nitrogen—a theory I brought out in the year 1869. My idea is that nitrogen is present to meet the variations of temperature. For instance, if I took an animal from a temperature of 60°, and placed it not in cold oxygen, but in cold common air at 30°; if I fed it well, and covered its body closely; if, in fact, I placed it in the condition of a well fed Esquimau, I found the animal would want to take largely of food—would begin to make an excess of carbonic acid; and, if only fed as at 60°, would commence to waste. The reason for this is, that the oxygen is abundant in the air, and, at the same time, is sufficiently diluted to be able to combine with the blood and the tissues, and the result is a greater production of primary force, by which the animal is enabled, when well fed, to sustain the effects of the surrounding cold. If, from this extreme degree of cold, I move the animal to a temperature of 70°, still supplying it with common air, I find, if food be kept up, and all else be equal, the animal ceases to crave so much for food, produces less carbonic acid, and, with decreased waste, tends to grow fat. The reason for this is, that the oxygen diluted still for ready combination, does not meet the blood with the same degree of pressure, and the result is that the animal, which in the warmer medium does not require so free a production of force, produces less force. If, in repeating these experiments, I use pure oxygen instead of common air, the animal at the lower temperature will want no food, will make a minimum of carbonic acid, and will sleep and die from not burning; while the animal in the higher temperature will eat ravenously, get very hot, produce an excess of carbonic acid, and, if not largely supplied with food, would die from waste. The differences in the result of these experiments, as compared with those related before, are due to the absence of the equalizing nitrogen, which, existing in the proportion of four to one in common air, resists just in that proportion the excessive action both of heat and cold.

The practical application of these principles to Mr. Fleuss's apparatus is that there would be some degree of danger in using it in extreme cold or in extreme heat. The waste would be excessive in extreme heat, and that would lead to exhaustion. In long continued extreme cold the temperature of the body would go down, and there would be danger from that cause. I observed that was the case in the first observation made on Mr. Fleuss. The temperature went down to 92°, and the wonder was he could live so well in that temperature. Below that it would not be safe, in my opinion, to use this apparatus in the manner in which it is now brought forward.

For the use to which Mr. Fleuss's apparatus may be applied, I think some improvements admit of being made. It strikes me that a feeding apparatus might be introduced. Mr. Fleuss says he can live in it as long as he can go without food; and I think, if there were a bottle containing food—liquid meat, or milk within the cuirass, and a tube were passed upward through the mouthpiece, so as to come to the mouth, he might very easily take food and stop for a longer period under the water, perhaps for eight or ten hours. Another improvement which might be made would be specially useful for mines—that, viz., of having a telephonic arrangement, so that he could communicate with those above by means of connecting wires. Those are improvements which, I think, the apparatus will admit of in the future.

The conclusion we may arrive at is that we have an apparatus now at our command in which, under certain conditions, a man can live for a long time under water, and be capable of carrying out active movement with perfect freedom, in which also a person can enter into an irrespirable gas. The apparatus may be used for diving, but how far it will extend for that use exclusively has to be proved. There is a great difference, I understand, among divers as to the distance below water at which Mr. Fleuss can work with his apparatus. He himself has been 25 feet under water with it, and has felt no embarrassment. He has walked 400 yards under water and felt no embarrassment; but whether he can go to the great depths which some divers have gone with the ordinary dress, is a matter which remains yet for inquiry. It may interest you to know to what depths divers can go. Mr. Siebe has related that one diver, named Hooper, descended, near Cape Horn, actually to the depth of 200 feet, and remained working for forty-two minutes; the extremest depth to which a man has descended. That man, it is said, descended seven times, and remained under water forty-two minutes each time. The statement has not been confirmed by after experiments, perhaps because no one has had occasion to go to such a depth, but the very able writer of the article on diving in the "Encyclopædia Britannica" shows most distinctly that in some experiments made in Scottish waters, a depth of 86 feet was attained by the divers; so that we may be quite sure, from the observations then made, that 86 feet is an attainable depth. On theoretical grounds, Mr. Fleuss ought to do the same, but he has yet to win his spurs to show that he can descend to that depth, and perform work the same as divers can who are supplied with air through a tube from above.

Whether the invention is to be useful in the way of a diving apparatus or not, certain it is, it may be very useful for many other purposes. It may be extremely useful, I think, for entering into houses that are on fire, and my suggestion will be that a dress be made of very light material for this purpose, and of a fireproof material. That is to say, perhaps a felt dress, saturated in nephate of ammonia, and made in such a way that the limbs can move easily in it. Then I see no reason why a man should not enter into a burning house and fetch out persons who are being burnt or subjected to danger, without any danger at all, in so far as the bad air is concerned. Of course he could not resist great heat, nor the danger from falling materials, but he would resist the suffocating smoke and air. I believe that this will be one of the most admirable contrivances, and I should expect that the day will come when every fire engine room in London will be supplied with one of them. Again, I think the apparatus may be used with great effect in mines. I have already shown, by an experiment with Mr. Fleuss, in the most crucial form, that he can live in the most active narcotic atmosphere. That he could be let down into a mine at any time after an explosion and traverse wherever he could see, and ascertain what persons were there, and render assistance, I have not the slightest doubt. He could do that to any extent, if he could carry a light. There an improvement wants to be brought forward again, a light that will illuminate all round, and yet, at the same time not set fire to explosive gas. Once more, he could enter wells and places where carbonic acid is being given off freely. The dogs in the Grotto del Cane die rapidly when they are put on the floor; Mr. Fleuss could lie down in the place all day, if he could feed himself quite safely.

In conclusion, let me put before you one demonstration. I have been favored by the Royal Institution with the loan of the glass chamber in which Professor Tyndall made the experiment of entering into smoke, using a filter mask over his mouth. That chamber, which has, I suppose, a capacity of about 45 cubic feet, has been charged with carbonic acid. The whole of the atmospheric air in it may not be removed, but like the lower part of the Grotto del Cane, nothing could live in it. Mr. Fleuss will, however, go into it, and set us at defiance, for he cares nothing about an atmosphere of that kind.

[Mr. Fleuss went into the chamber of carbonic acid gas, and remained a considerable time.]

There is one further advance which will probably be made on this, and that will be to fit up a small submerged vessel with propelling power, so that men may live in it under water and pass beneath the sea considerable distances, carrying with them their own atmosphere and food. When I once said that a great branch of geographical discovery made by the Salutlanders was the exploration of the floors of the great depths, I was very much laughed at; now, I think the laugh is going to be on my side, and that that achievement will even come to pass in the course of the next half century.

It remains, sir, for me only to express to Mr. Fleuss our debt of gratitude, not only that he should with great labor, trouble, and expense, have worked out this ingenious apparatus to such perfection, but that he should, also, with true English courage and pluck, have been himself the first to experiment with it, and to enter into deep water, not knowing whether he should come out alive from the trial. It has been to me a work of much pleasure indeed, and I esteem it an honor to be connected with this apparatus, by giving the first lecture on what I am quite sure will lead to a new era in the art of living in factitious gases, and beneath the sea.

SIEMENS' ELECTRIC RAILWAY.

The idea of superseding the steam locomotive by an electric engine is by no means a novel one; but it was never practically realized until last year, when Dr. Werner Siemens built and operated an electric tramway in the grounds of the Industrial Exhibition at Berlin. In connection with the history of this subject it is worth while to mention that an attempt was made to devise an electric locomotive in America some thirty-three years ago. The SCIENTIFIC AMERICAN for September 25, 1847, contains a description of a new mode of railway propulsion, the joint invention of Mr. Lilly and Dr. Colton, of Pittsburg, Pennsylvania. "The machine," says this account, "is a small locomotive, and is placed upon a circular railway, around which it is driven by electricity. The power is applied not to the locomotive, but to the *track*, in a very curious manner. Two currents of electricity, negative and positive, are applied to the rails, and by them communicated to the engine. The latter is provided with two magnets, which, by a process of alternate attraction and repulsion, drive the car over the track. A piece of lead is placed on the locomotive, making in all a weight of 10 lb., and on the application of the battery the machine moved with astonishing rapidity up a plane inclined about 5°." In this apparatus the current was supplied by a battery, a fact which, together with the imperfect state of electric science at the time, doubtless caused its failure.

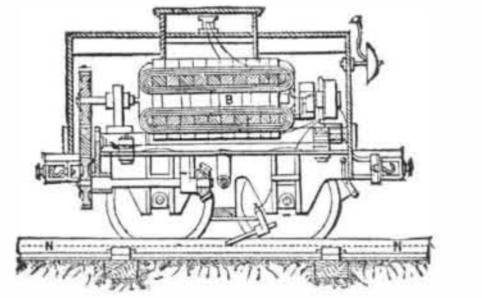
Another claimant for priority of invention of the electric railway is M. Boué, *sous-intendant militaire* at Belfort, in France. This gentleman took out a French patent in 1878 for the propulsion of carriages on a railway by means of electricity; and not only does the patent describe a means for driving a single train of cars, but also a vibratory apparatus whereby the power of the current may be distributed to several separate trains so as to propel them all. Perhaps, too, we ought to mention that Mr. Edison has of late been relieving his severer labors by the erection of an electric railway, on which it is his delight to whisk admiring visitors along. Curiously enough, he also intends to build a line at a very steep gradient (1 in 6) in order to show the capabilities of his electric railway for overcoming inclines. We say curiously enough, because that is one of the purposes which Dr. Werner Siemens has expressly stated that the new electric train would be adapted to.

Historical mention is justly accorded to the pioneers of a new invention, though the chief merit rests with him who makes it a success. To Dr. Werner Siemens belongs the honor of recognizing that the improved means now at our disposal for generating electricity and applying it to the transmission of power are sufficient to operate an electric railway on a practicable scale.

The Berlin Railway was a narrow gauge line, laid down in a circle 900 yards long. A train of three or four carriages was placed upon it, and on the first carriage a medium-sized dynamo-electric machine was fixed to the axle of one pair of wheels in such a manner as to rotate the wheels when the armature of the machine was rotated by the passage of a current through its coils. The rails were laid upon wooden sleepers, which, even in wet weather, insulated the rails very well for this length of line. A third rail ran between the other two, and it was by this central conductor that the current was led from the generating machine placed at one terminus of the line. The current was drawn from this rail to the armature of the machine on the locomotive by means of a brush of copper wires; and after traversing the coils of the armature it was led to the axle of the driving wheels, which was insulated from the body of the car, and thence by the driving wheels to the outer rails, and by them back to the dynamo machine at the terminus. The annexed figure represents a section through the locomotive, showing the dynamo-electric machine, B, and the central rail, N, with the metal brush for abducting the current.

Between twenty and thirty persons could be accommodated on the train at a time, including the conductor, who rode on the first carriage; and during the course of the summer no fewer than 100,000 were conveyed over the line at a speed of from fifteen to twenty miles an hour. Crowded trains left the stations every five or ten minutes, and a considerable sum was earned in this way for the benefit of charitable institutions. The locomotive was capable of exerting five horse power, and instead of being fitted with a steam valve like a locomotive to start or stop it, it was simply provided with a commutator for closing or opening the circuit of the current.

"It is," says Dr. C. W. Siemens, "a remarkable circumstance in favor of the electric transmission of power, that while the motion of the electro magnetic or power-receiving machine is small, its potential of force is at its maximum, and it is owing to this favorable circumstance that the electric train starts with a remarkable degree of energy. With the increase of motion the accelerating power diminishes until it comes to zero, when the velocity of the magneto or driven machine becomes equal to that of the dynamo or current-producing machine. Between the two limits of rest and maximum velocity the driving power regulates itself according to the velocity of the train; thus, on an ascending gradient the speed of the train diminishes, but the same effect is automatically produced which results from the turning on of more steam in the case of the locomotive engine. When running on the level, the velocity of the train should be such that the magneto-electric machine should make one-half to two-thirds of the number of revolutions per minute of the dynamo-electric machine. When descending, the speed of the magneto-electric machine will be increased in consequence of the increased velocity of the train, until it exceeds that of the dynamo-electric machine, from which moment the functions of the two machines will be reversed; the machine on the train will become a current generator, and pay back as it were its spare power into store, performing at the same time the useful action of a brake in checking further increase in the velocity of the train. If two trains be placed upon the same pair of rails, the one moving upon an ascending portion, the other upon a descending portion of the same, power will be transmitted through the rails from the latter to the former, and they may, therefore, be considered as connected by means of an invisible rope."



With regard to the relations of work done to energy expended on the electric railway, the proportion of power actually transmitted varies with the speed of the train, and reaches a maximum when the angular velocity of the armature of the machine on the train is about two-thirds that of the armature of the current generator. Under this condition it is found in practice that something over fifty per cent. of the motive power of the stationary engine driving the generator is utilized in drawing the train.

It is not to be expected that the electric locomotive will compete with the steam locomotive on long lines of railway, any more than the electric light will at present rival gas for general use, but it may prove very serviceable under special circumstances and on short lines. For steep gradients, tramways in mines, docks, large works, or cities, it is particularly well adapted, owing to its freedom from noise or noxious fumes. It is also well adapted for the transmission of letters along subterranean tubes; and we understand that experiments are being made in Paris with a view to supplanting the pneumatic system of carrying letters by an underground "electric post."

A more important project, however, is the scheme of Dr. Werner Siemens for an elevated tramway to connect one end of the city of Berlin with the other. It is proposed to have two separate lines, one for the going and the other for the return journey. The rails are to be 3 ft. 3 in. apart, and only two rails will be required for each line, the current coming from the terminal engine by one line, and returning by the other. Each train has fourteen narrow cars, four to convey standing passengers, and ten for sitting passengers. A 60-horse power engine will be stationed at one end of each line, and the speed will be twenty miles per hour. A good deal of opposition to the project has been offered by the owners of property along the route under the impression that it will depreciate the value of their houses, and a commission has been appointed to examine these objections.

The freedom of the electro-locomotive from smoke is of great importance in passing through a long adit or tunnel, and it is interesting to learn that the administration of the St. Gothard Tunnel seriously contemplate its application to the conveyance of their trains through that gigantic tunnel. Existing circumstances are in this case favorable to the employment of electric power, for at both ends of the tunnel turbines of enormous aggregate power were established to assist in boring, and still stand ready for use. All that has to be done, therefore, is to insulate the rails, and connect up dynamo-electric machines of sufficient power to the turbines and the train. Instead of insulating one of the rails, it might be advisable to convey the current by a conducting rope resting on wooden or glass supports in such a manner that it can be picked up by the train as it passes, and run over one or more contact pulleys connected to the armature of the machine carried by the train, then deposited again on its insulating supports. In this way, no doubt, the insulation of the rails could be avoided, but it remains to be determined by the experiment whether the high velocity of the train would not render such a plan impracticable.—*Engineering.*

NEW APPLICATIONS OF THE DYNAMO-ELECTRIC CURRENT.

So long as the production of electricity was confined to voltaic batteries and small imperfect magneto-electric machines, the use of electric currents was necessarily much restricted. In fact they could only be employed in cases where the mechanical or other sensible effects were small, such, for example, as the electric telegraph, and those devices in which purely mechanical arrangements would have been too cumbrous or otherwise impracticable. The improvement of the dynamo-electric generator, however, enables the electrician to deal with very powerful currents, and accomplish work on a massive scale. Even in telegraphing the dynamo-electric current is supplanting the voltaic battery for supplying the electric power, and the colossal Western Union Telegraph Company of the United States now transmit all the messages from their central office in New York by the currents drawn from four Siemens machines. The recent success, says *Engineering*, of the electric light is another triumph for this mode of generating electricity, and the new applications we are about to describe open up to our view a vast horizon of possible uses in the future.

The name of Siemens is in the front of this advance, and will ever be associated with the industrial capabilities of the electric current. It is to Dr. C. W. Siemens that we owe two of the most recent uses of the current, namely, the fusion of refractory metals in considerable quantities in an electric furnace, and the promotion of vegetation under the action of the electric light. To Dr. Werner Siemens, of Berlin, we are indebted for a third application, which promises to become very widely extended: we mean the propulsion of cars along rail or tramways by the dynamo-electric current, and, in general, the driving of machinery.

The chief results of these three applications which have as yet been obtained were communicated by Dr. C. W. Siemens to the Society of Telegraph Engineers at a special meeting on June 3, and we shall now proceed to review them.

FUSION OF METALS BY ELECTRICITY.

Taking up the subject of electric fusion first, perhaps because it is the most novel of the three applications, Dr. Siemens remarked that the oxyhydrogen blast was the most used, especially the form of M. St. Claire de Ville, known as the "Deville furnace," which has been applied by Mr. G. Matthey, F.R.S., for the fusion of considerable quantities of platinum. The regenerative gas furnace, now used for the production of mild steel, is another plan for creating extremely high temperatures; and by the application of the open-hearth process from 10 to 15 tons of malleable iron, containing only traces of carbon or other alloy, may be seen on the open hearth of the furnace in a perfectly fluid state, and at a temperature probably equal to the melting point of platinum. The only building material capable of withstanding so fierce a heat is a brick composed of 98·5 per cent. of silica and only 1·5 per cent. of alumina, iron, and lime, to bind the silica together.

The degree of heat attainable, either in the Deville or the Siemens regenerative furnace, is, however, limited to the temperature of dissociation of carbonic acid and aqueous vapor, that is from 2,500° to 2,800° C. It is, therefore, to the electric arc that we must look for the production of temperatures exceeding the dissociation point of the fuel employed in combustion furnaces. The germ of this application lies in the decomposition of potash by Sir Humphry Davy in 1807, and the discovery of the electric light by the same philosopher in 1810. Spectroscopists have found the value of the arc in dissociating elements, and quite recently Professor Dewar employed the dynamo-electric current to vaporize metals in a crucible of lime. Nor should we forget that Mr. Werderman once patented a plan for fusing blast holes in hard rock by means of the electric arc, thus obviating the use of diamond drills. But Dr. Siemens is, we believe, the first to produce what may be called large effects of intense heat by the same means.

Fig: 1.

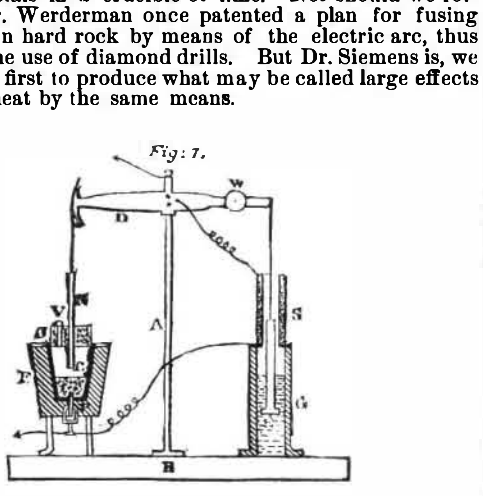


Fig. 1 illustrates the Siemens electric furnace. It consists of an ordinary crucible, C, of plumbago, or other highly refractory material, inclosed in a metal casing holding a packing, F, of pounded charcoal, or other bad conductor of heat. An electrode, P, for the positive current of iron, platinum, or dense carbon enters the crucible from below, and a negative electrode, N, of compressed carbon enters from above by the lid, L, in which is pierced a vent, V. The negative electrode, N, is hung from the end of a beam, D, by a strip of copper. The beam is supported by a stand, A, fixed on a base, B, and carries at its other extremity a hollow cylinder of iron, E, with a piston end. This core is free to move up and down within a solenoid of wire, S, when attracted more or less by the current circulating in the latter, and the water contained in the barrel, G, gives a stability to its motion. A weight, W, can be slid on the beam so as to balance the magnetic pull on the core in the solenoid. The solenoid is a coil of 50 ohms resistance, and it is connected up as a derived or "cut-off" circuit to the main circuit through the arc; therefore, if the arc should become too wide, and consequently the arc current too small, a stronger current will traverse the solenoid or by-circuit and pull up the iron cylinder. This will have the effect of raising the solenoid end of the beam and lowering the carbon, N, further into the crucible, thereby bringing back the arc to its proper width. As the temperature of the crucible is always rising a regulating action of this kind is necessary, for the resistance of the arc correspondingly diminishes, and the length has to be increased. Moreover, the sudden sinking of the melting charge occasions equally sudden variations in the length of the air-gap across which the current has to pass.

An important element in the success of the electric furnace is the employment of the material to be fused as the positive pole, or that pole where most heat is developed. This course will, however, only be available with metals or conducting ores, and when non-conductors are to be fused it will be necessary to employ a positive pole of platinum or iridium, which may melt into a pool at the bottom of the crucible. The use of a dense carbon for the negative pole incurs the objection that particles of the carbon may adulterate the charge, but the consumption of the negative pole in a neutral atmosphere is usually very slow. To guard against any impurities of this nature, however, Dr. Siemens has devised a non-wasting pole formed of a copper tube cooled by an interior circulation of water.

From theoretical considerations Dr. Siemens finds that the effective heat attainable in the electric furnace is one-fifteenth of the heat energy residing in the coal consumed under the boiler of the engine driving the dynamo-electric machine. It follows from this calculation that one pound of coal is capable of melting an equal weight of mild steel in the furnace. Now in the ordinary Sheffield air furnace it takes three tons of best Durham coke to melt a ton of mild steel in crucibles, whereas with the regenerative gas furnace, one ton of coal suffices to fuse a ton of steel in crucibles, and on the open hea th of this furnace 12 cwt. of coal will produce one ton of steel. The electric furnace is, therefore, more economical that the ordinary air furnace, and but for some incidental losses of heat would nearly be as economical as the gas furnace. Practically, with a medium-sized dynamo-machine, capable of producing a current 36 webers in strength with an expenditure of 4-horse power, a crucible 8 inches deep is raised to white heat in less than half an hour, and over 2 lb. of steel can be fused in the same time. At the Society of Telegraph Engineers, with a current of 70 webers, Dr. Siemens fused the same quantity of broken files in about fifteen minutes, starting with a cold furnace. Indeed, the files were poured out in a molten state before the crucible was hot. It is almost needless to say that succeeding fusions in a heated crucible could be effected in a shorter time.

For melting the precious metals, for effecting the reduction of refractory ores, and the dissociation of chemical substances, the electric furnace will doubtless prove useful, inasmuch as it is capable of providing a temperature theoretically unlimited and a neutral atmosphere. Moreover, the operation may be conveniently carried on in the laboratory without much preparation; and very high temperatures may be attained with ordinary crucibles, owing to the fact that the heat of fusion is directly brought to bear on the material to be fused rather than the crucible itself.

GROWING PLANTS BY THE ELECTRIC LIGHT.

The extreme temperature of the electric arc and its peculiar blistering effect, which, like burning sunshine, it exercises upon the skin, first suggested to Dr. Siemens that its action on vegetable life might be analogous to that of sunlight. Curiously enough the use of the electric light for forcing fruit and flowers was independently suggested nearly two years ago by a writer in *Cassell's Magazine*. In fostering vegetation the solar radiance produces chlorophyl, the matter which gives a green color to the leaves of plants, and also effects within the vegetable cell the decomposition of the carbonic acid and aqueous vapor inhaled by the leaf from the atmosphere, thus supplying the plant with starch and carbon to build up its woody tissues. The electric arc is a kind of miniature sun emitting rays of almost every refrangibility, and hence it is not surprising that Dr. Siemens should have found it act like solar light in producing chlorophyl and decomposing carbonic acid and water in the leaves of plants. Some of his results, however, are very interesting, and could not have been predicted.

The experiments were made at his country residence of Sherwood, near Tunbridge Wells. The apparatus employed consists of a vertical Siemens dynamo machine of small size, making 1,000 revolutions a minute under a driving force of 2-horse power, and developing a continuous current of about 26 webers, having an electro-motive force of 70 volts. A 3-horse power Otto silent gas engine was employed to generate the driving power; and the light was obtained from a Siemens regulator lamp, having two carbons of 12 and 10 millimeters diameter respectively. This lamp yielded a light equivalent to 1,400 candles.

In the first experiment made by Dr. Siemens the electric lamp was placed about 7 feet above the outside of a sunk melon-house, and fitted with a reflector to throw the light down on the sash. Pots of quick-growing seeds, such as mustard, carrots, melons, etc., were brought at stated intervals under the influence of solar or electric light, or both combined, and others were kept in the dark. The results showed that the plants kept in the dark were pale and sickly, those exposed to the electric light alone had a light green tint and considerable vitality, those kept under sunlight alone were of a darker green and greater vitality, while those exposed to both sources of light were decidedly superior to the rest both in hue and vigor. Judging from this experiment, the power of sunlight is about twice as great as the electric light for purposes of growth; but it was clear that the electric light was not placed so as to give its full effect, owing to the globe round the lamp and the moisture condensed on the frame.

To overcome this loss of power, Dr. Siemens next arranged the lamp within the melon-house, at the same time darkening the sash outside with thick matting and whitewashing the walls inside. And here to prevent scorching of the leaves it was necessary to keep the plants four or five feet from the light. Some of the plants were exposed only to day light, others only to the electric light during eleven hours of night, and others had the full benefit of daylight, followed by the electric light at night. The result showed that the daylight plants were healthier and greener than the electric light ones, but those subjected to continuous light were the richest and strongest of all. A striking token of the efficacy of the electric light in forcing flowers was likewise afforded by a pot of tulip buds which opened into full bloom after an exposure of about two hours.

"Another object I had in view in this experiment," says Dr. Siemens, "was to observe whether the plants were injured by the carbonic acid and nitrogenous compounds observed by Professor Dewar to be produced within the electric arc. All continuous access of air into the stove was stopped, and, in order to prevent excessive accumulation of heat, the stovepipes were thickly covered with matting and wet leaves. But although the access of stove heat was thus stopped, the temperature of the house continued through the night at 72° Fahr., proving that the electric light furnished not only light, but sufficient heat also. No injurious effect was observed on the plants from want of ventilation, and it is probable that the supply of carbonic acid given off by the complete combustion of the carbon electrodes at high temperature, and under the influence of an excess of oxygen, sustained their vital functions. If nitrogenous compounds were produced in large quantities it is likely the plants would have been injured, but they could not be perceived by their smell in the stove when all the ventilators were closed, and no injurious effects on the plants have been observed." To these remarks it may be added that the invigorating effect of the light seems to counteract the withering influence of stove heat.

The electric lamp was next placed in the interior of a conservatory in the corner, and as high as possible, so that its rays might fall on the plants at the same angle as the solar rays at noon, a condition which was fulfilled in all its experiments. Young vines, nectarines, roses, geraniums, and orchids were placed on the floor at various distances from the light. The temperature of the hothouse was maintained at 65° Fahr., and the lamp was kept lit from 5 P.M. to 6 A.M. for one week (February 18 to February 24), excepting Sunday night. It was then seen that the plants nearest the light had made most progress; but all exhibited an increased vigor, and the flowers were manifestly brighter than they otherwise would have been. Moreover, the scenic display of the vivid foliage under the enhancing radiance of the arc was very fine.

The effect of the light on plants in the open air was also tried, and Dr. Siemens is of opinion that flowering plants thus grown are brought forward even more rapidly than by daylight. The heat given off by the arc, too, would seem to ward off night frosts, and it is probable that the buds of wall fruit may be saved by this means from the nipping cold of spring.

It is clear, then, from these experiments, that the growth and flowering of plants is promoted under the stimulating influence of the electric light; and it is put beyond a doubt, too, that plants can grow continuously. The experience of arctic summers, during which the sun never sets, is evidence in favor of this view, and, according to the experiments of Dr. Schübeler, of Christiania, plants develop more brilliant flowers and larger and more aromatic fruit when exposed to continuous light than when they experience alternations of daylight and darkness. Some botanists assert that plants grow chiefly in the night time, but these experiments demonstrate that growth takes place by day as well as night, and that exposure to continuous light will produce the finest flowers and fruit, whether the light be wholly electric or part electric and part sunshine. Perhaps, however, it would be advisable to investigate this question further in case it should be found that short intervals of rest were really favorable to the healthy growth of the plant.

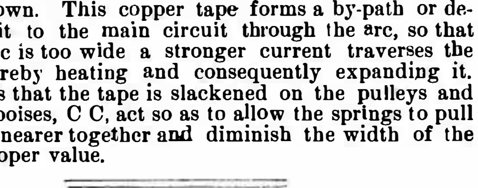
The efficacy of the electric lamp in forcing fruit has also been studied by Dr. Siemens, and it is clear that it possesses the power of forming the sugar and aromatic essences of ripening fruit. A pot of strawberries kept for ten days under continuous illumination by solar and electric light showed clusters of rich red fruit of a most luscious flavor and delicious fragrance, while similar plants kept under daylight alone exhibited only green berries. It is probable, therefore, that early grapes, peaches, and other fruit will be forced during our dark foggy winters by the electric light, which will render our gardeners to some extent independent of the sun.

The practical success of artificial lighting in horticulture will, of course, depend largely on its cost; but Dr. Siemens thinks that the medium-sized machine, which gives a light of 6,000 candles, with an expenditure of 4-horse power, will be economical. The lamp would require to be fixed 20 feet above the plants, and if the surface to be illuminated were large the radiating centers should be placed at distances apart equal to twice or thrice their distances above ground, so as to blend the light into sensible uniformity; for a square foot of surface midway between would receive from each center one-half the number of rays falling upon the same area immediately below a center. Nine lights so placed would illuminate about three-quarters of an acre. A brick wall surrounding this area would receive the benefit of the light for forcing fruit, and would screen off cold winds, as also would the vertical glass partitions of Sir William Armstrong. To maintain this illumination a 36-horse power engine would be required. This would consume 90 lb. of coal per hour, which for a night of twelve hours, with 40 lb. for getting up steam, amounts to 10 cwt., costing, say, 8s. per night. To this must be added the cost of carbons and an attendant, making a total of 16s. per night. If, however, the engine could be utilized for other work by day, or, better still, the waste power of a waterfall employed, the cost would be very much less. The 1,400 candle light used by Dr. Siemens himself costs about 5d. per hour, including carbons, but exclusive of attendance. Such a light at 7 feet distance is about equal in effect to the average daylight of February; but the larger lights are more economical.

To test this question on a working scale, Mr. Siemens is having a 6-horse power horizontal Soho engine, made by Tangye Brothers, and a Cornish boiler laid down at Sherwood for the purpose of driving two medium machines, giving a total light of 12,000 candles. The steam, after actuating the engine, will be used to heat the hot-houses, and it is expected that little more fuel will be needed than was formerly required to warm the flues. The engine will be further utilized by day in turning the machines for cutting wood, chaff, and turnips at the home farm, a quarter of a mile away, by means of a dynamo-electric machine. With this apparatus Dr. Siemens also proposes to ascertain what rays of the spectrum produce chlorophyl, starch, wood, and sugar, by exposing plants in a darkened chamber to the actinic, optic, and thermal rays of a spectrum of the electric light.

The lamp to be used in these experiments is shown in Fig. 2, which, by means of horizontal carbons, P N, pro-

Fig: 2.



vides a fixed focus, and allows the rays to be projected downward by a parabolic reflector, M. The carbons are contained in brass tubes, supported by four rods, and they are pulled together by means of two volute springs, V V, and cords. On the other hand, they are also drawn apart by the regulator so as to form the proper arc. The regulator consists of a thin ribbon of copper, R R, passing over pulleys, as shown. This copper tape forms a by-path or derived circuit to the main circuit through the arc, so that when the arc is too wide a stronger current traverses the by-path, thereby heating and consequently expanding it. The result is that the tape is slackened on the pulleys and the counterpoises, C C, act so as to allow the springs to pull the carbons nearer together and diminish the width of the arc to its proper value.

OBELISKS AS LIGHTNING CONDUCTORS.

MR. F. LE PAGE RENOUF, a student of the Coptic language, writes as follows to the *Academy:* "A good deal was written some time ago on the subject of obelisks. I am not aware that attention has ever yet been called to an important piece of evidence as to the use of this kind of monument. This evidence is found in an inscription from the temple at Edfu, published by Brugsch Bey in the *Zeitschrift für Aegyptische Sprache*, September, 1875. In the thirty-fourth line of this text 'two large obelisks' are expressly said to have been constructed, *her tekes shena enen en Nu*, 'for the purpose of cleaving asunder the storm-cloud of heaven.' Brugsch had already, in the *Zeitschrift* of 1871, p. 143, quoted a similar text in reference to the great flagstaffs of the pylones."

As a general rule, M. J. Reiset finds from what appears to be a very accurate method, that in 100,000 parts of atmospheric air there are 29·78 parts by volume of carbonic acid. At any time the relation of carbonic acid to the other constituents of the atmosphere does not vary very much, but it is slightly more abundant by night than by day, and in foggy than in fair weather, though by no means to such a degree as to be serviceable for meteorological purposes.