Scientific American.

Ichnenmonidæ.

Dr. David W. Flora, of Newyago, Mich., sends us the following interesting particulars:

The SCIENTIFIC AMERICAN of January 31 contains an article on "The Mason Wasp," which brings to mind some observations made twenty years ago. On the half grown, wrinkled body of a "tomato worm" hung fifty or more little oblong pearl colored balls about the size of small rice grains. Placing the mass under observation, about three days thereafter a little lid or cap was raised from the larger end; out came a fiery, active, dark bluish-green fly. I was able readily to place it in the large family of *Hymenoptera*, and very soon saw enough of its habits to class it according to Cuvier as a member of the *Ichneumonidæ*. A few days after the advent of the little fly, I saw one alight upon the half grown body of a tomato worm, and in spite of its squirming, sputtering of green saliva, and striking out with that formidable "horn," our plucky little one kept on striking its stinger, or *ovipositor*, deep into the body of the worm, at every stroke depositing an egg. Some ten or twelve days thereafter there was an eruption all over the skin of "Mr. Worm." The surface seemed alive with little worms, which were larvæ of the ichneumon fly.

Instead of seeking some other spot in which to pass the "pupa" stage, it fastened a thread to a hair or spiracle of the "worm skin," and then and there proceeded to spin itself a cocoon. These threads were so fine that when magnified 2,500 times they were not much larger than No. 30 sewing thread. Under the magnifier I saw the cocoon completed in about two hours and our larva retire from sight, to reappear after fourteen days as already described.

Baron Cuvier says: "They are so called from the Egyptian ichneumon, which was supposed to deposit its eggs in the entrails of the crocodile, which the larvæ afterward devoured.

"In Europe alone, there are more than 1,650 species of this family, and there are more than 6,000 species already known."

What a conservative influence this host of insects must exert upon the vegetable kingdom! Every species has many varieties, and this myriad host wages perpetual warfare upon the caterpillars and larvæ of the Lepidoptera generally.

This tiny insect cannot carry away bodily the great bulky tomato worm, nor even the smaller larvæ and spiders which the mason wasp does to feed its young, but it provides for its progeny by depositing the egg in the large succulent bodies of other insect larvæ, there to hatch and feed.

But so skillfully does the young ichneumon feed that neither the digestive nor ganglionic system of the victim is injured. Only the chyliferous vessels are sucked dry. Something like the fable of Prometheus, only the liver and vital organs are spared.

Our vast lumber interest is under obligation to the Ichneumonidæ. It seeks out by some subtle sense the location of the "wood borer," and with its long flexible ovipositor deposits its eggs in the body of that larva. I have seen it pierce the seasoned hickory wood nearly two inches to reach this matrix for its young.

From the description of the "mason wasp" given in the article referred to, and from my own study of its habits, I think it ought to be classed with the ichneumon family.

To make a "rope of sand" is conceded to be a feat impossible to accomplish, and the mud wasp in my opinion is not more likely to build its cell of sand, as stated in the article referred to. I have invariably seen them make their lump of the best, most tenacious blue yellow or other colored clay, of which they built their cell.

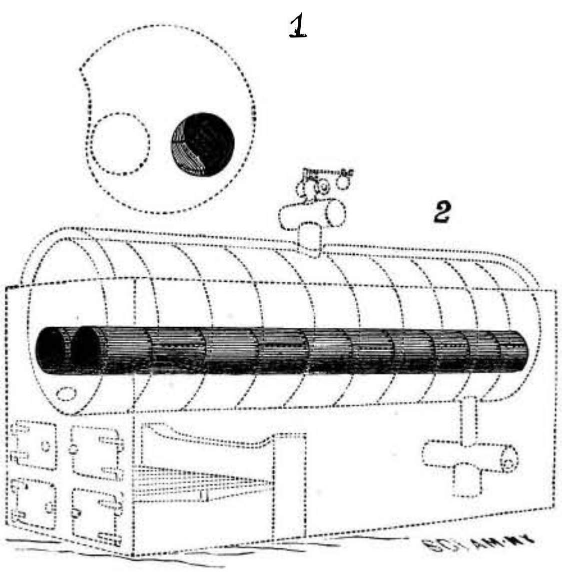
Red Ants.

The following by Prof. C. V. Riley will be of interest to housekeepers:

The small red ants are undoubtedly the most troublesome of the insects infesting houses, and to destroy them or even to keep them in check appears to be nearly a hopeless task, owing to the countless numbers of specimens and the remarkable persistency they exhibit in their attacks. All that can be done is to carry on an incessant and untiring warfare against them by means of liberal and frequent applications of pyrethrum powder, kerosene or kerosene emulsions, hot water, naphthaline, etc. Shallow dishes half filled with sweetened water and placed at suitable places will also attract multitudes of ants, which may be easily destroyed from time to time. Should the hole by which they enter the house be discovered (a matter of no small difficulty and sometimes even impossible), they can be more readily kept out by a good dose of kerosene poured across their path. A sponge saturated with sweetened water will soon teem with them, and if repeatedly cast into hot water when charged with the ants, will help materially to abate the nuisance.

A BOILER EXPLOSION AT CINCINNATI, OHIO.

The boiler at the Cincinnati Sheet Lead and Pipe Works recently exploded, doing no damage to the property and causing no loss of life; it is somewhat of a curiosity, as a great many attribute the cause to shortness of water, the usual scapegoat in such cases.



A BOILER EXPLOSION AT CINCINNATI, OHIO.

The boiler is shown in Fig. 1 by dotted lines, except the flues, and part of the bottom, which were damaged. The appearance of the collapsed flue from the end is shown in Fig. 2.

The boiler was 42 inches in diameter and 26 feet long, with two 15 inch flues, and was made of ¼ inch plates.

The furnace was under the forward end of the boiler, the frame passing for 26 feet under the boiler and for 26 feet back through the flues, 52 feet in all; the right hand flue collapsed at the second or third ring from the front and upward; it also split along the under side of the longitudinal seam.

The theory of many was, at first sight, that the water became low and the flue then collapsed, of course by becoming overheated.

An examination into the whole conditions will show, I think, the true cause; the boiler was very old, and the flues according to modern practice very large; a defect occurred at the seam in the flue, gradually increasing till it so far weakened the sheet that it gave way along this seam, and the flue collapsed at this point, when, of course, the water went out (indeed, this may have been leaking out all night, the accident occurring at 10 A. M.); the boiler being empty, or nearly so, the bottom sheets would become heated and bulged, as shown.

If the boiler had been short of water, and the flues collapsed from that cause, it would have done so at the rear end of flue, and on the top, and also both flues would have been damaged.

This must, I think, be classed among accidents from a defective flue. A. R. P.

Indefinite Cost of Electric Lighting.

It has always been a difficult matter to get anything like a reliable estimate of the cost of electric lighting. The conditions of the problem vary according to the source of power, the number of lamps in use, the average time they are burned, etc., etc., so that electric lighting may prove to be economical in one mill or workshop, and more expensive than gas in another. Still it would be possible, no doubt, to ascertain the average cost of producing a certain amount of light under ordinary conditions, if the lighting companies were disposed to furnish the public with such information. That they do not want to do so was shown in the recent Electric Light Convention in Chicago. A committee had been appointed to ascertain the relative cost of producing the light by water power and steam power, but on second thought the Convention determined that it would be unwise to publish the figures. The committee was therefore discharged before any report was presented, and this for the avowed purpose, the *Phila. Ledger* thinks, of keeping the public in ignorance of the cost of electric lighting. It is doubtful whether such secrecy pays. It gives rise to the impression that the profits on present rates are enormous, and so encourages the formation of rival corporations.

PRACTICAL STUDIES OF MAN'S LOCOMOTION.

Our readers already know about the Paris Physiological Station,* and some of the experiments that have been performed there, and they have been enabled to see, by means of a series of instantaneous photographs, how we analyze the complicated mechanism of walking, running, and leaping, and how motions so rapid that the eye can scarcely seize them are fixed in a sort of diagram which faithfully reproduces their least details.

Such experiments, which are interesting to the physiologist, whom they permit to understand the mechanism of motion better and better, have, in addition, from a practical point of view, a utility that it will perhaps be not without interest to give prominence to.

Good walkers, good runners, and agile leapers are not only men who are endowed with special aptitudes, or who, by frequent exercise, have acquired muscular strength, but they are also *professionals*, that is to say, by the unconscious work that accompanies every frequently repeated act, they have gradually found a means of managing their forces so as to produce the best effect possible. Although every one has the pretension of knowing how to walk and run, there are, among walkers and runners, virtuosos after their kind, who exert no useless stress, and who regulate the rhythm and length of their step according as the stretch is to be a long one or the gait rapid. These professionals would be incapable of transmitting the secret of their skillfulness, since they know it not themselves, having scarcely reflected upon the acts which they perform, after a manner, mechanically. But this secret may be taken by surprise. For this purpose, I propose, as soon as fine weather sets in, to submit the motions of remarkable walkers and runners to photographic analysis. There is nothing rash in discounting the success of these future experiments, for the peculiarities of the improved gaits will certainly reveal themselves in the photographs. Finally, it is allowable to hope that, from the time when the characters of a correct gait shall be well known, it will become possible to teach the principles of walking, running, and leaping, and of all exercises of the body generally, in a methodical manner.

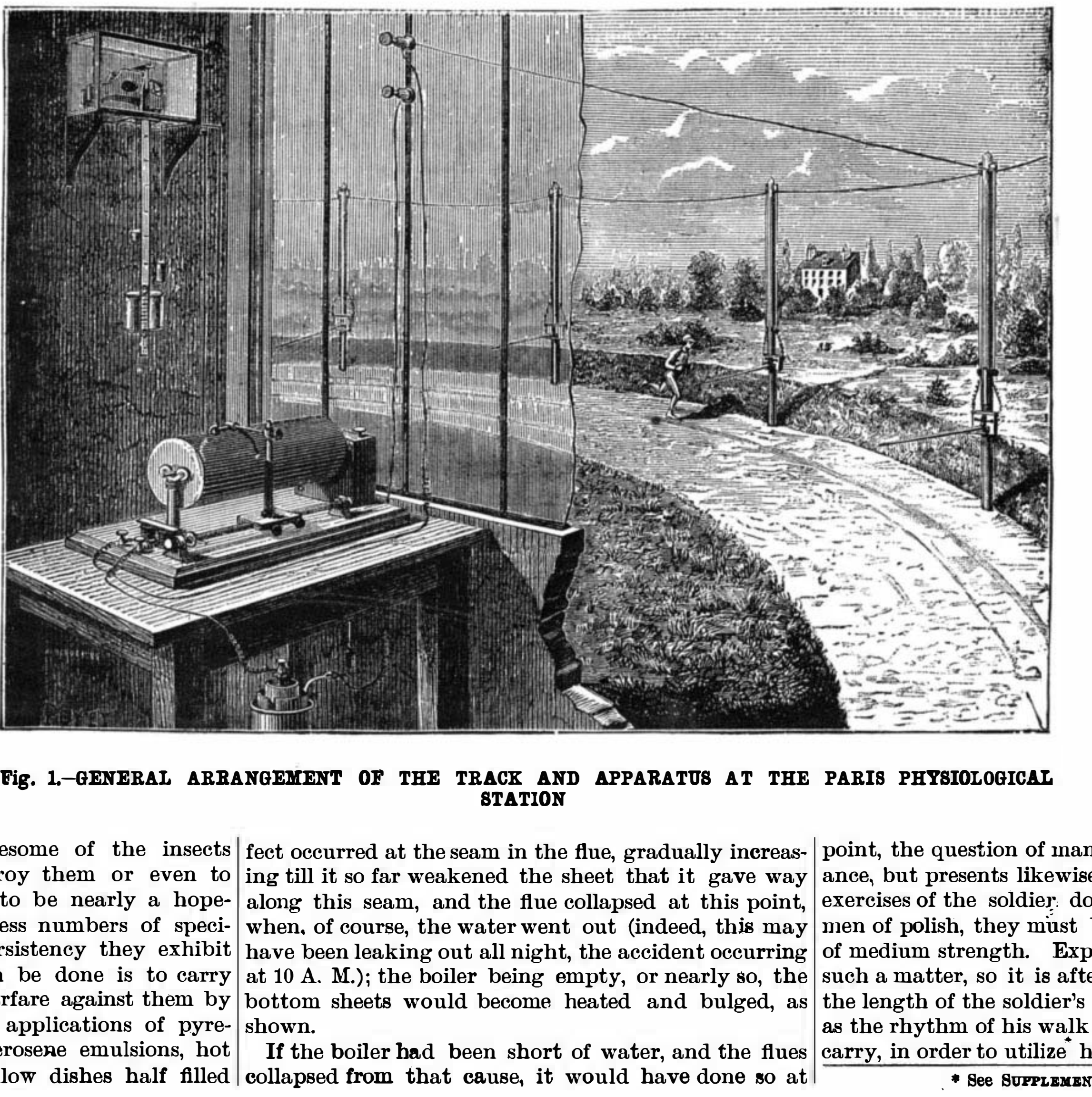


Fig. 1.—GENERAL ARRANGEMENT OF THE TRACK AND APPARATUS AT THE PARIS PHYSIOLOGICAL STATION

From a military standpoint, the question of man's walk is of peculiar importance, but presents likewise special difficulties. As the exercises of the soldier do not address themselves to men of polish, they must be regulated for individuals of medium strength. Experience alone must decide in such a matter, so it is after laborious researches that the length of the soldier's step has been fixed, as well as the rhythm of his walk and the load that he must carry, in order to utilize his forces in the best manner

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* See SUPPLEMENT, Nos. 408 and 414.

possible. Nevertheless, if we consider that different nations do not have like customs in this respect, and that, moreover, the same nation modifies its military regulations from time to time, we must conclude therefrom that we do not as yet sufficiently know the physiological laws of man's work. This is why I have undertaken, with the aid of a few officers of rank, some experiments designed to perfect the ideas that I have in regard to the most favorable conditions connected with walking and running. The difficulty of such studies is due to the large number of observations that they necessitate, and to the unremitting attention and the almost superhuman patience that they require. So I have confided the tiresome business of registering the peculiarities of each individual observation to machines, leaving to the experimenter only the task of drawing general conclusions therefrom.

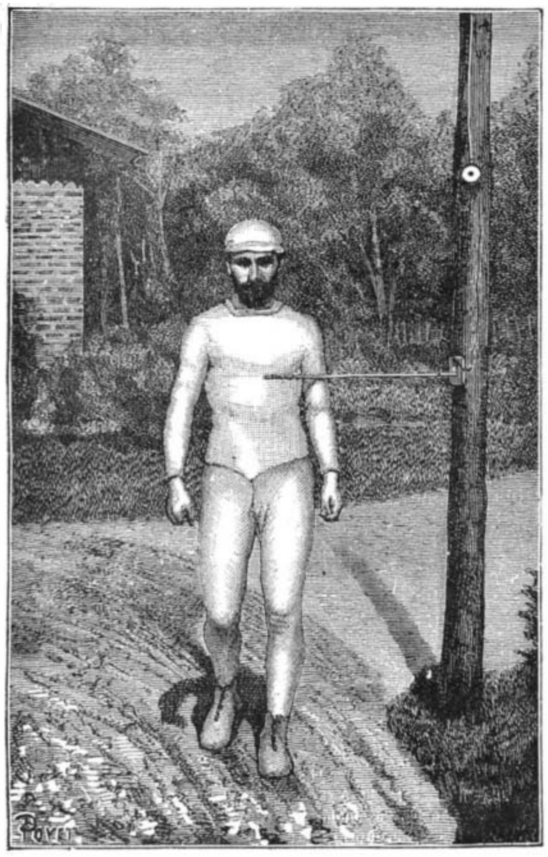

Fig. 2.—ARRANGEMENT OF THE INTERRUPTER.

An apparatus which I described a few years ago, the *odograph*, after certain modifications in detail, has been found capable of inscribing the walk of man, and of faithfully translating the speed of his gait and its greater or less regularity, the number and length of his steps, and finally the modifications that the characters of the walk experience under different influences.

Fig. 1 shows a man running around the experimental track, and the apparatus that are inscribing the characters of his gait. Communication between the man, who is moving freely out of doors (upon a circular track about 1,600 feet in circumference), and the inscribing apparatus, which remains permanently upon a table in the laboratory, is established by a series of electric signals situated very near one another.

To this effect, a telegraph line, whose poles are spaced about 160 feet apart, runs all around the track. To each pole there is affixed an interrupting apparatus which sends a signal at the precise moment the man is passing the pole. The runner, in fact, finds his passage barred at these points by a horizontal rod (Fig. 2) which yields at the least pressure, but which cannot be deflected without producing an interruption in the circuit of the telegraph line. Now such interruption is translated by the movement of a pencil, which makes a mark upon a sheet of paper that covers a revolving cylinder. Each of such movements of the pencil shows that 160 feet have just been passed over by the runner. The mechanism of the electric interrupter is very simple. The rod is inserted into a copper tube, which revolves around a vertical axis and which is cut obliquely at its upper part, upon which rests a piece that moves vertically. This latter is beveled off beneath in a direction contrary to the bevel of the other. Every lateral motion given the rod will cause one of the beveled surfaces to slide upon the other, and lift the upper piece. It is this lifting that breaks the line circuit. To this effect, a horizontal spring that rests upon a metallic button establishes in front of each of the poles a contact that will be broken every time the movable piece lifts the spring. Such breakage will occur at every movement of the rod, whatever be the direction in which the man is moving upon the track. Immediately after the passage of the runner, the rod resumes its original position of itself through the action of the beveled surfaces that press upon each other. At the same time, the interrupted current is re-established. A new breakage will occur every time the runner, on passing a pole, comes into contact with one of the rods.

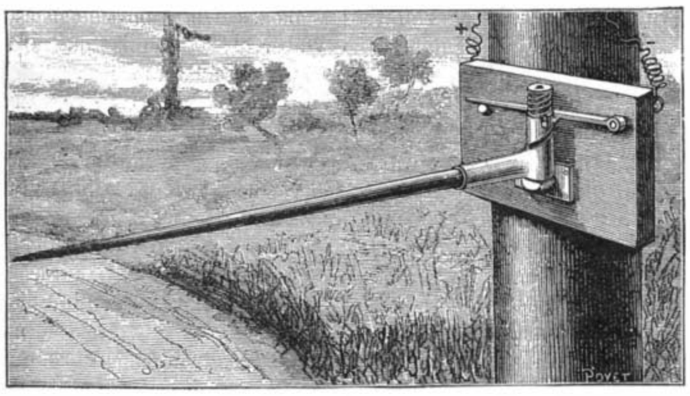

Fig. 3.—DETAILS OF AN INTERRUPTER.

The current of a single element traverses the entire line, and, if we follow its passage in Fig. 1, we shall see it start from one pole of the pile, go to the top of the first pole, descend along it, traverse the contact which, in the interrupting apparatus, forms the spring that presses upon a metallic button, and then ascend to the top of the pole, whence it starts for the next pole, and so on. Starting from the last pole, it reaches the laboratory, traverses the electro-magnet of the odograph, and returns to the pile. As long as the current is closed, the electro-magnet, strongly attracted, throws into gear the clockwork which carries the pencil. At each breakage of the current, the wheelwork becomes free for an instant, and starts the pencil and causes it to move over the paper.

A few explanations will suffice to make the working of the odograph understood. The paper covered cylinder revolves uniformly under the influence of a clockwork movement placed at the extremity of its axis in a closed box. The velocity of its rotation is such that there passes in front of the pencil one-fifth of an inch of paper per minute. On another hand, the pencil (whose point, carried by a metallic arm, rests upon the upper part of the cylinder) is given a motion every time the line current is interrupted. To effect this, the carriage that carries the pencil parallel with the generatrix of the cylinder is traversed by a screw which a train of wheels contained in the clockwork box tends to revolve continuously. It is clear that the revolution of this screw will cause the carriage to move upon its rails and the pencil upon the paper. But the screw carries two lugs that hook on to the under side of the armature of the electro-magnet and prevent any movement of the screw. As soon as an interruption of the current occurs, the screw is set free and begins to revolve; but the passage of the walker in front of the interrupter takes but a moment, and the current soon closes and the soft iron is attracted anew, and when the screw has made a half turn, its second lug hooks on to the armature of the magnet. The pencil therefore moves forward at every breakage of the current a regular distance that corresponds to half the length of the screw's pitch, that is to say, four one-hundredths of an inch.

After a walk or run, the sheet of paper exhibits a sinuous line like that shown at *a* in Fig. 4. In this diagram the time is reckoned in a horizontal direction, in which the minutes are equivalent to two-fifths of an inch. The laps are counted in a vertical direction, in which each new ascent of the line corresponds to a movement of the pencil, that is to say, to a breakage of the current by the walker who is passing a pole. Every movement of the style, that is to say, every step of the sinuous line, *a*, therefore shows that the walker has made 160 feet progress. Thus, the line, *a*, of Fig. 4 corresponds to a walk in which 3,840 feet have been gone over in 15 m. 35 s.

Upon drawing a line that shall join all the salient angles of the zigzag line, *a*, we shall get a simpler expression of the walk; and this is what has been done with the lines, *b*, *c*, *d*, etc., which, through their greater or less inclination, show that the gait has been more or less rapid.

The more suddenly the line rises, the more rapid a gait it shows. Thus the curve *i*, the one that rises most suddenly, corresponds to a run in which 5,120 feet have been made in 9½ minutes; the slowest gait corresponds to the curve *c*—a walk at the rate of 2,400 feet in 16 minutes.

In Fig. 4, we have been unable, because of its limited dimensions, to give anything but fragments of the tracings. The interest of this sort of an inscription consists, on the contrary, in collecting long tracings corresponding to several hours' walking. In this way we have a more faithful expression of the character of the gait, and may see therein the effect of excitement, which, in some men, quickens the walk during the first quarter hour, or that of fatigue, which, eventually, and in more or less marked manner, slackens it. With certain individuals the walk is wonderfully uniform, this being shown by the perfectly straight odographic tracing. Every irregularity in the speed, on the contrary, is shown by inflections of the line, which rises when the walk quickens and descends when it slackens. Such is the experimental arrangement employed at the physiological station for studying the different influences that modify the speed of walking, the influences of the load carried, of the form of the foot gear, of the rapidity of the rhythm of the clarion that regulates the step of soldiers, etc. These experiments are under way, and will not be finished in a long time, but they have already given quite interesting results.

We have just hinted that the form of the foot gear has an influence upon the speed of walking. In order to determine the best form of foot gear for walkers, I have had gaiters made of which the heel consists of plates two-fifths of an inch thick that may be superposed so as to give a height varying from two-fifths to two and two-fifths inches. In a series of experiments made with heels of decreasing height, I have always found that the speed of the gait increases in measure as the height of the heel decreases. And this result is due to an increase in the length of the step. Upon substituting long, medium, and short soles for each other, I have found that the step is elongated and the gait becomes more rapid when the length of the sole perceptibly exceeds that of the foot. Above a certain limit, the precise determination of which cannot be made until after numerous experiments have been performed, the elongation of the sole is accompanied with a notable fatigue, and the walk is interfered with.

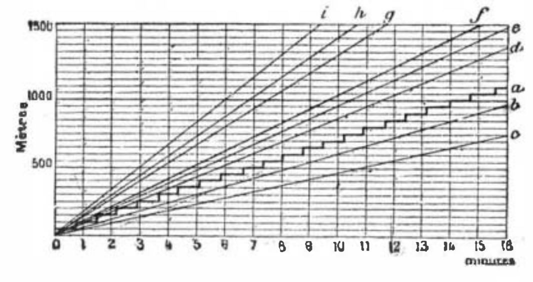

Fig. 4.—TRACINGS MADE BY THE OLOGRAPH.

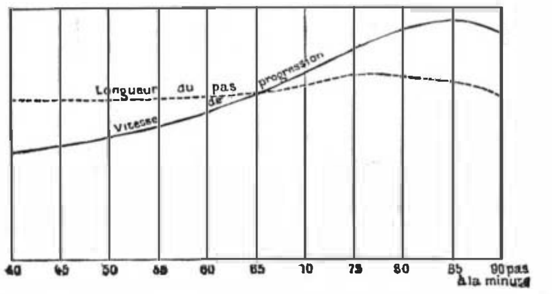

Fig. 5.—CURVES OF THE SPEED OF WALKING AND OF THE LENGTH OF STEP AS A FUNCTION OF THE RHYTHM OF THE GAIT.

The rhythm of the drum or clarion regulates the soldier on a march, and, when it is desired that a body of troops shall quicken its step, the music is made more lively, and the number of steps taken in a given time becomes greater. But does it follow that the speed of the gait increases in the same proportion? We shall see that the problem is very complex, and that the acceleration of the rhythm of the walk increases the speed of the gait up to a certain rhythm bordering upon 80 steps to the minute. Beyond that the increase in the frequency of the step brings about a slowing up of the walk.

In order to determine such influence of the rhythm, it is necessary to add to the arrangement above described an apparatus that shall regulate with absolute accuracy the number of steps taken every minute. A pendulum, shown to the left in Fig. 1, at every oscillation interrupts the current of a powerful pile which actuates a bell located in the center of the track. This electric bell is placed upon a high wooden framework, so that it can be heard from all points of the track. It is impossible for the walker not to regulate his steps by the ringing of the bell, so that, at the end of any period whatever, the number of steps taken will be exactly that of the oscillations of the pendulum. Now, a slide running along the pendulum rod gives the latter a number of oscillations that is exactly determined beforehand for each of the positions. Upon giving the walk a slow rhythm of 40 steps to the minute, and then operating with more and more rapid ones, we find that the same number of feet is passed over in unequal times, according to the rhythm of the step.

Two celebrated German physiologists, the brothers Weber, have admitted that the steps became greater and greater in measure as their rhythm accelerates; but this formula is too general, as we shall see, and if it is true that, in a slow walk, the acceleration of the rhythm increases the length of the step, a greater acceleration finally shortens it.

But, it will be asked, how do you estimate the length of the step in such experiments? This length is simply deduced from the number of oscillations of the pendulum made during one turn around the track, which represents a perfectly well known distance. Now, experiment has shown that the progressive acceleration of the rhythm of the steps brings about modifications in their lengths that are expressed in the following table. Thus, an increase in the rhythm from 60 to 80 steps per minute has increased the length of the step; but, starting from the latter figure, the acceleration has produced an entirely contrary effect, it having diminished the step's length. The accompanying numerical table may be advantageously replaced by a graphic expression of the variations in the velocity of the gait and of the length of the step as a function of the frequency of the rhythm. Such a table is shown in Fig. 5. It is certainly more explicit than the three columns of figures from which it was constructed.

Time taken to travel 5,058 ft.	Number of double double steps per minute.	Length of double steps.
20′ 30″	60	4·43 feet.
18′ 40″	65	4·49 "
16′ 27″	70	4·75 "
14′ 38″	75	4·95 "
13′ 52″	80	4·92 "
13′ 3″	85	4·87 "
14′ 1″	90	4·34 "

The physical reason for this shortening of the step in very rapid rhythms has been determined, but to explain it would require details that would lengthen an article which is already too long. My only object on the present occasion has been to show how the precise methods of physiology may serve to improve the most ordinary acts of life.—*E. Marey in La Nature.*

Electricity Man's Slave.

BY THOMAS A. EDISON.

Among the many factors which have developed commerce and industry and stimulated all the forces of progress during the last half century, none has played a part so radical and essential as electricity. Hardly a single nerve or fiber of that complex body which we call society that has not thrilled and vibrated with its influence. It has strengthened the bonds of international amity; it has quickened all the methods of trade, and lent tenfold precision and celerity to the innumerable agencies by which it works; it has breathed new vitality into the arts and sciences; it has even warmed and strengthened the social forces; and, in a word, one may justly claim for it such a universal stimulus as cannot be credited to any other purely physical agency in the world's history.

It is not yet fifty years since the invention of the electro-magnetic telegraph, made by Prof. S. F. B. Morse, was first put into operation between Washington and Baltimore. To-day there is hardly a hamlet so small and so remote that a telegraph station does not link its inhabitants with every point of the civilized world. The crude apparatus first used by Professor Morse has been again and again improved on by subsequent inventors in the same field.

Only a few years elapsed after the success of Professor Morse before the first submarine cable operated in America was laid between Cape Ray and the shores of New Brunswick. This achievement in 1852 suggested to Mr. Cyrus W. Field, we believe, the connection of the New World with the Old, by means of a submarine cable. The history of the first Atlantic cable laid, the jubilee over its triumphant completion on August 6, 1857, its short life of less than a month, the pluck and energy displayed by capitalists in their endeavors to lay a second cable nine years later, the failure of this second effort, the ultimate success attained by the laying of the Anglo-American Telegraph Company's, and its final opening as a medium of public traffic on August 26, 1866—all these things are sufficiently well known to most of our readers.

Closely connected with the development of the telegraph came the invention of the speaking telephone, this being the logical consequence of the former. When it was once found possible to transmit signals over a length of wire by means of the electrical fluid, it was certain that sooner or later experiments would be made ultimately with a view to employing the same agent as a means of transmitting articulate speech to a long distance. These experiments reached a successful conclusion in 1876–77 by the invention of the magneto receiving telephone by Professor Alexander Graham Bell, and the carbon transmitting telephone of the writer of this article. Many others have laid claim to the invention of the telephone, or to so-called improvements on the original devices. But so far the only instruments commercially successful are the Bell receiver and the Edison carbon transmitter, now universally accepted throughout the world.

Coincident with [illegible] development of the speaking telephone, the electric light was first brought to a practical success by the illumination of the Avenue de l'Opera in Paris by the Jablochkoff candle in 1878. Prior to this but little had been done in the way of electric illumination on an extended scale. The exhibition made in Paris gave a great impetus to lighting as a business. From that time to the present the progress has been marvelous and rapid, only second to that of the telephone.

Many inventors, among them Staite, King, Kossloff, Swan, and Sawyer, had previously been experimenting with a view to making useful lamps giving light by means of incandescence. But these experiments had been based on fallacious theories, and were foredoomed to failure. The writer was led to the invention of the filament lamp by keeping in mind the commercial necessities of the case as applied to a lamp forming but one unit of a complete system. His object, therefore, was not merely the device of an electric lamp; he aimed to invent a system of electrical illumination which could be operated on an extended scale in the same manner as in the business of gas illumination; to find some means by which electrical energy could be turned into light, and that light be used for household purposes and sold by meter record—in short, a system superior to that of gas and able to compete with it commercially. The final result of these experiments was the invention of a complete incandescent system, and the starting of a central station in New York at 3 P.M. on September 4, 1882. Then for the first time electricity for the production of light was supplied and sold on a meter. This station has been in operation since, night and day, and has been followed by the establishment of other stations, both in this country and in Europe.

In addition to the foregoing, electricity has been brought to the aid of metal workers for the purposes of electroplating and electrotyping; it has assumed a place in our houses for the operation of call-bells and annunciators, for protection against burglars, and for the correction of our clocks and other purposes.

Yet though so much has been already done in the last fifty years in the way of electrical development, the writer is confident that far greater progress will be made in the future. We stand to-day only on the threshold of its tremendous probabilities. The uses to which the electrical energy can be adapted are so numerous that the present generation hardly dreams of them. Nothing of any startling character can be expected of the electrical telegraph. The business has been so long established, the improvements are so numerous, that very little remains to be done. Some day there will be, no doubt, a sextuplex system, which will make one wire do the work of six. While none so far tried has succeeded commercially, the expanding magnitude of telegraphy makes it a necessity. This will enable the present telegraphic plant to do more work, and lessen the investment necessary for the installment of any future plant. The necessity for economic running expenses must lead to the use of a system of autographic telegraphy, which will enable the telegraph companies to dispense with most of their skilled labor.

The development of the telephone is in its very infancy. In the first instance, those in the center of cities alone had the advantage of telephone service; then the suburbs were reached, and later on towns adjacent. The service in cities is by no means satisfactory, and between cities and towns adjacent it is far more inefficient. The business has reached such magnitude that it has outgrown the present equipment. The company controlling the telephone business in this country fully recognizes this, and is working with all the talent which money and interest can obtain to improve the service. The result will be greatly to the advantage of the public, and consequently to the commercial development of the telephone.

The efforts made with a view to long distance telephoning have already proved quite satisfactory in a commercial way, and promise excellent results. Conversation has been conducted between Cleveland and New York, and is now daily carried on between New York and Boston to a limited extent. The great difficulty in long-distance telephoning is the loss of the current by static induction on the earth and wires in close proximity. If a single wire could be placed sufficiently high as to amply clear all the mountain tops, one could whisper around the world with perfect ease; or if a wire could be stretched from the earth to the moon, the connection would also be adequate. Perfect results were recently obtained on a government line in Arizona, a distance of about a thousand miles, the wire stretching over a treeless space of country, more perfect far than can now be had between New York and Hartford. The loss of the electrical energy by static absorption, and the running together of the electrical waves, is the fact that utterly precludes the possibility of submarine telephoning across the ocean. One thing, however, is now certain: that the time is close at hand when the telephone will be perfectly successful in an unbroken circuit for a distace of at least 300 miles; and that a subscriber will be able to communicate with 75,000 commercial houses. More than this, even, it is probable that by means of repeating stations communication can be had over all parts of the United States.

The changes wrought by the telegraph and telephone will be equaled, if not eclipsed, by the transformation wrought through electrical lighting. Two years' experience proves beyond a doubt that the electric light for household purposes can be produced and sold in competition with gas.

It is immaterial whether the electrical energy is used for light or for other purposes. It is so easy of control, the apparatus required so inexpensive, that it can be used as a motor power for purposes innumerable. In a house it can be utilized to drive miniature fans for cooling purposes, to operate a sewing machine, to pump water, to work a dumbwaiter or an elevator, and for a hundred other domestic uses which now require personal labor. In places where small steam engines are used at great expense, owing to the special attendance requisite, the electric motor will be invaluable. Electricity as a lighting agent has the great advantage over gas that it can be used at will for motor purposes, and that its operation for the latter purpose is as simple as for incandescence, which is done by the mere turning of a key like a gas cock. The function of electricity as a motor for household purposes will be hardly less useful than its value in illumination.

The great problem to be solved, however, by the physicist and electrician, before the art of electrical application attains its ultimate triumph, is the direct production of electrical energy from coal. The dream of certain French and German scientists that it may be transformed directly from the solar energy is a wild chimera, or at least it is remote and untrustworthy; but that it will be derived in some simple and inexpensive way directly from coal, which is solar heat and light stored up by nature, the writer believes to be a certain fact. The present methods of producing electricity are, at their best, very cumbersome and expensive. Expensive boilers, engines, and dynamo machines are the media through which the carbon of the coal is transmuted into electricity, and with enormous waste at that. A large amount of expensive labor, too, is needed, so that with the cost of the plant and of the labor to operate it, the ultimate product is very costly. Once, however, the secret of the direct production of the electrical energy from coal is discovered, a marvelous revolution will take place. The cost to the consumer will be very small. From one great central station in a city electricity will be furnished to give light, heat, and power to houses, stores, public buildings, factories, and workshops, and at so reduced a cost as to materially lessen the expenses of life and work. This is something more than a dream. It is a future fact which many now living will probably see realized. Such a direct transformation of coal into electricity would utilize 80 per cent; now by the process of turning the energy of carbon into heat, heat into energy of motion, and this into electrical energy, at least 90 per cent is lost.

Electricity as a motive power will not be confined to household or factory purposes. It has already been successfully used (for experimental purposes) at Berlin, Paris, Portrush (Ireland), and by the writer at Menlo Park as a motive power on a railroad. These various experiments have perfectly proved the practicability of the electric locomotive, and indicate that it will be largely adopted in the future in place of the steam locomotive.

Various experiments have been made with a view to the electric propulsion of carriages, cabs, drays, etc. The drawback has been that the power has been obtained from secondary or storage batteries, the depreciation in which is so rapid, and the weight of the receptacle so great, that until some radical improvements are made in connection with the storage of electricity, or the production of the same directly from coal, we cannot hope to see the subtle fluid used as a means of propelling street conveyances. Still daylight begins to shine on the problem, and the writer has no doubt that eventually most of our trucks and cabs will use this power. When this time comes, we shall find the scope of electricity vastly widened, and see carriages without horses, yachts without steam or sail, and many other novel adaptations. The problem of aerial navigation, too, will then be easily solved.

The vast deposits of rebellious ores, which for the want of an economical method of working are to-day practically useless, will probably at some date not far hence yield to man the precious metal they contain by assistance of electricity. Though the experiments have not been very successful, enough has been done to show that there will be eventual success.

Such, briefly told, are the marvels of electricity, as already accomplished, or as marked out on the sure lines of scientific foresight. If the story could have been told as a prophecy fifty years ago, it would have dazed even the most adventurous mind. Yet the other half of the story hidden behind the veil will not be a jot less wonderful. The writer, in reviewing what he believes from a long and absorbing study of the problems of electricity, has only touched on those phases of development which experiment has shown to be within the grasp of the scientific inventor. To discuss its possibilities would bring into play a line of speculation seemingly more akin to the dreams of the poet than to the sober judgment of the practical worker.—*N. Y. Tribune.*

To Make Watch Hands Red.

Mix to a paste over a lamp, one ounce of carmine, one ounce chloride of silver, and a half ounce tinner's japan. Put some of the paste on the hands, and lay them face upward on a sheet of copper, holding it over a spirit lamp until the desired color appears.