ber of attendants required to look after various engines, boilers, line shafting, etc., displaced; saving in fuel from use of blast furnace gases for driving engines and generator sets at power station; dispensing with large numbers of engines, boilers, piping, etc., of low economy. By the introduction of electricity a large amount of hydraulic and compressed air machinery is displaced, and this class of machinery reduced to a minimum, while the moving of heavy masses of hot metal by electric appliances dispenses with much hand labor and the work is carried out far more expeditiously.

The utilization of the waste gases from the blast furnaces alone is of vast importance, and will lead to far more important results in the future, as the principal steel and iron plants all over the world are rapidly changing to electrically-operated tools and the use of the gas engine is increasing enormously.

It is said that in the production of 100 tons of pig iron 2,000 horse power of energy can be obtained by using the waste gases in large engines, and for electrical power transmission purposes 30,000 horse power or more could be obtained from the Liege district alone.

A technical commission under the direction of H. Hubert, engineering director of mines and professor at the University of Liege, carried out a series of tests on a powerful blast-furnace gas engine of 200 horse power which has been operating since 1898 at the Cockerill Works, Seraing. The current generated by the dynamo driven by this engine was used for operating motors, and the test lasted several days and established the best working conditions and admissible overload for the engine. The test showed the consumption of gas when engine was running at full load to be 3,113 cubic millimeters per horse power hour, the coke used having a calorific value of 997 calories.

It was found by the test, taking into account the respective efficiencies and output of engine and generator, that a comparison of the power developed by the explosion of gas in the cylinder with the power available at the terminals of the dynamo gives an actual heat efficiency of 21 per cent for the combination; while the best modern steam engines seldom show more than 10 per cent of the calorific power of the fuel burnt in the boiler furnace.

At the Ougree Blast Furnaces the electrical locomotives are especially useful, as the furnaces are nearly 1,300 yards from the steel furnaces, which are in turn a considerable distance from the rolling mills. It is well known that it is highly important that the metal should not be allowed to cool down when once heated until it has passed from the finishing rolls a completed bar or rail. One of the electric locomotives used at this iron and steel works is used for hauling the 20-ton steel ladle to and from the Siemens-Martin furnace, and is fitted with a 37 horse power motor which has a speed of travel of 190 feet per minute. The following method is employed for supplying the necessary current to the locomotive, instead of a slot conduit, third-rail or trolley, which cannot be used on account of the close proximity to the steel furnaces and the little headroom which is available. A double-insulated cable serves to convey the current from the mains to the locomotive. This is done by means of a drum, around which the flexible cable is coiled as the locomotive travels. There are two brushes, which press on gun-metal rings which are connected to the end of the cable attached to the drum. A counterweight prevents the cable dragging along the floor. The accompanying illustrations show the electrically-equipped apparatus at this important industrial plant.

FOUCAULT'S PENDULUM AT THE PANTHEON.

In its sitting of the 8th of January the Astronomical Society of France requested its general secretary, M. Camille Flammarion, to make arrangements with the authorities of the Society of Fine Arts for installing the pendulum of Léon Foucault at the Pantheon, where it was suspended during a part of the year 1851. The experiments of the celebrated academician were perfectly successful with reference to the popular demonstration. A large number of spectators came to see the earth revolve, but from a scientific view-point the experiments were incomplete. Indeed, the author died without leaving a full account of his experiments. In operating with a pendulum 67 meters in length scientists meet with a crowd of difficulties, which it will be quite instructive to study with the aid of the present perfected methods of observation. This appears from the article which Foucault himself published in the Journal des Débats on the 31st of May, 1851, which is the most complete account we have of his magnificent undertaking. Since that time a large number of attempts have been made, notably at Rio de Janeiro, on the initiative of the Emperor Dom Pedro II.; on the tower of Saint Jacques; on the Eiffel Tower and at the Conservatory of Arts and Trades, where the pendulum of Foucault is constantly at work. But the two most striking experiments are those which took place in the Cathedral of Reims and in the Cathedral of Amiens; the first by M. Dubois, professor of astronomy, and the second by Maumenée, the celebrated chemist and physicist, who died a few years ago. The architecture of these venerable edifices harmonizes perfectly with the oscillations of a giant pendulum. In consequence of a regrettable error, it was supposed by some that scientific demonstrations and researches were contrary to the canonical regulations and could not take place within edifices devoted to worship. At the time of the oscillations in the Cathedral at Amiens the bishop delivered an eloquent sermon to protest against such an imputation. Was it not in pagan temples that astronomy had its birth? Who would maintain that the worship of the true God, less favored than that of idols, could be incompatible with the search after truth?

The Revue Chronométrique continues the subject. Newton was the first to notice the possibility of causing the diurnal movement of the terrestrial globe to be made apparent by experiment. If the earth revolves all the points of its surface, he reasoned, are animated with an angular velocity, which increases with the distance from the ideal axis of rotation, and consequently ceases at the poles, and is maximum at the equator.

As a consequence of this conception of the movement of the earth the summit of any edifice moves from west to east with more rapidity than its base. Hence it follows that if a ball of lead is allowed to fall from the top of a tower, this body, preserving its initial velocity during the fall, should strike the ground a little to the east of the foot of the vertical passing through the point where it is left to itself.

Experiments confirm this ideal of movement, and the scientist Benzenberg, who repeated them at the commencement of the nineteenth century in the interior of a church tower and of a mining shaft, could measure the deviations with precision, notwithstanding the restricted height for the fall of the bodies.

Later, Léon Foucault had recourse to the pendulum to demonstrate, in a striking and impressive way, the rotation of the earth. He was inspired by the law of the independence of simultaneous movements brought to view by Galileo, and which may be enunciated thus: The movement common to several bodies does not control their individual movements.

In support of this principle, which experiment alone can verify, the regular rate of watches may be cited, notwithstanding the varied movements to which they are subjected; the regular rate of clocks, whatever their orientation. If the movement of the earth influences the pendulum, a clock adjusted in the plane N—S would cease to indicate the exact time in the plane E—W.

The experiment which especially served as the base for Foucault's demonstration of the diurnal movement of the earth was the following: A plumb-line is suspended to a potence, whose foot rests on a horizontal platform capable of taking a movement of rotation around its center; the plumb line is removed from the vertical and an observation taken, with reference to a fixed point of the orientation of the plane in which the pendulum moves; then a circular movement is impressed on the platform by means of a crank carrying a pinion, which engages with a toothed wheel placed in the circumference of the platform. Whatever may be the velocity of rotation, the invariability of the plane of oscillation of the pendulum is made manifest.

Suppose now a pendulum suspended above the pole in the prolongation of the terrestrial axis; remove it from its perpendicular position without giving it a lateral impulse and leave it to the action of its weight; the mass of the pendulum will oscillate, describing the arc of a circle in a well-determined plane, invariable in direction.

Admit that this direction passes through the center of the sun. If the earth is fixed and the sun movable, the pendulum will keep the same position with respect to terrestrial objects, and the sun will move from the plane of oscillation. If, on the contrary, the sun is fixed and the earth movable, the pendulum, preserving its direction invariable in space, by virtue of the inertia inherent in its mass, will continue to move in the plane of the sun and be displaced with reference to terrestrial objects.

The observer, participating in the movement of the globe, will, without consciousness, refer his displacement to the pendulum, in such a way that the plane of oscillation will appear to turn around the vertical of the point of attachment with the same velocity as the earth (15 deg. per hour), but from east to west; that is to say, in the direction of the apparent movement of the heavens. Such are the conditions in which the rotation of the terrestrial axis, with reference to the sun, would be visible at the poles.

Foucault endeavored to ascertain what action the distance of any point of the globe relatively to one of the two poles exercises on the plane of the pendulum. By calculation he found that at the equator the apparent movement of the plane of rotation ceases, because it is perpendicular to the terrestrial axis, and consequently that it becomes the more visible as the pole is approached. To confirm these theoretic results, Foucault caused to be fastened at the top of the vault of the Pantheon a solid piece of metal for supporting a steel wire 64 meters in length, at the lower extremity of which was fixed a heavy sphere, turned and polished so that its center of gravity was made to coincide exactly with the center of the object. This sphere at its lowest part had an appendage terminated by a point, which furrowed a passage in a layer of fine sand spread upon the floor. After each oscillation, the retrogradation of the oscillating plane could be observed.

At Paris, whose latitude is 48 deg. 50 min., the deviation of the pendulum is 11 deg. 17 min. 33 sec. per siderial hour, and 31 hours 48 minutes are necessary for an entire revolution of the oscillating plane.

Nothing could depict the surprise which the observer experiences in following the slow oscillation of such a majestic pendulum. He notices that his position is displaced continuously with the edifice in which the pendulum is suspended, and receives from this observation a profound and durable impression.

PROGRESS OF THE YEAR IN ASTRONOMY.*

The most prominent astronomical feature of the year has been the new star of Perseus. Of all the Novæ which have appeared up to the present, it is perhaps this one which has presented the most novel and interesting features, and yet it cannot be said that the mystery is cleared up. The circumstances which have lately been brought to light are so astonishing and unforeseen that they only make it, so to speak, still more mysterious. As to what is the cause of these catastrophes, so grandiose and sudden, and lasting so short a time, we are reduced to hypotheses. Some astronomers think that these phenomena are due to a shock between two enormous masses, moving with a great speed; the heat produced by the shock would explain the sudden appearing of the light. They remark that the new stars become thus brilliant in the Milky Way, that is, in the region where there are the most stars, and hence a greater chance of collision. Others suppose that the sudden brilliancy of the temporary stars must be due to eruptions analogous to those which produce the solar protuberances, but incomparably more intense; in fact, the spectra, at certain periods of the transition, show the brilliant rays which are characteristic of these protuberances. Others again combine the two explanations; they admit the eruptions, but attribute them to a shock, either that an obscure body brought about the phenomena by penetrating into a sun, or that it passed only in the neighborhood and that its attraction produced gigantic tidal waves. The question still remains unsolved, and none of these theories has definitely triumphed. The alternations in the brilliancy of the new star will be remembered. On February 20, 1901, it was not even of the twelfth magnitude, but on the 23d it exceeded the first magnitude; on the 1st of March it fell to the second magnitude, and during the second half of March and the month of April it oscillated between the fourth and sixth. These oscillations were strikingly periodic in character and were continued during the following months, superposed upon the slow and continued diminution which has followed up to the present. The spectrum of the star has passed by a series of phases; at first it recalled that of the stars of Orion, with numerous black bands, but shortly after the point of maximum brightness, a series of brilliant bands appeared. The contrast between the bright and dark bands went on increasing, and the bands became extremely wide. Last, as in all the preceding Novæ, appeared the lines which are characteristic of nebulæ. We may ask whether we have witnessed, not the transformation of a nebula into a star, as would seem natural, but the inverse transformation of a star into a nebula.

Two explanations may be given for the broadening and the displacement of the bands. All may be explained by the movements of the incandescent mass, either in the case of two bodies, one obscure and the other brilliant, moving in opposite directions, or by the mass itself being possessed of a gigantic vortex movement. The hypothesis of two moving bodies, which may have answered in former cases, will hardly suffice here, where the structure of the lines is more complex and presents several maxima, thus supposing the presence of more than two layers possessed of different movements. In all cases these velocities would be enormous, and reach several thousand miles per second. At first sight the imagination refuses to admit that matter can reach such extraordinary speeds, and it rejects such an explanation. Another idea is that the bands are enlarged and displaced not by the movements of matter, but by the enormous pressures which it undergoes. This explanation was in favor for a while, as it was new, and did not require such a stretch of imagination. In fact, the question is not yet decided. But observers were not long in revealing a still more striking circumstance. A discussion was held before the Society as regards a certain nebulous appearance which was remarked about the stars' disk on a photograph obtained at M. Flammarion's laboratory. The nebulosity was not a real one, as it was due to the light of the star and could be explained by optical laws; however, the attention of astronomers was excited and soon there were discovered in the neighborhood of the star several nebulæ which this time proved real. Subsequent observation proved that these nebulæ moved away from the star with a speed of about 11 minutes of arc per year; this is about 100 times the highest of the proper motions known up to the present. To find the corresponding linear speed, we must know the distance of the star. Measurements of the parallax have given negative results. It is therefore certain that the parallax is below 1-10th second and probably does not exceed 1-100th. That is, the nebulæ move certainly at a higher rate than 18,000 miles a second and probably travel nearly as fast as light. What is it, then, that is displaced at such a great speed? Can it be matter? What can we think, then, of the power of an explosion which can send out projectiles rivaling the speed of light waves. The velocities which were before shown by the spectroscope, and which seemed so great that we hesitated to admit them, are still 100 times too small; no doubt they were only those of the heavier and less rapid projectiles. If not matter, this must be a form of radiation, of whatever nature. It is possible that they may be cathode rays, but as these are not very well known, it may be too easy to explain phenomena in this way.

The explanation of M. Kapetyn is the most ingenious and perhaps the most probable of all. The nebulæ existed previously; the light coming from the star at its brightest period illuminates successively the different parts, and thus the visible portions seem to be displaced with speed of light. Another interpretation was proposed later. The bands of the spectra show, as was observed, a very complex structure, as if the light, before reaching us, had traversed a series of absorbent layers having different speeds. It was supposed that these layers formed a series of concentric spheres, proceeding from the central star and enveloping each other mutually. As they recede from the star, their speed diminishes owing to the attraction of the central mass, like a stone thrown from the earth. Observations of these different speeds give us data as to the mass of the star, and it is found that the mass is 1100 times that of the sun. To form an idea of the full scope of these results, it must be remembered that most of the stars seem to have masses comparable to that of the sun, and even Sirius, which is much more brilliant, is only two or three times as heavy. We might ask if the accident which has just occurred in this far-off world could not happen to us at any time. What would become of us if our sun, by a sudden caprice, became in 24 hours 10,000 times as hot? But if, as the above author thinks, it is too small to be capable of such effects, we may be reassured. In sum, new problems have been proposed, and the old ones are not as yet solved and probably will not be before the star is extinguished. Such phenomena show what a variety of riches the stellar world contains, and that the multitude of brilliant points do not represent a monotonous infinity of systems all on the same plan.

In the early part of the present year the Observatories of Paris and Greenwich united their efforts in

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