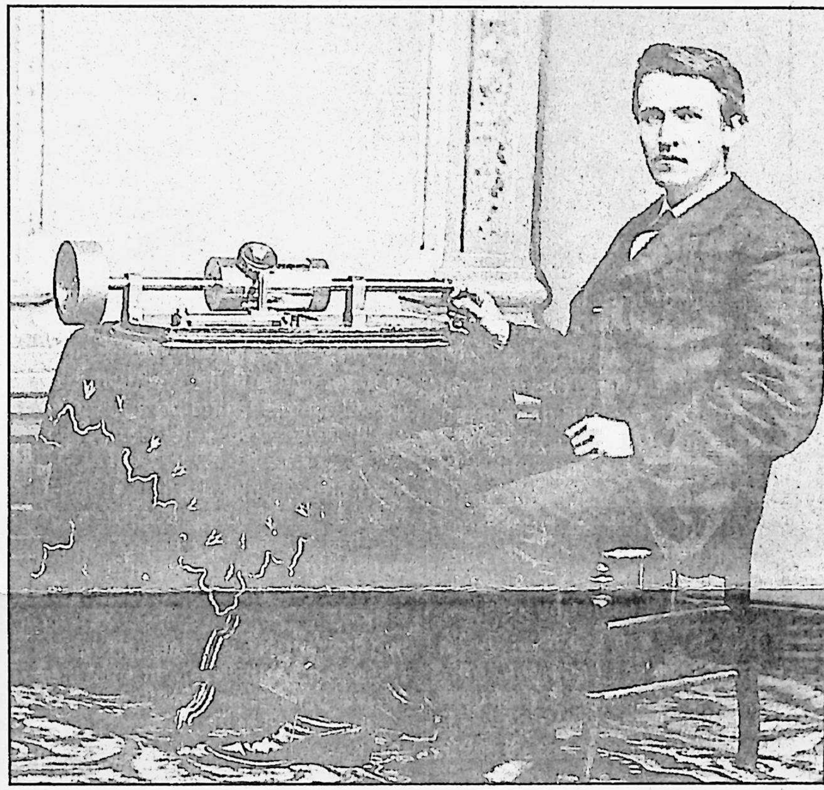
This is not the aging businessman-legend speaking, but the vibrant, freshly famous "Wizard of Menlo Park." Edison was 41, flush with the excitement of new inventions, on the cusp of changing society.

"He sounds like a man taking on the world," says Jerry Fabris, sound curator at the Edison National Historic Site, who heard the 154-second recording when it was first played in August.

In it, Edison addresses a "Mr. Blaine," apparently James Gillespie Blaine, a congressman, 1884 presidential candidate and secretary of state. Edison sounds jaunty, whimsical, aware of his once-in-an-epoch mix of pragmatism and technical genius.

"Mr. Blaine, as you've been nearly round the world, I'll take you round the world on the phonograph. I'll not charge you anything." Edison's voice is high-pitched, laced with an unidentifiable brogue.

He goes on to describe a journey that starts with a steamer trip across the Atlantic Ocean to Liverpool and winds through Europe, northern Africa and Asia before returning by train across the United States to New York.



—CP photo

FAVORITE INVENTION: Edison with an early version of the phonograph in 1878, the year after he invented it

Until now, the earliest known recording of Edison's voice was from 1906, when he was 59. The newly found one was recorded shortly after Edison moved to West Orange in 1887 from his workshop in Menlo Park, New Jersey (now called Edison, New Jersey).

The discovery is a cream-colored, 10-centimetre-long wax cylinder, about the size and shape of an empty toilet paper roll. It had been on the grounds all along, but when Edison died in 1931 nobody went through all his material.

He left five million documents, 25,000 flat records, 10,000 cylinders, 65,000 photos and 500,000 miscellaneous items. All went into storage. A cataloguing project began in 1993. But preservation took precedence, and Fabris spent two years putting the material into archival-quality storage so it wouldn't decay further. He began recording cylinders only recently.

He expected a few disjointed words to emerge from the static of decay on the long-forgotten cylinder. Instead, out came Edison — clear and uninterrupted.

"We'd never heard anything like this before," Fabris says. "This is Edison at the peak of his creative years. You hear a very energetic person, a very bold person talking about sending his ideas around the world. On the later ones, he sounds usually very weak. They're greetings — saying hello to the country or Merry Christmas, things like that."

Edison first recorded sound in 1877, using a foil cylinder. But he spent the next decade on the light bulb before returning to the phonograph, his favorite invention, and perfecting a wax-cylinder model in June 1888.

Fabris believes the newly found recording, one of the earliest in existence, was made months afterward.