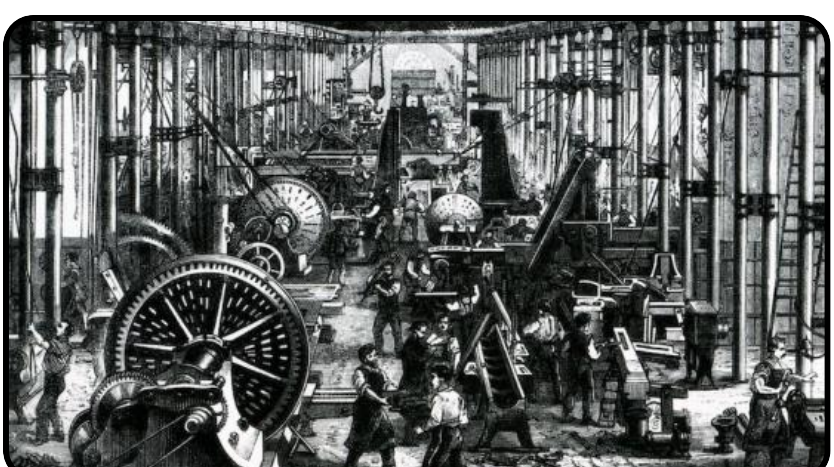
Modern Industrial Progress

by Charles H Ochrane



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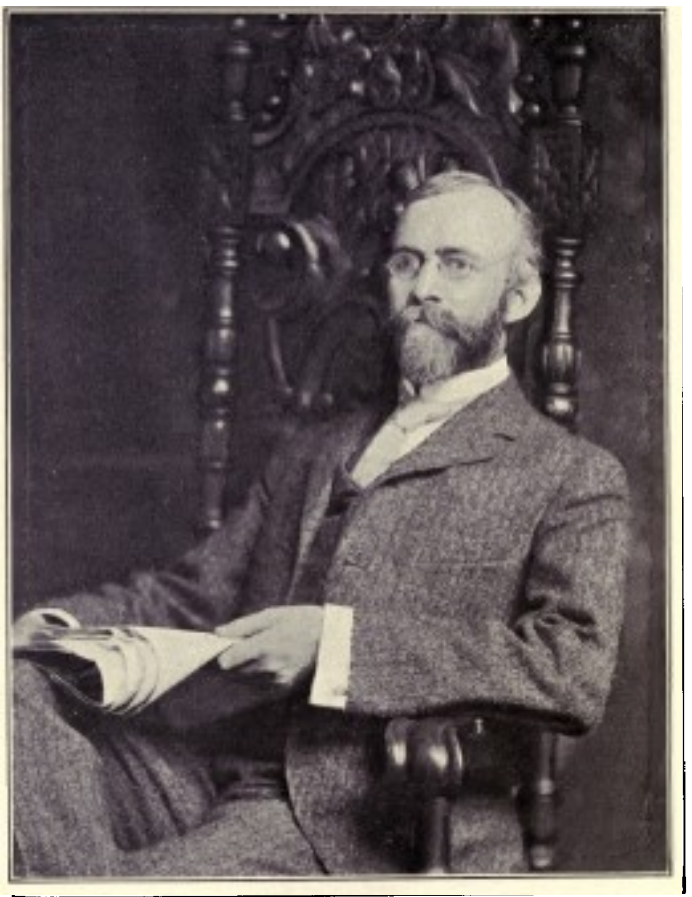


Yours for progression,

Chas. H. Cochrane.

PREFACE

WE live in a world of wonders, and each one's life is of necessity so hemmed in by circumstances that none can see much beyond the horizon of his own habitat. We recognize the progress of an industry that comes within our own experience, but we know little of those with which we are not in personal contact. The pressman who clamps the plates upon a modern lightning news- paper press does not see anything very startling or interesting in the work; the man who pulls levers in the pulpit of a great steel- works is not apt to recognize that there has been marvellous prog- ress in that line of manufacturing; the attendant on a bottle- blowing machine has learned to take his work as a matter of course--- and so we find it through the entire list of trades and occupations. Yet each of these men is at times impressed with the remarkable advances made in some industry other than his own, because such knowledge comes to one, as it were, suddenly, and not by the almost imperceptible movement that marks progress in the work that is familiar. The means that have brought about industrial development are worth studying. In the eighteenth century England was the one great centre of mechanical progress. She manufactured not only for Great Britain and her colonies, but for practically all other important civilized portions of the globe. Early emigrants to America did not bring with them the tools of their trades, excepting those of the simplest character. The laws of England expressly forbade the exportation of tools and machines for manufacturing, or the taking of skilled workmen to the colonies. Her statesmen desired to retain for Great Britain the position of manufacturer and supply-house for the world. Wise and laudable as was this purpose, from a strictly British point of view, the means

employed in the seventeenth and eighteenth centuries to guard England's exclusive position in mechanics and manufacturing were a prime cause of American supremacy in several industries in the nineteenth and twentieth centuries. For many years the restrictive laws tended to the advantage of Britain, but little by little the secrets of machine tools and methods of manufacture extended more and more to the United States, Germany, France, and other countries. The immigrant weaver who sought to follow his trade in the New World a hun- dred or more years ago, when without a loom built one; the printer who wished to issue a newspaper· usually had to construct his own press;. the tanner had to make his own vats, and the currier to fashion his own beaming knife and table; and so on through the various trades and arts. What was the natural result? Necessity quickened ingenuity, and those who thus built from the raw material introduced improve- ments into the machines that they made for their own use, and, while their first work was usually crude, it often contained the germs of better things than had ever been contrived at the original centre of machine development. It was this lack of imported ma- chines that caused American machine builders to branch out in new lines, resulting in the development of a race of mechanicians that have revolutionized construction in numerous industries, and are largely responsible for bringing about the modern rapid advances in all kinds of machinery and manufacturing processes. This is why American steel-mills are the wonder of the world; this is why we send more ore through the locks of Sault Ste. Marie Canal, on Lake Superior, than all Europe sends of all sorts of freight through the Suez Canal; this is why we mine coal in Penn- sylvania at twice the speed it is taken out at New Castle; this is why American printing machines are used to produce the great newspapers of Europe; this is why American factory-made shoes are worn in China, India, and

South Africa; this is why we make tin and teme plate better and cheaper than in Wales; this is why Swiss watches no longer sell in America; and why the cargoes of cut nails that used to sail westward are replaced by cargoes of wire nails that steam to the east. There is another side to this picture. America has not yet won all the prizes in the industrial world. Her ship-building in- dustry might nearly as well be in the depths of the Pacific. We can hold the America cup at every trial, but we cannot hold a candle beside the beacon lights that illumine the ship-yards on the Clyde. Our native wines sell at half a dollar a bottle, while the foreign article commands four dollars. We can burn out our stomach linings with our own Kentucky whiskey, but we have to go to France and Italy for our light wines. Santos Dumont flew around the Eiffel Tower while our own Langley machine tumbled into the Potomac. To France we had to go to learn how to build automobiles and to Hungary to learn how to mill flour. No armed and muscled warrior ever sprang full-grown from his cradle, and no giant industry has ever come into being. in a ( ) year or a decade. it takes time to develop the machinery and acquaint the world with the advantages of a new aid to manu- facturing, commerce, civilization, or human comfort. The signal- fires on Sparta's hills were but the forerunners of Marconi's wire- less telegraph. The stone axes of the cave-dwellers were the first types of the wonderful carving and sculpturing machines of the twentieth century. Electricity had its Franklin as well as its Edi- son. The Damascus blade had to come before the dynamite gun, and Gutenberg with his movable types was needed to lay the foun- dations for the wonderful presses and machines that roll out our modern mammoth editions of daily newspapers. It goes without saying that this book is not a complete record of the world's industrial progress, because in the nature of things a single volume does not afford the space for so vast a record.it is only possible to

select some of the more prominent industries, and to point out the strides by which they have advanced to their present proportions. vVhile America is now at the fore of industrial progress in many lines, owing to the conditions described, it is questionable whether she can hope to retain her lead, as many of the causes that led to the upbuilding of our industries are sure to be repeated with increased force in those other quarters of the globe that are opening up to progress and civilization, and which we have been pleased to think of heretofore as benighted regions. He who reads the chapter describing railway progress in Africa, China, Asia, Aus- tralia, etc., can hardly fail to be impressed with the idea that no man can measure the possibilities of their industrial growth. Who can say that at the close of the twentieth century Darkest Africa may not be underselling us in our home markets? Who can be sure that in the development of China and the East there may not come an industrial supremacy that shall pale our light? How can we know that there are not now in far-off Australia some prat- tling Newtons, Faradays, and Roentgens who will paralyze our industries by new discoveries? Perhaps from the hills of old Peru or the broad acres of Brazil may spring new and better conditions that will leave the United States tottering along as a tail-ender in the race. To-day the industry is exceptional in which there has not been an entire alteration and renewal in the machinery used within fif- teen years. Machines have to be thrown into the scrap- heap more often because they are too slow and out of date rather than that they are worn out. Invention has been stimulated to a degree here- tofore unknown, and the rewards obtained by the sale of improved machinery are so great in many cases as to stimulate experiment to a surprising degree, so much so that it has been remarked in more than one field of industry that more money has been spent in trying to improve machines than has .been made by their operation. A preface is usually a word of

apology, and, although it takes first position in a book, it is written last. I opine that the reason why the average preface takes the apologetic tone is that the aver- age author at the close of his work comes to feel how inadequately he has performed his task. In my own case it is with mingled feelings of pride for America's position in the world of industry, and regret that I have been unable to present it in more complete and elaborate form, that I lay down my pen and resign this work to the mercies of the reading public.

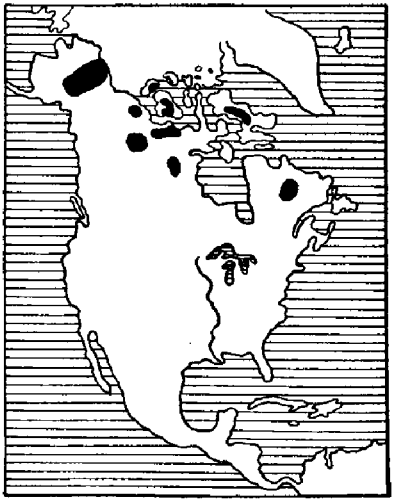
Charles H. Cochrane.
New York,
December 3, 1904

INTRODUCTORY

COULD George Washington, who died in December, 1799, have returned to the world in this twentieth century, he would find in America a land comparable with those portrayed in the Arabian Nights, while every other quarter of the globe also scintillated the wonderful progress wrought by the march of what we call industries. It is not the geographers who have changed the maps of the continent as here illustrated, but the mechanics, and manufacturers, and merchants, who,



North America in 1800.

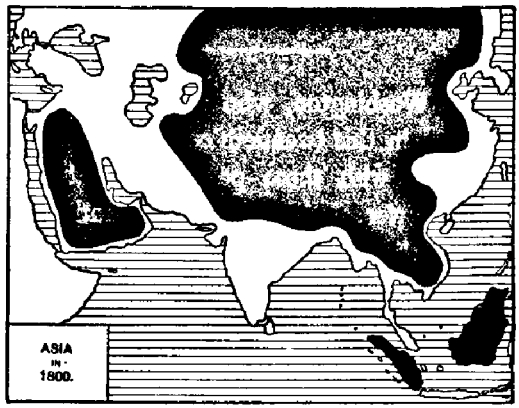


North America in 1900.

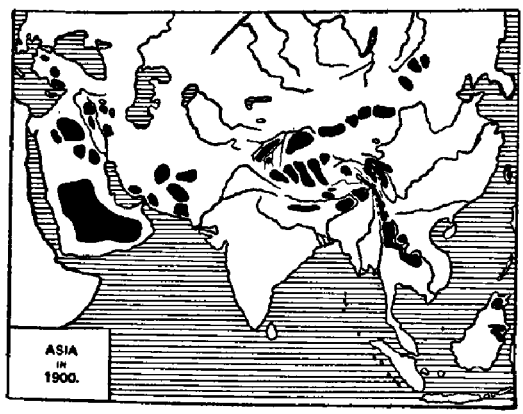
in their efforts to advance their own interests, have built giant industries that have literally altered conditions from pole to pole.

Our Washington did not know what it was to ride in a railway train, or to read a live morning newspaper; he received no telegrams, and wrote his letters with a quill pen; he never slept in a steam-heated room, nor wore a pair of machine-made shoes. Nearly all the things that we of to-day regard as necessities were to him utterly unknown.

But he gave us the chance to make America what it is, the leader of the world's industries, and so we have profited by the foundation-stones he laid, and therefore revere his memory.

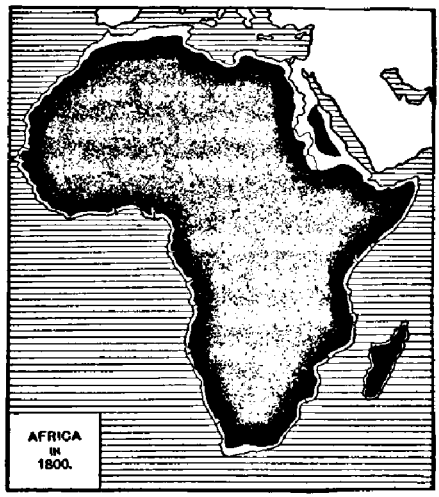


When we look on these maps, and see North America as it was and as it is, Asia as it was and is, and Africa as it was and is, we cannot but realize that the civilization of the world has just begun, and that education is only now reaching out everywhere, with the probable result that all men of all races, all tongues, and all colors will ere long

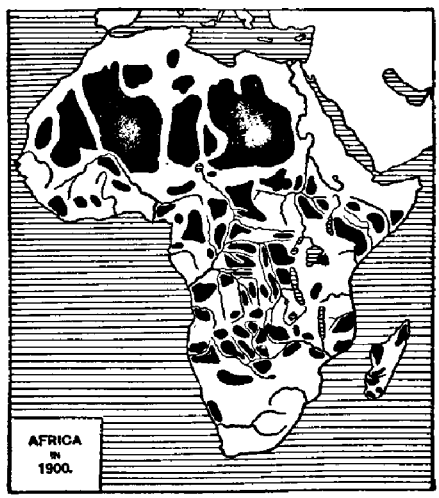


take up their share of progress in industrial science, with results that must prove as marvellous in the future, as the progress of the past would seem to Washington.

It is a tale of manufacturing progress that is not half told, and which never can be told in full, because it grows faster than the ability



to record its development. In every industry in every city on the globe are geniuses studying how to advance the lines of work in which



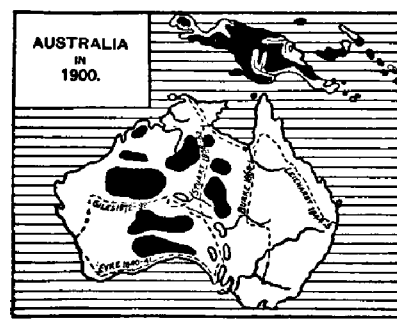
they are engaged. Every year the standards that win success are set higher, yet every year witnesses increasing gains and greater triumphs.

There seems to be no end to industrial progress. The world is full of workers—men who love to work for the sake of the work itself, and these are the ones who contribute to the growth I have attempted to describe in these pages.

America's growth is most marked in the past quarter of a century, because she is the youngest of the great nations. The next quarter of a century may bring the industrious Japanese into the lime-light, or perhaps some South American country may eclipse all records of development.

Some idea of the enormous advances made by the United States during the last half-century may be gleaned by studying the diagram showing the development of manufacturing in the several States. The length of the heavy black lines indicates hundreds of millions of dollars.





For instance, in 1850 New York's gross manufactures for the year amounted to $240,000,000, while in 1900 they totalled $2,175,000,000. All of the older States show amazing increases of this character.

The manufactured goods exchanged by the nations of the world amount to about $4,000,000,000 annually, and the United States contributes about one-tenth of the total. Our exports of manufactured goods doubled between 1895 and 1904, but we are still a long way behind Great Britain, which contributes a fourth of the total, and Germany, which contributes a fifth. Curiously enough, half of the manufactured goods we send out goes to Great Britain, the nation that supplies so many others with manufactured articles.

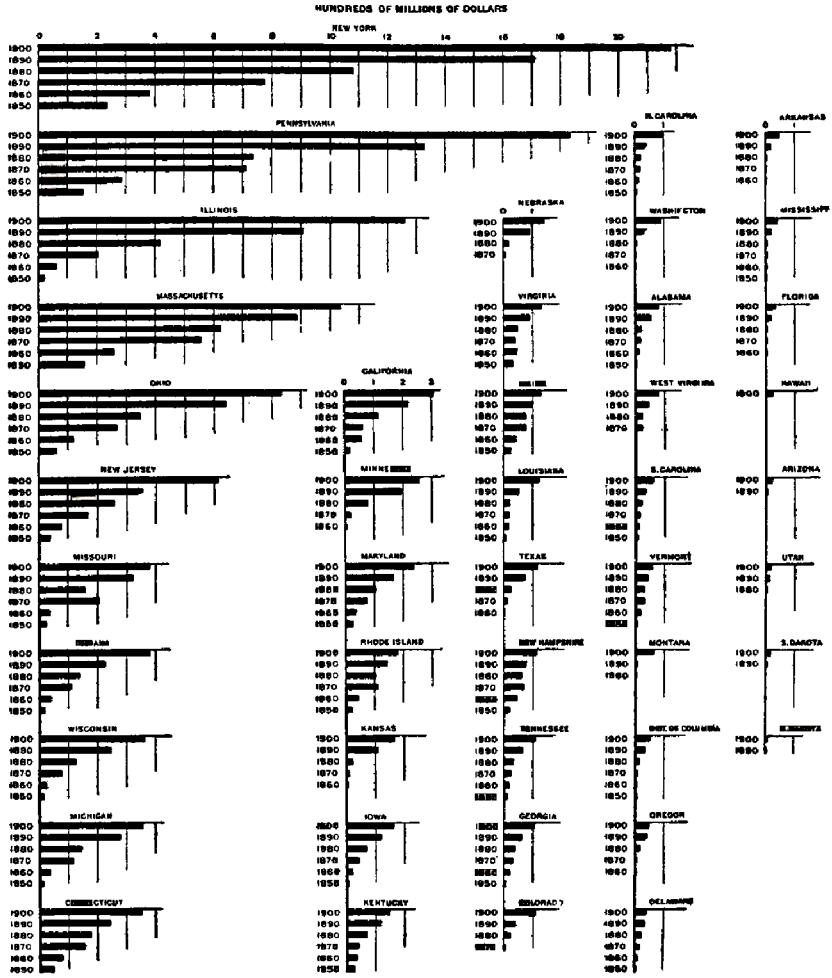
The following table shows the total value of manufactures imported

into and exported out of the leading countries of the world, and the percentage which manufactures form of the total in each case:

Countries.	Imports.	Per Cent. of Mfd. Imports.	Exports.	Per Cent. of Mfd. Exports.
Argentine Republic	$67,717,000	6.81	$704,000	0.4
Australia	156,204,000	76.3	13,754,000	10.2
Austria-Hungary	113,988,000	32.6	187,364,000	48.3
Belgium	104,210,000	23.7	178,840,000	49.9
Brazil	43,020,000	44.8	43,000	. .
Canada	112,506,000	57.3	18,076,000	10.5
Denmark	39,855,000	37.5	3,882,000	4.9
France	212,592,000	24.9	508,803,000	63.2
Germany	366,669,000	28.4	824,051,000	78.1
Italy	101,739,000	36.8	75,373,900	28.5
Japan	69,895,000	51.7	59,902,000	47.0
Netherlands	241,739,000	29.5	231,510,000	33.3
Norway	33,595,000	43.5	12,083,000	28.8
Portugal	23,986,000	39.9	3,366,000	10.9
Russia	158,166,000	56.4	56,069,000	14.5
Spain	57,943,000	37.6	41,330,000	29.0
Sweden	51,835,000	42.0	39,419,000	41.6
Switzerland	93,049,000	42.7	113,111,000	60.1
United Kingdom	725,752,000	28.2	1,076,046,000	77.9
United States	344,816,000	38.2	403,631,020	29.7

In the following pages I have endeavored to outline some impressions as to what has been accomplished in a number of leading divisions of the world's work. They may serve to interest those who have not closely followed the progress of events in particular lines; but in a dozen years from now all that is written here will be an old story, and new inventions and new developments will have shifted the centre of observation to other scenes. It may then be the age of radium, of helium, or of something for which there is not a word coined, because it is not yet known to us.

GROSS VALUE OF MANUFACTURED PRODUCTS OF THE UNITED STATES BETWEEN 1850 AND 1900.



MODERN INDUSTRIAL PROGRESS

ELECTRICAL MARVELS OF THE LAST DECADE

ELECTRICITY is believed to pervade the universe. Astronomers see evidence of its action in the sun, in the stars, and in comets. Its properties are so varied, and it affects substances so differently, that it is safe to say that we have as yet learned but a fraction of what mankind is destined to know about this wonderful thing. It comes nearer to being a source of energy or the fabled perpetual motion than anything else in the encyclopædia. Because it so readily lends itself to the transmission of energy, we think of it as a source of power, whereas in reality it is but a means of transmitting power, as are the endless leather belts commonly used to drive machinery. Experience indicates that it can be used for the transmission of almost anything, and that it is possible by electricity to cause a repetition of almost any act at a distance. We can now telegraph through the ether across the Atlantic, and are on the threshold of wireless telephony also, as described in the chapter entitled "Marconi's Victory over the Ether."

As a matter of fact, we do not know what electricity is, and the theories regarding its nature have changed very much within a few years, and unquestionably will be subject to still further revision. Electricians have simply taken the facts about electricity and constructed theories to fit them; as new facts have been learned, the theories have been modified or expanded as the case required.

We know that when a wire is moved about in a magnetic field there is set up an electromotive force. We do not know why this is, but Faraday proved the fact, and all our electric motors and dynamos are based on it. So are our theories, and just as our motors and dynamos are subject to change and improvement as we learn more, so our theories require occasional revision. It is really no great drawback that we have not more fully mastered the nature of electricity. As long as we know how to generate it cheaply, and how to use it to do our work and convey our messages, we are doing very well for mortals with limitations.

The fact that the American maker is thus tied to existing machines puts a clog on development, and causes him in many cases to resist a tendency to better machines.

Another difference in the manufacture of electrical goods and machinery here and abroad is that the American manufacturer is apt to concentrate his energies on a single class of machines, trying to produce the best of certain styles at the lowest cost, in large quantities, while the Continental manufacturer usually undertakes to make a wide range of machines in one establishment. Here the American system undoubtedly yields the best results, as is commonly the case with specialization. There is also a difference in the systems or customs of finishing electrical goods here and abroad. The foreign manufacturer often puts a fine exterior finish or polish on non-exposed parts, and when his machine is apart it looks much better than the American make. On this side of the Atlantic such finish is regarded as a waste of labor, and seldom or never do manufacturers give a finish to parts that are covered up in the completed article.

Government assistance has been furnished liberally to manufacturers of electrical machinery abroad, while those of the United States have had no such assistance, except as the tariff might protect the home market. Great Britain has its Electrical Standards Laboratory of the Board of Trade, being a department of the government, much as is the Agricultural Bureau in the United States, and it aids the interests of English electrical manufacturers in numerous ways. Very similar is the Central Laboratory of France, where many experiments are carried on which would be impossible or at least impracticable for a single manufacturer. Russia also has a large government electrical laboratory, and the Physikalisch-Technische Reichsanstalt of Germany is famous for its electrical standards of measurement.

Some of the lesser-known discoveries in connection with electricity are quite as marvellous as the sending of messages without wires by Hertzian waves. It is one of the curious things about electricity that every new fact we learn in connection with it seems at first sight to be miraculous. It is not thus with improvements or discoveries in pure mechanics: these are reasoned out and seem natural; but when we stumble on a new fact in the electrical field, it often fills us with wonder akin to awe.

The time is coming when we shall see things a thousand miles away as easily as we now telephone from New York to Chicago. I do not mean that we shall see the things themselves at that dis-

tance any more than we hear the real voices of those who talk to us over the long-distance telephone; but we shall see the representation of what exists or is happening at the other end of the line of communication. Already the way is pointed out. Some years ago Leon le Pontois described a theoretical apparatus for reproducing a scene by electricity, calling it a telectroscope. It was never worked out, but showed the possibility of such an instrument. A number of inventors have succeeded in reproducing crude portraits by telegraphy, though these have never been good enough for commercial reproduction in newspapers.

Edison, Dussard, and others have devoted much time and thought to this interesting field for electricity; but, though all are in agreement that telectroscopy is possible, yet none has hit upon the means of producing it in practice. One of the methods that has been studied, and which may yet yield a practical solution, consists in projecting an image on ground glass and producing reflections in swinging mirrors. The motion of the mirrors is used to vary the strength of electric currents sent to the receiving station, where is located a series of selenium cells, which, being affected by the varying light produced by the varying current, may theoretically reproduce the original picture.

The uses of selenium in connection with electricity constitute a field of remarkable interest. Selenium was discovered in 1817 by J. J. Berzelius, a Swedish chemist, while engaged in the distillation of sulphuric acid and iron. It is classed as a non-metallic element, and in a common form is a lead-gray crystalline mass. If it is heated, the resistance diminishes, but when it is melted so as to liquefy, the resistance suddenly increases. In 1873, May, a telegraph operator of Valencia, discovered that in the crystalline form selenium has less resistance when exposed to the light than in the dark, and it is this quality that has been employed to secure many noteworthy results.

The selenium cell, which is used in many interesting instruments, consists of a sheet or rod of selenium and one of copper included in an electric circuit, which when exposed to the light produces a slight variation in the electric current, because the selenium has become a poor conductor while the copper has remained a good one. Another and the more common form of selenium cell is made by winding a pair of conducting wires about a glass tube. Selenium powder that has been fused is then crowded between the spaces of the wires, and the whole baked at the temperature of boiling water for about twelve hours, by which time the selenium has crystallized

sufficiently to be extremely sensitive to the action of light. The selenium cell made possible that wonderful instrument the photophone, which is a telephone using a beam of light, instead of a wire and an electric current, to connect the transmitter and receiver. In Professor Bell's photophone a vibrating beam of light is allowed to fall on the selenium cell, and as the light vibrates an electric circuit is varied, affecting a telephone receiver. He attached a little silvered concave mirror to the back of a telephone transmitter, and allowed the sunlight (or a strong electric light) to fall on the mirror. By means of lenses the light was concentrated in a small beam and directed towards the receiving instrument, which consisted of a selenium cell and a telephone receiver in circuit with it, a current being supplied by a battery. Thus was accomplished the wonderful result of using a ray of light instead of wires to carry the human voice. When a person spoke into the transmitter, the sound vibrations caused vibrations of the ray of light, and these vibrations of light acted on the selenium cell at the receiver, and set up vibrating currents that caused the diaphragm of the receiver to vibrate just as did the diaphragm in the transmitter, and so the voice was repeated just as when the vibration was caused direct by the electric current carried by a connecting wire in the ordinary telephonic arrangement.

The photophone proved to be of no commercial value, and has remained a scientific toy, but it has been improved upon, securing a combination which utters the spoken message so loud that it can be heard throughout a large room. Instead of an indirect ray of light, there is introduced the " speaking arc," invented by Professor Simon. This speaking arc is obtained by placing a strong arc light in circuit with the transmitter, the alternating current set up by the vibration of the voice in the transmitter being imposed on the direct current of the arc light, and the vibrations of the receiver strengthened, so that it speaks loudly. It is a curious fact that, while the current making the arc light is being varied constantly under this arrangement, yet the eye detects no change in the light, though the promptness with which the current registers the changes at the receiver determines the success of the entire system. This combination of photophone and speaking arc might be employed to reproduce a lecture or speech in some hall distant from where the speaker was located, but there seems to be no demand for anything of the sort, probably because audiences require that a live speaker shall face them and impart life and fire to his remarks by gesture and physical animation.

Turning to the practical side of the selenium cell in its com-



Courtesy Electrical World and Engineer.

Engine-Room of an Electric-Power Station.

mercial use, we find it employed to light buoys automatically in harbors, on coasts, etc., through a mechanism invented by Herr Ruhmer. Buoys are necessary to mark a channel in a harbor, keeping vessels off shoal spots, and they serve a purpose akin to that of a light-house on a rocky or irregular coast. To be of use at night the buoys must bear lights. In times gone by the work of lighting these buoys was very tedious, requiring a boat to visit them regularly. Where buoys are numerous, as in New York harbor, wire connections for electric lighting are practicable; but where the buoys are at considerable distances, the selenium device has been a great boon. In this most interesting mechanism the darkness itself is utilized to light the gas-lamps of the buoys.

Such buoys are usually lighted by gas under pressure, as in the Pintsch light commonly used on railway trains. In clear weather such a light is visible about six miles away, and serves to warn vessels off a point where a light-house is impracticable. Before the selenium device came into use each light-tank was supplied with as much gas as practicable, and it was allowed to burn until it went out or an attendant came along and replenished the gas. With the introduction of the selenium cell for automatically shutting off the gas during the hours of daylight, the time that the gas lasts is doubled. As soon as the dawning day brings enough light to act on the selenium cell of a buoy, its resistance is reduced and a magnet brought into operation that closes the gas-valve; and at nightfall, when the deepening shades increase the resistance, the current is reduced, and by means of a relay a magnet operates in the other direction, opening the gas-valve. The light may either be turned down low, or it may be turned out altogether, and ignited by an electric spark.

A burglar-alarm, one of the best made, owes its existence to the selenium cell, and the typical dark lantern of the burglar is made his undoing, or if he lights the gas down-stairs, when he imagines all are safely asleep above him, off goes a big gong and up blazes every other gas-jet in the house.

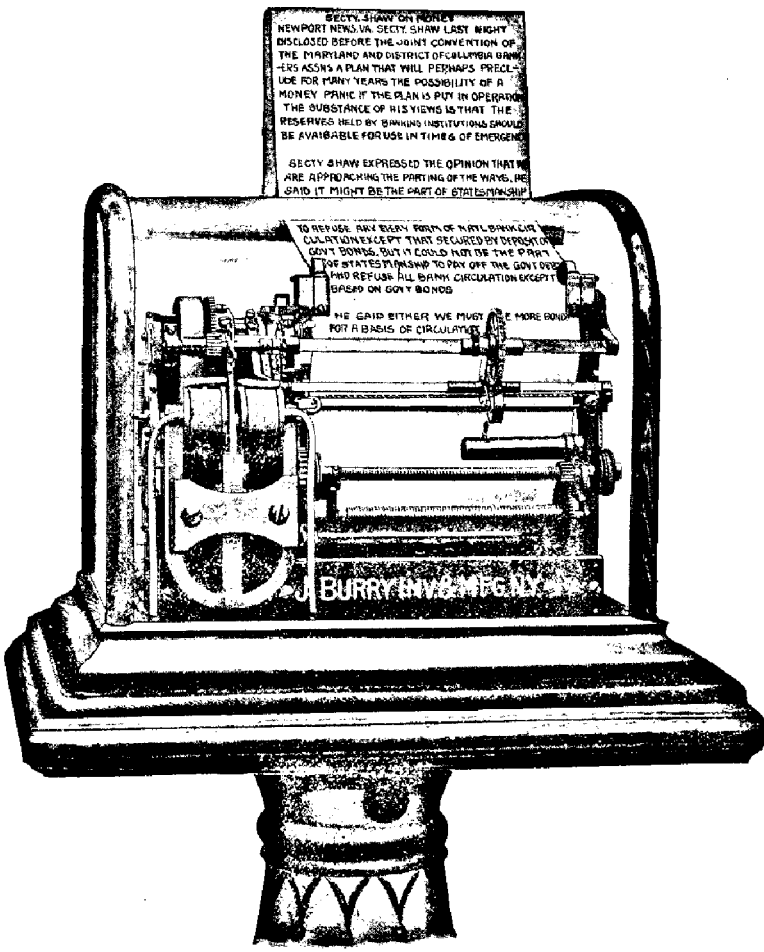
The selenium cell is so much quicker than the eye in noting the action of light that it has been employed to observe an eclipse and make a record of light changes beyond the ability of the eye to follow. Professor Barnard, of the Lick Observatory, in California, has employed selenium in a device for automatically detecting comets, the theory being that when the telescope was pointed into a field where there was a comet, the increased light would affect the selenium so promptly and surely as to be manifest electrically with greater ease than it could be visually at the eye-piece.

A method of ore-finding by electricity has met with some success in California, Alaska, and Wales. It was devised by Leo Draft and Alfred Williams, and with it they have successfully located and mapped out a number of metalliferous deposits which had failed of detection in any other way, notably a lost vein of a lead-mine owned by H. Gamman, in Wales. The system consists in placing two electrodes in the ground at some distance apart, these being connected with an apparatus for generating electric waves. An interrupter breaks the earth-connection 700 times a minute, while the breaks are heard in a resonator. The prospector shifts his earth-connections from place to place, and when he is directly over a lode of metal ore the noise in the resonator is the loudest. The system is valuable as an aid to the prospector, rather than as a sure thing for finding valuable deposits. It will show the same results for an iron pipe under ground as for an ore vein, and even a stratum of wet earth or a subterranean stream may produce the same noises as the desired vein. Therefore the apparatus requires to be used by competent prospectors, who also make use of the older methods of judging where deposits are likely to be found.

The fact that the telegraph uses an alphabet of its own, which is understandable only to those who know the Morse code of dots and dashes, has led to many endeavors to substitute a mechanical means of rendering messages in ordinary printed characters. Inventions having this object in view are called printing telegraphs, and a vast number of patents have been granted for such, most of which have failed of general use because of the complexity of the mechanism. A few simple ones have been developed, however, which it is of interest to consider. It will be recognized that if a receiving telegraph instrument, instead of punching little holes in a paper tape, registers them after the fashion of a typewriter on a neat sheet of paper, many advantages accrue, besides the one of allowing anybody to read it who can read print. It avoids the chance of clerical error in copying the message after receipt, and it permits numerous copies to be made automatically, all of which must be exact copies of the message sent, the chance for error being confined to the individual who sends the message originally.

The printing telegraph of John Burry, of New York, uses two line wires, and by the manipulation of a keyboard impulses may be sent to any number of receiving machines, where the message will be automatically printed in sheet form in capital letters. (See illustration.) It is obvious that such a printing telegraph has uses far beyond those of a telegraph company. The broker, who is in the

habit of receiving numerous telegrams daily, simply installs a machine in his office, and in come the messages ready printed in the machine, with no delay for delivery. The printing wheel, bearing the rubber type, is much like the type-wheel of some typewriters,

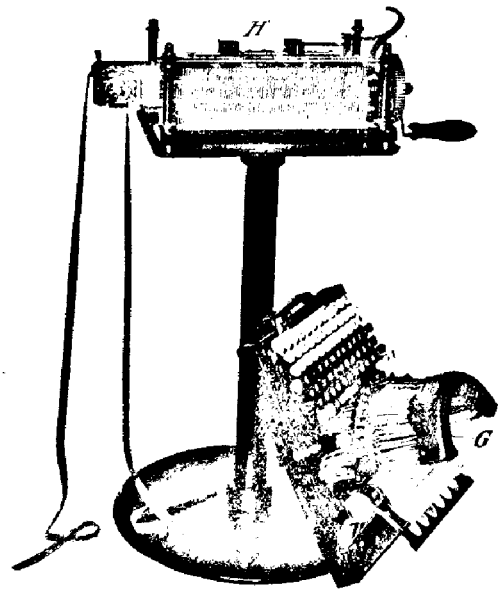


Burry's Printing Telegraph.

except that it slides sideways along the rod in front of the paper, while the paper is stationary, except when reeled up a space for a new line. Something like a thousand of these ingenious little printing telegraphs have been placed in use. The mechanism is operated entirely by magnets, so that the user has only to connect it properly

with an electric current, and to keep it in order and supplied with paper, to enable it to do its work automatically.

The printing telegraph of Professor Henry A. Rowland, of Baltimore, consists of a sender having keys like a typewriter, on which the message is written. An alternating current of constant frequency is passed over the line to operate synchronous motors. The different characters are obtained by the suppressing of various combinations of half waves of the current. The receiving instrument has a type-wheel that prints the message on a sheet of paper, the wheel rotating continuously, and being pressed against the paper



Murray's Printing Telegraph.

the instant the desired letter is over the printing point. Connected with the receiver are a large number of relays, various combinations of which operate a few magnets for printing the characters. Four messages may be sent at one time in each direction over the same wire, making a total of eight messages, and at a speed, it is claimed, of forty-five words per minute. This remarkable machine is not yet ready for the market, requiring considerable simplifying before it can come into general use.

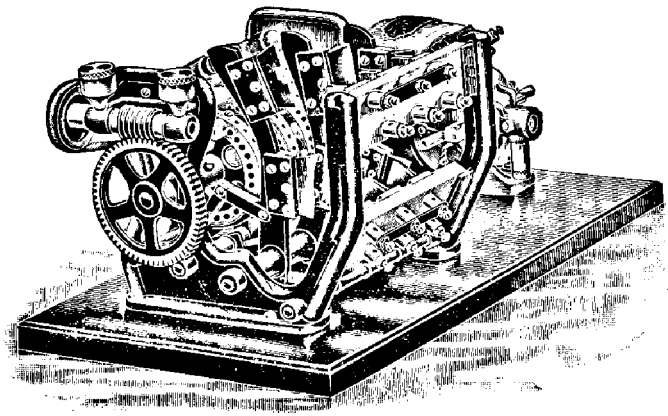
The printing telegraph of Donald Murray is intended for long-distance work, and is in use by the Postal Telegraph Company. In this interesting and simple machine, an endless tape, punched with

holes of a modified Morse code, is translated mechanically to a typewriter and written out, the attendant simply turning a crank at the side of the typewriter, which operates at about three times the speed it could be fingered. In the illustration the typewriter is removed to show the interlocking mechanism *H*, by which the perforated characters on the tape are made to strike the keys of the Roman alphabet on the typewriter. The turning of the crank on the right draws the tape along and introduces a series of little feelers to the holes in the tape. As these feelers drop in they occupy a position that allows the proper type-bar of the typewriter to drop and print a letter. A slight electric current furnishes power for depressing the keys. It is apparent that this system is exceedingly well adapted to taking long reports for the Associated Press, or anything that is lengthy. By using carbons in the typewriter several copies may be obtained at the same time, and each will read exactly as does the punched paper tape.

A recently exploited novelty in telegraphs is a system for using slight electrical shocks sent in the Morse code, to be read by the finger-tips, just as any operator might now read a message if his finger took the place of a key in receiving the "tick, tick" of the ordinary telegraph receiver. It was originally designed for the use of deaf mutes and blind mutes, but it is apparent that it might be applied to many other uses. Two persons can walk along the street with instruments in their pockets and carry on a conversation that would be entirely unsuspected by any onlooker. In the same way at night, from different rooms, with a connecting wire, they could talk without being overheard or disturbing any one else, or even getting out of bed. The sensation is received by means of thimbles made like open-end sewing thimbles and placed one on the thumb and one on the forefinger. To send a message one person brings his finger and thumb together, making the dots and dashes of the Morse code, and the other person reads the message by feeling, without any effort. The thing is so simple and requires so little apparatus, that it should find considerable use. A very slight battery and connecting wires are all the mechanism needed. Any one having an electric door-bell in the house can steal a little of the current, and rig up the apparatus for use as wanted.

Electric signs have attained a high state of development, and in every large city may now be seen nightly signs that are changed in the reading every moment by electrical mechanism. One of the machines for accomplishing this result is the electric light and sign flasher here illustrated. This can be used to operate a variety of

signs, as the waving flag, rotating wheels, etc., these being electric optical delusions operated automatically. In one form of machine a man with a typewriter is in control, and the sign displays whatever he writes on the machine, up to the limit of the number of words it carries.



Courtesy Electric Motor and Equipment Company.

Electric Sign Flasher.

Electricity is undoubtedly gaining ground in therapeutics. While the physician no longer attempts to cure patients of all sorts of ills by having them take a current from a battery, it has come to be recognized that certain things can be accomplished. The value of the electric cautery was demonstrated many years ago, and there is a long list of instruments in which the electric light coupled with a speculum enables the physician actually to see the condition of interior membranes in his patients. The circulation in a particular part of the body can be stimulated by the electric current, and the heart's action can be affected. Electrical anæsthesia has also been applied superficially for dental operations, and a French surgeon has succeeded in producing insensibility to pain in a patient during a very trying operation by subjecting him to the action of currents of high frequency during the whole course of the operation.

A French physicist, M. Leduc, produces local anæsthesia and also sleep by a continuous current from an accumulator, placing a small resistance in the circuit. If this current is applied to the wrist, there is a prickling sensation, but no feeling otherwise. If applied to the head and the buttocks, respiration is at first stopped, and on reducing the current the breathing is resumed, the patient remaining asleep with what appears a natural and tranquil repose. As insomnia

is a result of disturbance of the nerve-centres, it is reasonable to conclude that this method of quieting the nerves may prove to be the practical cure for this trying affliction. The drawback to the introduction of the system lies in the fact that when the current is first applied the immediate result is to produce apparent death, from which the patient has to be resuscitated. Physicians will want to feel very sure of their ability to bring patients back to a normal condition on short notice before they will adopt this method of treating insomnia.

In this connection it is well to note the latest form of X-ray apparatus and of fluoroscope. These are well shown in the accompanying illustration.

Electric heating has made considerable progress because of its convenience, though it is vastly more expensive than heating with coal. Still, when the coal gives out, the human race may be very glad that it has in every waterfall a power that may be transformed into electricity and thus into heat. Electric cooking is not so expensive in a small household, where its use is intermittent, and the few cents of extra cost are offset in hot weather by the fact that very little heat is sent out into the room. As a plate-warmer, or convenience for supplying a little hot water when wanted, or heating a hair-curler at a lady's dressing-table, the electric heater is in some demand. In laundries it also has some sale, as it saves times and can be turned off to stop expense when not in use. A theatre can be heated electrically with a heater under every chair in a manner agreeable to the patrons, as the heat comes where wanted, and can be shut off by the occupant of the chair if he or she is too warm.

The *Electrical Review* estimated in October, 1902, that there were at least 150,000 electric car-heaters in use, 50,000 heating-irons, and 5000 chafing-dishes. The United States census gives the sales during 1900 of electric heating and cooking apparatus, including the rheostats, at $1,186,000, and it is safe to say that it is now (1904) at least a million and a half a year. A single New Jersey hat-factory uses 250 horse-power for electric heating apparatus, which is found specially useful in that business. Whenever the power-furnishing companies choose to make a specialty of selling current for this purpose at a price that consumers can afford to pay, the use will increase very rapidly. That they have not done so is perhaps owing to the fact that the trolley companies have had such rapidly increasing demands from traffic that they cared not to go into another field, while the electric-light plants are too often controlled by gas corporations that prefer to sell gas for heating.



The X-Ray and Fluoroscope in Surgery.

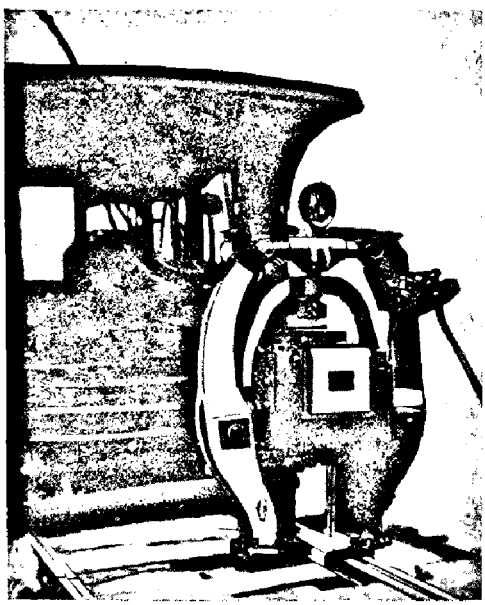
I, Induction coil; P, primary current; S, secondary current; C, Crookes tube set at correct angle; F, Edison's fluoroscope; X, point in the tube from which the hemisphere of X-ray activity radiates.

The principle of an electric heater is simply the use of a metal offering sufficient resistance to a current of electricity to be readily heated when a current is turned through it. This metal is surrounded by some non-inflammable conductor of heat, as porcelain or asbestos. In a well-known type a metallic paint is fired upon mica strips, which are formed into groups or sets, so that a heater can be built of any size by adding more sets. For heating an electric car either four or six sets of conducting wires coiled around porcelain tubes are commonly used, the current being taken along with the motor-current from the trolley wire or other source, which is unfortunate for the passengers at times, for when the power is short the heat is ruthlessly shut off. The average cost of heating electric cars by electricity is perhaps seventy-five cents per day of eighteen hours, and the temperature of a car may be raised in this manner about 40° F. above that prevailing outside, in spite of the constantly open doors.

Early in 1902 there was a public exhibition in Milwaukee of an invention for using the electric arc for cutting steel. An enormous boiler foundation, made in one piece of metal, had to be removed from the basement of a building, where it had been put at the time the basement was built. It was so heavy that local mechanics despaired of being able to cut it in order to get it out. The inventor of the process of using the arc for steel-cutting was called in, put on a pair of blue spectacles, connected his apparatus with a strong current, and touched the steel plate with his carbon point. A strong white light and brilliant flame sprang up, and the steel was cut, or more correctly burned, away, at the rate of a foot in five minutes, so that within a short time the whole plate was divided into blocks that could be transported away. Whether the invention will find many practical uses remains an open question. So far it has served principally to alarm bankers as to the efficiency of their great safes if attacked by an up-to-date electrician.

Electric track-welding has become an important business, and the methods employed have shown much improvement within recent years. Rail-joints are welded together just as they lie on the ties, a welding-train of two cars doing the work. The result is a practically continuous rail that makes riding less jolty for passengers and also prevents the ends of rails from wearing out by the pounding of the car-wheels, as is the case where the joints are slightly open. An improved process of doing the work was introduced in 1897 and another in 1901. The latest outfit is mounted on trolley-cars of special design having axles that may be adapted to different

widths of track. The first operation is sand-blasting, to free the rail-ends from dust and dirt. An apparatus that resembles an enormous horseshoe is projected from in front of the forward trolley-car, being suspended by a crane. This is the welder, and its ends are placed on either side of the rail at the joint. Thin strips of steel having been placed at the sides of the joint, the current is turned on, and the metal at the joint soon rises to a welding heat. Then the current is shut off, and the hydraulic jaws produce a great pressure, as much as thirty-seven tons, on the joint. This completes the weld very quickly. The current used approximates from



Electric Track-Welding Machine.

25,000 to 30,000 amperes at seven volts. The supply at the welder is regulated at about 300 volts. After welding, a grinding device is employed, in order to reduce the slight bulge which is produced purposely. This grinding is done with an emery-wheel under the guidance of a man on the car. With this apparatus a line of track is welded in a comparatively short time at moderate expense.

Electric trains are now run that emulate the European trains de luxe, as they call a string of Pullmans. One of these elegantly furnished electric parlor-cars is shown on p. 36, being arranged for summer travel. Within a few years it is probable that the more

prominent lines of electric cars running to seaside resorts will run these parlor-cars occasionally, charging a higher rate of fare, thus enabling those who have the spare cash to ride in comfort and escape the crowd.

Although the electro-magnet is one of the commonest parts of electrical machinery, yet the magnet for holding or lifting purposes has been employed but little. There is first the toy magnet which is used for drawing pieces of steel out of the eye. Then the magnetic

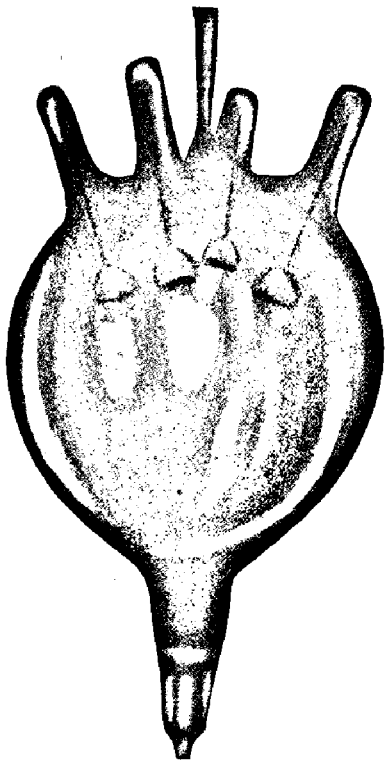


Courtesy Electrical World and Engineer.

Electro-Magnet for Lifting Pig-Iron.

clutch, for holding a piece of work to the bed of a machinist's drill or planer, and Edison's large electro-magnets for separating the iron from crushed ore. There are also little magnets that pick up the tacks or brads for the machines that make gift-boxes for berries, and tremendous electro-magnets in steel works, that are attached to cranes, and that will pick up ten- or twelve-ton pieces of metal, by magnetism alone, to transport them to some other point, saving the time that would be lost in fastening them with hooks and chains and releasing them again.

It is well known that a great deal of electrical work is done with the alternating current and other work with the direct current, and that it is often necessary for electricians to convert one sort of current into the other for some specific use. For this purpose a converter is employed, being a rather massive machine, one rated at eight kilowatts weighing about 750 pounds. Early in 1903 Peter C. Hewitt announced that he had succeeded in making a very sim-



Courtesy Literary Digest.

A Selective Converter.

ple "selective converter," and that one of four pounds' weight would do the work of the 750-pound converter. His device is a globe that somewhat resembles a Crookes tube, as used in X-ray apparatus. He fills the glass globe with mercury vapor of a certain degree of attenuation, and admits the terminal wires of the various currents into the globe. The theory of its operation is that, "when an alternating current is caused to jump through a space filled with mercury vapor of a certain degree of attenuation, it presents a ready

passage to certain portions of the wave, whereas other portions of the wave are damped back, or form a selective electric valve, which allows impressed electromotive force of a certain character only to flow through the apparatus."

This remarkable invention cuts away the barrier separating the alternating and direct-current fields, and constitutes one of the most important mechanical improvements in electric apparatus of the opening years of the century.

A Russian engineer, Nicholas Gherassimoff, has invented a novel electrical means of protecting vessels at sea from collisions with



Electric Parlor-Car Interior.

other vessels or with derelicts or with shoals. His idea is to provide electrically propelled bodies, which he calls feelers, moving in advance of the vessel at the same rate of speed, and far enough under water to protect the hull of the ship. He provides three feelers, one in line with the keel and the others at some distance to the right and left. The feelers are controlled by three electric cables, which have a junction point connected with an indicating apparatus on the vessel. This indicator shows when a feeler is thrown out of its natural course, which is a sign of danger. There are also little light-buoys sailing over each of the feelers, so that under

favorable conditions it can be seen whether they are performing their work in proper position.

The telegraphone is a much-advertised electrical instrument that has so far failed of commercial success, though it does seem as if it ought to be very valuable. It was invented a few years ago by a Dane named Poulson, and was exhibited at Paris in 1900. It is a magnetic phonograph, and has a long hardened steel wire that is passed quickly near the magnet of a telephone receiver, with wonderful results. The wire appears to acquire in the form of permanent magnetism all the vibrations that occurred in the receiver at the time it was exposed, and when the wire is passed under certain small bits of iron attached to a diaphragm, the sounds from the telephone are reproduced, just as they would be in a phonograph, with the improvement that they are rid of that scratching noise which is so trying to the ears of most people.

Electric haulage in canals, though abandoned after an imperfect trial on the Erie Canal, is a success in Belgium. It doubles the speed of haulage without increasing the cost. Electric automobiles are used to draw the canal boats, just as did the mules before them. These autos are only about five horse-power, and cost little. When two of them meet on the tow-path, they swap boats. Where the canals are deep enough an electric tug is run, drawing its power from an overhead wire by a trolley-pole. These make a speed of about eight miles an hour with their tows.

The Miami and Erie Canal Transportation Company has a thirty-five-year franchise to operate an electric towing system between Cincinnati and Toledo, a distance of 244 miles. At present forty-two miles are in operation. The company owns seven Westinghouse-Baldwin electric locomotives of the mining type and twenty boats with a capacity of sixty-five tons each. The track is standard gauge, and one locomotive can tow six boats at a time at a rate of four miles per hour, this being the maximum allowable speed on account of excessive wash on the canal banks.

Power is transmitted from Cincinnati by three-phase, sixty-cycle, 4200-volt, alternating current to a sub-station five miles out of the city. Here, by means of transformers and a synchronous motor-generator set, it is transformed to 33,000 volts and twenty-five cycles and transmitted to other sub-stations twelve miles apart along the line, where the voltage is reduced to 1170 and at this pressure fed to the trolley-wires. The high-pressure transmission cables are of aluminum, but the trolley-wires, two in number, are copper. The locomotives are equipped with two eighty horse-power,

three-phase induction motors, the first of this kind to be used for traction purposes in this country.

But this chapter grows too long. The writer recognizes that this is but a very cursory and superficial summing up of the advances made in recent years in electrical science and industry. The subject is large enough for ten volumes instead of one short chapter, and it has been thought best to describe some of the most interesting points rather than to attempt a dry catalogue of all the improvements undertaken and discoveries made. No industry stands still, and least of all the electric industry, which is yet in its infancy, and is dividing into numerous industries, with the promise in time of invading a large number of fields as yet untouched by its magic influence. Verily, this is the age of electricity.

ELECTRICITY FOR THE MILLION

SOME one has said that " electricity makes the world go round," and, while this may not be literally true, in a figurative sense the facts go far to back up the assertion. The progress made in a dozen years in electrical industries is really marvellous, while the magic force has intruded itself so insidiously into our daily lives that we are apt not to appreciate how completely it has imbued almost everything we touch and do.

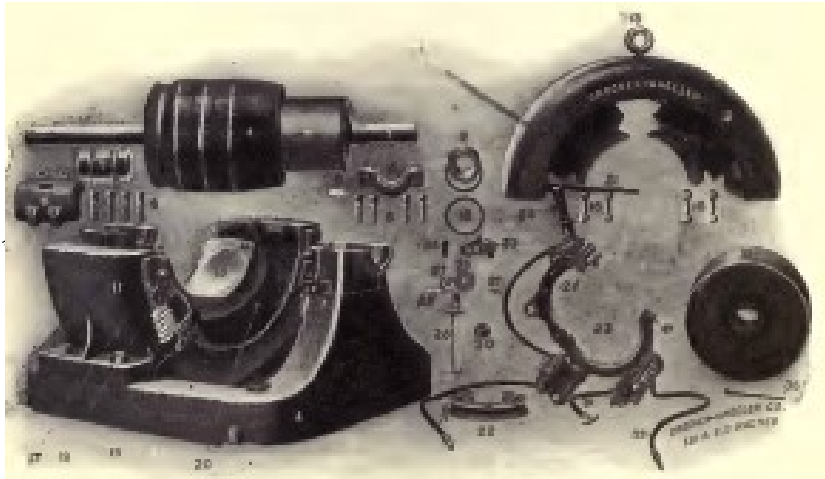
In this chapter let us consider electricity as it enters into and surrounds us in our daily lives. I use the word electricity here in the broad sense of all things that depend upon or utilize this potent agent. A few statistics will assist us at the outset. In 1900 there were 580 establishments in the country manufacturing electrical apparatus and supplies, and 712 more that were partially engaged in this business, the number being three times as great as in 1890. In this year of 1904 the number has probably gained fifty to sixty per cent., so that it is within bounds to assert that there are nearly 2000 establishments in the United States more or less devoted to the manufacture of these supplies. The product of these establishments, estimated in the same way, amounts to $150,000,000 a year. When it is understood that these figures are exclusive of the telegraph, telephone, electric-railway, and electric-lighting industries, which are treated of in other chapters, it is very apparent that something is doing in the smaller fields of electrical industry.

In the census year of 1900 over $10,500,000 worth of dynamo-electric generators were in use in the United States, furnishing a total horse-power of 770,000. To this figure we must add $24,000,000 worth of electric motors, of which $14,000,000 were for direct current and $10,000,000 for alternating current, a large proportion of the above being used for automobiles, fans, elevators, etc.

Just here the non-technical reader may wish to gain a clearer idea of the construction of a dynamo and a motor. The dynamo is a mechanically-driven machine, for which a water-wheel or more commonly a steam-engine furnishes the power. It has an armature (1), or core of iron wound with copper wires, and when this armature is rotated by a steam-engine close to the poles of an electro-magnet a current is set up. By fixing on the same axle or shaft (3) as the armature a commutator (2), or device for rectifying the

current, and allowing copper brushes to rest lightly on this rotating commutator, and connecting wires with the brushes, a direct current may be led off, and the greater part of the energy received from the steam-engine may be delivered to a motor at a distant point, or to a light-circuit, or to heating apparatus, or applied to any purpose for which the current is useful. An electric motor is simply a dynamo reversed in action. The current, coming in on two wires to the commutator, causes the rotation of the armature, and this drives a pulley, from which the power may be taken by a belt.

Such are roughly the general principles of a dynamo and motor, omitting the detail. In practice, dynamos are differentiated



The Parts of a Dynamo.

from motors, and a great many details of construction are introduced to secure certain results. If the electro-magnet, or field-magnet, as it is more commonly called in this usage, has only two poles, the machine is said to be bipolar; if more than two, it is multipolar. Whether or not the machine has a commutator determines whether it shall send out a direct or an alternating current, the latter being a current which is turned in one direction and then in the opposite, alternating commonly at the rate of 7200 times a minute, while the direct current flows always in one direction.

A simple alternating current does very well for transmission purposes and for electric lights, but for motors, except in very small sizes, a polyphase current must be used. An alternating current

generator can be so constructed that it will generate two or more currents alternating at the same rate, but not at the same time. That is, one current will just be stopping and changing its direction when the other current is flowing with full force; the next instant of time the first current will come up to its full value and the second current will stop and reverse. Two or three currents alternating in this way can be combined and transmitted to a distance on three wires and the combination is called a two-, three-, or in general a polyphase current. When such a polyphase current is applied to an alternating current motor, called an induction motor, it produces a uniform rotation of the armature, much in the same way that in a marine engine a uniform rotation of the shaft is produced by having the cranks connected at right angles to each other, or 120 degrees apart in case there are three cranks.

In the case of the motor, one current is doing its maximum work while the other is going through the zero point, exactly as in the engine, one crank is doing its maximum work while the other is at its dead-centre and doing nothing. An induction motor operated on a single-phase current will run after once being started, but, like a single-crank engine on dead-centre, will not start of itself.

Only twelve per cent. of the dynamos made are alternating-current, but the size and power of the alternating-current dynamos are so much greater on the average that forty-five per cent. of the total horse-power of dynamos built in the census year were of this type. A peculiarity of the alternating current is that, by the use of transformers for raising and lowering its pressure, it can be delivered at very considerable distances at slight loss, whereas the direct current is limited in quantity, pressure, and distance.

The alternating-current dynamo tends to grow larger and larger. Thomas C. Martin, expert special agent of the Census Bureau, calculated that the average dynamos of this sort manufactured in 1900 were of 254 horse-power, but he states that they are growing so fast that this really appears a minimum figure. Thousand horse-power dynamos are becoming common, and even the great 5000 horse-power dynamos at Niagara Falls have become too small for their needs, and the latest dynamos going in there are of 10,000 horse-power. In these machines the current is generated at a potential of 12,000 volts, which dispenses with transformers for raising the voltage. The cost of building these enormous dynamos is seven dollars per horse-power, which is about half the cost of building the average dynamo.

Curiously enough, the development of the dynamo seems to

have affected the business methods as well as the mechanical lines along which electric lighting and power have developed. The first companies in the electric field were those that took a comparatively

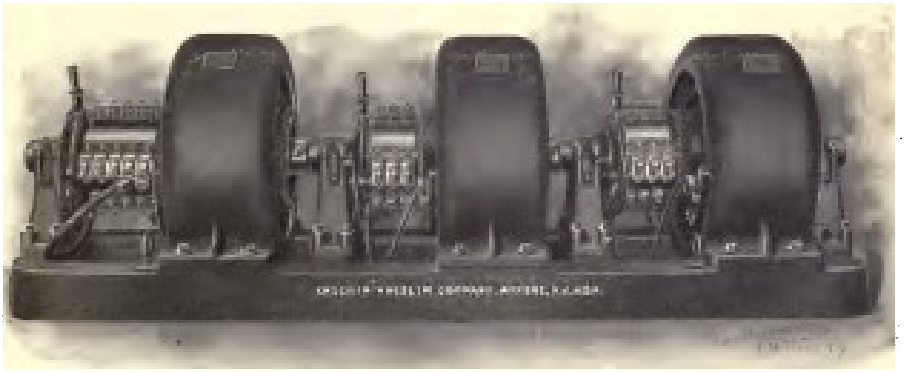


Cutting Wheel-Pit for Shafts of the Great Dynamos at Niagara Falls.

small territory and undertook to introduce arc lighting, incandescent lighting, or a trolley railway, each enterprise, as a rule, being separate. The two kinds of light were first rivals, then they tended to grow together, and now there is a tendency for companies to furnish

both electric light and power to customers for any use, this sometimes including power for operating a street railway.

The fact that the alternating current could be sent to greater distances than the direct, led to expansion of territory by the users of alternating-current dynamos, until practically all companies have settled down to the same general basis of operations, generating current with alternators of the polyphase type at large central stations, and transmitting it at high-pressure to sub-stations, where it can be sent out under lower pressure as either direct or alternating current or used to charge batteries for storage. This method has proved best for railways, for lighting, and for general power purposes, and business conditions are adjusting themselves to it. Direct-current dynamos are not increasing rapidly in use, and are employed



A Three-Unit Balancing Transformer.

mainly in isolated plants, where there is not likely to be any demand for serving current to others.

It is apparent from the foregoing that the transformer plays an important part in modern electrical equipment. The transformer is a sort of modern form of the induction coil, with which students of electricity were familiar twenty years ago. Its essential parts are a core of laminated sheet-iron wound with two coils of copper wire, one coil consisting of a great many turns of fine wire, and the other of a few turns of coarse wire. If the fine wire coil is connected to the line a current at a much lower pressure can be drawn from the other coil, or secondary, as it is called. If the connections are reversed and the fine wire coil used for the secondary, a current at a greatly increased pressure is generated. Thus the transformer can

be used either to "step up" or "step down" the pressure, and the ratio of transformation depends upon the ratio of the number of turns in the two coils. If, for instance, we have a 1100-volt current we wish to use for incandescent lamps at 110 volts, we simply use a transformer having a primary coil of 500 turns and a secondary coil of fifty turns.

In 1890 transformers were able to furnish current to only a few lights, because of their small capacity. Then their average capacity was from eighteen to twenty amperes, or sufficient for perhaps forty lights; now they average about twelve horse-power, with a capacity of perhaps one hundred and fifty lights. Some of the largest transformers in the world are those installed at the Niagara power plant, these being 3000 horse-power each.

The electric motor is not so new a thing as many believe. It was used for propelling boats and cars in 1830, receiving current from a battery. But, as the primary batteries of that day were expensive and non-commercial, there was really no use for a motor. It was the discovery of the fact that a reversed motor became a dynamo, and the perfecting of the dynamo, that made the present system of power transmission by electricity practical. Very satisfactory electric motors were shown at the Philadelphia electrical exhibition in 1884, but they made such slow progress that in 1890 there were in use in New York City only 360 small motors, of a total of 310 horse-power, and only 4.4 per cent. of the manufacturing power used in the country was electrical. After 1890 the demand for motors came with a rush, and the census returns for 1900 show that their use increased 1897 per cent. in the decade. The census records the railways as using in 1900 motors to the amount of 666,669 horse-power, automobiles 8220, fans 12,766, and elevators 6730. The longest distance to which power is transmitted to drive motors is 220 miles, from the Sierras to San Francisco.

One of the most important and widely used of all electrical devices is the battery. There are two kinds of electric battery, the primary and the secondary or storage battery. The former, which we see used for telephones, electric bells, annunciators, gas engine igniters for automobiles, and countless other things which require only a small amount of power, consists usually of two plates, one of zinc and the other of carbon, immersed in a solution of sal-ammoniac, the whole being contained in a jar. For the sake of convenience and portability, the solution is commonly mixed with plaster of Paris, making a pasty mass; the whole cell is sealed air-tight, and we have the ordinary dry battery.

For furnishing large quantities of electric power primary batteries are inadequate; so in electric-light or railway-power stations storage batteries are used. The first storage battery of importance was the Planté, made in 1860, and having lead plates immersed in a ten per cent. solution of sulphuric acid. Faure improved the storage battery greatly about 1880, and it has steadily developed ever since. In batteries of the Faure type the plates are first covered with a paste of litharge or lead oxide, and then a strong current of electricity is sent through the cell. The current decomposes the oxide on one plate, leaving a coating of porous spongy metallic lead, while on the other plate the oxide is converted into lead peroxide. When the battery is in this condition, it is said to be charged, and is capable of furnishing an amount of electrical energy nearly equivalent to that which was first required to charge it. Thus we see that electricity is not stored up in a storage battery, as is commonly supposed, but the electrical energy is converted into chemical energy, and in this form can be stored indefinitely.

The storage battery recently developed by Thomas A. Edison has for its elements nickel-oxide and iron immersed in a solution of caustic potash. This battery promises great things for automobile use, on account of its light weight and great durability, but for central stations the lead storage battery will probably hold its own for some time to come. Storage batteries are used chiefly in power stations where the load is variable, the reason for this being that at certain hours, usually between 5 and 7 P.M., the station is called upon to furnish an amount of power far in excess of the average load. In the early morning hours, when the load is light, some of the dynamos are used to charge the battery; then, when the heavy load comes on and the station is taxed to the limit of its capacity, the storage battery is used to help the dynamos and returns the energy which was stored up in it.

When the central distributing station receives its power from a distance as is usually the case when water-power is employed, alternating currents are used for transmission purposes. An alternating current cannot be used for charging a battery; so the high potential alternating current is stepped down by means of transformers, and then converted into direct current by means of rotary converters, the rotary converter being an alternating-current motor and a direct-current generator combined in one machine. The direct current from the converter is used to charge the battery, and when the central station supplies power for street cars, which always run on direct current, both the battery and the converters supply the current. In

case extra power is needed on the alternating-current distributing lines, the battery current is changed back into alternating current by means of the same converter and used in its original form.

At the extremity of a long suburban trolley line the electromotive force or pressure is liable to be low, on account of "drop" in the line. To overcome this "boosters" are sometimes used. A booster is a machine resembling in outward appearance a direct-current motor or dynamo, it being in reality a combination of both. It receives the low-pressure current from the line and in return supplies a high-pressure current to the line, in this way keeping the pressure up to 550 volts when it otherwise would be down to 300 volts or less. Sometimes a storage battery is used in connection with the booster. When few cars are running the booster charges the battery, but when the load is heavy and the pressure is low the current from the battery runs back into the line. A system of this kind regulates itself automatically; the batteries are always charged and are said to be "floating" on the line.

During the ten years ending with the census year, the railways of the United States installed about 2,000,000 horse-power of motors on cars and about 1,000,000 horse-power of dynamos to drive them. The census experts estimated the investment in storage batteries in the United States in 1900 to be $11,000,000, with a capacity of 300,000 horse-power hours.

The copper industry depends very largely upon electric apparatus for its support. Most of the commercial copper is produced electrolytically, and thus electricity both gives to and takes from the copper industry. Copper is beginning to have a competitor in aluminum, however, as a conductor. An aluminum wire of the same current-carrying capacity as a copper wire is one-fourth larger in diameter, but weighs only about one-half as much and costs less. So copper must have a care, or the light metal will be ousting it from its best field.

The insulated wire and cable business of the country amounted to over $21,000,000 in value in 1900, this large business having grown up entirely as tributary to electrical apparatus. The first braiding of insulation on wires was done by F. Bridges and C. S. Bishop, about 1859, using the methods then common to braiding whips. A number of efforts were made to introduce rubber into the insulation, these being finally successful, when Mr. Bishop laid a cable across the Hudson at New York City, it being protected with three gutta-percha coverings. From this sprang the use of submarine cables for crossing rivers, and the use of similar cables in underground conduits in cities, etc., is an outgrowth.

The tendency to place electric wires underground is a growing one. At first this was considered a hardship by the companies having to bear the expense, and it was only forced by legislation against networks of overhead wires. But as methods of underground insulation improved and cables were laid on a larger scale, it was found to be less expensive than at first, and that this expense was largely offset by a reduced charge for repairs and an improved service to the public, so that now the practice is often undertaken voluntarily by companies having numerous lines to care for.

Overhead telegraph and telephone wires are often thrown out of business during severe storms, entailing a loss of receipts as well as extra expense for repairs on the companies, whereas the underground wires are not only free from this sort of annoyance, but require very much less in the way of general repairs. When once put under ground in a right manner, the wires are apt to stay right. The method of laying wires underground consists in wrapping each individual wire in an insulating sheath, as of specially desiccated paper. Bundles of these insulated wires, forming a cable, are then enclosed in a leaden pipe, the work being done in a dry atmosphere to avoid all moisture. The bundles of wire enclosed in the lead pipe are reeled on enormous wooden drums, so that considerable lengths can be handled conveniently.

A trench being dug and vitrified tile conduit laid in, the lead cable is run into the conduit, being first well greased with petrolatum, which not only serves to lubricate its passage, but is a farther preventive of moisture. The trench is made deep enough to avoid contact with anything from the surface that might be deleterious, and the sections of conduit are carefully joined with cement. At points where sections of cable have to be joined together extra care is taken to secure the same conditions of dryness and perfect insulation. The wires and the insulating paper are all spliced at different points, so that there is little bulging of the cable, and the junction of the adjacent lead pipes is carefully sealed.

The British Postal Telegraph Department in 1900 placed under ground all its wires between London and Birmingham, a distance of 117 miles, for the purpose of rendering its service more positive and unfailing. The larger portion of the line was already under ground, the work consisting in changing those sections that were operated overhead. This is, or was at that date, the longest underground telegraph line in the world.

The American Bell Telephone Company now has more wire under ground than above, they having a little more than a million

miles of wire in use. Of those above ground a large portion are now encased in insulated cables, very much after the underground method. In long lines, test-boxes are placed at intervals of a few miles, at which points access may be had to the wires to test their making the proper connections, and an opportunity is afforded to connect branch wires. All electric-lighting circuits in large cities are now laid under ground, and the same is true of many small cities.

Among the minor developments of electrical industry may be mentioned annunciators or call-bells, of which a quarter of a million dollars' worth are made in the United States yearly; electric clocks, automatically corrected or kept to the true time by a current sent over a wire from a central source, which industry does a business of $150,000 a year; lightning arresters and fuses, manufactured to an annual total of over $600,000; and electric meters, which total up about $2,000,000 yearly.

There are several forms of lightning arrester on the market, all operating upon the same general principle. It was discovered by A. J. Wurtz that a high-potential, high-frequency, lightning discharge will jump across an air-gap and find its way to the ground in preference to following a circuitous wire into a power station or trolley-car and there doing damage. The usual form consists of a series of cylinders made of an alloy that will not arc, and with a knurled surface, these being set about a thirty-second of an inch apart on a porcelain block. The spaces are for spark gaps, and when a bolt of lightning enters, it jumps the gaps and is led into the ground; the arc which follows is interrupted by the non-conducting oxide thrown off. This is used generally in connection with a flat spiral choking coil, which impedes the lightning but interferes very little with the working current.

A very high-potential lightning arrester usually has ten, twenty, or more cylinders arranged in series, with a non-inductive resistance of from a hundred to several thousand ohms connected in parallel with one-half the gaps. It is used with choking coils, and the number of spark gaps depends upon the potential of the circuit. The Thomson magnetic blow-out consists of a pair of curved metal strips between the poles of a compact electro-magnet that is energized by the arcing current. The line being connected with one curved strip and the ground with the other, when the lightning comes and leaps the gap, the arc is repelled to the tips of the curved strips and blown out.

How impossible it is even to mention the great variety of electrical supplies now on the market can be gathered from the fact

that the catalogue of a well-known supply house enumerates over two thousand separate and distinct articles, apart from large electrical machinery, and classed as supplies. These include such things as physicians' batteries and other electrotherapeutical apparatus, scientific apparatus for colleges, electrical toys, cigar- and gas-lighters, insulators, brushes, carbons, special tools for burning patterns on wood or trimming the pile of velvet, etc., etc.

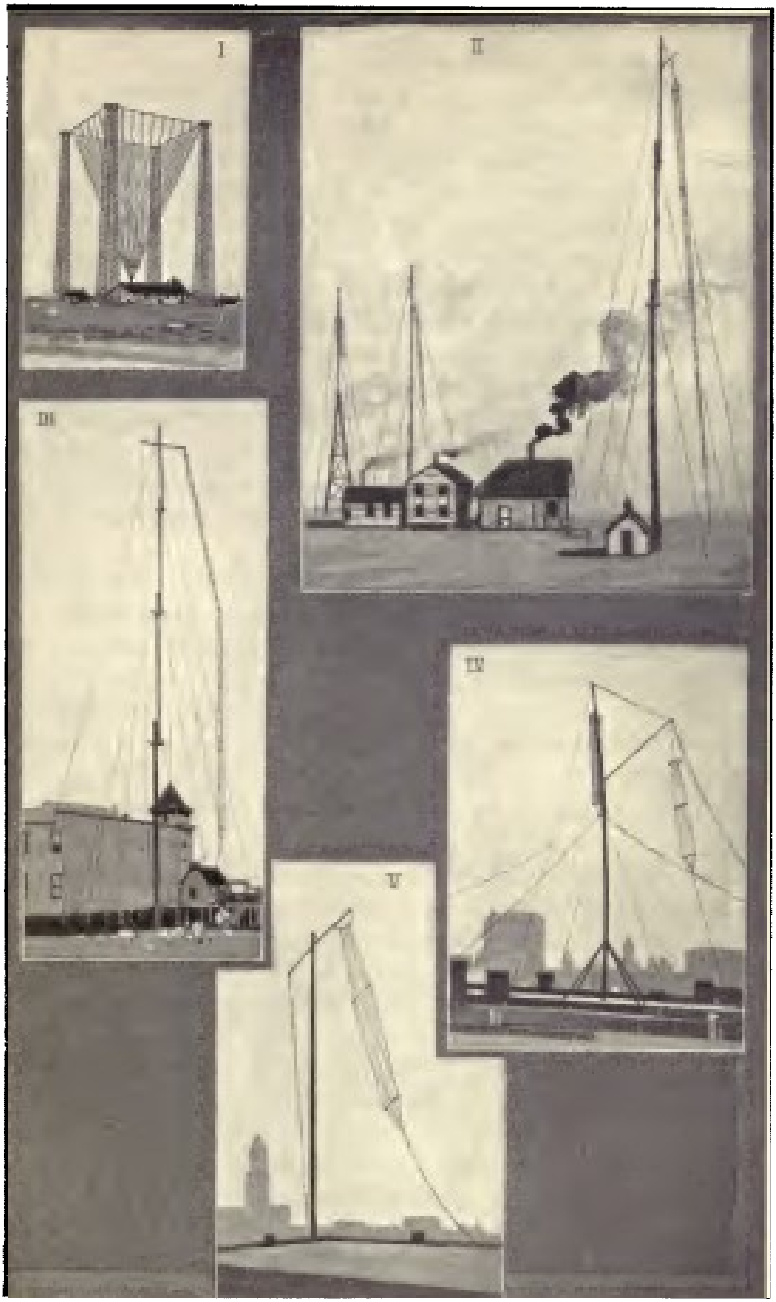
I am obliged to leave the subject here, as too large for farther space in a work of this character. The reader who is specially interested in electrical development will find plenty of books in any public library, and for recent and up-to-date information there are a number of reliable and well-edited electrical journals.

MARCONI'S VICTORY OVER THE ETHER

THE ancients pictured Jove as playing with the lightning; now Man harnesses the electric current that it may do his work. When Benjamin Franklin took a shock from a kite-string, when Cyrus W. Field tried to girdle the earth with a cable, when Thomas A. Edison burned a platinum wire in a vacuum, when Alexander Graham Bell first heard a whisper over the telephone, when the letter S came out of the mists of the Atlantic to Marconi's coherer—then mile-stones were planted along the highway of electrical progress. And as the years go on and we rush forward with increasing energy, it seems as if these mile-stones thickened by the way, and, while they used to be separated by years, now only months or sometimes weeks intervene between the announcement of one startling success in the world of electricity and the next new marvel.

The more men study this wonderful thing we call electricity the more it seems to give forth that which is useful and convenient for mankind. Because we cannot handle it as we can iron and wood, and because it does not so readily manifest its presence to the senses, its properties remained hidden from primitive man. What we know of it now is mainly through studying its effects and reasoning from result to cause. We can see it in the lightning, the arc lamp, and the incandescent light; we can feel it in the current of the physician's battery, and note its pulling power in the magnet; we know that it may both kill and cure—and for the rest the average man or woman depends upon the electrician or the scientist, and takes his word as to phenomena whose description is too full of technique to be agreeable.

That we may describe intelligibly the more recent developments in this field, let us first try to arrive at an understanding of the nature of electricity. It manifests itself in a hypothetical medium named the ether. This ether is assumed to pervade all things. When the ether is disturbed, vibrations are set up. Some of these vibrations come to our senses as light, and some of them we know as electricity. When the disturbance is sufficiently violent, we have heat as a manifestation. It is not strange, then, that by electricity we can produce light and heat; neither is it strange that we can act upon things at a distance, since the medium is all-pervading. Through electricity it is theoretically possible to repeat almost any mechanical operation at a distance.



Marconi Wireless Telegraph Stations.

I. Four-Tower Station (see page 55); II. U. S. Wireless Telegraph Station at North Tru; III. Wireless Telegraph Tower, 210 feet high; IV. Mast on Michigan Avenue; V. T-Station.

Electricity, like water, seeks its level, and, as water goes down through every convenient aperture, so electricity flows along the lines of least resistance. We can charge a substance with electricity by friction, provided that substance is insulated,—that is, surrounded by poor conductors of electricity. By burning coal under a steam-boiler, and using the pressure of the steam to drive an engine, and using the force of the engine to rotate an arrangement of wires constituting an electrical magnet, we can transform a part of the energy of the coal into a current that flows out along conductors and will drive motors to do our work. From one of the same conductors we can take off light, either by leaving a short gap in the conductor, across which the current leaps, forming an electric arc; or by using a filament that is a poor conductor, as carbon, and which therefore heats with the stress and becomes incandescent. Heat for any ordinary purpose may also be obtained by the use of poor conductors or resistance in the circuit.

For fifty years the student in electrical science has operated by means of wires, choosing good conductors, as copper, to convey currents, and transmit thought, energy, light, motion, etc., to some desired point. Now comes Marconi, in the train of other exploiters in the wireless field, and demonstrates that if only sender and receiver are tuned alike, and the instruments delicate enough, we can use the ether around us to carry our messages. This is done by means of the etheric waves whose existence was demonstrated by Heinrich Hertz, and which are therefore called Hertzian waves. These waves or vibrations of the ether are much slower in rate of vibration than light waves, and Marconi and other inventors who have made progress in wireless telegraphy have done so by devising means for better controlling and detecting these waves. Previous to December, 1901, two hundred miles was the greatest distance to which any message had been received without wires.

This record was held by William Marconi, who was even then the acknowledged leader in this line of scientific research. In that month Marconi left his station at Poldhu, Cornwall, and sailed for Newfoundland. He left instructions that after the time for his arrival in America, the letter S should be signalled from Poldhu from 3 to 6 P.M. daily, this time corresponding to 11.30 to 2.30 at Signal Hill, St. John's harbor, the place at which he had established his receiving station. None but his confidential assistants knew his purpose. He had calculated that, with a certain amount of electrical energy sent out at Poldhu, the waves should be strong enough to affect a coherer at St. John's, 1800 miles distant; but he could not afford to let the world know if he failed.

To receive the Hertzian waves an elevated wire was required. He first tried sending one up in a balloon, but the strong winds which prevail there carried it away. Then he tried kites, and on the memorable 12th of December, 1901, succeeded in keeping his kite elevated over four hundred feet for a period of four hours, during that time hearing the letter S recorded on the Morse instrument, by three taps, at least twenty-five times. Notwithstanding that he knew better than any one else that the expected result should come, we can imagine the feeling of reverential awe that must have swept over Marconi as he realized that he was hearing for the first time sounds actually sent out by his own direction from the other side of the broad Atlantic. Even the great Edison doubted the truth of the reports when he heard them, for at that time it was generally thought that the Hertzian waves travelled in straight lines, though Marconi had proved to his own satisfaction that they followed the curvature of the earth.

Almost the first recognition that Marconi received came in the shape of a warning from the Anglo-American Cable Company that he was interfering with a franchise of theirs in telegraphing from St. John's. So he chose Table Head, a promontory east of Glace Bay, Cape Breton Island, for farther experiment, and began the erection of a station there, and later one at South Wellfleet, Cape Cod.

But he was not long in breaking another record. On February 25 and 26, 1902, on board the steamship Philadelphia, steaming towards America, he received messages from Poldhu up to 1551.5 miles and signals up to 2099 miles. Curiously enough he found that messages sent during the hours of daylight at distances of over 700 miles failed entirely, whereas at night he was able to receive them to more than double the distance, proving apparently that daylight exerted an unfavorable influence on the Hertzian waves. By improving his apparatus he was able to secure better results, however, and during the following summer received messages in the harbor of Cronstadt, Russia, from Poldhu, 1400 miles distant, this being accomplished in the presence of the Czar and the King of Italy. Victor Emmanuel was so impressed that he gave Marconi the use of the cruiser Carlo Alberta for six months, to assist his experiments.

January 18, 1903, Marconi sent from Cape Cod a message dictated by President Roosevelt to King Edward, which was successfully transmitted about 2500 miles, this result convincing all doubters that there existed no positive limit to the distance that

might be covered by Marconi's system, the strength of the currents set up and the reliability of the instruments being the determining factors. As only seven kilowatts were used in transmitting this message, it was abundantly demonstrated that the electric energy necessary to carry on long-distance work was not of a character to interfere with other electric apparatus located near a sending station, as was at first argued by detractors of the system. Those who had prophesied numerous fires as a result of sending out such tremendous sparkings were nonplussed by evidence that a current sufficient to act upon a coherer at fifty miles would not set on fire a piece of paper placed directly in the spark of the transmitter.

The record message referred to, which occupied four minutes in sending, read as follows:

"HIS MAJESTY KING EDWARD VII., London, by Marconi Transatlantic Wireless Telegraphy:

"In taking advantage of the wonderful triumph of scientific research and ingenuity which has been achieved in perfecting a system of wireless telegraphy, I extend, on behalf of the American people, most cordial greetings and good wishes to you and to all the people of the British Empire.

THEODORE ROOSEVELT.

"Washington, D. C."

It seems that Marconi did not expect at the time of sending that he could make the distance direct, but intended to transmit the message to Glace Bay and thence have it repeated to Poldhu. While he was communicating with Glace Bay, the operator there sent him back word that he had just heard from Poldhu that their instruments had received the message at the time Marconi was transmitting it to be received by Glace Bay.

Marconi's early apparatus consisted of a modified form of Hertzian oscillator, which had one sphere of the spark-discharger earthed and the other connected to an elevated and practically vertical wire. When sparks are discharged by this apparatus, some of the electric energy is thrown off in the form of a displacement wave in the ether, and the vertical wire radiates electric waves. The regulating of the spark action by the strokes of a Morse telegraph-key causes the waves to vary so that they reproduce at a receiving station in the Morse alphabet, and may be read by any telegraph operator in dots and dashes.

The receiver used previous to 1903 was a coherer, a simple instrument, consisting essentially of a small glass tube plugged at either end with a wire, and having between the wires a gap partly filled with filings, preferably a mixture of silver and nickel filings.

The wire at one end of the coherer is earthed, and the other is run up vertically to catch the waves. When such a coherer becomes affected by a Hertzian wave, the filings arrange themselves in a line and form a connection, that may be registered by an ordinary telegraph recorder or be heard in the telephone. The wave having passed it is necessary to throw the filings out of line by tapping the coherer, this tapper being called a decoherer. The Hertzian wave from a long distance is too weak of itself to operate a telegraph instrument, but it is strong enough to affect the filings, and when these connect the wires at either end of the coherer, a local current is brought in as a relay, and this in turn causes another stronger current to operate the recording instrument and also the decoherer.

Marconi signal stations have been constructed in several different ways, one method being as follows: Four towers are erected at the angles of a quadrangle, and run up to a height of about 250 feet, at a distance apart of perhaps 160 feet. These towers are well braced with wires and connected at the top by bridges. From each of the four bridges depend on either side sets of fifty copper cables, which converge towards a central building, in which they terminate. These copper cables are the elevated wires that catch the waves of messages received, and that radiate the waves of messages sent out.

In order that messages sent by various stations may not conflict, tuning is resorted to. This means the use at a given sending and receiving station of apparatus that responds to a given period of vibrations, just as one tuning-fork responds to another of like character, or as a piano-wire sometimes responds to the note of a violin. Tuning-forks and piano-wires vibrate the air, and in wireless telegraphy the ether must be vibrated; otherwise the principle involved is the same. A number of tuning systems have been devised, and that of Professor M. I. Pupin, of Columbia University, has been taken up by the Marconi Company, which has the exclusive license for its use. This system provides for the construction of several branch electric circuits in connection with a given line, the arrangement being such that each circuit corresponds to a certain pitch of frequency. Then by impressing an alternating electromotive force on the line, or on the ether, as the case may be, the corresponding receiver alone will respond.

The principle involved in this system of tuning is said to have been thought out by Marconi and by Professor Pupin at about the same time, each, of course, without knowledge of the other's efforts. By having a series of such transmitters and receivers at stations, different messages can be sent by the corresponding instruments over