culuation of water from the pumps by means of a small pipe, which completes a circuit to an annular in the bearings back to the discharge pipe while the pump is in motion, requiring no oil and making it seemingly impossible to heat these bearings.

"The large cast steel valves placed in the embouchement of the casing, it was thought, might act to check the free discharge, and arrangements were provided for raising and keeping them open by a long lever key attached to their axes of revolution, but, to our great surprise, at the first gush from the pumps these valves, weighing nearly 1,500 pounds, were lifted into their recessed chambers, giving an unobstructed opening to the flow, and they floated on its surface unsupported, save by the swiftly flowing water, without a movement, while the pump was in operation.

"The steam-actuated valves in the suction and discharge pipes worked very well, and the water cushion gave a slow, uniform motion, and without shock, either in opening or closing them.

"The engines worked noiselessly, without shock or labor. At no time during the trial was the throttle valve open more than three-eighths of an inch.

"The indicator cards taken at various intervals gave 796 horse power, and the revolutions did not exceed 160 at any time, though it was estimated that 900 horse power and 210 revolutions would be necessary to attain the requisite delivery. So that there is a large reserve of power available at any time.

"The erection of this massive machinery has been admirably done. The parts, as sent from the shops of the contractor, have matched in all cases without interference here; and, when lowered into place, its final adjustment was then made without the use of chisel or file, and has never been touched since.

"The joints of the steam and water connections were perfect, and the method of concentrating all valves, waste pipes, and important movements at the post of the engineer in charge gives him complete control of the whole system of each engine and pump without leaving his place, and reduces to a minimum the necessary attendance. All the parts are strong and of excellent design and workmanship; simple, and without ornamentation.

"Looking down upon them from a level of the pump house gallery, they are impressive and massive in their simplicity.

"The government is well worthy of congratulation in possessing the largest pumping machinery of this type and of the greatest capacity in the world, and the contractors have reason to be proud of their work."—*Proc. Eng. Club.*

THE PART THAT ELECTRICITY PLAYS IN CRYSTALLIZATION.

SINCE the discovery of the multiplying galvanometer, we know for an absolute certainty that in every chemical action there is a production of electricity in a more or less notable quantity, according to the nature of the bodies in presence. Though, in the play of affinity, there is a manifestation of electricity, is it the same with cohesion, which also is a chemical force?

We know, on another hand, that, on causing electricity to intervene, we bring about the crystallization of a large number of substances. But is the converse true? Is spontaneous crystallization accompanied with an appreciable manifestation of electricity? If we consult the annals of science and works treating on electricity in regard to this subject, we find very few examples and experiments proper to elucidate the question.

Mr. Mascart is content to say: "Some experiments seem to indicate that the solidification of a body produces electricity." Mr. Becquerel does more than doubt—he denies: "As regards the disengagement of electricity in the changing of the state of bodies, we find none." This assertion is too sweeping, for further along we shall cite facts that prove, on the contrary, that in the phenomena of crystallization (to speak of this change of state only) there is an unequivocal production of electricity. Let us remark, in the first place, that when a number of phenomena of physical and chemical order incontestably testify to the very intimate correlation that exists between the molecular motions of bodies and their electrical state, it would not be very logical to grant that electricity is absent in crystallization.

Thus, to select an example from among physical effects, the vibratory phenomena that occur in telephone transmissions, under the influence of a very feeble electric current, show us that the molecular constitution of a solid body is extremely variable, although within slight limits. The feeblest modification in the electric current may be shown by molecular motions capable of propagating themselves to considerable distances in the conducting wire. Conversely, it is logical to suppose that a modification in the molecular state of a body must bring electricity into play. If, in the phenomena of solidification, and particularly of crystallization, we collect but small quantities of electricity, that may be due to the fact that, under the experimental conditions involved, the electricity is more or less completely absorbed by the work of crystal building.

On another hand, the behavior of electricity shows in advance the multiple role that this agent may play in the various physical, chemical, and mechanical phenomena.

There is no doubt that electricity exists immovable or in circulation everywhere, latent or imperceptible, around us, and within ourselves, and that it enters as a cause into the majority of the chemical, physical, and mechanical phenomena that are constantly taking place before our eyes. A body cannot change state, nature, temperature, form, or place, even, without electricity being brought into play, and without its accompanying such modifications, if it presides therein. Like heat, it is the natural agent *par excellence*; it is the invisible and ever present force which, in the ultimate particles of matter, causes those motions, vibrations, and rotations that have the effect of changing the properties of bodies. Upon entering their intimate structure, it orients or groups their atoms, and separates their molecules or brings them together. From this, would it not be surprising if it did not intervene in the wonderful phenomenon of crystallization? Crystallization, in fact, depends upon cohesion, and, in the thermic theory, this force is not distinct from affinity,

just as solution and dissociation are not distinct from combination.

On this occasion, it is necessary to say that, between affinity, heat, and electricity there is such a correlation, such a dependency, that physicists have endeavored to reduce to one single principle all the causes that are now distinct. The mechanical theory of heat has made a great stride in this direction.

The equivalence of the thermic, mechanical and chemical forces has been demonstrated; the only question hereafter will be to select from among such forces the one that must be adopted as the sole principle, in order to account for all the phenomena that depend upon these causes of various orders. But in the present state of science, it is not yet possible to explain completely by heat or electricity, taken isolatedly, all the effects dependent upon the causes just mentioned. We must confine ourselves for the present to a study of the relations that exist between the principal natural forces—affinity, molecular forces, heat, electricity, and light. But from the mutual dependence of such forces, it is admitted that, in every natural phenomenon, there is a more or less apparent simultaneous concurrence of these causes.

In order to explain electric or magnetic phenomena, and also those of crystallization, it is admitted that the atoms of which bodies are composed are surrounded, each of them, with a sort of atmosphere formed of electric currents, owing to which these atoms are attracted or repelled on certain sides, and produce those varied effects that we observe under different circumstances. According to this theory, then, atoms would be small electro-magnets behaving like genuine magnets. Entirely free in gases, but less so in liquids and still less so in solids, they are nevertheless capable of arranging themselves and of becoming polarized in a regular order, special to each kind of atom, in order to produce crystals of geometrical form characteristic of each species. Thus, as Mr. Saigey remarks in "Physique Moderne" (p. 181): "So long as the atmospheres of the molecules do not touch each other, no trace of cohesion manifests itself; but as soon as they come together force is born. We understand why the temperatures of fusion and solidification are fixed for the same body. Such effects occur at the precise moment at which these atmospheres, which are variable with the temperature, have reached the desired diameter."

Although the phenomenon of crystallization does not essentially depend upon temperature, but rather upon the relative quantity of liquid that holds the substance

in solution, it will be conceived that a moment will arrive when, the liquid having evaporated, the atmospheres will be close enough to each other to attract each other and become polarized and symmetrically juxtaposed, and, in a word, to crystallize.

Before giving examples of the production of electricity in the phenomenon of crystallization, it will be well to examine, beforehand, the different circumstances under which electricity acts as the determining cause of crystallization or intervenes among the causes that bring about the phenomenon. In the first place, two words concerning crystallization itself: We know that crystallization is the passage, or rather the result of the passage, of a body from a liquid or gaseous state to a solid one. It occurs when the substance has lost its cohesion through any cause whatever, and when, such cause ceasing to act, the body slowly returns to a solid state.

Under such circumstances, it may take on regular, geometrical forms called crystalline. Such conditions are brought about by different processes—fusion, volatilization, solution, the dry way, wet way, and electric way. Further along, we shall give some examples of the last named means.

Let us add that crystallization may be regarded as a general property of bodies, for the majority of substances are capable of crystallizing. Although certain bodies seem to be amorphous at first sight, it is only necessary to examine their fracture with a lens or microscope to see that they are formed of a large number of small juxtaposed crystals. Many amorphous precipitates become crystalline in the long run.

In the examination of the various crystallizations that occupy us, we shall distinguish the following: (1) Those that are produced through the direct intervention of the electric current; (2) those in which electricity is manifestly produced by small voltaic couples resulting from the presence of two different metals in the solution experimented with; (3) those in which there are no voltaic couples, but in which it is proved that electricity is one of the causes that concur in the production of the phenomenon; (4) finally, those in which it is rational, through analogy with the preceding, to infer that electricity is not absent from the phenomenon.

I. We know that, by means of voltaic electricity or induction, we can crystallize a large number of substances.

Despretz tried this means for months at a time upon carbon, either by using the electricity from a Ruhmkorff coil or the current from a weak Daniell's battery. In both cases, he obtained on the platinum wires a black powder, in which were found very small octohedral crystals, having the property of polishing rubies rapidly and perfectly—a property characteristic of diamonds.

The use of voltaic apparatus of high tension has allowed Mr. Cross to form a large number of mineral sub-

stances artificially, and among these we may mention carbonate of lime, arragonite, quartz, arseniate of copper, crystalline sulphur, etc.

As regards products formed with the concurrence of electricity (oxides, sulphides, chlorides, iodides, etc.), see "Des Forces Physico-Chimiques," by Becquerel (p. 231).

There is no doubt as to the part played by electricity in the chemical effects of electro-metallurgy, but it will not prove useless for our subject to remark that when, in this operation, the current has become too weak, the deposit of metal, instead of forming in a thin, adherent, and uniform layer, sometimes occurs under the form of protuberances and crystalline, brittle nodules. When, on the contrary, the current is very strong, the deposit is pulverulent, that is, in a confused crystallization or in an amorphous state.

Further along, we shall find an application of this remark. We obtain, moreover, all the intermediate effects of cohesion, form, and color of galvanic deposits.

When, into a solution of acetate of lead, we pass a current through two platinum electrodes, we observe the formation, at the negative pole, of numerous arborizations of metallic lead that grow under the observer's eye (Fig. 1). The phenomenon is of a most interesting character when, by means of solar or electric light, we project these brilliant vegetations on a screen. One might believe that he was witness of the rapid growth of a plant (Fig. 2). The same phenomenon occurs none the less brilliantly with a solution of nitrate of silver. A large number of saline solutions are adapted to these decompositions, in which the metal is laid bare under a crystalline form. Further along we shall see another means of producing analogous ramifications, without the direct use of the electric current. —C. Decharme, in *La Lumière Electrique*.

ELECTRIC TIME.

By M. LIPPMANN.

THE unit of time universally adopted, the second, undergoes only very slow secular variations, and can be determined with a precision and an ease which compel its employment. Still it is true that the second is an arbitrary and a variable unit—arbitrary, in as far as it has no relation with the properties of matter, with physical constants; variable, since the duration of the diurnal movement undergoes causes of secular perturbation, some of which, such as the friction of the tides, are not as yet calculable.

We may ask if it is possible to define an absolutely invariable unit of time; it would be desirable to determine with sufficient precision, if only once in a century, the relation of the second to such a unit, so that we might verify the variations of the second indirectly and independently of any astronomical hypothesis.

Now, the study of certain electrical phenomena furnishes a unit of time which is absolutely invariable, as this magnitude is a specific constant. Let us consider a conductive substance which may always be found identical with itself, and to fix our ideas let us choose mercury, taken at the temperature of 0° C., which completely fulfils this condition. We may determine by several methods the specific electric resistance, ρ , of mercury in absolute electrostatic units; ρ is a specific property of mercury, and is consequently a magnitude absolutely invariable. Moreover, ρ is an interval of time. We might, therefore, take ρ as a unit of time, unless we prefer to consider this value as an imperishable standard of time.

In fact, ρ is not simply a quantity the measure of which is found to be in relation with the measure of time. It is a concrete interval of time, disregarding every convention established with reference to measures and every selection of unit. It may at first sight appear singular that an interval of time is found in a manner hidden under the designation *electric resistance*. But we need merely call to mind that in the electrostatic system the intensities of the current are speeds of efflux and that the resistances are times, *i. e.*, the times necessary for the efflux of the electricity under given conditions. We must, in particular, remember what is meant by the specific resistance, ρ , of mercury in the electrostatic system. If we consider a circuit having a resistance equal to that of a cube of mercury, the side of which = the unit of length, the circuit being submitted to an electromotive force equal to unity, this circuit will take a given time to be traversed by the unit quantity of electricity, and this time is precisely ρ . It must be remarked that the selection of the unit of length like that of the unit of mass, is indifferent, for the different units brought here into play depend on it in such a manner that ρ is not affected.

It is now required to bring this definition experimentally into action, *i. e.*, to realize an interval of time which may be a known multiple of ρ . This problem may be solved in various ways,* and especially by means of the following apparatus.

A battery of an arbitrary electromotive force, E, actuates at the same time the two antagonistic circuits of a differential galvanometer. In the first circuit, which

* In this system the measurement of time is not effected, as ordinarily, by observing the movements of a material system, but by experiments of equilibrium. All the parts of the apparatus remain immovable, the electricity alone being in motion. Such appliances are in a manner clepsydre. This analogy with the clepsydre will be perceived if we consider the form of the following experiment: Two immovable metallic plates constitute the armatures of a charged condenser, and attract each other with a force, F. If the plates are insulated, these charges remain constant, as well as the force, F. If, on the contrary, we connect the armatures of resistance, R, their charges diminish and the force, F, becomes a function of the time, t ; the time, t , inversely becomes a function of F. We find t by the following formula:

$$t = \rho \frac{S}{8\pi e s} \log \frac{F_0}{F}$$

F_0 and F being the values of the force at the beginning and at the end of the time, t . The above formula is independent of the choice of units. If we wish t to be expressed in seconds, we must give ρ the corresponding value ($\rho = 1.058 \times 10^{-10}$). If we take ρ as a unit we measure $\rho = 1$, and we find the absolute value of the time by the expression:

$$t = \frac{S}{8\pi e s} \log \frac{F_0}{F}$$

We remark that this expression of time contains only abstract numbers, being independent of the choice of the units of length and force. S and e denote surface and the thickness of the condenser; s and l the section and the length of a column of mercury of the resistance, R. This form of apparatus enables us practically to measure the notable values of t only if the value of the resistance, R, is enormous, the arrangement described in the text has not the same inconvenience.

has a resistance, R , the battery sends a continuous current of the intensity, I ; in the second circuit the battery sends a discontinuous series of discharges, obtained by charging periodically by means of the battery a condenser of the capacity, C , which is then discharged through this second circuit. The needle of the galvanometer remains in equilibrium if the two currents yield equal quantities of electricity during one and the same time, τ .

Let us suppose this condition of equilibrium realized and the needle remaining motionless at zero; it is easy to write the conditions of equilibrium. During the time, τ , the continuous current yields a quantity of

electricity $= \frac{E}{R} \tau$; on the other hand, each charge of the condenser $= C E$, and during the time, τ , the

number of discharges $= \frac{\tau}{t}$, t being the fixed time

between two discharges; τ and t are here supposed to be expressed by the aid of an arbitrary unit of time; the second circuit yields, therefore, a quantity of elec-

tricity equal to $C E \times \frac{\tau}{t}$. The condition of equilibrium

is then $\frac{E}{R} \tau = C E \times \frac{\tau}{t}$; or, more simply, $t = C R$.

C and R are known in absolute values, *i. e.*, we know that C is equal to p times the capacity of a sphere of the radius, l ; we have, therefore, $C = p l$; in the same manner we know that R is equal to q times the resistance of a cube of mercury having l for its side. We

have, therefore, $R = q \rho \frac{l}{l^2} = q \frac{\rho}{l}$; and consequently

$t = p q \rho$.

Such is the value of t obtained on leaving all the units undetermined. If we express ρ as a function of the second, we have t in seconds. If we take $\rho = 1$, we have the absolute value Θ of the same interval of time as a function of this unit; we have simply $\Theta = p q$.

If we suppose that the commutator which produces the successive charges and discharges of the condenser consists of a vibrating tuning fork, we see that the duration of a vibration is equal to the product of the two abstract numbers, $p q$.

It remains for us to ascertain to what degree of approximation we can determine p and q . To find q we must first construct a column of mercury of known dimensions; this problem was solved by the International Bureau of Weights and Measures for the construction of the legal ohm. The legal ohm is supposed to have a resistance equal to 106.00 times that of a cube of mercury of 0.01 meter, side measurement. The approximation obtained is comprised between $\frac{1}{1000000}$ and $\frac{1}{10000000}$. To obtain p , we must be able to construct a plane condenser of known capacity. The difficulty here consists in knowing with a sufficient approximation the thickness of the stratum of air. We may employ as armatures two surfaces of glass, ground optically, silvered to render them conductive, but so slightly as to obtain by transparency Fizeau's interference rings. Fizeau's method will then permit us to arrive at a close approximation. In fine, then, we may, *a priori*, hope to reach an approximation of one hundred-thousandth of the value of $p q$.

Independently of the use which may be made of it for measuring time in absolute value, the apparatus described possesses peculiar properties. It constitutes a kind of clock which indicates, registers, and, if needful, corrects automatically its own variations of speed. The apparatus being regulated so that the magnetic needle may be at zero, if the speed of the commutator is slightly increased, the equilibrium is disturbed and the magnetic needle deviates in the corresponding direction; if on the contrary the speed diminishes, the action of the antagonistic circuit predominates, and the needle deviates in the contrary direction. These deviations, when small, are proportional to the variations of speed. They may be, in the first place, observed. They may, further, be registered, either photographically or by employing a Redier apparatus, like that which M. Mascart has adapted to his quadrant electrometer; finally, we may arrange the Redier to react upon the speed so as to reduce its variations to zero. If these variations are not completely annulled, they will still be registered and can be taken into account.

As an indicator of variations this apparatus can be of remarkable sensitiveness, which may be increased indefinitely by enlarging its dimensions.

With a battery of 10 volts, a condenser of a microfarad, 10 discharges per second, and a Thomson's differential galvanometer sensitive to 10^{-10} amperes, we obtain already a sensitiveness of $\frac{1}{10000000}$, *i. e.*, a variation of $\frac{1}{10000000}$ in the speed is shown after some seconds of a deviation of one millimeter. Even the stroboscopic method does not admit of such sensitiveness.

We may therefore find, with a very close approximation, a speed always the same on condition that the solid parts of the apparatus (the condenser and the resistance) are protected from causes of variation and used always at the same temperature. Doubtless, a well-constructed astronomical clock maintains a very uniform movement; but the electric clock is placed in better conditions for invariability, for all the parts are massive and immovable; they are merely required to remain unchanged, and there is no question of the wear and tear of wheel-work, the oxidation of oils, or the variations of weight. In other words, the system formed by a condenser and a resistance constitutes a standard of time easy of preservation.

NEW METHOD OF MAINTAINING THE VIBRATION OF A PENDULUM.

A RECENT number of the *Comptes Rendus* contains a note by M. J. Carpentier describing a method of maintaining the vibrations of a pendulum by means of electricity, which differs from previous devices of the same character in that the impulse given to the pendulum at each vibration is independent of the strength of the current employed, and that the pendulum itself is entirely free, save at the point of suspension. The vibrations are maintained, not by direct impulsions, but

by a slight horizontal displacement of the point of suspension in alternate directions.

This, as M. Carpentier observes, is the method which we naturally adopt in order to maintain the amplitude of swing of a heavy body suspended from a cord held in the hand. The required movement of the point of suspension is effected by means of a polarized relay, through the coils of which the current is periodically reversed by the action of the pendulum, in a manner which will presently be explained. The armature of the relay oscillates between two stops whose distance apart is capable of fine adjustment.

It is clear, therefore, that the impulse is independent of the strength of the current in the relay, provided that the armature is brought up to the stop on either side. The reversal of the current is effected by means of a small magnet carried by the bob of the pendulum, and which as it passes underneath the point of suspension is brought close to a soft iron armature, which has the form of an arc of a circle described about the point of suspension. This armature is pivoted at its center, and thus executes vibrations synchronously with those of the pendulum. These vibrations are adjusted to a very narrow range, but are sufficient to close the contacts of a commutator which reverses the current at each semi-vibration of the pendulum.

The beauty and ingenuity of this device will readily be appreciated.

DR. MORELL MACKENZIE.

THE name of the great English laryngologist, which has long been honored by scientists of England and the Continent, has lately become familiar to every one, even in unprofessional circles, in Germany because of

in 1837, and studied first in London. At the age of twenty-two he passed his examination, then practiced as physician in the London Hospital, and obtained his degree in 1862. A year later he received the Jackson prize from the Royal Society of Surgeons for his treatment of a laryngeal case.

He completed his studies in Paris, Vienna (with Siegmund), and Budapest. In the latter place he worked with Czermak, making a special study of the laryngoscope. Later he published an excellent work on "Diseases of the Throat and Nose," which was the fruit of twelve years' work. The evening before the day on which this work was to have been issued, the whole edition was destroyed by a fire which occurred in the printing establishment, and had to be reprinted from the proof sheets, which were saved. In 1870 his work "On Growths in the Throat" appeared, and he has also published many articles in the *British Medical Journal*, the *Lancet*, *Medical Times and Gazette*, etc., which have been translated into different languages, making his name renowned all over Europe.

Since he founded the first English hospital for diseases of the throat and chest, in London in 1863, and held the position of lecturer on diseases of the throat in the London Medical College, his career has been watched with interest by the public, and his practice in England is remarkable. Therefore it is no wonder that his lately published work "On the Hygiene of the Vocal Organs" has reached its fourth edition already. This work is read not only by physicians, but also by singers and lecturers.

As a learned man in his profession, as an experienced diagnostician, and as a skillful and fortunate practitioner, he is surpassed by none; and his ability will be well known far beyond the borders of Great Britain

DR. MORELL MACKENZIE.

his operations on the Crown Prince's throat. If his wide experience and great skill enable him to permanently remove the growth from the throat of his royal patient, if his diagnosis and prognosis are confirmed, so that no fear need be entertained for the life and health of the Crown Prince, the English specialist will certainly deserve the most sincere thanks of the German nation. Every phase of this treatment, every new development, is watched with suspense and hope.

Many have been unable to suppress the expression of regret that this important case was not under the care of a German, and part of the press look upon it as unjust treatment of the German specialists. But science is international, it knows no political boundaries, and the choice of Dr. Mackenzie by the family of the Crown Prince, whose sympathy with England is natural, cannot be considered a slight to German physicians when it is taken into consideration that the German authorities pronounced the growth suspicious and advised a difficult and doubtful operation, and that Prof. v. Bergmann recommended that a foreign authority be consulted. As Dr. Mackenzie removed the obstruction, which had already become threatening and, in fact, dangerous, causing a loss of voice, and promised to remove any new growth from the inside without danger to the patient, the Crown Prince naturally trusted him. Since Virchow has made a microscopic examination of the part which was cut away, and has declared the new growth to be benign, all Germans should watch the results of Dr. Mackenzie's operations with sympathy, trusting that all further growth will be prevented, and that the Crown Prince will be restored to the German people in his former state of health.

Dr. Morell Mackenzie has lately reached his fiftieth year, and has attained the height of his fame as an author and practitioner. He was born at Leytonston

if fortune favors him and he restores the future Emperor of Germany to his former strength and vigor, without which we cannot imagine this knightly form. The certainty with which Dr. Mackenzie speaks of permanent cures which he has effected in similar cases, together with the clear and satisfactory report of the great pathologist Virchow, lead us to look to the future with confidence.—*Illustrirte Zeitung*.

HYPNOTISM IN FRANCE.*

THE voluntary production of those abnormal conditions of the nerves which to-day are denoted by the term "hypnotic researches" has manifested itself in all ages and among most of the nations that are known to us. Within modern times these phenomena were first reduced to a system by Mesmer, and, on this account, for the future deserve the attention of the scientific world. The historical description of this department, if one intends to give a connected account of its development, and not a series of isolated facts, must begin with a notice of Mesmer's personality, and we must not confound the more recent development of our subject with its past history.

The period of mesmerism is sufficiently understood from the numerous writings on the subject, but it would be a mistake to suppose that in Braid's "Exposition of Hypnotism" the end of this subject had been reached. In a later work I hope to show that the fundamental ideas of biomagnetism have not only had in all periods of this century capable and enthusiastic advocates, but that even in our day they have been subjected to tests by French and English investigators from which they have issued triumphant.

The second division of this historical development is

* Translated for Science from *Der Spinn*.