THE ASTRONOMICAL CLOCK AT LYONS.

A WONDERFUL TIMEPIECE.

BY CHARLES A. BRASSLER.

The ancient astronomical clock in the cathedral of St. Jean at Lyons, France, shown in our illustrations, is incontestably, if not the most beautiful, at least one of the most beautiful monuments of early horology that exists. It exhibits, at all events, one peculiarity not common to many of the other old clocks, which is that it is still running, as far as its essential organs are concerned, and is not resting quietly behind the

Graham escapement (1782). From the Revolution until 1894 the poor old clock was doctored by several pseudo-horologists, who fairly massacred it without being able to make it go. Finally in 1894 the Chateau Brothers, watch and clock makers at Paris, undertook its complete restoration, and succeeded so well that it has been running regularly ever since.

The total height of the monument is about 10 meters,

in the ordinary and also in the Roman calendar; besides that, the festival for each day is added. At the close of the year an outside disk measuring 3 feet in circumference and divided into 66 parts moves up one notch, and changes thus the general figures for the year, visible through a vertical slot, which may be distinguished in one cut. These figures are the yearly dates, and they run up to 1959, the number of the

THE AUTOMATICALLY OPERATED FIGURES OF THE FAMOUS LYONS CLOCK.

glass of some conspicuous case in a museum. The old clock has recently been overhauled and repaired by the well-known firm of Chateau Frères & Cie., Paris.

If we are to believe the text of the inscription from the seventeenth century which accompanies an old cut, this clock dates back only to 1660. It assures us that in that year the lord canons of Lyons installed it. In reality they only had it repaired at that period.

More than one hundred years before that date it was already in existence, since an act of the chapter expressly declares that in 1572 "it did not run any more"! Again in 1598 the whole system was put in a state of complete order by Nicolas Lippius, a renowned mathematician of Basle, who was called to the work by the horologist Hugues Levet, of Lyons, to whom the canons had confided a task which he himself was incapable of performing. In 1660 the restoration mentioned in the inscription was effected by Guillaume Nourrisson, whose name is engraved upon the front of the base. In 1779 Charmy undertook anew the task of repairing it, and during the course of his work he added to it a

or something over 30 feet. The pendulum, which measures 9 feet useful length, regulates the movement, which actuates the hand of the oval dial for the minutes, that is visible to the right of one of our illustrations; also all that part of the astronomical works that we find enlarged in another cut, and which comprise a calendar and a very complete astrolabe.

The striking work contains a small chime tuned to the ordinary scale, and the hour strike work trips the rods of this chime. Finally, the clock is completed by the addition of divers automata—a cock that crows being placed upon the very summit of the structure, a beadle who approaches to make his rounds, and statuettes that represent the days of the week. While the chimes are playing, an angel beats the time with her wings, her head, and her foot. When the chimes have done, another angel turns an hourglass. Although the automata are interesting and even entertaining, we shall not dilate further upon their play, which closely resembles that of all the ancient automata, but we shall devote our time to the more enlightening consideration of the astronomical features. They are comprised, as we have said, in the two dials on the front of the clock, but particularly on the upper one, the lower one being reserved for the calendar.

The calendar, which provides the changes for 66 years, is built up of a crown having an outside diameter of 5 feet and an interior diameter of about 3 feet. It is divided into 365 divisions radiating from the center. Made of wood, it is covered with parchment. Each division indicates a day of the year

Sundays after the Epiphany and Pentecost, the Septuagesima Sunday, Easter, Pentecost, the Ascension, the feast of the Holy Sacrament, the first Sunday in Advent, the Dominical Letter, the Golden Number, the Epact, the Roman Indiction, and the Martyrological Letter.

As for the astrolabe, it is composed of several parts, one of them fixed, the others movable. The fixed portion is represented herewith. It is what the Arabs called a *safiha*, and called during the middle ages a tympanum. It is a stereographic projection of a hemisphere, of which the zenith of Lyons forms the summit. The plane of the projection is tangent to the sphere at the North Pole, and the point of view is taken at the South Pole. The three concentric circles extending over the surface from the outer edge of the center represent the tropic of Capricorn, the equator, and the tropic of Cancer. The hemisphere is marked off in meridians 10 degrees apart and in parallels 5 degrees apart. The first of the parallels, that which forms the limit of the projected hemisphere,

FRONT DIAL OF ASTROLABE AND CALENDAR.

LA SAFIHA.

FRONT VIEW OF THE LYONS CLOCK.

was called among the Arabs the first of the *almon-quantarat*. There is on this surface another parallel drawn in about 18 deg. from the first of the *almon-quantarat*. This is the limit of twilight. The vertical straight line is the meridian of Lyons. It is the line of the *zaoual*, or the true noontide. The right line which cuts this at right angles is the east and west line. The divisions marked in the lower half of the *safha* by Roman numerals represent the *unequal* hours, while the divisions in the upper half, and distinguished by Arabic numerals, mark the *Houses of the Heavens*.

The movable parts of the astrolabe are the *alankabout*, *arana*, and the *alidada*. Their form is sufficiently presented in detail herewith. The clock actuates the *alidada* by means of a large wheel with 240 teeth. This *alidada* turns through 24 hours, which are painted on the border surrounding the dial and forming a part of the cabinet. The *alidada* is also provided with a longitudinal slot, which affords an easy passage of a block, upon the very top of which is fixed a picture of the sun, the lower extremity of the block sliding easily in an eccentric groove which

represents the ecliptic. The *arana* is driven by a train of differential gears and turns a little faster than the *alidada medicinium*, and just fast enough to gain one revolution in 366 days and 6 hours. In this manner the sun taking part in the movement of both the *alidada* and the *arana* moves back upon the sphere one day for each sidereal year, which produces its true movement.

Upon the *arana* are to be found divisions corresponding to 365 days. There are also the twelve months of the year and the twelve zodiacal signs, a scale of 360 deg., the eccentric circle of the ecliptic, and a further scheme of decoration, whatever may be its name, upon which are fixed in their respective places the twenty-six principal stars in the projected hemisphere. The moon is also moved by a differential train of gears, which causes it to make one turn more than the *alidada* in 29½ days. This latter carries also a small circle divided into 29½ parts, and wherever it is found under the satellite, it indicates its exact age.

We shall add for the benefit of those who may be interested in the science of astrology that the Houses of the Heavens are thus named: The House of Life,

of Riches, of Brothers, of Parents, of Children, of Health, of Marriage, of Death, of Piety, of Office, of Friends, and of Enemies.

It must be added that these divisions have long since disappeared. It remains nevertheless that the astrolabe of Lyons is the most curious that has come down to us, and for that reason alone the clock should be rescued from oblivion and accorded more than a passing mention.

The cathedral in which this clock stands is one of the most famous in France, and one, moreover, of the most interesting in the south. Notwithstanding that Lyons is a city frequently visited by Americans and Englishmen, it is comparatively little known. The church is of small size but highly interesting. It was built chiefly at the end of the twelfth century, but was continued in the thirteenth and fourteenth, and was completed, with its main front, in the fifteenth century. Its Bourbon chapel is an extraordinarily rich example of late Gothic architecture. The cathedral abounds in historic associations, and contains many rich and splendid works of art. This clock is one of its most remarkable possessions.

THE INDESTRUCTIBILITY OF MATTER.

SOME VIEWS ON THE CONSERVATION OF MASS.

BY PROF. G. ZENGHELI.

THE law of indestructibility of matter, or as it is technically called, of conservation of mass, forms the very foundation stone of modern chemistry. For that science may be said to date from the time when Lavoisier introduced the balance for the investigation of all chemical reactions, and established the law that in every reaction the total weight of the reacting substances is the same before and after the transformation. This same law had been stated previously, no less than twenty-three centuries before, by the Greek philosophers Anaxagoras, Aristotle, Empedocles, and Democritus. The last mentioned, for example, says: "Nothing can arise out of nothing, and nothing can ever be destroyed; all the events which occur in the world consist in changes of form, in the mixing and separating of bodies; the essence of nature is a perpetual cycle."

No attempt was, however, made by the philosophers of antiquity to apply these ideas to every-day phenomena, or to test rigorously the truth of the law. To Lavoisier belongs the credit of having given the true interpretation of the process of combustion, through the aid of the balance, his sure guide in all chemical operations.

Neither Lavoisier, however, nor the later chemists deemed it necessary to put the principle to a crucial test. For in every chemical reaction and every analysis its truth was so plainly demonstrated that it seemed unnecessary to seek for further proof.

Nevertheless, in connection with certain operations which call for the highest degree of accuracy, as in the determination of atomic weights, the question of the absolute truth of the law has been raised. Thus Stass found that in the synthesis of silver bromide and iodide from their elements, the mass of the product always fell by a few milligrammes below the sum of masses of the constituents. The losses ranged from one twenty-thousandth to one seventy-two-thousandth of the total weight. From the point of view of theory also some doubts were expressed as to the absolute constancy of mass, by those who considered the several elements as composed of "protyle," i. e., of one ultimate or fundamental element.

Kreichgauer was the first to make actual experiments with a view to elucidating the point, and the matter was taken up after him by others. Foremost among these investigations stands the work of Landolt. He experimented with reactions which take place in aqueous solution. The reagents were placed in sealed glass tubes, and the experiments were conducted in masterly fashion, with the most extreme precautions, so as to eliminate or correct for every imaginable source of error. The work was begun in 1893. Later, in 1901, when a new balance of the greatest precision, specially constructed for this purpose, was in readiness, Landolt repeated his experiments. The result was, that in 42 out of 54 cases there was found to be a loss in weight. The greatest loss occurred in the case of the reaction between ferrous sulphate and silver nitrate, and between iodic and hydriodic acid. It amounted to 0.069 to 0.199 milligramme. In view of the extreme care with which the work was carried out—the error in weighing did not exceed 0.03 milligramme in 300 grammes—we are forced to the conclusion that there must have been an escape of some of the matter in the tube through the glass walls. Landolt himself is in favor of this view. Following up this point the author then conducted a series of experiments to determine whether there

actually are gases or vapors which are capable of diffusing through glass. For this purpose use was made of a very delicate test for traces of metallic and other vapors. This consists in exposing to the suspected vapor leaves of very fine silver foil. If such silver foil is, for example, suspended in a closed vessel over a solid substance, say a metallic oxide or salt, or the powdered metal itself, the foil after some time becomes visibly attacked and tarnished by the vapor emitted from the solid. The substances to be examined were inclosed in fused glass vessels. Pieces of silver foil were attached to the outer surface of the containing vessel, and the latter was then placed under a bell jar resting upon a glass plate, to which the jar was sealed by means of paraffin wax. In this way over fifteen substances were examined, among them those with which Landolt has observed the greatest losses. The attack of the silver foil was plainly evident to the eye and was confirmed qualitatively, and in some cases quantitatively, by analysis.

These experiments showed conclusively that many gases or vapors, even those given off by solid bodies, are capable of diffusing through glass. This faculty does not stand in any direct relation to the volatility of the substance. Thus iodine passes through glass more readily than chlorine or bromine. Reduced pressure and a small thickness of the glass walls largely promote the effect. It is probable that a vapor, in order to be capable of passing through glass, must first undergo a dissociation or disintegration. This would be quite in accordance with a number of phenomena which have been observed. According to Thomson, most substances give off emanations, which must be regarded as products of the disintegration of matter. Rutherford supposes that there are transformations similar to radioactive transformations, but unaccompanied by the emission of active rays.

It is therefore very probable that the products of disintegration of gases and vapors pass through the pores of the glass, just as cathode rays do. These latter also have very small mass and are transmitted by the glass.

Helium also possesses in a high degree the faculty of diffusing through glass, and it is well known that hydrogen passes readily through iron.

These facts serve to explain the losses of weight observed by Landolt. At the same time they point to the occurrence of processes by which matter is disintegrated into particles more elementary than the atoms. The supposition that such processes might occur has of late years been substantiated by the study of radio-active bodies, but it had already previously been rendered plausible by experimental observations.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Umschau.

THE LIFE OF A COMET.

In an article by Mr. A. C. D. Crommelin, F.R.A.S., which appears in the current number of Science Progress, and which deals with the expected return of Halley's Comet, he remarks on some aspects of resemblance between Halley's Comet at its appearance in 1835 and the Comet Morehouse. The nucleus in each case appeared to be in a state of great activity, and ejected streams of matter in various directions with a violence that has been compared to a volcanic outburst. These streams are at once repelled by the sun, the repulsive force being either of an electrical nature or being simply the action of light on very

finely divided matter. "The main tail is directed almost exactly away from the sun, but there are a number of lateral tails or brushes making various angles with this. It was shown by Bessel that some of the changes could be explained by supposing that the comet was rotating in about five days. A similar suggestion was made for Comet Morehouse. . . . Another feature that Halley's Comet in 1835 shared with the Comet Morehouse was that both at times lost their tails for a short period. Since we may be sure that the sun's repulsive action did not cease, we must suppose that this arose from some change in the head of the comet, the nature of which we cannot guess. Comet Morehouse seemed to have a fairly regular cycle of changes, so that it was even possible to predict when the tail was likely to disappear, and when a new outburst was likely to occur."

An almost continuous series of photographs was obtained of Comet Morehouse through the co-operation of several observatories; and we have yet to receive those which were made in the Southern Hemisphere after the comet had passed beyond the reach of northern observers. A most striking series of photographs was obtained by the Rev. Joel Metcalf at the Observatory, Taunton, Mass., and these have been published by Harvard College Observatory. The instruments employed by Mr. Metcalf were two doublets of his own construction. The first of these has an aperture of 12 inches, and a focal length of 87.5 inches. The second doublet has an aperture of 5.8 inches, and a focal length of 20 inches. The method which he has used so successfully, in discovering and following asteroids, was employed after September 15th. The cross wires of a finding telescope were kept upon the image of a star, while the plate was moved every minute, by an amount, and in a direction, equal to the theoretical motion of the comet as determined from its ephemeris. This method proved particularly advantageous, since this comet had no well defined nucleus which could be used for following in the ordinary way. The effectiveness of the method is shown by the smoothness of the trails of the stars. In all cases, two photographs were obtained simultaneously with these telescopes, except on November 12th, when the smaller instrument only was used.

By observation of the several features of the tail it was possible to trace their direction and speed as they were repelled from the head of the comet. The repulsive force was shown to be considerably stronger than gravitation, so that clearly the comet loses altogether what the head appears to part with; and it is easy to understand why Halley's Comet has appeared less terrific at recent returns (and probably may be quite insignificant in appearance next year) than when it struck dismay into the minds of people some centuries ago. Mr. Crommelin thinks that Halley's Comet will almost certainly be found this autumn; and he thinks that the most probable date of its perihelion passage will be April 16th, 1910. It will be nearly stationary in Pisces in January and February, and probably visible with small telescopes, possibly even with the naked eye. It will then pass behind the sun, being a fairly bright morning star in April and the beginning of May. It will again pass the sun on May 17th, and for a few days after this may be expected to be at its greatest splendor, and distant only twelve millions of miles from the earth. It is likely then to make its best display in the Southern Hemisphere.—Knowledge and Scientific News.