Our Astronomical Column.

THE LUNAR ECLIPSE.—On the whole this eclipse was seen under favourable weather conditions, though for a time there was drifting cloud. The eclipsed portion was easily visible, being at first of a greenish tint, and later assuming the familiar coppery hue. Mr. A. Burnet had prepared a list of stars occulted during totality; they were few, and faint, and only one of these phenomena was observed at Greenwich. There will not be another total lunar eclipse visible in London with the moon at a considerable altitude until November 7, 1938, which is a much longer interval than usual.

THE NATURE OF PHOTOGRAPHIC IMAGES.—Dr. Kenneth Mees, director of the Research Institute of the Eastman Kodak Co., New York, gave an address at the meeting of the British Astronomical Association on April 28 on the nature of photographic images. Various points were raised that are of importance in the application of photography to astrophysics. Thus in the extra-focal determination of stellar magnitudes it was demonstrated that stars of different colours might have their magnitudes arranged in a different order, according to the exposures given and the developer employed.

Magnified sections of films were thrown on the screen, showing that with some developers the image of a luminous object caused an elevation of the film, but with other developers a depression. In either case the film in the neighbourhood suffers strain (sometimes to the point of cracking), so that images of faint stars near a bright one are subject to displacement. Prof. Turner noted some time ago an apparent displacement of a star near a *réseau* line which was probably due to this cause. It is possible to minimise the effect by a judicious choice of developer. The address contained many other hints of a practical nature; it will be published in the B.A.A. Journal for April. The Astronomer-Royal, proposing a vote of thanks, said that photography was the only way of obtaining information about the fainter stars in bulk. While some of the phenomena described by the lecturer were a little disquieting, the careful analysis of their origin and effects could not fail to be of great value.

THE BINARY KRUEGER 60.—This system is of particular interest as being one of our nearest neighbours, and since the *comes* has the smallest mass yet found for any star. *Astronomical Journal*, No. 767, contains researches on the parallax, proper motion, and orbit made at the Leander McCormick Observatory by S. A. Mitchell and C. P. Olivier. They find for the relative parallax $0.266'' \pm 0.009''$. Combining this with the determinations of Barnard, Schlesinger, and Russell, and adding $0.005''$ as the estimated value for the comparison stars, the absolute value $0.261'' \pm 0.006''$ results.

Their orbit makes the period nearly fifty years, a being $2.68''$, or 10 astronomical units. Hence the combined mass is 0.42 in terms of the sun. The ratio of masses of the two components is still uncertain; three estimates are 0.35, 0.53, and 0.83. Taking it as 0.5, the faint component is $1/7$ th of the sun in mass, while it is only $1/2500$ th of it in luminosity. Prof. Eddington considered that the minimum mass necessary for the attainment of a stellar state may not be much below $1/7$ th of the sun.

It is pointed out that the photographs of the close pair give as good results as visual measures, while for the distant optical component, observed for the purpose of deducing the relative masses, they are more accurate. Comparisons continued for another twenty-five years should give a satisfactory determination both of the orbit and the mass-ratio.

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Leonardo da Vinci.¹

By EDWARD McCURDY.

AMONG the greater names in the history of Italian art some are found to be pivotal by reason of the influence of their work upon that of other artists. Giotto and Masaccio are the most conspicuous instances among the earlier masters. Giotto created the scientific basis of the naturalism of the art of the Renaissance by contrast with the decorative symbolism of the earlier art of Byzantium. Masaccio reinforced these tenets with noteworthy access of realism in the frescoes in the Church of the Carmine in Florence. The names of Antonio Pollaiuolo and Andrea Verrocchio serve to indicate how in Florentine art of the Quattrocento the study of structure gained new scientific precision from anatomical research. Piero de' Franceschi reveals a deeper knowledge of the various problems of perspective, arrangement, and light and shade in his works at Arezzo than was possessed by any of his contemporaries, but the influence which his work would naturally exert was restricted by reason of its remoteness from the greater centres of art training.

The divergent aims of this small band, who may be termed the upholders of the scientific tradition in Italian art, are realised with singular completeness in the work of Leonardo da Vinci. Born in the year 1452, the illegitimate son of a Florentine notary, descended from a long line of Florentine notaries, having shown, according to Vasari, marvellous talent as a boy in the art of design, he was placed by his father in the studio of Andrea Verrocchio, who is described by the same writer as at once goldsmith, master of perspective, sculptor, inlayer of woods, painter, and musician. It was apparently a sort of clearing-house for ideas for the art world of Florence, and there Leonardo became acquainted with Botticelli and Perugino. His apprenticeship had ceased in 1472, for in that year his name occurs in the Red Book of the Guild of Painters of Florence.

In the year 1483 Leonardo, being then in his thirty-second year, left Florence and went to Milan, where he entered the service of Ludovic Sforza. Making all possible allowance for what may have been lost, the sum total of his work in art up to this time is astonishingly small as covering the period from his apprenticeship to his thirty-second year. Already in his few pictures the detailed treatment of the herbage, the gradation of the light, the presentment of muscle and tendon, all reveal the scientific study of the laws which defined their structure. The inference is irresistible that while still at Florence he had commenced those studies of natural and applied science the rumour of which, superimposed upon the fame of his artistic work, caused his name to be endowed among his contemporaries with a half-legendary universality. Some of the forms of this nascent activity are enumerated by Vasari. I quote from the translation by Mr. Herbert Horne:—

"In architecture he made many drawings, both of plans as of other projections of buildings; and he was the first, although a mere youth, that put forward the project of reducing the River Arno to a navigable channel from Pisa to Florence. He made designs for flour-mills, fulling-mills, and machines which might be driven by the force of water. . . .

"And he was for ever making models and designs to enable men to remove mountains with facility, and to bore them in order to pass from one level to another; and by means of levers, and cranes, and screws he showed how great weights could be lifted and drawn; together with methods of emptying

¹ From a discourse delivered at the Royal Institution on Friday, March 19.

harbours and pumps for drawing up water from low places, all which his brain never ceased from inventing."

In the famous draft of a letter to Ludovic Sforza, in the Codice Atlantico, written presumably immediately on his arrival in Milan, Leonardo offers his services in the capacity of military or naval engineer, detailing the various inventions of which he possesses the secret, and offering to make trial of any, either in the ducal park or in whatsoever place might please his Excellency, in case any of the said inventions should seem to be impossible. If natural incredulity, which the writer of the letter apparently expected to meet with, by reason of the scope and variety of the inventions, which comprise pontoons, scaling-ladders, cannon or bombards, mines, covered chariots, catapults, mangonels, and smoke-powders, should dispose any to look on the list merely as a piece of rodomontade, it may be observed that the contents of Leonardo's manuscripts at Paris and Milan fully substantiate every claim contained in the letter.

The position which Leonardo desired to occupy under Ludovic Sforza was not very unlike that of military engineer and inspector of fortresses which he occupied at a later period in the service of Cæsar Borgia.

The concluding paragraphs of the letter to Ludovic Sforza refer to Leonardo's readiness to be employed in the arts of peace—in architecture as a designer of both public and private buildings, in the construction of watercourses, in painting, and in sculpture, whether of marble, bronze, or clay, and especially in the execution of the equestrian statue of Francesco Sforza, upon which he laboured intermittently for sixteen years. The extent and fervency of the researches that he considered necessary, which comprised studies of various antique equestrian statues, and numerous notes on the proportions of particular horses, as well as a treatise on the anatomy of the horse, were such that the very desire of perfection prevented the execution of the work. As Vasari says, quoting Petrarch's line: "*L'opera fosse ritardata dal desio.*" The monk, Sabba da Castiglione, who was present when the French entered Milan in 1499, records the fact of the destruction of the clay model under the arrows of the Gascon bowmen. The statue ranked with Donatello's *Gattamelata* at Padua and Verrocchio's *Bartolommeo Colleone* at Venice as one of the three great examples of equestrian statues of the Italian Renaissance. So far as it is possible to form an opinion from the very numerous studies in the Royal Collection at Windsor, it would seem to have been in advance of both the others in freedom and vigour of movement. The sequence of studies shows a change of purpose from the attitude of the horse galloping to that of it walking. Leonardo says in a note in one of his manuscripts, "The trot is almost the nature of the free horse."

Few paintings are now in existence the execution of which can be connected with Leonardo's first period of residence in Milan. The most important of these is the haunting ruin of the *Last Supper*. The paucity of the list, even allowing for the inevitable mischances of time, confirms the testimony of Sabba da Castiglione, who says that, besides the *Last Supper*, few other works in painting by Leonardo were to be seen at Milan in the middle of the sixteenth century, "because when he ought to have attended to painting, in which without doubt he would have proved a new Apelles, he gave himself entirely to geometry, architecture, and anatomy."

The external history of his life is sharply divided by circumstances into three periods. First the early years at Florence. Then his life at Milan under

Ludovic Sforza. The third period was that of the *Odyssey* of wanderings commenced on his leaving Milan with Fra Luca Paciolo two months after the flight of Ludovic Sforza, and extended for the remaining twenty years of his life.

At Venice, as Leonardo's manuscripts show, he studied the tides of the Adriatic, and apparently prepared a scheme for flooding part of the Veneto in order to stem the Turkish invasion, and also an apparatus by which it would be possible to approach the Turkish galleys under water. A note in the Codice Atlantico tells of his hurried departure from Florence to travel in the Romagna as architect and military engineer in the service of Cæsar Borgia. His manuscripts refer to works planned at Urbino, Cesena, and Porto Cesenatico. But the office ended with the rebellion of the Duchy, and in March, 1503, Leonardo was once more back in Florence. There he was employed to divert the channel of the Arno, in connection with the war with Pisa. He painted at this time the portrait of Madonna Lisa del Giocondo, the world-famous *Mona Lisa*, and also the cartoon for the *Battle of Anghiari*. His work on this composition was interrupted by an invitation to Milan, and this led to his entering the service of the French. Louis XII. refers to him in a letter to the Signoria as "our painter and engineer in ordinary." He consulted him as to the conduit in the garden of the Château of Blois, and employed him on hydraulic work in Lombardy. It was probably in May, 1509, when Louis XII. made a triumphal entry into Milan after the victory of Agnadello, that Leonardo constructed as part of the pageant an automatic lion which walked a few paces and then, opening its breast, revealed it full of lilies. There was much study of anatomy with Marc Antonio della Torre at this period, and his intercourse with French artists is shown by a note to inquire from Jean de Paris the method of painting in tempera, but he did not engage in any great artistic work.

In the year 1512 the French lost Milan, and after the re-entry of the Sforzas, in the person of the young Maximilian, there is no record of Leonardo's further employment. On September 24 in the following year he set out from Milan to Rome with his assistants, and was there lodged in the Belvedere of the Vatican. According to Vasari, the Pope gave him a commission, and then was indignant because he began by experimenting with the varnish. The practice of painting, however, had no more than a secondary interest for him. His manuscripts reveal him as engaged in studies in optics, acoustics, and geometry, studying geology in the Campagna, improving the method of coining at the Mint at Rome, busy with engineering work at Cività Vecchia, and in studying anatomy at the hospital, for which last-named pursuit he was denounced to the Pope by one of his apprentices. He seems to have gone with the Papal army to Bologna, where in December, 1515, the Concordat was held between the Pope and Francis I., and a month later he accompanied the king on his return to France with the office of "his painter and engineer," being given as a residence the Château of Cloux, near Amboise, where he died on May 2, 1519.

A record of a visit paid to him at Cloux by the Cardinal of Aragon on October 10, 1517, makes special mention of the anatomical drawings, and the diarist states that Leonardo told the visitors that in preparation for these he had dissected more than thirty bodies. They saw also his treatise on the nature of water, and others on various machines, there being, as it appeared, "an endless number of volumes all in the vulgar tongue, which if they be published will be profitable and very delectable."

The activities of Leonardo's mind fall naturally into

such as found expression, either mainly or in part, in constructive work and those revealed only in his writings. The first category comprises painting, sculpture, architecture, and engineering. In painting it is enough to instance the fresco of the Last Supper and the portrait of Mona Lisa, each of its type unique among all works of the Renaissance, and beyond all power to appraise in its union of technical mastery and the inevitability of supreme art. In sculpture the Sforza statue, the master-work of his Milanese years, lives only in the drawings which furnish some faint index of its power. In architecture there is no outstanding memorial.

Sir Theodore Cook, in his elaborate study of spiral forms entitled "The Curves of Life," has collected a remarkable array of evidence in favour of attributing to Leonardo the design for the open spiral staircase in the Château of Blois. The documentary evidence is missing, but the date of construction is known to have been between the years 1516 and 1519, and Leonardo was then living a few miles distant in the manor-house of Cloux, near Amboise. A spiral staircase occurs in one of Leonardo's drawings for a fortified tower, and he made many studies of spiral formations occurring in Nature, in shells, in smoke, and in the eddies of water. The staircase at Blois is apparently modelled on *Voluta vespertilio*, a shell common on the coast of northern Italy. The theory has obvious attractions. It supplies an example of a work in architecture emanating from the brain of Leonardo, and this a work of supreme distinction.

Records of his activity as an engineer are concerned with schemes of canalisation in Florence, in connection with the diversion of the Arno from Pisa as a war measure; and in Friuli, in similar circumstances, he devised movable sluices in order to prevent the advance of the Turks across the Isonzo. He made canals in Lombardy for purposes of irrigation, and also aqueducts to improve the water-supply of Milan; and the canal of Romorantin, for which he made plans when in France, was intended to connect the waters of the Loire and the Saône.

The potential list of Leonardo's activities in the construction of instruments of warfare figures in the letter to Ludovic Sforza. He says there: "I can make armoured wagons safe and immune from attack which will open up a passage through the enemy with their artillery, and, however great the multitude of the enemy may be, they will be able to break through. And behind them the infantry will be able to follow quite unhurt and without hindrance."

This armoured wagon is seen ready for action in a drawing in the British Museum. It is moved on wheels, and a sketch of the lower half shows the internal machinery, but it is not possible to discern the nature of the motive power. The use of the armoured wagon in order to open up a passage through the enemy, as described above, is identical with that of the tank in the late war. The manuscripts reveal a strangely prophetic insight in regard to two other developments of recent warfare, namely, poison gas and submarining.

Leonardo contemplated the use of poisonous gas or powders in naval warfare for the purpose of suffocating the enemy, and told how to make a simple preventive mask. He also contemplated the contingency—as happened on occasions in Flanders—of an adverse wind causing the poison to recoil upon the users. The passage, which occurs in MS. B of the Paris manuscripts, is entitled "How to throw poison in the form of powder upon ships."

"By means of catapults," he says, "a mixture of powdered quicklime, arsenic, and verdigris may be

thrown upon the ships of the enemy, and all who inhale the powder will die.

"But take care that the wind is favourable, lest it blow the powder back upon you, and be sure you have a fine piece of damp cloth to cover the nose and mouth in order that the powder may not enter."

In the Leicester manuscript (folio 22b) he foretells the horrors of submarine warfare, and refuses to impart any information as to the machine which he has constructed lest it should serve to bring them about:

"How by means of a certain machine many people may stay some time under water. How and why I do not describe my method of remaining under water, or how long I can remain without eating; and I do not publish or divulge this because of the evil nature of men who would use them as means of destruction at the bottom of the sea by smashing the ships in the keel and sinking them together with the men in them. But I will impart others which are not dangerous, because the mouth of the tube by which you breathe appears above the water supported on leather bottles or corks."

In connection with this passage reference may be made to one in MS. B of the Paris manuscripts entitled "A Way of Escaping in a Tempest or Shipwreck at Sea," in which Leonardo tells how to construct a coat of leather of double thickness which will be capable of being inflated when necessary, and thus of serving as a life-saving jacket in case of emergency.

Senatore Luca Beltrami associates the former of these passages with the Turkish war. Leonardo, as a reference to his manuscript shows, had been employed in the construction of a movable dam which should enable the line of the Isonzo to be flooded in the defence of the Veneto against the Turkish invasion. The reference is to the construction of submarine boats in order to sink the Turkish galleys in the Gulf of Venice "by smashing the ships in the keel and sinking them together with the men in them." Leonardo considers this to be justifiable, because it is an act of defence "for the safety of our Italian lands" ("delli nostre parti italiane"); but he will not give any details of the construction of his submarine craft in which it would be possible to remain under water for four hours, because he is fearful of the evil use to which it might be put in future times.

(To be continued.)

Public Support of Scientific Research.

ON Wednesday, April 28, a public meeting was held at Birkbeck College to hear an address from Prof. F. Soddy on "The Public Support of Scientific Research." Mr. H. G. Wells, who took the chair, claimed that everything in which the world of to-day differed from that of years ago was due to science and the scientific worker. Prof. Soddy expressed his regret that the greater encouragement of scientific research during the war had not resulted in any appreciable improvement in the position of pure science, which was the tree of which applied—industrial and trade—science were the fruits. He deprecated the exploitation of science by financiers and commercial men and its employment to increase the indebtedness to them of those who had done the creative work of the world. The scheme framed by the Government to foster scientific research endeavoured to place the man of science who was to do the work under the same type of men—often the same men—as had thwarted progress in the past. The change from gross inefficiency in the medical