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The Notebooks of Leonardo Da Vinci

XI.

The notes on Sculpture.

Compared with the mass of manuscript treating of Painting, a very small number of passages bearing on the practice and methods of Sculpture are to be found scattered through the note books; these are here given at the beginning of this section (Nos. 706-709). There is less cause for surprise at finding that the equestrian statue of Francesco Sforza is only incidentally spoken of; for, although Leonardo must have worked at it for a long succession of years, it is not in the nature of the case that it could have given rise to much writing. We may therefore regard it as particularly fortunate that no fewer than thirteen notes in the master's handwriting can be brought together, which seem to throw light on the mysterious history of this famous work. Until now writers on Leonardo were acquainted only with the passages numbered 712, 719, 720, 722 and 723.

In arranging these notes on sculpture I have given the precedence to those which treat of the casting of the monument, not merely because they are the fullest, but more especially with a view to reconstructing the monument, an achievement which really almost lies within our reach by combining and comparing the whole of the materials now brought to light, alike in notes and in sketches.

A good deal of the first two passages, Nos. 710 and 711, which refer to this subject seems obscure and incomprehensible; still, they supplement each other and one contributes in no small degree to the comprehension of the other. A very interesting and instructive commentary on these passages may be found in the fourth chapter of Vasari's *Introduzione della Scultura* under the title "Come si fanno i modelli per fare di bronzo le figure grandi e piccole, e come le forme per buttarle; come si armino di ferri, e come si gettino di metallo," &c. Among the drawings of models of the moulds for casting we find only one which seems to represent the horse in the act of galloping--No. 713. All the other designs show the horse as pacing quietly and as these studies of the horse are accompanied by copious notes as to the method of casting, the question as to the position of the horse in the model finally selected, seems to be decided by preponderating evidence. "Il cavallo dello Sforza"--C. Boito remarks

very appositely in the Saggio on page 26, "doveva sembrare fratello al cavallo del Colleoni. E si direbbe che questo fosse figlio del cavallo del Gattamelata, il quale pare figlio di uno dei quattro cavalli che stavano forse sull' Arco di Nerone in Roma" (now at Venice). The publication of the Saggio also contains the reproduction of a drawing in red chalk, representing a horse walking to the left and supported by a scaffolding, given here on Pl. LXXVI, No. 1. It must remain uncertain whether this represents the model as it stood during the preparations for casting it, or whether--as seems to me highly improbable--this sketch shows the model as it was exhibited in 1493 on the Piazza del Castello in Milan under a triumphal arch, on the occasion of the marriage of the Emperor Maximilian to Bianca Maria Sforza. The only important point here is to prove that strong evidence seems to show that, of the numerous studies for the equestrian statue, only those which represent the horse pacing agree with the schemes of the final plans.

The second group of preparatory sketches, representing the horse as galloping, must therefore be considered separately, a distinction which, in recapitulating the history of the origin of the monument seems justified by the note given under No. 720.

Galeazzo Maria Sforza was assassinated in 1476 before his scheme for erecting a monument to his father Francesco Sforza could be carried into effect. In the following year Ludovico il Moro the young aspirant to the throne was exiled to Pisa, and only returned to Milan in 1479 when he was Lord (Governatore) of the State of Milan, in 1480 after the minister Cecco Simonetta had been murdered. It may have been soon after this that Ludovico il Moro announced a competition for an equestrian statue, and it is tolerably certain that Antonio del Pollajuolo took part in it, from this passage in Vasari's Life of this artist: "E si trovo, dopo la morte sua, il disegno e modello che a Lodovico Sforza egli aveva fatto per la statua a cavallo di Francesco Sforza, duca di Milano; il quale disegno e nel nostro Libro, in due modi: in uno egli ha sotto Verona; nell'altro, egli tutto armato, e sopra un basamento pieno di battaglie, fa saltare il cavallo addosso a un armato; ma la cagione perche non mettesse questi disegni in opera, non ho gia potuto sapere." One of Pollajuolo's drawings, as here described, has lately been discovered by Senatore Giovanni Morelli in the Munich Pinacothek. Here the profile of the horseman is a portrait of Francesco Duke of Milan, and under the horse, who is galloping to the left, we see a warrior thrown and lying on the ground; precisely the same idea as we find in some of Leonardo's designs for the monument, as on Pl. LXVI, LXVII, LXVIII, LXIX and LXXII No. 1; and, as it is impossible to explain this remarkable coincidence by supposing that either artist borrowed it from the other, we can only conclude that in the terms of the competition the subject proposed was the Duke on a horse in full gallop, with a fallen foe under its hoofs.

Leonardo may have been in the competition there and then, but the means for executing the monument do not seem to have been at once

forthcoming. It was not perhaps until some years later that Leonardo in a letter to the Duke (No. 719) reminded him of the project for the monument. Then, after he had obeyed a summons to Milan, the plan seems to have been so far modified, perhaps in consequence of a remonstrance on the part of the artist, that a pacing horse was substituted for one galloping, and it may have been at the same time that the colossal dimensions of the statue were first decided on. The designs given on Pl. LXX, LXXI, LXXII, 2 and 3, LXXIII and LXXIV and on pp. 4 and 24, as well as three sketches on Pl. LXIX may be studied with reference to the project in its new form, though it is hardly possible to believe that in either of these we see the design as it was actually carried out. It is probable that in Milan Leonardo worked less on drawings, than in making small models of wax and clay as preparatory to his larger model. Among the drawings enumerated above, one in black chalk, Pl. LXXIII--the upper sketch on the right hand side, reminds us strongly of the antique statue of Marcus Aurelius. If, as it would seem, Leonardo had not until then visited Rome, he might easily have known this statue from drawings by his former master and friend Verrocchio, for Verrocchio had been in Rome for a long time between 1470 and 1480. In 1473 Pope Sixtus IV had this antique equestrian statue restored and placed on a new pedestal in front of the church of San Giovanni in Luterano. Leonardo, although he was painting independently as early as in 1472 is still spoken of as working in Verrocchio's studio in 1477. Two years later the Venetian senate decided on erecting an equestrian statue to Colleoni; and as Verrocchio, to whom the work was entrusted, did not at once move from Florence to Venice--where he died in 1488 before the casting was completed--but on the contrary remained in Florence for some years, perhaps even till 1485, Leonardo probably had the opportunity of seeing all his designs for the equestrian statue at Venice and the red chalk drawing on Pl. LXXIV may be a reminiscence of it.

The pen and ink drawing on Pl. LXXII, No. 3, reminds us of Donatello's statue of Gattamelata at Padua. However it does not appear that Leonardo was ever at Padua before 1499, but we may conclude that he took a special interest in this early bronze statue and the reports he could procure of it, form an incidental remark which is to be found in C. A. 145a; 432a, and which will be given in Vol. II under Ricordi or Memoranda. Among the studies--in the widest sense of the word--made in preparation statue we may include the Anatomy of the Horse which Lomazzo and Vas mention; the most important parts of this work still exist in the Queen's Li Windsor. It was beyond a doubt compiled by Leonardo when at Milan; only interesting records to be found among these designs are reproduced in Nos. 716a but it must be pointed out that out of 40 sheets of studies of the movements of the belonging to that treatise, a horse in full gallop occurs but once.

If we may trust the account given by Paulus Jovius--about 1527--Leonardo's horse was represented as "vehementer incitatus et anhelatus". Jovius had probably seen the model exhibited at Milan; but, need we, in fact, infer from this description that the horse

was galloping? Compare Vasari's description of the Gattamelata monument at Padua: "Egli [Donatello] vi ando ben volentieri, e fece il cavallo di bronzo, che e in sulla piazza di Sant Antonio, nel quale si dimostra lo sbuffamento ed il fremito del cavallo, ed il grande animo e la fierezza vivacissimamente espressa dall'arte nella figura che lo cavalca".

These descriptions, it seems to me, would only serve to mark the difference between the work of the middle ages and that of the renaissance.

We learn from a statement of Sabba da Castiglione that, when Milan was taken by the French in 1499, the model sustained some injury; and this informant, who, however is not invariably trustworthy, adds that Leonardo had devoted fully sixteen years to this work (la forma del cavallo, intorno a cui Leonardo avea sedici anni continui consumati). This often-quoted passage has given ground for an assumption, which has no other evidence to support it, that Leonardo had lived in Milan ever since 1483. But I believe it is nearer the truth to suppose that this author's statement alludes to the fact that about sixteen years must have past since the competition in which Leonardo had taken part.

I must in these remarks confine myself strictly to the task in hand and give no more of the history of the Sforza monument than is needed to explain the texts and drawings I have been able to reproduce. In the first place, with regard to the drawings, I may observe that they are all, with the following two exceptions, in the Queen's Library at Windsor Castle; the red chalk drawing on Pl. LXXVI No. 1 is in the MS. C. A. (see No. 712) and the fragmentary pen and ink drawing on page 4 is in the Ambrosian Library. The drawings from Windsor on Pl. LXVI have undergone a trifling reduction from the size of the originals.

There can no longer be the slightest doubt that the well-known engraving of several horsemen (Passavant, *Le Peintre-Graveur*, Vol. V, p. 181, No. 3) is only a copy after original drawings by Leonardo, executed by some unknown engraver; we have only to compare the engraving with the facsimiles of drawings on Pl. LXV, No. 2, Pl. LXVII, LXVIII and LXIX which, it is quite evident, have served as models for the engraver.

On Pl. LXV No. 1, in the larger sketch to the right hand, only the base is distinctly visible, the figure of the horseman is effaced. Leonardo evidently found it unsatisfactory and therefore rubbed it out.

The base of the monument--the pedestal for the equestrian statue--is repeatedly sketched on a magnificent plan. In the sketch just mentioned it has the character of a shrine or aedicula to contain a sarcophagus. Captives in chains are here represented on the entablature with their backs turned to that portion of the monument which more

strictly constitutes the pedestal of the horse. The lower portion of the aedicula is surrounded by columns. In the pen and ink drawing Pl. LXVI--the lower drawing on the right hand side--the sarcophagus is shown between the columns, and above the entablature is a plinth on which the horse stands. But this arrangement perhaps seemed to Leonardo to lack solidity, and in the little sketch on the left hand, below, the sarcophagus is shown as lying under an arched canopy. In this the trophies and the captive warriors are detached from the angles. In the first of these two sketches the place for the trophies is merely indicated by a few strokes; in the third sketch on the left the base is altogether broader, buttresses and pinnacles having been added so as to form three niches. The black chalk drawing on Pl. LXVIII shows a base in which the angles are formed by niches with pilasters. In the little sketch to the extreme left on Pl. LXV, No. 1, the equestrian statue serves to crown a circular temple somewhat resembling Bramante's tempietto of San Pietro in Montorio at Rome, while the sketch above to the right displays an arrangement faintly reminding us of the tomb of the Scaligers in Verona. The base is thus constructed of two platforms or slabs, the upper one considerably smaller than the lower one which is supported on flying buttresses with pinnacles.

On looking over the numerous studies in which the horse is not galloping but merely walking forward, we find only one drawing for the pedestal, and this, to accord with the altered character of the statue, is quieter and simpler in style (Pl. LXXIV). It rises almost vertically from the ground and is exactly as long as the pacing horse. The whole base is here arranged either as an independent baldaquin or else as a projecting canopy over a recess in which the figure of the deceased Duke is seen lying on his sarcophagus; in the latter case it was probably intended as a tomb inside a church. Here, too, it was intended to fill the angles with trophies or captive warriors. Probably only No. 724 in the text refers to the work for the base of the monument.

If we compare the last mentioned sketch with the description of a plan for an equestrian monument to Gian Giacomo Trivulzio (No. 725) it seems by no means impossible that this drawing is a preparatory study for the very monument concerning which the manuscript gives us detailed information. We have no historical record regarding this sketch nor do the archives in the Trivulzio Palace give us any information. The simple monument to the great general in San Nazaro Maggiore in Milan consists merely of a sarcophagus placed in recess high on the wall of an octagonal chapel. The figure of the warrior is lying on the sarcophagus, on which his name is inscribed; a piece of sculpture which is certainly not Leonardo's work. Gian Giacomo Trivulzio died at Chartres in 1518, only five months before Leonardo, and it seems to me highly improbable that this should have been the date of this sketch; under these circumstances it would have been done under the auspices of Francis I, but the Italian general was certainly not in favour with the French monarch at the time. Gian Giacomo Trivulzio was a sworn foe to Ludovico il Moro,

whom he strove for years to overthrow. On the 6th September 1499 he marched victorious into Milan at the head of a French army. In a short time, however, he was forced to quit Milan again when Ludovico il Moro bore down upon the city with a force of Swiss troops. On the 15th of April following, after defeating Lodovico at Novara, Trivulzio once more entered Milan as a Conqueror, but his hopes of becoming _Governatore_ of the place were soon wrecked by intrigue. This victory and triumph, historians tell us, were signalled by acts of vengeance against the dethroned Sforza, and it might have been particularly flattering to him that the casting and construction of the Sforza monument were suspended for the time.

It must have been at this moment--as it seems to me--that he commissioned the artist to prepare designs for his own monument, which he probably intended should find a place in the Cathedral or in some other church. He, the husband of Margherita di Nicolino Colleoni, would have thought that he had a claim to the same distinction and public homage as his less illustrious connection had received at the hands of the Venetian republic. It was at this very time that Trivulzio had a medal struck with a bust portrait of himself and the following remarkable inscription on the reverse: _DEO FAVENTE--1499--DICTVS--10--IA--EXPVLIT--LVDOVICV--SF--(Sfortiam) DVC-- (ducem) MLI (Mediolani)--NOIE (nomine)--REGIS--FRANCORVM--EODEM--ANN --(anno) RED'T (redit)--LVS (Ludovicus)--SVPERATVS ET CAPTVS--EST--AB--EO. _In the Library of the Palazzo Trivulzio there is a MS. of Callimachus Siculus written at the end of the XVth or beginning of the XVIth century. At the beginning of this MS. there is an exquisite illuminated miniature of an equestrian statue with the name of the general on the base; it is however very doubtful whether this has any connection with Leonardo's design.

Nos. 731-740, which treat of casting bronze, have probably a very indirect bearing on the arrangements made for casting the equestrian statue of Francesco Sforza. Some portions evidently relate to the casting of cannon. Still, in our researches about Leonardo's work on the monument, we may refer to them as giving us some clue to the process of bronze casting at that period.

Some practical hints (706-709).

706.

OF A STATUE.

If you wish to make a figure in marble, first make one of clay, and when you have finished it, let it dry and place it in a case which should be large enough, after the figure is taken out of it, to receive also the marble, from which you intend to reveal the figure in imitation of the one in clay. After you have put the clay figure into this said case, have little rods which will exactly slip in to the holes in it, and thrust them so far in at each hole that each white rod may touch the figure in different parts of it. And colour

the portion of the rod that remains outside black, and mark each rod and each hole with a countersign so that each may fit into its place. Then take the clay figure out of this case and put in your piece of marble, taking off so much of the marble that all your rods may be hidden in the holes as far as their marks; and to be the better able to do this, make the case so that it can be lifted up; but the bottom of it will always remain under the marble and in this way it can be lifted with tools with great ease.

707.

Some have erred in teaching sculptors to measure the limbs of their figures with threads as if they thought that these limbs were equally round in every part where these threads were wound about them.

708.

MEASUREMENT AND DIVISION OF A STATUE.

Divide the head into 12 degrees, and each degree divide into 12 points, and each point into 12 minutes, and the minutes into minims and the minims into semi minims.

Degree--point--minute--minim.

709.

Sculptured figures which appear in motion, will, in their standing position, actually look as if they were falling forward.

[Footnote: *_figure di rilievo_*. Leonardo applies this term exclusively to wholly detached figures, especially to those standing free. This note apparently refers to some particular case, though we have no knowledge of what that may have been. If we suppose it to refer to the first model of the equestrian statue of Francesco Sforza (see the introduction to the notes on Sculpture) this observation may be regarded as one of his arguments for abandoning the first scheme of the Sforza Monument, in which the horse was to be galloping (see page 2). It is also in favour of this theory that the note is written in a manuscript volume already completed in 1492. Leonardo's opinions as to the shortcomings of plastic works when compared with paintings are given under No. 655 and 656.]

Notes on the casting of the Sforza monument (710-715).

710.

Three braces which bind the mould.

[If you want to make simple casts quickly, make them in a box of river sand wetted with vinegar.]

[When you shall have made the mould upon the horse you must make the thickness of the metal in clay.]

Observe in alloying how many hours are wanted for each hundredweight. [In casting each one keep the furnace and its fire well stopped up.] [Let the inside of all the moulds be wetted with linseed oil or oil of turpentine, and then take a handful of powdered borax and Greek pitch with aqua vitae, and pitch the mould over outside so that being under ground the damp may not [damage it?]

[To manage the large mould make a model of the small mould, make a small room in proportion.]

[Make the vents in the mould while it is on the horse.]

Hold the hoofs in the tongs, and cast them with fish glue. Weigh the parts of the mould and the quantity of metal it will take to fill them, and give so much to the furnace that it may afford to each part its amount of metal; and this you may know by weighing the clay of each part of the mould to which the quantity in the furnace must correspond. And this is done in order that the furnace for the legs when filled may not have to furnish metal from the legs to help out the head, which would be impossible. [Cast at the same casting as the horse the little door]

[Footnote: The importance of the notes included under this number is not diminished by the fact that they have been lightly crossed out with red chalk. Possibly they were the first scheme for some fuller observations which no longer exist; or perhaps they were crossed out when Leonardo found himself obliged to give up the idea of casting the equestrian statue. In the original the first two sketches are above l. 1, and the third below l. 9.]

711.

THE MOULD FOR THE HORSE.

Make the horse on legs of iron, strong and well set on a good foundation; then grease it and cover it with a coating, leaving each coat to dry thoroughly layer by layer; and this will thicken it by the breadth of three fingers. Now fix and bind it with iron as may be necessary. Moreover take off the mould and then make the thickness. Then fill the mould by degrees and make it good throughout; encircle and bind it with its irons and bake it inside where it has to touch the bronze.

OF MAKING THE MOULD IN PIECES.

Draw upon the horse, when finished, all the pieces of the mould with which you wish to cover the horse, and in laying on the clay cut it in every piece, so that when the mould is finished you can take it off, and then recompose it in its former position with its joins, by

the countersigns.

The square blocks _a b_ will be between the cover and the core, that is in the hollow where the melted bronze is to be; and these square blocks of bronze will support the intervals between the mould and the cover at an equal distance, and for this reason these squares are of great importance.

The clay should be mixed with sand.

Take wax, to return [what is not used] and to pay for what is used.

Dry it in layers.

Make the outside mould of plaster, to save time in drying and the expense in wood; and with this plaster enclose the irons [props] both outside and inside to a thickness of two fingers; make terra cotta. And this mould can be made in one day; half a boat load of plaster will serve you.

Good.

Dam it up again with glue and clay, or white of egg, and bricks and rubbish.

[Footnote: See Pl. LXXV. The figure "40," close to the sketch in the middle of the page between lines 16 and 17 has been added by a collector's hand.

In the original, below line 21, a square piece of the page has been cut out about 9 centimetres by 7 and a blank piece has been gummed into the place.

Lines 22-24 are written on the margin. l. 27 and 28 are close to the second marginal sketch. l. 42 is a note written above the third marginal sketch and on the back of this sheet is the text given as No. 642. Compare also No. 802.]

712.

All the heads of the large nails.

[Footnote: See Pl. LXXVI, No. i. This drawing has already been published in the "_Saggio delle Opere di L. da Vinci_" Milano 1872, Pl. XXIV, No. i. But, for various reasons I cannot regard the editor's suggestions as satisfactory. He says: "_Veggonsi le armature di legname colle quali forse venne sostenuto il modello, quando per le nozze di Bianca Maria Sforza con Massimiliano imperatore, esso fu collocato sotto un arco trionfale davanti al Castello_"

713.

These bindings go inside.

714.

Salt may be made from human excrements, burnt and calcined, made into lees and dried slowly at a fire, and all the excrements produce salt in a similar way and these salts when distilled, are very strong.

[Footnote: VASARI repeatedly states, in the fourth chapter of his *Introduzione della Scultura*, that in preparing to cast bronze statues horse-dung was frequently used by sculptors. If, notwithstanding this, it remains doubtful whether I am justified in having introduced here this text of but little interest, no such doubt can be attached to the sketch which accompanies it.]

715.

METHOD OF FOUNDING AGAIN.

This may be done when the furnace is made [Footnote: this note is written below the sketches.] strong and bruised.

Models for the horse of the Sforza monument (716-718).

716.

Messer Galeazzo's big genet

717.

Messer Galeazzo's Sicilian horse.

[Footnote: These notes are by the side of a drawing of a horse with figured measurements.]

718.

Measurement of the Sicilian horse the leg from behind, seen in front, lifted and extended.

[Footnote: There is no sketch belonging to this passage. Galeazzo here probably means Galeazzo di San Severino, the famous captain who married Bianca the daughter of Ludovico il Moro.]

Occasional references to the Sforza monument (719-724).

719.

Again, the bronze horse may be taken in hand, which is to be to the immortal glory and eternal honour of the happy memory of the prince your father, and of the illustrious house of Sforza.

[Footnote: The letter from which this passage is here extracted will be found complete in section XXI. (see the explanation of it, on page 2).]

720.

On the 23rd of April 1490 I began this book, and recommenced the horse.

721.

There is to be seen, in the mountains of Parma and Piacenza, a multitude of shells and corals full of holes, still sticking to the rocks, and when I was at work on the great horse for Milan, a large sackful of them, which were found thereabout, was brought to me into my workshop, by certain peasants.

722.

Believe me, Leonardo the Florentine, who has to do the equestrian bronze statue of the Duke Francesco that he does not need to care about it, because he has work for all his life time, and, being so great a work, I doubt whether he can ever finish it. [Footnote: This passage is quoted from a letter to a committee at Piacenza for whom Leonardo seems to have undertaken to execute some work. The letter is given entire in section XXL; in it Leonardo remonstrates as to some unreasonable demands.]

723.

Of the horse I will say nothing because I know the times. [Footnote: This passage occurs in a rough copy of a letter to Ludovico il Moro, without date (see below among the letters).]

724.

During ten years the works on the marbles have been going on I will not wait for my payment beyond the time, when my works are finished. [Footnote: This possibly refers to the works for the pedestal of the equestrian statue concerning which we have no farther information in the MSS. See p. 6.]

The project of the Trivulzio monument.

725.

THE MONUMENT TO MESSER GIOVANNI JACOMO DA TREVULZO.

[2] Cost of the making and materials for the horse [5].

[Footnote: In the original, lines 2-5, 12-14, 33-35, are written on the margin. This passage has been recently published by G. Govi in Vol. V, Ser. 3a, of *Transunti*, Reale Accademia dei Lincei, sed. del

5 Giugno, 1881, with the following introductory note: "Desidero intanto che siano stampati questi pochi frammenti perche so che sono stati trascritti ultimamente, e verranno messi in luce tra poco fuori d'Italia. Li ripubblichi pure chi vuole, ma si sappia almeno che anche tra noi si conoscevano, e s'eran raccolti da anni per comporne, quando che fosse, una edizione ordinata degli scritti di Leonardo." _

The learned editor has left out line 22 and has written 3 _pie_ for 8 _piedi_ in line 25. There are other deviations of less importance from the original.]

A courser, as large as life, with the rider requires for the cost of the metal, duc. 500.

And for cost of the iron work which is inside the model, and charcoal, and wood, and the pit to cast it in, and for binding the mould, and including the furnace where it is to be cast ... duc. 200.

To make the model in clay and then in wax..... duc. 432.

To the labourers for polishing it when it is cast. duc. 450.

in all. . duc. 1582.

[12] Cost of the marble of the monument [14].

Cost of the marble according to the drawing. The piece of marble under the horse which is 4 braccia long, 2 braccia and 2 inches wide and 9 inches thick 58 hundredweight, at 4 Lire and 10 Soldi per hundredweight.. duc. 58.

And for 13 braccia and 6 inches of cornice, 7 in. wide and 4 in. thick, 24 hundredweight..... duc. 24.

And for the frieze and architrave, which is 4 br. and 6 in. long, 2 br. wide and 6 in. thick, 29 hundredweight., duc. 20.

And for the capitals made of metal, which are 8, 5 inches in. square and 2 in. thick, at the price of 15 ducats each, will come to..... duc. 122.

And for 8 columns of 2 br. 7 in., 4 1/2 in. thick, 20 hundredweight duc. 20.

And for 8 bases which are 5 1/2 in. square and 2 in. high 5 hund'.. duc. 5.

And for the slab of the tombstone 4 br. io in. long, 2 br. 4 1/2 in. wide 36 hundredweight..... duc. 36.

And for 8 pedestal feet each 8 br. long and 6 1/2 in. wide and 6 1/2

in. thick, 20 hundredweight come to... duc. 20.

And for the cornice below which is 4 br. and 10 in. long, and 2 br. and 5 in. wide, and 4 in. thick, 32 hund'.. duc. 32.

And for the stone of which the figure of the deceased is to be made which is 3 br. and 8 in. long, and 1 br. and 6 in. wide, and 9 in. thick, 30 hund'.. duc. 30.

And for the stone on which the figure lies which is 3 br. and 4 in. long and 1 br. and 2 in., wide and 4 1/2 in. thick duc. 16.

And for the squares of marble placed between the pedestals which are 8 and are 9 br. long and 9 in. wide, and 3 in. thick, 8 hundredweight . . . duc. 8. in all. . duc. 389.

[33]Cost of the work in marble[35].

Round the base on which the horse stands there are 8 figures at 25 ducats each duc. 200.

And on the same base there are 8 festoons with some other ornaments, and of these there are 4 at the price of 15 ducats each, and 4 at the price of 8 ducats each duc. 92.

And for squaring the stones duc. 6.

Again, for the large cornice which goes below the base on which the horse stands, which is 13 br. and 6 in., at 2 due. per br. duc. 27.

And for 12 br. of frieze at 5 due. per br. duc. 60.

And for 12 br. of architrave at 1 1/2 duc. per br. duc. 18.

And for 3 rosettes which will be the soffit of the monument, at 20 ducats each duc. 60.

And for 8 fluted columns at 8 ducats each duc. 64.

And for 8 bases at 1 ducat each, duc. 8.

And for 8 pedestals, of which 4 are at 10 duc. each, which go above the angles; and 4 at 6 duc. each .. duc. 64.

And for squaring and carving the moulding of the pedestals at 2 duc. each, and there are 8 duc. 16.

And for 6 square blocks with figures and trophies, at 25 duc. each .. duc. 150.

And for carving the moulding of the stone under the figure of the deceased duc. 40.

For the statue of the deceased, to do it well duc. 100.

For 6 harpies with candelabra, at 25 ducats each duc. 150.

For squaring the stone on which the statue lies, and carving the moulding duc. 20.

in all .. duc. 1075.

The sum total of every thing added together amount to duc. 3046.

726.

MINT AT ROME.

It can also be made without a spring. But the screw above must always be joined to the part of the movable sheath: [Margin note: The mint of Rome.] [Footnote: See Pl. LXXVI. This passage is taken from a note book which can be proved to have been used in Rome.]

All coins which do not have the rim complete, are not to be accepted as good; and to secure the perfection of their rim it is requisite that, in the first place, all the coins should be a perfect circle; and to do this a coin must before all be made perfect in weight, and size, and thickness. Therefore have several plates of metal made of the same size and thickness, all drawn through the same gauge so as to come out in strips. And out of [24] these strips you will stamp the coins, quite round, as sieves are made for sorting chestnuts [27]; and these coins can then be stamped in the way indicated above; &c.

[31] The hollow of the die must be uniformly wider than the lower, but imperceptibly [35].

This cuts the coins perfectly round and of the exact thickness, and weight; and saves the man who cuts and weighs, and the man who makes the coins round. Hence it passes only through the hands of the gauger and of the stamper, and the coins are very superior. [Footnote: See Pl. LXXVI No. 2. The text of lines 31-35 stands parallel 1. 24-27.

Farther evidence of Leonardo's occupations and engagements at Rome under Pope Leo X. may be gathered from some rough copies of letters which will be found in this volume. Hitherto nothing has been known of his work in Rome beyond some doubtful, and perhaps mythical, statements in Vasari.]

727.

POWDER FOR MEDALS.

The incombustible growth of soot on wicks reduced to powder, burnt tin and all the metals, alum, isinglass, smoke from a brass forge, each ingredient to be moistened, with aqua vitae or malmsey or strong malt vinegar, white wine or distilled extract of turpentine, or oil; but there should be little moisture, and cast in moulds.

[Margin note: On the coining of medals (727. 728).] [Footnote: The meaning of *_scagliuolo_* in this passage is doubtful.]

728.

OF TAKING CASTS OF MEDALS.

A paste of emery mixed with aqua vitae, or iron filings with vinegar, or ashes of walnut leaves, or ashes of straw very finely powdered.

[Footnote: The meaning of *_scagliuolo_* in this passage is doubtful.]

The diameter is given in the lead enclosed; it is beaten with a hammer and several times extended; the lead is folded and kept wrapped up in parchment so that the powder may not be spilt; then melt the lead, and the powder will be on the top of the melted lead, which must then be rubbed between two plates of steel till it is thoroughly pulverised; then wash it with aqua fortis, and the blackness of the iron will be dissolved leaving the powder clean.

Emery in large grains may be broken by putting it on a cloth many times doubled, and hit it sideways with the hammer, when it will break up; then mix it little by little and it can be founded with ease; but if you hold it on the anvil you will never break it, when it is large.

Any one who grinds smalt should do it on plates of tempered steel with a cone shaped grinder; then put it in aqua fortis, which melts away the steel that may have been worked up and mixed with the smalt, and which makes it black; it then remains purified and clean; and if you grind it on porphyry the porphyry will work up and mix with the smalt and spoil it, and aqua fortis will never remove it because it cannot dissolve the porphyry.

If you want a fine blue colour dissolve the smalt made with tartar, and then remove the salt.

Vitrified brass makes a fine red.

729.

STUCCO.

Place stucco over the prominence of the..... which may be composed of Venus and Mercury, and lay it well over that prominence of the thickness of the side of a knife, made with the ruler and cover this with the bell of a still, and you will have again the moisture with

which you applied the paste. The rest you may dry [Margin note: On stucco (729. 730).] [Footnote: In this passage a few words have been written in a sort of cipher--that is to say backwards; as in l. 3 _erenev_ for _Venere_, l. 4 _oirucrem_ for Mercurio, l. 12 _il orreve_ for _il everro_ (?) co borace_. The meaning of the word before "_di gesso_" in l. 1 is unknown; and the sense, in which _sagoma_ is used here and in other passages is obscure.-- _Venere_ and _Mercurio_ may mean 'marble' and 'lime', of which stucco is composed.

12. The meaning of _orreve_ is unknown.]

well; afterwards fire it, and beat it or burnish it with a good burnisher, and make it thick towards the side.

STUCCO.

Powder ... with borax and water to a paste, and make stucco of it, and then heat it so that it may dry, and then varnish it, with fire, so that it shines well.

730.

STUCCO FOR MOULDING.

Take of butter 6 parts, of wax 2 parts, and as much fine flour as when put with these 2 things melted, will make them as firm as wax or modelling clay.

GLUE.

Take mastic, distilled turpentine and white lead.

On bronze casting generally (731-740).

731.

TO CAST.

Tartar burnt and powdered with plaster and cast cause the plaster to hold together when it is mixed up again; and then it will dissolve in water.

732.

TO CAST BRONZE IN PLASTER.

Take to every 2 cups of plaster 1 of ox-horns burnt, mix them together and make your cast with it.

733.

When you want to take a cast in wax, burn the scum with a candle,

and the cast will come out without bubbles.

734.

2 ounces of plaster to a pound of metal;-- walnut, which makes it like the curve.

[Footnote: The second part of this is quite obscure.]

735.

[Dried earth 16 pounds, 100 pounds of metal wet clay 20,--of wet 100,-half,- which increases 4 lbs. of water,--1 of wax, 1 lb. of metal, a little less,-the scrapings of linen with earth, measure for measure.] [Footnote: The translation is given literally, but the meaning is quite obscure.]

736.

Such as the mould is, so will the cast be.

737.

HOW CASTS OUGHT TO BE POLISHED.

Make a bunch of iron wire as thick as thread, and scrub them with [this and] water; hold a bowl underneath that it may not make a mud below.

HOW TO REMOVE THE ROUGH EDGES FROM BRONZE.

Make an iron rod, after the manner of a large chisel, and with this rub over those seams on the bronze which remain on the casts of the guns, and which are caused by the joins in the mould; but make the tool heavy enough, and let the strokes be long and broad.

TO FACILITATE MELTING.

First alloy part of the metal in the crucible, then put it in the furnace, and this being in a molten state will assist in beginning to melt the copper.

TO PREVENT THE COPPER COOLING IN THE FURNACE.

When the copper cools in the furnace, be ready, as soon as you perceive it, to cut it with a long stick while it is still in a paste; or if it is quite cold cut it as lead is cut with broad and large chisels.

IF YOU HAVE TO MAKE A LARGE CAST.

If you have to make a cast of a hundred thousand pounds do it with two furnaces and with 2000 pounds in each, or as much as 3000 pounds

at most.

738.

HOW TO PROCEED TO BREAK A LARGE MASS OF BRONZE.

If you want to break up a large mass of bronze, first suspend it, and then make round it a wall on the four sides, like a trough of bricks, and make a great fire therein. When it is quite red hot give it a blow with a heavy weight raised above it, and with great force.

739.

TO COMBINE LEAD WITH OTHER METAL.

If you wish for economy in combining lead with the metal in order to lessen the amount of tin which is necessary in the metal, first alloy the lead with the tin and then add the molten copper.

How TO MELT [METAL] IN A FURNACE.

The furnace should be between four well founded pillars.

OF THE THICKNESS OF THE COATING.

The coating should not be more than two fingers thick, it should be laid on in four thicknesses over fine clay and then well fixed, and it should be fired only on the inside and then carefully covered with ashes and cow's dung.

OF THE THICKNESS OF THE GUN.

The gun being made to carry 600 lbs. of ball and more, by this rule you will take the measure of the diameter of the ball and divide it into 6 parts and one of these parts will be its thickness at the muzzle; but at the breech it must always be half. And if the ball is to be 700 lbs., $\frac{1}{7}$ th of the diameter of the ball must be its thickness in front; and if the ball is to be 800, the eighth of its diameter in front; and if 900, $\frac{1}{8}$ th and $\frac{1}{2}$ [$\frac{3}{16}$], and if 1000, $\frac{1}{9}$ th.

OF THE LENGTH OF THE BODY OF THE GUN.

If you want it to throw a ball of stone, make the length of the gun to be 6, or as much as 7 diameters of the ball; and if the ball is to be of iron make it as much as 12 balls, and if the ball is to be of lead, make it as much as 18 balls. I mean when the gun is to have the mouth fitted to receive 600 lbs. of stone ball, and more.

OF THE THICKNESS OF SMALL GUNS.

The thickness at the muzzle of small guns should be from a half to one third of the diameter of the ball, and the length from 30 to 36

balls.

740.

OF LUTING THE FURNACE WITHIN.

The furnace must be luted before you put the metal in it, with earth from Valenza, and over that with ashes.

[Footnote 1. 2.: _Terra di Valenza_--Valenza is north of Alessandria on the Po.]

OF RESTORING THE METAL WHEN IT IS BECOMING COOL.

When you see that the bronze is congealing take some willow-wood cut in small chips and make up the fire with it.

THE CAUSE OF ITS CURDLING.

I say that the cause of this congealing often proceeds from too much fire, or from ill-dried wood.

TO KNOW THE CONDITION OF THE FIRE.

You may know when the fire is good and fit for your purpose by a clear flame, and if you see the tips of the flames dull and ending in much smoke do not trust it, and particularly when the flux metal is almost fluid.

OF ALLOYING THE METAL.

Metal for guns must invariably be made with 6 or even 8 per cent, that is 6 of tin to one hundred of copper, for the less you put in, the stronger will the gun be.

WHEN THE TIN SHOULD BE ADDED TO THE COPPER.

The tin should be put in with the copper when the copper is reduced to a fluid.

HOW TO HASTEN THE MELTING.

You can hasten the melting when 2/3ds of the copper is fluid; you can then, with a stick of chestnut-wood, repeatedly stir what of copper remains entire amidst what is melted.

Introductory Observations on the Architectural Designs (XII), and Writings on Architecture (XIII).
_

_Until now very little has been known regarding Leonardo's labours in the domain of Architecture. No building is known to have been planned and executed by him, though by some contemporary writers incidental allusion is made to his occupying himself with

architecture, and his famous letter to Lodovico il Moro,--which has long been a well-known document,--in which he offers his service as an architect to that prince, tends to confirm the belief that he was something more than an amateur of the art. This hypothesis has lately been confirmed by the publication of certain documents, preserved at Milan, showing that Leonardo was not only employed in preparing plans but that he took an active part, with much credit, as member of a commission on public buildings; his name remains linked with the history of the building of the Cathedral at Pavia and that of the Cathedral at Milan._

Leonardo's writings on Architecture are dispersed among a large number of MSS., and it would be scarcely possible to master their contents without the opportunity of arranging, sorting and comparing the whole mass of materials, so as to have some comprehensive idea of the whole. The sketches, when isolated and considered by themselves, might appear to be of but little value; it is not till we understand their general purport, from comparing them with each other, that we can form any just estimate of their true worth.

Leonardo seems to have had a project for writing a complete and separate treatise on Architecture, such as his predecessors and contemporaries had composed--Leon Battista Alberti, Filarete, Francesco di Giorgio and perhaps also Bramante. But, on the other hand, it cannot be denied that possibly no such scheme was connected with the isolated notes and researches, treating on special questions, which are given in this work; that he was merely working at problems in which, for some reason or other he took a special interest.

A great number of important buildings were constructed in Lombardy during the period between 1472 and 1499, and among them there are several by unknown architects, of so high an artistic merit, that it is certainly not improbable that either Bramante or Leonardo da Vinci may have been, directly or indirectly, concerned in their erection.

Having been engaged, for now nearly twenty years, in a thorough study of Bramante's life and labours, I have taken a particular interest in detecting the distinguishing marks of his style as compared with Leonardo's. In 1869 I made researches about the architectural drawings of the latter in the Codex Atlanticus at Milan, for the purpose of finding out, if possible the original plans and sketches of the churches of Santa Maria delle Grazie at Milan, and of the Cathedral at Pavia, which buildings have been supposed to be the work both of Bramante and of Leonardo. Since 1876 I have repeatedly examined Leonardo's architectural studies in the collection of his manuscripts in the Institut de France, and some of these I have already given to the public in my work on "Les Projets Primitifs pour la Basilique de St. Pierre de Rome", _P1. 43. In 1879 I had the opportunity of examining the manuscript in the Palazzo Trivulzio at Milan, and in 1880 Dr Richter showed me in London the manuscripts in the possession of Lord Ashburnham, and those in the

British Museum. I have thus had opportunities of seeing most of Leonardo's architectural drawings in the original, but of the manuscripts themselves I have deciphered only the notes which accompany the sketches. It is to Dr Richter's exertions that we owe the collected texts on Architecture which are now published, and while he has undertaken to be responsible for the correct reading of the original texts, he has also made it his task to extract the whole of the materials from the various MSS. It has been my task to arrange and elucidate the texts under the heads which have been adopted in this work. MS. B. at Paris and the Codex Atlanticus at Milan are the chief sources of our knowledge of Leonardo as an architect, and I have recently subjected these to a thorough re-investigation expressly with a view to this work._

A complete reproduction of all Leonardo's architectural sketches has not, indeed, been possible, but as far as the necessarily restricted limits of the work have allowed, the utmost completeness has been aimed at, and no efforts have been spared to include every thing that can contribute to a knowledge of Leonardo's style. It would have been very interesting, if it had been possible, to give some general account at least of Leonardo's work and studies in engineering, fortification, canal-making and the like, and it is only on mature reflection that we have reluctantly abandoned this idea. Leonardo's occupations in these departments have by no means so close a relation to literary work, in the strict sense of the word as we are fairly justified in attributing to his numerous notes on Architecture.

Leonardo's architectural studies fall naturally under two heads:

I. Those drawings and sketches, often accompanied by short remarks and explanations, which may be regarded as designs for buildings or monuments intended to be built. With these there are occasionally explanatory texts.

II. Theoretical investigations and treatises. A special interest attaches to these because they discuss a variety of questions which are of practical importance to this day. Leonardo's theory as to the origin and progress of cracks in buildings is perhaps to be considered as unique in its way in the literature of Architecture.

HENRY DE GEYMULLER

XII.

Architectural Designs.

I. Plans for towns.

A. Sketches for laying out a new town with a double system of high-level and low-level road-ways.

_Pl. LXXVII, No. 1 (MS. B, 15b). A general view of a town, with the

roads outside it sloping up to the high-level ways within._

Pl. LXXVII, No. 3 (MS. B, 16b. see No. 741; and MS. B. 15b, see No. 742) gives a partial view of the town, with its streets and houses, with explanatory references.

Pl. LXXVII, No. 2 (MS. B, 15b; see No. 743). View of a double staircaise with two opposite flights of steps.

Pl. LXXVIII, Nos. 2 and 3 (MS. B, 37a). Sketches illustrating the connection of the two levels of roads by means of steps. The lower galleries are lighted by openings in the upper roadway.

B. Notes on removing houses (MS. Br. M., 270b, see No. 744).

741.

The roads m are 6 braccia higher than the roads p s, and each road must be 20 braccia wide and have 1/2 braccio slope from the sides towards the middle; and in the middle let there be at every braccio an opening, one braccio long and one finger wide, where the rain water may run off into hollows made on the same level as p s. And on each side at the extremity of the width of the said road let there be an arcade, 6 braccia broad, on columns; and understand that he who would go through the whole place by the high level streets can use them for this purpose, and he who would go by the low level can do the same. By the high streets no vehicles and similar objects should circulate, but they are exclusively for the use of gentlemen. The carts and burdens for the use and convenience of the inhabitants have to go by the low ones. One house must turn its back to the other, leaving the lower streets between them. Provisions, such as wood, wine and such things are carried in by the doors n, and privies, stables and other fetid matter must be emptied away underground. From one arch to the next

742.

must be 300 braccia, each street receiving its light through the openings of the upper streets, and at each arch must be a winding stair on a circular plan because the corners of square ones are always fouled; they must be wide, and at the first vault there must be a door entering into public privies and the said stairs lead from the upper to the lower streets and the high level streets begin outside the city gates and slope up till at these gates they have attained the height of 6 braccia. Let such a city be built near the sea or a large river in order that the dirt of the city may be carried off by the water.

743.

The construction of the stairs: The stairs c d go down to f g, and in the same way f g goes down to h k.

744.

ON MOVING HOUSES.

Let the houses be moved and arranged in order; and this will be done with facility because such houses are at first made in pieces on the open places, and can then be fitted together with their timbers in the site where they are to be permanent.

[9] Let the men of the country [or the village] partly inhabit the new houses when the court is absent [12].

[Footnote: On the same page we find notes referring to Romolontino and Villafranca with a sketch-map of the course of the "Sodro" and the "(Lo)cra" (both are given in the text farther on). There can hardly be a doubt that the last sentence of the passage given above, refers to the court of Francis I. King of France.--L.9-13 are written inside the larger sketch, which, in the original, is on the right hand side of the page by the side of lines 1-8. The three smaller sketches are below. J. P. R.]

_II. Plans for canals and streets in a town.

Pl. LXXIX, 1. and 2, (MS. B, 37b, see No. 745, and MS. B. 36a, see No. 746). A Plan for streets and canals inside a town, by which the cellars of the houses are made accessible in boats.

The third text given under No. 747 refers to works executed by Leonardo in France._

745.

The front _a m_ will give light to the rooms; _a e_ will be 6 braccia--_a b_ 8 braccia --_b e_ 30 braccia, in order that the rooms under the porticoes may be lighted; _c d f_ is the place where the boats come to the houses to be unloaded. In order to render this arrangement practicable, and in order that the inundation of the rivers may not penetrate into the cellars, it is necessary to chose an appropriate situation, such as a spot near a river which can be diverted into canals in which the level of the water will not vary either by inundations or drought. The construction is shown below; and make choice of a fine river, which the rains do not render muddy, such as the Ticino, the Adda and many others. [Footnote 12: _Tesino, Adda e molti altri, i.e._ rivers coming from the mountains and flowing through lakes.] The construction to oblige the waters to keep constantly at the same level will be a sort of dock, as shown below, situated at the entrance of the town; or better still, some way within, in order that the enemy may not destroy it [14].

[Footnote: L. 1-4 are on the left hand side and within the sketch given on Pl. LXXIX, No. I. Then follows after line 14, the drawing of a sluicagate--_conca_--of which the use is explained in the text below it. On the page 38a, which comes next in the original MS. is

the sketch of an oval plan of a town over which is written "_modo di canali per la citta_" and through the longer axis of it "_canale magior_" is written with "_Tesino_" on the prolongation of the canal. J. P. R.]

746.

Let the width of the streets be equal to the average height of the houses.

747.

The main underground channel does not receive turbid water, but that water runs in the ditches outside the town with four mills at the entrance and four at the outlet; and this may be done by damming the water above Romorantin.

[11]There should be fountains made in each piazza[13].

[Footnote: In the original this text comes immediately after the passage given as No. 744. The remainder of the writing on the same page refers to the construction of canals and is given later, in the "Topographical Notes".

Lines 1-11 are written to the right of the plan lines 11-13 underneath it. J. P. R.]

[Footnote 10: _Romolontino_ is Romorantin, South of Orleans in France.]

_III. Castles and Villas.

A. Castles.

Pl. LXXX, No. 1 (P. V. fol. 39b; No. d'ordre 2282). The fortified place here represented is said by Vallardi to be the "_castello" _at Milan, but without any satisfactory reason. The high tower behind the "_rivellino" _ravelin--seems to be intended as a watch-tower.

Pl. LXXX, No. 2 (MS. B, 23b). A similarly constructed tower probably intended for the same use.

Pl. LXXX, No. 3 (MS. B). Sketches for corner towers with steps for a citadel.

Pl. LXXX, No. 4 (W. XVI). A cupola crowning a corner tower; an interesting example of decorative fortification. In this reproduction of the original pen and ink drawing it appears reversed.

B. Projects for Palaces.

Pl. LXXXI, No. 2 (MS. C. A, 75b; 221a, see No. 748). Project for a

royal residence at Amboise in France.

Pl. LXXXII, No. 1 (C. A. 308a; 939a). A plan for a somewhat extensive residence, and various details; but there is no text to elucidate it; in courts are written the three names:

Sam	cosi	giova
(St. Mark)	_(Cosmo)_	_(John)_
arch	mo	nino

C. Plans for small castles or Villas.

The three following sketches greatly resemble each other. Pl. LXXXII, No. 2 (MS. K3 36b; see No. 749).

_Pl. LXXXII, No. 3 (MS. B 60a; See No. 750).

Pl. LXXXIII (W. XVII). The text on this sheet refers to Cyprus (see Topographical Notes No. 1103), but seems to have no direct connection with the sketches inserted between.

Pl. LXXXVIII, Nos. 6 and 7 (MS. B, 12a; see No. 751). A section of a circular pavilion with the plan of a similar building by the side of it. These two drawings have a special historical interest because the text written below mentions the Duke and Duchess of Milan.

The sketch of a villa on a terrace at the end of a garden occurs in C. A. 150; and in C. A. 77b; 225b is another sketch of a villa somewhat resembling the _Belvedere_ of Pope Innocent VIII, at Rome. In C. A. 62b; 193b there is a Loggia.

Pl. LXXXII, No. 4 (C. A. 387a; 1198a) is a tower-shaped _Loggia_ above a fountain. The machinery is very ingeniously screened from view.

748.

The Palace of the prince must have a piazza in front of it.

Houses intended for dancing or any kind of jumping or any other movements with a multitude of people, must be on the ground- floor; for I have already witnessed the destruction of some, causing death to many persons, and above all let every wall, be it ever so thin, rest on the ground or on arches with a good foundation.

Let the mezzanines of the dwellings be divided by walls made of very thin bricks, and without wood on account of fire.

Let all the privies have ventilation [by shafts] in the thickness of the walls, so as to exhale by the roofs.

The mezzanines should be vaulted, and the vaults will be stronger in proportion as they are of small size.

The ties of oak must be enclosed in the walls in order to be protected from fire.

[Footnote: The remarks accompanying the plan reproduced on Pl. LXXXI, No. 2 are as follows: Above, to the left: "_in_ a _anghola stia la guardia de la sstalla_" (in the angle _a_ may be the keeper of the stable). Below are the words "_strada dabosa_" (road to Amboise), parallel with this "_fossa br 40_" (the moat 40 braccia) fixing the width of the moat. In the large court surrounded by a portico "_in terre No.--Largha br.80 e lugha br 120_" To the right of the castle is a large basin for aquatic sports with the words "_Giostre colle nave cioe li giostra li stieno sopra le na_" (Jousting in boats that is the men are to be in boats). J. P. R.]

The privies must be numerous and going one into the other in order that the stench may not penetrate into the dwellings., and all their doors must shut off themselves with counterpoises.

The main division of the facade of this palace is into two portions; that is to say the width of the court-yard must be half the whole facade; the 2nd ...

749.

30 braccia wide on each side; the lower entrance leads into a hall 10 braccia wide and 30 braccia long with 4 recesses each with a chimney.

[Footnote: On each side of the castle, Pl. LXXXII. No. 2 there are drawings of details, to the left "_Camino_" a chimney, to the right the central lantern, sketched in red "_8 lati_" _i.e._ an octagon.]

750.

The firststorey [or terrace] must be entirely solid.

751.

The pavilion in the garden of the Duchess of Milan.

The plan of the pavilion which is in the middle of the labyrinth of the Duke of Milan.

[Footnote: This passage was first published by AMORETTI in _Memorie Storiche_ Cap. X: Una sua opera da riportarsi a quest' anno fu il bagno fatto per la duchessa Beatrice nel parco o giardino del Castello. Lionardo non solo ne disegno il piccolo edifizio a foggia di padiglione, nel cod. segnato Q. 3, dandone anche separatamente la pianta; ma sotto vi scrisse: Padiglione del giardino della duchessa; e sotto la pianta: Fondamento del padiglione ch'e nel mezzo del labirinto del duca di Milano; nessuna data e presso il padiglione, disegnato nella pagina 12, ma poco sopra fra molti circoli

intrecciati vedesi = 10 Luglio 1492 = e nella pagina 2 presso ad alcuni disegni di legumi qualcheduno ha letto Settembre 1482 in vece di 1492, come dovea scriverevi, e probabilmente scrisse Lionardo.

The original text however hardly bears the interpretation put upon it by AMORETTI. He is mistaken as to the mark on the MS. as well as in his statements as to the date, for the MS. in question has no date; the date he gives occurs, on the contrary, in another note-book. Finally, it appears to me quite an open question whether Leonardo was the architect who carried out the construction of the dome-like Pavilion here shown in section, or of the ground plan of the Pavilion drawn by the side of it. Must we, in fact, suppose that "_il duca di Milano_" here mentioned was, as has been generally assumed, Ludovico il Moro? He did not hold this title from the Emperor before 1494; till that date he was only called _Governatore_ and Leonardo in speaking of him, mentions him generally as "_il Moro_" even after 1494. On January 18, 1491, he married Beatrice d'Este the daughter of Ercole I, Duke of Ferrara. She died on the 2nd January 1497, and for the reasons I have given it seems improbable that it should be this princess who is here spoken of as the "_Duchessa di Milano_". From the style of the handwriting it appears to me to be beyond all doubt that the MS. B, from which this passage is taken, is older than the dated MSS. of 1492 and 1493. In that case the Duke of Milan here mentioned would be Gian Galeazzo (1469-1494) and the Duchess would be his wife Isabella of Aragon, to whom he was married on the second February 1489. J. P. R.]

752.

The earth that is dug out from the cellars must be raised on one side so high as to make a terrace garden as high as the level of the hall; but between the earth of the terrace and the wall of the house, leave an interval in order that the damp may not spoil the principal walls.

_IV. Ecclesiastical Architecture.

A. General Observations._

753.

A building should always be detached on all sides so that its form may be seen.

[Footnote: The original text is reproduced on Pl. XCII, No. 1 to the left hand at the bottom.]

754.

Here there cannot and ought not to be any _campanile_; on the contrary it must stand apart like that of the Cathedral and of San Giovanni at Florence, and of the Cathedral at Pisa, where the campanile is quite detached as well as the dome. Thus each can

display its own perfection. If however you wish to join it to the church, make the lantern serve for the campanile as in the church at Chiaravalle.

[Footnote: This text is written by the side of the plan given on Pl. XCI. No. 2.]

[Footnote 12: The Abbey of Chiaravalle, a few miles from Milan, has a central tower on the intersection of the cross in the style of that of the Certosa of Pavia, but the style is mediaeval (A. D. 1330). Leonardo seems here to mean, that in a building, in which the circular form is strongly conspicuous, the campanile must either be separated, or rise from the centre of the building and therefore take the form of a lantern.]

755.

It never looks well to see the roofs of a church; they should rather be flat and the water should run off by gutters made in the frieze.

[Footnote: This text is to the left of the domed church reproduced on Pl. LXXXVII, No. 2.]

_B. The theory of Dome Architecture.

This subject has been more extensively treated by Leonardo in drawings than in writing. Still we may fairly assume that it was his purpose, ultimately to embody the results of his investigation in a "Trattato delle Cupole." _The amount of materials is remarkably extensive. MS. B is particularly rich in plans and elevations of churches with one or more domes--from the simplest form to the most complicated that can be imagined. Considering the evident connexion between a great number of these sketches, as well as the impossibility of seeing in them designs or preparatory sketches for any building intended to be erected, the conclusion is obvious that they were not designed for any particular monument, but were theoretical and ideal researches, made in order to obtain a clear understanding of the laws which must govern the construction of a great central dome, with smaller ones grouped round it; and with or without the addition of spires, so that each of these parts by itself and in its juxtaposition to the other parts should produce the grandest possible effect.

In these sketches Leonardo seems to have exhausted every imaginable combination. [Footnote 1: In MS. B, 32b (see Pl. C III, No. 2) we find eight geometrical patterns, each drawn in a square; and in MS. C.A., fol. 87 to 98 form a whole series of patterns done with the same intention.] The results of some of these problems are perhaps not quite satisfactory; still they cannot be considered to give evidence of a want of taste or of any other defect in Leonardo's architectural capacity. They were no doubt intended exclusively for his own instruction, and, before all, as it seems, to illustrate the features or consequences resulting from a given principle._

_I have already, in another place, [Footnote 1: Les Projets Primitifs pour la Basilique de St. Pierre de Rome, par Bramante, Raphael etc., Vol. I, p. 2.] _pointed out the law of construction for buildings crowned by a large dome: namely, that such a dome, to produce the greatest effect possible, should rise either from the centre of a Greek cross, or from the centre of a structure of which the plan has some symmetrical affinity to a circle, this circle being at the same time the centre of the whole plan of the building.

Leonardo's sketches show that he was fully aware, as was to be expected, of this truth. Few of them exhibit the form of a Latin cross, and when this is met with, it generally gives evidence of the determination to assign as prominent a part as possible to the dome in the general effect of the building.

While it is evident, on the one hand, that the greater number of these domes had no particular purpose, not being designed for execution, on the other hand several reasons may be found for Leonardo's perseverance in his studies of the subject.

Besides the theoretical interest of the question for Leonardo and his _Trattato _and besides the taste for domes prevailing at that time, it seems likely that the intended erection of some building of the first importance like the Duomos of Pavia and Como, the church of Sta. Maria delle Grazie at Milan, and the construction of a Dome or central Tower_ (Tiburio) _on the cathedral of Milan, may have stimulated Leonardo to undertake a general and thorough investigation of the subject; whilst Leonardo's intercourse with Bramante for ten years or more, can hardly have remained without influence in this matter. In fact now that some of this great Architect's studies for S. Peter's at Rome have at last become known, he must be considered henceforth as the greatest master of Dome-Architecture that ever existed. His influence, direct or indirect even on a genius like Leonardo seems the more likely, since Leonardo's sketches reveal a style most similar to that of Bramante, whose name indeed, occurs twice in Leonardo's manuscript notes. It must not be forgotten that Leonardo was a Florentine; the characteristic form of the two principal domes of Florence, Sta. Maria del Fiore and the Battisterio, constantly appear as leading features in his sketches.

The church of San Lorenzo at Milan, was at that time still intact. The dome is to this day one of the most wonderful cupolas ever constructed, and with its two smaller domes might well attract the attention and study of a never resting genius such as Leonardo. A whole class of these sketches betray in fact the direct influence of the church of S. Lorenzo, and this also seems to have suggested the plan of Bramante's dome of St. Peter's at Rome.

In the following pages the various sketches for the construction of domes have been classified and discussed from a general point of view. On two sheets: Pl. LXXXIV (C.A. 354b; 118a) and Pl. LXXXV,

Nos. 1-11 (Ash. II, 6b) we see various dissimilar types, grouped together; thus these two sheets may be regarded as a sort of nomenclature of the different types, on which we shall now have to treat.

_1. Churches formed on the plan of a Greek cross.

Group I.

Domes rising from a circular base.

The simplest type of central building is a circular edifice.

Pl. LXXXIV, No. 9. Plan of a circular building surrounded by a colonnade.

Pl. LXXXIV, No. 8. Elevation of the former, with a conical roof.

Pl. XC. No. 5. A dodecagon, as most nearly approaching the circle.

Pl. LXXXVI, No. 1, 2, 3. Four round chapels are added at the extremities of the two principal axes;--compare this plan with fig. 1 on p. 44 and fig. 3 on p. 47 (W. P. 5b) where the outer wall is octagonal.

Group II.

Domes rising from a square base.

The plan is a square surrounded by a colonnade, and the dome seems to be octagonal.

Pl. LXXXIV. The square plan below the circular building No. 8, and its elevation to the left, above the plan: here the ground-plan is square, the upper storey octagonal. A further development of this type is shown in two sketches C. A. 3a (not reproduced here), and in

Pl. LXXXVI, No. 5 (which possibly belongs to No. 7 on Pl. LXXXIV).

Pl. LXXXV, No. 4, and p. 45, Fig. 3, a Greek cross, repeated p. 45, Fig. 3, is another development of the square central plan.

The remainder of these studies show two different systems; in the first the dome rises from a square plan,--in the second from an octagonal base.

_Group III.

Domes rising from a square base and four pillars. [Footnote 1: The ancient chapel San Satiro, via del Falcone, Milan, is a specimen of this type.]

a) First type. _A Dome resting on four pillars in the centre of a

square edifice, with an apse in the middle, of each of the four sides. We have eleven variations of this type.

aa) Pl. LXXXVIII, No. 3.

bb) Pl. LXXX, No. 5.

cc) Pl. LXXXV, Nos. 2, 3, 5.

dd) Pl. LXXXIV, No. 1 and 4 beneath.

ee) Pl. LXXXV, Nos. 1, 7, 10, 11._

b) Second type. _This consists in adding aisles to the whole plan of the first type; columns are placed between the apses and the aisles; the plan thus obtained is very nearly identical with that of S. Lorenzo at Milan.

Fig. 1 on p. 56. (MS. B, 75a) shows the result of this treatment adapted to a peculiar purpose about which we shall have to say a few words later on.

Pl. XCV, No. 1, shows the same plan but with the addition of a short nave. This plan seems to have been suggested by the general arrangement of S. Sepolcro at Milan.

MS. B. 57b (see the sketch reproduced on p.51). By adding towers in the four outer angles to the last named plan, we obtain a plan which bears the general features of Bramante's plans for S. Peter's at Rome. [Footnote 2: See_ Les projets primitifs _etc., Pl. 9-12.] (See p. 51 Fig. 1.)

Group IV.

Domes rising from an octagonal base.

This system, developed according to two different schemes, has given rise to two classes with many varieties.

In a) On each side of the octagon chapels of equal form are added.

In b) The chapels are dissimilar; those which terminate the principal axes being different in form from those which are added on the diagonal sides of the octagon.

a. First Class.

The Chapel_ "degli Angeli," _at Florence, built only to a height of about 20 feet by Brunellesco, may be considered as the prototype of this group; and, indeed it probably suggested it. The fact that we see in MS. B. 11b (Pl. XCIV, No. 3) by the side of Brunellesco's plan for the Basilica of Sto. Spirito at Florence, a plan almost identical with that of the_ Capella degli Angeli, _confirms this

supposition. Only two small differences, or we may say improvements, have been introduced by Leonardo. Firstly the back of the chapels contains a third niche, and each angle of the Octagon a folded pilaster like those in Bramante's *Sagrestia di S. M. presso San Satiro* at Milan, instead of an interval between the two pilasters as seen in the *Battistero* at Florence and in the *Sacristy of Sto. Spirito* in the same town and also in the above named chapel by Brunellesco.

The first set of sketches which come under consideration have at first sight the appearance of mere geometrical studies. They seem to have been suggested by the plan given on page 44 Fig. 2 (MS. B, 55a) in the centre of which is written "*Santa Maria in perticha da Pavia*", at the place marked A on the reproduction.

a) (MS. B, 34b, page 44 Fig. 3). In the middle of each side a column is added, and in the axes of the intercolumnar spaces a second row of columns forms an aisle round the octagon. These are placed at the intersection of a system of semicircles, of which the sixteen columns on the sides of the octagon are the centres.

b) The preceding diagram is completed and becomes more monumental in style in the sketch next to it (MS. B, 35a, see p. 45 Fig. 1). An outer aisle is added by circles, having for radius the distance between the columns in the middle sides of the octagon.

c) (MS. B. 96b, see p. 45 Fig. 2). Octagon with an aisle round it; the angles of both are formed by columns. The outer sides are formed by 8 niches forming chapels. The exterior is likewise octagonal, with the angles corresponding to the centre of each of the interior chapels.

Pl. XCII, No. 2 (MS. B. 96b). Detail and modification of the preceding plan--half columns against piers--an arrangement by which the chapels of the aisle have the same width of opening as the inner arches between the half columns. Underneath this sketch the following note occurs: *questo vole - avere 12 facce - co 12 tabernaculi - come - a - b.* (This will have twelve sides with twelve tabernacles as a b.) In the remaining sketches of this class the octagon is not formed by columns at the angles.

The simplest type shows a niche in the middle of each side and is repeated on several sheets, viz: MS. B 3; MS. C.A. 354b (see Pl. LXXXIV, No. 11) and MS. Ash II 6b; (see Pl. LXXXV, No. 9 and the elevations No. 8; Pl. XCII, No. 3; MS. B. 4b [not reproduced here] and Pl. LXXXIV, No. 2).

Pl. XCII, 3 (MS. B, 56b) corresponds to a plan like the one in MS. B 35a, in which the niches would be visible outside or, as in the following sketch, with the addition of a niche in the middle of each chapel.

Pl. XC, No. 6. The niches themselves are surrounded by smaller

niches (see also No. 1 on the same plate).

Octagon expanded on each side.

A. by a square chapel:

MS. B. 34b (not reproduced here).

B. by a square with 3 niches:

MS. B. 11b (see Pl. XCIV, No. 3).

C. by octagonal chapels:

a) MS. B, 21a; Pl. LXXXVIII, No. 4.

b) No. 2 on the same plate. Underneath there is the remark:_"quest'e come le 8 cappele ano a essere facte" _(this is how the eight chapels are to be executed).

c) Pl. LXXXVIII, No. 5. Elevation to the plans on the same sheet, it is accompanied by the note:_"ciasscuno de' 9 tiburi no'uole - passare l'alteza - di - 2 - quadri" _(neither of the 9 domes must exceed the height of two squares).

d) Pl. LXXXVIII, No. 1. Inside of the same octagon. MS. B, 30a, and 34b; these are three repetitions of parts of the same plan with very slight variations.

D. by a circular chapel:

MS. B, 18a (see Fig. 1 on page 47) gives the plan of this arrangement in which the exterior is square on the ground floor with only four of the chapels projecting, as is explained in the next sketch.

Pl. LXXXIX, MS. B, 17b. Elevation to the preceding plan sketched on the opposite side of the sheet, and also marked A. It is accompanied by the following remark, indicating the theoretical character of these studies:_"questo - edifitio - anchora - starebbe - bene affarlo dalla linja - _a_ - _b_ - _c_ - _d_ - insu. _("This edifice would also produce a good effect if only the part above the lines_ a b, c d, _were executed").

Pl. LXXXIV, No. 11. The exterior has the form of an octagon, but the chapels project partly beyond it. On the left side of the sketch they appear larger than on the right side.

Pl. XC, No. 1, (MS. B, 25b); Repetition of Pl. LXXXIV, No. 11.

Pl. XC, No. 2. Elevation to the plan No. 1, and also to No. 6 of the same sheet._

_E. By chapels formed by four niches:

Pl. LXXXIV, No. 7 (the circular plan on the left below) shows this arrangement in which the central dome has become circular inside and might therefore be classed after this group. [Footnote 1: This plan and some others of this class remind us of the plan of the Mausoleum of Augustus as it is represented for instance by Durand. See_ Cab. des Estampes, Bibliotheque Nationale, Paris, Topographie de Rome, V, 6, 82..]

The sketch on the right hand side gives most likely the elevation for the last named plan.

F. By chapels of still richer combinations, which necessitate an octagon of larger dimensions:

Pl. XCI, No. 2 (MS. Ash. 11. 8b) [Footnote 2: The note accompanying this plan is given under No. 754.]; on this plan the chapels themselves appear to be central buildings formed like the first type of the third group. Pl. LXXXVIII, No. 3.

Pl. XCI, No. 2 above; the exterior of the preceding figure, particularly interesting on account of the alternation of apses and niches, the latter containing statues of a gigantic size, in proportion to the dimension of the niches.

b. Second Class.

Composite plans of this class are generally obtained by combining two types of the first class--the one worked out on the principal axes, the other on the diagonal ones.

MS. B. 22 shows an elementary combination, without any additions on the diagonal axes, but with the dimensions of the squares on the two principal axes exceeding those of the sides of the octagon.

In the drawing W. P. 5b (see page 44 Fig. 1) the exterior only of the edifice is octagonal, the interior being formed by a circular colonnade; round chapels are placed against the four sides of the principal axes.

The elevation, drawn on the same sheet (see page 47 Fig. 3), shows the whole arrangement which is closely related with the one on Pl. LXXXVI No. 1, 2.

MS. B. 21a shows:

a) four sides with rectangular chapels crowned by pediments Pl. LXXXVII No. 3 (plan and elevation);

b) four sides with square chapels crowned by octagonal domes. Pl. LXXXVII No. 4; the plan underneath.

MS. B. 18a shows a variation obtained by replacing the round chapels in the principal axes of the sketch MS. B. 18a by square ones, with an apse. Leonardo repeated both ideas for better comparison side by side, see page 47. Fig. 2.

Pl. LXXXIX (MS. B. 17b). Elevation for the preceding figure. The comparison of the drawing marked M with the plan on page 47 Fig. 2, bearing the same mark, and of the elevation on Pl. LXXXIX below (marked A) with the corresponding plan on page 47 is highly instructive, as illustrating the spirit in which Leonardo pursued these studies.

Pl. LXXXIV No. 12 shows the design Pl. LXXXVII No. 3 combined with apses, with the addition of round chapels on the diagonal sides.

Pl. LXXXIV No. 13 is a variation of the preceding sketch.

Pl. XC No. 3. MS. B. 25b. The round chapels of the preceding sketch are replaced by octagonal chapels, above which rise campaniles.

Pl. XC No. 4 is the elevation for the preceding plan.

Pl. XCII No. 1. (MS. B. 39b.); the plan below. On the principal as well as on the diagonal axes are diagonal chapels, but the latter are separated from the dome by semicircular recesses. The communication between these eight chapels forms a square aisle round the central dome.

Above this figure is the elevation, showing four campaniles on the angles. [Footnote 1: The note accompanying this drawing is reproduced under No. 753.]

Pl. LXXXIV No. 3. On the principal axes are square chapels with three niches; on the diagonals octagonal chapels with niches. Cod. Atl. 340b gives a somewhat similar arrangement.

MS. B. 30. The principal development is thrown on the diagonal axes by square chapels with three niches; on the principal axes are inner recesses communicating with outer ones.

The plan Pl. XCIII No. 2 (MS. B. 22) differs from this only in so far as the outer semicircles have become circular chapels, projecting from the external square as apses; one of them serves as the entrance by a semicircular portico.

The elevation is drawn on the left side of the plan.

MS. B. 19. A further development of MS. B. 18, by employing for the four principal chapels the type Pl. LXXXVIII No. 3, as we have already seen in Pl. XCI No. 2; the exterior presents two varieties.

a) The outer contour follows the inner. [Footnote 2: These chapels are here sketched in two different sizes; it is the smaller type

which is thus formed.]

b) It is semicircular.

Pl. LXXXVII No. 2 (MS. B. 18b) Elevation to the first variation MS. B. 19. If we were not certain that this sketch was by Leonardo, we might feel tempted to take it as a study by Bramante for St. Peter's at Rome. [Footnote 3: See_ Les projets primitifs Pl. 43._]

_MS. P. V. 39b. In the principal axes the chapels of MS. B. 19, and semicircular niches on the diagonals. The exterior of the whole edifice is also an octagon, concealing the form of the interior chapels, but with its angles on their axes.

Group V.

Suggested by San Lorenzo at Milan.

In MS. C. A. 266 IIb, 8I2b there is a plan almost identical with that of San Lorenzo. The diagonal sides of the irregular octagon are not indicated.

If it could be proved that the arches which, in the actual church, exist on these sides in the first story, were added in 1574 by Martimo Bassi, then this plan and the following section would be still nearer the original state of San Lorenzo than at present. A reproduction of this slightly sketched plan has not been possible. It may however be understood from Pl. LXXXVIII No. 3, by suppressing the four pillars corresponding to the apses.

Pl. LXXXVII No. 1 shows the section in elevation corresponding with the above-named plan. The recessed chapels are decorated with large shells in the halfdomes like the arrangement in San Lorenzo, but with proportions like those of Bramante's Sacristy of Santa Maria presso S. Satiro.

MS. C. A. 266; a sheet containing three views of exteriors of Domes. On the same sheet there is a plan similar to the one above-named but with uninterrupted aisles and with the addition of round chapels in the axes (compare Pl. XCVII No. 3 and page 44 Fig. 1), perhaps a reminiscence of the two chapels annexed to San Lorenzo.--Leonardo has here sketched the way of transforming this plan into a Latin cross by means of a nave with side aisles.

Pl. XCI No. 1. Plan showing a type deprived of aisles and comprised in a square building which is surrounded by a portico. It is accompanied by the following text: _

756.

This edifice is inhabited [accessible] below and above, like San Sepolcro, and it is the same above as below, except that the upper story has the dome _c d_; and the [Footnote: The church of San

Sepolcro at Milan, founded in 1030 and repeatedly rebuilt after the middle of the XVIth century, still stands over the crypt of the original structure.] lower has the dome _a b_, and when you enter into the crypt, you descend 10 steps, and when you mount into the upper you ascend 20 steps, which, with 1/3 braccio for each, make 10 braccia, and this is the height between one floor of the church and the other.

_Above the plan on the same sheet is a view of the exterior. By the aid of these two figures and the description, sections of the edifice may easily be reconstructed. But the section drawn on the left side of the building seems not to be in keeping with the same plan, notwithstanding the explanatory note written underneath it: "dentro il difitio di sopra" (interior of the edifice above)[Footnote 1: _The small inner dome corresponds to_ a b _on the plan--it rises from the lower church into the upper-- above, and larger, rises the dome_ c d. _The aisles above and below thus correspond_ (e di sopra come di sotto, salvoche etc.). _The only difference is, that in the section Leonardo has not taken the trouble to make the form octagonal, but has merely sketched circular lines in perspective._ J. P. R._].

_Before leaving this group, it is well to remark that the germ of it seems already indicated by the diagonal lines in the plans PI. LXXXV No. 11 and No. 7. We shall find another application of the same type to the Latin cross in PI. XCVII No. 3.

_2. Churches formed on the plan of a Latin cross.

We find among Leonardo's studies several sketches for churches on the plan of the Latin cross; we shall begin by describing them, and shall add a few observations.

A. Studies after existing Monuments.

PI. XCIV No. 2. (MS. B. 11b.) Plan of Santo Spirito at Florence, a basilica built after the designs of Brunellesco.--Leonardo has added the indication of a portico in front, either his own invention or the reproduction of a now lost design.

PI. XCV No. 2. Plan accompanied by the words: "A_ e santo sepolcro di milano di sopra"(A _is the upper church of S. Sepolcro at Milan); although since Leonardo's time considerably spoilt, it is still the same in plan.

The second plan with its note: "B_ e la sua parte socto tera" (B _is its subterranean part [the crypt]) still corresponds with the present state of this part of the church as I have ascertained by visiting the crypt with this plan. Excepting the addition of a few insignificant walls, the state of this interesting part of the church still conforms to Leonardo's sketch; but in the Vestibolo the two columns near the entrance of the winding stairs are absent.

B. Designs or Studies.

PL. XCV No. 1. Plan of a church evidently suggested by that of San Sepolcro at Milan. The central part has been added to on the principle of the second type of Group III. Leonardo has placed the "coro" (choir) in the centre.

PI. XCVI No. 2. In the plan the dome, as regards its interior, belongs to the First Class of Group IV, and may be grouped with the one in MS. B. 35a. The nave seems to be a development of the type represented in PI. XCV No. 2, B. by adding towers and two lateral porticos[Footnote 1: Already published in Les projets primitifs PI. XLIII.].

On the left is a view of the exterior of the preceding plan. It is accompanied by the following note:

757.

This building is inhabited below and above; the way up is by the campaniles, and in going up one has to use the platform, where the drums of the four domes are, and this platform has a parapet in front, and none of these domes communicate with the church, but they are quite separate.

PI. XCVI No. 1 (MS. C. A. 16b; 65a). Perspective view of a church seen from behind; this recalls the Duomo at Florence, but with two campaniles[Footnote 2: Already published in the Saggio PI. IX.].

PI. XCVII No. 3 (MS. B. 52a). The central part is a development of S. Lorenzo at Milan, such as was executed at the Duomo of Pavia. There is sufficient analogy between the building actually executed and this sketch to suggest a direct connection between them. Leonardo accompanied Francesco di Giorgio[Footnote 3: See MALASPINA, *il Duomo di Pavia. Documents.*] when the latter was consulted on June 21st, 1490 as to this church; the fact that the only word accompanying the plan is "sagrestia", seems to confirm our supposition, for the sacristies were added only in 1492, i. e. four years after the beginning of the Cathedral, which at that time was most likely still sufficiently unfinished to be capable of receiving the form of the present sketch.

PI. XCVII No. 2 shows the exterior of this design. Below is the note: edifitio al proposito del fodameto figurato di sotto (edifice proper for the ground plan figured below).

Here we may also mention the plan of a Latin cross drawn in MS. C. A. fol. 266 (see p. 50).

PI. XCIV No. 1 (MS. L. 15b). External side view of Brunellesco's Florentine basilica San Lorenzo, seen from the North.

PI. XCIV No. 4 (V. A. V, 1). Principal front of a nave, most likely

of a church on the plan of a Latin cross. We notice here not only the principal features which were employed afterwards in Alberti's front of S. Maria Novella, but even details of a more advanced style, such as we are accustomed to meet with only after the year 1520.

In the background of Leonardo's unfinished picture of St. Jerome (Vatican Gallery) a somewhat similar church front is indicated (see the accompanying sketch).

[Illustration with caption: The view of the front of a temple, apparently a dome in the centre of four corinthian porticos bearing pediments (published by Amoretti Tav. II. B as being by Leonardo), is taken from a drawing, now at the Ambrosian Gallery. We cannot consider this to be by the hand of the master.]

_C. Studies for a form of a Church most proper for preaching.

The problem as to what form of church might answer the requirements of acoustics seems to have engaged Leonardo's very particular attention. The designation of "teatro" given to some of these sketches, clearly shows which plan seemed to him most favourable for hearing the preacher's voice.

Pl. XCVII, No. 1 (MS. B, 52). Rectangular edifice divided into three naves with an apse on either side, terminated by a semicircular theatre with rising seats, as in antique buildings. The pulpit is in the centre. Leonardo has written on the left side of the sketch: "teatro da predicare" (Theatre for preaching).

MS. B, 55a (see page 56, Fig. 1). A domed church after the type of Pl. XCV, No. 1, shows four theatres occupying the apses and facing the square "coro" (choir), which is in the centre between the four pillars of the dome. [Footnote 1: The note teatro de predicar, on the right side is, I believe, in the handwriting of Pompeo Leoni. J. P. R.] The rising arrangement of the seats is shown in the sketch above. At the place marked B Leonardo wrote teatri per uldire messa (rows of seats to hear mass), at T teatri, and at C coro (choir).

In MS. C.A. 260, are slight sketches of two plans for rectangular choirs and two elevations of the altar and pulpit which seem to be in connection with these plans.

In MS. Ash II, 8a (see p. 56 and 57, Fig. 2 and 3). "Locho dove si predica" (Place for preaching). A most singular plan for a building. The interior is a portion of a sphere, the centre of which is the summit of a column destined to serve as the preacher's pulpit. The inside is somewhat like a modern theatre, whilst the exterior and the galleries and stairs recall the ancient amphitheatres.

[Illustration with caption: Page 57, Fig. 4. A plan accompanying the

two preceding drawings. If this gives the complete form Leonardo intended for the edifice, it would have comprised only about two thirds of the circle. Leonardo wrote in the centre_ "fondamento", _a word he often employed for plans, and on the left side of the view of the exterior: _ locho dove si predicha _(a place for preaching in)._]

_D. Design for a Mausoleum.

Pl. XCVIII (P. V., 182._ No. d'ordre 2386). In the midst of a hilly landscape rises an artificial mountain in the form of a gigantic cone, crowned by an imposing temple. At two thirds of the height a terrace is cut out with six doorways forming entrances to galleries, each leading to three sepulchral halls, so constructed as to contain about five hundred funeral urns, disposed in the customary antique style. From two opposite sides steps ascend to the terrace in a single flight and beyond it to the temple above. A large circular opening, like that in the Pantheon, is in the dome above what may be the altar, or perhaps the central monument on the level of the terrace below.

The section of a gallery given in the sketch to the right below shows the roof to be constructed on the principle of superimposed horizontal layers, projecting one beyond the other, and each furnished with a sort of heel, which appears to be undercut, so as to give the appearance of a beam from within. Granite alone would be adequate to the dimensions here given to the key stone, as the thickness of the layers can hardly be considered to be less than a foot. In taking this as the basis of our calculation for the dimensions of the whole construction, the width of the chamber would be about 25 feet but, judging from the number of urns it contains--and there is no reason to suppose that these urns were larger than usual--it would seem to be no more than about 8 or 10 feet.

The construction of the vaults resembles those in the galleries of some etruscan tumuli, for instance the Regulini Galeassi tomb at Cervetri (lately discovered) and also that of the chamber and passages of the pyramid of Cheops and of the treasury of Atreus at Mycenae.

The upper cone displays not only analogies with the monuments mentioned in the note, but also with Etruscan tumuli, such as the Cocumella tomb at Vulci, and the Regulini Galeassi tomb_[Footnote 1: _See_ FERSGUSON, _Handbook of Architecture, I, 291.]. _The whole scheme is one of the most magnificent in the history of Architecture.

It would be difficult to decide as to whether any monument he had seen suggested this idea to Leonardo, but it is worth while to enquire, if any monument, or group of monuments of an earlier date may be supposed to have done so._[Footnote 2: _There are, in Algiers, two Monuments, commonly called_ "Le Madracen" _and_ "Le

tombeau de la Chretienne," _which somewhat resemble Leonardo's design. They are known to have served as the Mausolea of the Kings of Mauritania. Pomponius Mela, the geographer of the time of the Emperor Claudius, describes them as having been_ "Monumentum commune regiae gentis." _See_ Le Madracen, Rapport fait par M. le Grand Rabbin AB. CAHEN, Constantine 1873--Memoire sur les fouilles executees au Madras'en .. par le Colonel BRUNON, Constantine 1873.--Deux Mausolees Africains, le Madracen et le tombeau de la Chretienne par M. J. DE LAURIERE, Tours 1874.--Le tombeau de la Chretienne, Mausolee des rois Mauritanien par M. BERBRUGGER, Alger 1867.--_I am indebted to M. LE BLANC, of the Institut, and M. LUD, LALANNE, Bibliothecaire of the Institut for having first pointed out to me the resemblance between these monuments; while M. ANT. HERON DE VILLEFOSSE of the Louvre was kind enough to place the abovementioned rare works at my disposal. Leonardo's observations on the coast of Africa are given later in this work. The Herodium near Bethlehem in Palestine_ (Jebel el Fureidis, _the Frank Mountain) was, according to the latest researches, constructed on a very similar plan. See_ Der Frankenberg, von Baurath C. SCHICK in Jerusalem, Zeitschrift des Deutschen Palastina-Vereins, _Leipzig_ 1880, _Vol. III, pages_ 88-99 _and Plates IV and V._ J. P. R.]

_E. Studies for the Central Tower, or Tiburio of Milan Cathedral.

Towards the end of the fifteenth century the Fabbricceria del Duomo had to settle on the choice of a model for the crowning and central part of this vast building. We learn from a notice published by G. L. Calvi [Footnote: G. L. CALVI, Notizie sulla vita e sulle opere dei principali architetti scultori e pittori che fiorirono in Milano, Part III, 20. See also: H. DE GEYMULLER, Les projets primitifs etc. I, 37 and 116-119.--The Fabbricceria of the Duomo has lately begun the publication of the archives, which may possibly tell us more about the part taken by Leonardo, than has hitherto been known.] that among the artists who presented models in the year 1488 were: Bramante, Pietro da Gorgonzola, Luca Paperio (Fancelli), and Leonardo da Vinci.--

Several sketches by Leonardo refer to this important project:

Pl. XCIX, No. 2 (MS. S. K. III, No. 36a) a small plan of the whole edifice.--The projecting chapels in the middle of the transept are wanting here. The nave appears to be shortened and seems to be approached by an inner "vestibolo".--

Pl. C, No. 2 (Tr. 21). Plan of the octagon tower, giving the disposition of the buttresses; starting from the eight pillars adjoining the four principal piers and intended to support the eight angles of the Tiburio. These buttresses correspond exactly with those described by Bramante as existing in the model presented by Omodeo. [Footnote: Bramante's opinion was first published by G. MONGERI, Arch. stor. Lomb. V, fasc. 3 and afterwards by me in the publication mentioned in the preceding note.]

Pl. C, 3 (MS. Tr. 16). Two plans showing different arrangements of the buttresses, which seem to be formed partly by the intersection of a system of pointed arches such as that seen in **

Pl. C, No. 5 (MS. B, 27a) destined to give a broader base to the drum. The text underneath is given under No. 788.

MS. B, 3--three slight sketches of plans in connexion with the preceding ones._

Pl. XCIX, No.1 (MS. Tr. 15) contains several small sketches of sections and exterior views of the Dome; some of them show buttress-walls shaped as inverted arches. Respecting these Leonardo notes:

758.

L'arco rivescio e migliore per fare spalla che l'ordinario, perche il rovescio trova sotto se muro resistete alla sua debolezza, e l'ordinario no trova nel suo debole se non aria

The inverted arch is better for giving a shoulder than the ordinary one, because the former finds below it a wall resisting its weakness, whilst the latter finds in its weak part nothing but air.

[Footnote: _Three slight sketches of sections on the same leaf--above those reproduced here--are more closely connected with the large drawing in the centre of Pl. C, No. 4 (M.S, Tr. 41) which shows a section of a very elevated dome, with double vaults, connected by ribs and buttresses ingeniously disposed, so as to bring the weight of the lantern to bear on the base of the dome.

A sketch underneath it shows a round pillar on which is indicated which part of its summit is to bear the weight: "il pilastro sara charicho in . a . b." (The column will bear the weight at a b.) Another note is above on the right side:_ L'arco regiera tanto sotto asse chome di sopra se _(The arch supports as much below it [i. e. a hanging weight] as above it).

Pl. C, No. 1 (C. A. 303a). Larger sketch of half section of the Dome, with a very complicated system of arches, and a double vault. Each stone is shaped so as to be knit or dovetailed to its neighbours. Thus the inside of the Dome cannot be seen from below.

MS. C. A. 303b. A repetition of the preceding sketch with very slight modifications._]

[Figs. 1. and Fig. 2. two sketeches of the dome]

MS. Tr. 9 (see Fig. 1 and 2). Section of the Dome with reverted buttresses between the windows, above which iron anchors or chains seem to be intended. Below is the sketch of the outside._

_Pl. XCIX, No. 3 (C. A., 262a) four sketches of the exterior of the Dome.

C. A. 12. Section, showing the points of rupture of a gothic vault, in evident connection with the sketches described above.

It deserves to be noticed how easily and apparently without effort, Leonardo manages to combine gothic details and structure with the more modern shape of the Dome.

The following notes are on the same leaf, _oni cosa poderosa, _and_ _oni cosa poderosa desidera de(scendere); _farther below, several multiplications most likely intended to calculate the weight of some parts of the Dome, thus $16 \times 47 = 720$; $720 \times 800 = 176000$, next to which is written: _peso del pilastro di 9 teste _ (weight of the pillar 9 diameters high).

Below: $176000 \times 8 = 1408000$; _and below:_

Semjlio e se ce 80 (?) il peso del tiburio _ (six millions six hundred (?) 80 the weight of the Dome).

Bossi hazarded the theory that Leonardo might have been the architect who built the church of Sta. Maria delle Grazie, but there is no evidence to support this, either in documents or in the materials supplied by Leonardos manuscripts and drawings. The sketch given at the side shows the arrangement of the second and third socle on the apses of the choir of that church; and it is remarkable that those sketches, in MS. S. K. M. II2, 2a and Ib, occur with the passage given in Volume I as No. 665 and 666 referring to the composition of the Last Supper in the Refectory of that church. _]

_F. The Project for lifting up the Battistero of Florence and setting it on a basement. _

_Among the very few details Vasari gives as to the architectural studies of Leonardo, we read: "And among these models and designs there was one by way of which he showed several times to many ingenious citizens who then governed Florence, his readiness to lift up without ruining it, the church of San Giovanni in Florence (the Battistero, opposite the Duomo) in order to place under it the missing basement with steps; he supported his assertions with reasons so persuasive, that while he spoke the undertaking seemed feasible, although every one of his hearers, when he had departed, could see by himself the impossibility of so vast an undertaking." _

[Footnote: _This latter statement of Vasari's must be considered to be exaggerated. I may refer here to some data given by_ LIBRI, Histoire des sciences mathematiques en Italie (II, 216, 217): "On a cru dans ces derniers temps faire un miracle en mecanique en effectuant ce transport, et cependant des l'annee 1455, Gaspard Nadi et Aristote de Fioravantio avaient transporte, a une distance considerable, la tour de la Magione de Bologne, avec ses fondements,

qui avait presque quatre-vingts pieds de haut. Le continuateur de la chronique de Pugliola dit que le trajet fut de 35 pieds et que durant le transport auquel le chroniqueur affirme avoir assiste, il arriva un accident grave qui fit pencher de trois pieds la tour pendant qu'elle etait suspendue, mais que cet accident fut promptement repare (Muratori, *Scriptores rer. ital.* Tom. XVIII, col. 717, 718). Alidosi a raporte une note ou Nadi rend compte de ce transport avec une rare simplicité. D'apres cette note, on voit que les operations de ce genre n'étaient pas nouvelles. Celle-ci ne couta que 150 livres (monnaie d'alors) y compris le cadeau que le Legat fit aux deux mecaniciens. Dans la meme annee, Aristote redressa le clocher de Cento, qui penchait de plus de cinq pieds (Alidosi, *instruttione* p. 188-- Muratori, *Scriptores rer. ital.*, tom. XXIII, col. 888.--Bossii, *chronica Mediol.*, 1492, in-fol. ad ann. 1455). On ne concoit pas comment les historiens des beaux-arts ont pu negliger de tels hommes." J. P. R.]

In the MS. C. A. fol. 293, there are two sketches which possibly might have a bearing on this bold enterprise. We find there a plan of a circular or polygonal edifice surrounded by semicircular arches in an oblique position. These may be taken for the foundation of the steps and of the new platform. In the perspective elevation the same edifice, forming a polygon, is shown as lifted up and resting on a circle of inverted arches which rest on an other circle of arches in the ordinary position, but so placed that the inverted arches above rest on the spandrels of the lower range.

What seems to confirm the supposition that the lifting up of a building is here in question, is the indication of engines for winding up, such as jacks, and a rack and wheel. As the lifting apparatus represented on this sheet does not seem particularly applicable to an undertaking of such magnitude, we may consider it to be a first sketch or scheme for the engines to be used.

G. Description of an unknown Temple.

759.

Twelve flights of steps led up to the great temple, which was eight hundred braccia in circumference and built on an octagonal plan. At the eight corners were eight large plinths, one braccia and a half high, and three wide, and six long at the bottom, with an angle in the middle; on these were eight great pillars, standing on the plinths as a foundation, and twenty four braccia high. And on the top of these were eight capitals three braccia long and six wide, above which were the architrave frieze and cornice, four braccia and a half high, and this was carried on in a straight line from one pillar to the next and so, continuing for eight hundred braccia, surrounded the whole temple, from pillar to pillar. To support this entablature there were ten large columns of the same height as the pillars, three braccia thick above their bases which were one braccia and a half high.

The ascent to this temple was by twelve flights of steps, and the temple was on the twelfth, of an octagonal form, and at each angle rose a large pillar; and between the pillars were placed ten columns of the same height as the pillars, rising at once from the pavement to a height of twenty eight braccia and a half; and at this height the architrave, frieze and cornice were placed which surrounded the temple having a length of eight hundred braccia. At the same height, and within the temple at the same level, and all round the centre of the temple at a distance of 24 braccia farther in, are pillars corresponding to the eight pillars in the angles, and columns corresponding to those placed in the outer spaces. These rise to the same height as the former ones, and over these the continuous architrave returns towards the outer row of pillars and columns.

[Footnote: Either this description is incomplete, or, as seems to me highly probable, it refers to some ruin. The enormous dimensions forbid our supposing this to be any temple in Italy or Greece. Syria was the native land of colossal octagonal buildings, in the early centuries A. D. The Temple of Baalbek, and others are even larger than that here described. J. P. R.]

_V. Palace architecture.

But a small number of Leonardo's drawings refer to the architecture of palaces, and our knowledge is small as to what style Leonardo might have adopted for such buildings.

Pl. CII No. 1 (W. XVIII). A small portion of a facade of a palace in two stories, somewhat resembling Alberti's Palazzo Rucellai.--Compare with this Bramante's painted front of the Casa Silvestri, and a painting by Montorfano in San Pietro in Gessate at Milan, third chapel on the left hand side and also with Bramante's palaces at Rome. The pilasters with arabesques, the rustica between them, and the figures over the window may be painted or in sgraffito. The original is drawn in red chalk.

Pl. LXXXI No. 1 (MS. Tr. 42). Sketch of a palace with battlements and decorations, most likely graffiti; the details remind us of those in the Castello at Vigevano. [Footnote 1: _Count GIULIO PORRO, in his valuable contribution to the _ Archivio Storico Lombardo, Anno VIII, Fasc. IV (31 Dec. 1881): Leonardo da Vinci, Libro di Annotazioni e Memorie, _refers to this in the following note: _ "Alla pag. 41 vi e uno schizzo di volta ed accanto scrisse: "il pilastro sara charicho in su 6' e potrebbe darsi che si riferisse alla cupola della chiesa delle Grazie tanto piu che a pag. 42 vi e un disegno che rassomiglia assai al basamento che oggi si vede nella parte esterna del coro di quella chiesa." _This may however be doubted. The drawing, here referred to, on page 41 of the same manuscript, is reproduced on Pl. C No. 4 and described on page 61 as being a study for the cupola of the Duomo of Milan. _ J. P. R.]

_MS. Mz. 0", contains a design for a palace or house with a loggia in the middle of the first story, over which rises an attic with a

Pediment reproduced on page 67. The details drawn close by on the left seem to indicate an arrangement of coupled columns against the wall of a first story.

Pl. LXXXV No. 14 (MS. S. K. M. III 79a) contains a very slight sketch in red chalk, which most probably is intended to represent the facade of a palace. Inside is the short note *7 he 7 (7 and 7)*._{_}

{}MS. J2 8a (see pages 68 Fig. 1 and 2) contains a view of an unknown palace. Its plan is indicated at the side._{_}

{}In MS. Br. M. 126a(see Fig. 3 on page 68) there is a sketch of a house, on which Leonardo notes; *casa con tre terrazi* (house with three terraces)._{_}

{}Pl. CX, No. 4 (MS. L. 36b) represents the front of a fortified building drawn at Cesena in 1502 (see No. 1040)._{_}

{}Here we may also mention the singular building in the allegorical composition represented on Pl. LVIII in Vol. I. In front of it appears the head of a sphinx or of a dragon which seems to be carrying the palace away._{_}

{}The following texts refer to the construction of palaces and other buildings destined for private use:_{_}

760.

In the courtyard the walls must be half the height of its width, that is if the court be 40 braccia, the house must be 20 high as regards the walls of the said courtyard; and this courtyard must be half as wide as the whole front.

[Footnote: See Pl. CI, no. 1, and compare the dimensions here given, with No. 748 lines 26-29; and the drawing belonging to it Pl. LXXXI, no. 2.]

On the dispositions of a stable.

761.

FOR MAKING A CLEAN STABLE.

The manner in which one must arrange a stable. You must first divide its width in 3 parts, its depth matters not; and let these 3 divisions be equal and 6 braccia broad for each part and 10 high, and the middle part shall be for the use of the stablemasters; the 2 side ones for the horses, each of which must be 6 braccia in width and 6 in length, and be half a braccio higher at the head than behind. Let the manger be at 2 braccia from the ground, to the bottom of the rack, 3 braccia, and the top of it 4 braccia. Now, in order to attain to what I promise, that is to make this place, contrary to the general custom, clean and neat: as to the upper part

of the stable, i. e. where the hay is, that part must have at its outer end a window 6 braccia high and 6 broad, through which by simple means the hay is brought up to the loft, as is shown by the machine _E_; and let this be erected in a place 6 braccia wide, and as long as the stable, as seen at _k p_. The other two parts, which are on either side of this, are again divided; those nearest to the hay-loft are 4 braccia, _p s_, and only for the use and circulation of the servants belonging to the stable; the other two which reach to the outer walls are 2 braccia, as seen at _s k_, and these are made for the purpose of giving hay to the mangers, by means of funnels, narrow at the top and wide over the manger, in order that the hay should not choke them. They must be well plastered and clean and are represented at 4 _f s_. As to the giving the horses water, the troughs must be of stone and above them [cisterns of] water. The mangers may be opened as boxes are uncovered by raising the lids. [Footnote: See Pl. LXXVIII, No.1.]

Decorations for feasts.

762.

THE WAY TO CONSTRUCT A FRAME-WORK FOR DECORATING BUILDINGS.

The way in which the poles ought to be placed for tying bunches of juniper on to them. These poles must lie close to the framework of the vaulting and tie the bunches on with osier withes, so as to clip them even afterwards with shears.

Let the distance from one circle to another be half a braccia; and the juniper [sprigs] must lie top downwards, beginning from below.

Round this column tie four poles to which willows about as thick as a finger must be nailed and then begin from the bottom and work upwards with bunches of juniper sprigs, the tops downwards, that is upside down. [Footnote: See Pl. CII, No. 3. The words here given as the title line, lines 1--4, are the last in the original MS.--Lines 5--16 are written under fig. 4.]

763.

The water should be allowed to fall from the whole circle _a b_. [Footnote: Other drawings of fountains are given on Pl. CI (W. XX); the original is a pen and ink drawing on blue paper; on Pl. CIII (MS. B.) and Pl. LXXXII.]

VI. Studies of architectural details.

_Several of Leonardo's drawings of architectural details prove that, like other great masters of that period, he had devoted his attention to the study of the proportion of such details. As every organic being in nature has its law of construction and growth, these masters endeavoured, each in his way, to discover and prove a law of proportion in architecture. The following notes in Leonardo's

manuscripts refer to this subject.

MS. S. K. M. III, 47b (see Fig. 1). A diagram, indicating the rules as given by Vitruvius and by Leon Battista Alberti for the proportions of the Attic base of a column.

MS. S. K. M. III 55a (see Fig. 2). Diagram showing the same rules.

764.

B toro superiore toro superiore
2B nestroli astragali quadre
3B orbiculo troclea
4B nestroli astragali quadre
5B toro iferiore toro iferiore
6B latastro plintho

[Footnote: No explanation can be offered of the meaning of the letter B, which precedes each name. It may be meant for *_basa_* (base). Perhaps it refers to some author on architecture or an architect (Bramante?) who employed the designations, thus marked for the mouldings. 3. *_troclea_* Philander: *_Trochlea sive trochalia aut rechanum_*. 6. *_Laterculus_* or *_latastrum_* is the Latin name for *_Plinthus_* (π lambda Xiv) but Vitruvius adopted this Greek name and "latastro" seems to have been little in use. It is to be found besides the text given above, as far as I am aware, only two drawings of the Uffizi Collection, where in one instance, it indicates the *_abacus_* of a Doric capital.]

765.

STEPS OF URBINO.

The plinth must be as broad as the thickness of the wall against which the plinth is built. [Footnote: See Pl. CX No. 3. The hasty sketch on the right hand side illustrates the unsatisfactory effect produced when the plinth is narrower than the wall.]

766.

The ancient architects beginning with the Egyptians (?) who, as Diodorus Siculus writes, were the first to build and construct large cities and castles, public and private buildings of fine form, large and well proportioned

The column, which has its thickness at the third part The one which would be thinnest in the middle, would break ...; the one which is of equal thickness and of equal strength, is better for the edifice. The second best as to the usefulness will be the one whose greatest thickness is where it joins with the base.

[Footnote: See Pl. CIII, No. 3, where the sketches belonging to lines 10--16 are reproduced, but reversed. The sketch of columns,

There they appear coupled, and in two stories one above the other. The archivolls which seem to spring out of the columns, are shaped like twisted cords, meant perhaps to be twisted branches. The walls between the columns seem to be formed out of blocks of wood, the pedestals are ornamented with a reticulated pattern. From all this we may suppose that Leonardo here had in mind either some festive decoration, or perhaps a pavilion for some hunting place or park. The sketch of columns marked "35" gives an example of columns shaped like candelabra, a form often employed at that time, particularly in Milan, and the surrounding districts for instance in the Cortile di Casa Castiglione now Silvestre, in the cathedral of Como, at Porta della Rana &c._

769.

CONCERNING ARCHITRAVES OF ONE OR SEVERAL PIECES.

An architrave of several pieces is stronger than that of one single piece, if those pieces are placed with their length in the direction of the centre of the world. This is proved because stones have their grain or fibre generated in the contrary direction i. e. in the direction of the opposite horizons of the hemisphere, and this is contrary to fibres of the plants which have ...

[Footnote: The text is incomplete in the original.]

_The Proportions of the stories of a building are indicated by a sketch in MS. S. K. M. II2 11b (see Pl. LXXXV No. 15). The measures are written on the left side, as follows: br 1 1/2--6 3/4--br 1/12--2 br--9 e 1/2--1 1/2--br 5--o 9--o 3 [br=braccia; o=oncie].

Pl. LXXXV No. 13 (MS. B. 62a) and Pl. XCIII No. 1. (MS. B. 15a) give a few examples of arches supported on piers._

_XIII.

Theoretical writings on Architecture.

Leonardo's original writings on the theory of Architecture have come down to us only in a fragmentary state; still, there seems to be no doubt that he himself did not complete them. It would seem that Leonardo entertained the idea of writing a large and connected book on Architecture; and it is quite evident that the materials we possess, which can be proved to have been written at different periods, were noted down with a more or less definite aim and purpose. They might all be collected under the one title: "Studies on the Strength of Materials". Among them the investigations on the subject of fissures in walls are particularly thorough, and very fully reported; these passages are also especially interesting, because Leonardo was certainly the first writer on architecture who ever treated the subject at all. Here, as in all other cases Leonardo carefully avoids all abstract argument. His data are not derived from the principles of algebra, but from the laws of

mechanics, and his method throughout is strictly experimental.

Though the conclusions drawn from his investigations may not have that precision which we are accustomed to find in Leonardo's scientific labours, their interest is not lessened. They prove at any rate his deep sagacity and wonderfully clear mind. No one perhaps, who has studied these questions since Leonardo, has combined with a scientific mind anything like the artistic delicacy of perception which gives interest and lucidity to his observations.

I do not assert that the arrangement here adopted for the passages in question is that originally intended by Leonardo; but their distribution into five groups was suggested by the titles, or headings, which Leonardo himself prefixed to most of these notes. Some of the longer sections perhaps should not, to be in strict agreement with this division, have been reproduced in their entirety in the place where they occur. But the comparatively small amount of the materials we possess will render them, even so, sufficiently intelligible to the reader; it did not therefore seem necessary or desirable to subdivide the passages merely for the sake of strict classification._

The small number of chapters given under the fifth class, treating on the centre of gravity in roof-beams, bears no proportion to the number of drawings and studies which refer to the same subject. Only a small selection of these are reproduced in this work since the majority have no explanatory text.

I.

ON FISSURES IN WALLS.

770.

First write the treatise on the causes of the giving way of walls and then, separately, treat of the remedies.

Parallel fissures constantly occur in buildings which are erected on a hill side, when the hill is composed of stratified rocks with an oblique stratification, because water and other moisture often penetrates these oblique seams carrying in greasy and slippery soil; and as the strata are not continuous down to the bottom of the valley, the rocks slide in the direction of the slope, and the motion does not cease till they have reached the bottom of the valley, carrying with them, as though in a boat, that portion of the building which is separated by them from the rest. The remedy for this is always to build thick piers under the wall which is slipping, with arches from one to another, and with a good scarp and let the piers have a firm foundation in the strata so that they may not break away from them.

In order to find the solid part of these strata, it is necessary to make a shaft at the foot of the wall of great depth through the

strata; and in this shaft, on the side from which the hill slopes, smooth and flatten a space one palm wide from the top to the bottom; and after some time this smooth portion made on the side of the shaft, will show plainly which part of the hill is moving.

[Footnote: See Pl. CIV.]

771.

The cracks in walls will never be parallel unless the part of the wall that separates from the remainder does not slip down.

WHAT IS THE LAW BY WHICH BUILDINGS HAVE STABILITY.

The stability of buildings is the result of the contrary law to the two former cases. That is to say that the walls must be all built up equally, and by degrees, to equal heights all round the building, and the whole thickness at once, whatever kind of walls they may be. And although a thin wall dries more quickly than a thick one it will not necessarily give way under the added weight day by day and thus, [16] although a thin wall dries more quickly than a thick one, it will not give way under the weight which the latter may acquire from day to day. Because if double the amount of it dries in one day, one of double the thickness will dry in two days or thereabouts; thus the small addition of weight will be balanced by the smaller difference of time [18].

The adversary says that a which projects, slips down.

And here the adversary says that r slips and not c.

HOW TO PROGNOSTICATE THE CAUSES OF CRACKS IN ANY SORT OF WALL.

The part of the wall which does not slip is that in which the obliquity projects and overhangs the portion which has parted from it and slipped down.

ON THE SITUATION OF FOUNDATIONS AND IN WHAT PLACES THEY ARE A CAUSE OF RUIN.

When the crevice in the wall is wider at the top than at the bottom, it is a manifest sign, that the cause of the fissure in the wall is remote from the perpendicular line through the crevice.

[Footnote: Lines 1-5 refer to Pl. CV, No. 2. Line 9 alle due anteciedete, see on the same page.

Lines 16-18. The translation of this is doubtful, and the meaning in any case very obscure.

Lines 19-23 are on the right hand margin close to the two sketches on Pl. CII, No. 3.]

772.

OF CRACKS IN WALLS, WHICH ARE WIDE AT THE BOTTOM AND NARROW AT THE TOP AND OF THEIR CAUSES.

That wall which does not dry uniformly in an equal time, always cracks.

A wall though of equal thickness will not dry with equal quickness if it is not everywhere in contact with the same medium. Thus, if one side of a wall were in contact with a damp slope and the other were in contact with the air, then this latter side would remain of the same size as before; that side which dries in the air will shrink or diminish and the side which is kept damp will not dry. And the dry portion will break away readily from the damp portion because the damp part not shrinking in the same proportion does not cohere and follow the movement of the part which dries continuously.

OF ARCHED CRACKS, WIDE AT THE TOP, AND NARROW BELOW.

Arched cracks, wide at the top and narrow below are found in walled-up doors, which shrink more in their height than in their breadth, and in proportion as their height is greater than their width, and as the joints of the mortar are more numerous in the height than in the width.

The crack diminishes less in r o than in m n, in proportion as there is less material between r and o than between n and m.

Any crack made in a concave wall is wide below and narrow at the top; and this originates, as is here shown at b c d, in the side figure.

1. That which gets wet increases in proportion to the moisture it imbibes.

2. And a wet object shrinks, while drying, in proportion to the amount of moisture which evaporates from it.

[Footnote: The text of this passage is reproduced in facsimile on Pl. CVI to the left. L. 36-40 are written inside the sketch No. 2. L. 41-46 are partly written over the sketch No. 3 to which they refer.]

773.

OF THE CAUSES OF FISSURES IN [THE WALLS OF] PUBLIC AND PRIVATE BUILDINGS.

The walls give way in cracks, some of which are more or less vertical and others are oblique. The cracks which are in a vertical direction are caused by the joining of new walls, with old walls, whether straight or with indentations fitting on to those of the old

wall; for, as these indentations cannot bear the too great weight of the wall added on to them, it is inevitable that they should break, and give way to the settling of the new wall, which will shrink one braccia in every ten, more or less, according to the greater or smaller quantity of mortar used between the stones of the masonry, and whether this mortar is more or less liquid. And observe, that the walls should always be built first and then faced with the stones intended to face them. For, if you do not proceed thus, since the wall settles more than the stone facing, the projections left on the sides of the wall must inevitably give way; because the stones used for facing the wall being larger than those over which they are laid, they will necessarily have less mortar laid between the joints, and consequently they settle less; and this cannot happen if the facing is added after the wall is dry.

a b the new wall, _c_ the old wall, which has already settled; and the part _a b_ settles afterwards, although _a_, being founded on _c_, the old wall, cannot possibly break, having a stable foundation on the old wall. But only the remainder _b_ of the new wall will break away, because it is built from top to bottom of the building; and the remainder of the new wall will overhang the gap above the wall that has sunk.

774.

A new tower founded partly on old masonry.

775.

OF STONES WHICH DISJOIN THEMSELVES FROM THEIR MORTAR.

Stones laid in regular courses from bottom to top and built up with an equal quantity of mortar settle equally throughout, when the moisture that made the mortar soft evaporates.

By what is said above it is proved that the small extent of the new wall between _A_ and _n_ will settle but little, in proportion to the extent of the same wall between _c_ and _d_. The proportion will in fact be that of the thinness of the mortar in relation to the number of courses or to the quantity of mortar laid between the stones above the different levels of the old wall.

[Footnote: See Pl. CV, No. 1. The top of the tower is wanting in this reproduction, and with it the letter _n_ which, in the original, stands above the letter _A_ over the top of the tower, while _c_ stands perpendicularly over _d_.]

776.

This wall will break under the arch _e f_, because the seven whole square bricks are not sufficient to sustain the spring of the arch placed on them. And these seven bricks will give way in their middle exactly as appears in _a b_. The reason is, that the brick _a_ has

above it only the weight ak , whilst the last brick under the arch has above it the weight $cdx a$.

cd seems to press on the arch towards the abutment at the point p but the weight po opposes resistance to it, whence the whole pressure is transmitted to the root of the arch. Therefore the foot of the arch acts like 76, which is more than double of xz .

II.

ON FISSURES IN NICHES.

777.

ON FISSURES IN NICHES.

An arch constructed on a semicircle and bearing weights on the two opposite thirds of its curve will give way at five points of the curve. To prove this let the weights be at nm which will break the arch ab, bf . I say that, by the foregoing, as the extremities c and a are equally pressed upon by the thrust n , it follows, by the 5th, that the arch will give way at the point which is furthest from the two forces acting on them and that is the middle e . The same is to be understood of the opposite curve, $dg b$; hence the weights nm must sink, but they cannot sink by the 7th, without coming closer together, and they cannot come together unless the extremities of the arch between them come closer, and if these draw together the crown of the arch must break; and thus the arch will give way in two places as was at first said &c.

I ask, given a weight at a what counteracts it in the direction nf and by what weight must the weight at f be counteracted.

778.

ON THE SHRINKING OF DAMP BODIES OF DIFFERENT THICKNESS AND WIDTH.

The window a is the cause of the crack at b ; and this crack is increased by the pressure of n and m which sink or penetrate into the soil in which foundations are built more than the lighter portion at b . Besides, the old foundation under b has already settled, and this the piers n and m have not yet done. Hence the part b does not settle down perpendicularly; on the contrary, it is thrown outwards obliquely, and it cannot on the contrary be thrown inwards, because a portion like this, separated from the main wall, is larger outside than inside and the main wall, where it is broken, is of the same shape and is also larger outside than inside; therefore, if this separate portion were to fall inwards the larger would have to pass through the smaller--which is impossible. Hence it is evident that the portion of the semicircular wall when disunited from the main wall will be thrust outwards, and not inwards as the adversary says.

When a dome or a half-dome is crushed from above by an excess of weight the vault will give way, forming a crack which diminishes towards the top and is wide below, narrow on the inner side and wide outside; as is the case with the outer husk of a pomegranate, divided into many parts lengthwise; for the more it is pressed in the direction of its length, that part of the joints will open most, which is most distant from the cause of the pressure; and for that reason the arches of the vaults of any apse should never be more loaded than the arches of the principal building. Because that which weighs most, presses most on the parts below, and they sink into the foundations; but this cannot happen to lighter structures like the said apses.

[Footnote: The figure on Pl. CV, No. 4 belongs to the first paragraph of this passage, lines 1-14; fig. 5 is sketched by the side of lines 15--and following. The sketch below of a pomegranate refers to line 22. The drawing fig. 6 is, in the original, over line 37 and fig. 7 over line 54.]

Which of these two cubes will shrink the more uniformly: the cube _A_ resting on the pavement, or the cube _b_ suspended in the air, when both cubes are equal in weight and bulk, and of clay mixed with equal quantities of water?

The cube placed on the pavement diminishes more in height than in breadth, which the cube above, hanging in the air, cannot do. Thus it is proved. The cube shown above is better shown here below.

The final result of the two cylinders of damp clay that is _a_ and _b_ will be the pyramidal figures below _c_ and _d_. This is proved thus: The cylinder _a_ resting on block of stone being made of clay mixed with a great deal of water will sink by its weight, which presses on its base, and in proportion as it settles and spreads all the parts will be somewhat nearer to the base because that is charged with the whole weight.

III.

ON THE NATURE OF THE ARCH.

779.

WHAT IS AN ARCH?

The arch is nothing else than a force originated by two weaknesses, for the arch in buildings is composed of two segments of a circle, each of which being very weak in itself tends to fall; but as each opposes this tendency in the other, the two weaknesses combine to form one strength.

OF THE KIND OF PRESSURE IN ARCHES.

As the arch is a composite force it remains in equilibrium because

the thrust is equal from both sides; and if one of the segments weighs more than the other the stability is lost, because the greater pressure will outweigh the lesser.

OF DISTRIBUTING THE PRESSURE ABOVE AN ARCH.

Next to giving the segments of the circle equal weight it is necessary to load them equally, or you will fall into the same defect as before.

WHERE AN ARCH BREAKS.

An arch breaks at the part which lies below half way from the centre.

SECOND RUPTURE OF THE ARCH.

If the excess of weight be placed in the middle of the arch at the point a, that weight tends to fall towards b, and the arch breaks at $\frac{2}{3}$ of its height at c e; and g e is as many times stronger than e a, as m o goes into m n.

ON ANOTHER CAUSE OF RUIN.

The arch will likewise give way under a transversal thrust, for when the charge is not thrown directly on the foot of the arch, the arch lasts but a short time.

780.

ON THE STRENGTH OF THE ARCH.

The way to give stability to the arch is to fill the spandrils with good masonry up to the level of its summit.

ON THE LOADING OF ROUND ARCHES.

ON THE PROPER MANNER OF LOADING THE POINTED ARCH.

ON THE EVIL EFFECTS OF LOADING THE POINTED ARCH DIRECTLY ABOVE ITS CROWN.

ON THE DAMAGE DONE TO THE POINTED ARCH BY THROWING THE PRESSURE ON THE FLANKS.

An arch of small curve is safe in itself, but if it be heavily charged, it is necessary to strengthen the flanks well. An arch of a very large curve is weak in itself, and stronger if it be charged, and will do little harm to its abutments, and its places of giving way are o p.

[Footnote: Inside the large figure on the right is the note: Da pesare la forza dell' arco.]

781.

ON THE REMEDY FOR EARTHQUAKES.

The arch which throws its pressure perpendicularly on the abutments will fulfil its function whatever be its direction, upside down, sideways or upright.

The arch will not break if the chord of the outer arch does not touch the inner arch. This is manifest by experience, because whenever the chord ao of the outer arch na approaches the inner arch xy the arch will be weak, and it will be weaker in proportion as the inner arch passes beyond that chord. When an arch is loaded only on one side the thrust will press on the top of the other side and be transmitted to the spring of the arch on that side; and it will break at a point half way between its two extremes, where it is farthest from the chord.

782.

A continuous body which has been forcibly bent into an arch, thrusts in the direction of the straight line, which it tends to recover.

783.

In an arch judiciously weighted the thrust is oblique, so that the triangle cnb has no weight upon it.

784.

I here ask what weight will be needed to counterpoise and resist the tendency of each of these arches to give way?

[Footnote: The two lower sketches are taken from the MS. S. K. M. III, 10a; they have there no explanatory text.]

785.

ON THE STRENGTH OF THE ARCH IN ARCHITECTURE.

The stability of the arch built by an architect resides in the tie and in the flanks.

ON THE POSITION OF THE TIE IN THE ABOVE NAMED ARCH.

The position of the tie is of the same importance at the beginning of the arch and at the top of the perpendicular pier on which it rests. This is proved by the 2nd "of supports" which says: that part of a support has least resistance which is farthest from its solid attachment; hence, as the top of the pier is farthest from the middle of its true foundation and the same being the case at the opposite extremities of the arch which are the points farthest from

the middle, which is really its [upper] attachment, we have concluded that the tie *a b* requires to be in such a position as that its opposite ends are between the four above-mentioned extremes.

The adversary says that this arch must be more than half a circle, and that then it will not need a tie, because then the ends will not thrust outwards but inwards, as is seen in the excess at *a c*, *b d*. To this it must be answered that this would be a very poor device, for three reasons. The first refers to the strength of the arch, since it is proved that the circular parallel being composed of two semicircles will only break where these semicircles cross each other, as is seen in the figure *n m*; besides this it follows that there is a wider space between the extremes of the semicircle than between the plane of the walls; the third reason is that the weight placed to counterbalance the strength of the arch diminishes in proportion as the piers of the arch are wider than the space between the piers. Fourthly in proportion as the parts at *c a b d* turn outwards, the piers are weaker to support the arch above them. The 5th is that all the material and weight of the arch which are in excess of the semicircle are useless and indeed mischievous; and here it is to be noted that the weight placed above the arch will be more likely to break the arch at *a b*, where the curve of the excess begins that is added to the semicircle, than if the pier were straight up to its junction with the semicircle [spring of the arch].

AN ARCH LOADED OVER THE CROWN WILL GIVE WAY AT THE LEFT HAND AND RIGHT HAND QUARTERS.

This is proved by the 7th of this which says: The opposite ends of the support are equally pressed upon by the weight suspended to them; hence the weight shown at *f* is felt at *b c*, that is half at each extremity; and by the third which says: in a support of equal strength [throughout] that portion will give way soonest which is farthest from its attachment; whence it follows that *d* being equally distant from *f*, *e*

If the centering of the arch does not settle as the arch settles, the mortar, as it dries, will shrink and detach itself from the bricks between which it was laid to keep them together; and as it thus leaves them disjoined the vault will remain loosely built, and the rains will soon destroy it.

786.

ON THE STRENGTH AND NATURE OF ARCHES, AND WHERE THEY ARE STRONG OR WEAK; AND THE SAME AS TO COLUMNS.

That part of the arch which is nearer to the horizontal offers least resistance to the weight placed on it.

When the triangle *a z n*, by settling, drives backwards the 2/3 of

each 1/2 circle that is *a s* and in the same way *z m*, the reason is that *a* is perpendicularly over *b* and so likewise *z* is above *f*.

Either half of an arch, if overweighted, will break at 2/3 of its height, the point which corresponds to the perpendicular line above the middle of its bases, as is seen at *a b*; and this happens because the weight tends to fall past the point *r*.--And if, against its nature it should tend to fall towards the point *s* the arch *n s* would break precisely in its middle. If the arch *n s* were of a single piece of timber, if the weight placed at *n* should tend to fall in the line *n m*, the arch would break in the middle of the arch *e m*, otherwise it will break at one third from the top at the point *a* because from *a* to *n* the arch is nearer to the horizontal than from *a* to *o* and from *o* to *s*, in proportion as *p t* is greater than *t n*, *a o* will be stronger than *a n* and likewise in proportion as *s o* is stronger than *o a*, *r p* will be greater than *p t*.

The arch which is doubled to four times of its thickness will bear four times the weight that the single arch could carry, and more in proportion as the diameter of its thickness goes a smaller number of times into its length. That is to say that if the thickness of the single arch goes ten times into its length, the thickness of the doubled arch will go five times into its length. Hence as the thickness of the double arch goes only half as many times into its length as that of the single arch does, it is reasonable that it should carry half as much more weight as it would have to carry if it were in direct proportion to the single arch. Hence as this double arch has 4 times the thickness of the single arch, it would seem that it ought to bear 4 times the weight; but by the above rule it is shown that it will bear exactly 8 times as much.

THAT PIER, WHICH is CHARGED MOST UNEQUALLY, WILL SOONEST GIVE WAY.

The column *c b*, being charged with an equal weight, [on each side] will be most durable, and the other two outward columns require on the part outside of their centre as much pressure as there is inside of their centre, that is, from the centre of the column, towards the middle of the arch.

Arches which depend on chains for their support will not be very durable.

THAT ARCH WILL BE OF LONGER DURATION WHICH HAS A GOOD ABUTMENT OPPOSED TO ITS THRUST.

The arch itself tends to fall. If the arch be 30 braccia and the interval between the walls which carry it be 20, we know that 30 cannot pass through the 20 unless 20 becomes likewise 30. Hence the arch being crushed by the excess of weight, and the walls offering insufficient resistance, part, and afford room between them, for the fall of the arch.

But if you do not wish to strengthen the arch with an iron tie you must give it such abutments as can resist the thrust; and you can do this thus: fill up the spandrels *_m n_* with stones, and direct the lines of the joints between them to the centre of the circle of the arch, and the reason why this makes the arch durable is this. We know very well that if the arch is loaded with an excess of weight above its quarter as *_a b_*, the wall *_f g_* will be thrust outwards because the arch would yield in that direction; if the other quarter *_b c_* were loaded, the wall *_f g_* would be thrust inwards, if it were not for the line of stones *_x y_* which resists this.

787.

PLAN.

Here it is shown how the arches made in the side of the octagon thrust the piers of the angles outwards, as is shown by the line *_h c_* and by the line *_t d_* which thrust out the pier *_m_*; that is they tend to force it away from the centre of such an octagon.

788.

An Experiment to show that a weight placed on an arch does not discharge itself entirely on its columns; on the contrary the greater the weight placed on the arches, the less the arch transmits the weight to the columns. The experiment is the following. Let a man be placed on a steel yard in the middle of the shaft of a well, then let him spread out his hands and feet between the walls of the well, and you will see him weigh much less on the steel yard; give him a weight on the shoulders, you will see by experiment, that the greater the weight you give him the greater effort he will make in spreading his arms and legs, and in pressing against the wall and the less weight will be thrown on the steel yard.

IV.

ON FOUNDATIONS, THE NATURE OF THE GROUND AND SUPPORTS.

789.

The first and most important thing is stability.

As to the foundations of the component parts of temples and other public buildings, the depths of the foundations must bear the same proportions to each other as the weight of material which is to be placed upon them.

Every part of the depth of earth in a given space is composed of layers, and each layer is composed of heavier or lighter materials, the lowest being the heaviest. And this can be proved, because these layers have been formed by the sediment from water carried down to the sea, by the current of rivers which flow into it. The heaviest

part of this sediment was that which was first thrown down, and so on by degrees; and this is the action of water when it becomes stagnant, having first brought down the mud whence it first flowed. And such layers of soil are seen in the banks of rivers, where their constant flow has cut through them and divided one slope from the other to a great depth; where in gravelly strata the waters have run off, the materials have, in consequence, dried and been converted into hard stone, and this happened most in what was the finest mud; whence we conclude that every portion of the surface of the earth was once at the centre of the earth, and *_vice-versa_* &c.

790.

The heaviest part of the foundations of buildings settles most, and leaves the lighter part above it separated from it.

And the soil which is most pressed, if it be porous yields most.

You should always make the foundations project equally beyond the weight of the walls and piers, as shown at *_m a b_*. If you do as many do, that is to say if you make a foundation of equal width from the bottom up to the surface of the ground, and charge it above with unequal weights, as shown at *_b e_* and at *_e o_*, at the part of the foundation at *_b e_*, the pier of the angle will weigh most and thrust its foundation downwards, which the wall at *_e o_* will not do; since it does not cover the whole of its foundation, and therefore thrusts less heavily and settles less. Hence, the pier *_b e_* in settling cracks and parts from the wall *_e o_*. This may be seen in most buildings which are cracked round the piers.

791.

The window *_a_* is well placed under the window *_c_*, and the window *_b_* is badly placed under the pier *_d_*, because this latter is without support and foundation; mind therefore never to make a break under the piers between the windows.

792.

OF THE SUPPORTS.

A pillar of which the thickness is increased will gain more than its due strength, in direct proportion to what it loses in relative height.

EXAMPLE.

If a pillar should be nine times as high as it is broad--that is to say, if it is one braccio thick, according to rule it should be nine braccia high--then, if you place 100 such pillars together in a mass this will be ten braccia broad and 9 high; and if the first pillar could carry 10000 pounds the second being only about as high as it is wide, and thus lacking 8 parts of its proper length, it, that is

to say, each pillar thus united, will bear eight times more than when disconnected; that is to say, that if at first it would carry ten thousand pounds, it would now carry 90 thousand.

V.

ON THE RESISTANCE OF BEAMS.

793.

That angle will offer the greatest resistance which is most acute, and the most obtuse will be the weakest.

[Footnote: The three smaller sketches accompany the text in the original, but the larger one is not directly connected with it. It is to be found on fol. 89a of the same Manuscript and there we read in a note, written underneath, *_coverchio della perdicha del castello_* (roof of the flagstaff of the castle),--Compare also Pl. XCIII, No. 1.]

794.

If the beams and the weight *_o_* are 100 pounds, how much weight will be wanted at *_ae_* to resist such a weight, that it may not fall down?

795.

ON THE LENGTH OF BEAMS.

That beam which is more than 20 times as long as its greatest thickness will be of brief duration and will break in half; and remember, that the part built into the wall should be steeped in hot pitch and filleted with oak boards likewise so steeped. Each beam must pass through its walls and be secured beyond the walls with sufficient chaining, because in consequence of earthquakes the beams are often seen to come out of the walls and bring down the walls and floors; whilst if they are chained they will hold the walls strongly together and the walls will hold the floors. Again I remind you never to put plaster over timber. Since by expansion and shrinking of the timber produced by damp and dryness such floors often crack, and once cracked their divisions gradually produce dust and an ugly effect. Again remember not to lay a floor on beams supported on arches; for, in time the floor which is made on beams settles somewhat in the middle while that part of the floor which rests on the arches remains in its place; hence, floors laid over two kinds of supports look, in time, as if they were made in hills [Footnote: 19 M. RAVAISSON, in his edition of MS. A gives a very different rendering of this passage translating it thus: *_Les planchers qui sont soutenus par deux differentes natures de supports paraissent avec le temps faits en voute a chollli_*.]

Remarks on the style of Leonardo's architecture.

A few remarks may here be added on the style of Leonardo's architectural studies. However incomplete, however small in scale, they allow us to establish a certain number of facts and probabilities, well worthy of consideration.

When Leonardo began his studies the great name of Brunellesco was still the inspiration of all Florence, and we cannot doubt that Leonardo was open to it, since we find among his sketches the plan of the church of Santo Spirito[Footnote 1: See Pl. XCIV, No. 2. Then only in course of erection after the designs of Brunellesco, though he was already dead; finished in 1481.] and a lateral view of San Lorenzo (Pl. XCIV No. 1), a plan almost identical with the chapel Degli Angeli, only begun by him (Pl. XCIV, No. 3) while among Leonardo's designs for domes several clearly betray the influence of Brunellesco's Cupola and the lantern of Santa Maria del Fiore[Footnote 2: A small sketch of the tower of the Palazzo della Signoria (MS. C.A. 309) proves that he also studied mediaeval monuments.]

The beginning of the second period of modern Italian architecture falls during the first twenty years of Leonardo's life. However the new impetus given by Leon Battista Alberti either was not generally understood by his contemporaries, or those who appreciated it, had no opportunity of showing that they did so. It was only when taken up by Bramante and developed by him to the highest rank of modern architecture that this new influence was generally felt. Now the peculiar feature of Leonardo's sketches is that, like the works of Bramante, they appear to be the development and continuation of Alberti's.

_But a question here occurs which is difficult to answer. Did Leonardo, till he quitted Florence, follow the direction given by the dominant school of Brunellesco, which would then have given rise to his "First manner", or had he, even before he left Florence, felt Alberti's influence--either through his works (Palazzo Rucellai, and the front of Santa Maria Novella) or through personal intercourse? Or was it not till he went to Milan that Alberti's work began to impress him through Bramante, who probably had known Alberti at Mantua about 1470 and who not only carried out Alberti's views and ideas, but, by his designs for St. Peter's at Rome, proved himself the greatest of modern architects. When Leonardo went to Milan Bramante had already been living there for many years. One of his earliest works in Milan was the church of Santa Maria presso San Satiro, Via del Falcone[Footnote 1: Evidence of this I intend to give later on in a Life of Bramante, which I have in preparation.].

Now we find among Leonardos studies of Cupolas on Plates LXXXIV and LXXXV and in Pl. LXXX several sketches which seem to me to have been suggested by Bramante's dome of this church.

The MSS. B and Ash. II contain the plans of S. Sepolcro, the pavilion in the garden of the duke of Milan, and two churches,

evidently inspired by the church of San Lorenzo at Milan.

MS. B. contains besides two notes relating to Pavia, one of them a design for the sacristy of the Cathedral at Pavia, which cannot be supposed to be dated later than 1492, and it has probably some relation to Leonardo's call to Pavia June 21, 1490[Footnote 2: The sketch of the plan of Brunellesco's church of Santo Spirito at Florence, which occurs in the same Manuscript, may have been done from memory.]. These and other considerations justify us in concluding, that Leonardo made his studies of cupolas at Milan, probably between the years 1487 and 1492 in anticipation of the erection of one of the grandest churches of Italy, the Cathedral of Pavia. This may explain the decidedly Lombardo-Bramantesque tendency in the style of these studies, among which only a few remind us of the forms of the cupolas of S. Maria del Fiore and of the Baptistery of Florence. Thus, although when compared with Bramante's work, several of these sketches plainly reveal that master's influence, we find, among the sketches of domes, some, which show already Bramante's classic style, of which the Tempietto of San Pietro in Montorio, his first building executed at Rome, is the foremost example[Footnote 3: It may be mentioned here, that in 1494 Bramante made a similar design for the lantern of the Cupola of the Church of Santa Maria delle Grazie.].

On Plate LXXXIV is a sketch of the plan of a similar circular building; and the Mausoleum on Pl. XCVIII, no less than one of the pedestals for the statue of Francesco Sforza (Pl. LXV), is of the same type.

The drawings Pl. LXXXIV No. 2, Pl. LXXXVI No. 1 and 2 and the ground flour ("flour" sic but should be "floor" ?) of the building in the drawing Pl. XCI No. 2, with the interesting decoration by gigantic statues in large niches, are also, I believe, more in the style Bramante adopted at Rome, than in the Lombard style. Are we to conclude from this that Leonardo on his part influenced Bramante in the sense of simplifying his style and rendering it more congenial to antique art? The answer to this important question seems at first difficult to give, for we are here in presence of Bramante, the greatest of modern architects, and with Leonardo, the man comparable with no other. We have no knowledge of any buildings erected by Leonardo, and unless we admit personal intercourse--which seems probable, but of which there is no proof--, it would be difficult to understand how Leonardo could have affected Bramante's style. The converse is more easily to be admitted, since Bramante, as we have proved elsewhere, drew and built simultaneously in different manners, and though in Lombardy there is no building by him in his classic style, the use of brick for building, in that part of Italy, may easily account for it._

Bramante's name is incidentally mentioned in Leonardo's manuscripts in two passages (Nos. 1414 and 1448). On each occasion it is only a slight passing allusion, and the nature of the context gives us no due information as to any close connection between the two artists.

It might be supposed, on the ground of Leonardo's relations with the East given in sections XVII and XXI of this volume, that some evidence of oriental influence might be detected in his architectural drawings. I do not however think that any such traces can be pointed out with certainty unless perhaps the drawing for a Mausoleum, Pl. XC VIII.

Among several studies for the construction of cupolas above a Greek cross there are some in which the forms are decidedly monotonous. These, it is clear, were not designed as models of taste; they must be regarded as the results of certain investigations into the laws of proportion, harmony and contrast.

The designs for churches, on the plan of a Latin cross are evidently intended to depart as little as possible from the form of a Greek cross; and they also show a preference for a nave surrounded with outer porticos.

The architectural forms preferred by Leonardo are pilasters coupled (Pl. LXXXII No. 1; or grouped (Pl. LXXX No. 5 and XCIV No. 4), often combined with niches. We often meet with orders superposed, one in each story, or two small orders on one story, in combination with one great order (Pl. XCVI No. 2).

The drum (tamburo) of these cupolas is generally octagonal, as in the cathedral of Florence, and with similar round windows in its sides. In Pl. LXXXVII No. 2 it is circular like the model actually carried out by Michael Angelo at St. Peter's.

The cupola itself is either hidden under a pyramidal roof, as in the Baptistery of Florence, San Lorenzo of Milan and most of the Lombard churches (Pl. XCI No. 1 and Pl. XCII No. 1); but it more generally suggests the curve of Sta Maria del Fiore (Pl. LXXXVIII No. 5; Pl. XC No. 2; Pl. LXXXIX, M; Pl. XC No. 4, Pl. XCVI No. 2). In other cases (Pl. LXXX No. 4; Pl. LXXXIX; Pl. XC No. 2) it shows the sides of the octagon crowned by semicircular pediments, as in Brunellesco's lantern of the Cathedral and in the model for the Cathedral of Pavia.

Finally, in some sketches the cupola is either semicircular, or as in Pl. LXXXVII No. 2, shows the beautiful line, adopted sixty years later by Michael Angelo for the existing dome of St. Peter's.

It is worth noticing that for all these domes Leonardo is not satisfied to decorate the exterior merely with ascending ribs or mouldings, but employs also a system of horizontal parallels to complete the architectural system. Not the least interesting are the designs for the tiburio (cupola) of the Milan Cathedral. They show some of the forms, just mentioned, adapted to the peculiar gothic style of that monument.

The few examples of interiors of churches recall the style employed

in Lombardy by Bramante, for instance in S. Maria di Canepanuova at Pavia, or by Dolcebuono in the Monastero Maggiore at Milan (see Pl. CI No. 1 [C. A. 181b; 546b]; Pl. LXXXIV No. 10).

The few indications concerning palaces seem to prove that Leonardo followed Alberti's example of decorating the walls with pilasters and a flat rustica, either in stone or by graffitti (Pl. CII No. 1 and Pl. LXXXV No. 14).

By pointing out the analogies between Leonardo's architecture and that of other masters we in no way pretend to depreciate his individual and original inventive power. These are at all events beyond dispute. The project for the Mausoleum (Pl. XCVIII) would alone suffice to rank him among the greatest architects who ever lived. The peculiar shape of the tower (Pl. LXXX), of the churches for preaching (Pl. XCVII No. 1 and pages 56 and 57, Fig. 1-4), his curious plan for a city with high and low level streets (Pl. LXXVII and LXXVIII No. 2 and No. 3), his Loggia with fountains (Pl. LXXXII No. 4) reveal an originality, a power and facility of invention for almost any given problem, which are quite wonderful.

In addition to all these qualities he probably stood alone in his day in one department of architectural study,--his investigations, namely, as to the resistance of vaults, foundations, walls and arches.

_As an application of these studies the plan of a semicircular vault (Pl. CIII No. 2) may be mentioned here, disposed so as to produce no thrust on the columns on which it rests: _ volta i botte e non ispiagne ifori le colone. _Above the geometrical patterns on the same sheet, close to a circle inscribed in a square is the note: _ la raggio d'una volta cioe il terzo del diametro della sua ... del tedesco in domo.

There are few data by which to judge of Leonardo's style in the treatment of detail. On Pl. LXXXV No. 10 and Pl. CIII No. 3, we find some details of pillars; on Pl. CI No. 3 slender pillars designed for a fountain and on Pl. CIII No. 1 MS. B, is a pen and ink drawing of a vase which also seems intended for a fountain. Three handles seem to have been intended to connect the upper parts with the base. There can be no doubt that Leonardo, like Bramante, but unlike Michael Angelo, brought infinite delicacy of motive and execution to bear on the details of his work.

XIV.

Anatomy, Zoology and Physiology.

_Leonardo's eminent place in the history of medicine, as a pioneer in the sciences of Anatomy and Physiology, will never be appreciated till it is possible to publish the mass of manuscripts in which he largely treated of these two branches of learning. In the present work I must necessarily limit myself to giving the reader a general

view of these labours, by publishing his introductory notes to the various books on anatomical subjects. I have added some extracts, and such observations as are scattered incidentally through these treatises, as serving to throw a light on Leonardo's scientific attitude, besides having an interest for a wider circle than that of specialists only._

VASARI expressly mentions Leonardo's anatomical studies, having had occasion to examine the manuscript books which refer to them. According to him Leonardo studied Anatomy in the companionship of Marc Antonio della Torre "aiutato e scambievolmente aiutando." _--This learned Anatomist taught the science in the universities first of Padua and then of Pavia, and at Pavia he and Leonardo may have worked and studied together. We have no clue to any exact dates, but in the year 1506 Marc Antonio della Torre seems to have not yet left Padua. He was scarcely thirty years old when he died in 1512, and his writings on anatomy have not only never been published, but no manuscript copy of them is known to exist._

_This is not the place to enlarge on the connection between Leonardo and Marc Antonio della Torre. I may however observe that I have not been able to discover in Leonardo's manuscripts on anatomy any mention of his younger contemporary. The few quotations which occur from writers on medicine--either of antiquity or of the middle ages are printed in Section XXII. Here and there in the manuscripts mention is made of an anonymous "adversary" _ (avversario) _whose views are opposed and refuted by Leonardo, but there is no ground for supposing that Marc Antonio della Torre should have been this "adversary"._

_Only a very small selection from the mass of anatomical drawings left by Leonardo have been published here in facsimile, but to form any adequate idea of their scientific merit they should be compared with the coarse and inadequate figures given in the published books of the early part of the XVI. century.

William Hunter, the great surgeon--a competent judge--who had an opportunity in the time of George III. of seeing the originals in the King's Library, has thus recorded his opinion: "I expected to see little more than such designs in Anatomy as might be useful to a painter in his own profession. But I saw, and indeed with astonishment, that Leonardo had been a general and deep student. When I consider what pains he has taken upon every part of the body, the superiority of his universal genius, his particular excellence in mechanics and hydraulics, and the attention with which such a man would examine and see objects which he has to draw, I am fully persuaded that Leonardo was the best Anatomist, at that time, in the world ... Leonardo was certainly the first man, we know of, who introduced the practice of making anatomical drawings" (Two introductory letters. London 1784, pages 37 and 39).

The illustrious German Naturalist Johan Friedrich Blumenback esteemed them no less highly; he was one of the privileged few who,

after Hunter, had the chance of seeing these Manuscripts. He writes:
_Der Scharfblick dieses grossen Forschers und Darstellers der Natur
hat schon auf Dinge geachtet, die noch Jahrhunderte nachher
unbemerkt geblieben sind_" (see _Blumenbach's medicinische
Bibliothek_, Vol. 3, St. 4, 1795. page 728).

These opinions were founded on the drawings alone. Up to the present
day hardly anything has been made known of the text, and, for the
reasons I have given, it is my intention to reproduce here no more
than a selection of extracts which I have made from the originals at
Windsor Castle and elsewhere. In the Bibliography of the
Manuscripts, at the end of this volume a short review is given of
the valuable contents of these Anatomical note books which are at
present almost all in the possession of her Majesty the Queen of
England. It is, I believe, possible to assign the date with
approximate accuracy to almost all the fragments, and I am thus led
to conclude that the greater part of Leonardo's anatomical
investigations were carried out after the death of della Torre.

Merely in reading the introductory notes to his various books on
Anatomy which are here printed it is impossible to resist the
impression that the Master's anatomical studies bear to a very great
extent the stamp of originality and independent thought.

I.

ANATOMY.

796.

A general introduction

I wish to work miracles;--it may be that I shall possess less than
other men of more peaceful lives, or than those who want to grow
rich in a day. I may live for a long time in great poverty, as
always happens, and to all eternity will happen, to alchemists, the
would-be creators of gold and silver, and to engineers who would
have dead water stir itself into life and perpetual motion, and to
those supreme fools, the necromancer and the enchanter.

[Footnote 23: The following seems to be directed against students of
painting and young artists rather than against medical men and
anatomists.]

And you, who say that it would be better to watch an anatomist at
work than to see these drawings, you would be right, if it were
possible to observe all the things which are demonstrated in such
drawings in a single figure, in which you, with all your cleverness,
will not see nor obtain knowledge of more than some few veins, to
obtain a true and perfect knowledge of which I have dissected more
than ten human bodies, destroying all the other members, and
removing the very minutest particles of the flesh by which these
veins are surrounded, without causing them to bleed, excepting the

insensible bleeding of the capillary veins; and as one single body would not last so long, since it was necessary to proceed with several bodies by degrees, until I came to an end and had a complete knowledge; this I repeated twice, to learn the differences [59].

[Footnote: Lines 1-59 and 60-89 are written in two parallel columns. When we here find Leonardo putting himself in the same category as the Alchemists and Necromancers, whom he elsewhere mocks at so bitterly, it is evidently meant ironically. In the same way Leonardo, in the introduction to the Books on Perspective sets himself with transparent satire on a level with other writers on the subject.]

And if you should have a love for such things you might be prevented by loathing, and if that did not prevent you, you might be deterred by the fear of living in the night hours in the company of those corpses, quartered and flayed and horrible to see. And if this did not prevent you, perhaps you might not be able to draw so well as is necessary for such a demonstration; or, if you had the skill in drawing, it might not be combined with knowledge of perspective; and if it were so, you might not understand the methods of geometrical demonstration and the method of the calculation of forces and of the strength of the muscles; patience also may be wanting, so that you lack perseverance. As to whether all these things were found in me or not [Footnote 84: Leonardo frequently, and perhaps habitually, wrote in note books of a very small size and only moderately thick; in most of those which have been preserved undivided, each contains less than fifty leaves. Thus a considerable number of such volumes must have gone to make up a volume of the bulk of the 'Codex Atlanticus' which now contains nearly 1200 detached leaves. In the passage under consideration, which was evidently written at a late period of his life, Leonardo speaks of his Manuscript note-books as numbering 120; but we should hardly be justified in concluding from this passage that the greater part of his Manuscripts were now missing (see *Prolegomena*, Vol. I, pp. 5-7).], the hundred and twenty books composed by me will give verdict Yes or No. In these I have been hindered neither by avarice nor negligence, but simply by want of time. Farewell [89].

Plans and suggestions for the arrangement of materials (797-802).

797.

OF THE ORDER OF THE BOOK.

This work must begin with the conception of man, and describe the nature of the womb and how the foetus lives in it, up to what stage it resides there, and in what way it quickens into life and feeds. Also its growth and what interval there is between one stage of growth and another. What it is that forces it out from the body of the mother, and for what reasons it sometimes comes out of the mother's womb before the due time.

Then I will describe which are the members, which, after the boy is born, grow more than the others, and determine the proportions of a boy of one year.

Then describe the fully grown man and woman, with their proportions, and the nature of their complexions, colour, and physiognomy.

Then how they are composed of veins, tendons, muscles and bones. This I shall do at the end of the book. Then, in four drawings, represent four universal conditions of men. That is, Mirth, with various acts of laughter, and describe the cause of laughter. Weeping in various aspects with its causes. Contention, with various acts of killing; flight, fear, ferocity, boldness, murder and every thing pertaining to such cases. Then represent Labour, with pulling, thrusting, carrying, stopping, supporting and such like things.

Further I would describe attitudes and movements. Then perspective, concerning the functions and effects of the eye; and of hearing--here I will speak of music--, and treat of the other senses.

And then describe the nature of the senses.

This mechanism of man we will demonstrate in ... figures; of which the three first will show the ramification of the bones; that is: first one to show their height and position and shape: the second will be seen in profile and will show the depth of the whole and of the parts, and their position. The third figure will be a demonstration of the bones of the backparts. Then I will make three other figures from the same point of view, with the bones sawn across, in which will be shown their thickness and hollowness. Three other figures of the bones complete, and of the nerves which rise from the nape of the neck, and in what limbs they ramify. And three others of the bones and veins, and where they ramify. Then three figures with the muscles and three with the skin, and their proper proportions; and three of woman, to illustrate the womb and the menstrual veins which go to the breasts.

[Footnote: The meaning of the word _nervo_ varies in different passages, being sometimes used for _muscolo_ (muscle).]

798.

THE ORDER OF THE BOOK.

This depicting of mine of the human body will be as clear to you as if you had the natural man before you; and the reason is that if you wish thoroughly to know the parts of man, anatomically, you--or your eye--require to see it from different aspects, considering it from below and from above and from its sides, turning it about and seeking the origin of each member; and in this way the natural anatomy is sufficient for your comprehension. But you must understand that this amount of knowledge will not continue to

satisfy you; seeing the very great confusion that must result from the combination of tissues, with veins, arteries, nerves, sinews, muscles, bones, and blood which, of itself, tinges every part the same colour. And the veins, which discharge this blood, are not discerned by reason of their smallness. Moreover integrity of the tissues, in the process of the investigating the parts within them, is inevitably destroyed, and their transparent substance being tinged with blood does not allow you to recognise the parts covered by them, from the similarity of their blood-stained hue; and you cannot know everything of the one without confusing and destroying the other. Hence, some further anatomy drawings become necessary. Of which you want three to give full knowledge of the veins and arteries, everything else being destroyed with the greatest care. And three others to display the tissues; and three for the sinews and muscles and ligaments; and three for the bones and cartilages; and three for the anatomy of the bones, which have to be sawn to show which are hollow and which are not, which have marrow and which are spongy, and which are thick from the outside inwards, and which are thin. And some are extremely thin in some parts and thick in others, and in some parts hollow or filled up with bone, or full of marrow, or spongy. And all these conditions are sometimes found in one and the same bone, and in some bones none of them. And three you must have for the woman, in which there is much that is mysterious by reason of the womb and the foetus. Therefore by my drawings every part will be known to you, and all by means of demonstrations from three different points of view of each part; for when you have seen a limb from the front, with any muscles, sinews, or veins which take their rise from the opposite side, the same limb will be shown to you in a side view or from behind, exactly as if you had that same limb in your hand and were turning it from side to side until you had acquired a full comprehension of all you wished to know. In the same way there will be put before you three or four demonstrations of each limb, from various points of view, so that you will be left with a true and complete knowledge of all you wish to learn of the human figure[Footnote 35: Compare Pl. CVII. The original drawing at Windsor is 28 1/2 X 19 1/2 centimetres. The upper figures are slightly washed with Indian ink. On the back of this drawing is the text No. 1140.].

Thus, in twelve entire figures, you will have set before you the cosmography of this lesser world on the same plan as, before me, was adopted by Ptolemy in his cosmography; and so I will afterwards divide them into limbs as he divided the whole world into provinces; then I will speak of the function of each part in every direction, putting before your eyes a description of the whole form and substance of man, as regards his movements from place to place, by means of his different parts. And thus, if it please our great Author, I may demonstrate the nature of men, and their customs in the way I describe his figure.

And remember that the anatomy of the nerves will not give the position of their ramifications, nor show you which muscles they branch into, by means of bodies dissected in running water or in

lime water; though indeed their origin and starting point may be seen without such water as well as with it. But their ramifications, when under running water, cling and unite--just like flat or hemp carded for spinning--all into a skein, in a way which makes it impossible to trace in which muscles or by what ramification the nerves are distributed among those muscles.

799.

THE ARRANGEMENT OF ANATOMY

First draw the bones, let us say, of the arm, and put in the motor muscle from the shoulder to the elbow with all its lines. Then proceed in the same way from the elbow to the wrist. Then from the wrist to the hand and from the hand to the fingers.

And in the arm you will put the motors of the fingers which open, and these you will show separately in their demonstration. In the second demonstration you will clothe these muscles with the secondary motors of the fingers and so proceed by degrees to avoid confusion. But first lay on the bones those muscles which lie close to the said bones, without confusion of other muscles; and with these you may put the nerves and veins which supply their nourishment, after having first drawn the tree of veins and nerves over the simple bones.

800.

Begin the anatomy at the head and finish at the sole of the foot.

801.

3 men complete, 3 with bones and nerves, 3 with the bones only. Here we have 12 demonstrations of entire figures.

802.

When you have finished building up the man, you will make the statue with all its superficial measurements.

[Footnote: *_'Cresciere l'omo_'*. The meaning of this expression appears to be different here and in the passage C.A. 157a, 468a (see No. 526, Note 1. 2). Here it can hardly mean anything else than modelling, since the sculptor forms the figure by degrees, by adding wet clay and the figure consequently increases or grows. *_'Tu farai la statua_'* would then mean, you must work out the figure in marble. If this interpretation is the correct one, this passage would have no right to find a place in the series on anatomical studies. I may say that it was originally inserted in this connection under the impression that *_'di cresciere_'* should be read *_'descrivere_'*.]

Plans for the representation of muscles by drawings (803-809).

803.

You must show all the motions of the bones with their joints to follow the demonstration of the first three figures of the bones, and this should be done in the first book.

804.

Remember that to be certain of the point of origin of any muscle, you must pull the sinew from which the muscle springs in such a way as to see that muscle move, and where it is attached to the ligaments of the bones.

NOTE.

You will never get any thing but confusion in demonstrating the muscles and their positions, origin, and termination, unless you first make a demonstration of thin muscles after the manner of linen threads; and thus you can represent them, one over another as nature has placed them; and thus, too, you can name them according to the limb they serve; for instance the motor of the point of the great toe, of its middle bone, of its first bone, &c. And when you have the knowledge you will draw, by the side of this, the true form and size and position of each muscle. But remember to give the threads which explain the situation of the muscles in the position which corresponds to the central line of each muscle; and so these threads will demonstrate the form of the leg and their distance in a plain and clear manner.

I have removed the skin from a man who was so shrunk by illness that the muscles were worn down and remained in a state like thin membrane, in such a way that the sinews instead of merging in muscles ended in wide membrane; and where the bones were covered by the skin they had very little over their natural size.

[Footnote: The photograph No. 41 of Grosvenor Gallery Publications: a drawing of the muscles of the foot, includes a complete facsimile of the text of this passage.]

805.

Which nerve causes the motion of the eye so that the motion of one eye moves the other?

Of frowning the brows, of raising the brows, of lowering the brows,--of closing the eyes, of opening the eyes,--of raising the nostrils, of opening the lips, with the teeth shut, of pouting with the lips, of smiling, of astonishment.--

Describe the beginning of man when it is caused in the womb and why an eight months child does not live. What sneezing is. What yawning is. Falling sickness, spasms, paralysis, shivering with cold, sweating, fatigue, hunger, sleepiness, thirst, lust.

Of the nerve which is the cause of movement from the shoulder to the elbow, of the movement from the elbow to the hand, from the joint of the hand to the springing of the fingers. From the springing of the fingers to the middle joints, and from the middle joints to the last.

Of the nerve which causes the movement of the thigh, and from the knee to the foot, and from the joint of the foot to the toes, and then to the middle of the toes and of the rotary motion of the leg.

806.

ANATOMY.

Which nerves or sinews of the hand are those which close and part the fingers and toes laterally?

807.

Remove by degrees all the parts of the front of a man in making your dissection, till you come to the bones. Description of the parts of the bust and of their motions.

808.

Give the anatomy of the leg up to the hip, in all views and in every action and in every state; veins, arteries, nerves, sinews and muscles, skin and bones; then the bones in sections to show the thickness of the bones.

[Footnote: A straightened leg in profile is sketched by the side of this text.]

On corpulency and leanness (809-811).

809.

Make the rule and give the measurement of each muscle, and give the reasons of all their functions, and in which way they work and what makes them work &c.

[4] First draw the spine of the back; then clothe it by degrees, one after the other, with each of its muscles and put in the nerves and arteries and veins to each muscle by itself; and besides these note the vertebrae to which they are attached; which of the intestines come in contact with them; and which bones and other organs &c.

The most prominent parts of lean people are most prominent in the muscular, and equally so in fat persons. But concerning the difference in the forms of the muscles in fat persons as compared with muscular persons, it shall be described below.

[Footnote: The two drawings given on Pl. CVIII no. 1 come between lines 3 and 4. A good and very early copy of this drawing without the written text exists in the collection of drawings belonging to Christ's College Oxford, where it is attributed to Leonardo.]

810.

Describe which muscles disappear in growing fat, and which become visible in growing lean.

And observe that that part which on the surface of a fat person is most concave, when he grows lean becomes more prominent.

Where the muscles separate one from another you must give profiles and where they coalesce ...

811.

OF THE HUMAN FIGURE.

Which is the part in man, which, as he grows fatter, never gains flesh?

Or what part which as a man grows lean never falls away with a too perceptible diminution? And among the parts which grow fat which is that which grows fattest?

Among those which grow lean which is that which grows leanest?

In very strong men which are the muscles which are thickest and most prominent?

In your anatomy you must represent all the stages of the limbs from man's creation to his death, and then till the death of the bone; and which part of him is first decayed and which is preserved the longest.

And in the same way of extreme leanness and extreme fatness.

The divisions of the head (812. 813).

812.

ANATOMY.

There are eleven elementary tissues:-- Cartilage, bones, nerves, veins, arteries, fascia, ligament and sinews, skin, muscle and fat.

OF THE HEAD.

The divisions of the head are 10, viz. 5 external and 5 internal, the external are the hair, skin, muscle, fascia and the skull; the internal are the dura mater, the pia mater, [which enclose] the

brain. The pia mater and the dura mater come again underneath and enclose the brain; then the rete mirabile, and the occipital bone, which supports the brain from which the nerves spring.

813.

a. hair

n. skin

c. muscle

m. fascia

o. skull _i.e._ bone

b. dura mater

d. pia mater

f. brain

r. pia mater, below

t. dura mater

l. rete mirabile

s. the occipital bone.

[Footnote: See Pl. CVIII, No. 3.]

Physiological problems (814. 815).

814.

Of the cause of breathing, of the cause of the motion of the heart, of the cause of vomiting, of the cause of the descent of food from the stomach, of the cause of emptying the intestines.

Of the cause of the movement of the superfluous matter through the intestines.

Of the cause of swallowing, of the cause of coughing, of the cause of yawning, of the cause of sneezing, of the cause of limbs getting asleep.

Of the cause of losing sensibility in any limb.

Of the cause of tickling.

Of the cause of lust and other appetites of the body, of the cause of urine and also of all the natural excretions of the body.

[Footnote: By the side of this text stands the pen and ink drawing reproduced on Pl. CVIII, No. 4; a skull with indications of the veins in the fleshy covering.]

815.

The tears come from the heart and not from the brain.

Define all the parts, of which the body is composed, beginning with the skin with its outer cuticle which is often chapped by the influence of the sun.

II.

ZOOLOGY AND COMPARATIVE ANATOMY.

The divisions of the animal kingdom (816. 817).

816.

Man. The description of man, which includes that of such creatures as are of almost the same species, as Apes, Monkeys and the like, which are many,

The Lion and its kindred, as Panthers. [Footnote 3: Leonza--wild cat? "Secondo alcuni, lo stesso che Leonessa; e secondo altri con piu certezza, lo stesso che Pantera" FANFANI, Vocabolario page 858.] Wildcats (?) Tigers, Leopards, Wolves, Lynxes, Spanish cats, common cats and the like.

The Horse and its kindred, as Mule, Ass and the like, with incisor teeth above and below.

The Bull and its allies with horns and without upper incisors as the Buffalo, Stag Fallow Deer, Wild Goat, Swine, Goat, wild Goats Muskdeers, Chamois, Giraffe.

817.

Describe the various forms of the intestines of the human species, of apes and such like. Then, in what way the leonine species differ, and then the bovine, and finally birds; and arrange this description after the manner of a disquisition.

Miscellaneous notes on the study of Zoology (818-821).

818.

Procure the placenta of a calf when it is born and observe the form of the cotyledons, if their cotyledons are male or female.

819.

Describe the tongue of the woodpecker and the jaw of the crocodile.

820.

Of the flight of the 4th kind of butterflies that consume winged ants. Of the three principal positions of the wings of birds in downward flight.

[Footnote: A passing allusion is all I can here permit myself to Leonardo's elaborate researches into the flight of birds. Compare the observations on this subject in the Introduction to section XVIII and in the Bibliography of Manuscripts at the end of the work.]

821.

Of the way in which the tail of a fish acts in propelling the fish; as in the eel, snake and leech.

[Footnote: A sketch of a fish, swimming upwards is in the original, inserted above this text.--Compare No. 1114.]

Comparative study of the structure of bones and of the action of muscles (822-826).

822.

OF THE PALM OF THE HAND.

Then I will discourse of the hands of each animal to show in what they vary; as in the bear, which has the ligatures of the sinews of the toes joined above the instep.

823.

A second demonstration inserted between anatomy and [the treatise on] the living being.

You will represent here for a comparison, the legs of a frog, which have a great resemblance to the legs of man, both in the bones and in the muscles. Then, in continuation, the hind legs of the hare, which are very muscular, with strong active muscles, because they are not encumbered with fat.

[Footnote: This text is written by the side of a drawing in black chalk of a nude male figure, but there is no connection between the sketch and the text.]

824.

Here I make a note to demonstrate the difference there is between man and the horse and in the same way with other animals. And first

I will begin with the bones, and then will go on to all the muscles which spring from the bones without tendons and end in them in the same way, and then go on to those which start with a single tendon at one end.

[Footnote: See Pl. CVIII, No. 2.]

825.

Note on the bendings of joints and in what way the flesh grows upon them in their flexions or extensions; and of this most important study write a separate treatise: in the description of the movements of animals with four feet; among which is man, who likewise in his infancy crawls on all fours.

826.

OF THE WAY OF WALKING IN MAN.

The walking of man is always after the universal manner of walking in animals with 4 legs, inasmuch as just as they move their feet crosswise after the manner of a horse in trotting, so man moves his 4 limbs crosswise; that is, if he puts forward his right foot in walking he puts forward, with it, his left arm and vice versa, invariably.

III.

PHYSIOLOGY.

Comparative study of the organs of sense in men and animals.

827.

I have found that in the composition of the human body as compared with the bodies of animals the organs of sense are duller and coarser. Thus it is composed of less ingenious instruments, and of spaces less capacious for receiving the faculties of sense. I have seen in the Lion tribe that the sense of smell is connected with part of the substance of the brain which comes down the nostrils, which form a spacious receptacle for the sense of smell, which enters by a great number of cartilaginous vesicles with several passages leading up to where the brain, as before said, comes down.

The eyes in the Lion tribe have a large part of the head for their sockets and the optic nerves communicate at once with the brain; but the contrary is to be seen in man, for the sockets of the eyes are but a small part of the head, and the optic nerves are very fine and long and weak, and by the weakness of their action we see by day but badly at night, while these animals can see as well at night as by day. The proof that they can see is that they prowl for prey at night and sleep by day, as nocturnal birds do also.

Advantages in the structure of the eye in certain animals (828-831).

828.

Every object we see will appear larger at midnight than at midday, and larger in the morning than at midday.

This happens because the pupil of the eye is much smaller at midday than at any other time.

In proportion as the eye or the pupil of the owl is larger in proportion to the animal than that of man, so much the more light can it see at night than man can; hence at midday it can see nothing if its pupil does not diminish; and, in the same way, at night things look larger to it than by day.

829.

OF THE EYES IN ANIMALS.

The eyes of all animals have their pupils adapted to dilate and diminish of their own accord in proportion to the greater or less light of the sun or other luminary. But in birds the variation is much greater; and particularly in nocturnal birds, such as horned owls, and in the eyes of one species of owl; in these the pupil dilates in such away as to occupy nearly the whole eye, or diminishes to the size of a grain of millet, and always preserves the circular form. But in the Lion tribe, as panthers, pards, ounces, tigers, lynxes, Spanish cats and other similar animals the pupil diminishes from the perfect circle to the figure of a pointed oval such as is shown in the margin. But man having a weaker sight than any other animal is less hurt by a very strong light and his pupil increases but little in dark places; but in the eyes of these nocturnal animals, the horned owl--a bird which is the largest of all nocturnal birds--the power of vision increases so much that in the faintest nocturnal light (which we call darkness) it sees with much more distinctness than we do in the splendour of noon day, at which time these birds remain hidden in dark holes; or if indeed they are compelled to come out into the open air lighted up by the sun, they contract their pupils so much that their power of sight diminishes together with the quantity of light admitted.

Study the anatomy of various eyes and see which are the muscles which open and close the said pupils of the eyes of animals.

[Footnote: Compare No. 24, lines 8 and fol.]

830.

a b n is the membrane which closes the eye from below, upwards, with an opaque film, _c n b_ encloses the eye in front and behind with a transparent membrane.

It closes from below, upwards, because it [the eye] comes downwards.

When the eye of a bird closes with its two lids, the first to close is the nictitating membrane which closes from the lacrymal duct over to the outer corner of the eye; and the outer lid closes from below upwards, and these two intersecting motions begin first from the lacrymatory duct, because we have already seen that in front and below birds are protected and use only the upper portion of the eye from fear of birds of prey which come down from above and behind; and they uncover first the membrane from the outer corner, because if the enemy comes from behind, they have the power of escaping to the front; and again the muscle called the nictitating membrane is transparent, because, if the eye had not such a screen, they could not keep it open against the wind which strikes against the eye in the rush of their rapid flight. And the pupil of the eye dilates and contracts as it sees a less or greater light, that is to say intense brilliancy.

831.

If at night your eye is placed between the light and the eye of a cat, it will see the eye look like fire.

Remarks on the organs of speech

(832. 833).

832.

_a e i o u
ba be bi bo bu
ca ce ci co cu
da de di do du
fa fe fi fo fu
ga ge gi go gu
la le li lo lu
ma me mi mo mu
na ne ni no nu
pa pe pi po pu
qa qe qi qo qu
ra re ri ro ru
sa se si so su
ta te ti to tu_

The tongue is found to have 24 muscles which correspond to the six muscles which compose the portion of the tongue which moves in the mouth.

And when _a o u_ are spoken with a clear and rapid pronunciation, it is necessary, in order to pronounce continuously, without any pause between, that the opening of the lips should close by degrees; that is, they are wide apart in saying _a_, closer in saying _o_, and much closer still to pronounce _u_.

It may be shown how all the vowels are pronounced with the farthest portion of the false palate which is above the epiglottis.

833.

If you draw in breath by the nose and send it out by the mouth you will hear the sound made by the division that is the membrane in [Footnote 5: The text here breaks off.]...

On the conditions of sight (834. 835).

834.

OF THE NATURE OF SIGHT.

I say that sight is exercised by all animals, by the medium of light; and if any one adduces, as against this, the sight of nocturnal animals, I must say that this in the same way is subject to the very same natural laws. For it will easily be understood that the senses which receive the images of things do not project from themselves any visual virtue [Footnote 4: Compare No. 68.]. On the contrary the atmospheric medium which exists between the object and the sense incorporates in itself the figure of things, and by its contact with the sense transmits the object to it. If the object--whether by sound or by odour--presents its spiritual force to the ear or the nose, then light is not required and does not act. The forms of objects do not send their images into the air if they are not illuminated [8]; and the eye being thus constituted cannot receive that from the air, which the air does not possess, although it touches its surface. If you choose to say that there are many animals that prey at night, I answer that when the little light which suffices the nature of their eyes is wanting, they direct themselves by their strong sense of hearing and of smell, which are not impeded by the darkness, and in which they are very far superior to man. If you make a cat leap, by daylight, among a quantity of jars and crocks you will see them remain unbroken, but if you do the same at night, many will be broken. Night birds do not fly about unless the moon shines full or in part; rather do they feed between sun-down and the total darkness of the night.

[Footnote 8: See No. 58-67.]

No body can be apprehended without light and shade, and light and shade are caused by light.

835.

WHY MEN ADVANCED IN AGE SEE BETTER AT A DISTANCE.

Sight is better from a distance than near in those men who are advancing in age, because the same object transmits a smaller impression of itself to the eye when it is distant than when it is

near.

The seat of the common sense.

836.

The Common Sense, is that which judges of things offered to it by the other senses. The ancient speculators have concluded that that part of man which constitutes his judgment is caused by a central organ to which the other five senses refer everything by means of impressibility; and to this centre they have given the name Common Sense. And they say that this Sense is situated in the centre of the head between Sensation and Memory. And this name of Common Sense is given to it solely because it is the common judge of all the other five senses _i.e._ Seeing, Hearing, Touch, Taste and Smell. This Common Sense is acted upon by means of Sensation which is placed as a medium between it and the senses. Sensation is acted upon by means of the images of things presented to it by the external instruments, that is to say the senses which are the medium between external things and Sensation. In the same way the senses are acted upon by objects. Surrounding things transmit their images to the senses and the senses transfer them to the Sensation. Sensation sends them to the Common Sense, and by it they are stamped upon the memory and are there more or less retained according to the importance or force of the impression. That sense is most rapid in its function which is nearest to the sensitive medium and the eye, being the highest is the chief of the others. Of this then only we will speak, and the others we will leave in order not to make our matter too long. Experience tells us that the eye apprehends ten different natures of things, that is: Light and Darkness, one being the cause of the perception of the nine others, and the other its absence:-- Colour and substance, form and place, distance and nearness, motion and stillness [Footnote 15: Compare No. 23].

On the origin of the soul.

837.

Though human ingenuity may make various inventions which, by the help of various machines answering the same end, it will never devise any inventions more beautiful, nor more simple, nor more to the purpose than Nature does; because in her inventions nothing is wanting, and nothing is superfluous, and she needs no counterpoise when she makes limbs proper for motion in the bodies of animals. But she puts into them the soul of the body, which forms them that is the soul of the mother which first constructs in the womb the form of the man and in due time awakens the soul that is to inhabit it. And this at first lies dormant and under the tutelage of the soul of the mother, who nourishes and vivifies it by the umbilical vein, with all its spiritual parts, and this happens because this umbilicus is joined to the placenta and the cotyledons, by which the child is attached to the mother. And these are the reason why a wish, a strong craving or a fright or any other mental suffering in

the mother, has more influence on the child than on the mother; for there are many cases when the child loses its life from them, &c.

This discourse is not in its place here, but will be wanted for the one on the composition of animated bodies--and the rest of the definition of the soul I leave to the imaginations of friars, those fathers of the people who know all secrets by inspiration.

[Footnote 57: *_lettere incoronate_*. By this term Leonardo probably understands not the Bible only, but the works of the early Fathers, and all the books recognised as sacred by the Roman Church.] I leave alone the sacred books; for they are supreme truth.

On the relations of the soul to the organs of sense.

838.

HOW THE FIVE SENSES ARE THE MINISTERS OF THE SOUL.

The soul seems to reside in the judgment, and the judgment would seem to be seated in that part where all the senses meet; and this is called the Common Sense and is not all-pervading throughout the body, as many have thought. Rather is it entirely in one part. Because, if it were all-pervading and the same in every part, there would have been no need to make the instruments of the senses meet in one centre and in one single spot; on the contrary it would have sufficed that the eye should fulfil the function of its sensation on its surface only, and not transmit the image of the things seen, to the sense, by means of the optic nerves, so that the soul--for the reason given above-- may perceive it in the surface of the eye. In the same way as to the sense of hearing, it would have sufficed if the voice had merely sounded in the porous cavity of the indurated portion of the temporal bone which lies within the ear, without making any farther transit from this bone to the common sense, where the voice confers with and discourses to the common judgment. The sense of smell, again, is compelled by necessity to refer itself to that same judgment. Feeling passes through the perforated cords and is conveyed to this common sense. These cords diverge with infinite ramifications into the skin which encloses the members of the body and the viscera. The perforated cords convey volition and sensation to the subordinate limbs. These cords and the nerves direct the motions of the muscles and sinews, between which they are placed; these obey, and this obedience takes effect by reducing their thickness; for in swelling, their length is reduced, and the nerves shrink which are interwoven among the particles of the limbs; being extended to the tips of the fingers, they transmit to the sense the object which they touch.

The nerves with their muscles obey the tendons as soldiers obey the officers, and the tendons obey the Common [central] Sense as the officers obey the general. [27] Thus the joint of the bones obeys the nerve, and the nerve the muscle, and the muscle the tendon and the tendon the Common Sense. And the Common Sense is the seat of the

soul [28], and memory is its ammunition, and the impressibility is its referendary since the sense waits on the soul and not the soul on the sense. And where the sense that ministers to the soul is not at the service of the soul, all the functions of that sense are also wanting in that man's life, as is seen in those born mute and blind.

[Footnote: The peculiar use of the words _nervo_, _muscolo_, _corda_, _senso comune_, which are here literally rendered by nerve, muscle cord or tendon and Common Sense may be understood from lines 27 and 28.]

On involuntary muscular action.

839.

HOW THE NERVES SOMETIMES ACT OF THEMSELVES WITHOUT ANY COMMANDS FROM THE OTHER FUNCTIONS OF THE SOUL.

This is most plainly seen; for you will see palsied and shivering persons move, and their trembling limbs, as their head and hands, quake without leave from their soul and their soul with all its power cannot prevent their members from trembling. The same thing happens in falling sickness, or in parts that have been cut off, as in the tails of lizards. The idea or imagination is the helm and guiding-rein of the senses, because the thing conceived of moves the sense. Pre-imagining, is imagining the things that are to be. Post-imagining, is imagining the things that are past.

Miscellaneous physiological observations (840-842).

840.

There are four Powers: memory and intellect, desire and covetousness. The two first are mental and the others sensual. The three senses: sight, hearing and smell cannot well be prevented; touch and taste not at all. Smell is connected with taste in dogs and other gluttonous animals.

841.

I reveal to men the origin of the first, or perhaps second cause of their existence.

842.

Lust is the cause of generation.

Appetite is the support of life. Fear or timidity is the prolongation of life and preservation of its instruments.

The laws of nutrition and the support of life (843-848).

843.

HOW THE BODY OF ANIMALS IS CONSTANTLY DYING AND BEING RENEWED.

The body of any thing whatever that takes nourishment constantly dies and is constantly renewed; because nourishment can only enter into places where the former nourishment has expired, and if it has expired it no longer has life. And if you do not supply nourishment equal to the nourishment which is gone, life will fail in vigour, and if you take away this nourishment, the life is entirely destroyed. But if you restore as much is destroyed day by day, then as much of the life is renewed as is consumed, just as the flame of the candle is fed by the nourishment afforded by the liquid of this candle, which flame continually with a rapid supply restores to it from below as much as is consumed in dying above: and from a brilliant light is converted in dying into murky smoke; and this death is continuous, as the smoke is continuous; and the continuance of the smoke is equal to the continuance of the nourishment, and in the same instant all the flame is dead and all regenerated, simultaneously with the movement of its own nourishment.

844.

King of the animals--as thou hast described him--I should rather say king of the beasts, thou being the greatest--because thou hast spared slaying them, in order that they may give thee their children for the benefit of the gullet, of which thou hast attempted to make a sepulchre for all animals; and I would say still more, if it were allowed me to speak the entire truth [5]. But we do not go outside human matters in telling of one supreme wickedness, which does not happen among the animals of the earth, inasmuch as among them are found none who eat their own kind, unless through want of sense (few indeed among them, and those being mothers, as with men, albeit they be not many in number); and this happens only among the rapacious animals, as with the leonine species, and leopards, panthers lynxes, cats and the like, who sometimes eat their children; but thou, besides thy children devourest father, mother, brothers and friends; nor is this enough for thee, but thou goest to the chase on the islands of others, taking other men and these half-naked, the ... and the ... thou fattenest, and chasest them down thy own throat[18]; now does not nature produce enough simples, for thee to satisfy thyself? and if thou art not content with simples, canst thou not by the mixture of them make infinite compounds, as Platina wrote[Footnote 21: *_Come scrisse il Platina_* (Bartolomeo Sacchi, a famous humanist). The Italian edition of his treatise *_De arte coquinaria_*, was published under the title *_De la honesta voluptate, e valetudine, Venezia_* 1487.], and other authors on feeding?

[Footnote: We are led to believe that Leonardo himself was a vegetarian from the following interesting passage in the first of Andrea Corsali's letters to Giuliano de'Medici: *_Alcuni gentili chiamati Guzzarati non si cibano di cosa, alcuna che tenga sangue, ne fra essi loro consentono che si nocchia ad alcuna cosa animata,*

come il nostro Leonardo da Vinci_.

5-18. Amerigo Vespucci, with whom Leonardo was personally acquainted, writes in his second letter to Pietro Soderini, about the inhabitants of the Canary Islands after having stayed there in 1503: "_Hanno una scelerata liberta di viuere; ... si cibano di carne humana, di maniera che il padre magia il figliuolo, et all'incontro il figliuolo il padre secondo che a caso e per sorte auiene. Io viddi un certo huomo sceleratissimo che si vantaaua, et si teneua a non piccola gloria di hauer mangiato piu di trecento huomini. Viddi anche vna certa citta, nella quale io dimorai forse ventisette giorni, doue le carni humane, hauendole salate, eran appicate alli traui, si come noi alli traui di cucina__appicchiamo le carni di cinghali secche al sole o al fumo, et massimamente salsiccie, et altre simil cose: anzi si marauigliuano gradem ete che noi non magiaissimo della carne de nemici, le quali dicono muouere appetito, et essere di marauiglioso sapore, et le lodano come cibi soauo et delicati (Lettere due di Amerigo Vespucci Fiorentino drizzate al magnifico Pietro Soderini, Gonfaloniere della eccelsa Republica di Firenze_; various editions).]

845.

Our life is made by the death of others.

In dead matter insensible life remains, which, reunited to the stomachs of living beings, resumes life, both sensual and intellectual.

846.

Here nature appears with many animals to have been rather a cruel stepmother than a mother, and with others not a stepmother, but a most tender mother.

847.

Man and animals are really the passage and the conduit of food, the sepulchre of animals and resting place of the dead, one causing the death of the other, making themselves the covering for the corruption of other dead [bodies].

On the circulation of the blood (848-850).

848.

Death in old men, when not from fever, is caused by the veins which go from the spleen to the valve of the liver, and which thicken so much in the walls that they become closed up and leave no passage for the blood that nourishes it.

[6]The incessant current of the blood through the veins makes these veins thicken and become callous, so that at last they close up and

prevent the passage of the blood.

849.

The waters return with constant motion from the lowest depths of the sea to the utmost height of the mountains, not obeying the nature of heavier bodies; and in this they resemble the blood of animated beings which always moves from the sea of the heart and flows towards the top of the head; and here it may burst a vein, as may be seen when a vein bursts in the nose; all the blood rises from below to the level of the burst vein. When the water rushes out from the burst vein in the earth, it obeys the law of other bodies that are heavier than the air since it always seeks low places.

[Footnote: From this passage it is quite plain that Leonardo had not merely a general suspicion of the circulation of the blood but a very clear conception of it. Leonardo's studies on the muscles of the heart are to be found in the MS. W. An. III. but no information about them has hitherto been made public. The limits of my plan in this work exclude all purely anatomical writings, therefore only a very brief excerpt from this note book can be given here. WILLIAM HARVEY (born 1578 and Professor of Anatomy at Cambridge from 1615) is always considered to have been the discoverer of the circulation of the blood. He studied medicine at Padua in 1598, and in 1628 brought out his memorable and important work: *De motu cordis et sanguinis*.]

850.

That the blood which returns when the heart opens again is not the same as that which closes the valves of the heart.

Some notes on medicine (851-855).

851.

Make them give you the definition and remedies for the case ... and you will see that men are selected to be doctors for diseases they do not know.

852.

A remedy for scratches taught me by the Herald to the King of France. 4 ounces of virgin wax, 4 ounces of colophony, 2 ounces of incense. Keep each thing separate; and melt the wax, and then put in the incense and then the colophony, make a mixture of it and put it on the sore place.

853.

Medicine is the restoration of discordant elements; sickness is the discord of the elements infused into the living body.

854.

Those who are annoyed by sickness at sea should drink extract of wormwood.

855.

To keep in health, this rule is wise: Eat only when you want and relish food. Chew thoroughly that it may do you good. Have it well cooked, unspiced and undisguised. He who takes medicine is ill advised.

[Footnote: This appears to be a sketch for a poem.]

856.

I teach you to preserve your health; and in this you will succeed better in proportion as you shun physicians, because their medicines are the work of alchemists.

[Footnote: This passage is written on the back of the drawing Pl. CVIII. Compare also No. 1184.]

XV.

Astronomy.

Ever since the publication by Venturi in 1797 _and Libri in_ 1840 _of some few passages of Leonardo's astronomical notes, scientific astronomers have frequently expressed the opinion, that they must have been based on very important discoveries, and that the great painter also deserved a conspicuous place in the history of this science. In the passages here printed, a connected view is given of his astronomical studies as they lie scattered through the manuscripts, which have come down to us. Unlike his other purely scientific labours, Leonardo devotes here a good deal of attention to the opinions of the ancients, though he does not follow the practice universal in his day of relying on them as authorities; he only quotes them, as we shall see, in order to refute their arguments. His researches throughout have the stamp of independent thought. There is nothing in these writings to lead us to suppose that they were merely an epitome of the general learning common to the astronomers of the period. As early as in the XIVth century there were chairs of astronomy in the universities of Padua and Bologna, but so late as during the entire XVIth century Astronomy and Astrology were still closely allied._

It is impossible now to decide whether Leonardo, when living in Florence, became acquainted in his youth with the doctrines of Paolo Toscanelli the great astronomer and mathematician (died 1482_), of whose influence and teaching but little is now known, beyond the fact that he advised and encouraged Columbus to carry out his project of sailing round the world. His name is nowhere mentioned by

Leonardo, and from the dates of the manuscripts from which the texts on astronomy are taken, it seems highly probable that Leonardo devoted his attention to astronomical studies less in his youth than in his later years. It was evidently his purpose to treat of Astronomy in a connected form and in a separate work (see the beginning of Nos. 866 and 892; compare also No. 1167). It is quite in accordance with his general scientific thoroughness that he should propose to write a special treatise on Optics as an introduction to Astronomy (see Nos. 867 and 877). Some of the chapters belonging to this Section bear the title "Prospettiva" (see Nos. 869 and 870), this being the term universally applied at the time to Optics as well as Perspective (see Vol. I, p. 10, note to No. 13, l. 10).

At the beginning of the XVIth century the Ptolemaic theory of the universe was still universally accepted as the true one, and Leonardo conceives of the earth as fixed, with the moon and sun revolving round it, as they are represented in the diagram to No. 897. He does not go into any theory of the motions of the planets; with regard to these and the fixed stars he only investigates the phenomena of their luminosity. The spherical form of the earth he takes for granted as an axiom from the first, and he anticipates Newton by pointing out the universality of Gravitation not merely in the earth, but even in the moon. Although his acute research into the nature of the moon's light and the spots on the moon did not bring to light many results of lasting importance beyond making it evident that they were a refutation of the errors of his contemporaries, they contain various explanations of facts which modern science need not modify in any essential point, and discoveries which history has hitherto assigned to a very much later date.

The ingenious theory by which he tries to explain the nature of what is known as earth shine, the reflection of the sun's rays by the earth towards the moon, saying that it is a peculiar refraction, originating in the innumerable curved surfaces of the waves of the sea may be regarded as absurd; but it must not be forgotten that he had no means of detecting the fundamental error on which he based it, namely: the assumption that the moon was at a relatively short distance from the earth. So long as the motion of the earth round the sun remained unknown, it was of course impossible to form any estimate of the moon's distance from the earth by a calculation of its parallax.

Before the discovery of the telescope accurate astronomical observations were only possible to a very limited extent. It would appear however from certain passages in the notes here printed for the first time, that Leonardo was in a position to study the spots in the moon more closely than he could have done with the unaided eye. So far as can be gathered from the mysterious language in which the description of his instrument is wrapped, he made use of magnifying glasses; these do not however seem to have been constructed like a telescope--telescopes were first made about

1600. _As LIBRI pointed out_ (Histoire des Sciences mathematiques III, 101) _Fracastoro of Verona_ (1473-1553) _succeeded in magnifying the moon's face by an arrangement of lenses (compare No._ 910, _note), and this gives probability to Leonardo's invention at a not much earlier date._

I.

THE EARTH AS A PLANET.

The earth's place in the universe (857. 858).

857.

The equator, the line of the horizon, the ecliptic, the meridian:

These lines are those which in all their parts are equidistant from the centre of the globe.

858.

The earth is not in the centre of the Sun's orbit nor at the centre of the universe, but in the centre of its companion elements, and united with them. And any one standing on the moon, when it and the sun are both beneath us, would see this our earth and the element of water upon it just as we see the moon, and the earth would light it as it lights us.

The fundamental laws of the solar system (859-864).

859.

Force arises from dearth or abundance; it is the child of physical motion, and the grand-child of spiritual motion, and the mother and origin of gravity. Gravity is limited to the elements of water and earth; but this force is unlimited, and by it infinite worlds might be moved if instruments could be made by which the force could be generated.

Force, with physical motion, and gravity, with resistance are the four external powers on which all actions of mortals depend.

Force has its origin in spiritual motion; and this motion, flowing through the limbs of sentient animals, enlarges their muscles. Being enlarged by this current the muscles are shrunk in length and contract the tendons which are connected with them, and this is the cause of the force of the limbs in man.

The quality and quantity of the force of a man are able to give birth to other forces, which will be proportionally greater as the motions produced by them last longer.

[Footnote: Only part of this passage belongs, strictly speaking, to

this section. The principle laid down in the second paragraph is more directly connected with the notes given in the preceding section on Physiology.]

860.

Why does not the weight _o_ remain in its place? It does not remain because it has no resistance. Where will it move to? It will move towards the centre [of gravity]. And why by no other line? Because a weight which has no support falls by the shortest road to the lowest point which is the centre of the world. And why does the weight know how to find it by so short a line? Because it is not independant and does not move about in various directions.

[Footnote: This text and the sketch belonging to it, are reproduced on Pl. CXXI.]

861.

Let the earth turn on which side it may the surface of the waters will never move from its spherical form, but will always remain equidistant from the centre of the globe.

Granting that the earth might be removed from the centre of the globe, what would happen to the water?

It would remain in a sphere round that centre equally thick, but the sphere would have a smaller diameter than when it enclosed the earth.

[Footnote: Compare No. 896, lines 48-64; and No. 936.]

862.

Supposing the earth at our antipodes which supports the ocean were to rise and stand uncovered, far out of the sea, but remaining almost level, by what means afterwards, in the course of time, would mountains and vallies be formed?

And the rocks with their various strata?

863.

Each man is always in the middle of the surface of the earth and under the zenith of his own hemisphere, and over the centre of the earth.

864.

Mem.: That I must first show the distance of the sun from the earth; and, by means of a ray passing through a small hole into a dark chamber, detect its real size; and besides this, by means of the aqueous sphere calculate the size of the globe ...

Here it will be shown, that when the sun is in the meridian of our hemisphere [Footnote 10: *Antipodi orientali cogli occidentali*. The word *Antipodes* does not here bear its literal sense, but--as we may infer from the simultaneous reference to inhabitants of the North and South-- is used as meaning men living at a distance of 90 degrees from the zenith of the rational horizon of each observer.], the antipodes to the East and to the West, alike, and at the same time, see the sun mirrored in their waters; and the same is equally true of the arctic and antarctic poles, if indeed they are inhabited.

How to prove that the earth is a planet (865-867).

865.

That the earth is a star.

866.

In your discourse you must prove that the earth is a star much like the moon, and the glory of our universe; and then you must treat of the size of various stars, according to the authors.

867.

THE METHOD OF PROVING THAT THE EARTH IS A STAR.

First describe the eye; then show how the twinkling of a star is really in the eye and why one star should twinkle more than another, and how the rays from the stars originate in the eye; and add, that if the twinkling of the stars were really in the stars --as it seems to be--that this twinkling appears to be an extension as great as the diameter of the body of the star; therefore, the star being larger than the earth, this motion effected in an instant would be a rapid doubling of the size of the star. Then prove that the surface of the air where it lies contiguous to fire, and the surface of the fire where it ends are those into which the solar rays penetrate, and transmit the images of the heavenly bodies, large when they rise, and small, when they are on the meridian. Let *a* be the earth and *ndm* the surface of the air in contact with the sphere of fire; *hfg* is the orbit of the moon or, if you please, of the sun; then I say that when the sun appears on the horizon *g*, its rays are seen passing through the surface of the air at a slanting angle, that is *om*; this is not the case at *dk*. And so it passes through a greater mass of air; all of *em* is a denser atmosphere.

868.

Beyond the sun and us there is darkness and so the air appears blue.

[Footnote: Compare Vol. I, No. 301.]

PERSPECTIVE.

It is possible to find means by which the eye shall not see remote objects as much diminished as in natural perspective, which diminishes them by reason of the convexity of the eye which necessarily intersects, at its surface, the pyramid of every image conveyed to the eye at a right angle on its spherical surface. But by the method I here teach in the margin [9] these pyramids are intersected at right angles close to the surface of the pupil. The convex pupil of the eye can take in the whole of our hemisphere, while this will show only a single star; but where many small stars transmit their images to the surface of the pupil those stars are extremely small; here only one star is seen but it will be large.

And so the moon will be seen larger and its spots of a more defined form [Footnote 20 and fol.: Telescopes were not in use till a century later. Compare No. 910 and page 136.]. You must place close to the eye a glass filled with the water of which mention is made in number 4 of Book 113 "On natural substances" [Footnote 23: *_libro_* 113. This is perhaps the number of a book in some library catalogue. But it may refer, on the other hand, to one of the 120 Books mentioned in No. 796. l. 84.]; for this water makes objects which are enclosed in balls of crystalline glass appear free from the glass.

OF THE EYE.

Among the smaller objects presented to the pupil of the eye, that which is closest to it, will be least appreciable to the eye. And at the same time, the experiments here made with the power of sight, show that it is not reduced to speck if the &c. [32][Footnote 32: Compare with this the passage in Vol. I, No. 52, written about twenty years earlier.].

Read in the margin.

[34]Those objects are seen largest which come to the eye at the largest angles.

But the images of the objects conveyed to the pupil of the eye are distributed to the pupil exactly as they are distributed in the air: and the proof of this is in what follows; that when we look at the starry sky, without gazing more fixedly at one star than another, the sky appears all strewn with stars; and their proportions to the eye are the same as in the sky and likewise the spaces between them [61].

[Footnote: 9. 32. *_in margine:_* lines 34-61 are, in the original, written on the margin and above them is the diagram to which Leonardo seems to refer here.]

PERSPECTIVE.

Among objects moved from the eye at equal distance, that undergoes least diminution which at first was most remote.

When various objects are removed at equal distances farther from their original position, that which was at first the farthest from the eye will diminish least. And the proportion of the diminution will be in proportion to the relative distance of the objects from the eye before they were removed.

That is to say in the object *_t_* and the object *_e_* the proportion of their distances from the eye *_a_* is quintuple. I remove each from its place and set it farther from the eye by one of the 5 parts into which the proposition is divided. Hence it happens that the nearest to the eye has doubled the distance and according to the last proposition but one of this, is diminished by the half of its whole size; and the body *_e_*, by the same motion, is diminished 1/5 of its whole size. Therefore, by that same last proposition but one, that which is said in this last proposition is true; and this I say of the motions of the celestial bodies which are more distant by 3500 miles when setting than when overhead, and yet do not increase or diminish in any sensible degree.

871.

a b is the aperture through which the sun passes, and if you could measure the size of the solar rays at *_n m_*, you could accurately trace the real lines of the convergence of the solar rays, the mirror being at *_a b_*, and then show the reflected rays at equal angles to *_n m_*; but, as you want to have them at *_n m_*, take them at the inner side of the aperture at *cd*, where they maybe measured at the spot where the solar rays fall. Then place your mirror at the distance *_a b_*, making the rays *_d b_*, *_c a_* fall and then be reflected at equal angles towards *_c d_*; and this is the best method, but you must use this mirror always in the same month, and the same day, and hour and instant, and this will be better than at no fixed time because when the sun is at a certain distance it produces a certain pyramid of rays.

872.

a, the side of the body in light and shade *_b_*, faces the whole portion of the hemisphere *bed_e f_*, and does not face any part of the darkness of the earth. And the same occurs at the point *_o_*; therefore the space *a_o_* is throughout of one and the same brightness, and *s* faces only four degrees of the hemisphere *_d e f g h_*, and also the whole of the earth *_s h_*, which will render it darker; and how much must be demonstrated by calculation. [Footnote: This passage, which has perhaps a doubtful right to its place in this connection, stands in the Manuscript between those given in Vol. I as No. 117 and No. 427.]

873.

THE REASON OF THE INCREASED SIZE OF THE SUN IN THE WEST.

Some mathematicians explain that the sun looks larger as it sets, because the eye always sees it through a denser atmosphere, alleging that objects seen through mist or through water appear larger. To these I reply: No; because objects seen through a mist are similar in colour to those at a distance; but not being similarly diminished they appear larger. Again, nothing increases in size in smooth water; and the proof of this may be seen by throwing a light on a board placed half under water. But the reason why the sun looks larger is that every luminous body appears larger in proportion as it is more remote. [Footnote: Lines 5 and 6 are thus rendered by M. RAVAISSON in his edition of MS. A. "_De meme, aucune chose ne croit dans l'eau plane, et tu en feras l'experience_ en calquant un ais sous l'eau."--Compare the diagrams in Vol. I, p. 114.]

On the luminosity of the Earth in the universal space (874-878).

874.

In my book I propose to show, how the ocean and the other seas must, by means of the sun, make our world shine with the appearance of a moon, and to the remoter worlds it looks like a star; and this I shall prove.

Show, first that every light at a distance from the eye throws out rays which appear to increase the size of the luminous body; and from this it follows that 2 ...[Footnote 10: Here the text breaks off; lines 11 and fol. are written in the margin.]

[11]The moon is cold and moist. Water is cold and moist. Thus our seas must appear to the moon as the moon does to us.

875.

The waves in water magnify the image of an object reflected in it.

Let a be the sun, and m the ruffled water, b the image of the sun when the water is smooth. Let f be the eye which sees the image in all the waves included within the base of the triangle cef . Now the sun reflected in the unruffled surface occupied the space cd , while in the ruffled surface it covers all the watery space ce (as is proved in the 4th of my "Perspective") [Footnote 9: "_Nel quarto della mia prospettiva_". If this reference is to the diagrams accompanying the text--as is usual with Leonardo--and not to some particular work, the largest of the diagrams here given must be meant. It is the lowest and actually the fifth, but he would have called it the fourth, for the text here given is preceded on the same page of the manuscript by a passage on whirlpools, with the diagram belonging to it also reproduced here. The words *della mia*

prospettiva_ may therefore indicate that the diagram to the preceding chapter treating on a heterogeneous subject is to be excluded. It is a further difficulty that this diagram belongs properly to lines 9-10 and not to the preceding sentence. The reflection of the sun in water is also discussed in the Theoretical part of the Book on Painting; see Vol. I, No. 206, 207.] and it will cover more of the water in proportion as the reflected image is remote from the eye [10].

[Footnote: In the original sketch, inside the circle in the first diagram, is written _Sole_ (sun), and to the right of it _luna_ (moon). Thus either of these heavenly bodies may be supposed to fill that space. Within the lower circle is written _simulacro_ (image). In the two next diagrams at the spot here marked _L_ the word _Luna_ is written, and in the last _sole_ is written in the top circle at _a_.]

The image of the sun will be more brightly shown in small waves than in large ones--and this is because the reflections or images of the sun are more numerous in the small waves than in large ones, and the more numerous reflections of its radiance give a larger light than the fewer.

Waves which intersect like the scales of a fir cone reflect the image of the sun with the greatest splendour; and this is the case because the images are as many as the ridges of the waves on which the sun shines, and the shadows between these waves are small and not very dark; and the radiance of so many reflections together becomes united in the image which is transmitted to the eye, so that these shadows are imperceptible.

That reflection of the sun will cover most space on the surface of the water which is most remote from the eye which sees it.

Let _a_ be the sun, _p q_ the reflection of the sun; _a b_ is the surface of the water, in which the sun is mirrored, and _r_ the eye which sees this reflection on the surface of the water occupying the space _o m_. _c_ is the eye at a greater distance from the surface of the water and also from the reflection; hence this reflection covers a larger space of water, by the distance between _n_ and _o_.

876.

It is impossible that the side of a spherical mirror, illuminated by the sun, should reflect its radiance unless this mirror were undulating or filled with bubbles.

You see here the sun which lights up the moon, a spherical mirror, and all of its surface, which faces the sun is rendered radiant.

Whence it may be concluded that what shines in the moon is water like that of our seas, and in waves as that is; and that portion which does not shine consists of islands and terra firma.

This diagram, of several spherical bodies interposed between the eye and the sun, is given to show that, just as the reflection of the sun is seen in each of these bodies, in the same way that image may be seen in each curve of the waves of the sea; and as in these many spheres many reflections of the sun are seen, so in many waves there are many images, each of which at a great distance is much magnified to the eye. And, as this happens with each wave, the spaces interposed between the waves are concealed; and, for this reason, it looks as though the many suns mirrored in the many waves were but one continuous sun; and the shadows,, mixed up with the luminous images, render this radiance less brilliant than that of the sun mirrored in these waves.

[Footnote: In the original, at letter A in the diagram "Sole" (the sun) is written, and at o "occhio" (the eye).]

877.

This will have before it the treatise on light and shade.

The edges in the moon will be most strongly lighted and reflect most light, because, there, nothing will be visible but the tops of the waves of the water [Footnote 5: I have thought it unnecessary to reproduce the detailed explanation of the theory of reflection on waves contained in the passage which follows this.].

878.

The sun will appear larger in moving water or on waves than in still water; an example is the light reflected on the strings of a monochord.

II.

THE SUN.

The question of the true and of the apparent size of the sun (879-884).

879.

IN PRAISE OF THE SUN.

If you look at the stars, cutting off the rays (as may be done by looking through a very small hole made with the extreme point of a very fine needle, placed so as almost to touch the eye), you will see those stars so minute that it would seem as though nothing could be smaller; it is in fact their great distance which is the reason of their diminution, for many of them are very many times larger than the star which is the earth with water. Now reflect what this our star must look like at such a distance, and then consider how many stars might be added--both in longitude and latitude--between

those stars which are scattered over the darkened sky. But I cannot forbear to condemn many of the ancients, who said that the sun was no larger than it appears; among these was Epicurus, and I believe that he founded his reason on the effects of a light placed in our atmosphere equidistant from the centre of the earth. Any one looking at it never sees it diminished in size at whatever distance; and the rea-

[Footnote 879-882: What Leonardo says of Epicurus-- who according to LEWIS, *The Astronomy of the ancients*, and MADLER, *Geschichte der Himmelskunde*, did not devote much attention to the study of celestial phenomena-- he probably derived from Book X of Diogenes Laertius, whose *Vitae Philosophorum* was not printed in Greek till 1533, but the Latin translation appeared in 1475.]

880.

sons of its size and power I shall reserve for Book 4. But I wonder greatly that Socrates

[Footnote 2: *Socrates*; I have little light to throw on this reference. Plato's Socrates himself declares on more than one occasion that in his youth he had turned his mind to the study of celestial phenomena (METEWPA) but not in his later years (see G. C. LEWIS, *The Astronomy of the ancients*, page 109; MADLER, *Geschichte der Himmelskunde*, page 41). Here and there in Plato's writings we find incidental notes on the sun and other heavenly bodies. Leonardo may very well have known of these, since the Latin version by Ficinus was printed as early as 1491; indeed an undated edition exists which may very likely have appeared between 1480--90.

There is but one passage in Plato, *Epinomis* (p. 983) where he speaks of the physical properties of the sun and says that it is larger than the earth.

Aristotle who goes very fully into the subject says the same. A complete edition of Aristotele's works was first printed in Venice 1495-98, but a Latin version of the Books *De Coelo et Mundo* and *De Physica* had been printed in Venice as early as in 1483 (H. MULLER-STRUBING).]

should have depreciated that solar body, saying that it was of the nature of incandescent stone, and the one who opposed him as to that error was not far wrong. But I only wish I had words to serve me to blame those who are fain to extol the worship of men more than that of the sun; for in the whole universe there is nowhere to be seen a body of greater magnitude and power than the sun. Its light gives light to all the celestial bodies which are distributed throughout the universe; and from it descends all vital force, for the heat that is in living beings comes from the soul [vital spark]; and there is no other centre of heat and light in the universe as will be shown in Book 4; and certainly those who have chosen to worship men as gods--as Jove, Saturn, Mars and the like--have fallen into

the gravest error, seeing that even if a man were as large as our earth, he would look no bigger than a little star which appears but as a speck in the universe; and seeing again that these men are mortal, and putrid and corrupt in their sepulchres.

Marcellus [Footnote 23: I have no means of identifying _Marcello_ who is named in the margin. It may be Nonius Marcellus, an obscure Roman Grammarian of uncertain date (between the IInd and Vth centuries A. C.) the author of the treatise _De compendiosa doctrina per litteras ad filium_ in which he treats _de rebus omnibus et quibusdam aliis_. This was much read in the middle ages. The _editto princeps_ is dated 1470 (H. MULLER-STRUBING).] and many others praise the sun.

881.

Epicurus perhaps saw the shadows cast by columns on the walls in front of them equal in diameter to the columns from which the shadows were cast; and the breadth of the shadows being parallel from beginning to end, he thought he might infer that the sun also was directly opposite to this parallel and that consequently its breadth was not greater than that of the column; not perceiving that the diminution in the shadow was insensibly slight by reason of the remoteness of the sun. If the sun were smaller than the earth, the stars on a great portion of our hemisphere would have no light, which is evidence against Epicurus who says the sun is only as large as it appears.

[Footnote: In the original the writing is across the diagram.]

882.

Epicurus says the sun is the size it looks. Hence as it looks about a foot across we must consider that to be its size; it would follow that when the moon eclipses the sun, the sun ought not to appear the larger, as it does. Then, the moon being smaller than the sun, the moon must be less than a foot, and consequently when our world eclipses the moon, it must be less than a foot by a finger's breadth; inasmuch as if the sun is a foot across, and our earth casts a conical shadow on the moon, it is inevitable that the luminous cause of the cone of shadow must be larger than the opaque body which casts the cone of shadow.

883.

To measure how many times the diameter of the sun will go into its course in 24 hours.

Make a circle and place it to face the south, after the manner of a sundial, and place a rod in the middle in such a way as that its length points to the centre of this circle, and mark the shadow cast in the sunshine by this rod on the circumference of the circle, and this shadow will be--let us say-- as broad as from _a_ to _n_. Now

measure how many times this shadow will go into this circumference of a circle, and that will give you the number of times that the solar body will go into its orbit in 24 hours. Thus you may see whether Epicurus was [right in] saying that the sun was only as large as it looked; for, as the apparent diameter of the sun is about a foot, and as that sun would go a thousand times into the length of its course in 24 hours, it would have gone a thousand feet, that is 300 braccia, which is the sixth of a mile. Whence it would follow that the course of the sun during the day would be the sixth part of a mile and that this venerable snail, the sun will have travelled 25 braccia an hour.

884.

Posidonius composed books on the size of the sun. [Footnote: Poseidonius of Apamea, commonly called the Rhodian, because he taught in Rhodes, was a Stoic philosopher, a contemporary and friend of Cicero's, and the author of numerous works on natural science, among them.

Strabo quotes no doubt from one of his works, when he says that Poseidonius explained how it was that the sun looked larger when it was rising or setting than during the rest of its course (III, p. 135). Kleomedes, a later Greek Naturalist also mentions this observation of Poseidonius' without naming the title of his work; however, as Kleomedes' *Cyclia Theorica* was not printed till 1535, Leonardo must have derived his quotation from Strabo. He probably wrote this note in 1508, and as the original Greek was first printed in Venice in 1516, we must suppose him to quote here from the translation by Guarinus Veronensis, which was printed as early as 1471, also at Venice (H. MULLER-STRUBING).]

Of the nature of Sunlight.

885.

OF THE PROOF THAT THE SUN IS HOT BY NATURE AND NOT BY VIRTUE.

Of the nature of Sunlight.

That the heat of the sun resides in its nature and not in its virtue [or mode of action] is abundantly proved by the radiance of the solar body on which the human eye cannot dwell and besides this no less manifestly by the rays reflected from a concave mirror, which--when they strike the eye with such splendour that the eye cannot bear them--have a brilliancy equal to the sun in its own place. And that this is true I prove by the fact that if the mirror has its concavity formed exactly as is requisite for the collecting and reflecting of these rays, no created being could endure the heat that strikes from the reflected rays of such a mirror. And if you argue that the mirror itself is cold and yet send forth hot rays, I should reply that those rays come really from the sun and that it is the ray of the concave mirror after having passed through

the window.

Considerations as to the size of the sun (886-891).

886.

The sun does not move. [Footnote: This sentence occurs incidentally among mathematical notes, and is written in unusually large letters.]

887.

PROOF THAT THE NEARER YOU ARE TO THE SOURCE OF THE SOLAR RAYS, THE LARGER WILL THE REFLECTION OF THE SUN FROM THE SEA APPEAR TO YOU.

[Footnote: Lines 4 and fol. Compare Vol. I, Nos. 130, 131.] If it is from the centre that the sun employs its radiance to intensify the power of its whole mass, it is evident that the farther its rays extend, the more widely they will be divided; and this being so, you, whose eye is near the water that mirrors the sun, see but a small portion of the rays of the sun strike the surface of the water, and reflecting the form of the sun. But if you were near to the sun--as would be the case when the sun is on the meridian and the sea to the westward--you would see the sun, mirrored in the sea, of a very great size; because, as you are nearer to the sun, your eye taking in the rays nearer to the point of radiation takes more of them in, and a great splendour is the result. And in this way it can be proved that the moon must have seas which reflect the sun, and that the parts which do not shine are land.

888.

Take the measure of the sun at the solstice in mid-June.

889.

WHY THE SUN APPEARS LARGER WHEN SETTING THAN AT NOON, WHEN IT IS NEAR TO US.

Every object seen through a curved medium seems to be of larger size than it is.

[Footnote: At A is written _sole_ (the sun), at B _terra_ (the earth).]

890.

Because the eye is small it can only see the image of the sun as of a small size. If the eye were as large as the sun it would see the image of the sun in water of the same size as the real body of the sun, so long as the water is smooth.

891.

A METHOD OF SEEING THE SUN ECLIPSED WITHOUT PAIN TO THE EYE.

Take a piece of paper and pierce holes in it with a needle, and look at the sun through these holes.

III.

THE MOON.

On the luminosity of the moon (892-901).

892.

OF THE MOON.

As I propose to treat of the nature of the moon, it is necessary that first I should describe the perspective of mirrors, whether plane, concave or convex; and first what is meant by a luminous ray, and how it is refracted by various kinds of media; then, when a reflected ray is most powerful, whether when the angle of incidence is acute, right, or obtuse, or from a convex, a plane, or a concave surface; or from an opaque or a transparent body. Besides this, how it is that the solar rays which fall on the waves of the sea, are seen by the eye of the same width at the angle nearest to the eye, as at the highest line of the waves on the horizon; but notwithstanding this the solar rays reflected from the waves of the sea assume the pyramidal form and consequently, at each degree of distance increase proportionally in size, although to our sight, they appear as parallel.

1st. Nothing that has very little weight is opaque.

2dly. Nothing that is excessively weighty can remain beneath that which is heavier.

3dly. As to whether the moon is situated in the centre of its elements or not.

And, if it has no proper place of its own, like the earth, in the midst of its elements, why does it not fall to the centre of our elements? [Footnote 26: The problem here propounded by Leonardo was not satisfactorily answered till Newton in 1682 formulated the law of universal attraction and gravitation. Compare No. 902, lines 5-15.]

And, if the moon is not in the centre of its own elements and yet does not fall, it must then be lighter than any other element.

And, if the moon is lighter than the other elements why is it opaque and not transparent?

When objects of various sizes, being placed at various distances,

look of equal size, there must be the same relative proportion in the distances as in the magnitudes of the objects.

[Footnote: In the diagram Leonardo wrote _sole_ at the place marked _A_.]

893.

OF THE MOON AND WHETHER IT IS POLISHED AND SPHERICAL.

The image of the sun in the moon is powerfully luminous, and is only on a small portion of its surface. And the proof may be seen by taking a ball of burnished gold and placing it in the dark with a light at some distance from it; and then, although it will illuminate about half of the ball, the eye will perceive its reflection only in a small part of its surface, and all the rest of the surface reflects the darkness which surrounds it; so that it is only in that spot that the image of the light is seen, and all the rest remains invisible, the eye being at a distance from the ball. The same thing would happen on the surface of the moon if it were polished, lustrous and opaque, like all bodies with a reflecting surface.

Show how, if you were standing on the moon or on a star, our earth would seem to reflect the sun as the moon does.

And show that the image of the sun in the sea cannot appear one and undivided, as it appears in a perfectly plane mirror.

894.

How shadows are lost at great distances, as is shown by the shadow side of the moon which is never seen. [Footnote: Compare also Vol. I, Nos. 175-179.]

895.

Either the moon has intrinsic luminosity or not. If it has, why does it not shine without the aid of the sun? But if it has not any light in itself it must of necessity be a spherical mirror; and if it is a mirror, is it not proved in Perspective that the image of a luminous object will never be equal to the extent of surface of the reflecting body that it illuminates? And if it be thus [Footnote 13: At A, in the diagram, Leonardo wrote "_sole_" (the sun), and at B "_luna o noi terra_" (the moon or our earth). Compare also the text of No. 876.], as is here shown at _r s_ in the figure, whence comes so great an extent of radiance as that of the full moon as we see it, at the fifteenth day of the moon?

896.

OF THE MOON.

The moon has no light in itself; but so much of it as faces the sun is illuminated, and of that illumined portion we see so much as faces the earth. And the moon's night receives just as much light as is lent it by our waters as they reflect the image of the sun, which is mirrored in all those waters which are on the side towards the sun. The outside or surface of the waters forming the seas of the moon and of the seas of our globe is always ruffled little or much, or more or less--and this roughness causes an extension of the numberless images of the sun which are repeated in the ridges and hollows, the sides and fronts of the innumerable waves; that is to say in as many different spots on each wave as our eyes find different positions to view them from. This could not happen, if the aqueous sphere which covers a great part of the moon were uniformly spherical, for then the images of the sun would be one to each spectator, and its reflections would be separate and independent and its radiance would always appear circular; as is plainly to be seen in the gilt balls placed on the tops of high buildings. But if those gilt balls were rugged or composed of several little balls, like mulberries, which are a black fruit composed of minute round globules, then each portion of these little balls, when seen in the sun, would display to the eye the lustre resulting from the reflection of the sun, and thus, in one and the same body many tiny suns would be seen; and these often combine at a long distance and appear as one. The lustre of the new moon is brighter and stronger, than when the moon is full; and the reason of this is that the angle of incidence is more obtuse in the new than in the full moon, in which the angles [of incidence and reflection] are highly acute. The waves of the moon therefore mirror the sun in the hollows of the waves as well as on the ridges, and the sides remain in shadow. But at the sides of the moon the hollows of the waves do not catch the sunlight, but only their crests; and thus the images are fewer and more mixed up with the shadows in the hollows; and this intermingling of the shaded and illuminated spots comes to the eye with a mitigated splendour, so that the edges will be darker, because the curves of the sides of the waves are insufficient to reflect to the eye the rays that fall upon them. Now the new moon naturally reflects the solar rays more directly towards the eye from the crests of the waves than from any other part, as is shown by the form of the moon, whose rays a strike the waves _b_ and are reflected in the line _b d_, the eye being situated at _d_. This cannot happen at the full moon, when the solar rays, being in the west, fall on the extreme waters of the moon to the East from _n_ to _m_, and are not reflected to the eye in the West, but are thrown back eastwards, with but slight deflection from the straight course of the solar ray; and thus the angle of incidence is very wide indeed.

The moon is an opaque and solid body and if, on the contrary, it were transparent, it would not receive the light of the sun.

The yellow or yolk of an egg remains in the middle of the albumen, without moving on either side; now it is either lighter or heavier than this albumen, or equal to it; if it is lighter, it ought to

rise above all the albumen and stop in contact with the shell of the egg; and if it is heavier, it ought to sink, and if it is equal, it might just as well be at one of the ends, as in the middle or below [54].

[Footnote 48-64: Compare No. 861.]

The innumerable images of the solar rays reflected from the innumerable waves of the sea, as they fall upon those waves, are what cause us to see the very broad and continuous radiance on the surface of the sea.

897.

That the sun could not be mirrored in the body of the moon, which is a convex mirror, in such a way as that so much of its surface as is illuminated by the sun, should reflect the sun unless the moon had a surface adapted to reflect it--in waves and ridges, like the surface of the sea when its surface is moved by the wind.

[Footnote: In the original diagrams *_sole_* is written at the place marked *_A_*; *luna_* at *_C_*, and *_terra_* at the two spots marked *_B_*.]

The waves in water multiply the image of the object reflected in it.

These waves reflect light, each by its own line, as the surface of the fir cone does [Footnote 14: See the diagram p. 145.]

These are 2 figures one different from the other; one with undulating water and the other with smooth water.

It is impossible that at any distance the image of the sun cast on the surface of a spherical body should occupy the half of the sphere.

Here you must prove that the earth produces all the same effects with regard to the moon, as the moon with regard to the earth.

The moon, with its reflected light, does not shine like the sun, because the light of the moon is not a continuous reflection of that of the sun on its whole surface, but only on the crests and hollows of the waves of its waters; and thus the sun being confusedly reflected, from the admixture of the shadows that lie between the lustrous waves, its light is not pure and clear as the sun is.

[Footnote 38: This refers to the small diagram placed between *_B_* and *_B_*--]. The earth between the moon on the fifteenth day and the sun. [Footnote 39: See the diagram below the one referred to in the preceding note.] Here the sun is in the East and the moon on the fifteenth day in the West. [Footnote 40.41: Refers to the diagram below the others.] The moon on the fifteenth [day] between the earth and the sun. [41]Here it is the moon which has the sun to the West and the earth to the East.

898.

WHAT SORT OF THING THE MOON IS.

The moon is not of itself luminous, but is highly fitted to assimilate the character of light after the manner of a mirror, or of water, or of any other reflecting body; and it grows larger in the East and in the West, like the sun and the other planets. And the reason is that every luminous body looks larger in proportion as it is remote. It is easy to understand that every planet and star is farther from us when in the West than when it is overhead, by about 3500 miles, as is proved on the margin [Footnote 7: refers to the first diagram.--A = *_sole_* (the sun), B = *_terra_* (the earth), C = *_luna_* (the moon).], and if you see the sun or moon mirrored in the water near to you, it looks to you of the same size in the water as in the sky. But if you recede to the distance of a mile, it will look 100 times larger; and if you see the sun reflected in the sea at sunset, its image would look to you more than 10 miles long; because that reflected image extends over more than 10 miles of sea. And if you could stand where the moon is, the sun would look to you, as if it were reflected from all the sea that it illuminates by day; and the land amid the water would appear just like the dark spots that are on the moon, which, when looked at from our earth, appears to men the same as our earth would appear to any men who might dwell in the moon.

[Footnote: This text has already been published by LIBRI: *_Histoire des Sciences, III_*, pp. 224, 225.]

OF THE NATURE OF THE MOON.

When the moon is entirely lighted up to our sight, we see its full daylight; and at that time, owing to the reflection of the solar rays which fall on it and are thrown off towards us, its ocean casts off less moisture towards us; and the less light it gives the more injurious it is.

899.

OF THE MOON.

I say that as the moon has no light in itself and yet is luminous, it is inevitable but that its light is caused by some other body.

900.

OF THE MOON.

All my opponent's arguments to say that there is no water in the moon. [Footnote: The objections are very minutely noted down in the manuscript, but they hardly seem to have a place here.]

901.

Answer to Maestro Andrea da Imola, who said that the solar rays reflected from a convex mirror are mingled and lost at a short distance; whereby it is altogether denied that the luminous side of the moon is of the nature of a mirror, and that consequently the light is not produced by the innumerable multitude of the waves of that sea, which I declared to be the portion of the moon which is illuminated by the solar rays.

Let o be the body of the sun, c the moon, and b the eye which, above the base c of the cathetus cm , sees the body of the sun reflected at equal angles c ; and the same again on moving the eye from b to a . [Footnote: The large diagram on the margin of page 161 belongs to this chapter.]

Explanation of the lumen cinereum in the moon.

902.

OF THE MOON.

No solid body is less heavy than the atmosphere.

[Footnote: 1. On the margin are the words *tola romantina*, *tola--ferro stagnato* (tinned iron); *romantina* is some special kind of sheet-iron no longer known by that name.]

Having proved that the part of the moon that shines consists of water, which mirrors the body of the sun and reflects the radiance it receives from it; and that, if these waters were devoid of waves, it would appear small, but of a radiance almost like the sun; --[5] It must now be shown whether the moon is a heavy or a light body: for, if it were a heavy body--admitting that at every grade of distance from the earth greater levity must prevail, so that water is lighter than the earth, and air than water, and fire than air and so on successively--it would seem that if the moon had density as it really has, it would have weight, and having weight, that it could not be sustained in the space where it is, and consequently that it would fall towards the centre of the universe and become united to the earth; or if not the moon itself, at least its waters would fall away and be lost from it, and descend towards the centre, leaving the moon without any and so devoid of lustre. But as this does not happen, as might in reason be expected, it is a manifest sign that the moon is surrounded by its own elements: that is to say water, air and fire; and thus is, of itself and by itself, suspended in that part of space, as our earth with its element is in this part of space; and that heavy bodies act in the midst of its elements just as other heavy bodies do in ours [Footnote 15: This passage would certainly seem to establish Leonardo's claim to be regarded as the original discoverer of the cause of the ashy colour of the new moon (*lumen cinereum*). His observations however, having hitherto remained unknown to astronomers, Moestlin and Kepler have been

credited with the discoveries which they made independently a century later.

Some disconnected notes treat of the same subject in MS. C. A. 239b; 718b and 719b; "_Perche la luna cinta della parte alluminata dal sole in ponente, tra maggior splendore in mezzo a tal cerchio, che quando essa eclissava il sole. Questo accade perche nell' eclissare il sole ella ombrava il nostro oceano, il qual caso non accade essendo in ponente, quando il sole alluma esso oceano_." The editors of the "_Saggio_" who first published this passage (page 12) add another short one about the seasons in the moon which I confess not to have seen in the original manuscript: "_La luna ha ogni mese un verno e una state, e ha maggiori freddi e maggiori caldi, e i suoi equinozii son piu freddi de' nostri._"]

When the eye is in the East and sees the moon in the West near to the setting sun, it sees it with its shaded portion surrounded by luminous portions; and the lateral and upper portion of this light is derived from the sun, and the lower portion from the ocean in the West, which receives the solar rays and reflects them on the lower waters of the moon, and indeed affords the part of the moon that is in shadow as much radiance as the moon gives the earth at midnight. Therefore it is not totally dark, and hence some have believed that the moon must in parts have a light of its own besides that which is given it by the sun; and this light is due, as has been said, to the above- mentioned cause,--that our seas are illuminated by the sun.

Again, it might be said that the circle of radiance shown by the moon when it and the sun are both in the West is wholly borrowed from the sun, when it, and the sun, and the eye are situated as is shown above.

[Footnote 23. 24: The larger of the two diagrams reproduced above stands between these two lines, and the smaller one is sketched in the margin. At the spot marked _A_ Leonardo wrote _corpo solare_ (solar body) in the larger diagram and _Sole_ (sun) in the smaller one. At _C luna_ (moon) is written and at _B terra_ (the earth).]

Some might say that the air surrounding the moon as an element, catches the light of the sun as our atmosphere does, and that it is this which completes the luminous circle on the body of the moon.

Some have thought that the moon has a light of its own, but this opinion is false, because they have founded it on that dim light seen between the horns of the new moon, which looks dark where it is close to the bright part, while against the darkness of the background it looks so light that many have taken it to be a ring of new radiance completing the circle where the tips of the horns illuminated by the sun cease to shine [Footnote 34: See Pl. CVIII, No. 5.]. And this difference of background arises from the fact that the portion of that background which is conterminous with the bright part of the moon, by comparison with that brightness looks darker than it is; while at the upper part, where a portion of the luminous

circle is to be seen of uniform width, the result is that the moon, being brighter there than the medium or background on which it is seen by comparison with that darkness it looks more luminous at that edge than it is. And that brightness at such a time itself is derived from our ocean and other inland-seas. These are, at that time, illuminated by the sun which is already setting in such a way as that the sea then fulfils the same function to the dark side of the moon as the moon at its fifteenth day does to us when the sun is set. And the small amount of light which the dark side of the moon receives bears the same proportion to the light of that side which is illuminated, as that... [Footnote 42: Here the text breaks off; lines 43-52 are written on the margin.]

If you want to see how much brighter the shaded portion of the moon is than the background on which it is seen, conceal the luminous portion of the moon with your hand or with some other more distant object.

On the spots in the moon (903-907).

903.

THE SPOTS ON THE MOON.

Some have said that vapours rise from the moon, after the manner of clouds and are interposed between the moon and our eyes. But, if this were the case, these spots would never be permanent, either as to position or form; and, seeing the moon from various aspects, even if these spots did not move they would change in form, as objects do which are seen from different sides.

904.

OF THE SPOTS ON THE MOON.

Others say that the moon is composed of more or less transparent parts; as though one part were something like alabaster and others like crystal or glass. It would follow from this that the sun casting its rays on the less transparent portions, the light would remain on the surface, and so the denser part would be illuminated, and the transparent portions would display the shadow of their darker depths; and this is their account of the structure and nature of the moon. And this opinion has found favour with many philosophers, and particularly with Aristotle, and yet it is a false view--for, in the various phases and frequent changes of the moon and sun to our eyes, we should see these spots vary, at one time looking dark and at another light: they would be dark when the sun is in the West and the moon in the middle of the sky; for then the transparent hollows would be in shadow as far as the tops of the edges of those transparent hollows, because the sun could not then fling his rays into the mouth of the hollows, which however, at full moon, would be seen in bright light, at which time the moon is in the East and faces the sun in the West; then the sun would

illuminate even the lowest depths of these transparent places and thus, as there would be no shadows cast, the moon at these times would not show us the spots in question; and so it would be, now more and now less, according to the changes in the position of the sun to the moon, and of the moon to our eyes, as I have said above.

905.

OF THE SPOTS ON THE MOON.

It has been asserted, that the spots on the moon result from the moon being of varying thinness or density; but if this were so, when there is an eclipse of the moon the solar rays would pierce through the portions which were thin as is alleged [Footnote 3-5: *_Eclissi_*. This word, as it seems to me, here means eclipses of the sun; and the sense of the passage, as I understand it, is that by the foregoing hypothesis the moon, when it comes between the sun and the earth must appear as if pierced,--we may say like a sieve.]. But as we do not see this effect the opinion must be false.

Others say that the surface of the moon is smooth and polished and that, like a mirror, it reflects in itself the image of our earth.

This view is also false, inasmuch as the land, where it is not covered with water, presents various aspects and forms. Hence when the moon is in the East it would reflect different spots from those it would show when it is above us or in the West; now the spots on the moon, as they are seen at full moon, never vary in the course of its motion over our hemisphere. A second reason is that an object reflected in a convex body takes up but a small portion of that body, as is proved in perspective [Footnote 18: *_come e provato_*. This alludes to the accompanying diagram.]. The third reason is that when the moon is full, it only faces half the hemisphere of the illuminated earth, on which only the ocean and other waters reflect bright light, while the land makes spots on that brightness; thus half of our earth would be seen girt round with the brightness of the sea lighted up by the sun, and in the moon this reflection would be the smallest part of that moon. Fourthly, a radiant body cannot be reflected from another equally radiant; therefore the sea, since it borrows its brightness from the sun,--as the moon does--, could not cause the earth to be reflected in it, nor indeed could the body of the sun be seen reflected in it, nor indeed any star opposite to it.

906.

If you keep the details of the spots of the moon under observation you will often find great variation in them, and this I myself have proved by drawing them. And this is caused by the clouds that rise from the waters in the moon, which come between the sun and those waters, and by their shadow deprive these waters of the sun's rays. Thus those waters remain dark, not being able to reflect the solar body.

907.

How the spots on the moon must have varied from what they formerly were, by reason of the course of its waters.

On the moon's halo.

908.

OF HALOS ROUND THE MOON.

I have found, that the circles which at night seem to surround the moon, of various sizes, and degrees of density are caused by various gradations in the densities of the vapours which exist at different altitudes between the moon and our eyes. And of these halos the largest and least red is caused by the lowest of these vapours; the second, smaller one, is higher up, and looks redder because it is seen through two vapours. And so on, as they are higher they will appear smaller and redder, because, between the eye and them, there is thicker vapour. Whence it is proved that where they are seen to be reddest, the vapours are most dense.

On instruments for observing the moon (909. 910).

909.

If you want to prove why the moon appears larger than it is, when it reaches the horizon; take a lens which is highly convex on one surface and concave on the opposite, and place the concave side next the eye, and look at the object beyond the convex surface; by this means you will have produced an exact imitation of the atmosphere included beneath the sphere of fire and outside that of water; for this atmosphere is concave on the side next the earth, and convex towards the fire.

910.

Construct glasses to see the moon magnified.

[Footnote: See the Introduction, p. 136, Fracastoro says in his work Homocentres: "_Per dua specilla ocularia si quis perspiciat, alteri altero superposito, majora multo et propinquiora videbit omnia.--Quin imo quaedam specilla ocularia fiunt tantae densitatis, ut si per ea quis aut lunam, aut aliud siderum spectet, adeo propinqua illa iudicet, ut ne turres ipsas excedant_" (sect. II c. 8 and sect. III, c. 23).]

I.

THE STARS.

On the light of the stars (911-913).

911.

The stars are visible by night and not by day, because we are eneath the dense atmosphere, which is full of innumerable

articles of moisture, each of which independently, when the rays of the sun fall upon it, reflects a radiance, and so these numberless bright particles conceal the stars; and if it were not for this atmosphere the sky would always display the stars against its darkness.

[Footnote: See No. 296, which also refers to starlight.]

912.

Whether the stars have their light from the sun or in themselves. Some say that they shine of themselves, alledging that if Venus and Mercury had not a light of their own, when they come between our eye and the sun they would darken so much of the sun as they could cover from our eye. But this is false, for it is proved that a dark object against a luminous body is enveloped and entirely concealed by the lateral rays of the rest of that luminous body and so remains invisible. As may be seen when the sun is seen through the boughs of trees bare of their leaves, at some distance the branches do not conceal any portion of the sun from our eye. The same thing happens with the above mentioned planets which, though they have no light of their own, do not--as has been said--conceal any part of the sun from our eye [18].

SECOND ARGUMENT.

Some say that the stars appear most brilliant at night in proportion as they are higher up; and that if they had no light of their own, the shadow of the earth which comes between them and the sun, would darken them, since they would not face nor be faced by the solar body. But those persons have not considered that the conical shadow of the earth cannot reach many of the stars; and even as to those it does reach, the cone is so much diminished that it covers very little of the star's mass, and all the rest is illuminated by the sun.

Footnote: From this and other remarks (see No. 902) it is clear that Leonardo was familiar with the phenomena of Irradiation.]

13.

Why the planets appear larger in the East than they do overhead, whereas the contrary should be the case, as they are 3500 miles nearer to us when in mid sky than when on the horizon.

All the degrees of the elements, through which the images of the celestial bodies pass to reach the eye, are equal curves and the angles by which the central line of those images passes through them, are unequal angles [Footnote 13: *unequali*, here and elsewhere does not mean unequal in the sense of not being equal to each other, but angles which are not right angles.]; and the distance is greater, as is shown by the excess of *a b* beyond *a d*; and the enlargement of these celestial bodies on the horizon is shown by the 9th of the 7th.

Observations on the stars.

914.

To see the real nature of the planets open the covering and note at the base [Footnote 4: *_basa_*. This probably alludes to some instrument, perhaps the Camera obscura.] one single planet, and the reflected movement of this base will show the nature of the said planet; but arrange that the base may face only one at the time.

On history of astronomy.

915.

Cicero says in [his book] *De Divinatione* that Astrology has been practised five hundred seventy thousand years before the Trojan war.

57000.

[Footnote: The statement that CICERO, *_De Divin._* ascribes the discovery of astrology to a period 57000 years before the Trojan war I believe to be quite erroneous. According to ERNESTI, *_Clavis Ciceroniana, CH. G. SCHULZ (_Lexic. Cicer._)* and the edition of *_De Divin._* by GIESE the word *Astrologia* occurs only twice in CICERO: *_De Divin. II_, 42. _Ad Chaldaeorum monstra veniamus, de quibus Eudoxus, Platonis auditor, in astrologia judicio doctissimorum hominum facile princeps, sic opinatur (id quod scriptum reliquit): Chaldaeis in praedictione et in notatione cujusque vitae ex natali die minime esse credendum._*" He then quotes the condemnatory verdict of other philosophers as to the teaching of the Chaldaeans but says nothing as to the antiquity and origin of astronomy. CICERO further notes *_De oratore_ I, 16* that Aratus was "*_ignarus astrologiae_*" but that is all. So far as I know the word occurs nowhere else in CICERO; and the word *_Astronomia_* he does not seem to have used at all. (H. MULLER-STRUBING.)]

Of time and its divisions (916-918).

916.

Although time is included in the class of Continuous Quantities, being indivisible and immaterial, it does not come entirely under the head of Geometry, which represents its divisions by means of figures and bodies of infinite variety, such as are seen to be continuous in their visible and material properties. But only with its first principles does it agree, that is with the Point and the Line; the point may be compared to an instant of time, and the line may be likened to the length of a certain quantity of time, and just as a line begins and terminates in a point, so such a space of time begins and terminates in an instant. And whereas a line is infinitely divisible, the divisibility of a space of time is of the same nature; and as the divisions of the line may bear a certain proportion to each other, so may the divisions of time.

[Footnote: This passage is repeated word for word on page 190b of the same manuscript and this is accounted for by the text in Vol. I, No. 4. Compare also No. 1216.]

917.

Describe the nature of Time as distinguished from the Geometrical definitions.

918.

Divide an hour into 3000 parts, and this you can do with a clock by making the pendulum lighter or heavier.

_XVI.

Physical Geography.

Leonardo's researches as to the structure of the earth and sea were made at a time, when the extended voyages of the Spaniards and Portuguese had also excited a special interest in geographical questions in Italy, and particularly in Tuscany. Still, it need scarcely surprise us to find that in deeper questions, as to the structure of the globe, the primitive state of the earth's surface, and the like, he was far in advance of his time.

The number of passages which treat of such matters is relatively considerable; like almost all Leonardo's scientific notes they deal partly with theoretical and partly with practical questions. Some of his theoretical views of the motion of water were collected in a copied manuscript volume by an early transcriber, but without any acknowledgment of the source whence they were derived. This copy is now in the Library of the Barberini palace at Rome and was published under the title: "De moto e misura dell'acqua," by FRANCESCO CARDINALI, Bologna_ 1828. _In this work the texts are arranged under the following titles:_ Libr. I. Della sfera dell'acqua; Libr. II. Del moto dell'acqua; Libr. III. Dell'onda dell'acqua; Libr. IV. Dei retrosi d'acqua; Libr. V. Dell'acqua cadente; Libr. VI. Delle rotture fatte dall'acqua; Libr. VII Delle cose portate dall'acqua; Libr. VIII. Dell'oncia dell'acqua e delle canne; Libr. IX. De molini e d'altri ordigni d'acqua.

The large number of isolated observations scattered through the manuscripts, accounts for our so frequently finding notes of new schemes for the arrangement of those relating to water and its motions, particularly in the Codex Atlanticus: I have printed several of these plans as an introduction to the Physical Geography, and I have actually arranged the texts in accordance with the clue afforded by one of them which is undoubtedly one of the latest notes referring to the subject (No. 920_). The text given as No._ 930 _which is also taken from a late note-book of Leonardo's, served as a basis for the arrangement of the first of the seven books--or

sections-- , bearing the title: Of the Nature of Water_ (Dell'acque in se).

As I have not made it any part of this undertaking to print the passages which refer to purely physical principles, it has also been necessary to exclude those practical researches which, in accordance with indications given in 920, _ought to come in as Books_ 13, 14 _and_ 15. _I can only incidentally mention here that Leonardo--as it seems to me, especially in his youth--devoted a great deal of attention to the construction of mills. This is proved by a number of drawings of very careful and minute execution, which are to be found in the Codex Atlanticus. Nor was it possible to include his considerations on the regulation of rivers, the making of canals and so forth (No._ 920, _Books_ 10, 11 _and_ 12_); but those passages in which the structure of a canal is directly connected with notices of particular places will be found duly inserted under section XVII (Topographical notes). In Vol. I, No._ 5 _the text refers to canal-making in general._

On one point only can the collection of passages included under the general heading of Physical Geography claim to be complete. When comparing and sorting the materials for this work I took particular care not to exclude or omit any text in which a geographical name was mentioned even incidentally, since in all such researches the chief interest, as it appeared to me, attached to the question whether these acute observations on the various local characteristics of mountains, rivers or seas, had been made by Leonardo himself, and on the spot. It is self-evident that the few general and somewhat superficial observations on the Rhine and the Danube, on England and Flanders, must have been obtained from maps or from some informants, and in the case of Flanders Leonardo himself acknowledges this (see No. 1008_). But that most of the other and more exact observations were made, on the spot, by Leonardo himself, may be safely assumed from their method and the style in which he writes of them; and we should bear it in mind that in all investigations, of whatever kind, experience is always spoken of as the only basis on which he relies. Incidentally, as in No._ 984, _he thinks it necessary to allude to the total absence of all recorded observations._

I.

INTRODUCTION.

Schemes for the arrangement of the materials (919-928).

919.

These books contain in the beginning: Of the nature of water itself in its motions; the others treat of the effects of its currents, which change the world in its centre and its shape.

920.

DIVISIONS OF THE BOOK.

Book 1 of water in itself.

Book 2 of the sea.

Book 3 of subterranean rivers.

Book 4 of rivers.

Book 5 of the nature of the abyss.

Book 6 of the obstacles.

Book 7 of gravels.

Book 8 of the surface of water.

Book 9 of the things placed therein.

Book 10 of the repairing of rivers.

Book 11 of conduits.

Book 12 of canals.

Book 13 of machines turned by water.

Book 14 of raising water.

Book 15 of matters worn away by water.

921.

First you shall make a book treating of places occupied by fresh waters, and the second by salt waters, and the third, how by the disappearance of these, our parts of the world were made lighter and in consequence more remote from the centre of the world.

922.

First write of all water, in each of its motions; then describe all its bottoms and their various materials, always referring to the propositions concerning the said waters; and let the order be good, for otherwise the work will be confused.

Describe all the forms taken by water from its greatest to its smallest wave, and their causes.

923.

Book 9, of accidental risings of water.

924.

THE ORDER OF THE BOOK.

Place at the beginning what a river can effect.

925.

A book of driving back armies by the force of a flood made by releasing waters.

A book showing how the waters safely bring down timber cut in the mountains.

A book of boats driven against the impetus of rivers.

A book of raising large bridges higher. Simply by the swelling of the waters.

A book of guarding against the impetus of rivers so that towns may not be damaged by them.

926.

A book of the ordering of rivers so as to preserve their banks.

A book of the mountains, which would stand forth and become land, if our hemisphere were to be uncovered by the water.

A book of the earth carried down by the waters to fill up the great abyss of the seas.

A book of the ways in which a tempest may of itself clear out filled up sea-ports.

A book of the shores of rivers and of their permanency.

A book of how to deal with rivers, so that they may keep their bottom scoured by their own flow near the cities they pass.

A book of how to make or to repair the foundations for bridges over the rivers.

A book of the repairs which ought to be made in walls and banks of rivers where the water strikes them.

A book of the formation of hills of sand or gravel at great depths in water.

927.

Water gives the first impetus to its motion.

A book of the levelling of waters by various means,

A book of diverting rivers from places where they do mischief.

A book of guiding rivers which occupy too much ground.

A book of parting rivers into several branches and making them fordable.

A book of the waters which with various currents pass through seas.

A book of deepening the beds of rivers by means of currents of water.

A book of controlling rivers so that the little beginnings of mischief, caused by them, may not increase.

A book of the various movements of waters passing through channels of different forms.

A book of preventing small rivers from diverting the larger one into which their waters run.

A book of the lowest level which can be found in the current of the surface of rivers.

A book of the origin of rivers which flow from the high tops of mountains.

A book of the various motions of waters in their rivers.

928.

[1] Of inequality in the concavity of a ship. [Footnote 1: The first line of this passage was added subsequently, evidently as a correction of the following line.]

[1] A book of the inequality in the curve of the sides of ships.

[1] A book of the inequality in the position of the tiller.

[1] A book of the inequality in the keel of ships.

[2] A book of various forms of apertures by which water flows out.

[3] A book of water contained in vessels with air, and of its movements.

[4] A book of the motion of water through a syphon. [Footnote 7: _cicognole_, see No. 966, 11, 17.]

[5] A book of the meetings and union of waters coming from different

directions.

[6] A book of the various forms of the banks through which rivers pass.

[7] A book of the various forms of shoals formed under the sluices of rivers.

[8] A book of the windings and meanderings of the currents of rivers.

[9] A book of the various places whence the waters of rivers are derived.

[10] A book of the configuration of the shores of rivers and of their permanency.

[11] A book of the perpendicular fall of water on various objects.

[12] A book of the course of water when it is impeded in various places.

[12] A book of the various forms of the obstacles which impede the course of waters.

[13] A book of the concavity and globosity formed round various objects at the bottom.

[14] A book of conducting navigable canals above or beneath the rivers which intersect them.

[15] A book of the soils which absorb water in canals and of repairing them.

[16] A book of creating currents for rivers, which quit their beds, [and] for rivers choked with soil.

General introduction.

929.

THE BEGINNING OF THE TREATISE ON WATER.

By the ancients man has been called the world in miniature; and certainly this name is well bestowed, because, inasmuch as man is composed of earth, water, air and fire, his body resembles that of the earth; and as man has in him bones the supports and framework of his flesh, the world has its rocks the supports of the earth; as man has in him a pool of blood in which the lungs rise and fall in breathing, so the body of the earth has its ocean tide which likewise rises and falls every six hours, as if the world breathed; as in that pool of blood veins have their origin, which ramify all over the human body, so likewise the ocean sea fills the body of the

earth with infinite springs of water. The body of the earth lacks sinews and this is, because the sinews are made expressly for movements and, the world being perpetually stable, no movement takes place, and no movement taking place, muscles are not necessary. --But in all other points they are much alike.

I.

OF THE NATURE OF WATER.

The arrangement of Book I.

930.

THE ORDER OF THE FIRST BOOK ON WATER.

Define first what is meant by height and depth; also how the elements are situated one inside another. Then, what is meant by solid weight and by liquid weight; but first what weight and lightness are in themselves. Then describe why water moves, and why its motion ceases; then why it becomes slower or more rapid; besides this, how it always falls, being in contact with the air but lower than the air. And how water rises in the air by means of the heat of the sun, and then falls again in rain; again, why water springs forth from the tops of mountains; and if the water of any spring higher than the ocean can pour forth water higher than the surface of that ocean. And how all the water that returns to the ocean is higher than the sphere of waters. And how the waters of the equatorial seas are higher than the waters of the North, and higher beneath the body of the sun than in any part of the equatorial circle; for experiment shows that under the heat of a burning brand the water near the brand boils, and the water surrounding this ebullition always sinks with a circular eddy. And how the waters of the North are lower than the other seas, and more so as they become colder, until they are converted into ice.

Definitions (931. 932).

931.

OF WHAT IS WATER.

Among the four elements water is the second both in weight and in instability.

932.

THE BEGINNING OF THE BOOK ON WATER.

Sea is the name given to that water which is wide and deep, in which the waters have not much motion.

[Footnote: Only the beginning of this passage is here given, the

remainder consists of definitions which have no direct bearing on the subject.]

Of the surface of the water in relation to the globe (933-936).

933.

The centres of the sphere of water are two, one universal and common to all water, the other particular. The universal one is that which is common to all waters not in motion, which exist in great quantities. As canals, ditches, ponds, fountains, wells, dead rivers, lakes, stagnant pools and seas, which, although they are at various levels, have each in itself the limits of their superficies equally distant from the centre of the earth, such as lakes placed at the tops of high mountains; as the lake near Pietra Pana and the lake of the Sybil near Norcia; and all the lakes that give rise to great rivers, as the Ticino from Lago Maggiore, the Adda from the lake of Como, the Mincio from the lake of Garda, the Rhine from the lakes of Constance and of Chur, and from the lake of Lucerne, like the Tigris which passes through Asia Minor carrying with it the waters of three lakes, one above the other at different heights of which the highest is Munace, the middle one Pallas, and the lowest Triton; the Nile again flows from three very high lakes in Ethiopia.

[Footnote 5: _Pietra Pana_, a mountain near Florence. If for Norcia, we may read Norchia, the remains of the Etruscan city near Viterbo, there can be no doubt that by '_Lago della Sibilla_'--a name not known elsewhere, so far as I can learn--Leonardo meant _Lago di Vico_ (Lacus Ciminus, Aen. 7).]

934.

OF THE CENTRE OF THE OCEAN.

The centre of the sphere of waters is the true centre of the globe of our world, which is composed of water and earth, having the shape of a sphere. But, if you want to find the centre of the element of the earth, this is placed at a point equidistant from the surface of the ocean, and not equidistant from the surface of the earth; for it is evident that this globe of earth has nowhere any perfect rotundity, excepting in places where the sea is, or marshes or other still waters. And every part of the earth that rises above the water is farther from the centre.

935.

OF THE SEA WHICH CHANGES THE WEIGHT OF THE EARTH.

The shells, oysters, and other similar animals, which originate in sea-mud, bear witness to the changes of the earth round the centre of our elements. This is proved thus: Great rivers always run turbid, being coloured by the earth, which is stirred by the friction of their waters at the bottom and on their shores; and this

wearing disturbs the face of the strata made by the layers of shells, which lie on the surface of the marine mud, and which were produced there when the salt waters covered them; and these strata were covered over again from time to time, with mud of various thickness, or carried down to the sea by the rivers and floods of more or less extent; and thus these layers of mud became raised to such a height, that they came up from the bottom to the air. At the present time these bottoms are so high that they form hills or high mountains, and the rivers, which wear away the sides of these mountains, uncover the strata of these shells, and thus the softened side of the earth continually rises and the antipodes sink closer to the centre of the earth, and the ancient bottoms of the seas have become mountain ridges.

936.

Let the earth make whatever changes it may in its weight, the surface of the sphere of waters can never vary in its equal distance from the centre of the world.

Of the proportion of the mass of water to that of the earth (937. 938).

937.

WHETHER THE EARTH IS LESS THAN THE WATER.

Some assert that it is true that the earth, which is not covered by water is much less than that covered by water. But considering the size of 7000 miles in diameter which is that of this earth, we may conclude the water to be of small depth.

938.

OF THE EARTH.

The great elevations of the peaks of the mountains above the sphere of the water may have resulted from this that: a very large portion of the earth which was filled with water that is to say the vast cavern inside the earth may have fallen in a vast part of its vault towards the centre of the earth, being pierced by means of the course of the springs which continually wear away the place where they pass.

Sinking in of countries like the Dead Sea in Syria, that is Sodom and Gomorrah.

It is of necessity that there should be more water than land, and the visible portion of the sea does not show this; so that there must be a great deal of water inside the earth, besides that which rises into the lower air and which flows through rivers and springs.

[Footnote: The small sketch below on the left, is placed in the

original close to the text referring to the Dead Sea.]

The theory of Plato.

939.

THE FIGURES OF THE ELEMENTS.

Of the figures of the elements; and first as against those who deny the opinions of Plato, and who say that if the elements include one another in the forms attributed to them by Plato they would cause a vacuum one within the other. I say it is not true, and I here prove it, but first I desire to propound some conclusions. It is not necessary that the elements which include each other should be of corresponding magnitude in all the parts, of that which includes and of that which is included. We see that the sphere of the waters varies conspicuously in mass from the surface to the bottom, and that, far from investing the earth when that was in the form of a cube that is of 8 angles as Plato will have it, that it invests the earth which has innumerable angles of rock covered by the water and various prominences and concavities, and yet no vacuum is generated between the earth and water; again, the air invests the sphere of waters together with the mountains and valleys, which rise above that sphere, and no vacuum remains between the earth and the air, so that any one who says a vacuum is generated, speaks foolishly.

But to Plato I would reply that the surface of the figures which according to him the elements would have, could not exist.

That the flow of rivers proves the slope of the land.

940.

PROVES HOW THE EARTH IS NOT GLOBULAR AND NOT BEING GLOBULAR CANNOT HAVE A COMMON CENTRE.

We see the Nile come from Southern regions and traverse various provinces, running towards the North for a distance of 3000 miles and flow into the Mediterranean by the shores of Egypt; and if we will give to this a fall of ten braccia a mile, as is usually allowed to the course of rivers in general, we shall find that the Nile must have its mouth ten miles lower than its source. Again, we see the Rhine, the Rhone and the Danube starting from the German parts, almost the centre of Europe, and having a course one to the East, the other to the North, and the last to Southern seas. And if you consider all this you will see that the plains of Europe in their aggregate are much higher than the high peaks of the maritime mountains; think then how much their tops must be above the sea shores.

Theory of the elevation of water within the mountains.

941.

OF THE HEAT THAT IS IN THE WORLD.

Where there is life there is heat, and where vital heat is, there is movement of vapour. This is proved, inasmuch as we see that the element of fire by its heat always draws to itself damp vapours and thick mists as opaque clouds, which it raises from seas as well as lakes and rivers and damp valleys; and these being drawn by degrees as far as the cold region, the first portion stops, because heat and moisture cannot exist with cold and dryness; and where the first portion stops the rest settle, and thus one portion after another being added, thick and dark clouds are formed. They are often wafted about and borne by the winds from one region to another, where by their density they become so heavy that they fall in thick rain; and if the heat of the sun is added to the power of the element of fire, the clouds are drawn up higher still and find a greater degree of cold, in which they form ice and fall in storms of hail. Now the same heat which holds up so great a weight of water as is seen to rain from the clouds, draws them from below upwards, from the foot of the mountains, and leads and holds them within the summits of the mountains, and these, finding some fissure, issue continuously and cause rivers.

The relative height of the surface of the sea to that of the land (942-945).

942.

OF THE SEA, WHICH TO MANY FOOLS APPEARS TO BE HIGHER THAN THE EARTH WHICH FORMS ITS SHORE.

b d is a plain through which a river flows to the sea; this plain ends at the sea, and since in fact the dry land that is uncovered is not perfectly level--for, if it were, the river would have no motion--as the river does move, this place is a slope rather than a plain; hence this plain d b so ends where the sphere of water begins that if it were extended in a continuous line to b a it would go down beneath the sea, whence it follows that the sea a c b looks higher than the dry land.

Obviously no portions of dry land left uncovered by water can ever be lower than the surface of the watery sphere.

943.

OF CERTAIN PERSONS WHO SAY THE WATERS WERE HIGHER THAN THE DRY LAND.

Certainly I wonder not a little at the common opinion which is contrary to truth, but held by the universal consent of the judgment of men. And this is that all are agreed that the surface of the sea is higher than the highest peaks of the mountains; and they allege many vain and childish reasons, against which I will allege only one simple and short reason; We see plainly that if we could remove the

shores of the sea, it would invest the whole earth and make it a perfect sphere. Now, consider how much earth would be carried away to enable the waves of the sea to cover the world; therefore that which would be carried away must be higher than the sea-shore.

944.

THE OPINION OF SOME PERSONS WHO SAY THAT THE WATER OF SOME SEAS IS HIGHER THAN THE HIGHEST SUMMITS OF MOUNTAINS; AND NEVERTHELESS THE WATER WAS FORCED UP TO THESE SUMMITS.

Water would not move from place to place if it were not that it seeks the lowest level and by a natural consequence it never can return to a height like that of the place where it first on issuing from the mountain came to light. And that portion of the sea which, in your vain imagining, you say was so high that it flowed over the summits of the high mountains, for so many centuries would be swallowed up and poured out again through the issue from these mountains. You can well imagine that all the time that Tigris and Euphrates

945.

have flowed from the summits of the mountains of Armenia, it must be believed that all the water of the ocean has passed very many times through these mouths. And do you not believe that the Nile must have sent more water into the sea than at present exists of all the element of water? Undoubtedly, yes. And if all this water had fallen away from this body of the earth, this terrestrial machine would long since have been without water. Whence we may conclude that the water goes from the rivers to the sea, and from the sea to the rivers, thus constantly circulating and returning, and that all the sea and the rivers have passed through the mouth of the Nile an infinite number of times [Footnote: *_Moti Armeni, Ermini_* in the original, in M. RAVAISSON'S transcript *_"monti ernini [le loro ruine?]"_*. He renders this *_ "Le Tigre et l'Euphrate se sont deverses par les sommets des montagnes [avec leurs eaux destructives?] on pent cro're" &c.* Leonardo always writes *_Ermini, Erminia_*, for *_Armeni, Armenia_* (Arabic: *_Irminiah_*). M. RAVAISSON also deviates from the original in his translation of the following passage: *"_Or tu ne crois pas que le Nil ait mis plus d'eau dans la mer qu'il n'y en a a present dans tout l'element de l'eau. Il est certain que si cette eau etait tombee_" &c.*]

II.

ON THE OCEAN.

Refutation of Pliny's theory as to the saltness of the sea (946. 947).

946.

WHY WATER IS SALT.

Pliny says in his second book, chapter 103, that the water of the sea is salt because the heat of the sun dries up the moisture and drinks it up; and this gives to the wide stretching sea the savour of salt. But this cannot be admitted, because if the saltness of the sea were caused by the heat of the sun, there can be no doubt that lakes, pools and marshes would be so much the more salt, as their waters have less motion and are of less depth; but experience shows us, on the contrary, that these lakes have their waters quite free from salt. Again it is stated by Pliny in the same chapter that this saltness might originate, because all the sweet and subtle portions which the heat attracts easily being taken away, the more bitter and coarser part will remain, and thus the water on the surface is fresher than at the bottom [Footnote 22: Compare No. 948.]; but this is contradicted by the same reason given above, which is, that the same thing would happen in marshes and other waters, which are dried up by the heat. Again, it has been said that the saltness of the sea is the sweat of the earth; to this it may be answered that all the springs of water which penetrate through the earth, would then be salt. But the conclusion is, that the saltness of the sea must proceed from the many springs of water which, as they penetrate into the earth, find mines of salt and these they dissolve in part, and carry with them to the ocean and the other seas, whence the clouds, the begetters of rivers, never carry it up. And the sea would be saltier in our times than ever it was at any time; and if the adversary were to say that in infinite time the sea would dry up or congeal into salt, to this I answer that this salt is restored to the earth by the setting free of that part of the earth which rises out of the sea with the salt it has acquired, and the rivers return it to the earth under the sea.

[Footnote: See PLINY, Hist. Nat. II, CIII [C]. *_Itaque Solis ardore siccatur liquor: et hoc esse masculum sidus accepimus, torrens cuncta sorbensque._* (cp. CIV.) *_Sic mari late patenti saporem incoqui salis, aut quia exhausto inde dulci tenuique, quod facillime trahat vis ignea, omne asperius crassiusque linquatur: ideo summa aequorum aqua dulciorem profundam; hanc esse veriorem causam, quam quod mare terrae sudor sit aeternus: aut quia plurimum ex arido misceatur illi vapore: aut quia terrae natura sicut medicatas aquas inficiat_* ... (cp. CV): *_altissimum mare XV. stadiorum Fabianus tradit. Alii n Ponto coadverso Coraxorum gentis (vocant B Ponti) trecentis fere a continenti stadiis immensam altitudinem maris tradunt, vadis nunquam repertis._* (cp. CVI [CIII]) *_Mirabilis id faciunt aquae dulces, juxta mare, ut fistulis emicantes. Nam nec aquarum natura a miraculis cessat. Dulces mari invehuntur, leviores haud dubie. Ideo et marinae, quarum natura gravior, magis invecta sustinent. Quaedam vero et dulces inter se supermeant alias._*]

947.

For the third and last reason we will say that salt is in all created things; and this we learn from water passed over the ashes

and cinders of burnt things; and the urine of every animal, and the superfluities issuing from their bodies, and the earth into which all things are converted by corruption.

But,--to put it better,--given that the world is everlasting, it must be admitted that its population will also be eternal; hence the human species has eternally been and would be consumers of salt; and if all the mass of the earth were to be turned into salt, it would not suffice for all human food [Footnote 27: That is, on the supposition that salt, once consumed, disappears for ever.]; whence we are forced to admit, either that the species of salt must be everlasting like the world, or that it dies and is born again like the men who devour it. But as experience teaches us that it does not die, as is evident by fire, which does not consume it, and by water which becomes salt in proportion to the quantity dissolved in it,--and when it is evaporated the salt always remains in the original quantity--it must pass through the bodies of men either in the urine or the sweat or other excretions where it is found again; and as much salt is thus got rid of as is carried every year into towns; therefore salt is dug in places where there is urine.-- Sea hogs and sea winds are salt.

We will say that the rains which penetrate the earth are what is under the foundations of cities with their inhabitants, and are what restore through the internal passages of the earth the saltiness taken from the sea; and that the change in the place of the sea, which has been over all the mountains, caused it to be left there in the mines found in those mountains, &c.

The characteristics of sea water (948. 949).

948.

The waters of the salt sea are fresh at the greatest depths.

949.

THAT THE OCEAN DOES NOT PENETRATE UNDER THE EARTH.

The ocean does not penetrate under the earth, and this we learn from the many and various springs of fresh water which, in many parts of the ocean make their way up from the bottom to the surface. The same thing is farther proved by wells dug beyond the distance of a mile from the said ocean, which fill with fresh water; and this happens because the fresh water is lighter than salt water and consequently more penetrating.

Which weighs most, water when frozen or when not frozen?

FRESH WATER PENETRATES MORE AGAINST SALT WATER THAN SALT WATER AGAINST FRESH WATER.

That fresh water penetrates more against salt water, than salt water

against fresh is proved by a thin cloth dry and old, hanging with the two opposite ends equally low in the two different waters, the surfaces of which are at an equal level; and it will then be seen how much higher the fresh water will rise in this piece of linen than the salt; by so much is the fresh lighter than the salt.

On the formation of Gulfs (950. 951).

950.

All inland seas and the gulfs of those seas, are made by rivers which flow into the sea.

951.

HERE THE REASON IS GIVEN OF THE EFFECTS PRODUCED BY THE WATERS IN THE ABOVE MENTIONED PLACE.

All the lakes and all the gulfs of the sea and all inland seas are due to rivers which distribute their waters into them, and from impediments in their downfall into the Mediterranean --which divides Africa from Europe and Europe from Asia by means of the Nile and the Don which pour their waters into it. It is asked what impediment is great enough to stop the course of the waters which do not reach the ocean.

On the encroachments of the sea on the land and vice versa (952-954).

952.

OF WAVES.

A wave of the sea always breaks in front of its base, and that portion of the crest will then be lowest which before was highest.

[Footnote: The page of FRANCESCO DI GIORGIO'S *_Trattato_*, on which Leonardo has written this remark, contains some notes on the construction of dams, harbours &c.]

953.

That the shores of the sea constantly acquire more soil towards the middle of the sea; that the rocks and promontories of the sea are constantly being ruined and worn away; that the Mediterranean seas will in time discover their bottom to the air, and all that will be left will be the channel of the greatest river that enters it; and this will run to the ocean and pour its waters into that with those of all the rivers that are its tributaries.

954.

How the river Po, in a short time might dry up the Adriatic sea in

the same way as it has dried up a large part of Lombardy.

The ebb and flow of the tide (955-960).

955.

Where there is a larger quantity of water, there is a greater flow and ebb, but the contrary in narrow waters.

Look whether the sea is at its greatest flow when the moon is half way over our hemisphere [on the meridian].

956.

Whether the flow and ebb are caused by the moon or the sun, or are the breathing of this terrestrial machine. That the flow and ebb are different in different countries and seas.

[Footnote: 1. Allusion may here be made to the mythological explanation of the ebb and flow given in the Edda. Utgardloki says to Thor (Gylfaginning 48): "When thou wert drinking out of the horn, and it seemed to thee that it was slow in emptying a wonder befell, which I should not have believed possible: the other end of the horn lay in the sea, which thou sawest not; but when thou shalt go to the sea, thou shalt see how much thou hast drunk out of it. And that men now call the ebb tide."

Several passages in various manuscripts treat of the ebb and flow. In collecting them I have been guided by the rule only to transcribe those which named some particular spot.]

957.

Book 9 of the meeting of rivers and their flow and ebb. The cause is the same in the sea, where it is caused by the straits of Gibraltar. And again it is caused by whirlpools.

958.

OF THE FLOW AND EBB.

All seas have their flow and ebb in the same period, but they seem to vary because the days do not begin at the same time throughout the universe; in such wise as that when it is midday in our hemisphere, it is midnight in the opposite hemisphere; and at the Eastern boundary of the two hemispheres the night begins which follows on the day, and at the Western boundary of these hemispheres begins the day, which follows the night from the opposite side. Hence it is to be inferred that the above mentioned swelling and diminution in the height of the seas, although they take place in one and the same space of time, are seen to vary from the above mentioned causes. The waters are then withdrawn into the fissures which start from the depths of the sea and which ramify inside the

body of the earth, corresponding to the sources of rivers, which are constantly taking from the bottom of the sea the water which has flowed into it. A sea of water is incessantly being drawn off from the surface of the sea. And if you should think that the moon, rising at the Eastern end of the Mediterranean sea must there begin to attract to herself the waters of the sea, it would follow that we must at once see the effect of it at the Eastern end of that sea. Again, as the Mediterranean sea is about the eighth part of the circumference of the aqueous sphere, being 3000 miles long, while the flow and ebb only occur 4 times in 24 hours, these results would not agree with the time of 24 hours, unless this Mediterranean sea were six thousand miles in length; because if such a superabundance of water had to pass through the straits of Gibraltar in running behind the moon, the rush of the water through that strait would be so great, and would rise to such a height, that beyond the straits it would for many miles rush so violently into the ocean as to cause floods and tremendous seething, so that it would be impossible to pass through. This agitated ocean would afterwards return the waters it had received with equal fury to the place they had come from, so that no one ever could pass through those straits. Now experience shows that at every hour they are passed in safety, but when the wind sets in the same direction as the current, the strong ebb increases [Footnote 23: In attempting to get out of the Mediterranean, vessels are sometimes detained for a considerable time; not merely by the causes mentioned by Leonardo but by the constant current flowing eastwards through the middle of the straits of Gibraltar.]. The sea does not raise the water that has issued from the straits, but it checks them and this retards the tide; then it makes up with furious haste for the time it has lost until the end of the ebb movement.

959.

That the flow and ebb are not general; for on the shore at Genoa there is none, at Venice two braccia, between England and Flanders 18 braccia. That in the straits of Sicily the current is very strong because all the waters from the rivers that flow into the Adriatic pass there.

[Footnote: A few more recent data may be given here to facilitate comparison. In the Adriatic the tide rises 2 and 1/2 feet, at Terracina 1 1/4. In the English channel between Calais and Kent it rises from 18 to 20 feet. In the straits of Messina it rises no more than 2 1/2 feet, and that only in stormy weather, but the current is all the stronger. When Leonardo accounts for this by the southward flow of all the Italian rivers along the coasts, the explanation is at least based on a correct observation; namely that a steady current flows southwards along the coast of Calabria and another northwards, along the shores of Sicily; he seems to infer, from the direction of the fust, that the tide in the Adriatic is caused by it.]

960.

In the West, near to Flanders, the sea rises and decreases every 6 hours about 20 braccia, and 22 when the moon is in its favour; but 20 braccia is the general rule, and this rule, as it is evident, cannot have the moon for its cause. This variation in the increase and decrease of the sea every 6 hours may arise from the damming up of the waters, which are poured into the Mediterranean by the quantity of rivers from Africa, Asia and Europe, which flow into that sea, and the waters which are given to it by those rivers; it pours them to the ocean through the straits of Gibraltar, between Abila and Calpe [Footnote 5: *_Abila_*, Lat. *_Abyla_*, Gr. , now Sierra *_Ximiera_* near Ceuta; *_Calpe_*, Lat. *_Calpe_*. Gr., now Gibraltar. Leonardo here uses the ancient names of the rocks, which were known as the Pillars of Hercules.]. That ocean extends to the island of England and others farther North, and it becomes dammed up and kept high in various gulfs. These, being seas of which the surface is remote from the centre of the earth, have acquired a weight, which as it is greater than the force of the incoming waters which cause it, gives this water an impetus in the contrary direction to that in which it came and it is borne back to meet the waters coming out of the straits; and this it does most against the straits of Gibraltar; these, so long as this goes on, remain dammed up and all the water which is poured out meanwhile by the aforementioned rivers, is pent up [in the Mediterranean]; and this might be assigned as the cause of its flow and ebb, as is shown in the 21st of the 4th of my theory.

III.

SUBTERRANEAN WATER COURSES.

Theory of the circulation of the waters (961. 962).

961.

Very large rivers flow under ground.

962.

This is meant to represent the earth cut through in the middle, showing the depths of the sea and of the earth; the waters start from the bottom of the seas, and ramifying through the earth they rise to the summits of the mountains, flowing back by the rivers and returning to the sea.

Observations in support of the hypothesis (963-969).

963.

The waters circulate with constant motion from the utmost depths of the sea to the highest summits of the mountains, not obeying the nature of heavy matter; and in this case it acts as does the blood of animals which is always moving from the sea of the heart and

flows to the top of their heads; and here it is that veins burst--as one may see when a vein bursts in the nose, that all the blood from below rises to the level of the burst vein. When the water rushes out of a burst vein in the earth it obeys the nature of other things heavier than the air, whence it always seeks the lowest places. [7] These waters traverse the body of the earth with infinite ramifications.

[Footnote: The greater part of this passage has been given as No. 849 in the section on Anatomy.]

964.

The same cause which stirs the humours in every species of animal body and by which every injury is repaired, also moves the waters from the utmost depth of the sea to the greatest heights.

965.

It is the property of water that it constitutes the vital human of this arid earth; and the cause which moves it through its ramified veins, against the natural course of heavy matters, is the same property which moves the humours in every species of animal body. But that which crowns our wonder in contemplating it is, that it rises from the utmost depths of the sea to the highest tops of the mountains, and flowing from the opened veins returns to the low seas; then once more, and with extreme swiftness, it mounts again and returns by the same descent, thus rising from the inside to the outside, and going round from the lowest to the highest, from whence it rushes down in a natural course. Thus by these two movements combined in a constant circulation, it travels through the veins of the earth.

966.

WHETHER WATER RISES FROM THE SEA TO THE TOPS OF MOUNTAINS.

The water of the ocean cannot make its way from the bases to the tops of the mountains which bound it, but only so much rises as the dryness of the mountain attracts. And if, on the contrary, the rain, which penetrates from the summit of the mountain to the base, which is the boundary of the sea, descends and softens the slope opposite to the said mountain and constantly draws the water, like a syphon [Footnote 11: Cicognola, Syphon. See Vol. I, Pl. XXIV, No. 1.] which pours through its longest side, it must be this which draws up the water of the sea; thus if s n were the surface of the sea, and the rain descends from the top of the mountain a to n on one side, and on the other sides it descends from a to m, without a doubt this would occur after the manner of distilling through felt, or as happens through the tubes called syphons [Footnote 17: Cicognola, Syphon. See Vol. I, Pl. XXIV, No. 1.]. And at all times the water which has softened the mountain, by the great rain which runs down the two opposite sides, would constantly attract the rain a n, on

its longest side together with the water from the sea, if that side of the mountain _a m_ were longer than the other _a n_; but this cannot be, because no part of the earth which is not submerged by the ocean can be lower than that ocean.

967.

OF SPRINGS OF WATER ON THE TOPS OF MOUNTAINS.

It is quite evident that the whole surface of the ocean--when there is no storm--is at an equal distance from the centre of the earth, and that the tops of the mountains are farther from this centre in proportion as they rise above the surface of that sea; therefore if the body of the earth were not like that of man, it would be impossible that the waters of the sea--being so much lower than the mountains--could by their nature rise up to the summits of these mountains. Hence it is to be believed that the same cause which keeps the blood at the top of the head in man keeps the water at the summits of the mountains.

[Footnote: This conception of the rising of the blood, which has given rise to the comparison, was recognised as erroneous by Leonardo himself at a later period. It must be remembered that the MS. A, from which these passages are taken, was written about twenty years earlier than the MS. Leic. (Nos. 963 and 849) and twenty-five years before the MS. W. An. IV.

There is, in the original a sketch with No. 968 which is not reproduced. It represents a hill of the same shape as that shown at No. 982. There are veins, or branched streams, on the side of the hill, like those on the skull Pl. CVIII, No. 4]

968.

IN CONFIRMATION OF WHY THE WATER GOES TO THE TOPS OF MOUNTAINS.

I say that just as the natural heat of the blood in the veins keeps it in the head of man,--for when the man is dead the cold blood sinks to the lower parts--and when the sun is hot on the head of a man the blood increases and rises so much, with other humours, that by pressure in the veins pains in the head are often caused; in the same way veins ramify through the body of the earth, and by the natural heat which is distributed throughout the containing body, the water is raised through the veins to the tops of mountains. And this water, which passes through a closed conduit inside the body of the mountain like a dead thing, cannot come forth from its low place unless it is warmed by the vital heat of the spring time. Again, the heat of the element of fire and, by day, the heat of the sun, have power to draw forth the moisture of the low parts of the mountains and to draw them up, in the same way as it draws the clouds and collects their moisture from the bed of the sea.

969.

That many springs of salt water are found at great distances from the sea; this might happen because such springs pass through some mine of salt, like that in Hungary where salt is hewn out of vast caverns, just as stone is hewn.

[Footnote: The great mine of Wieliczka in Galicia, out of which a million cwt. of rock-salt are annually dug out, extends for 3000 metres from West to East, and 1150 metres from North to South.]

IV.

OF RIVERS.

On the way in which the sources of rivers are fed.

970.

OF THE ORIGIN OF RIVERS.

The body of the earth, like the bodies of animals, is intersected with ramifications of waters which are all in connection and are constituted to give nutriment and life to the earth and to its creatures. These come from the depth of the sea and, after many revolutions, have to return to it by the rivers created by the bursting of these springs; and if you chose to say that the rains of the winter or the melting of the snows in summer were the cause of the birth of rivers, I could mention the rivers which originate in the torrid countries of Africa, where it never rains--and still less snows--because the intense heat always melts into air all the clouds which are borne thither by the winds. And if you chose to say that such rivers, as increase in July and August, come from the snows which melt in May and June from the sun's approach to the snows on the mountains of Scythia [Footnote 9: Scythia means here, as in Ancient Geography, the whole of the Northern part of Asia as far as India.], and that such meltings come down into certain valleys and form lakes, into which they enter by springs and subterranean caves to issue forth again at the sources of the Nile, this is false; because Scythia is lower than the sources of the Nile, and, besides, Scythia is only 400 miles from the Black sea and the sources of the Nile are 3000 miles distant from the sea of Egypt into which its waters flow.

The tide in estuaries.

971.

Book 9, of the meeting of rivers and of their ebb and flow. The cause is the same in the sea, where it is caused by the straits of Gibraltar; and again it is caused by whirlpools.

[3] If two rivers meet together to form a straight line, and then below two right angles take their course together, the flow and ebb

will happen now in one river and now in the other above their confluence, and principally if the outlet for their united volume is no swifter than when they were separate. Here occur 4 instances.

[Footnote: The first two lines of this passage have already been given as No. 957. In the margin, near line 3 of this passage, the text given as No. 919 is written.]

On the alterations, caused in the courses of rivers by their confluence (972-974).

972.

When a smaller river pours its waters into a larger one, and that larger one flows from the opposite direction, the course of the smaller river will bend up against the approach of the larger river; and this happens because, when the larger river fills up all its bed with water, it makes an eddy in front of the mouth of the other river, and so carries the water poured in by the smaller river with its own. When the smaller river pours its waters into the larger one, which runs across the current at the mouth of the smaller river, its waters will bend with the downward movement of the larger river. [Footnote: In the original sketches the word *Arno* is written at the spot here marked *A*, at *R. Rifredi*, and at *M. Mugnone*.]

973.

When the fulness of rivers is diminished, then the acute angles formed at the junction of their branches become shorter at the sides and wider at the point; like the current *a n* and the current *d n*, which unite in *n* when the river is at its greatest fulness. I say, that when it is in this condition if, before the fullest time, *d n* was lower than *a n*, at the time of fulness *d n* will be full of sand and mud. When the water *d n* falls, it will carry away the mud and remain with a lower bottom, and the channel *a n* finding itself the higher, will fling its waters into the lower, *d n*, and will wash away all the point of the sand-spit *b n c*, and thus the angle *a c d* will remain larger than the angle *a n d* and the sides shorter, as I said before.

[Footnote: Above the first sketch we find, in the original, this note: "*Sopra il pote rubaconte alla torricella*"; and by the second, which represents a pier of a bridge, "*Sotto l'ospedale del ceppo*."]]

974.

WATER.

OF THE MOVEMENT OF A SUDDEN RUSH MADE BY A RIVER IN ITS BED PREVIOUSLY DRY.

In proportion as the current of the water given forth by the draining of the lake is slow or rapid in the dry river bed, so will this river be wider or narrower, or shallower or deeper in one place than another, according to this proposition: the flow and ebb of the sea which enters the Mediterranean from the ocean, and of the rivers which meet and struggle with it, will raise their waters more or less in proportion as the sea is wider or narrower.

[Footnote: In the margin is a sketch of a river which winds so as to form islands.]

Whirlpools.

975.

Whirlpools, that is to say caverns; that is to say places left by precipitated waters.

On the alterations in the channels of rivers.

976.

OF THE VIBRATION OF THE EARTH.

The subterranean channels of waters, like those which exist between the air and the earth, are those which unceasingly wear away and deepen the beds of their currents.

The origin of the sand in rivers (977. 978).

977.

A river that flows from mountains deposits a great quantity of large stones in its bed, which still have some of their angles and sides, and in the course of its flow it carries down smaller stones with the angles more worn; that is to say the large stones become smaller. And farther on it deposits coarse gravel and then smaller, and as it proceeds this becomes coarse sand and then finer, and going on thus the water, turbid with sand and gravel, joins the sea; and the sand settles on the sea-shores, being cast up by the salt waves; and there results the sand of so fine a nature as to seem almost like water, and it will not stop on the shores of the sea but returns by reason of its lightness, because it was originally formed of rotten leaves and other very light things. Still, being almost--as was said--of the nature of water itself, it afterwards, when the weather is calm, settles and becomes solid at the bottom of the sea, where by its fineness it becomes compact and by its smoothness resists the waves which glide over it; and in this shells are found; and this is white earth, fit for pottery.

978.

All the torrents of water flowing from the mountains to the sea

carry with them the stones from the hills to the sea, and by the influx of the sea-water towards the mountains; these stones were thrown back towards the mountains, and as the waters rose and retired, the stones were tossed about by it and in rolling, their angles hit together; then as the parts, which least resisted the blows, were worn off, the stones ceased to be angular and became round in form, as may be seen on the banks of the Elsa. And those remained larger which were less removed from their native spot; and they became smaller, the farther they were carried from that place, so that in the process they were converted into small pebbles and then into sand and at last into mud. After the sea had receded from the mountains the brine left by the sea with other humours of the earth made a concretion of these pebbles and this sand, so that the pebbles were converted into rock and the sand into tufa. And of this we see an example in the Adda where it issues from the mountains of Como and in the Ticino, the Adige and the Oglio coming from the German Alps, and in the Arno at Monte Albano [Footnote 13: At the foot of _Monte Albano_ lies Vinci, the birth place of Leonardo. Opposite, on the other bank of the Arno, is _Monte Lupo_], near Monte Lupo and Capraia where the rocks, which are very large, are all of conglomerated pebbles of various kinds and colours.

V.

ON MOUNTAINS.

The formation of mountains (979-983).

979.

Mountains are made by the currents of rivers.

Mountains are destroyed by the currents of rivers.

[Footnote: Compare 789.]

980.

That the Northern bases of some Alps are not yet petrified. And this is plainly to be seen where the rivers, which cut through them, flow towards the North; where they cut through the strata in the living stone in the higher parts of the mountains; and, where they join the plains, these strata are all of potter's clay; as is to be seen in the valley of Lamona where the river Lamona, as it issues from the Appenines, does these things on its banks.

That the rivers have all cut and divided the mountains of the great Alps one from the other. This is visible in the order of the stratified rocks, because from the summits of the banks, down to the river the correspondence of the strata in the rocks is visible on either side of the river. That the stratified stones of the mountains are all layers of clay, deposited one above the other by the various floods of the rivers. That the different size of the

strata is caused by the difference in the floods--that is to say greater or lesser floods.

981.

The summits of mountains for a long time rise constantly.

The opposite sides of the mountains always approach each other below; the depths of the valleys which are above the sphere of the waters are in the course of time constantly getting nearer to the centre of the world.

In an equal period, the valleys sink much more than the mountains rise.

The bases of the mountains always come closer together.

In proportion as the valleys become deeper, the more quickly are their sides worn away.

982.

In every concavity at the summit of the mountains we shall always find the divisions of the strata in the rocks.

983.

OF THE SEA WHICH ENCIRCLES THE EARTH.

I find that of old, the state of the earth was that its plains were all covered up and hidden by salt water. [Footnote: This passage has already been published by Dr. M. JORDAN: *Das Malerbuch des L. da Vinci*, Leipzig_ 1873, p. 86. However, his reading of the text differs from mine.]

The authorities for the study of the structure of the earth.

984.

Since things are much more ancient than letters, it is no marvel if, in our day, no records exist of these seas having covered so many countries; and if, moreover, some records had existed, war and conflagrations, the deluge of waters, the changes of languages and of laws have consumed every thing ancient. But sufficient for us is the testimony of things created in the salt waters, and found again in high mountains far from the seas.

VI.

GEOLOGICAL PROBLEMS.

985.

In this work you have first to prove that the shells at a thousand braccia of elevation were not carried there by the deluge, because they are seen to be all at one level, and many mountains are seen to be above that level; and to inquire whether the deluge was caused by rain or by the swelling of the sea; and then you must show how, neither by rain nor by swelling of the rivers, nor by the overflow of this sea, could the shells--being heavy objects--be floated up the mountains by the sea, nor have carried there by the rivers against the course of their waters.

Doubts about the deluge.

986.

A DOUBTFUL POINT.

Here a doubt arises, and that is: whether the deluge, which happened at the time of Noah, was universal or not. And it would seem not, for the reasons now to be given: We have it in the Bible that this deluge lasted 40 days and 40 nights of incessant and universal rain, and that this rain rose to ten cubits above the highest mountains in the world. And if it had been that the rain was universal, it would have covered our globe which is spherical in form. And this spherical surface is equally distant in every part, from the centre of its sphere; hence the sphere of the waters being under the same conditions, it is impossible that the water upon it should move, because water, in itself, does not move unless it falls; therefore how could the waters of such a deluge depart, if it is proved that it has no motion? and if it departed how could it move unless it went upwards? Here, then, natural reasons are wanting; hence to remove this doubt it is necessary to call in a miracle to aid us, or else to say that all this water was evaporated by the heat of the sun.

[Footnote: The passages, here given from the MS. Leic., have hitherto remained unknown. Some preliminary notes on the subject are to be found in MS. F 80a and 80b; but as compared with the fuller treatment here given, they are, it seems to me, of secondary interest. They contain nothing that is not repeated here more clearly and fully. LIBRI, *„Histoire des Sciences mathematiques III„*, pages 218--221, has printed the text of F 80a and 80b, therefore it seemed desirable to give my reasons for not inserting it in this work.]

That marine shells could not go up the mountains.

987.

OF THE DELUGE AND OF MARINE SHELLS.

If you were to say that the shells which are to be seen within the confines of Italy now, in our days, far from the sea and at such heights, had been brought there by the deluge which left them there,

I should answer that if you believe that this deluge rose 7 cubits above the highest mountains-- as he who measured it has written--these shells, which always live near the sea-shore, should have been left on the mountains; and not such a little way from the foot of the mountains; nor all at one level, nor in layers upon layers. And if you were to say that these shells are desirous of remaining near to the margin of the sea, and that, as it rose in height, the shells quitted their first home, and followed the increase of the waters up to their highest level; to this I answer, that the cockle is an animal of not more rapid movement than the snail is out of water, or even somewhat slower; because it does not swim, on the contrary it makes a furrow in the sand by means of its sides, and in this furrow it will travel each day from 3 to 4 braccia; therefore this creature, with so slow a motion, could not have travelled from the Adriatic sea as far as Monferrato in Lombardy [Footnote: *_Monferrato di Lombardia_*. The range of hills of Monferrato is in Piedmont, and Casale di Monferrato belonged, in Leonardo's time, to the Marchese di Mantova.], which is 250 miles distance, in 40 days; which he has said who took account of the time. And if you say that the waves carried them there, by their gravity they could not move, excepting at the bottom. And if you will not grant me this, confess at least that they would have to stay at the summits of the highest mountains, in the lakes which are enclosed among the mountains, like the lakes of Lario, or of Como and il Maggiore [Footnote: *_Lago di Lario_*. Lacus Larius was the name given by the Romans to the lake of Como. It is evident that it is here a slip of the pen since the the words in the MS. are: *_ "Come Lago di Lario o'l Magare e di Como,"_* In the MS. after line 16 we come upon a digression treating of the weight of water; this has here been omitted. It is 11 lines long.] and of Fiesole, and of Perugia, and others.

And if you should say that the shells were carried by the waves, being empty and dead, I say that where the dead went they were not far removed from the living; for in these mountains living ones are found, which are recognisable by the shells being in pairs; and they are in a layer where there are no dead ones; and a little higher up they are found, where they were thrown by the waves, all the dead ones with their shells separated, near to where the rivers fell into the sea, to a great depth; like the Arno which fell from the Gonfolina near to Monte Lupo [Footnote: *_Monte Lupo_*, compare 970, 13; it is between Empoli and Florence.], where it left a deposit of gravel which may still be seen, and which has agglomerated; and of stones of various districts, natures, and colours and hardness, making one single conglomerate. And a little beyond the sandstone conglomerate a tufa has been formed, where it turned towards Castel Florentino; farther on, the mud was deposited in which the shells lived, and which rose in layers according to the levels at which the turbid Arno flowed into that sea. And from time to time the bottom of the sea was raised, depositing these shells in layers, as may be seen in the cutting at Colle Gonzoli, laid open by the Arno which is wearing away the base of it; in which cutting the said layers of shells are very plainly to be seen in clay of a bluish colour, and

various marine objects are found there. And if the earth of our hemisphere is indeed raised by so much higher than it used to be, it must have become by so much lighter by the waters which it lost through the rift between Gibraltar and Ceuta; and all the more the higher it rose, because the weight of the waters which were thus lost would be added to the earth in the other hemisphere. And if the shells had been carried by the muddy deluge they would have been mixed up, and separated from each other amidst the mud, and not in regular steps and layers-- as we see them now in our time.

The marine shells were not produced away from the sea.

988.

As to those who say that shells existed for a long time and were born at a distance from the sea, from the nature of the place and of the cycles, which can influence a place to produce such creatures--to them it may be answered: such an influence could not place the animals all on one line, except those of the same sort and age; and not the old with the young, nor some with an operculum and others without their operculum, nor some broken and others whole, nor some filled with sea-sand and large and small fragments of other shells inside the whole shells which remained open; nor the claws of crabs without the rest of their bodies; nor the shells of other species stuck on to them like animals which have moved about on them; since the traces of their track still remain, on the outside, after the manner of worms in the wood which they ate into. Nor would there be found among them the bones and teeth of fish which some call arrows and others serpents' tongues, nor would so many [Footnote: I. Scilla argued against this hypothesis, which was still accepted in his days; see: *La vana Speculazione*, Napoli_ 1670.] portions of various animals be found all together if they had not been thrown on the sea shore. And the deluge cannot have carried them there, because things that are heavier than water do not float on the water. But these things could not be at so great a height if they had not been carried there by the water, such a thing being impossible from their weight. In places where the valleys have not been filled with salt sea water shells are never to be seen; as is plainly visible in the great valley of the Arno above Gonfolina; a rock formerly united to Monte Albano, in the form of a very high bank which kept the river pent up, in such a way that before it could flow into the sea, which was afterwards at its foot, it formed two great lakes; of which the first was where we now see the city of Florence together with Prato and Pistoia, and Monte Albano. It followed the rest of its bank as far as where Serravalle now stands. >From the Val d'Arno upwards, as far as Arezzo, another lake was formed, which discharged its waters into the former lake. It was closed at about the spot where now we see Girone, and occupied the whole of that valley above for a distance of 40 miles in length. This valley received on its bottom all the soil brought down by the turbid waters. And this is still to be seen at the foot of Prato Magno; it there lies very high where the rivers have not worn it away. Across this land are to be seen the deep cuts of the rivers

that have passed there, falling from the great mountain of Prato Magno; in these cuts there are no vestiges of any shells or of marine soil. This lake was joined with that of Perugia [Footnote: See Pl. CXIII.]

A great quantity of shells are to be seen where the rivers flow into the sea, because on such shores the waters are not so salt owing to the admixture of the fresh water, which is poured into it. Evidence of this is to be seen where, of old, the Appenines poured their rivers into the Adriatic sea; for there in most places great quantities of shells are to be found, among the mountains, together with bluish marine clay; and all the rocks which are torn off in such places are full of shells. The same may be observed to have been done by the Arno when it fell from the rock of Gonfolina into the sea, which was not so very far below; for at that time it was higher than the top of San Miniato al Tedesco, since at the highest summit of this the shores may be seen full of shells and oysters within its flanks. The shells did not extend towards Val di Nievole, because the fresh waters of the Arno did not extend so far.

That the shells were not carried away from the sea by the deluge, because the waters which came from the earth although they drew the sea towards the earth, were those which struck its depths; because the water which goes down from the earth, has a stronger current than that of the sea, and in consequence is more powerful, and it enters beneath the sea water and stirs the depths and carries with it all sorts of movable objects which are to be found in the earth, such as the above-mentioned shells and other similar things. And in proportion as the water which comes from the land is muddier than sea water it is stronger and heavier than this; therefore I see no way of getting the said shells so far in land, unless they had been born there. If you were to tell me that the river Loire [Footnote: Leonardo has written Era instead of Loera or Loira--perhaps under the mistaken idea that _Lo_ was an article.], which traverses France covers when the sea rises more than eighty miles of country, because it is a district of vast plains, and the sea rises about 20 braccia, and shells are found in this plain at the distance of 80 miles from the sea; here I answer that the flow and ebb in our Mediterranean Sea does not vary so much; for at Genoa it does not rise at all, and at Venice but little, and very little in Africa; and where it varies little it covers but little of the country.

The course of the water of a river always rises higher in a place where the current is impeded; it behaves as it does where it is reduced in width to pass under the arches of a bridge.

Further researches (989-991).

989.

A CONFUTATION OF THOSE WHO SAY THAT SHELLS MAY HAVE BEEN CARRIED TO A DISTANCE OF MANY DAYS' JOURNEY FROM THE SEA BY THE DELUGE, WHICH WAS SO HIGH AS TO BE ABOVE THOSE HEIGHTS.

I say that the deluge could not carry objects, native to the sea, up to the mountains, unless the sea had already increased so as to create inundations as high up as those places; and this increase could not have occurred because it would cause a vacuum; and if you were to say that the air would rush in there, we have already concluded that what is heavy cannot remain above what is light, whence of necessity we must conclude that this deluge was caused by rain water, so that all these waters ran to the sea, and the sea did not run up the mountains; and as they ran to the sea, they thrust the shells from the shore of the sea and did not draw them to wards themselves. And if you were then to say that the sea, raised by the rain water, had carried these shells to such a height, we have already said that things heavier than water cannot rise upon it, but remain at the bottom of it, and do not move unless by the impact of the waves. And if you were to say that the waves had carried them to such high spots, we have proved that the waves in a great depth move in a contrary direction at the bottom to the motion at the top, and this is shown by the turbidity of the sea from the earth washed down near its shores. Anything which is lighter than the water moves with the waves, and is left on the highest level of the highest margin of the waves. Anything which is heavier than the water moves, suspended in it, between the surface and the bottom; and from these two conclusions, which will be amply proved in their place, we infer that the waves of the surface cannot convey shells, since they are heavier than water.

If the deluge had to carry shells three hundred and four hundred miles from the sea, it would have carried them mixed with various other natural objects heaped together; and we see at such distances oysters all together, and sea-snails, and cuttlefish, and all the other shells which congregate together, all to be found together and dead; and the solitary shells are found wide apart from each other, as we may see them on sea-shores every day. And if we find oysters of very large shells joined together and among them very many which still have the covering attached, indicating that they were left here by the sea, and still living when the strait of Gibraltar was cut through; there are to be seen, in the mountains of Parma and Piacenza, a multitude of shells and corals, full of holes, and still sticking to the rocks there. When I was making the great horse for Milan, a large sack full was brought to me in my workshop by certain peasants; these were found in that place and among them were many preserved in their first freshness.

Under ground, and under the foundations of buildings, timbers are found of wrought beams and already black. Such were found in my time in those diggings at Castel Fiorentino. And these had been in that deep place before the sand carried by the Arno into the sea, then covering the plain, had been raised to such a height; and before the plains of Casentino had been so much lowered, by the earth being constantly carried down from them.

[Footnote: These lines are written in the margin.]

And if you were to say that these shells were created, and were continually being created in such places by the nature of the spot, and of the heavens which might have some influence there, such an opinion cannot exist in a brain of much reason; because here are the years of their growth, numbered on their shells, and there are large and small ones to be seen which could not have grown without food, and could not have fed without motion--and here they could not move [Footnote: These lines are written in the margin.]

990.

That in the drifts, among one and another, there are still to be found the traces of the worms which crawled upon them when they were not yet dry. And all marine clays still contain shells, and the shells are petrified together with the clay. From their firmness and unity some persons will have it that these animals were carried up to places remote from the sea by the deluge. Another sect of ignorant persons declare that Nature or Heaven created them in these places by celestial influences, as if in these places we did not also find the bones of fishes which have taken a long time to grow; and as if, we could not count, in the shells of cockles and snails, the years and months of their life, as we do in the horns of bulls and oxen, and in the branches of plants that have never been cut in any part. Besides, having proved by these signs the length of their lives, it is evident, and it must be admitted, that these animals could not live without moving to fetch their food; and we find in them no instrument for penetrating the earth or the rock where we find them enclosed. But how could we find in a large snail shell the fragments and portions of many other sorts of shells, of various sorts, if they had not been thrown there, when dead, by the waves of the sea like the other light objects which it throws on the earth? Why do we find so many fragments and whole shells between layer and layer of stone, if this had not formerly been covered on the shore by a layer of earth thrown up by the sea, and which was afterwards petrified? And if the deluge before mentioned had carried them to these parts of the sea, you might find these shells at the boundary of one drift but not at the boundary between many drifts. We must also account for the winters of the years during which the sea multiplied the drifts of sand and mud brought down by the neighbouring rivers, by washing down the shores; and if you chose to say that there were several deluges to produce these rifts and the shells among them, you would also have to affirm that such a deluge took place every year. Again, among the fragments of these shells, it must be presumed that in those places there were sea coasts, where all the shells were thrown up, broken, and divided, and never in pairs, since they are found alive in the sea, with two valves, each serving as a lid to the other; and in the drifts of rivers and on the shores of the sea they are found in fragments. And within the limits of the separate strata of rocks they are found, few in number and in pairs like those which were left by the sea, buried alive in the mud, which subsequently dried up and, in time, was petrified.

991.

And if you choose to say that it was the deluge which carried these shells away from the sea for hundreds of miles, this cannot have happened, since that deluge was caused by rain; because rain naturally forces the rivers to rush towards the sea with all the things they carry with them, and not to bear the dead things of the sea shores to the mountains. And if you choose to say that the deluge afterwards rose with its waters above the mountains, the movement of the sea must have been so sluggish in its rise against the currents of the rivers, that it could not have carried, floating upon it, things heavier than itself; and even if it had supported them, in its receding it would have left them strewn about, in various spots. But how are we to account for the corals which are found every day towards Monte Ferrato in Lombardy, with the holes of the worms in them, sticking to rocks left uncovered by the currents of rivers? These rocks are all covered with stocks and families of oysters, which as we know, never move, but always remain with one of their halves stuck to a rock, and the other they open to feed themselves on the animalcules that swim in the water, which, hoping to find good feeding ground, become the food of these shells. We do not find that the sand mixed with seaweed has been petrified, because the weed which was mingled with it has shrunk away, and this the Po shows us every day in the debris of its banks.

Other problems (992-994).

992.

Why do we find the bones of great fishes and oysters and corals and various other shells and sea-snails on the high summits of mountains by the sea, just as we find them in low seas?

993.

You now have to prove that the shells cannot have originated if not in salt water, almost all being of that sort; and that the shells in Lombardy are at four levels, and thus it is everywhere, having been made at various times. And they all occur in valleys that open towards the seas.

994.

>From the two lines of shells we are forced to say that the earth indignantly submerged under the sea and so the first layer was made; and then the deluge made the second.

[Footnote: This note is in the early writing of about 1470--1480. On the same sheet are the passages No. 1217 and 1219. Compare also No. 1339. All the foregoing chapters are from Manuscripts of about 1510. This explains the want of connection and the contradiction between this and the foregoing texts.]

VII.

ON THE ATMOSPHERE.

Constituents of the atmosphere.

995.

That the brightness of the air is occasioned by the water which has dissolved itself in it into imperceptible molecules. These, being lighted by the sun from the opposite side, reflect the brightness which is visible in the air; and the azure which is seen in it is caused by the darkness that is hidden beyond the air. [Footnote: Compare Vol. I, No. 300.]

On the motion of air (996--999).

996.

That the return eddies of wind at the mouth of certain valleys strike upon the waters and scoop them out in a great hollow, whirl the water into the air in the form of a column, and of the colour of a cloud. And I saw this thing happen on a sand bank in the Arno, where the sand was hollowed out to a greater depth than the stature of a man; and with it the gravel was whirled round and flung about for a great space; it appeared in the air in the form of a great bell-tower; and the top spread like the branches of a pine tree, and then it bent at the contact of the direct wind, which passed over from the mountains.

997.

The element of fire acts upon a wave of air in the same way as the air does on water, or as water does on a mass of sand --that is earth; and their motions are in the same proportions as those of the motors acting upon them.

998.

OF MOTION.

I ask whether the true motion of the clouds can be known by the motion of their shadows; and in like manner of the motion of the sun.

999.

To know better the direction of the winds. [Footnote: In connection with this text I may here mention a hygrometer, drawn and probably invented by Leonardo. A facsimile of this is given in Vol. I, p. 297 with the note: *'Modi di pesare l'arie eddi sapere quando s'a arrampere il tepo'* (Mode of weighing the air and of knowing when the weather will change); by the sponge *"Spugnea"* is written.]

The globe an organism.

1000.

Nothing originates in a spot where there is no sentient, vegetable and rational life; feathers grow upon birds and are changed every year; hairs grow upon animals and are changed every year, excepting some parts, like the hairs of the beard in lions, cats and their like. The grass grows in the fields, and the leaves on the trees, and every year they are, in great part, renewed. So that we might say that the earth has a spirit of growth; that its flesh is the soil, its bones the arrangement and connection of the rocks of which the mountains are composed, its cartilage the tufa, and its blood the springs of water. The pool of blood which lies round the heart is the ocean, and its breathing, and the increase and decrease of the blood in the pulses, is represented in the earth by the flow and ebb of the sea; and the heat of the spirit of the world is the fire which pervades the earth, and the seat of the vegetative soul is in the fires, which in many parts of the earth find vent in baths and mines of sulphur, and in volcanoes, as at Mount Aetna in Sicily, and in many other places.

[Footnote: Compare No. 929.]

XVII.

Topographical Notes.

_A large part of the texts published in this section might perhaps have found their proper place in connection with the foregoing chapters on Physical Geography. But these observations on Physical Geography, of whatever kind they may be, as soon as they are localised acquire a special interest and importance and particularly as bearing on the question whether Leonardo himself made the observations recorded at the places mentioned or merely noted the statements from hearsay. In a few instances he himself tells us that he writes at second hand. In some cases again, although the style and expressions used make it seem highly probable that he has derived his information from others-- though, as it seems to me, these cases are not very numerous--we find, on the other hand, among these topographical notes a great number of observations, about which it is extremely difficult to form a decided opinion. Of what the Master's life and travels may have been throughout his sixty-seven years of life we know comparatively little; for a long course of time, and particularly from about 1482 to 1486, we do not even know with certainty that he was living in Italy. Thus, from a biographical point of view a very great interest attaches to some of the topographical notes, and for this reason it seemed that it would add to their value to arrange them in a group by themselves. Leonardo's intimate knowledge with places, some of which were certainly remote from his native home, are of importance as contributing to decide the still open question as to the extent of

Leonardo's travels. We shall find in these notes a confirmation of the view, that the MSS. in which the Topographical Notes occur are in only a very few instances such diaries as may have been in use during a journey. These notes are mostly found in the MSS. books of his later and quieter years, and it is certainly remarkable that Leonardo is very reticent as to the authorities from whom he quotes his facts and observations: For instance, as to the Straits of Gibraltar, the Nile, the Taurus Mountains and the Tigris and Euphrates. Is it likely that he, who declared that in all scientific research, his own experience should be the foundation of his statements (see XIX Philosophy No. 987--991,) should here have made an exception to this rule without mentioning it?_

As for instance in the discussion as to the equilibrium of the mass of water in the Mediterranean Sea--a subject which, it may be observed, had at that time attracted the interest and study of hardly any other observer. The acute remarks, in Nos. 985--993, on the presence of shells at the tops of mountains, suffice to prove--as it seems to me--that it was not in his nature to allow himself to be betrayed into wide generalisations, extending beyond the limits of his own investigations, even by such brilliant results of personal study.

Most of these Topographical Notes, though suggesting very careful and thorough research, do not however, as has been said, afford necessarily indisputable evidence that that research was Leonardo's own. But it must be granted that in more than one instance probability is in favour of this idea.

Among the passages which treat somewhat fully of the topography of Eastern places by far the most interesting is a description of the Taurus Mountains; but as this text is written in the style of a formal report and, in the original, is associated with certain letters which give us the history of its origin, I have thought it best not to sever it from that connection. It will be found under No. XXI (Letters).

That Florence, and its neighbourhood, where Leonardo spent his early years, should be nowhere mentioned except in connection with the projects for canals, which occupied his attention for some short time during the first ten years of the XVth century, need not surprise us. The various passages relating to the construction of canals in Tuscany, which are put together at the beginning, are immediately followed by those which deal with schemes for canals in Lombardy; and after these come notes on the city and vicinity of Milan as well as on the lakes of North Italy.

_The notes on some towns of Central Italy which Leonardo visited in 1502, when in the service of Cesare Borgia, are reproduced here in the same order as in the note book used during these travels (MS. L., Institut de France). These notes have but little interest in themselves excepting as suggesting his itinerary. The maps of the districts drawn by Leonardo at the time are more valuable (see No.

1054 note). The names on these maps are not written from right to left, but in the usual manner, and we are permitted to infer that they were made in obedience to some command, possibly for the use of Cesare Borgia himself; the fact that they remained nevertheless in Leonardo's hands is not surprising when we remember the sudden political changes and warlike events of the period. There can be no doubt that these maps, which are here published for the first time, are original in the strictest sense of the word, that is to say drawn from observations of the places themselves; this is proved by the fact--among others--that we find among his manuscripts not only the finished maps themselves but the rough sketches and studies for them. And it would perhaps be difficult to point out among the abundant contributions to geographical knowledge published during the XVIth century, any maps at all approaching these in accuracy and finish._

_The interesting map of the world, so far as it was then known, which is among the Leonardo MSS. at Windsor (published in the 'Archaeologia' _Vol. XI) cannot be attributed to the Master, as the Marchese Girolamo d'Adda has sufficiently proved; it has not therefore been reproduced here._

Such of Leonardo's observations on places in Italy as were made before or after his official travels as military engineer to Cesare Borgia, have been arranged in alphabetical order, under Nos. 1034-1054. The most interesting are those which relate to the Alps and the Appenines, Nos. 1057-1068.

Most of the passages in which France is mentioned have hitherto remained unknown, as well as those which treat of the countries bordering on the Mediterranean, which come at the end of this section. Though these may be regarded as of a more questionable importance in their bearing on the biography of the Master than those which mention places in France, it must be allowed that they are interesting as showing the prominent place which the countries of the East held in his geographical studies. He never once alludes to the discovery of America.

I.

ITALY.

Canals in connection with the Arno (1001-1008).

1001.

CANAL OF FLORENCE.

Sluices should be made in the valley of la Chiana at Arezzo, so that when, in the summer, the Arno lacks water, the canal may not remain dry: and let this canal be 20 braccia wide at the bottom, and at the top 30, and 2 braccia deep, or 4, so that two of these braccia may flow to the mills and the meadows, which will benefit the country;

and Prato, Pistoia and Pisa, as well as Florence, will gain two hundred thousand ducats a year, and will lend a hand and money to this useful work; and the Lucchese the same, for the lake of Sesto will be navigable; I shall direct it to Prato and Pistoia, and cut through Serravalle and make an issue into the lake; for there will be no need of locks or supports, which are not lasting and so will always be giving trouble in working at them and keeping them up.

And know that in digging this canal where it is 4 braccia deep, it will cost 4 dinari the square braccio; for twice the depth 6 dinari, if you are making 4 braccia [Footnote: This passage is illustrated by a slightly sketched map, on which these places are indicated from West to East: Pisa, Luccha, Lago, Seravalle, Pistoja, Prato, Firenze.] and there are but 2 banks; that is to say one from the bottom of the trench to the surface of the edges of it, and the other from these edges to the top of the ridge of earth which will be raised on the margin of the bank. And if this bank were of double the depth only the first bank will be increased, that is 4 braccia increased by half the first cost; that is to say that if at first 4 dinari were paid for 2 banks, for 3 it would come to 6, at 2 dinari the bank, if the trench measured 16 braccia at the bottom; again, if the trench were 16 braccia wide and 4 deep, coming to 4 lire for the work, 4 Milan dinari the square braccio; a trench which was 32 braccia at the bottom would come to 8 dinari the square braccio.

1002.

>From the wall of the Arno at [the gate of] la Giustizia to the bank of the Arno at Sardigna where the walls are, to the mills, is 7400 braccia, that is 2 miles and 1400 braccia and beyond the Arno is 5500 braccia.

[Footnote: 2. Giustizia. By this the Porta della Giustizia seems to be meant; from the XVth to the XVIth centuries it was also commonly known as Porta Guelfa, Porta San Francesco del Renaio, Porta Nuova, and Porta Reale. It was close to the Arno opposite to the Porta San Niccolo, which still exists.]

1003.

By guiding the Arno above and below a treasure will be found in each acre of ground by whomsoever will.

1004.

The wall of the old houses runs towards the gate of San Nicolo.

[Footnote: By the side of this text there is an indistinct sketch, resembling that given under No.973. On the bank is written the word Casace. There then follows in the original a passage of 12 lines in which the consequences of the windings of the river are discussed. A larger but equally hasty diagram on the same page represents the shores of the Arno inside Florence as in two parallel

lines. Four horizontal lines indicate the bridges. By the side these measures are stated in figures: I. (at the Ponte alla Carraja):
230--largho br. 12 e 2 di spoda e 14 di pile e a 4 pilastri; 2.
(at the Ponte S. Trinita); _l88--largho br. 15 e 2 di spode he 28
di pilastri for delle spode e pilastri so 2;_ 3. (at the Ponte
vecchio); _pote lung br. 152 e largo;_ 4. (at the Ponte alle
Grazie): _290 ellargo 12 e 2 di spode e 6 di pili._

There is, in MS. W. L. 212b, a sketched plan of Florence, with the following names of gates:

_Nicholo--Saminiato--Giorgo--Ghanolini--Porta San Fredian
--Prato--Faenza--Ghallo--Pinti--Giustitia_]

1005.

The ruined wall is 640 braccia; 130 is the wall remaining with the mill; 300 braccia were broken in 4 years by Bisarno.

1006.

They do not know why the Arno will never remain in a channel. It is because the rivers which flow into it deposit earth where they enter, and wear it away on the opposite side, bending the river in that direction. The Arno flows for 6 miles between la Caprona and Leghorn; and for 12 through the marshes, which extend 32 miles, and 16 from La Caprona up the river, which makes 48; by the Arno from Florence beyond 16 miles; to Vico 16 miles, and the canal is 5; from Florence to Fucechio it is 40 miles by the river Arno.

56 miles by the Arno from Florence to Vico; by the Pistoia canal it is 44 miles. Thus it is 12 miles shorter by the canal than by the Arno.

[Footnote: This passage is written by the side of a map washed in Indian ink, of the course of the Arno; it is evidently a sketch for a completer map.

These investigations may possibly be connected with the following documents. _Francesco Guiducci alla Balia di Firenze. Dal Campo contro Pisa_ 24 _Luglio_ 1503 (_Archivio di Stato, Firenze, Lettere alla Balia_; published by J. GAYE, _Carteggio inedito d'Artisti, Firenze_ 1840, _Tom. II_, p. 62): _Ex Castris, Franciscus Ghuiduccius,_ 24. _Jul._ 1503. _Appresso fu qui hieri con una di V. Signoria Alexandro degli Albizi insieme con Leonardo da Vinci et certi altri, et veduto el disegno insieme con el ghovernatore, doppo molte discussioni et dubii conclusesi che l'opera fussi molto al proposito, o si veramente Arno volgersi qui, o restarvi con un canale, che almeno vieterebbe che le colline da nemici non potrebbono essere offese; come tucto referiranno loro a bocha V. S._

And, _Archivio di Stato, Firenze, Libro d'Entrata e Uscita di cassa de' Magnifici Signori di luglio e agosto_

1503_a_51_T.: Andata di Leonardo al Campo sotto Pisa. Spese straordinarie dieno dare a di XXVI di luglio L. LVI sol. XII per loro a Giovanni Piffero; e sono per tanti, asegnia avere spexi in vetture di sei chavalli a spese di vitto per andare chon Lionardo da Vinci a livellare Arno in quello di Pisa per levallò del lilo suo. (Published by MILANESI, _Archivio Storico Italiano, Serie III, Tom. XVI.) VASARI asserts: _(Leonardo) fu il primo ancora, che giovanetto discorresse sopra il fiume d'Arno per metterlo in canale da Pisa a Fiorenza_ (ed. SANSONI, IV, 20).

The passage above is in some degree illustrated by the map on Pl. CXII, where the course of the Arno westward from Empoli is shown.]

1007.

The eddy made by the Mensola, when the Arno is low and the Mensola full.

[Footnote: _Mensola_ is a mountain stream which falls into the Arno about a mile and a half above Florence.

A=Arno, I=Isola, M=Mvgone, P=Pesa, N=Mesola.]

1008.

That the river which is to be turned from one place to another must be coaxed and not treated roughly or with violence; and to do this a sort of floodgate should be made in the river, and then lower down one in front of it and in like manner a third, fourth and fifth, so that the river may discharge itself into the channel given to it, or that by this means it may be diverted from the place it has damaged, as was done in Flanders--as I was told by Niccolo di Forsore.

How to protect and repair the banks washed by the water, as below the island of Cocomeri.

Ponte Rubaconte (Fig. 1); below [the palaces] Bisticci and Canigiani (Fig. 2). Above the flood gate of la Giustizia (Fig. 3); _a b_ is a sand bank opposite the end of the island of the Cocomeri in the middle of the Arno (Fig. 4). [Footnote: The course of the river Arno is also discussed in Nos. 987 and 988.]

Canals in the Milanese (1009-1013).

1009.

The canal of San Cristofano at Milan made May 3rd 1509. [Footnote: This observation is written above a washed pen and ink drawing which has been published as Tav. VI in the _,,Saggio."_ The editors of that work explain the drawing as _"uno Studio di bocche per estrazione d'acqua."_]]

1010.

OF THE CANAL OF MARTESANA.

By making the canal of Martesana the water of the Adda is greatly diminished by its distribution over many districts for the irrigation of the fields. A remedy for this would be to make several little channels, since the water drunk up by the earth is of no more use to any one, nor mischief neither, because it is taken from no one; and by making these channels the water which before was lost returns again and is once more serviceable and useful to men.

[Footnote: _"el navilio di Martagano"_ is also mentioned in a note written in red chalk, MS. H2 17a Leonardo has, as it seems, little to do with Lodovico il Moro's scheme to render this canal navigable. The canal had been made in 1460 by Bertonino da Novara. Il Moro issued his degree in 1493, but Leonardo's notes about this canal were, with the exception of one (No. 1343), written about sixteen years later.]

1011.

No canal which is fed by a river can be permanent if the river whence it originates is not wholly closed up, like the canal of Martesana which is fed by the Ticino.

1012.

>From the beginning of the canal to the mill.

>From the beginning of the canal of Brivio to the mill of Travaglia is 2794 trabochi, that is 11176 braccia, which is more than 3 miles and two thirds; and here the canal is 57 braccia higher than the surface of the water of the Adda, giving a fall of two inches in every hundred trabochi; and at that spot we propose to take the opening of our canal.

[Footnote: The following are written on the sketches: At the place marked _N: navilio da dacquiue_ (canal of running water); at _M: molin del Travaglia_ (Mill of Travaglia); at _R: rochetta ssanta maria_ (small rock of Santa Maria); at _A: Adda;_ at _L: Lagho di Lecho ringorgato alli 3 corni in Adda,--Concha perpetua_ (lake of Lecco overflowing at Tre Corni, in Adda,-- a permanent sluice). Near the second sketch, referring to the sluice near _Q: qui la chatena ttalie d'u peso_ (here the chain is in one piece). At _M_ in the lower sketch: _mol del travaglia, nel cavare la concha il tereno ara chotrapero co cassa d'acqua._ (Mill of Travaglia, in digging out the sluice the soil will have as a counterpoise a vessel of water).]

1013.

If it be not reported there that this is to be a public canal, it will be necessary to pay for the land; [Footnote 3: _il re_. Louis

XII or Francis I of France. It is hardly possible to doubt that the canals here spoken of were intended to be in the Milanese. Compare with this passage the rough copy of a letter by Leonardo, to the _"Presidente dell' Ufficio regolatore dell' acqua"_ on No. 1350. See also the note to No. 745, 1. 12.] and the king will pay it by remitting the taxes for a year.

Estimates and preparatory studies for canals (1014. 1015).

1014.

CANAL.

The canal which may be 16 braccia wide at the bottom and 20 at the top, we may say is on the average 18 braccia wide, and if it is 4 braccia deep, at 4 dinari the square braccia; it will only cost 900 ducats, to excavate by the mile, if the square braccio is calculated in ordinary braccia; but if the braccia are those used in measuring land, of which every 4 are equal to 4 1/2 and if by the mile we understand three thousand ordinary braccia; turned into land braccia, these 3000 braccia will lack 1/4; there remain 2250 braccia, which at 4 dinari the braccio will amount to 675 ducats a mile. At 3 dinari the square braccio, the mile will amount to 506 1/4 ducats so that the excavation of 30 miles of the canal will amount to 15187 1/2 ducats.

1015.

To make the great canal, first make the smaller one and conduct into it the waters which by a wheel will help to fill the great one.

Notes on buildings in Milan (1016-1019)

1016.

Indicate the centre of Milan.

Moforte--porta resa--porta nova--strada nova--navilio--porta cumana--barco--porta giovia--porta vercellina--porta sco Anbrogio--porta Tesinese--torre dell' Imperatore-- porta Lodovica--acqua.

[Footnote: See Pl. CIX. The original sketch is here reduced to about half its size. The gates of the town are here named, beginning at the right hand and following the curved line. In the bird's eye view of Milan below, the cathedral is plainly recognisable in the middle; to the right is the tower of San Gottardo. The square, above the number 9147, is the Lazzaretto, which was begun in 1488. On the left the group of buildings of the _'Castello'_ will be noticed. On the sketched Plan of Florence (see No. 1004 note) Leonardo has written on the margin the following names of gates of Milan: Vercellina --Ticinese--Ludovica--Romana--Orientale-- Nova--Beatrice--Cumana--Compare too No. 1448, 11. 5, 12.]

1017.

The moat of Milan.

Canal 2 braccia wide.

The castle with the moats full.

The filling of the moats of the Castle of Milan.

1018.

THE BATH.

To heat the water for the stove of the Duchess take four parts of cold water to three parts of hot water.

[Footnote: Duchessa di Milano, Beatrice d'Este, wife of Ludovico il Moro to whom she was married, in 1491. She died in June 1497.]

1019.

In the Cathedral at the pulley of the nail of the cross.

Item.

To place the mass v r in the...

[Footnote: On this passage AMORETTI remarks (Memorie Storiche chap. IX): Nell'anno stesso lo veggiamo formare un congegno di carucole e di corde, con cui trasportare in piu venerabile e piu sicuro luogo, cioe nell'ultima arcata della nave di mezzo della metropolitana, la sacra reliquia del Santo Chiodo, che ivi ancor si venera. Al fol. 15 del codice segnato Q. R. in 16, egli ci ha lasciata di tal congegno una doppia figura, cioe una di quattro carucole, e una di tre colle rispettive corde, soggiugnandovi: in Domo alla carucola del Chiodo della Croce.

AMORETTI'S views as to the mark on the MS, and the date when it was written are, it may be observed, wholly unfounded. The MS. L, in which it occurs, is of the year 1502, and it is very unlikely that Leonardo was in Milan at that time; this however would not prevent the remark, which is somewhat obscure, from applying to the Cathedral at Milan.]

1020.

OF THE FORCE OF THE VACUUM FORMED IN A MOMENT.

I saw, at Milan, a thunderbolt fall on the tower della Credenza on its Northern side, and it descended with a slow motion down that side, and then at once parted from that tower and carried with it

and tore away from that wall a space of 3 braccia wide and two deep; and this wall was 4 braccia thick and was built of thin and small old bricks; and this was dragged out by the vacuum which the flame of the thunderbolt had caused, &c.

[Footnote: With reference to buildings at Milan see also Nos. 751 and 756, and Pl. XCV, No. 2 (explained on p. 52), Pl. C (explained on pages 60-62). See also pages 25, 39 and 40.]

Remarks on natural phenomena in and near Milan (1021. 1022).

1021.

I have already been to see a great variety (of atmospheric effects). And lately over Milan towards Lago Maggiore I saw a cloud in the form of an immense mountain full of rifts of glowing light, because the rays of the sun, which was already close to the horizon and red, tinged the cloud with its own hue. And this cloud attracted to it all the little clouds that were near while the large one did not move from its place; thus it retained on its summit the reflection of the sunlight till an hour and a half after sunset, so immensely large was it; and about two hours after sunset such a violent wind arose, that it was really tremendous and unheard of.

[Footnote: *_di arie_* is wanting in the original but may safely be inserted in the context, as the formation of clouds is under discussion before this text.]

1022.

On the 10th day of December at 9 o'clock a. m. fire was set to the place.

On the 18th day of December 1511 at 9 o'clock a. m. this second fire was kindled by the Swiss at Milan at the place called DCXC.

[Footnote: With these two texts, (l. 1--2 and l. 3--5 are in the original side by side) there are sketches of smoke wreaths in red chalk.]

Note on Pavia.

1023.

The chimneys of the castle of Pavia have 6 rows of openings and from each to the other is one braccio.

[Footnote: Other notes relating to Pavia occur on p. 43 and p. 53 (Pl. XCVIII, No. 3). Compare No. 1448, 26.]

Notes on the Sforzesca near Vigevano (1024-1028).

1024.

On the 2nd day of February 1494. At Sforzesca I drew twenty five steps, $\frac{2}{3}$ braccia to each, and 8 braccia wide.

[Footnote: See Pl. CX, No. 2. The rest of the notes on this page refer to the motion of water. On the lower sketch we read: 4 _br._ (four braccia) and _giara_ (for _ghiaja_, sand, gravel).]

1025.

The vineyards of Vigevano on the 20th day of March 1494.

[Footnote: On one side there is an effaced sketch in red chalk.]

1026.

To lock up a butteris at Vigevano.

1027.

Again if the lowest part of the bank which lies across the current of the waters is made in deep and wide steps, after the manner of stairs, the waters which, in their course usually fall perpendicularly from the top of such a place to the bottom, and wear away the foundations of this bank can no longer descend with a blow of too great a force; and I find the example of this in the stairs down which the water falls in the fields at Sforzesca at Vigevano over which the running water falls for a height of 50 braccia.

1028.

Stair of Vigevano below La Sforzesca, 130 steps, $\frac{1}{4}$ braccio high and $\frac{1}{2}$ braccio wide, down which the water falls, so as not to wear away anything at the end of its fall; by these steps so much soil has come down that it has dried up a pool; that is to say it has filled it up and a pool of great depth has been turned into meadows.

Notes on the North Italian lake. (1029-1033)

1029.

In many places there are streams of water which swell for six hours and ebb for six hours; and I, for my part, have seen one above the lake of Como called Fonte Pliniana, which increases and ebbs, as I have said, in such a way as to turn the stones of two mills; and when it fails it falls so low that it is like looking at water in a deep pit.

[Footnote: The fountain is known by this name to this day: it is near Torno, on the Eastern shore of Como. The waters still rise and fall with the flow and ebb of the tide as Pliny described it (Epist. IV, 30; Hist. Nat. II, 206).]

1030.

LAKE OF COMO. VALLEY OF CHIAVENNA.

Above the lake of Como towards Germany is the valley of Chiavenna where the river Mera flows into this lake. Here are barren and very high mountains, with huge rocks. Among these mountains are to be found the water-birds called gulls. Here grow fir trees, larches and pines. Deer, wildgoats, chamois, and terrible bears. It is impossible to climb them without using hands and feet. The peasants go there at the time of the snows with great snares to make the bears fall down these rocks. These mountains which very closely approach each other are parted by the river. They are to the right and left for the distance of 20 miles throughout of the same nature. >From mile to mile there are good inns. Above on the said river there are waterfalls of 400 braccia in height, which are fine to see; and there is good living at 4 soldi the reckoning. This river brings down a great deal of timber.

VAL SASINA.

Val Sasina runs down towards Italy; this is almost the same form and character. There grow here many _mappello_ and there are great ruins and falls of water [Footnote 14: The meaning of _mappello_ is unknown.].

VALLEY OF INTROZZO.

This valley produces a great quantity of firs, pines and larches; and from here Ambrogio Fereri has his timber brought down; at the head of the Valtellina are the mountains of Bormio, terrible and always covered with snow; marmots (?) are found there.

BELLAGGIO.

Opposite the castle Bellaggio there is the river Latte, which falls from a height of more than 100 braccia from the source whence it springs, perpendicularly, into the lake with an inconceivable roar and noise. This spring flows only in August and September.

VALTELLINA.

Valtellina, as it is called, is a valley enclosed in high and terrible mountains; it produces much strong wine, and there is so much cattle that the natives conclude that more milk than wine grows there. This is the valley through which the Adda passes, which first runs more than 40 miles through Germany; this river breeds the fish _temolo_ which live on silver, of which much is to be found in its sands. In this country every one can sell bread and wine, and the wine is worth at most one soldo the bottle and a pound of veal one soldo, and salt ten dinari and butter the same and their pound is 30 ounces, and eggs are one soldo the lot.

At BORMIO.

At Bormio are the baths;--About eight miles above Como is the Pliniana, which increases and ebbs every six hours, and its swell supplies water for two mills; and its ebbing makes the spring dry up; two miles higher up there is Nesso, a place where a river falls with great violence into a vast rift in the mountain. These excursions are to be made in the month of May. And the largest bare rocks that are to be found in this part of the country are the mountains of Mandello near to those of Lecco, and of Gravidona towards Bellinzona, 30 miles from Lecco, and those of the valley of Chiavenna; but the greatest of all is that of Mandello, which has at its base an opening towards the lake, which goes down 200 steps, and there at all times is ice and wind.

IN VAL SASINA.

In Val Sasina, between Vimognio and Introbbio, to the right hand, going in by the road to Lecco, is the river Troggia which falls from a very high rock, and as it falls it goes underground and the river ends there. 3 miles farther we find the buildings of the mines of copper and silver near a place called Pra' Santo Pietro, and mines of iron and curious things. La Grigna is the highest mountain there is in this part, and it is quite bare.

[Footnote: 1030 and 1031. From the character of the handwriting we may conclude that these observations were made in Leonardo's youth; and I should infer from their contents, that they were notes made in anticipation of a visit to the places here described, and derived from some person (unknown to us) who had given him an account of them.]

1032.

The lake of Pusiano flows into the lake of Segrino [Footnote 3: The statement about the lake Segrino is incorrect; it is situated in the Valle Assina, above the lake of Pusiano.] and of Annone and of Sala. The lake of Annone is 22 braccia higher at the surface of its water than the surface of the water of the lake of Lecco, and the lake of Pusiano is 20 braccia higher than the lake of Annone, which added to the afore said 22 braccia make 42 braccia and this is the greatest height of the surface of the lake of Pusiano above the surface of the lake of Lecco.

[Footnote: This text has in the original a slight sketch to illustrate it.]

1033.

At Santa Maria in the Valley of Ravagnate [Footnote 2: _Ravagnate_ (Leonardo writes _Ravagna_) in the Brianza is between Oggiono and Brivio, South of the lake of Como. M. Ravaisson avails himself of

this note to prove his hypothesis that Leonardo paid two visits to France. See Gazette des Beaux Arts, 1881 pag. 528:

_Au recto du meme feuillet, on lit encore une note relative a une vallee "nemonti brigatia"; il me semble qu'il s'agit bien des monts de Briancon, le Brigantio des anciens. Briancon est sur la route de Lyon en Italie. Ce fut par le mont Viso que passerent, en aout 1515, les troupes francaises qui allaient remporter la victoire de Marignan.

Leonard de Vinci, ingenieur de Francois Ier, comme il l'avait ete de Louis XII, aurait-il ete pour quelque chose dans le plan du celebre passage des Alpes, qui eut lieu en aout 1515, et a la suite duquel on le vit accompagner partout le chevaleresque vainqueur? Aurait-il ete appele par le jeune roi, de Rome ou l'artiste etait alors, des son avènement au trone?_] in the mountains of Brianza are the rods of chestnuts of 9 braccia and one out of an average of 100 will be 14 braccia.

At Varallo di Ponbia near to Sesto on the Ticino the quinces are white, large and hard.

[Footnote 5: Varallo di Ponbia, about ten miles South of Arona is distinct from Varallo the chief town in the Val di Sesia.]

Notes on places in Central Italy, visited in 1502 (1034-1054).

1034.

Pigeon-house at Urbino, the 30th day of July 1502. [Footnote: An indistinct sketch is introduced with this text, in the original, in which the word _Scolatoro_ (conduit) is written.]

1035.

Made by the sea at Piombino. [Footnote: Below the sketch there are eleven lines of text referring to the motion of waves.]

1036.

Acquapendente is near Orvieto. [Footnote: _Acquapendente_ is about 10 miles West of Orvieto, and is to the right in the map on Pl. CXIII, near the lake of Bolsena.]

1037.

The rock of Cesena. [Footnote: See Pl. XCIV No. 1, the lower sketch. The explanation of the upper sketch is given on p. 29.]

1038.

Siena, _a b_ 4 braccia, _a c_ 10 braccia. Steps at [the castle of] Urbino. [Footnote: See Pl. CX No. 3; compare also No. 765.]

1039.

The bell of Siena, that is the manner of its movement, and the place of the attachment of the clapper. [Footnote: The text is accompanied by an indistinct sketch.]

1040.

On St. Mary's day in the middle of August, at Cesena, 1502.
[Footnote: See Pl. CX, No. 4.]

1041.

Stairs of the [palace of the] Count of Urbino,--rough. [Footnote: The text is accompanied by a slight sketch.]

1042.

At the fair of San Lorenzo at Cesena. 1502.

1043.

Windows at Cesena. [Footnote: There are four more lines of text which refer to a slightly sketched diagram.]

1044.

At Porto Cesenatico, on the 6th of September 1502 at 9 o'clock a. m.

The way in which bastions ought to project beyond the walls of the towers to defend the outer talus; so that they may not be taken by artillery.

[Footnote: An indistinct sketch, accompanies this passage.]

1045.

The rock of the harbour of Cesena is four points towards the South West from Cesena.

1046.

In Romagna, the realm of all stupidity, vehicles with four wheels are used, of which O the two in front are small and two high ones are behind; an arrangement which is very unfavourable to the motion, because on the fore wheels more weight is laid than on those behind, as I showed in the first of the 5th on "Elements".

1047.

Thus grapes are carried at Cesena. The number of the diggers of the ditches is [arranged] pyramidically. [Footnote: A sketch,

representing a hook to which two bunches of grapes are hanging, refers to these first two lines. Cesena is mentioned again Fol. 82a: _Carro da Cesena_ (a cart from Cesena).]

1048.

There might be a harmony of the different falls of water as you saw them at the fountain of Rimini on the 8th day of August, 1502.

1049.

The fortress at Urbino. [Footnote: 1049. In the original the text is written inside the sketch in the place here marked _n_.]

1050.

Imola, as regards Bologna, is five points from the West, towards the North West, at a distance of 20 miles.

Castel San Piero is seen from Imola at four points from the West towards the North West, at a distance of 7 miles.

Faenza stands with regard to Imola between East and South East at a distance of ten miles. Forli stands with regard to Faenza between South East and East at a distance of 20 miles from Imola and ten from Faenza.

Forlimpopoli lies in the same direction at 25 miles from Imola.

Bertinoro, as regards Imola, is five points from the East towards the South East, at 27 miles.

1051.

Imola as regards Bologna is five points from the West towards the North West at a distance of 20 miles.

Castel San Pietro lies exactly North West of Imola, at a distance of 7 miles.

Faenza, as regards Imola lies exactly half way between the East and South East at a distance of 10 miles; and Forli lies in the same direction from Imola at a distance of 20 miles; and Forlimpopolo lies in the same direction from Forli at a distance of 25 miles.

Bertinoro is seen from Imola two points from the East towards the South East at a distance of 27 miles.

[Footnote: Leonardo inserted this passage on the margin of the circular plan, in water colour, of Imola--see Pl. CXI No. 1.--In the original the fields surrounding the town are light green; the moat, which surrounds the fortifications and the windings of the river Santerno, are light blue. The parts, which have come out blackish

close to the river are yellow ochre in the original. The dark groups of houses inside the town are red. At the four points of the compass drawn in the middle of the town Leonardo has written (from right to left): *Mezzodi* (South) at the top; to the left *Scirocho* (South east), *levante* (East), *Greco* (North East), *Septantrione* (North), *Maestro* (North West), *ponente* (West) *Libecco* (South West). The arch in which the plan is drawn is, in the original, 42 centimetres across.

At the beginning of October 1502 Cesare Borgia was shut up in Imola by a sudden revolt of the Condottieri, and it was some weeks before he could release himself from this state of siege (see Gregorovius, *Geschichte der Stadt Rom im Mittelalter*, Vol. VII, Book XIII, 5, 5).

Besides this incident Imola plays no important part in the history of the time. I therefore think myself fully justified in connecting this map, which is at Windsor, with the siege of 1502 and with Leonardo's engagements in the service of Cesare Borgia, because a comparison of these texts, Nos. 1050 and 1051, raise, I believe, the hypothesis to a certainty.]

1052.

>From Bonconventi to Casa Nova are 10 miles, from Casa Nova to Chiusi 9 miles, from Chiusi to Perugia, from, Perugia to Santa Maria degli Angeli, and then to Fuligno. [Footnote: Most of the places here described lie within the district shown in the maps on Pl. CXIII.]

1053.

On the first of August 1502, the library at Pesaro.

1054.

OF PAINTING.

On the tops and sides of hills foreshorten the shape of the ground and its divisions, but give its proper shape to what is turned towards you. [Footnote: This passage evidently refers to the making of maps, such as Pl. CXII, CXIII, and CXIV. There is no mention of such works, it is true, excepting in this one passage of MS. L. But this can scarcely be taken as evidence against my view that Leonardo busied himself very extensively at that time in the construction of maps; and all the less since the foregoing chapters clearly prove that at a time so full of events Leonardo would only now and then commit his observations to paper, in the MS. L.

By the side of this text we find, in the original, a very indistinct sketch, perhaps a plan of a position. Instead of this drawing I have here inserted a much clearer sketch of a position from the same MS., L. 82b and 83a. They are the only drawings of landscape, it may be noted, which occur at all in that MS.]

Alessandria in Piedmont (1055. 1056).

1055.

At Candia in Lombardy, near Alessandria della Paglia, in making a well for Messer Gualtieri [Footnote 2: Messer Gualtieri, the same probably as is mentioned in Nos. 672 and 1344.] of Candia, the skeleton of a very large boat was found about 10 braccia underground; and as the timber was black and fine, it seemed good to the said Messer Gualtieri to have the mouth of the well lengthened in such a way as that the ends of the boat should be uncovered.

1056.

At Alessandria della Paglia in Lombardy there are no stones for making lime of, but such as are mixed up with an infinite variety of things native to the sea, which is now more than 200 miles away.

The Alps (1057-1062).

1057.

At Monbracco, above Saluzzo,--a mile above the Certosa, at the foot of Monte Viso, there is a quarry of flakey stone, which is as white as Carrara marble, without a spot, and as hard as porphyry or even harder; of which my worthy gossip, Master Benedetto the sculptor, has promised to give me a small slab, for the colours, the second day of January 1511.

[Footnote: Saluzzo at the foot of the Alps South of Turin.]

[Footnote 9. 10.: _Maestro Benedetto scultore_; probably some native of Northern Italy acquainted with the place here described. Hardly the Florentine sculptor Benedetto da Majano. Amoretti had published this passage, and M. Ravaisson who gave a French translation of it in the _Gazette des Beaux Arts_ (1881, pag. 528), remarks as follows: _Le maitre sculpteur que Leonard appelle son "compare" ne serait-il pas Benedetto da Majano, un de ceux qui jugerent avec lui de la place a donner au David de Michel-Ange, et de qui le Louvre a acquis recemment un buste d'apres Philippe Strozzi?_ To this it may be objected that Benedetto da Majano had already lain in his grave fourteen years, in the year 1511, when he is supposed to have given the promise to Leonardo. The colours may have been given to the sculptor Benedetto and the stone may have been in payment for them. >From the description of the stone here given we may conclude that it is repeated from hearsay of the sculptor's account of it. I do not understand how, from this observation, it is possible to conclude that Leonardo was on the spot.]

1058.

That there are springs which suddenly break forth in earthquakes or

other convulsions and suddenly fail; and this happened in a mountain in Savoy where certain forests sank in and left a very deep gap, and about four miles from here the earth opened itself like a gulf in the mountain, and threw out a sudden and immense flood of water which scoured the whole of a little valley of the tilled soil, vineyards and houses, and did the greatest mischief, wherever it overflowed.

1059.

The river Arve, a quarter of a mile from Geneva in Savoy, where the fair is held on midsummerday in the village of Saint Gervais.

[Footnote: An indistinct sketch is to be seen by the text.]

1060.

And this may be seen, as I saw it, by any one going up Monbroso [Footnote: I have vainly enquired of every available authority for a solution of the mystery as to what mountain is intended by the name Monboso (Comp. Vol. I Nos. 300 and 301). It seems most obvious to refer it to Monte Rosa. ROSA derived from the Keltic ROS which survives in Breton and in Gaelic, meaning, in its first sense, a mountain spur, but which also--like HORN--means a very high peak; thus Monte Rosa would mean literally the High Peak.], a peak of the Alps which divide France from Italy. The base of this mountain gives birth to the 4 rivers which flow in four different directions through the whole of Europe. And no mountain has its base at so great a height as this, which lifts itself above almost all the clouds; and snow seldom falls there, but only hail in the summer, when the clouds are highest. And this hail lies [unmelted] there, so that if it were not for the absorption of the rising and falling clouds, which does not happen more than twice in an age, an enormous mass of ice would be piled up there by the layers of hail, and in the middle of July I found it very considerable; and I saw the sky above me quite dark, and the sun as it fell on the mountain was far brighter here than in the plains below, because a smaller extent of atmosphere lay between the summit of the mountain and the sun. [Footnote 6: *_in una eta_*. This is perhaps a slip of the pen on Leonardo's part and should be read *_estate_* (summer).]

Leic. 9b]

1061.

In the mountains of Verona the red marble is found all mixed with cockle shells turned into stone; some of them have been filled at the mouth with the cement which is the substance of the stone; and in some parts they have remained separate from the mass of the rock which enclosed them, because the outer covering of the shell had interposed and had not allowed them to unite with it; while in other places this cement had petrified those which were old and almost stripped the outer skin.

1062.

Bridge of Goertz-Wilbach (?).

[Footnote: There is a slight sketch with this text, Leonardo seems to have intended to suggest, with a few pen-strokes, the course of the Isonzo and of the Wipbach in the vicinity of Gorizia (Goerz). He himself says in another place that he had been in Friuli (see No. 1077 1. 19).]

The Appenins (1063-1068).

1063.

That part of the earth which was lightest remained farthest from the centre of the world; and that part of the earth became the lightest over which the greatest quantity of water flowed. And therefore that part became lightest where the greatest number of rivers flow; like the Alps which divide Germany and France from Italy; whence issue the Rhone flowing Southwards, and the Rhine to the North. The Danube or Tanoia towards the North East, and the Po to the East, with innumerable rivers which join them, and which always run turbid with the soil carried by them to the sea.

The shores of the sea are constantly moving towards the middle of the sea and displace it from its original position. The lowest portion of the Mediterranean will be reserved for the bed and current of the Nile, the largest river that flows into that sea. And with it are grouped all its tributaries, which at first fell into the sea; as may be seen with the Po and its tributaries, which first fell into that sea, which between the Appenines and the German Alps was united to the Adriatic sea.

That the Gallic Alps are the highest part of Europe.

1064.

And of these I found some in the rocks of the high Appenines and mostly at the rock of La Vernia. [Footnote 6: _Sasso della Vernia._ The frowning rock between the sources of the Arno and the Tiber, as Dante describes this mountain, which is 1269 metres in height.

This note is written by the side of that given as No. 1020; but their connection does not make it clear what Leonardo's purpose was in writing it.]

1065.

At Parma, at 'La Campana' on the twenty-fifth of October 1514.

[Footnote 2: _Capano_, an Inn.]

A note on the petrifications, or fossils near Parma will be found

under No. 989.]

1066.

A method for drying the marsh of Piombino. [Footnote: There is a slight sketch with this text in the original.--Piombino is also mentioned in Nos. 609, l. 55-58 (compare Pl. XXXV, 3, below). Also in No. 1035.]

1067.

The shepherds in the Romagna at the foot of the Apennines make peculiar large cavities in the mountains in the form of a horn, and on one side they fasten a horn. This little horn becomes one and the same with the said cavity and thus they produce by blowing into it a very loud noise. [Footnote: As to the Romagna see also No. 1046.]

1068.

A spring may be seen to rise in Sicily which at certain times of the year throws out chesnut leaves in quantities; but in Sicily chesnuts do not grow, hence it is evident that that spring must issue from some abyss in Italy and then flow beneath the sea to break forth in Sicily. [Footnote: The chesnut tree is very common in Sicily. In writing _cicilia_ Leonardo meant perhaps Cilicia.]

II.

FRANCE.

1069.

GERMANY.

FRANCE.

- a. Austria,
- b. Saxony.
- c. Nuremberg.
- d. Flanders.

- a. Picardy.
- b. Normandy.
- c. Dauphine.

SPAIN.

- a. Biscay.
- b. Castille.
- c. Galicia.
- d. Portugal.
- e. Taragona.
- f. Granada.

[Footnote: Two slightly sketched maps, one of Europe the other of Spain, are at the side of these notes.]

1070.

Perpignan. Roanne. Lyons. Paris. Ghent. Bruges. Holland.

[Footnote: Roana does not seem to mean here Rouen in Normandy, but is probably Roanne (Rodumna) on the upper Loire, Lyonnais (Dep. du Loire). This town is now unimportant, but in Leonardo's time was still a place of some consequence.]

1071.

At Bordeaux in Gascony the sea rises about 40 braccia before its ebb, and the river there is filled with salt water for more than a hundred and fifty miles; and the vessels which are repaired there rest high and dry on a high hill above the sea at low tide.

[Footnote 2: This is obviously an exaggeration founded on inaccurate information. Half of 150 miles would be nearer the mark.]

1072.

The Rhone issues from the lake of Geneva and flows first to the West and then to the South, with a course of 400 miles and pours its waters into the Mediterranean.

1073.

c d is the garden at Blois; a b is the conduit of Blois, made in France by Fra Giocondo, b c is what is wanting in the height of that conduit, c d is the height of the garden at Blois, e f is the siphon of the conduit, b c, e f, f g is where the siphon discharges into the river. [Footnote: The tenor of this note (see lines 2 and 3) seems to me to indicate that this passage was not written in France, but was written from oral information. We have no evidence as to when this note may have been written beyond the circumstance that Fra Giocondo the Veronese Architect left France not before the year 1505. The greater part of the magnificent Chateau of Blois has now disappeared. Whether this note was made for a special purpose is uncertain. The original form and extent of the Chateau is shown in Androvet, Les plus excellents Bastiments de France, Paris MDCVII, and it may be observed that there is in the middle of the garden a Pavilion somewhat similar to that shown on Pl. LXXXVIII No. 7.

See S. DE LA SAUSSAYE, Histoire du Chateau de Blois 4eme edition Blois et Paris, p. 175: En mariant sa fille ainee a Francois, comte d'Angouleme, Louis XII lui avait constitue en dot les comtes de Blois, d'Asti, de Coucy, de Montfort, d'Etampes et de Vertus. Une ordonnance de Francois I. lui laissa en 1516 l'administration du comte de Blois.

Le roi fit commencer, dans la meme annee, les travaux de celle belle partie du chateau, connue sous le nom d'aile de Francois I, et dont nous avons donne la description au commencement de ce livre. Nous trouvons en effet, dans les archives du Baron de Foursanvault, une piece qui en fixe parfaitement la date. On y lit: "Je, Baymon

Philippeaux, commis par le Roy a tenir le compte et fair le payement des bastiments, edifices et reparacions que le dit seigneur fait faire en son chastu de Blois, confesse avoir eu et receu ... la somme de trois mille livres tournois ... le cinquieme jour de juillet, l'an mil cinq cent et seize._ P. 24: _Les jardins avaient ete decorees avec beaucoup de luxe par les differents possesseurs du chateau. Il ne reste de tous les batiments qu'ils y eleverent que ceux des officiers charges de l'ad_ministration et de la culture des jardins, et un pavilion carre en pierre et en brique flanque de terrasses a chacun de ses angles. Quoique defigure par des mesures elevees sur les terrasses, cet edifice est tris-digne d'interet par l'originalite du plan, la decoration architecturale et le souvenir d'Anne de Bretagne qui le fit construire._ Felibien describes the garden as follows: _Le jardin haut etait fort bien dresse par grands compartimens de toutes sortes de figures, avec des allees de meuriers blancs et des palissades de coudriers. Deux grands berceaux de charpenterie separoient toute la longueur et la largeur du jardin, et dans les quatres angles des allees, ou ces berceaux se croissent, il y avoit 4 cabinets, de mesme charpenterie ... Il y a pas longtemps qu'il y avoit dans ce mesme jardin, a l'endroit ou se croissent les allees du milieu, un edifice de figure octogone, de plus de 7 toises de diametre et de plus de neuf toises de haut; avec 4 enfoncements en forme de niches dans les 4 angles des allies. Ce bastiment.... esloit de charpente mais d'un extraordinairement bien travaille. On y voyait particulierement la cordiliere qui regnati tout autour en forme de cordon. Car la Reyne affectait de la mettre nonseulement a ses armes et a ses chiffres mais de la faire representen en divers manieres dans tous les ouvrages qu'on lui faisait pour elle ... le bastiment estati couvert en forme de dome qui dans son milieu avait encore un plus petit dome, ou lanterne vitree au-dessus de laquelle estait une figure doree representant Saint Michel. Les deux domes estoient proprement couvert d'ardoise et de plomb dore par dehors; par dedans ils esloient lambrissez d'une menuiserie tres delicate. Au milieu de ce Salon il y avait un grand bassin octogone de marbre blanc, dont toutes les faces estoient enrichies de differentes sculptures, avec les armes et les chiffres du Roy Louis XII et de la Reine Anne, Dans ce bassin il y en avait un autre pose sur un pedestal lequel avoit sept piedz de diametre. Il estait de figure ronde a godrons, avec des masques et d'autres ornements tres scauamment taillez. Du milieu de ce deuxiesme bassin s'y levoit un autre petit pedestal qui portait un troisisme bassin de trois pieds de diametre, aussy parfaitement bien taille; c'estoit de ce dernier bassin que jallissoit l'eau qui se rependoit en suite dans les deux autres bassins. Les beaux ouvrages faits d'un marbre esgalement blanc et poli, furent brisez par la pesanteur de tout l'edifice, que les injures de l'air renverserent de fond en comble.]

1074.

The river Loire at Amboise.

The river is higher within the bank _b d_ than outside that bank.

The island where there is a part of Amboise.

This is the river that passes through Amboise; it passes at a b c d, and when it has passed the bridge it turns back, against the original current, by the channel d e, b f in contact with the bank which lies between the two contrary currents of the said river, a b, c d, and d e, b f. It then turns down again by the channel f l, g h, n m, and reunites with the river from which it was at first separated, which passes by k n, which makes k m, r t. But when the river is very full it flows all in one channel passing over the bank b d. [Footnote: See Pl. CXV. Lines 1-7 are above, lines 8-10 in the middle of the large island and the word Isola is written above d in the smaller island; a is written on the margin on the bank of the river above 1. l; in the reproduction it is not visible. As may be seen from the last sentence, the observation was made after long study of the river's course, when Leonardo had resided for some time at, or near, Amboise.]

1075.

The water may be dammed up above the level of Romorantin to such a height, that in its fall it may be used for numerous mills.

1075.

The river at Villefranche may be conducted to Romorantin which may be done by the inhabitants; and the timber of which their houses are built may be carried in boats to Romorantin [Footnote: Compare No. 744.]. The river may be dammed up at such a height that the waters may be brought back to Romorantin with a convenient fall.

1076.

As to whether it is better that the water should all be raised in a single turn or in two?

The answer is that in one single turn the wheel could not support all the water that it can raise in two turns, because at the half turn of the wheel it would be raising 100 pounds and no more; and if it had to raise the whole, 200 pounds in one turn, it could not raise them unless the wheel were of double the diameter and if the diameter were doubled, the time of its revolution would be doubled; therefore it is better and a greater advantage in expense to make such a wheel of half the size (?) the land which it would water and would render the country fertile to supply food to the inhabitants, and would make navigable canals for mercantile purposes.

The way in which the river in its flow should scour its own channel.

By the ninth of the third; the more rapid it is, the more it wears away its channel; and, by the converse proposition, the slower the

water the more it deposits that which renders it turbid.

And let the sluice be movable like the one I arranged in Friuli [Footnote 19: This passage reveals to us the fact that Leonardo had visited the country of Friuli and that he had stayed there for some time. Nothing whatever was known of this previously.], where when one sluice was opened the water which passed through it dug out the bottom. Therefore when the rivers are flooded, the sluices of the mills ought to be opened in order that the whole course of the river may pass through falls to each mill; there should be many in order to give a greater impetus, and so all the river will be scoured. And below the site of each of the two mills there may be one of the said sluice falls; one of them may be placed below each mill.

1078.

A trabocco is four braccia, and one mile is three thousand of the said braccia. Each braccio is divided into 12 inches; and the water in the canals has a fall in every hundred trabocchi of two of these inches; therefore 14 inches of fall are necessary in two thousand eight hundred braccia of flow in these canals; it follows that 15 inches of fall give the required momentum to the currents of the waters in the said canals, that is one braccio and a half in the mile. And from this it may be concluded that the water taken from the river of Ville-franche and lent to the river of Romorantin will..... Where one river by reason of its low level cannot flow into the other, it will be necessary to dam it up, so that it may acquire a fall into the other, which was previously the higher.

The eve of Saint Antony I returned from Romorantin to Amboise, and the King went away two days before from Romorantin.

>From Romorantin as far as the bridge at Saudre it is called the Saudre, and from that bridge as far as Tours it is called the Cher.

I would test the level of that channel which is to lead from the Loire to Romorantin, with a channel one braccio wide and one braccio deep.

[Footnote: Lines 6-18 are partly reproduced in the facsimile on p. 254, and the whole of lines 19-25.

The following names are written along the rivers on the larger sketch, _era f_ (the Loire) _scier f_ (the Cher) three times. _Pote Sodro_ (bridge of the Soudre). _Villa francha_ (Villefranche) _banco_ (sandbank) _Sodro_ (Soudre). The circle below shows the position of Romorantin. The words ' _orologio del sole_ ' written below do not belong to the map of the rivers. The following names are written by the side of the smaller sketch-map:--_tors_ (Tours), _Abosa_ (Amboise) _bres_ --for Bles (Blois) _mo rica_ (Montrichard). _Lione_ (Lyons). This map was also published in the 'Saggio' (Milano, 1872) Pl. XXII, and the editors remark: _Forse la linea retta che va da Amboise a Romorantin segna l'andamento proposto d'un

Canale, che poi rembra prolungarsi in giu fin dove sta scritto
Lione._

M. Ravaisson has enlarged on this idea in the Gazette des Beaux Arts (1881 p. 530): _Les traces de Leonard permettent d'entrevoir que le canal commençant soit aupres de Tours, soit aupres de Blois et passant par Romorantin, avec port d'embarquement a Villefranche, devait, au dela de Bourges, traverser l'Allier au-dessous des affluents de la Dore et de la Sioule, aller par Moulins jusqu' a Digoin; enfin, sur l'autre rive de la Loire, dépasser les monts du Charolais et rejoindre la Saone aupres de Macon._ It seems to me rash, however, to found so elaborate an hypothesis on these sketches of rivers. The slight stroke going to _Lione_ is perhaps only an indication of the direction.--With regard to the Loire compare also No. 988. l. 38.]

1079.

THE ROAD TO ORLEANS

At 1/4 from the South to the South East. At 1/3 from the South to the South East. At 1/4 from the South to the South East. At 1/5 from the South to the South East. Between the South West and South, to the East bearing to the South; from the South towards the East 1/8; thence to the West, between the South and South West; at the South.

[Footnote: The meaning is obscure; a more important passage referring to France is to be found under No. 744]

On the Germans (1080. 1081).

1080.

The way in which the Germans closing up together cross and interweave their broad leather shields against the enemy, stooping down and putting one of the ends on the ground while they hold the rest in their hand. [Footnote: Above the text is a sketch of a few lines crossing each other and the words _de ponderibus_. The meaning of the passage is obscure.]

1081.

The Germans are wont to annoy a garrison with the smoke of feathers, sulphur and realgar, and they make this smoke last 7 or 8 hours. Likewise the husks of wheat make a great and lasting smoke; and also dry dung; but this must be mixed with olive husks, that is olives pressed for oil and from which the oil has been extracted. [Footnote: There is with this passage a sketch of a round tower shrouded in smoke.]

The Danube.

1082.

That the valleys were formerly in great part covered by lakes the soil of which always forms the banks of rivers,--and by seas, which afterwards, by the persistent wearing of the rivers, cut through the mountains and the wandering courses of the rivers carried away the other plains enclosed by the mountains; and the cutting away of the mountains is evident from the strata in the rocks, which correspond in their sections as made by the courses of the rivers [Footnote 4: _Emus_, the Balkan; _Dardania_, now Servia.], The Haemus mountains which go along Thrace and Dardania and join the Sardonus mountains which, going on to the westward change their name from Sardus to Rebi, as they come near Dalmatia; then turning to the West cross Illyria, now called Sclavonia, changing the name of Rebi to Albanus, and going on still to the West, they change to Mount Odra in the North; and to the South above Istria they are named Caruancas; and to the West above Italy they join the Adula, where the Danube rises [8], which stretches to the East and has a course of 1500 miles; its shortest line is about 1000 miles, and the same or about the same is that branch of the Adula mountains changed as to their name, as before mentioned. To the North are the Carpathians, closing in the breadth of the valley of the Danube, which, as I have said extends eastward, a length of about 1000 miles, and is sometimes 200 and in some places 300 miles wide; and in the midst flows the Danube, the principal river of Europe as to size. The said Danube runs through the middle of Austria and Albania and northwards through Bavaria, Poland, Hungary, Wallachia and Bosnia and then the Danube or Donau flows into the Black Sea, which formerly extended almost to Austria and occupied the plains through which the Danube now courses; and the evidence of this is in the oysters and cockle shells and scollops and bones of great fishes which are still to be found in many places on the sides of those mountains; and this sea was formed by the filling up of the spurs of the Adula mountains which then extended to the East joining the spurs of the Taurus which extend to the West. And near Bithynia the waters of this Black Sea poured into the Propontis [Marmora] falling into the Aegean Sea, that is the Mediterranean, where, after a long course, the spurs of the Adula mountains became separated from those of the Taurus. The Black Sea sank lower and laid bare the valley of the Danube with the above named countries, and the whole of Asia Minor beyond the Taurus range to the North, and the plains from mount Caucasus to the Black Sea to the West, and the plains of the Don this side--that is to say, at the foot of the Ural mountains. And thus the Black Sea must have sunk about 1000 braccia to uncover such vast plains.

[Footnote 8: _Danubio_, in the original _Reno_; evidently a mistake as we may infer from _come dissi_ l. 10 &c.]

III.

THE COUNTRIES OF THE WESTERN END OF THE MEDITERRANEAN.

The straits of Gibraltar (1083-1085).

1083.

WHY THE SEA MAKES A STRONGER CURRENT IN THE STRAITS OF SPAIN THAN ELSEWHERE.

A river of equal depth runs with greater speed in a narrow space than in a wide one, in proportion to the difference between the wider and the narrower one.

This proposition is clearly proved by reason confirmed by experiment. Supposing that through a channel one mile wide there flows one mile in length of water; where the river is five miles wide each of the 5 square miles will require 1/5 of itself to be equal to the square mile of water required in the sea, and where the river is 3 miles wide each of these square miles will require the third of its volume to make up the amount of the square mile of the narrow part; as is demonstrated in *f g h* at the mile marked *n*.

[Footnote: In the place marked A in the diagram *Mare Mediterano* (Mediterranean Sea) is written in the original. And at B, *stretto di Spugna* (straits of Spain, *i.e.* Gibraltar). Compare No. 960.]

1084.

WHY THE CURRENT OF GIBRALTAR IS ALWAYS GREATER TO THE WEST THAN TO THE EAST.

The reason is that if you put together the mouths of the rivers which discharge into the Mediterranean sea, you would find the sum of water to be larger than that which this sea pours through the straits into the ocean. You see Africa discharging its rivers that run northwards into this sea, and among them the Nile which runs through 3000 miles of Africa; there is also the Bagrada river and the Schelif and others. [Footnote 5: *Bagrada* (Leonardo writes *Bragada*) in Tunis, now *Medscherda*; *Mavretano*, now *Schelif*.] Likewise Europe pours into it the Don and the Danube, the Po, the Rhone, the Arno, and the Tiber, so that evidently these rivers, with an infinite number of others of less fame, make its great breadth and depth and current; and the sea is not wider than 18 miles at the most westerly point of land where it divides Europe from Africa.

1085.

The gulf of the Mediterranean, as an inland sea, received the principal waters of Africa, Asia and Europe that flowed towards it; and its waters came up to the foot of the mountains that surrounded it and made its shores. And the summits of the Apennines stood up out of this sea like islands, surrounded by salt water. Africa again, behind its Atlas mountains did not expose uncovered to the sky the surface of its vast plains about 3000 miles in length, and Memphis [Footnote 6: *Mefi*. Leonardo can only mean here the citadel of Cairo on the Mokattam hills.] was on the shores of this sea, and above the plains of Italy, where now birds fly in flocks, fish were

wont to wander in large shoals.

1086.

Tunis.

The greatest ebb made anywhere by the Mediterranean is above Tunis, being about two and a half braccia and at Venice it falls two braccia. In all the rest of the Mediterranean sea the fall is little or none.

1087.

Libya.

Describe the mountains of shifting deserts; that is to say the formation of waves of sand borne by the wind, and of its mountains and hills, such as occur in Libya. Examples may be seen on the wide sands of the Po and the Ticino, and other large rivers.

1088.

Majorca.

Circumfulgore is a naval machine. It was an invention of the men of Majorca. [Footnote: The machine is fully described in the MS. and shown in a sketch.]

1089.

The Tyrrhene Sea.

Some at the Tyrrhene sea employ this method; that is to say they fastened an anchor to one end of the yard, and to the other a cord, of which the lower end was fastened to an anchor; and in battle they flung this anchor on to the oars of the opponent's boat and by the use of a capstan drew it to the side; and threw soft soap and tow, daubed with pitch and set ablaze, on to that side where the anchor hung; so that in order to escape that fire, the defenders of that ship had to fly to the opposite side; and in doing this they aided to the attack, because the galley was more easily drawn to the side by reason of the counterpoise. [Footnote: This text is illustrated in the original by a pen and ink sketch.]

IV.

THE LEVANT.

The Levantine Sea.

1090.

On the shores of the Mediterranean 300 rivers flow, and 40, 200

ports. And this sea is 3000 miles long. Many times has the increase of its waters, heaped up by their backward flow and the blowing of the West winds, caused the overflow of the Nile and of the rivers which flow out through the Black Sea, and have so much raised the seas that they have spread with vast floods over many countries. And these floods take place at the time when the sun melts the snows on the high mountains of Ethiopia that rise up into the cold regions of the air; and in the same way the approach of the sun acts on the mountains of Sarmatia in Asia and on those in Europe; so that the gathering together of these three things are, and always have been, the cause of tremendous floods: that is, the return flow of the sea with the West wind and the melting of the snows. So every river will overflow in Syria, in Samaria, in Judea between Sinai and the Lebanon, and in the rest of Syria between the Lebanon and the Taurus mountains, and in Cilicia, in the Armenian mountains, and in Pamphilia and in Lycia within the hills, and in Egypt as far as the Atlas mountains. The gulf of Persia which was formerly a vast lake of the Tigris and discharged into the Indian Sea, has now worn away the mountains which formed its banks and laid them even with the level of the Indian ocean. And if the Mediterranean had continued its flow through the gulf of Arabia, it would have done the same, that is to say, would have reduced the level of the Mediterranean to that of the Indian Sea.

The Red Sea. (1091. 1092).

1091.

For a long time the water of the Mediterranean flowed out through the Red Sea, which is 100 miles wide and 1500 long, and full of reefs; and it has worn away the sides of Mount Sinai, a fact which testifies, not to an inundation from the Indian sea beating on these coasts, but to a deluge of water which carried with it all the rivers which abound round the Mediterranean, and besides this there is the reflux of the sea; and then, a cutting being made to the West 3000 miles away from this place, Gibraltar was separated from Ceuta, which had been joined to it. And this passage was cut very low down, in the plains between Gibraltar and the ocean at the foot of the mountain, in the low part, aided by the hollowing out of some valleys made by certain rivers, which might have flowed here. Hercules [Footnote 9: Leonardo seems here to mention Hercules half jestingly and only in order to suggest to the reader an allusion to the legend of the pillars of Hercules.] came to open the sea to the westward and then the sea waters began to pour into the Western Ocean; and in consequence of this great fall, the Red Sea remained the higher; whence the water, abandoning its course here, ever after poured away through the Straits of Spain.

1092.

The surface of the Red Sea is on a level with the ocean.

A mountain may have fallen and closed the mouth of the Red Sea and

prevented the outlet of the Mediterranean, and the Mediterranean Sea thus overfilled had for outlet the passage below the mountains of Gades; for, in our own times a similar thing has been seen [Footnote 6: Compare also No. 1336, ll. 30, 35 and 36.-- Paolo Giovio, the celebrated historian (born at Como in 1483) reports that in 1513 at the foot of the Alps, above Bellinzona, on the road to Switzerland, a mountain fell with a very great noise, in consequence of an earthquake, and that the mass of rocks, which fell on the left (Western) side blocked the river Breno (T. I p. 218 and 345 of D. Sauvage's French edition, quoted in ALEXIS PERCY, *Memoire des tremblements de terre de la peninsule italique*; Academie Royale de Belgique. T. XXII).--]; a mountain fell seven miles across a valley and closed it up and made a lake. And thus most lakes have been made by mountains, as the lake of Garda, the lakes of Como and Lugano, and the Lago Maggiore. The Mediterranean fell but little on the confines of Syria, in consequence of the Gaditanean passage, but a great deal in this passage, because before this cutting was made the Mediterranean sea flowed to the South East, and then the fall had to be made by its run through the Straits of Gades.

At a the water of the Mediterranean fell into the ocean.

All the plains which lie between the sea and mountains were formerly covered with salt water.

Every valley has been made by its own river; and the proportion between valleys is the same as that between river and river.

The greatest river in our world is the Mediterranean river, which moves from the sources of the Nile to the Western ocean.

And its greatest height is in Outer Mauritania and it has a course of ten thousand miles before it reunites with its ocean, the father of the waters.

That is 3000 miles for the Mediterranean, 3000 for the Nile, as far as discovered and 3000 for the Nile which flows to the East, &c.

[Footnote: See Pl. CXI 2, a sketch of the shores of the Mediterranean Sea, where lines 11 to 16 may be seen. The large figures 158 are not in Leonardo's writing. The character of the writing leads us to conclude that this text was written later than the foregoing. A slight sketch of the Mediterranean is also to be found in MS. I', 47a.]

The Nile (1093-1098).

1093.

Therefore we must conclude those mountains to be of the greatest height, above which the clouds falling in snow give rise to the Nile.

1094.

The Egyptians, the Ethiopians, and the Arabs, in crossing the Nile with camels, are accustomed to attach two bags on the sides of the camel's bodies that is skins in the form shown underneath.

In these four meshes of the net the camels for baggage place their feet.

[Footnote: Unfortunately both the sketches which accompany this passage are too much effaced to be reproduced. The upper represents the two sacks joined by ropes, as here described, the other shows four camels with riders swimming through a river.]

1095.

The Tigris passes through Asia Minor and brings with it the water of three lakes, one after the other of various elevations; the first being Munace and the middle Pallas and the lowest Triton. And the Nile again springs from three very high lakes in Ethiopia, and runs northwards towards the sea of Egypt with a course of 4000 miles, and by the shortest and straightest line it is 3000 miles. It is said that it issues from the Mountains of the Moon, and has various unknown sources. The said lakes are about 4000 braccia above the surface of the sphere of water, that is 1 mile and $\frac{1}{3}$, giving to the Nile a fall of 1 braccia in every mile.

[Footnote 5: *_Incogniti principio._* The affluents of the lakes are probably here intended. Compare, as to the Nile, Nos. 970, 1063 and 1084.]

1096.

Very many times the Nile and other very large rivers have poured out their whole element of water and restored it to the sea.

1097.

Why does the inundation of the Nile occur in the summer, coming from torrid countries?

1098.

It is not denied that the Nile is constantly muddy in entering the Egyptian sea and that its turbidity is caused by soil that this river is continually bringing from the places it passes; which soil never returns in the sea which receives it, unless it throws it on its shores. You see the sandy desert beyond Mount Atlas where formerly it was covered with salt water.

Customs of Asiatic Nations (1099. 1100).

1099.

The Assyrians and the people of Euboea accustom their horses to carry sacks which they can at pleasure fill with air, and which in case of need they carry instead of the girth of the saddle above and at the side, and they are well covered with plates of cuir bouilli, in order that they may not be perforated by flights of arrows. Thus they have not on their minds their security in flight, when the victory is uncertain; a horse thus equipped enables four or five men to cross over at need.

1100.

SMALL BOATS.

The small boats used by the Assyrians were made of thin laths of willow plaited over rods also of willow, and bent into the form of a boat. They were daubed with fine mud soaked with oil or with turpentine, and reduced to a kind of mud which resisted the water and because pine would split; and always remained fresh; and they covered this sort of boats with the skins of oxen in safely crossing the river Sicuris of Spain, as is reported by Lucant; [Footnote 7: See Lucan's Pharsalia IV, 130: *_Utque habuit ripas Sicoris camposque reliquit, Primum cana salix madefacto vimine parvam Texitur in puppim, calsoque inducto juvenco Vectoris patiens tumidum supernatat amnem. Sic Venetus stagnante Pado, fusoque Britannus Navigat oceano, sic cum tenet omnia Nilus, Conseritur bibula Memphitis cymbo papyro. His ratibus transjecta manus festinat utrimque Succisam cavare nemus*]

The Spaniards, the Scythians and the Arabs, when they want to make a bridge in haste, fix hurdlework made of willows on bags of ox-hide, and so cross in safety.

Rhodes (1101. 1102).

1101.

In [fourteen hundred and] eighty nine there was an earthquake in the sea of Atalia near Rhodes, which opened the sea--that is its bottom--and into this opening such a torrent of water poured that for more than three hours the bottom of the sea was uncovered by reason of the water which was lost in it, and then it closed to the former level.

[Footnote: *_Nello ottanto_* 9. It is scarcely likely that Leonardo should here mean 89 AD. Dr. H. MULLER-STRUBING writes to me as follows on this subject: "With reference to Rhodes Ross says (*_Reise auf den Griechischen Inseln, III_ 70 _ff_. 1840*), that ancient history affords instances of severe earthquakes at Rhodes, among others one in the second year of the 138th Olympiad=270 B. C.; a remarkably violent one under Antoninus Pius (A. D. 138-161) and again under Constantine and later. But Leonardo expressly speaks of an earthquake "*_nel mar di Atalia presso a Rodi_*", which is

singular. The town of Attalia, founded by Attalus, which is what he no doubt means, was in Pamphylia and more than 150 English miles East of Rhodes in a straight line. Leake and most other geographers identify it with the present town of Adalia. Attalia is rarely mentioned by the ancients, indeed only by Strabo and Pliny and no earthquake is spoken of. I think therefore you are justified in assuming that Leonardo means 1489". In the elaborate catalogue of earthquakes in the East by Sciale Dshelal eddin Sayouthy (an unpublished Arabic MS. in the possession of Prof. SCHEFER, (Membre de l'Institut, Paris) mention is made of a terrible earthquake in the year 867 of the Mohamedan Era corresponding to the year 1489, and it is there stated that a hundred persons were killed by it in the fortress of Kerak. There are three places of this name. Kerak on the sea of Tiberias, Kerak near Tahle on the Libanon, which I visited in the summer of 1876--but neither of these is the place alluded to. Possibly it may be the strongly fortified town of Kerak=Kir Moab, to the West of the Dead Sea. There is no notice about this in ALEXIS PERCY, _Memoire sur les tremblements de terres ressentis dans la peninsule turco- hellenique et en Syrie (Memoires couronnees et memoires des savants etrangers, Academie Royale de Belgique, Tome XXIII)._]

1102.

Rhodes has in it 5000 houses.

Cyprus (1103. 1104).

1103.

SITE FOR [A TEMPLE OF] VENUS.

You must make steps on four sides, by which to mount to a meadow formed by nature at the top of a rock which may be hollowed out and supported in front by pilasters and open underneath in a large portico,

[Footnote: See Pl. LXXXIII. Compare also p. 33 of this Vol. The standing male figure at the side is evidently suggested by Michael Angelo's David. On the same place a slight sketch of horses seems to have been drawn first; there is no reason for assuming that the text and this sketch, which have no connection with each other, are of the same date.

Sito di Venere. By this heading Leonardo appears to mean Cyprus, which was always considered by the ancients to be the home and birth place of Aphrodite (Kirpic in Homer).]

in which the water may fall into various vases of granite, porphyry and serpentine, within semi-circular recesses; and the water may overflow from these. And round this portico towards the North there should be a lake with a little island in the midst of which should be a thick and shady wood; the waters at the top of the

pilasters should pour into vases at their base, from whence they should flow in little channels.

Starting from the shore of Cilicia towards the South you discover the beauties of the island of Cyprus.

The Caspian Sea (1105. 1106).

1104.

>From the shore of the Southern coast of Cilicia may be seen to the South the beautiful island of Cyprus, which was the realm of the goddess Venus, and many navigators being attracted by her beauty, had their ships and rigging broken amidst the reefs, surrounded by the whirling waters. Here the beauty of delightful hills tempts wandering mariners to refresh themselves amidst their flowery verdure, where the winds are tempered and fill the island and the surrounding seas with fragrant odours. Ah! how many a ship has here been sunk. Ah! how many a vessel broken on these rocks. Here might be seen barks without number, some wrecked and half covered by the sand; others showing the poop and another the prow, here a keel and there the ribs; and it seems like a day of judgment when there should be a resurrection of dead ships, so great is the number of them covering all the Northern shore; and while the North gale makes various and fearful noises there.

1105.

Write to Bartolomeo the Turk as to the flow and ebb of the Black sea, and whether he is aware if there be such a flow and ebb in the Hyrcanean or Caspian sea. [Footnote: The handwriting of this note points to a late date.]

1106.

WHY WATER IS FOUND AT THE TOP OF MOUNTAINS.

>From the straits of Gibraltar to the Don is 3500 miles, that is one mile and 1/6, giving a fall of one braccio in a mile to any water that moves gently. The Caspian sea is a great deal higher; and none of the mountains of Europe rise a mile above the surface of our seas; therefore it might be said that the water which is on the summits of our mountains might come from the height of those seas, and of the rivers which flow into them, and which are still higher.

The sea of Azov.

1107.

Hence it follows that the sea of Azov is the highest part of the Mediterranean sea, being at a distance of 3500 miles from the Straits of Gibraltar, as is shown by the map for navigation; and it has 3500 braccia of descent, that is, one mile and 1/6; therefore it

is higher than any mountains which exist in the West.

[Footnote: The passage before this, in the original, treats of the exit of the waters from Lakes in general.]

The Dardanelles.

1108.

In the Bosphorus the Black Sea flows always into the Egean sea, and the Egean sea never flows into it. And this is because the Caspian, which is 400 miles to the East, with the rivers which pour into it, always flows through subterranean caves into this sea of Pontus; and the Don does the same as well as the Danube, so that the waters of Pontus are always higher than those of the Egean; for the higher always fall towards the lower, and never the lower towards the higher.

Constantinople.

1109.

The bridge of Pera at Constantinople, 40 braccia wide, 70 braccia high above the water, 600 braccia long; that is 400 over the sea and 200 on the land, thus making its own abutments.

[Footnote: See Pl. CX No. 1. In 1453 by order of Sultan Mohamed II. the Golden Horn was crossed by a pontoon bridge laid on barrels (see Joh. Dukas' History of the Byzantine Empire XXXVIII p. 279). --The biographers of Michelangelo, Vasari as well as Condivi, relate that at the time when Michelangelo suddenly left Rome, in 1506, he entertained some intention of going to Constantinople, there to serve the Sultan, who sought to engage him, by means of certain Franciscan Monks, for the purpose of constructing a bridge to connect Constantinople with Pera. See VASARI, *_Vite_* (ed. Sansoni VII, 168): *_Michelangelo, veduto questa furia del papa, dubitando di lui, ebbe, secondo che si dice, voglia di andarsene in Costantinopoli a servire il Turco, per mezzo di certi frati di San Francesco, che desiderava averlo per fare un ponte che passassi da Costantinopoli a Pera._* And CONDIVI, *_Vita di M. Buonaroti chap._* 30_; Michelangelo allora vedendosi condotto a questo, temendo dell'ira del papa, penso d'andarsene in Levante; massimamente essendo stato dal Turco ricercato con grandissime promesse per mezzo di certi frati di San Francesco, per volersene servire in fare un ponte da Costantinopoli a Pera ed in altri affari._ Leonardo's plan for this bridge was made in 1502. We may therefore conclude that at about that time the Sultan Bajazet II. had either announced a competition in this matter, or that through his agents Leonardo had first been called upon to carry out the scheme.]

The Euphrates.

1110.

If the river will turn to the rift farther on it will never return to its bed, as the Euphrates does, and this may do at Bologna the one who is disappointed for his rivers.

Centrae Asia.

1111.

Mounts Caucasus, Comedorum, and Paropemisidae are joined together between Bactria and India, and give birth to the river Oxus which takes its rise in these mountains and flows 500 miles towards the North and as many towards the West, and discharges its waters into the Caspian sea; and is accompanied by the Oxus, Dargados, Arthamis, Xariaspes, Dargamaim, Ocus and Margus, all very large rivers. From the opposite side towards the South rises the great river Indus which sends its waters for 600 miles Southwards and receives as tributaries in this course the rivers Xaradrus, Hyphasis, Vadris, Vandabal Bislaspus to the East, Suastes and Coe to the West, uniting with these rivers, and with their waters it flows 800 miles to the West; then, turning back by the Arbiti mountains makes an elbow and turns Southwards, where after a course of about 100 miles it finds the Indian Sea, in which it pours itself by seven branches. On the side of the same mountains rises the great Ganges, which river flows Southwards for 500 miles and to the Southwest a thousand ... and Sarabas, Diarnuna, Soas and Scilo, Condranunda are its tributaries. It flows into the Indian sea by many mouths.

On the natives of hot countries.

1112.

Men born in hot countries love the night because it refreshes them and have a horror of light because it burns them; and therefore they are of the colour of night, that is black. And in cold countries it is just the contrary.

[Footnote: The sketch here inserted is in MS. H3 55b.]

XVIII.

Naval Warfare.--Mechanical Appliances.--Music.

_Such theoretical questions, as have been laid before the reader in Sections XVI and XVII, though they were the chief subjects of Leonardo's studies of the sea, did not exclusively claim his attention. A few passages have been collected at the beginning of this section, which prove that he had turned his mind to the practical problems of navigation, and more especially of naval warfare. What we know for certain of his life gives us no data, it is true, as to when or where these matters came under his consideration; but the fact remains certain both from these notes in his manuscripts, and from the well known letter to Ludovico il Moro

(No. 1340), in which he expressly states that he is as capable as any man, in this very department.

The numerous notes as to the laws and rationale of the flight of birds, are scattered through several note-books. An account of these is given in the Bibliography of the manuscripts at the end of this work. It seems probable that the idea which led him to these investigations was his desire to construct a flying or aerial machine for man. At the same time it must be admitted that the notes on the two subjects are quite unconnected in the manuscripts, and that those on the flight of birds are by far the most numerous and extensive. The two most important passages that treat of the construction of a flying machine are those already published as Tav. XVI, No. 1 and Tav. XVIII in the "Saggio delle opere di Leonardo da Vinci" (Milan 1872). The passages--Nos. 1120-1125--here printed for the first time and hitherto unknown--refer to the same subject and, with the exception of one already published in the Saggio-- No. 1126--they are, so far as I know, the only notes, among the numerous observations on the flight of birds, in which the phenomena are incidentally and expressly connected with the idea of a flying machine.

The notes on machines of war, the construction of fortifications, and similar matters which fall within the department of the Engineer, have not been included in this work, for the reasons given on page 26 of this Vol. An exception has been made in favour of the passages Nos. 1127 and 1128, because they have a more general interest, as bearing on the important question: whence the Master derived his knowledge of these matters. Though it would be rash to assert that Leonardo was the first to introduce the science of mining into Italy, it may be confidently said that he is one of the earliest writers who can be proved to have known and understood it; while, on the other hand, it is almost beyond doubt that in the East at that time, the whole science of besieging towns and mining in particular, was far more advanced than in Europe. This gives a peculiar value to the expressions used in No. 1127.

I have been unable to find in the manuscripts any passage whatever which throws any light on Leonardo's great reputation as a musician. Nothing therein illustrates VASARPS well-known statement: Avvenne che morto Giovan Galeazzo duca di Milano, e creato Lodovico Sforza nel grado medesimo anno 1494, fu condotto a Milano con gran riputazione Lionardo al duca, il quale molto si diletta del suono della lira, perche sonasse; e Lionardo porto quello strumento ch'egli aveva di sua mano fabbricato d'argento gran parte, in forma d'un teschio di cavallo, cosa bizzarra e nuova, acciocche l'armonia fosse con maggior tuba e piu sonora di voce; laonde supero tutti i musici che quivi erano concorsi a sonare.

The only notes on musical matters are those given as Nos. 1129 and 1130, which explain certain arrangements in instruments.

The ship's logs of Vitruvius, of Alberti and of Leonardo

1113.

ON MOVEMENTS;--TO KNOW HOW MUCH A SHIP ADVANCES IN AN HOUR.

The ancients used various devices to ascertain the distance gone by a ship each hour, among which Vitruvius [Footnote 6: See VITRUVIUS, *De Architectura* lib. X. C. 14 (p. 264 in the edition of Rose and Muller-Strubing). The German edition published at Bale in 1543 has, on fol. 596, an illustration of the contrivance, as described by Vitruvius.] gives one in his work on Architecture which is just as fallacious as all the others; and this is a mill wheel which touches the waves of the sea at one end and in each complete revolution describes a straight line which represents the circumference of the wheel extended to a straightness. But this invention is of no worth excepting on the smooth and motionless surface of lakes. But if the water moves together with the ship at an equal rate, then the wheel remains motionless; and if the motion of the water is more or less rapid than that of the ship, then neither has the wheel the same motion as the ship so that this invention is of but little use.

There is another method tried by experiment with a known distance between one island and another; and this is done by a board or under the pressure of wind which strikes on it with more or less swiftness. This is in Battista Alberti [Footnote 25: LEON BATTISTA ALBERTI, *De Architectura* lib. V., c. 12 treats 'de le navi e parti loro', but there is no reference to the machine, mentioned by Leonardo. Alberti says here: 'Noi abbiamo trattato lungamente in altro luogo de' modi de le navi, ma in questo luogo ne abbiamo detto quel tanto che si bisogna'. To this the following note is added in the most recent Italian edition: 'Questo libro e tuttora inedito e porta il titolo, secondo Gesnero di 'Liber navis'.].

Battista Alberti's method which is made by experiment on a known distance between one island and another. But such an invention does not succeed excepting on a ship like the one on which the experiment was made, and it must be of the same burden and have the same sails, and the sails in the same places, and the size of the waves must be the same. But my method will serve for any ship, whether with oars or sails; and whether it be small or large, broad or long, or high or low, it always serves [Footnote 52: Leonardo does not reveal the method invented by him.].

Methods of staying and moving in water

1114.

How an army ought to cross rivers by swimming with air-bags ... How fishes swim [Footnote 2: Compare No. 821.]; of the way in which they jump out of the water, as may be seen with dolphins; and it seems a wonderful thing to make a leap from a thing which does not resist but slips away. Of the swimming of animals of a long form, such as eels and the like. Of the mode of swimming against currents and in the rapid falls of rivers. Of the mode of swimming of fishes of a

round form. How it is that animals which have not long hind quarters cannot swim. How it is that all other animals which have feet with toes, know by nature how to swim, excepting man. In what way man ought to learn to swim. Of the way in which man may rest on the water. How man may protect himself against whirlpools or eddies in the water, which drag him down. How a man dragged to the bottom must seek the reflux which will throw him up from the depths. How he ought to move his arms. How to swim on his back. How he can and how he cannot stay under water unless he can hold his breath [13]. 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 stay without eating; and I do not publish nor divulge these by reason of the evil nature of men who would use them as means of destruction at the bottom of the sea, by sending ships to the bottom, and sinking them together with the men in them. And although I will impart others, there is no danger in them; because the mouth of the tube, by which you breathe, is above the water supported on bags or corks [19].

[Footnote: L. 13-19 will also be found in Vol. I No. 1.]

On naval warfare (1115. 1116).

1115.

Supposing in a battle between ships and galleys that the ships are victorious by reason of the high of their tops, you must haul the yard up almost to the top of the mast, and at the extremity of the yard, that is the end which is turned towards the enemy, have a small cage fastened, wrapped up below and all round in a great mattress full of cotton so that it may not be injured by the bombs; then, with the capstan, haul down the opposite end of this yard and the top on the opposite side will go up so high, that it will be far above the round-top of the ship, and you will easily drive out the men that are in it. But it is necessary that the men who are in the galley should go to the opposite side of it so as to afford a counterpoise to the weight of the men placed inside the cage on the yard.

1116.

If you want to build an armada for the sea employ these ships to ram in the enemy's ships. That is, make ships 100 feet long and 8 feet wide, but arranged so that the left hand rowers may have their oars to the right side of the ship, and the right hand ones to the left side, as is shown at M, so that the leverage of the oars may be longer. And the said ship may be one foot and a half thick, that is made with cross beams within and without, with planks in contrary directions. And this ship must have attached to it, a foot below the water, an iron-shod spike of about the weight and size of an anvil; and this, by force of oars may, after it has given the first blow, be drawn back, and driven forward again with fury give a second blow, and then a third, and so many as to destroy the other ship.

The use of swimming belts.

1117.

A METHOD OF ESCAPING IN A TEMPEST AND SHIPWRECK AT SEA.

Have a coat made of leather, which must be double across the breast, that is having a hem on each side of about a finger breadth. Thus it will be double from the waist to the knee; and the leather must be quite air-tight. When you want to leap into the sea, blow out the skirt of your coat through the double hems of the breast; and jump into the sea, and allow yourself to be carried by the waves; when you see no shore near, give your attention to the sea you are in, and always keep in your mouth the air-tube which leads down into the coat; and if now and again you require to take a breath of fresh air, and the foam prevents you, you may draw a breath of the air within the coat.

[Footnote: AMORETTI, *Memorie Storiche*, Tav. II. B. Fig. 5, gives the same figure, somewhat altered. 6. *La canna dell' aria*. Compare Vol. I. No. I. Note]

On the gravity of water.

1118.

If the weight of the sea bears on its bottom, a man, lying on that bottom and having 1000 braccia of water on his back, would have enough to crush him.

Diving apparatus and Skating (1119-1121).

1119.

Of walking under water. Method of walking on water.

[Footnote: The two sketches belonging to this passage are given by AMORETTI, *Memorie Storiche*. Tav. II, Fig. 3 and 4.]

1120.

Just as on a frozen river a man may run without moving his feet, so a car might be made that would slide by itself.

[Footnote: The drawings of carts by the side of this text have no direct connection with the problem as stated in words.--Compare No. 1448, I. 17.]

1121.

A definition as to why a man who slides on ice does not fall.

[Footnote: An indistinct sketch accompanies the passage, in the

original.]

On Flying machines (1122-1126).

1122.

Man when flying must stand free from the waist upwards so as to be able to balance himself as he does in a boat so that the centre of gravity in himself and in the machine may counterbalance each other, and be shifted as necessity demands for the changes of its centre of resistance.

1123.

Remember that your flying machine must imitate no other than the bat, because the web is what by its union gives the armour, or strength to the wings.

If you imitate the wings of feathered birds, you will find a much stronger structure, because they are pervious; that is, their feathers are separate and the air passes through them. But the bat is aided by the web that connects the whole and is not pervious.

1124.

TO ESCAPE THE PERIL OF DESTRUCTION.

Destruction to such a machine may occur in two ways; of which the first is the breaking of the machine. The second would be when the machine should turn on its edge or nearly on its edge, because it ought always to descend in a highly oblique direction, and almost exactly balanced on its centre. As regards the first--the breaking of the machine--, that may be prevented by making it as strong as possible; and in whichever direction it may tend to turn over, one centre must be very far from the other; that is, in a machine 30 braccia long the centres must be 4 braccia one from the other.

[Footnote: Compare No. 1428.]

1125.

Bags by which a man falling from a height of 6 braccia may avoid hurting himself, by a fall whether into water or on the ground; and these bags, strung together like a rosary, are to be fixed on one's back.

1126.

An object offers as much resistance to the air as the air does to the object. You may see that the beating of its wings against the air supports a heavy eagle in the highest and rarest atmosphere, close to the sphere of elemental fire. Again you may see the air in motion over the sea, fill the swelling sails and drive heavily laden

ships. From these instances, and the reasons given, a man with wings large enough and duly connected might learn to overcome the resistance of the air, and by conquering it, succeed in subjugating it and rising above it. [Footnote: A parachute is here sketched, with an explanatory remark. It is reproduced on Tav. XVI in the Saggio, and in: _Leonardo da Vinci als Ingenieur etc., Ein Beitrag zur Geschichte der Technik und der induktiven Wissenschaften, von Dr. Hermann Grothe, Berlin_ 1874, p. 50.]

Of mining.

1127.

If you want to know where a mine runs, place a drum over all the places where you suspect that it is being made, and upon this drum put a couple of dice, and when you are over the spot where they are mining, the dice will jump a little on the drum at every blow which is given underground in the mining.

There are persons who, having the convenience of a river or a lake in their lands, have made, close to the place where they suspect that a mine is being made, a great reservoir of water, and have countermined the enemy, and having found them, have turned the water upon them and destroyed a great number in the mine.

Of Greek fire.

1128.

GREEK FIRE.

Take charcoal of willow, and saltpetre, and sulphuric acid, and sulphur, and pitch, with frankincense and camphor, and Ethiopian wool, and boil them all together. This fire is so ready to burn that it clings to the timbers even under water. And add to this composition liquid varnish, and bituminous oil, and turpentine and strong vinegar, and mix all together and dry it in the sun, or in an oven when the bread is taken out; and then stick it round hempen or other tow, moulding it into a round form, and studding it all over with very sharp nails. You must leave in this ball an opening to serve as a fusee, and cover it with rosin and sulphur.

Again, this fire, stuck at the top of a long plank which has one braccio length of the end pointed with iron that it may not be burnt by the said fire, is good for avoiding and keeping off the ships, so as not to be overwhelmed by their onset.

Again throw vessels of glass full of pitch on to the enemy's ships when the men in them are intent on the battle; and then by throwing similar burning balls upon them you have it in your power to burn all their ships.

[Footnote: Venturi has given another short text about the Greek fire

in a French translation (Essai Section XIV). He adds that the original text is to be found in MS. B. 30 (?). Libri speaks of it in a note as follows (Histoire des sciences mathematiques en Italie Vol. II p. 129): La composition du feu gregeois est une des choses qui ont ete les plus cherchees et qui sont encore les plus douteuses. On dit qu'il fut invente au septieme siecle de l'ere chretienne par l'architecte Callinique (Constantini Porphyrogenetae opera, Lugd. Batav. 1617, in-8vo; p. 172, de admin, imper. exp. 48), et il se trouve souvent mentionne par les Historiens Byzantins. Tantot on le lancait avec des machines, comme on lancerait une banche, tantot on le soufflait avec de longs tubes, comme on soufflerait un gaz ou un liquide enflamme (Annae Comnenae Alexias, p. 335, lib. XI. Aeliani et Leonis, imperatoris tactica, Lugd.-Bat. 1613, in-4. part. 2 a, p. 322, Leonis tact. cap. 19. Joinville, histoire du Saint Louis collect. Petitot tom. II, p. 235). Les ecrivains contemporains disent que l'eau ne pouvait pas eteindre ce feu, mais qu'avec du vinaigre et du sable on y parvenait. Suivant quelques historiens le feu gregeois etait compose de soufre et de resine. Marcus Graecus (Liber ignium, Paris, 1804, in-40) donne plusieurs manieres de le faire qui ne sont pas tres intelligibles, mais parmi lesquelles on trouve la composition de la poudre a canon. Leonard de Vinci (MSS. de Leonard de Vinci, vol. B. f. 30,) dit qu'on le faisait avec du charbon de saule, du salpetre, de l'eau de vie, de la resine, du soufre, de la poix et du camphre. Mais il est probable que nous ne savons pas qu'elle etait sa composition, surtout a cause du secret qu'en faisaient les Grecs. En effet, l'empereur Constantin Porphyrogenete recommande a son fils de ne jamais en donner aux Barbares, et de leur repondre, s'ils en demandaient, qu'il avait ete apporte du ciel par un ange et que le secret en avait ete confie aux Chretiens (Constantini Porphyrogenetae opera, p. 26-27, de admin. imper., cap. 12).]

Of Music (1129. 1130).

1129.

A drum with cogs working by wheels with springs [2].

[Footnote: This chapter consists of explanations of the sketches shown on Pl. CXXI. Lines 1 and 2 of the text are to be seen at the top at the left hand side of the first sketch of a drum. Lines 3-5 refer to the sketch immediately below this. Line 6 is written as the side of the seventh sketch, and lines 7 and 8 at the side of the eighth. Lines 9-16 are at the bottom in the middle. The remainder of the text is at the side of the drawing at the bottom.]

A square drum of which the parchment may be drawn tight or slackened by the lever a b [5].

A drum for harmony [6].

[7] A clapper for harmony; that is, three clappers together.

[9] Just as one and the same drum makes a deep or acute sound according as the parchments are more or less tightened, so these parchments variously tightened on one and the same drum will make various sounds [16].

Keys narrow and close together; (bicchi) far apart; these will be right for the trumpet shown above.

a must enter in the place of the ordinary keys which have the ... in the openings of a flute.

1130.

Tymbals to be played like the monochord, or the soft flute.

[6] Here there is to be a cylinder of cane after the manner of clappers with a musical round called a Canon, which is sung in four parts; each singer singing the whole round. Therefore I here make a wheel with 4 teeth so that each tooth takes by itself the part of a singer.

[Footnote: In the original there are some more sketches, to which the text, from line 6, refers. They are studies for a contrivance exactly like the cylinder in our musical boxes.]

1131.

Of decorations.

White and sky-blue cloths, woven in checks to make a decoration.

Cloths with the threads drawn at _a b c d e f g h i k_, to go round the decoration.

XIX.

Philosophical Maxims. Morals. Polemics and Speculations.

Vasari indulges in severe strictures on Leonardo's religious views. He speaks, among other things, of his "capricci nel filosofar delle cose naturali" _and says on this point:_ "Per il che fece nell'animo un concetto si eretico che e' non si accostava a qualsi voglia religione, stimando per avventura assai piu lo esser filosofo che cristiano" _(see the first edition of_ 'Le Vite'_). But this accusation on the part of a writer in the days of the Inquisition is not a very serious one--and the less so, since, throughout the manuscripts, we find nothing to support it._

_Under the heading of "Philosophical Maxims" I have collected all the passages which can give us a clear comprehension of Leonardo's ideas of the world at large. It is scarcely necessary to observe that there is absolutely nothing in them to lead to the inference that he was an atheist. His views of nature and its laws are no

doubt very unlike those of his contemporaries, and have a much closer affinity to those which find general acceptance at the present day. On the other hand, it is obvious from Leonardo's will (see No. 1566) that, in the year before his death, he had professed to adhere to the fundamental doctrines of the Roman Catholic faith, and this evidently from his own personal desire and impulse.

The incredible and demonstrably fictitious legend of Leonardo's death in the arms of Francis the First, is given, with others, by Vasari and further embellished by this odious comment: "Mostrava tuttavia quanto avea offeso Dio e gli uomini del mondo, non avendo operato nell'arte come si conveniva." This last accusation, it may be remarked, is above all evidence of the superficial character of the information which Vasari was in a position to give about Leonardo. It seems to imply that Leonardo was disdainful of diligent labour. With regard to the second, referring to Leonardo's morality and dealings with his fellow men, Vasari himself nullifies it by asserting the very contrary in several passages. A further refutation may be found in the following sentence from the letter in which Melsi, the young Milanese nobleman, announces the Master's death to Leonardo's brothers: "Credo siate certificati della morte di Maestro Lionardo fratello vostro, e mio quanto ottimo padre, per la cui morte sarebbe impossibile che io potesse esprimere il dolore che io ho preso; e in mentre che queste mie membra si sosterranno insieme, io possedero una perpetua infelicità, e meritamente perche sviscerato et ardentissimo amore mi portava giornalmente. E dolto ad ognuno la perdita di tal uomo, quale non e piu in podesta della natura, ecc."

It is true that, in April 1476, we find the names of Leonardo and Verrocchio entered in the "Libro degli Uffiziali di notte e de' Monasteri" as breaking the laws; but we immediately after find the note "Absoluti cum condizione ut retamburentur" (Tamburini was the name given to the warrant cases of the night police). The acquittal therefore did not exclude the possibility of a repetition of the charge. It was in fact repeated, two months later, and on this occasion the Master and his pupil were again fully acquitted. Verrocchio was at this time forty and Leonardo four-and-twenty. The documents referring to this affair are in the State Archives of Florence; they have been withheld from publication, but it seemed to me desirable to give the reader this brief account of the leading facts of the story, as the vague hints of it, which have recently been made public, may have given to the incident an aspect which it had not in reality, and which it does not deserve.

The passages here classed under the head "Morals" reveal Leonardo to us as a man whose life and conduct were unfailingly governed by lofty principles and aims. He could scarcely have recorded his stern reprobation and unmeasured contempt for men who do nothing useful and strive only for riches, if his own life and ambitions had been such as they have so often been misrepresented.

At a period like that, when superstition still exercised unlimited dominion over the minds not merely of the illiterate crowd, but of the cultivated and learned classes, it was very natural that Leonardo's views as to Alchemy, Ghosts, Magicians, and the like should be met with stern reprobation whenever and wherever he may have expressed them; this accounts for the argumentative tone of all his utterances on such subjects which I have collected in Subdivision III of this section. To these I have added some passages which throw light on Leonardo's personal views on the Universe. They are, without exception, characterised by a broad spirit of naturalism of which the principles are more strictly applied in his essays on Astronomy, and still more on Physical Geography.

To avoid repetition, only such notes on Philosophy, Morals and Polemics, have been included in this section as occur as independent texts in the original MSS. Several moral reflections have already been given in Vol. I, in section "Allegorical representations, Mottoes and Emblems". Others will be found in the following section. Nos. 9 to 12, Vol. I, are also passages of an argumentative character. It did not seem requisite to repeat here these and similar passages, since their direct connection with the context is far closer in places where they have appeared already, than it would be here.

I.

PHILOSOPHICAL MAXIMS.

Prayers to God (1132. 1133).

1132.

I obey Thee Lord, first for the love I ought, in all reason to bear Thee; secondly for that Thou canst shorten or prolong the lives of men.

1133.

A PRAYER.

Thou, O God, dost sell us all good things at the price of labour.

The powers of Nature (1134-1139).

1134.

O admirable impartiality of Thine, Thou first Mover; Thou hast not permitted that any force should fail of the order or quality of its necessary results.

1135.

Necessity is the mistress and guide of nature.

Necessity is the theme and the inventress, the eternal curb and law of nature.

1136.

In many cases one and the same thing is attracted by two strong forces, namely Necessity and Potency. Water falls in rain; the earth absorbs it from the necessity for moisture; and the sun evaporates it, not from necessity, but by its power.

1137.

Weight, force and casual impulse, together with resistance, are the four external powers in which all the visible actions of mortals have their being and their end.

1138.

Our body is dependant on heaven and heaven on the Spirit.

1139.

The motive power is the cause of all life.

Psychology (1140-1147).

1140.

And you, O Man, who will discern in this work of mine the wonderful works of Nature, if you think it would be a criminal thing to destroy it, reflect how much more criminal it is to take the life of a man; and if this, his external form, appears to thee marvellously constructed, remember that it is nothing as compared with the soul that dwells in that structure; for that indeed, be it what it may, is a thing divine. Leave it then to dwell in His work at His good will and pleasure, and let not your rage or malice destroy a life--for indeed, he who does not value it, does not himself deserve it [Footnote 19: In MS. II 15a is the note: *_chi no stima la vita, non la merita._*].

[Footnote: This text is on the back of the drawings reproduced on Pl. CVII. Compare No. 798, 35 note on p. 111: Compare also No. 837 and 838.]

1141.

The soul can never be corrupted with the corruption of the body,, but is in the body as it were the air which causes the sound of the organ, where when a pipe bursts, the wind would cease to have any good effect. [Footnote: Compare No. 845.]

1142.

The part always has a tendency to reunite with its whole in order to escape from its imperfection.

The spirit desires to remain with its body, because, without the organic instruments of that body, it can neither act, nor feel anything.

1143.

If any one wishes to see how the soul dwells in its body, let him observe how this body uses its daily habitation; that is to say, if this is devoid of order and confused, the body will be kept in disorder and confusion by its soul.

1144.

Why does the eye see a thing more clearly in dreams than with the imagination being awake?

1145.

The senses are of the earth; Reason, stands apart in contemplation.

[Footnote: Compare No. 842.]

1146.

Every action needs to be prompted by a motive.

To know and to will are two operations of the human mind.

Discerning, judging, deliberating are acts of the human mind.

1147.

All our knowledge has its origin in our preceptions.

Science, its principles and rules (1148--1161)

1148.

Science is the observation of things possible, whether present or past; prescience is the knowledge of things which may come to pass, though but slowly.

1149.

Experience, the interpreter between formative nature and the human race, teaches how that nature acts among mortals; and being constrained by necessity cannot act otherwise than as reason, which is its helm, requires her to act.

1150.

Wisdom is the daughter of experience.

1151.

Nature is full of infinite causes that have never occurred in experience.

1152.

Truth was the only daughter of Time.

1153.

Experience never errs; it is only your judgments that err by promising themselves effects such as are not caused by your experiments.

Experience does not err; only your judgments err by expecting from her what is not in her power. Men wrongly complain of Experience; with great abuse they accuse her of leading them astray but they set Experience aside, turning from it with complaints as to our ignorance causing us to be carried away by vain and foolish desires to promise ourselves, in her name, things that are not in her power; saying that she is fallacious. Men are unjust in complaining of innocent Experience, constantly accusing her of error and of false evidence.

1154.

Instrumental or mechanical science is of all the noblest and the most useful, seeing that by means of this all animated bodies that have movement perform all their actions; and these movements are based on the centre of gravity which is placed in the middle dividing unequal weights, and it has dearth and wealth of muscles and also lever and counterlever.

1155.

OF MECHANICS.

Mechanics are the Paradise of mathematical science, because here we come to the fruits of mathematics. [Footnote: Compare No. 660, 11. 19--22 (Vol. I., p. 332). 1156.

Every instrument requires to be made by experience.

1157.

The man who blames the supreme certainty of mathematics feeds on confusion, and can never silence the contradictions of sophistical sciences which lead to an eternal quackery.

1158.

There is no certainty in sciences where one of the mathematical sciences cannot be applied, or which are not in relation with these mathematics.

1159.

Any one who in discussion relies upon authority uses, not his understanding, but rather his memory. Good culture is born of a good disposition; and since the cause is more to be praised than the effect, I will rather praise a good disposition without culture, than good culture without the disposition.

1160.

Science is the captain, and practice the soldiers.

1161.

OF THE ERRORS OF THOSE WHO DEPEND ON PRACTICE WITHOUT SCIENCE.

Those who fall in love with practice without science are like a sailor who enters a ship without a helm or a compass, and who never can be certain whither he is going.

II.

MORALS.

What is life? (1162. 1163).

1162.

Now you see that the hope and the desire of returning home and to one's former state is like the moth to the light, and that the man who with constant longing awaits with joy each new spring time, each new summer, each new month and new year--deeming that the things he longs for are ever too late in coming--does not perceive that he is longing for his own destruction. But this desire is the very quintessence, the spirit of the elements, which finding itself imprisoned with the soul is ever longing to return from the human body to its giver. And you must know that this same longing is that quintessence, inseparable from nature, and that man is the image of the world.

1163.

O Time! consumer of all things; O envious age! thou dost destroy all things and devour all things with the relentless teeth of years, little by little in a slow death. Helen, when she looked in her mirror, seeing the withered wrinkles made in her face by old age,

wept and wondered why she had twice been carried away.

O Time! consumer of all things, and O envious age! by which all things are all devoured.

Death.

1164.

Every evil leaves behind a grief in our memory, except the supreme evil, that is death, which destroys this memory together with life.

How to spend life (1165-1170).

1165.

O sleepers! what a thing is slumber! Sleep resembles death. Ah, why then dost thou not work in such wise as that after death thou mayst retain a resemblance to perfect life, when, during life, thou art in sleep so like to the hapless dead? [Footnote: Compare No. 676, Vol. I. p. 353.]

1166.

One pushes down the other.

By these square-blocks are meant the life and the studies of men.

1167.

The knowledge of past times and of the places on the earth is both an ornament and nutriment to the human mind.

1168.

To lie is so vile, that even if it were in speaking well of godly things it would take off something from God's grace; and Truth is so excellent, that if it praises but small things they become noble.

Beyond a doubt truth bears the same relation to falsehood as light to darkness; and this truth is in itself so excellent that, even when it dwells on humble and lowly matters, it is still infinitely above uncertainty and lies, disguised in high and lofty discourses; because in our minds, even if lying should be their fifth element, this does not prevent that the truth of things is the chief nutriment of superior intellects, though not of wandering wits.

But you who live in dreams are better pleased by the sophistical reasons and frauds of wits in great and uncertain things, than by those reasons which are certain and natural and not so far above us.

1169.

Avoid studies of which the result dies with the worker.

1170.

Men are in error when they lament the flight of time, accusing it of being too swift, and not perceiving that it is sufficient as it passes; but good memory, with which nature has endowed us, causes things long past to seem present.

1171.

Learning acquired in youth arrests the evil of old age; and if you understand that old age has wisdom for its food, you will so conduct yourself in youth that your old age will not lack for nourishment.

1172.

The acquisition of any knowledge is always of use to the intellect, because it may thus drive out useless things and retain the good.

For nothing can be loved or hated unless it is first known.

1173.

As a day well spent procures a happy sleep, so a life well employed procures a happy death.

1174.

The water you touch in a river is the last of that which has passed, and the first of that which is coming. Thus it is with time present.

Life if well spent, is long.

1175.

Just as food eaten without caring for it is turned into loathsome nourishment, so study without a taste for it spoils memory, by retaining nothing which it has taken in.

1176.

Just as eating against one's will is injurious to health, so study without a liking for it spoils the memory, and it retains nothing it takes in.

1177.

On Mount Etna the words freeze in your mouth and you may make ice of them.[Footnote 2: There is no clue to explain this strange sentence.]

Just as iron rusts unless it is used, and water putrefies or, in

cold, turns to ice, so our intellect spoils unless it is kept in use.

You do ill if you praise, and still worse if you reprove in a matter you do not understand.

When Fortune comes, seize her in front with a sure hand, because behind she is bald.

1178.

It seems to me that men of coarse and clumsy habits and of small knowledge do not deserve such fine instruments nor so great a variety of natural mechanism as men of speculation and of great knowledge; but merely a sack in which their food may be stowed and whence it may issue, since they cannot be judged to be any thing else than vehicles for food; for it seems to me they have nothing about them of the human species but the voice and the figure, and for all the rest are much below beasts.

1179.

Some there are who are nothing else than a passage for food and augmentors of excrement and fillers of privies, because through them no other things in the world, nor any good effects are produced, since nothing but full privies results from them.

On foolishness and ignorance (1180--1182).

1180.

The greatest deception men suffer is from their own opinions.

1181.

Folly is the shield of shame, as unreadiness is that of poverty glorified.

1182.

Blind ignorance misleads us thus and delights with the results of lascivious joys.

Because it does not know the true light. Because it does not know what is the true light.

Vain splendour takes from us the power of being behold! for its vain splendour we go into the fire, thus blind ignorance does mislead us. That is, blind ignorance so misleads us that ...

O! wretched mortals, open your eyes.

On riches (1183--1187).

1183.

That is not riches, which may be lost; virtue is our true good and the true reward of its possessor. That cannot be lost; that never deserts us, but when life leaves us. As to property and external riches, hold them with trembling; they often leave their possessor in contempt, and mocked at for having lost them.

1184.

Every man wishes to make money to give it to the doctors, destroyers of life; they then ought to be rich. [Footnote 2: Compare No. 856.]

Man has much power of discourse which for the most part is vain and false; animals have but little, but it is useful and true, and a small truth is better than a great lie.

1185.

He who possesses most must be most afraid of loss.

1186.

He who wishes to be rich in a day will be hanged in a year.

1187.

That man is of supreme folly who always wants for fear of wanting; and his life flies away while he is still hoping to enjoy the good things which he has with extreme labour acquired.

Rules of Life (1188-1202).

1188.

If you governed your body by the rules of virtue you would not walk on all fours in this world.

You grow in reputation like bread in the hands of a child.

[Footnote: The first sentence is obscure. Compare Nos. 825, 826.]

1189.

Savage he is who saves himself.

1190.

We ought not to desire the impossible. [Footnote: The writing of this note, which is exceedingly minute, is reproduced in facsimile on Pl. XLI No. 5 above the first diagram.]

1191.

Ask counsel of him who rules himself well.

Justice requires power, insight, and will; and it resembles the queen-bee.

He who does not punish evil commands it to be done.

He who takes the snake by the tail will presently be bitten by it.

The grave will fall in upon him who digs it.

1192.

The man who does not restrain wantonness, allies himself with beasts.

You can have no dominion greater or less than that over yourself.

He who thinks little, errs much.

It is easier to contend with evil at the first than at the last.

No counsel is more loyal than that given on ships which are in peril: He may expect loss who acts on the advice of an inexperienced youth.

1193.

Where there is most feeling, there is the greatest martyrdom;--a great martyr.

1194.

The memory of benefits is a frail defence against ingratitude.

Reprove your friend in secret and praise him openly.

Be not false about the past.

1195.

A SIMILE FOR PATIENCE.

Patience serves us against insults precisely as clothes do against the cold. For if you multiply your garments as the cold increases, that cold cannot hurt you; in the same way increase your patience under great offences, and they cannot hurt your feelings.

1196.

To speak well of a base man is much the same as speaking ill of a good man.

1197.

Envy wounds with false accusations, that is with detraction, a thing which scares virtue.

1198.

We are deceived by promises and time disappoints us ... [Footnote 2: The rest of this passage may be rendered in various ways, but none of them give a satisfactory meaning.]

1199.

Fear arises sooner than any thing else.

1200.

Just as courage imperils life, fear protects it.

Threats alone are the weapons of the threatened man.

Wherever good fortune enters, envy lays siege to the place and attacks it; and when it departs, sorrow and repentance remain behind.

He who walks straight rarely falls.

It is bad if you praise, and worse if you reprove a thing, I mean, if you do not understand the matter well.

It is ill to praise, and worse to reprimand in matters that you do not understand.

1201.

Words which do not satisfy the ear of the hearer weary him or vex him, and the symptoms of this you will often see in such hearers in their frequent yawns; you therefore, who speak before men whose good will you desire, when you see such an excess of fatigue, abridge your speech, or change your discourse; and if you do otherwise, then instead of the favour you desire, you will get dislike and hostility.

And if you would see in what a man takes pleasure, without hearing him speak, change the subject of your discourse in talking to him, and when you presently see him intent, without yawning or wrinkling his brow or other actions of various kinds, you may be certain that the matter of which you are speaking is such as is agreeable to him &c.

1202.

The lover is moved by the beloved object as the senses are by sensible objects; and they unite and become one and the same thing. The work is the first thing born of this union; if the thing loved is base the lover becomes base.

When the thing taken into union is perfectly adapted to that which receives it, the result is delight and pleasure and satisfaction.

When that which loves is united to the thing beloved it can rest there; when the burden is laid down it finds rest there.

Politics (1203. 1204).

1203.

There will be eternal fame also for the inhabitants of that town, constructed and enlarged by him.

All communities obey and are led by their magnates, and these magnates ally themselves with the lords and subjugate them in two ways: either by consanguinity, or by fortune; by consanguinity, when their children are, as it were, hostages, and a security and pledge of their suspected fidelity; by property, when you make each of these build a house or two inside your city which may yield some revenue and he shall have...; 10 towns, five thousand houses with thirty thousand inhabitants, and you will disperse this great congregation of people which stand like goats one behind the other, filling every place with fetid smells and sowing seeds of pestilence and death;

And the city will gain beauty worthy of its name and to you it will be useful by its revenues, and the eternal fame of its aggrandizement.

[Footnote: These notes were possibly written in preparation for a letter. The meaning is obscure.]

1204.

To preserve Nature's chiefest boon, that is freedom, I can find means of offence and defence, when it is assailed by ambitious tyrants, and first I will speak of the situation of the walls, and also I shall show how communities can maintain their good and just Lords.

[Footnote: Compare No. 1266.]

III.

POLEMICS.--SPECULATION.

Against Speculators (1205. 1206).

1205.

Oh! speculators on things, boast not of knowing the things that nature ordinarily brings about; but rejoice if you know the end of those things which you yourself devise.

1206.

Oh! speculators on perpetual motion how many vain projects of the like character you have created! Go and be the companions of the searchers for gold. [Footnote: Another short passage in MS. I, referring also to speculators, is given by LIBRI (*_Hist, des Sciences math._* III, 228): *_Sicche voi speculatori non vi fidate delli autori che anno sol col immaginazione voluto farsi interpreti tra la natura e l'omo, ma sol di quelli che non coi cienni della natura, ma cogli effetti delle sue esperienze anno esercitati i loro ingegni._*]

Against alchemists (1207. 1208).

1207.

The false interpreters of nature declare that quicksilver is the common seed of every metal, not remembering that nature varies the seed according to the variety of the things she desires to produce in the world.

1208.

And many have made a trade of delusions and false miracles, deceiving the stupid multitude.

Against friars.

1209.

Pharisees--that is to say, friars.

[Footnote: Compare No. 837, 11. 54-57, No. 1296 (p. 363 and 364), and No. 1305 (p. 370).]

Against writers of epitomes.

1210.

Abbreviators do harm to knowledge and to love, seeing that the love of any thing is the offspring of this knowledge, the love being the more fervent in proportion as the knowledge is more certain. And this certainty is born of a complete knowledge of all the parts, which, when combined, compose the totality of the thing which ought to be loved. Of what use then is he who abridges the details of those matters of which he professes to give thorough information, while he leaves behind the chief part of the things of which the

whole is composed? It is true that impatience, the mother of stupidity, praises brevity, as if such persons had not life long enough to serve them to acquire a complete knowledge of one single subject, such as the human body; and then they want to comprehend the mind of God in which the universe is included, weighing it minutely and mincing it into infinite parts, as if they had to dissect it!

Oh! human stupidity, do you not perceive that, though you have been with yourself all your life, you are not yet aware of the thing you possess most of, that is of your folly? and then, with the crowd of sophists, you deceive yourselves and others, despising the mathematical sciences, in which truth dwells and the knowledge of the things included in them. And then you occupy yourself with miracles, and write that you possess information of those things of which the human mind is incapable and which cannot be proved by any instance from nature. And you fancy you have wrought miracles when you spoil a work of some speculative mind, and do not perceive that you are falling into the same error as that of a man who strips a tree of the ornament of its branches covered with leaves mingled with the scented blossoms or fruit..... [Footnote 48: _Givstino_, Marcus Junianus Justinus, a Roman historian of the second century, who compiled an epitome from the general history written by Trogus Pompeius, who lived in the time of Augustus. The work of the latter writer no longer exist.] as Justinus did, in abridging the histories written by Trogus Pompeius, who had written in an ornate style all the worthy deeds of his forefathers, full of the most admirable and ornamental passages; and so composed a bald work worthy only of those impatient spirits, who fancy they are losing as much time as that which they employ usefully in studying the works of nature and the deeds of men. But these may remain in company of beasts; among their associates should be dogs and other animals full of rapine and they may hunt with them after...., and then follow helpless beasts, which in time of great snows come near to your houses asking alms as from their master....

On spirits (1211--1213).

1211.

O mathematicians shed light on this error.

The spirit has no voice, because where there is a voice there is a body, and where there is a body space is occupied, and this prevents the eye from seeing what is placed behind that space; hence the surrounding air is filled by the body, that is by its image.

1212.

There can be no voice where there is no motion or percussion of the air; there can be no percussion of the air where there is no instrument, there can be no instrument without a body; and this being so, a spirit can have neither voice, nor form, nor strength.

And if it were to assume a body it could not penetrate nor enter where the passages are closed. And if any one should say that by air, compressed and compacted together, a spirit may take bodies of various forms and by this means speak and move with strength--to him I reply that when there are neither nerves nor bones there can be no force exercised in any kind of movement made by such imaginary spirits.

Beware of the teaching of these speculators, because their reasoning is not confirmed by experience.

1213.

Of all human opinions that is to be reputed the most foolish which deals with the belief in Necromancy, the sister of Alchemy, which gives birth to simple and natural things. But it is all the more worthy of reprehension than alchemy, because it brings forth nothing but what is like itself, that is, lies; this does not happen in Alchemy which deals with simple products of nature and whose function cannot be exercised by nature itself, because it has no organic instruments with which it can work, as men do by means of their hands, who have produced, for instance, glass &c. but this Necromancy the flag and flying banner, blown by the winds, is the guide of the stupid crowd which is constantly witness to the dazzling and endless effects of this art; and there are books full, declaring that enchantments and spirits can work and speak without tongues and without organic instruments-- without which it is impossible to speak-- and can carry heaviest weights and raise storms and rain; and that men can be turned into cats and wolves and other beasts, although indeed it is those who affirm these things who first became beasts.

And surely if this Necromancy did exist, as is believed by small wits, there is nothing on the earth that would be of so much importance alike for the detriment and service of men, if it were true that there were in such an art a power to disturb the calm serenity of the air, converting it into darkness and making coruscations or winds, with terrific thunder and lightnings rushing through the darkness, and with violent storms overthrowing high buildings and rooting up forests; and thus to oppose armies, crushing and annihilating them; and, besides these frightful storms may deprive the peasants of the reward of their labours.--Now what kind of warfare is there to hurt the enemy so much as to deprive him of the harvest? What naval warfare could be compared with this? I say, the man who has power to command the winds and to make ruinous gales by which any fleet may be submerged, --surely a man who could command such violent forces would be lord of the nations, and no human ingenuity could resist his crushing force. The hidden treasures and gems reposing in the body of the earth would all be made manifest to him. No lock nor fortress, though impregnable, would be able to save any one against the will of the necromancer. He would have himself carried through the air from East to West and through all the opposite sides of the universe. But why should I

enlarge further upon this? What is there that could not be done by such a craftsman? Almost nothing, except to escape death. Hereby I have explained in part the mischief and the usefulness, contained in this art, if it is real; and if it is real why has it not remained among men who desire it so much, having nothing to do with any deity? For I know that there are numberless people who would, to satisfy a whim, destroy God and all the universe; and if this necromancy, being, as it were, so necessary to men, has not been left among them, it can never have existed, nor will it ever exist according to the definition of the spirit, which is invisible in substance; for within the elements there are no incorporate things, because where there is no body, there is a vacuum; and no vacuum can exist in the elements because it would be immediately filled up. Turn over.

1214.

OF SPIRITS.

We have said, on the other side of this page, that the definition of a spirit is a power conjoined to a body; because it cannot move of its own accord, nor can it have any kind of motion in space; and if you were to say that it moves itself, this cannot be within the elements. For, if the spirit is an incorporeal quantity, this quantity is called a vacuum, and a vacuum does not exist in nature; and granting that one were formed, it would be immediately filled up by the rushing in of the element in which the vacuum had been generated. Therefore, from the definition of weight, which is this--Gravity is an accidental power, created by one element being drawn to or suspended in another--it follows that an element, not weighing anything compared with itself, has weight in the element above it and lighter than it; as we see that the parts of water have no gravity or levity compared with other water, but if you draw it up into the air, then it would acquire weight, and if you were to draw the air beneath the water then the water which remains above this air would acquire weight, which weight could not sustain itself by itself, whence collapse is inevitable. And this happens in water; wherever the vacuum may be in this water it will fall in; and this would happen with a spirit amid the elements, where it would continuously generate a vacuum in whatever element it might find itself, whence it would be inevitable that it should be constantly flying towards the sky until it had quitted these elements.

AS TO WHETHER A SPIRIT HAS A BODY AMID THE ELEMENTS.

We have proved that a spirit cannot exist of itself amid the elements without a body, nor can it move of itself by voluntary motion unless it be to rise upwards. But now we will say how such a spirit taking an aerial body would be inevitably melt into air; because if it remained united, it would be separated and fall to form a vacuum, as is said above; therefore it is inevitable, if it is to be able to remain suspended in the air, that it should absorb a certain quantity of air; and if it were mingled with the air, two

difficulties arise; that is to say: It must rarefy that portion of the air with which it mingles; and for this cause the rarefied air must fly up of itself and will not remain among the air that is heavier than itself; and besides this the subtle spiritual essence disunites itself, and its nature is modified, by which that nature loses some of its first virtue. Added to these there is a third difficulty, and this is that such a body formed of air assumed by the spirits is exposed to the penetrating winds, which are incessantly sundering and dispersing the united portions of the air, revolving and whirling amidst the rest of the atmosphere; therefore the spirit which is infused in this

1215.

air would be dismembered or rent and broken up with the rending of the air into which it was incorporated.

AS TO WHETHER THE SPIRIT, HAVING TAKEN THIS BODY OF AIR, CAN MOVE OF ITSELF OR NOT.

It is impossible that the spirit infused into a certain quantity of air, should move this air; and this is proved by the above passage where it is said: the spirit rarefies that portion of the air in which it incorporates itself; therefore this air will rise high above the other air and there will be a motion of the air caused by its lightness and not by a voluntary movement of the spirit, and if this air is encountered by the wind, according to the 3rd of this, the air will be moved by the wind and not by the spirit incorporated in it.

AS TO WHETHER THE SPIRIT CAN SPEAK OR NOT.

In order to prove whether the spirit can speak or not, it is necessary in the first place to define what a voice is and how it is generated; and we will say that the voice is, as it were, the movement of air in friction against a dense body, or a dense body in friction against the air,--which is the same thing. And this friction of the dense and the rare condenses the rare and causes resistance; again, the rare, when in swift motion, and the rare in slow motion condense each other when they come in contact and make a noise and very great uproar; and the sound or murmur made by the rare moving through the rare with only moderate swiftness, like a great flame generating noises in the air; and the tremendous uproar made by the rare mingling with the rare, and when that air which is both swift and rare rushes into that which is itself rare and in motion, it is like the flame of fire which issues from a big gun and striking against the air; and again when a flame issues from the cloud, there is a concussion in the air as the bolt is generated. Therefore we may say that the spirit cannot produce a voice without movement of the air, and air in it there is none, nor can it emit what it has not; and if desires to move that air in which it is incorporated, it is necessary that the spirit should multiply itself, and that cannot multiply which has no quantity. And in the

4th place it is said that no rare body can move, if it has not a stable spot, whence it may take its motion; much more is it so when an element has to move within its own element, which does not move of itself, excepting by uniform evaporation at the centre of the thing evaporated; as occurs in a sponge squeezed in the hand held under water; the water escapes in every direction with equal movement through the openings between the fingers of the hand in which it is squeezed.

As to whether the spirit has an articulate voice, and whether the spirit can be heard, and what hearing is, and seeing; the wave of the voice passes through the air as the images of objects pass to the eye.

Nonentity.

1216.

Every quantity is intellectually conceivable as infinitely divisible.

[Amid the vastness of the things among which we live, the existence of nothingness holds the first place; its function extends over all things that have no existence, and its essence, as regards time, lies precisely between the past and the future, and has nothing in the present. This nothingness has the part equal to the whole, and the whole to the part, the divisible to the indivisible; and the product of the sum is the same whether we divide or multiply, and in addition as in subtraction; as is proved by arithmeticians by their tenth figure which represents zero; and its power has not extension among the things of Nature.]

[What is called Nothingness is to be found only in time and in speech. In time it stands between the past and future and has no existence in the present; and thus in speech it is one of the things of which we say: They are not, or they are impossible.]

With regard to time, nothingness lies between the past and the future, and has nothing to do with the present, and as to its nature it is to be classed among things impossible: hence, from what has been said, it has no existence; because where there is nothing there would necessarily be a vacuum.

[Footnote: Compare No. 916.]

Reflections on Nature (1217-1219).

1217.

EXAMPLE OF THE LIGHTNING IN CLOUDS.

[O mighty and once living instrument of formative nature. Incapable of availing thyself of thy vast strength thou hast to abandon a life

of stillness and to obey the law which God and time gave to procreative nature.]

Ah! how many a time the shoals of terrified dolphins and the huge tunny-fish were seen to flee before thy cruel fury, to escape; whilst thy fulminations raised in the sea a sudden tempest with buffeting and submersion of ships in the great waves; and filling the uncovered shores with the terrified and desperate fishes which fled from thee, and left by the sea, remained in spots where they became the abundant prey of the people in the neighbourhood.

O time, swift robber of all created things, how many kings, how many nations hast thou undone, and how many changes of states and of various events have happened since the wondrous forms of this fish perished here in this cavernous and winding recess. Now destroyed by time thou liest patiently in this confined space with bones stripped and bare; serving as a support and prop for the superimposed mountain.

[Footnote: The character of the handwriting points to an early period of Leonardo's life. It has become very indistinct, and is at present exceedingly difficult to decipher. Some passages remain doubtful.]

[Footnote: Compare No. 1339, written on the same sheet.]

1218.

The watery element was left enclosed between the raised banks of the rivers, and the sea was seen between the uplifted earth and the surrounding air which has to envelope and enclose the complicated machine of the earth, and whose mass, standing between the water and the element of fire, remained much restricted and deprived of its indispensable moisture; the rivers will be deprived of their waters, the fruitful earth will put forth no more her light verdure; the fields will no more be decked with waving corn; all the animals, finding no fresh grass for pasture, will die and food will then be lacking to the lions and wolves and other beasts of prey, and to men who after many efforts will be compelled to abandon their life, and the human race will die out. In this way the fertile and fruitful earth will remain deserted, arid and sterile from the water being shut up in its interior, and from the activity of nature it will continue a little time to increase until the cold and subtle air being gone, it will be forced to end with the element of fire; and then its surface will be left burnt up to cinder and this will be the end of all terrestrial nature. [Footnote: Compare No. 1339, written on the same sheet.]

1219.

Why did nature not ordain that one animal should not live by the death of another? Nature, being inconstant and taking pleasure in creating and making constantly new lives and forms, because she

knows that her terrestrial materials become thereby augmented, is more ready and more swift in her creating, than time in his destruction; and so she has ordained that many animals shall be food for others. Nay, this not satisfying her desire, to the same end she frequently sends forth certain poisonous and pestilential vapours upon the vast increase and congregation of animals; and most of all upon men, who increase vastly because other animals do not feed upon them; and, the causes being removed, the effects would not follow. This earth therefore seeks to lose its life, desiring only continual reproduction; and as, by the argument you bring forward and demonstrate, like effects always follow like causes, animals are the image of the world.

XX.

Humorous Writings.

Just as Michaelangelo's occasional poems reflect his private life as well as the general disposition of his mind, we may find in the writings collected in this section, the transcript of Leonardo's fanciful nature, and we should probably not be far wrong in assuming, that he himself had recited these fables in the company of his friends or at the court festivals of princes and patrons. Era tanto piacevole nella conversazione-- _so relates Vasari--_che tirava a se gli animi delle genti. _And Paulus Jovius says in his short biography of the artist:_ Fuit ingenio valde comi, nitido, liberali, vultu autem longe venustissimo, et cum elegantiae omnis deliciarumque maxime theatralium mirificus inventor ac arbiter esset, ad lyramque scito caneret, cunctis per omnem aetatem principibus mire placuit. _There can be no doubt that the fables are the original offspring of Leonardo's brain, and not borrowed from any foreign source; indeed the schemes and plans for the composition of fables collected in division V seem to afford an external proof of this, if the fables themselves did not render it self-evident. Several of them-- for instance No. _1279--_are so strikingly characteristic of Leonardo's views of natural science that we cannot do them justice till we are acquainted with his theories on such subjects; and this is equally true of the 'Prophecies' _.

_I have prefixed to these quaint writings the 'Studies on the life and habits of animals' which are singular from their peculiar aphoristic style, and I have transcribed them in exactly the order in which they are written in MS. H. This is one of the very rare instances in which one subject is treated in a consecutive series of notes, all in one MS., and Leonardo has also departed from his ordinary habits, by occasionally not completing the text on the page it is begun. These brief notes of a somewhat mysterious bearing have been placed here, simply because they may possibly have been intended to serve as hints for fables or allegories. They can scarcely be regarded as preparatory for a natural history, rather they would seem to be extracts. On the one hand the names of some of the animals seem to prove that Leonardo could not here be recording observations of his own; on the other hand the notes on their habits

and life appear to me to dwell precisely on what must have interested him most--so far as it is possible to form any complete estimate of his nature and tastes._

In No. 1293 _lines_ 1-10, _we have a sketch of a scheme for grouping the Prophecies. I have not however availed myself of it as a clue to their arrangement here because, in the first place, the texts are not so numerous as to render the suggested classification useful to the reader, and, also, because in reading the long series, as they occur in the original, we may follow the author's mind; and here and there it is not difficult to see how one theme suggested another. I have however regarded Leonardo's scheme for the classification of the Prophecies as available for that of the Fables and Jests, and have adhered to it as far as possible._

Among the humourous writings I might perhaps have included the'Rebusses', _of which there are several in the collection of Leonardo's drawings at Windsor; it seems to me not likely that many or all of them could be solved at the present day and the MSS. throw no light on them. Nor should I be justified if I intended to include in the literary works the well-known caricatures of human faces attributed to Leonardo-- of which, however, it may be incidentally observed, the greater number are in my opinion undoubtedly spurious. Two only have necessarily been given owing to their presence in text, which it was desired to reproduce: Vol. I page_ 326, _and Pl. CXXII. It can scarcely be doubted that some satirical intention is conveyed by the drawing on Pl. LXIV (text No. _688_).

My reason for not presenting Leonardo to the reader as a poet is the fact that the maxims and morals in verse which have been ascribed to him, are not to be found in the manuscripts, and Prof. Uzielli has already proved that they cannot be by him. Hence it would seem that only a few short verses can be attributed to him with any certainty._

I.

STUDIES ON THE LIFE AND HABITS OF ANIMALS.

1220.

THE LOVE OF VIRTUE.

The gold-finch is a bird of which it is related that, when it is carried into the presence of a sick person, if the sick man is going to die, the bird turns away its head and never looks at him; but if the sick man is to be saved the bird never loses sight of him but is the cause of curing him of all his sickness.

Like unto this is the love of virtue. It never looks at any vile or base thing, but rather clings always to pure and virtuous things and takes up its abode in a noble heart; as the birds do in green woods on flowery branches. And this Love shows itself more in adversity

than in prosperity; as light does, which shines most where the place is darkest.

1221.

ENVY.

We read of the kite that, when it sees its young ones growing too big in the nest, out of envy it pecks their sides, and keeps them without food.

CHEERFULNESS.

Cheerfulness is proper to the cock, which rejoices over every little thing, and crows with varied and lively movements.

SADNESS.

Sadness resembles the raven, which, when it sees its young ones born white, departs in great grief, and abandons them with doleful lamentations, and does not feed them until it sees in them some few black feathers.

1222.

PEACE.

We read of the beaver that when it is pursued, knowing that it is for the virtue [contained] in its medicinal testicles and not being able to escape, it stops; and to be at peace with its pursuers, it bites off its testicles with its sharp teeth, and leaves them to its enemies.

RAGE.

It is said of the bear that when it goes to the haunts of bees to take their honey, the bees having begun to sting him he leaves the honey and rushes to revenge himself. And as he seeks to be revenged on all those that sting him, he is revenged on none; in such wise that his rage is turned to madness, and he flings himself on the ground, vainly exasperating, by his hands and feet, the foes against which he is defending himself.

1223.

GRATITUDE.

The virtue of gratitude is said to be more [developed] in the birds called hoopoes which, knowing the benefits of life and food, they have received from their father and their mother, when they see them grow old, make a nest for them and brood over them and feed them, and with their beaks pull out their old and shabby feathers; and then, with a certain herb restore their sight so that they return to

a prosperous state.

AVARICE.

The toad feeds on earth and always remains lean; because it never eats enough:-- it is so afraid lest it should want for earth.

1224.

INGRATITUDE.

Pigeons are a symbol of ingratitude; for when they are old enough no longer to need to be fed, they begin to fight with their father, and this struggle does not end until the young one drives the father out and takes the hen and makes her his own.

CRUELTY.

The basilisk is so utterly cruel that when it cannot kill animals by its baleful gaze, it turns upon herbs and plants, and fixing its gaze on them withers them up.

1225.

GENEROSITY.

It is said of the eagle that it is never so hungry but that it will leave a part of its prey for the birds that are round it, which, being unable to provide their own food, are necessarily dependent on the eagle, since it is thus that they obtain food.

DISCIPLINE.

When the wolf goes cunningly round some stable of cattle, and by accident puts his foot in a trap, so that he makes a noise, he bites his foot off to punish himself for his folly.

1226.

FLATTERERS OR SYRENS.

The syren sings so sweetly that she lulls the mariners to sleep; then she climbs upon the ships and kills the sleeping mariners.

PRUDENCE.

The ant, by her natural foresight provides in the summer for the winter, killing the seeds she harvests that they may not germinate, and on them, in due time she feeds.

FOLLY.

The wild bull having a horror of a red colour, the hunters dress up

the trunk of a tree with red and the bull runs at this with great frenzy, thus fixing his horns, and forthwith the hunters kill him there.

1227.

JUSTICE.

We may liken the virtue of Justice to the king of the bees which orders and arranges every thing with judgment. For some bees are ordered to go to the flowers, others are ordered to labour, others to fight with the wasps, others to clear away all dirt, others to accompany and escort the king; and when he is old and has no wings they carry him. And if one of them fails in his duty, he is punished without reprieve.

TRUTH.

Although partridges steal each other's eggs, nevertheless the young born of these eggs always return to their true mother.

1228.

FIDELITY, OR LOYALTY.

The cranes are so faithful and loyal to their king, that at night, when he is sleeping, some of them go round the field to keep watch at a distance; others remain near, each holding a stone in his foot, so that if sleep should overcome them, this stone would fall and make so much noise that they would wake up again. And there are others which sleep together round the king; and this they do every night, changing in turn so that their king may never find them wanting.

FALSEHOOD.

The fox when it sees a flock of herons or magpies or birds of that kind, suddenly flings himself on the ground with his mouth open to look as he were dead; and these birds want to peck at his tongue, and he bites off their heads.

1229.

LIES.

The mole has very small eyes and it always lives under ground; and it lives as long as it is in the dark but when it comes into the light it dies immediately, because it becomes known;--and so it is with lies.

VALOUR.

The lion is never afraid, but rather fights with a bold spirit and

savage onslaught against a multitude of hunters, always seeking to injure the first that injures him.

FEAR OR COWARDICE.

The hare is always frightened; and the leaves that fall from the trees in autumn always keep him in terror and generally put him to flight.

1230.

MAGNANIMITY.

The falcon never preys but on large birds; and it will let itself die rather than feed on little ones, or eat stinking meat.

VAIN GLORY.

As regards this vice, we read that the peacock is more guilty of it than any other animal. For it is always contemplating the beauty of its tail, which it spreads in the form of a wheel, and by its cries attracts to itself the gaze of the creatures that surround it.

And this is the last vice to be conquered.

1231.

CONSTANCY.

Constancy may be symbolised by the phoenix which, knowing that by nature it must be resuscitated, has the constancy to endure the burning flames which consume it, and then it rises anew.

INCONSTANCY.

The swallow may serve for Inconstancy, for it is always in movement, since it cannot endure the smallest discomfort.

CONTINENCE.

The camel is the most lustful animal there is, and will follow the female for a thousand miles. But if you keep it constantly with its mother or sister it will leave them alone, so temperate is its nature.

1232.

INCONTINENCE.

The unicorn, through its intemperance and not knowing how to control itself, for the love it bears to fair maidens forgets its ferocity and wildness; and laying aside all fear it will go up to a seated damsel and go to sleep in her lap, and thus the hunters take it.

HUMILITY.

We see the most striking example of humility in the lamb which will submit to any animal; and when they are given for food to imprisoned lions they are as gentle to them as to their own mother, so that very often it has been seen that the lions forbear to kill them.

1233.

PRIDE.

The falcon, by reason of its haughtiness and pride, is fain to lord it and rule over all the other birds of prey, and longs to be sole and supreme; and very often the falcon has been seen to assault the eagle, the Queen of birds.

ABSTINENCE.

The wild ass, when it goes to the well to drink, and finds the water troubled, is never so thirsty but that it will abstain from drinking, and wait till the water is clear again.

GLUTTONY.

The vulture is so addicted to gluttony that it will go a thousand miles to eat a carrion [carcase]; therefore is it that it follows armies.

1234.

CHASTITY.

The turtle-dove is never false to its mate; and if one dies the other preserves perpetual chastity, and never again sits on a green bough, nor ever again drinks of clear water.

UNCHASTITY.

The bat, owing to unbridled lust, observes no universal rule in pairing, but males with males and females with females pair promiscuously, as it may happen.

MODERATION.

The ermine out of moderation never eats but once in the day; it will rather let itself be taken by the hunters than take refuge in a dirty lair, in order not to stain its purity.

1235.

THE EAGLE.

The eagle when it is old flies so high that it scorches its feathers, and Nature allowing that it should renew its youth, it falls into shallow water [Footnote 5: The meaning is obscure.]. And if its young ones cannot bear to gaze on the sun [Footnote 6: The meaning is obscure.]--; it does not feed them with any bird, that does not wish to die. Animals which much fear it do not approach its nest, although it does not hurt them. It always leaves part of its prey uneaten.

LUMERPA,--FAME.

This is found in Asia Major, and shines so brightly that it absorbs its own shadow, and when it dies it does not lose this light, and its feathers never fall out, but a feather pulled out shines no longer.

1236.

THE PELICAN.

This bird has a great love for its young; and when it finds them in its nest dead from a serpent's bite, it pierces itself to the heart, and with its blood it bathes them till they return to life.

THE SALAMANDER.

This has no digestive organs, and gets no food but from the fire, in which it constantly renews its scaly skin.

The salamander, which renews its scaly skin in the fire,--for virtue.

THE CAMELEON.

This lives on air, and there it is the prey of all the birds; so in order to be safer it flies above the clouds and finds an air so rarefied that it cannot support the bird that follows it.

At that height nothing can go unless it has a gift from Heaven, and that is where the chameleon flies.

1237.

THE ALEPO, A FISH.

The fish _alepo_ does not live out of water.

THE OSTRICH.

This bird converts iron into nourishment, and hatches its eggs by its gaze;--Armies under commanders.

THE SWAN.

The swan is white without any spot, and it sings sweetly as it dies, its life ending with that song.

THE STORK.

This bird, by drinking saltwater purges itself of distempers. If the male finds his mate unfaithful, he abandons her; and when it grows old its young ones brood over it, and feed it till it dies.

1238.

THE GRASSHOPPER.

This silences the cuckoo with its song. It dies in oil and revives in vinegar. It sings in the greatest heats

THE BAT.

The more light there is the blinder this creature becomes; as those who gaze most at the sun become most dazzled.--For Vice, that cannot remain where Virtue appears.

THE PARTRIDGE.

This bird changes from the female into the male and forgets its former sex; and out of envy it steals the eggs from others and hatches them, but the young ones follow the true mother.

THE SWALLOW.

This bird gives sight to its blind young ones by means of celandine.

1239.

THE OYSTER.--FOR TREACHERY.

This creature, when the moon is full opens itself wide, and when the crab looks in he throws in a piece of rock or seaweed and the oyster cannot close again, whereby it serves for food to that crab. This is what happens to him who opens his mouth to tell his secret. He becomes the prey of the treacherous hearer.

THE BASILISK.--CRUELTY.

All snakes flie from this creature; but the weasel attacks it by means of rue and kills it.

THE ASP.

This carries instantaneous death in its fangs; and, that it may not hear the charmer it stops its ears with its tail.

1240.

THE DRAGON.

This creature entangles itself in the legs of the elephant which falls upon it, and so both die, and in its death it is avenged.

THE VIPER.

She, in pairing opens her mouth and at last clenches her teeth and kills her husband. Then the young ones, growing within her body rend her open and kill their mother.

THE SCORPION.

Saliva, spit out when fasting will kill a scorpion. This may be likened to abstinence from greediness, which removes and heals the ills which result from that gluttony, and opens the path of virtue.

1241.

THE CROCODILE. HYPOCRISY.

This animal catches a man and straightway kills him; after he is dead, it weeps for him with a lamentable voice and many tears. Then, having done lamenting, it cruelly devours him. It is thus with the hypocrite, who, for the smallest matter, has his face bathed with tears, but shows the heart of a tiger and rejoices in his heart at the woes of others, while wearing a pitiful face.

THE TOAD.

The toad flies from the light of the sun, and if it is held there by force it puffs itself out so much as to hide its head below and shield itself from the rays. Thus does the foe of clear and radiant virtue, who can only be constrainedly brought to face it with puffed up courage.

1242.

THE CATERPILLAR.--FOR VIRTUE IN GENERAL.

The caterpillar, which by means of assiduous care is able to weave round itself a new dwelling place with marvellous artifice and fine workmanship, comes out of it afterwards with painted and lovely wings, with which it rises towards Heaven.

THE SPIDER.

The spider brings forth out of herself the delicate and ingenious web, which makes her a return by the prey it takes.

[Footnote: Two notes are underneath this text. The first: _'nessuna

chosa e da temere piu che lla sozza fama' _ is a repetition of the first line of the text given in Vol. I No. 695.

The second: _fatica fugga cholla fama in braccio quasi ochultata c_ is written in red chalk and is evidently an incomplete sentence.]

1243.

THE LION.

This animal, with his thundering roar, rouses his young the third day after they are born, teaching them the use of all their dormant senses and all the wild things which are in the wood flee away.

This may be compared to the children of Virtue who are roused by the sound of praise and grow up in honourable studies, by which they are more and more elevated; while all that is base flies at the sound, shunning those who are virtuous.

Again, the lion covers over its foot tracks, so that the way it has gone may not be known to its enemies. Thus it beseems a captain to conceal the secrets of his mind so that the enemy may not know his purpose.

1244.

THE TARANTULA.

The bite of the tarantula fixes a man's mind on one idea; that is on the thing he was thinking of when he was bitten.

THE SCREECH-OWL AND THE OWL.

These punish those who are scoffing at them by pecking out their eyes; for nature has so ordered it, that they may thus be fed.

1245.

THE ELEPHANT.

The huge elephant has by nature what is rarely found in man; that is Honesty, Prudence, Justice, and the Observance of Religion; inasmuch as when the moon is new, these beasts go down to the rivers, and there, solemnly cleansing themselves, they bathe, and so, having saluted the planet, return to the woods. And when they are ill, being laid down, they fling up plants towards Heaven as though they would offer sacrifice. --They bury their tusks when they fall out from old age.--Of these two tusks they use one to dig up roots for food; but they save the point of the other for fighting with; when they are taken by hunters and when worn out by fatigue, they dig up these buried tusks and ransom themselves.

1246.

They are merciful, and know the dangers, and if one finds a man alone and lost, he kindly puts him back in the road he has missed, if he finds the footprints of the man before the man himself. It dreads betrayal, so it stops and blows, pointing it out to the other elephants who form in a troop and go warily.

These beasts always go in troops, and the oldest goes in front and the second in age remains the last, and thus they enclose the troop. Out of shame they pair only at night and secretly, nor do they then rejoin the herd but first bathe in the river. The females do not fight as with other animals; and it is so merciful that it is most unwilling by nature ever to hurt those weaker than itself. And if it meets in the middle of its way a flock of sheep

1247.

it puts them aside with its trunk, so as not to trample them under foot; and it never hurts any thing unless when provoked. When one has fallen into a pit the others fill up the pit with branches, earth and stones, thus raising the bottom that he may easily get out. They greatly dread the noise of swine and fly in confusion, doing no less harm then, with their feet, to their own kind than to the enemy. They delight in rivers and are always wandering about near them, though on account of their great weight they cannot swim. They devour stones, and the trunks of trees are their favourite food. They have a horror of rats. Flies delight in their smell and settle on their back, and the beast scrapes its skin making its folds even and kills them.

1248.

When they cross rivers they send their young ones up against the stream of the water; thus, being set towards the fall, they break the united current of the water so that the current does not carry them away. The dragon flings itself under the elephant's body, and with its tail it ties its legs; with its wings and with its arms it also clings round its ribs and cuts its throat with its teeth, and the elephant falls upon it and the dragon is burst. Thus, in its death it is revenged on its foe.

THE DRAGON.

These go in companies together, and they twine themselves after the manner of roots, and with their heads raised they cross lakes, and swim to where they find better pasture; and if they did not thus combine

1249.

they would be drowned, therefore they combine.

THE SERPENT.

The serpent is a very large animal. When it sees a bird in the air it draws in its breath so strongly that it draws the birds into its mouth too. Marcus Regulus, the consul of the Roman army was attacked, with his army, by such an animal and almost defeated. And this animal, being killed by a catapult, measured 123 feet, that is 64 1/2 braccia and its head was high above all the trees in a wood.

THE BOA(?)

This is a very large snake which entangles itself round the legs of the cow so that it cannot move and then sucks it, in such wise that it almost dries it up. In the time of Claudius the Emperor, there was killed, on the Vatican Hill,

1250.

one which had inside it a boy, entire, that it had swallowed.

THE MACLI.--CAUGHT WHEN ASLEEP.

This beast is born in Scandinavia. It has the shape of a great horse, excepting that the great length of its neck and of its ears make a difference. It feeds on grass, going backwards, for it has so long an upper lip that if it went forwards it would cover up the grass. Its legs are all in one piece; for this reason when it wants to sleep it leans against a tree, and the hunters, spying out the place where it is wont to sleep, saw the tree almost through, and then, when it leans against it to sleep, in its sleep it falls, and thus the hunters take it. And every other mode of taking it is in vain, because it is incredibly swift in running.

1251.

THE BISON WHICH DOES INJURY IN ITS FLIGHT.

This beast is a native of Paeonia and has a neck with a mane like a horse. In all its other parts it is like a bull, excepting that its horns are in a way bent inwards so that it cannot butt; hence it has no safety but in flight, in which it flings out its excrement to a distance of 400 braccia in its course, and this burns like fire wherever it touches.

LIONS, PARDS, PANTHERS, TIGERS.

These keep their claws in the sheath, and never put them out unless they are on the back of their prey or their enemy.

THE LIONESS.

When the lioness defends her young from the hand of the hunter, in order not to be frightened by the spears she keeps her eyes on the ground, to the end that she may not by her flight leave her young

ones prisoners.

1252.

THE LION.

This animal, which is so terrible, fears nothing more than the noise of empty carts, and likewise the crowing of cocks. And it is much terrified at the sight of one, and looks at its comb with a frightened aspect, and is strangely alarmed when its face is covered.

THE PANTHER IN AFRICA.

This has the form of the lioness but it is taller on its legs and slimmer and long bodied; and it is all white and marked with black spots after the manner of rosettes; and all animals delight to look upon these rosettes, and they would always be standing round it if it were not for the terror of its face;

1253.

therefore knowing this, it hides its face, and the surrounding animals grow bold and come close, the better to enjoy the sight of so much beauty; when suddenly it seizes the nearest and at once devours it.

CAMELS.

The Bactrian have two humps; the Arabian one only. They are swift in battle and most useful to carry burdens. This animal is extremely observant of rule and measure, for it will not move if it has a greater weight than it is used to, and if it is taken too far it does the same, and suddenly stops and so the merchants are obliged to lodge there.

1254.

THE TIGER.

This beast is a native of Hyrcania, and it is something like the panther from the various spots on its skin. It is an animal of terrible swiftness; the hunter when he finds its young ones carries them off hastily, placing mirrors in the place whence he takes them, and at once escapes on a swift horse. The panther returning finds the mirrors fixed on the ground and looking into them believes it sees its young; then scratching with its paws it discovers the cheat. Forthwith, by means of the scent of its young, it follows the hunter, and when this hunter sees the tigress he drops one of the young ones and she takes it, and having carried it to the den she immediately returns to the hunter and does

1255.

the same till he gets into his boat.

CATOBLEPAS.

It is found in Ethiopia near to the source Nigricapo. It is not a very large animal, is sluggish in all its parts, and its head is so large that it carries it with difficulty, in such wise that it always droops towards the ground; otherwise it would be a great pest to man, for any one on whom it fixes its eyes dies immediately.

[Footnote: Leonardo undoubtedly derived these remarks as to the Catoblepas from Pliny, Hist. Nat. VIII. 21 (al. 32): *Apud Hesperios Aethiopus fons est Nigris* (different readings), *ut plerique existimavere, Nili caput.-----Juxta hunc fera appellatur catoblepas, modica alioquin, ceterisque membris iners, caput tantum praegrave aegre ferens; alias internecio humani generis, omnibus qui oculos ejus videre, confestim morientibus.* Aelian, *Hist. An.* gives a far more minute description of the creature, but he says that it poisons beasts not by its gaze, but by its venomous breath. Athenaeus 221 B, mentions both. If Leonardo had known of these two passages, he would scarcely have omitted the poisonous breath. (H. MULLER-STRUBING.)]

THE BASILISK.

This is found in the province of Cyrenaica and is not more than 12 fingers long. It has on its head a white spot after the fashion of a diadem. It scares all serpents with its whistling. It resembles a snake, but does not move by wriggling but from the centre forwards to the right. It is said that one

1256.

of these, being killed with a spear by one who was on horse-back, and its venom flowing on the spear, not only the man but the horse also died. It spoils the wheat and not only that which it touches, but where it breathes the grass dries and the stones are split.

THE WEASEL.

This beast finding the lair of the basilisk kills it with the smell of its urine, and this smell, indeed, often kills the weasel itself.

THE CERASTES.

This has four movable little horns; so, when it wants to feed, it hides under leaves all of its body except these little horns which, as they move, seem to the birds to be some small worms at play. Then they immediately swoop down to pick them and the Cerastes suddenly twines round them and encircles and devours them.

1257.

THE AMPHISBOENA.

This has two heads, one in its proper place the other at the tail; as if one place were not enough from which to fling its venom.

THE IACULUS.

This lies on trees, and flings itself down like a dart, and pierces through the wild beast and kills them.

THE ASP.

The bite of this animal cannot be cured unless by immediately cutting out the bitten part. This pestilential animal has such a love for its mate that they always go in company. And if, by mishap, one of them is killed the other, with incredible swiftness, follows him who has killed it; and it is so determined and eager for vengeance that it overcomes every difficulty, and passing by every troop it seeks to hurt none but its enemy. And it will travel any distance, and it is impossible to avoid it unless by crossing water and by very swift flight. It has its eyes turned inwards, and large ears and it hears better than it sees.

1258.

THE ICHNEUMON.

This animal is the mortal enemy of the asp. It is a native of Egypt and when it sees an asp near its place, it runs at once to the bed or mud of the Nile and with this makes itself muddy all over, then it dries itself in the sun, smears itself again with mud, and thus, drying one after the other, it makes itself three or four coatings like a coat of mail. Then it attacks the asp, and fights well with him, so that, taking its time it catches him in the throat and destroys him.

THE CROCODILE.

This is found in the Nile, it has four feet and lives on land and in water. No other terrestrial creature but this is found to have no tongue, and it only bites by moving its upper jaw. It grows to a length of forty feet and has claws and is armed with a hide that will take any blow. By day it is on land and at night in the water. It feeds on fishes, and going to sleep on the bank of the Nile with its mouth open, a bird called

1259.

trochilus, a very small bird, runs at once to its mouth and hops among its teeth and goes pecking out the remains of the food, and so inciting it with voluptuous delight tempts it to open the whole of its mouth, and so it sleeps. This being observed by the ichneumon it flings itself into its mouth and perforates its stomach and bowels, and finally kills it.

THE DOLPHIN.

Nature has given such knowledge to animals, that besides the consciousness of their own advantages they know the disadvantages of their foes. Thus the dolphin understands what strength lies in a cut from the fins placed on his chine, and how tender is the belly of the crocodile; hence in fighting with him it thrusts at him from beneath and rips up his belly and so kills him.

The crocodile is a terror to those that flee, and a base coward to those that pursue him.

1260.

THE HIPPOPOTAMUS.

This beast when it feels itself over-full goes about seeking thorns, or where there may be the remains of canes that have been split, and it rubs against them till a vein is opened; then when the blood has flowed as much as he needs, he plasters himself with mud and heals the wound. In form he is something like a horse with long haunches, a twisted tail and the teeth of a wild boar, his neck has a mane; the skin cannot be pierced, unless when he is bathing; he feeds on plants in the fields and goes into them backwards so that it may seem, as though he had come out.

THE IBIS.

This bird resembles a crane, and when it feels itself ill it fills its craw with water, and with its beak makes an injection of it.

THE STAG.

These creatures when they feel themselves bitten by the spider called father-long-legs, eat crabs and free themselves of the venom.

1261.

THE LIZARD.

This, when fighting with serpents eats the sow-thistle and is free.

THE SWALLOW.

This [bird] gives sight to its blind young ones, with the juice of the celandine.

THE WEASEL.

This, when chasing rats first eats of rue.

THE WILD BOAR.

This beast cures its sickness by eating of ivy.

THE SNAKE.

This creature when it wants to renew itself casts its old skin, beginning with the head, and changing in one day and one night.

THE PANTHER.

This beast after its bowels have fallen out will still fight with the dogs and hunters.

1262.

THE CHAMELEON.

This creature always takes the colour of the thing on which it is resting, whence it is often devoured together with the leaves on which the elephant feeds.

THE RAVEN.

When it has killed the Chameleon it takes laurel as a purge.

1263.

Moderation checks all the vices. The ermine will die rather than besmirch itself.

OF FORESIGHT.

The cock does not crow till it has thrice flapped its wings; the parrot in moving among boughs never puts its feet excepting where it has first put its beak. Vows are not made till Hope is dead.

Motion tends towards the centre of gravity.

1264.

MAGNANIMITY.

The falcon never seizes any but large birds and will sooner die than eat [tainted] meat of bad savour.

II.

FABLES.

Fables on animals (1265-1270).

1265.

A FABLE.

An oyster being turned out together with other fish in the house of a fisherman near the sea, he entreated a rat to take him to the sea. The rat purposing to eat him bid him open; but as he bit him the oyster squeezed his head and closed; and the cat came and killed him.

1266.

A FABLE.

The thrushes rejoiced greatly at seeing a man take the owl and deprive her of liberty, tying her feet with strong bonds. But this owl was afterwards by means of bird-lime the cause of the thrushes losing not only their liberty, but their life. This is said for those countries which rejoice in seeing their governors lose their liberty, when by that means they themselves lose all succour, and remain in bondage in the power of their enemies, losing their liberty and often their life.

1267.

A FABLE.

A dog, lying asleep on the fur of a sheep, one of his fleas, perceiving the odour of the greasy wool, judged that this must be a land of better living, and also more secure from the teeth and nails of the dog than where he fed on the dog; and without farther reflection he left the dog and went into the thick wool. There he began with great labour to try to pass among the roots of the hairs; but after much sweating had to give up the task as vain, because these hairs were so close that they almost touched each other, and there was no space where fleas could taste the skin. Hence, after much labour and fatigue, he began to wish to return to his dog, who however had already departed; so he was constrained after long repentance and bitter tears, to die of hunger.

1268.

A FABLE.

The vain and wandering butterfly, not content with being able to fly at its ease through the air, overcome by the tempting flame of the candle, decided to fly into it; but its sportive impulse was the cause of a sudden fall, for its delicate wings were burnt in the flame. And the hapless butterfly having dropped, all scorched, at the foot of the candlestick, after much lamentation and repentance, dried the tears from its swimming eyes, and raising its face exclaimed: O false light! how many must thou have miserably deceived in the past, like me; or if I must indeed see light so near, ought I not to have known the sun from the false glare of dirty tallow?

A FABLE.

The monkey, finding a nest of small birds, went up to it greatly delighted. But they, being already fledged, he could only succeed in taking the smallest; greatly delighted he took it in his hand and went to his abode; and having begun to look at the little bird he took to kissing it, and from excess of love he kissed it so much and turned it about and squeezed it till he killed it. This is said for those who by not punishing their children let them come to mischief.

1269.

A FABLE.

A rat was besieged in his little dwelling by a weasel, which with unwearied vigilance awaited his surrender, while watching his imminent peril through a little hole. Meanwhile the cat came by and suddenly seized the weasel and forthwith devoured it. Then the rat offered up a sacrifice to Jove of some of his store of nuts, humbly thanking His providence, and came out of his hole to enjoy his lately lost liberty. But he was instantly deprived of it, together with his life, by the cruel claws and teeth of the lurking cat.

1270.

A FABLE.

The ant found a grain of millet. The seed feeling itself taken prisoner cried out to her: "If you will do me the kindness to allow me accomplish my function of reproduction, I will give you a hundred such as I am." And so it was.

A Spider found a bunch of grapes which for its sweetness was much resorted to by bees and divers kinds of flies. It seemed to her that she had found a most convenient spot to spread her snare, and having settled herself on it with her delicate web, and entered into her new habitation, there, every day placing herself in the openings made by the spaces between the grapes, she fell like a thief on the wretched creatures which were not aware of her. But, after a few days had passed, the vintager came, and cut away the bunch of grapes and put it with others, with which it was trodden; and thus the grapes were a snare and pitfall both for the treacherous spider and the betrayed flies.

An ass having gone to sleep on the ice over a deep lake, his heat dissolved the ice and the ass awoke under water to his great grief, and was forthwith drowned.

A falcon, unable to endure with patience the disappearance of a duck, which, flying before him had plunged under water, wished to follow it under water, and having soaked his feathers had to remain in the water while the duck rising to the air mocked at the falcon as he drowned.

The spider wishing to take flies in her treacherous net, was cruelly killed in it by the hornet.

An eagle wanting to mock at the owl was caught by the wings in bird-lime and was taken and killed by a man.

Fables on lifeless objects (1271--1274).

1271.

The water finding that its element was the lordly ocean, was seized with a desire to rise above the air, and being encouraged by the element of fire and rising as a very subtle vapour, it seemed as though it were really as thin as air. But having risen very high, it reached the air that was still more rare and cold, where the fire forsook it, and the minute particles, being brought together, united and became heavy; whence its haughtiness deserting it, it betook itself to flight and it fell from the sky, and was drunk up by the dry earth, where, being imprisoned for a long time, it did penance for its sin.

1272.

A FABLE.

The razor having one day come forth from the handle which serves as its sheath and having placed himself in the sun, saw the sun reflected in his body, which filled him with great pride. And turning it over in his thoughts he began to say to himself: "And shall I return again to that shop from which I have just come? Certainly not; such splendid beauty shall not, please God, be turned to such base uses. What folly it would be that could lead me to shave the lathered beards of rustic peasants and perform such menial service! Is this body destined for such work? Certainly not. I will hide myself in some retired spot and there pass my life in tranquil repose." And having thus remained hidden for some months, one day he came out into the air, and issuing from his sheath, saw himself turned to the similitude of a rusty saw while his surface no longer reflected the resplendent sun. With useless repentance he vainly deplored the irreparable mischief saying to himself: "Oh! how far better was it to employ at the barbers my lost edge of such exquisite keenness! Where is that lustrous surface? It has been consumed by this vexatious and unsightly rust."

The same thing happens to those minds which instead of exercise give themselves up to sloth. They are like the razor here spoken of, and lose the keenness of their edge, while the rust of ignorance spoils their form.

A FABLE.

A stone of some size recently uncovered by the water lay on a

certain spot somewhat raised, and just where a delightful grove ended by a stony road; here it was surrounded by plants decorated by various flowers of divers colours. And as it saw the great quantity of stones collected together in the roadway below, it began to wish it could let itself fall down there, saying to itself: "What have I to do here with these plants? I want to live in the company of those, my sisters." And letting itself fall, its rapid course ended among these longed for companions. When it had been there sometime it began to find itself constantly toiling under the wheels of the carts the iron-shoed feet of horses and of travellers. This one rolled it over, that one trod upon it; sometimes it lifted itself a little and then it was covered with mud or the dung of some animal, and it was in vain that it looked at the spot whence it had come as a place of solitude and tranquil place.

Thus it happens to those who choose to leave a life of solitary contemplation, and come to live in cities among people full of infinite evil.

1273.

Some flames had already lasted in the furnace of a glass-blower, when they saw a candle approaching in a beautiful and glittering candlestick. With ardent longing they strove to reach it; and one of them, quitting its natural course, writhed up to an unburnt brand on which it fed and passed at the opposite end out by a narrow chink to the candle which was near. It flung itself upon it, and with fierce jealousy and greediness it devoured it, having reduced it almost to death, and, wishing to procure the prolongation of its life, it tried to return to the furnace whence it had come. But in vain, for it was compelled to die, the wood perishing together with the candle, being at last converted, with lamentation and repentance, into foul smoke, while leaving all its sisters in brilliant and enduring life and beauty.

1274.

A small patch of snow finding itself clinging to the top of a rock which was lying on the topmost height of a very high mountain and being left to its own imaginings, it began to reflect in this way, saying to itself: "Now, shall not I be thought vain and proud for having placed myself--such a small patch of snow--in so lofty a spot, and for allowing that so large a quantity of snow as I have seen here around me, should take a place lower than mine? Certainly my small dimensions by no means merit this elevation. How easily may I, in proof of my insignificance, experience the same fate as that which the sun brought about yesterday to my companions, who were all, in a few hours, destroyed by the sun. And this happened from their having placed themselves higher than became them. I will flee from the wrath of the sun, and humble myself and find a place befitting my small importance." Thus, flinging itself down, it began to descend, hurrying from its high home on to the other snow; but the more it sought a low place the more its bulk increased, so that

when at last its course was ended on a hill, it found itself no less in size than the hill which supported it; and it was the last of the snow which was destroyed that summer by the sun. This is said for those who, humbling themselves, become exalted.

Fables on plants (1275-1279).

1275.

The cedar, being desirous of producing a fine and noble fruit at its summit, set to work to form it with all the strength of its sap. But this fruit, when grown, was the cause of the tall and upright tree-top being bent over.

The peach, being envious of the vast quantity of fruit which she saw borne on the nut-tree, her neighbour, determined to do the same, and loaded herself with her own in such a way that the weight of the fruit pulled her up by the roots and broke her down to the ground.

The nut-tree stood always by a road side displaying the wealth of its fruit to the passers by, and every one cast stones at it.

The fig-tree, having no fruit, no one looked at it; then, wishing to produce fruits that it might be praised by men, it was bent and broken down by them.

The fig-tree, standing by the side of the elm and seeing that its boughs were bare of fruit, yet that it had the audacity to keep the Sun from its own unripe figs with its branches, said to it: "Oh elm! art thou not ashamed to stand in front of me. But wait till my offspring are fully grown and you will see where you are!" But when her offspring were mature, a troop of soldiers coming by fell upon the fig-tree and her figs were all torn off her, and her boughs cut away and broken. Then, when she was thus maimed in all her limbs, the elm asked her, saying: "O fig-tree! which was best, to be without offspring, or to be brought by them into so miserable a plight!"

1276.

The plant complains of the old and dry stick which stands by its side and of the dry stakes that surround it.

One keeps it upright, the other keeps it from low company.

1277.

A FABLE.

A nut, having been carried by a crow to the top of a tall campanile and released by falling into a chink from the mortal grip of its beak, it prayed the wall by the grace bestowed on it by God in allowing it to be so high and thick, and to own such fine bells and

of so noble a tone, that it would succour it, and that, as it had not been able to fall under the verdurous boughs of its venerable father and lie in the fat earth covered up by his fallen leaves it would not abandon it; because, finding itself in the beak of the cruel crow, it had there made a vow that if it escaped from her it would end its life in a little hole. At these words the wall, moved to compassion, was content to shelter it in the spot where it had fallen; and after a short time the nut began to split open and put forth roots between the rifts of the stones and push them apart, and to throw out shoots from its hollow shell; and, to be brief, these rose above the building and the twisted roots, growing thicker, began to thrust the walls apart, and tear out the ancient stones from their old places. Then the wall too late and in vain bewailed the cause of its destruction and in a short time, it wrought the ruin of a great part of it.

1278.

A FABLE.

The privet feeling its tender boughs loaded with young fruit, pricked by the sharp claws and beak of the insolent blackbird, complained to the blackbird with pitious remonstrance entreating her that since she stole its delicious fruits she should not deprive it of the leaves with which it preserved them from the burning rays of the sun, and that she should not divest it of its tender bark by scratching it with her sharp claws. To which the blackbird replied with angry upbraiding: "O, be silent, uncultured shrub! Do you not know that Nature made you produce these fruits for my nourishment; do you not see that you are in the world [only] to serve me as food; do you not know, base creature, that next winter you will be food and prey for the Fire?" To which words the tree listened patiently, and not without tears. After a short time the blackbird was taken in a net and boughs were cut to make a cage, in which to imprison her. Branches were cut, among others from the pliant privet, to serve for the small rods of the cage; and seeing herself to be the cause of the Blackbird's loss of liberty it rejoiced and spoke as follows: "O Blackbird, I am here, and not yet burnt by fire as you said. I shall see you in prison before you see me burnt."

A FABLE.

The laurel and the myrtle seeing the pear tree cut down cried out with a loud voice: "O pear-tree! whither are you going? Where is the pride you had when you were covered with ripe fruits? Now you will no longer shade us with your mass of leaves." Then the pear-tree replied: "I am going with the husbandman who has cut me down and who will take me to the workshop of a good sculptor who by his art will make me take the form of Jove the god; and I shall be dedicated in a temple and adored by men in the place of Jove, while you are bound always to remain maimed and stripped of your boughs, which will be placed round me to do me honour."

A FABLE.

The chesnut, seeing a man upon the fig-tree, bending its boughs down and pulling off the ripe fruits, which he put into his open mouth destroying and crushing them with his hard teeth, it tossed its long boughs and with a noisy rustle exclaimed: "O fig! how much less are you protected by nature than I. See how in me my sweet offspring are set in close array; first clothed in soft wrappers over which is the hard but softly lined husk; and not content with taking this care of me, and having given them so strong a shelter, on this she has placed sharp and close-set spines so that the hand of man cannot hurt me." Then the fig-tree and her offspring began to laugh and having laughed she said: "I know man to be of such ingenuity that with rods and stones and stakes flung up among your branches he will bereave you of your fruits; and when they are fallen, he will trample them with his feet or with stones, so that your offspring will come out of their armour, crushed and maimed; while I am touched carefully by their hands, and not like you with sticks and stones."

1279.

The hapless willow, finding that she could not enjoy the pleasure of seeing her slender branches grow or attain to the height she wished, or point to the sky, by reason of the vine and whatever other trees that grew near, but was always maimed and lopped and spoiled, brought all her spirits together and gave and devoted itself entirely to imagination, standing plunged in long meditation and seeking, in all the world of plants, with which of them she might ally herself and which could not need the help of her withes. Having stood for some time in this prolific imagination, with a sudden flash the gourd presented itself to her thoughts and tossing all her branches with extreme delight, it seemed to her that she had found the companion suited to her purpose, because the gourd is more apt to bind others than to need binding; having come to this conclusion she awaited eagerly some friendly bird who should be the mediator of her wishes. Presently seeing near her the magpie she said to him: "O gentle bird! by the memory of the refuge which you found this morning among my branches, when the hungry cruel, and rapacious falcon wanted to devour you, and by that repose which you have always found in me when your wings craved rest, and by the pleasure you have enjoyed among my boughs, when playing with your companions or making love--I entreat you find the gourd and obtain from her some of her seeds, and tell her that those that are born of them I will treat exactly as though they were my own flesh and blood; and in this way use all the words you can think of, which are of the same persuasive purport; though, indeed, since you are a master of language, I need not teach you. And if you will do me this service I shall be happy to have your nest in the fork of my boughs, and all your family without payment of any rent." Then the magpie, having made and confirmed certain new stipulations with the willow,--and principally that she should never admit upon her any snake or polecat, cocked his tail, and put down his head, and flung himself

from the bough, throwing his weight upon his wings; and these, beating the fleeting air, now here, now there, bearing about inquisitively, while his tail served as a rudder to steer him, he came to a gourd; then with a handsome bow and a few polite words, he obtained the required seeds, and carried them to the willow, who received him with a cheerful face. And when he had scraped away with his foot a small quantity of the earth near the willow, describing a circle, with his beak he planted the grains, which in a short time began to grow, and by their growth and the branches to take up all the boughs of the willow, while their broad leaves deprived it of the beauty of the sun and sky. And not content with so much evil, the gourds next began, by their rude hold, to drag the ends of the tender shoots down towards the earth, with strange twisting and distortion.

Then, being much annoyed, it shook itself in vain to throw off the gourd. After raving for some days in such plans vainly, because the firm union forbade it, seeing the wind come by it commended itself to him. The wind flew hard and opened the old and hollow stem of the willow in two down to the roots, so that it fell into two parts. In vain did it bewail itself recognising that it was born to no good end.

III.

JESTS AND TALES.

1280.

A JEST.

A priest, making the rounds of his parish on Easter Eve, and sprinkling holy water in the houses as is customary, came to a painter's room, where he sprinkled the water on some of his pictures. The painter turned round, somewhat angered, and asked him why this sprinkling had been bestowed on his pictures; then said the priest, that it was the custom and his duty to do so, and that he was doing good; and that he who did good might look for good in return, and, indeed, for better, since God had promised that every good deed that was done on earth should be rewarded a hundred-fold from above. Then the painter, waiting till he went out, went to an upper window and flung a large pail of water on the priest's back, saying: "Here is the reward a hundred-fold from above, which you said would come from the good you had done me with your holy water, by which you have damaged my pictures."

1281.

When wine is drunk by a drunkard, that wine is revenged on the drinker.

1282.

Wine, the divine juice of the grape, finding itself in a golden and richly wrought cup, on the table of Mahomet, was puffed up with pride at so much honour; when suddenly it was struck by a contrary reflection, saying to itself: "What am I about, that I should rejoice, and not perceive that I am now near to my death and shall leave my golden abode in this cup to enter into the foul and fetid caverns of the human body, and to be transmuted from a fragrant and delicious liquor into a foul and base one. Nay, and as though so much evil as this were not enough, I must for a long time lie in hideous receptacles, together with other fetid and corrupt matter, cast out from human intestines." And it cried to Heaven, imploring vengeance for so much insult, and that an end might henceforth be put to such contempt; and that, since that country produced the finest and best grapes in the whole world, at least they should not be turned into wine. Then Jove made that wine drunk by Mahomet to rise in spirit to his brain; and that in so deleterious a manner that it made him mad, and gave birth to so many follies that when he had recovered himself, he made a law that no Asiatic should drink wine, and henceforth the vine and its fruit were left free.

As soon as wine has entered the stomach it begins to ferment and swell; then the spirit of that man begins to abandon his body, rising as it were skywards, and the brain finds itself parting from the body. Then it begins to degrade him, and make him rave like a madman, and then he does irreparable evil, killing his friends.

1283.

An artizan often going to visit a great gentleman without any definite purpose, the gentleman asked him what he did this for. The other said that he came there to have a pleasure which his lordship could not have; since to him it was a satisfaction to see men greater than himself, as is the way with the populace; while the gentleman could only see men of less consequence than himself; and so lords and great men were deprived of that pleasure.

1284.

Franciscan begging Friars are wont, at certain times, to keep fasts, when they do not eat meat in their convents. But on journeys, as they live on charity, they have license to eat whatever is set before them. Now a couple of these friars on their travels, stopped at an inn, in company with a certain merchant, and sat down with him at the same table, where, from the poverty of the inn, nothing was served to them but a small roast chicken. The merchant, seeing this to be but little even for himself, turned to the friars and said: "If my memory serves me, you do not eat any kind of flesh in your convents at this season." At these words the friars were compelled by their rule to admit, without cavil, that this was the truth; so the merchant had his wish, and eat the chicken and the friars did the best they could. After dinner the messmates departed, all three together, and after travelling some distance they came to a river of some width and depth. All three being on foot--the friars by reason

of their poverty, and the other from avarice--it was necessary by the custom of company that one of the friars, being barefoot, should carry the merchant on his shoulders: so having given his wooden shoes into his keeping, he took up his man. But it so happened that when the friar had got to the middle of the river, he again remembered a rule of his order, and stopping short, he looked up, like Saint Christopher, to the burden on his back and said: "Tell me, have you any money about you?"--"You know I have", answered the other, "How do you suppose that a Merchant like me should go about otherwise?" "Alack!" cried the friar, "our rules forbid as to carry any money on our persons," and forthwith he dropped him into the water, which the merchant perceived was a facetious way of being revenged on the indignity he had done them; so, with a smiling face, and blushing somewhat with shame, he peaceably endured the revenge.

1285.

A JEST.

A man wishing to prove, by the authority of Pythagoras, that he had formerly been in the world, while another would not let him finish his argument, the first speaker said to the second: "It is by this token that I was formerly here, I remember that you were a miller." The other one, feeling himself stung by these words, agreed that it was true, and that by the same token he remembered that the speaker had been the ass that carried the flour.

A JEST.

It was asked of a painter why, since he made such beautiful figures, which were but dead things, his children were so ugly; to which the painter replied that he made his pictures by day, and his children by night.

1286.

A man saw a large sword which another one wore at his side. Said he "Poor fellow, for a long time I have seen you tied to that weapon; why do you not release yourself as your hands are untied, and set yourself free?" To which the other replied: "This is none of yours, on the contrary it is an old story." The former speaker, feeling stung, replied: "I know that you are acquainted with so few things in this world, that I thought anything I could tell you would be new to you."

1287.

A man gave up his intimacy with one of his friends because he often spoke ill of his other friends. The neglected friend one day lamenting to this former friend, after much complaining, entreated him to say what might be the cause that had made him forget so much friendship. To which he answered: "I will no longer be intimate with you because I love you, and I do not choose that you, by speaking

ill of me, your friend, to others, should produce in others, as in me, a bad impression of yourself, by speaking evil to them of me, your friend. Therefore, being no longer intimate together, it will seem as though we had become enemies; and in speaking evil of me, as is your wont, you will not be blamed so much as if we continued intimate.

1288.

A man was arguing and boasting that he knew many and various tricks. Another among the bystanders said: "I know how to play a trick which will make whomsoever I like pull off his breeches." The first man--the boaster--said: "You won't make me pull off mine, and I bet you a pair of hose on it." He who proposed the game, having accepted the offer, produced breeches and drew them across the face of him who bet the pair of hose and won the bet [4].

A man said to an acquaintance: "Your eyes are changed to a strange colour." The other replied: "It often happens, but you have not noticed it." "When does it happen?" said the former. "Every time that my eyes see your ugly face, from the shock of so unpleasing a sight they suddenly turn pale and change to a strange colour."

A man said to another: "Your eyes are changed to a strange colour." The other replied: "It is because my eyes behold your strange ugly face."

A man said that in his country were the strangest things in the world. Another answered: "You, who were born there, confirm this as true, by the strangeness of your ugly face."

[Footnote: The joke turns, it appears, on two meanings of *trarre* and is not easily translated.]

1289.

An old man was publicly casting contempt on a young one, and boldly showing that he did not fear him; on which the young man replied that his advanced age served him better as a shield than either his tongue or his strength.

1290.

A JEST.

A sick man finding himself in *_articulo mortis_* heard a knock at the door, and asking one of his servants who was knocking, the servant went out, and answered that it was a woman calling herself *Madonna Bona*. Then the sick man lifting his arms to Heaven thanked God with a loud voice, and told the servants that they were to let her come in at once, so that he might see one good woman before he died, since in all his life he had never yet seen one.

1291.

A JEST.

A man was desired to rise from bed, because the sun was already risen. To which he replied: "If I had as far to go, and as much to do as he has, I should be risen by now; but having but a little way to go, I shall not rise yet."

1292.

A man, seeing a woman ready to hold up the target for a jousting match, exclaimed, looking at the shield, and considering his spear: "Alack! this is too small a workman for so great a business."

IV.

PROPHECIES.

1293.

THE DIVISION OF THE PROPHECIES.

First, of things relating to animals; secondly, of irrational creatures; thirdly of plants; fourthly, of ceremonies; fifthly, of manners; sixthly, of cases or edicts or quarrels; seventhly, of cases that are impossible in nature [paradoxes], as, for instance, of those things which, the more is taken from them, the more they grow. And reserve the great matters till the end, and the small matters give at the beginning. And first show the evils and then the punishment of philosophical things.

(Of Ants.)

These creatures will form many communities, which will hide themselves and their young ones and victuals in dark caverns, and they will feed themselves and their families in dark places for many months without any light, artificial or natural.

[Footnote: Lines 1--51 are in the original written in one column, beginning with the text of line 11. At the end of the column is the programme for the arrangement of the prophecies, placed here at the head: Lines 56--79 form a second column, lines 80--97 a third one (see the reproduction of the text on the facsimile Pl. CXVIII).

Another suggestion for the arrangement of the prophecies is to be found among the notes 55--57 on page 357.]

(Of Bees.)

And many others will be deprived of their store and their food, and will be cruelly submerged and drowned by folks devoid of reason. Oh Justice of God! Why dost thou not wake and behold thy creatures thus

ill used?

(Of Sheep, Cows, Goats and the like.)

Endless multitudes of these will have their little children taken from them ripped open and flayed and most barbarously quartered.

(Of Nuts, and Olives, and Acorns, and Chesnuts, and such like.)

Many offspring shall be snatched by cruel thrashing from the very arms of their mothers, and flung on the ground, and crushed.

(Of Children bound in Bundles.)

O cities of the Sea! In you I see your citizens--both females and males--tightly bound, arms and legs, with strong withes by folks who will not understand your language. And you will only be able to assuage your sorrows and lost liberty by means of tearful complaints and sighing and lamentation among yourselves; for those who will bind you will not understand you, nor will you understand them.

(Of Cats that eat Rats.)

In you, O cities of Africa your children will be seen quartered in their own houses by most cruel and rapacious beasts of your own country.

(Of Asses that are beaten.)

[Footnote 48: Compare No. 845.] O Nature! Wherefore art thou so partial; being to some of thy children a tender and benign mother, and to others a most cruel and pitiless stepmother? I see children of thine given up to slavery to others, without any sort of advantage, and instead of remuneration for the good they do, they are paid with the severest suffering, and spend their whole life in benefitting those who ill treat them.

(Of Men who sleep on boards of Trees.)

Men shall sleep, and eat, and dwell among trees, in the forests and open country.

(Of Dreaming.)

Men will seem to see new destructions in the sky. The flames that fall from it will seem to rise in it and to fly from it with terror. They will hear every kind of animals speak in human language. They will instantaneously run in person in various parts of the world, without motion. They will see the greatest splendour in the midst of darkness. O! marvel of the human race! What madness has led you thus! You will speak with animals of every species and they with you in human speech. You will see yourself fall from great heights without any harm and torrents will accompany you, and will mingle

with their rapid course.

(Of Christians.)

Many who hold the faith of the Son only build temples in the name of the Mother.

(Of Food which has been alive.)

[84] A great portion of bodies that have been alive will pass into the bodies of other animals; which is as much as to say, that the deserted tenements will pass piecemeal into the inhabited ones, furnishing them with good things, and carrying with them their evils. That is to say the life of man is formed from things eaten, and these carry with them that part of man which dies . . .

1294.

(Of Funeral Rites, and Processions, and Lights, and Bells, and Followers.)

The greatest honours will be paid to men, and much pomp, without their knowledge.

[Footnote: A facsimile of this text is on Pl. CXVI below on the right, but the writing is larger than the other notes on the same sheet and of a somewhat different style. The ink is also of a different hue, as may be seen on the original sheet at Milan.]

1295.

(Of the Avaricious.)

There will be many who will eagerly and with great care and solicitude follow up a thing, which, if they only knew its malignity, would always terrify them.

(Of those men, who, the older they grow, the more avaricious they become, whereas, having but little time to stay, they should become more liberal.)

We see those who are regarded as being most experienced and judicious, when they least need a thing, seek and cherish it with most avidity.

(Of the Ditch.)

Many will be busied in taking away from a thing, which will grow in proportion as it is diminished.

(Of a Weight placed on a Feather-pillow.)

And it will be seen in many bodies that by raising the head they

swell visibly; and by laying the raised head down again, their size will immediately be diminished.

(Of catching Lice.)

And many will be hunters of animals, which, the fewer there are the more will be taken; and conversely, the more there are, the fewer will be taken.

(Of Drawing Water in two Buckets with a single Rope.)

And many will be busily occupied, though the more of the thing they draw up, the more will escape at the other end.

(Of the Tongues of Pigs and Calves in Sausage-skins.)

Oh! how foul a thing, that we should see the tongue of one animal in the guts of another.

(Of Sieves made of the Hair of Animals.)

We shall see the food of animals pass through their skin everyway excepting through their mouths, and penetrate from the outside downwards to the ground.

(Of Lanterns.)

[Footnote 35: Lanterns were in Italy formerly made of horn.] The cruel horns of powerful bulls will screen the lights of night against the wild fury of the winds.

(Of Feather-beds.)

Flying creatures will give their very feathers to support men.

(Of Animals which walk on Trees--wearing wooden Shoes.)

The mire will be so great that men will walk on the trees of their country.

(Of the Soles of Shoes, which are made from the Ox.)

And in many parts of the country men will be seen walking on the skins of large beasts.

(Of Sailing in Ships.)

There will be great winds by reason of which things of the East will become things of the West; and those of the South, being involved in the course of the winds, will follow them to distant lands.

(Of Worshipping the Pictures of Saints.)

Men will speak to men who hear not; having their eyes open, they will not see; they will speak to these, and they will not be answered. They will implore favours of those who have ears and hear not; they will make light for the blind.

(Of Sawyers.)

There will be many men who will move one against another, holding in their hands a cutting tool. But these will not do each other any injury beyond tiring each other; for, when one pushes forward the other will draw back. But woe to him who comes between them! For he will end by being cut in pieces.

(Of Silk-spinning.)

Dismal cries will be heard loud, shrieking with anguish, and the hoarse and smothered tones of those who will be despoiled, and at last left naked and motionless; and this by reason of the mover, which makes every thing turn round.

(Of putting Bread into the Mouth of the Oven and taking it out again.)

In every city, land, castle and house, men shall be seen, who for want of food will take it out of the mouths of others, who will not be able to resist in any way.

(Of tilled Land.)

The Earth will be seen turned up side down and facing the opposite hemispheres, uncovering the lurking holes of the fiercest animals.

(Of Sowing Seed.)

Then many of the men who will remain alive, will throw the victuals they have preserved out of their houses, a free prey to the birds and beasts of the earth, without taking any care of them at all.

(Of the Rains, which, by making the Rivers muddy, wash away the Land.)

[Footnote 81: Compare No. 945.] Something will fall from the sky which will transport a large part of Africa which lies under that sky towards Europe, and that of Europe towards Africa, and that of the Scythian countries will meet with tremendous revolutions
[Footnote 84: Compare No. 945].

(Of Wood that burns.)

The trees and shrubs in the great forests will be converted into cinder.

(Of Kilns for Bricks and Lime.)

Finally the earth will turn red from a conflagration of many days
and the stones will be turned to cinders.

(Of boiled Fish.)

The natives of the waters will die in the boiling flood.

(Of the Olives which fall from the Olive trees, shedding oil which
makes light.)

And things will fall with great force from above, which will give us
nourishment and light.

(Of Owls and screech owls and what will happen to certain birds.)

Many will perish of dashing their heads in pieces, and the eyes of
many will jump out of their heads by reason of fearful creatures
come out of the darkness.

(Of flax which works the cure of men.)

That which was at first bound, cast out and rent by many and various
beaters will be respected and honoured, and its precepts will be
listened to with reverence and love.

(Of Books which teach Precepts.)

Bodies without souls will, by their contents give us precepts by
which to die well.

(Of Flagellants.)

Men will hide themselves under the bark of trees, and, screaming,
they will make themselves martyrs, by striking their own limbs.

(Of the Handles of Knives made of the Horns of Sheep.)

We shall see the horns of certain beasts fitted to iron tools, which
will take the lives of many of their kind.

(Of Night when no Colour can be discerned.)

There will come a time when no difference can be discerned between
colours, on the contrary, everything will be black alike.

(Of Swords and Spears which by themselves never hurt any one.)

One who by himself is mild enough and void of all offence will
become terrible and fierce by being in bad company, and will most
cruelly take the life of many men, and would kill many more if they
were not hindered by bodies having no soul, that have come out of
caverns--that is, breastplates of iron.

(Of Snares and Traps.)

Many dead things will move furiously, and will take and bind the living, and will ensnare them for the enemies who seek their death and destruction.

(Of Metals.)

That shall be brought forth out of dark and obscure caves, which will put the whole human race in great anxiety, peril and death. To many that seek them, after many sorrows they will give delight, and to those who are not in their company, death with want and misfortune. This will lead to the commission of endless crimes; this will increase and persuade bad men to assassinations, robberies and treachery, and by reason of it each will be suspicious of his partner. This will deprive free cities of their happy condition; this will take away the lives of many; this will make men torment each other with many artifices deceptions and treasons. O monstrous creature! How much better would it be for men that every thing should return to Hell! For this the vast forests will be devastated of their trees; for this endless animals will lose their lives.

(Of Fire.)

One shall be born from small beginnings which will rapidly become vast. This will respect no created thing, rather will it, by its power, transform almost every thing from its own nature into another.

(Of Ships which sink.)

Huge bodies will be seen, devoid of life, carrying, in fierce haste, a multitude of men to the destruction of their lives.

(Of Oxen, which are eaten.)

The masters of estates will eat their own labourers.

(Of beating Beds to renew them.)

Men will be seen so deeply ungrateful that they will turn upon that which has harboured them, for nothing at all; they will so load it with blows that a great part of its inside will come out of its place, and will be turned over and over in its body.

(Of Things which are eaten and which first are killed.)

Those who nourish them will be killed by them and afflicted by merciless deaths.

(Of the Reflection of Walls of Cities in the Water of their Ditches.)

The high walls of great cities will be seen up side down in their ditches.

(Of Water, which flows turbid and mixed with Soil and Dust; and of Mist, which is mixed with the Air; and of Fire which is mixed with its own, and each with each.)

All the elements will be seen mixed together in a great whirling mass, now borne towards the centre of the world, now towards the sky; and now furiously rushing from the South towards the frozen North, and sometimes from the East towards the West, and then again from this hemisphere to the other.

(The World may be divided into two Hemispheres at any Point.)

All men will suddenly be transferred into opposite hemispheres.

(The division of the East from the West may be made at any point.)

All living creatures will be moved from the East to the West; and in the same way from North to South, and vice versa.

(Of the Motion of Water which carries wood, which is dead.)

Bodies devoid of life will move by themselves and carry with them endless generations of the dead, taking the wealth from the bystanders.

(Of Eggs which being eaten cannot form Chickens.)

Oh! how many will they be that never come to the birth!

(Of Fishes which are eaten unborn.)

Endless generations will be lost by the death of the pregnant.

(Of the Lamentation on Good Friday.)

Throughout Europe there will be a lamentation of great nations over the death of one man who died in the East.

(Of Dreaming.)

Men will walk and not stir, they will talk to those who are not present, and hear those who do not speak.

(Of a Man's Shadow which moves with him.)

Shapes and figures of men and animals will be seen following these animals and men wherever they flee. And exactly as the one moves the other moves; but what seems so wonderful is the variety of height they assume.

(Of our Shadow cast by the Sun, and our Reflection in the Water at one and the same time.)

Many a time will one man be seen as three and all three move together, and often the most real one quits him.

(Of wooden Chests which contain great Treasures.)

Within walnuts and trees and other plants vast treasures will be found, which lie hidden there and well guarded.

(Of putting out the Light when going to Bed.)

Many persons puffing out a breath with too much haste, will thereby lose their sight, and soon after all consciousness.

(Of the Bells of Mules, which are close to their Ears.)

In many parts of Europe instruments of various sizes will be heard making divers harmonies, with great labour to those who hear them most closely.

(Of Asses.)

The severest labour will be repaid with hunger and thirst, and discomfort, and blows, and goadings, and curses, and great abuse.

(Of Soldiers on horseback.)

Many men will be seen carried by large animals, swift of pace, to the loss of their lives and immediate death.

In the air and on earth animals will be seen of divers colours furiously carrying men to the destruction of their lives.

(Of the Stars of Spurs.)

By the aid of the stars men will be seen who will be as swift as any swift animal.

(Of a Stick, which is dead.)

The motions of a dead thing will make many living ones flee with pain and lamentation and cries.

(Of Tinder.)

With a stone and with iron things will be made visible which before were not seen.

(Of going in Ships.)

We shall see the trees of the great forests of Taurus and of Sinai and of the Appenines and others, rush by means of the air, from East to West and from North to South; and carry, by means of the air, great multitudes of men. Oh! how many vows! Oh! how many deaths! Oh! how many partings of friends and relations! Oh! how many will those be who will never again see their own country nor their native land, and who will die unburied, with their bones strewn in various parts of the world!

(Of moving on All Saints' Day.)

Many will forsake their own dwellings and carry with them all their belongings and will go to live in other parts.

(Of All Souls' Day.)

How many will they be who will bewail their deceased forefathers, carrying lights to them.

(Of Friars, who spending nothing but words, receive great gifts and bestow Paradise.)

Invisible money will procure the triumph of many who will spend it.

(Of Bows made of the Horns of Oxen.)

Many will there be who will die a painful death by means of the horns of cattle.

(Of writing Letters from one Country to another.)

Men will speak with each other from the most remote countries, and reply.

(Of Hemispheres, which are infinite; and which are divided by an infinite number of Lines, so that every Man always has one of these Lines between his Feet.)

Men standing in opposite hemispheres will converse and deride each other and embrace each other, and understand each other's language.

(Of Priests who say Mass.)

There will be many men who, when they go to their labour will put on the richest clothes, and these will be made after the fashion of aprons [petticoats].

(Of Friars who are Confessors.)

And unhappy women will, of their own free will, reveal to men all their sins and shameful and most secret deeds.

(Of Churches and the Habitations of Friars.)

Many will there be who will give up work and labour and poverty of life and goods, and will go to live among wealth in splendid buildings, declaring that this is the way to make themselves acceptable to God.

(Of Selling Paradise.)

An infinite number of men will sell publicly and unhindered things of the very highest price, without leave from the Master of it; while it never was theirs nor in their power; and human justice will not prevent it.

(Of the Dead which are carried to be buried.)

The simple folks will carry vast quantities of lights to light up the road for those who have entirely lost the power of sight.

(Of Dowries for Maidens.)

And whereas, at first, maidens could not be protected against the violence of Men, neither by the watchfulness of parents nor by strong walls, the time will come when the fathers and parents of those girls will pay a large price to a man who wants to marry them, even if they are rich, noble and most handsome. Certainly this seems as though nature wished to eradicate the human race as being useless to the world, and as spoiling all created things.

(Of the Cruelty of Man.)

Animals will be seen on the earth who will always be fighting against each other with the greatest loss and frequent deaths on each side. And there will be no end to their malignity; by their strong limbs we shall see a great portion of the trees of the vast forests laid low throughout the universe; and, when they are filled with food the satisfaction of their desires will be to deal death and grief and labour and wars and fury to every living thing; and from their immoderate pride they will desire to rise towards heaven, but the too great weight of their limbs will keep them down. Nothing will remain on earth, or under the earth or in the waters which will not be persecuted, disturbed and spoiled, and those of one country removed into another. And their bodies will become the sepulture and means of transit of all they have killed.

O Earth! why dost thou not open and engulf them in the fissures of thy vast abyss and caverns, and no longer display in the sight of heaven such a cruel and horrible monster.

1297.

PROPHECIES.

There will be many which will increase in their destruction.

(The Ball of Snow rolling over Snow.)

There will be many who, forgetting their existence and their name, will lie as dead on the spoils of other dead creatures.

(Sleeping on the Feathers of Birds.)

The East will be seen to rush to the West and the South to the North in confusion round and about the universe, with great noise and trembling or fury.

(In the East wind which rushes to the West.)

The solar rays will kindle fire on the earth, by which a thing that is under the sky will be set on fire, and, being reflected by some obstacle, it will bend downwards.

(The Concave Mirror kindles a Fire, with which we heat the oven, and this has its foundation beneath its roof.)

A great part of the sea will fly towards heaven and for a long time will not return. (That is, in Clouds.)

There remains the motion which divides the mover from the thing moved.

Those who give light for divine service will be destroyed. (The Bees which make the Wax for Candles)

Dead things will come from underground and by their fierce movements will send numberless human beings out of the world. (Iron, which comes from under ground is dead but the Weapons are made of it which kill so many Men.)

The greatest mountains, even those which are remote from the sea shore, will drive the sea from its place.

(This is by Rivers which carry the Earth they wash away from the Mountains and bear it to the Sea-shore; and where the Earth comes the sea must retire.)

The water dropped from the clouds still in motion on the flanks of mountains will lie still for a long period of time without any motion whatever; and this will happen in many and divers lands.

(Snow, which falls in flakes and is Water.)

The great rocks of the mountains will throw out fire; so that they will burn the timber of many vast forests, and many beasts both wild and tame.

(The Flint in the Tinder-box which makes a Fire that consumes all the loads of Wood of which the Forests are despoiled and with this the flesh of Beasts is cooked.)

Oh! how many great buildings will be ruined by reason of Fire.

(The Fire of great Guns.)

Oxen will be to a great extent the cause of the destruction of cities, and in the same way horses and buffaloes.

(By drawing Guns.)

1298.

The Lion tribe will be seen tearing open the earth with their clawed paws and in the caves thus made, burying themselves together with the other animals that are beneath them.

Animals will come forth from the earth in gloomy vesture, which will attack the human species with astonishing assaults, and which by their ferocious bites will make confusion of blood among those they devour.

Again the air will be filled with a mischievous winged race which will assail men and beasts and feed upon them with much noise--filling themselves with scarlet blood.

1299.

Blood will be seen issuing from the torn flesh of men, and trickling down the surface.

Men will have such cruel maladies that they will tear their flesh with their own nails. (The Itch.)

Plants will be seen left without leaves, and the rivers standing still in their channels.

The waters of the sea will rise above the high peaks of the mountains towards heaven and fall again on to the dwellings of men. (That is, in Clouds.)

The largest trees of the forest will be seen carried by the fury of the winds from East to West. (That is across the Sea.)

Men will cast away their own victuals. (That is, in Sowing.)

1300.

Human beings will be seen who will not understand each other's speech; that is, a German with a Turk.

Fathers will be seen giving their daughters into the power of man and giving up all their former care in guarding them. (When Girls are married.)

Men will come out their graves turned into flying creatures; and they will attack other men, taking their food from their very hand or table. (As Flies.)

Many will there be who, flaying their mother, will tear the skin from her back. (Husbandmen tilling the Earth.)

Happy will they be who lend ear to the words of the Dead. (Who read good works and obey them.)

1031.

Feathers will raise men, as they do birds, towards heaven (that is, by the letters which are written with quills.)

The works of men's hands will occasion their death. (Swords and Spears.)

Men out of fear will cling to the thing they most fear. (That is they will be miserable lest they should fall into misery.)

Things that are separate shall be united and acquire such virtue that they will restore to man his lost memory; that is papyrus [sheets] which are made of separate strips and have preserved the memory of the things and acts of men.

The bones of the Dead will be seen to govern the fortunes of him who moves them. (By Dice.)

Cattle with their horns protect the Flame from its death. (In a Lantern [Footnote 13: See note page 357].)

The Forests will bring forth young which will be the cause of their death. (The handle of the hatchet.)

1302.

Men will deal bitter blows to that which is the cause of their life. (In thrashing Grain.)

The skins of animals will rouse men from their silence with great outcries and curses. (Balls for playing Games.)

Very often a thing that is itself broken is the occasion of much union. (That is the Comb made of split Cane which unites the threads of Silk.)

The wind passing through the skins of animals will make men dance.

(That is the Bag-pipe, which makes people dance.)

1303.

(Of Walnut trees, that are beaten.)

Those which have done best will be most beaten, and their offspring taken and flayed or peeled, and their bones broken or crushed.

(Of Sculpture.)

Alas! what do I see? The Saviour crucified anew.

(Of the Mouth of Man, which is a Sepulchre.)

Great noise will issue from the sepulchres of those who died evil and violent deaths.

(Of the Skins of Animals which have the sense of feeling what is in the things written.)

The more you converse with skins covered with sentiments, the more wisdom will you acquire.

(Of Priests who bear the Host in their body.)

Then almost all the tabernacles in which dwells the Corpus Domini, will be plainly seen walking about of themselves on the various roads of the world.

1304.

And those who feed on grass will turn night into day (Tallow.)

And many creatures of land and water will go up among the stars (that is Planets.)

The dead will be seen carrying the living (in Carts and Ships in various places.)

Food shall be taken out of the mouth of many (the oven's mouth.)

And those which will have their food in their mouth will be deprived of it by the hands of others (the oven.)

1305.

(Of Crucifixes which are sold.)

I see Christ sold and crucified afresh, and his Saints suffering Martyrdom.

(Of Physicians, who live by sickness.)

Men will come into so wretched a plight that they will be glad that others will derive profit from their sufferings or from the loss of their real wealth, that is health.

(Of the Religion of Friars, who live by the Saints who have been dead a great while.)

Those who are dead will, after a thousand years be those who will give a livelihood to many who are living.

(Of Stones converted into Lime, with which prison walls are made.)

Many things that have been before that time destroyed by fire will deprive many men of liberty.

1306.

(Of Children who are suckled.)

Many Franciscans, Dominicans and Benedictines will eat that which at other times was eaten by others, who for some months to come will not be able to speak.

(Of Cockles and Sea Snails which are thrown up by the sea and which rot inside their shells.)

How many will there be who, after they are dead, will putrefy inside their own houses, filling all the surrounding air with a fetid smell.

1307.

(Of Mules which have on them rich burdens of silver and gold.)

Much treasure and great riches will be laid upon four-footed beasts, which will convey them to divers places.

1308.

(Of the Shadow cast by a man at night with a light.)

Huge figures will appear in human shape, and the nearer you get to them, the more will their immense size diminish.

[Footnote page 1307: It seems to me probable that this note, which occurs in the note book used in 1502, when Leonardo, in the service of Cesare Borgia, visited Urbino, was suggested by the famous pillage of the riches of the palace of Guidobaldo, whose treasures Cesare Borgia at once had carried to Cesena (see GREGOROVIVS, *„Geschichte der Stadt Rom im Mittelalter“*. XIII, 5, 4).]

1309.

(Of Snakes, carried by Storks.)

Serpents of great length will be seen at a great height in the air,
fighting with birds.

(Of great guns, which come out of a pit and a mould.)

Creatures will come from underground which with their terrific noise
will stun all who are near; and with their breath will kill men and
destroy cities and castles.

1310.

(Of Grain and other Seeds.)

Men will fling out of their houses those victuals which were
intended to sustain their life.

(Of Trees, which nourish grafted shoots.)

Fathers and mothers will be seen to take much more delight in their
step-children than in their own children.

(Of the Censer.)

Some will go about in white garments with arrogant gestures
threatening others with metal and fire which will do no harm at all
to them.

1311.

(Of drying Fodder.)

Innumerable lives will be destroyed and innumerable vacant spaces
will be made on the earth.

(Of the Life of Men, who every year change their bodily substance.)

Men, when dead, will pass through their own bowels.

1312.

(Shoemakers.)

Men will take pleasure in seeing their own work destroyed and
injured.

1313.

(Of Kids.)

The time of Herod will come again, for the little innocent children

will be taken from their nurses, and will die of terrible wounds inflicted by cruel men.

V.

DRAUGHTS AND SCHEMES FOR THE HUMOROUS WRITINGS.

Schemes for fables, etc. (1314-1323).

1314.

A FABLE.

The crab standing under the rock to catch the fish which crept under it, it came to pass that the rock fell with a ruinous downfall of stones, and by their fall the crab was crushed.

THE SAME.

The spider, being among the grapes, caught the flies which were feeding on those grapes. Then came the vintage, and the spider was cut down with the grapes.

The vine that has grown old on an old tree falls with the ruin of that tree, and through that bad companionship must perish with it.

The torrent carried so much earth and stones into its bed, that it was then constrained to change its course.

The net that was wont to take the fish was seized and carried away by the rush of fish.

The ball of snow when, as it rolls, it descends from the snowy mountains, increases in size as it falls.

The willow, which by its long shoots hopes as it grows, to outstrip every other plant, from having associated itself with the vine which is pruned every year was always crippled.

1315.

Fable of the tongue bitten by the teeth.

The cedar puffed up with pride of its beauty, separated itself from the trees around it and in so doing it turned away towards the wind, which not being broken in its fury, flung it uprooted on the earth.

The traveller's joy, not content in its hedge, began to fling its branches out over the high road, and cling to the opposite hedge, and for this it was broken away by the passers by.

1316.

The goldfinch gives victuals to its caged young. Death rather than loss of liberty. [Footnote: Above this text is another note, also referring to liberty; see No. 694.]

1317.

(Of Bags.)

Goats will convey the wine to the city.

1318.

All those things which in winter are hidden under the snow, will be uncovered and laid bare in summer. (for Falsehood, which cannot remain hidden).

1319.

A FABLE.

The lily set itself down by the shores of the Ticino, and the current carried away bank and the lily with it.

1320.

A JEST.

Why Hungarian ducats have a double cross on them.

1321.

A SIMILE.

A vase of unbaked clay, when broken, may be remoulded, but not a baked one.

1322.

Seeing the paper all stained with the deep blackness of ink, it he deeply regrets it; and this proves to the paper that the words, composed upon it were the cause of its being preserved.

1323.

The pen must necessarily have the penknife for a companion, and it is a useful companionship, for one is not good for much without the other.

Schemes for prophecies (1324-1329).

1324.

The knife, which is an artificial weapon, deprives man of his nails,

his natural weapons.

The mirror conducts itself haughtily holding mirrored in itself the Queen. When she departs the mirror remains there ...

1325.

Flax is dedicated to death, and to the corruption of mortals. To death, by being used for snares and nets for birds, animals and fish; to corruption, by the flaxen sheets in which the dead are wrapped when they are buried, and who become corrupt in these winding sheets.-- And again, this flax does not separate its fibre till it has begun to steep and putrefy, and this is the flower with which garlands and decorations for funerals should be made.

1326.

(Of Peasants who work in shirts)

Shadows will come from the East which will blacken with great colour darkness the sky that covers Italy.

(Of the Barbers.)

All men will take refuge in Africa.

1327.

The cloth which is held in the hand in the current of a running stream, in the waters of which the cloth leaves all its foulness and dirt, is meant to signify this &c.

By the thorn with inoculated good fruit is signified those natures which of themselves were not disposed towards virtue, but by the aid of their preceptors they have the reputation of it.

1328.

A COMMON THING.

A wretched person will be flattered, and these flatterers are always the deceivers, robbers and murderers of the wretched person.

The image of the sun where it falls appears as a thing which covers the person who attempts to cover it.

(Money and Gold.)

Out of cavernous pits a thing shall come forth which will make all the nations of the world toil and sweat with the greatest torments, anxiety and labour, that they may gain its aid.

(Of the Dread of Poverty.)

The malicious and terrible [monster] will cause so much terror of itself in men that they will rush together, with a rapid motion, like madmen, thinking they are escaping her boundless force.

(Of Advice.)

The man who may be most necessary to him who needs him, will be repaid with ingratitude, that is greatly contemned.

1329.

(Of Bees.)

They live together in communities, they are destroyed that we may take the honey from them. Many and very great nations will be destroyed in their own dwellings.

1330.

WHY DOGS TAKE PLEASURE IN SMELLING AT EACH OTHER.

This animal has a horror of the poor, because they eat poor food, and it loves the rich, because they have good living and especially meat. And the excrement of animals always retains some virtue of its origin as is shown by the faeces ...

Now dogs have so keen a smell, that they can discern by their nose the virtue remaining in these faeces, and if they find them in the streets, smell them and if they smell in them the virtue of meat or of other things, they take them, and if not, they leave them: And to return to the question, I say that if by means of this smell they know that dog to be well fed, they respect him, because they judge that he has a powerful and rich master; and if they discover no such smell with the virtue of meat, they judge that dog to be of small account and to have a poor and humble master, and therefore they bite that dog as they would his master.

1331.

The circular plans of carrying earth are very useful, inasmuch as men never stop in their work; and it is done in many ways. By one of these ways men carry the earth on their shoulders, by another in chests and others on wheelbarrows. The man who carries it on his shoulders first fills the tub on the ground, and he loses time in hoisting it on to his shoulders. He with the chests loses no time. [Footnote: The subject of this text has apparently no connection with the other texts of this section.]

Irony (1332).

1332.

If Petrarch was so fond of bay, it was because it is of a good taste in sausages and with tunny; I cannot put any value on their foolery. [Footnote: Conte Porro has published these lines in the _Archivio Stor. Lombarda_ VIII, IV; he reads the concluding line thus: _I no posso di loro gia (sic) co' far tesauero._--This is known to be by a contemporary poet, as Senatore Morelli informs me.]

Tricks (1333-1335).

1333.

We are two brothers, each of us has a brother. Here the way of saying it makes it appear that the two brothers have become four.

1334.

TRICKS OF DIVIDING.

Take in each hand an equal number; put 4 from the right hand into the left; cast away the remainder; cast away an equal number from the left hand; add 5, and now you will find 13 in this [left] hand; that is-I made you put 4 from the right hand into the left, and cast away the remainder; now your right hand has 4 more; then I make you throw away as many from the right as you threw away from the left; so, throwing from each hand a quantity of which the remainder may be equal, you now have 4 and 4, which make 8, and that the trick may not be detected I made you put 5 more, which made 13.

TRICKS OF DIVIDING.

Take any number less than 12 that you please; then take of mine enough to make up the number 12, and that which remains to me is the number which you at first had; because when I said, take any number less than 12 as you please, I took 12 into my hand, and of that 12 you took such a number as made up your number of 12; and what you added to your number, you took from mine; that is, if you had 8 to go as far as to 12, you took of my 12, 4; hence this 4 transferred from me to you reduced my 12 to a remainder of 8, and your 8 became 12; so that my 8 is equal to your 8, before it was made 12.

[Footnote 1334: G. Govi _says in the_ 'Saggio' p. 22: _Si diletta Leonarda, di giuochi di prestigi e molti (?) ne descrisse, che si leggono poi riportati dal Paciolo nel suo libro:_ de Viribus Quantitatis, _e che, se non tutti, sono certo in gran parte invenzioni del Vinci._]

1335.

If you want to teach someone a subject you do not know yourself, let him measure the length of an object unknown to you, and he will learn the measure you did not know before;--Master Giovanni da Lodi.

XXI.

Letters. Personal Records. Dated Notes.

When we consider how superficial and imperfect are the accounts of Leonardo's life written some time after his death by Vasari and others, any notes or letters which can throw more light on his personal circumstances cannot fail to be in the highest degree interesting. The texts here given as Nos. 1351--1353, set his residence in Rome in quite a new aspect; nay, the picture which irresistibly dwells in our minds after reading these details of his life in the Vatican, forms a striking contrast to the contemporary life of Raphael at Rome.

_I have placed foremost of these documents the very remarkable letters to the Defterdar of Syria. In these Leonardo speaks of himself as having staid among the mountains of Armenia, and as the biographies of the master tell nothing of any such distant journeys, it would seem most obvious to treat this passage as fiction, and so spare ourselves the onus of proof and discussion. But on close examination no one can doubt that these documents, with the accompanying sketches, are the work of Leonardo's own hand. Not merely is the character of the handwriting his, but the spelling and the language are his also. In one respect only does the writing betray any marked deviation from the rest of the notes, especially those treating on scientific questions; namely, in these observations he seems to have taken particular pains to give the most distinct and best form of expression to all he had to say; we find erasures and emendations in almost every line. He proceeded, as we shall see, in the same way in the sketches for letters to Giuliano de' Medici, and what can be more natural, I may ask, than to find the draft of a letter thus altered and improved when it is to contain an account of a definite subject, and when personal interests are in the scale? The finished copies as sent off are not known to exist; if we had these instead of the rough drafts, we might unhesitatingly have declared that some unknown Italian engineer must have been, at that time, engaged in Armenia in the service of the Egyptian Sultan, and that Leonardo had copied his documents. Under this hypothesis however we should have to state that this unknown writer must have been so far one in mind with Leonardo as to use the same style of language and even the same lines of thought. This explanation might--as I say--have been possible, if only we had the finished letters. But why should these rough drafts of letters be regarded as anything else than what they actually and obviously are? If Leonardo had been a man of our own time, we might perhaps have attempted to account for the facts by saying that Leonardo, without having been in the East himself, might have undertaken to write a Romance of which the scene was laid in Armenia, and at the desire of his publisher had made sketches of landscape to illustrate the text.

I feel bound to mention this singular hypothesis as it has actually been put forward (see No. 1336 note 5); and it would certainly seem as though there were no other possible way of evading the conclusion

to which these letters point, and their bearing on the life of the master,--absurd as the alternative is. But, if, on a question of such importance, we are justified in suggesting theories that have no foundation in probability, I could suggest another which, as compared with that of a Fiction by Leonardo, would be neither more nor less plausible; it is, moreover the only other hypothesis, perhaps, which can be devised to account for these passages, if it were possible to prove that the interpretation that the documents themselves suggest, must be rejected a priori; viz may not Leonardo have written them with the intention of mystifying those who, after his death, should try to decipher these manuscripts with a view to publishing them? But if, in fact, no objection that will stand the test of criticism can be brought against the simple and direct interpretation of the words as they stand, we are bound to regard Leonardo's travels in the East as an established fact. There is, I believe nothing in what we know of his biography to negative such a fact, especially as the details of his life for some few years are wholly unknown; nor need we be at a loss for evidence which may serve to explain--at any rate to some extent--the strangeness of his undertaking such a journey. We have no information as to Leonardo's history between 1482 and 1486; it cannot be proved that he was either in Milan or in Florence. On the other hand the tenor of this letter does not require us to assume a longer absence than a year or two. For, even if his appointment_ (offitio) _as Engineer in Syria had been a permanent one, it might have become untenable--by the death perhaps of the Defterdar, his patron, or by his removal from office-- , and Leonardo on his return home may have kept silence on the subject of an episode which probably had ended in failure and disappointment.

From the text of No. 1379 we can hardly doubt that Leonardo intended to make an excursion secretly from Rome to Naples, although so far as has hitherto been known, his biographers never allude to it. In another place (No. 1077) he says that he had worked as an Engineer in Friuli. Are we to doubt this statement too, merely because no biographer has hitherto given us any information on the matter? In the geographical notes Leonardo frequently speaks of the East, and though such passages afford no direct proof of his having been there, they show beyond a doubt that, next to the Nile, the Euphrates, the Tigris and the Taurus mountains had a special interest in his eyes. As a still further proof of the futility of the argument that there is nothing in his drawings to show that he had travelled in the East, we find on Pl. CXX a study of oriental heads of Armenian type,--though of course this may have been made in Italy.

If the style of these letters were less sober, and the expressions less strictly to the point throughout, it might be possible to regard them as a romantic fiction instead of a narrative of fact. Nay, we have only to compare them with such obviously fanciful passages as No. 1354, Nos. 670-673, and the Fables and Prophecies. It is unnecessary to discuss the subject any further here; such explanations as the letter needs are given in the foot notes.

The drafts of letters to Lodovico il Moro are very remarkable. Leonardo and this prince were certainly far less closely connected, than has hitherto been supposed. It is impossible that Leonardo can have remained so long in the service of this prince, because the salary was good, as is commonly stated. On the contrary, it would seem, that what kept him there, in spite of his sore need of the money owed him by the prince, was the hope of some day being able to carry out the project of casting the_ 'gran cavallo'.

Drafts of Letters and Reports referring to Armenia (1336. 1337).

1336.

To THE DEVATDAR OF SYRIA, LIEUTENANT OF THE SACRED SULTAN OF BABYLON.

[3] The recent disaster in our Northern parts which I am certain will terrify not you alone but the whole world, which

[Footnote: Lines 1-52 are reproduced in facsimile on Pl. CXVI.

1. _Diodario._ This word is not to be found in any Italian dictionary, and for a long time I vainly sought an explanation of it. The youthful reminiscences of my wife afforded the desired clue. The chief town of each Turkish Villayet, or province --such as Broussa, for instance, in Asia Minor, is the residence of a Defterdar, who presides over the financial affairs of the province. _Defterdar hane_ was, in former times, the name given to the Ministry of Finance at Constantinople; the Minister of Finance to the Porte is now known as the _Mallie-Nazri_ and the _Defterdars_ are his subordinates. A _Defterdar_, at the present day is merely the head of the finance department in each Provincial district. With regard to my suggestion that Leonardo's _Diodario_ might be identical with the Defterdar of former times, the late M. C. DEFREMERIE, Arabic Professor, and Membre de l'Institut de France wrote to me as follows: _Votre conjecture est parfaitement fondee; diodario est Vequivalent de devadar ou plus exactement devatdar, titre d'une importante dignite en Egypt'e, sous les Mamlouks._

The word however is not of Turkish, but of Perso-Arabie derivation.

[Defter written in arab?] literally _Defter_ (Arabic) meaning _folio_; for _dar_ (Persian) Bookkeeper or holder is the English equivalent; and the idea is that of a deputy in command. During the Mamelook supremacy over Syria, which corresponded in date with Leonardo's time, the office of Defterdar was the third in importance in the State.

Soltano di Babilonia. The name of Babylon was commonly applied to Cairo in the middle ages. For instance BREIDENBACH, _Itinerarium Hierosolyma_ p. 218 says: "At last we reached Babylon. But this is not that Babylon which stood on the further shore of the river Chober, but that which is called the Egyptian Babylon. It is close

by Cairo and the twain are but one and not two towns; one half is called Cairo and the other Babylon, whence they are called together Cairo-Babylon; originally the town is said to have been named Memphis and then Babylon, but now it is called Cairo." Compare No. 1085, 6.

Egypt was governed from 1382 till 1517 by the Borgite or Tcherkessian dynasty of the Mamelook Sultans. One of the most famous of these, Sultan Kait Bey, ruled from 1468-1496 during whose reign the Gama (or Mosque) of Kait Bey and tomb of Kait Bey near the Okella Kait Bey were erected in Cairo, which preserve his name to this day. Under the rule of this great and wise prince many foreigners, particularly Italians, found occupation in Egypt, as may be seen in the 'Viaggio di Josaphat Barbaro', among other travellers. "Next to Leonardo (so I learn from Prof. Jac. Burckhardt of Bale) Kait Bey's most helpful engineer was a German who in about 1487, superintended the construction of the Mole at Alexandria. Felix Fabri knew him and mentions him in his *Historia Suevorum*, written in 1488."

3. *Il nuovo accidente accaduto*, or as Leonardo first wrote and then erased, *e accaduto un nuovo accidente*. From the sequel this must refer to an earthquake, and indeed these were frequent at that period, particularly in Asia Minor, where they caused immense mischief. See No. 1101 note.]

shall be related to you in due order, showing first the effect and then the cause. [Footnote 4: The text here breaks off. The following lines are a fresh beginning of a letter, evidently addressed to the same person, but, as it would seem, written at a later date than the previous text. The numerous corrections and amendments amply prove that it is not a copy from any account of a journey by some unknown person; but, on the contrary, that Leonardo was particularly anxious to choose such words and phrases as might best express his own ideas.]

Finding myself in this part of Armenia [Footnote 5: *Parti d'Erminia*. See No. 945, note. The extent of Armenia in Leonardo's time is only approximately known. In the XVth century the Persians governed the Eastern, and the Arabs the Southern portions. Arabic authors--as, for instance Abulfeda--include Cilicia and a part of Cappadocia in Armenia, and Greater Armenia was the tract of that country known later as Turcomania, while Armenia Minor was the territory between Cappadocia and the Euphrates. It was not till 1522, or even 1574 that the whole country came under the dominion of the Ottoman Turks, in the reign of Selim I.

The Mamelook Sultans of Egypt seem to have taken a particular interest in this, the most Northern province of their empire, which was even then in danger of being conquered by the Turks. In the autumn of 1477 Sultan Kait Bey made a journey of inspection, visiting Antioch and the valleys of the Tigris and Euphrates with a numerous and brilliant escort. This tour is briefly alluded to by

Moodshireddin p. 561; and by WEIL, _Geschichte der Abbasiden_ V, p. 358. An anonymous member of the suite wrote a diary of the expedition in Arabic, which has been published by R. V. LONZONE (_'Viaggio in Palestina e Soria di Kaid Ba XVIII sultano della II dinastia mamelucca, fatto nel 1477. Testo arabo. Torino 1878'_, without notes or commentary). Compare the critique on this edition, by J. GILDEMEISTER in _Zeitschrift des Deutschen Palaestina Vereins_ (Vol. III p. 246--249). Lanzone's edition seems to be no more than an abridged copy of the original. I owe to Professor Sche'fer, Membre de l'Institut, the information that he is in possession of a manuscript in which the text is fuller, and more correctly given. The Mamelook dynasty was, as is well known, of Circassian origin, and a large proportion of the Egyptian Army was recruited in Circassia even so late as in the XVth century. That was a period of political storms in Syria and Asia Minor and it is easy to suppose that the Sultan's minister, to whom Leonardo addresses his report as his superior, had a special interest in the welfare of those frontier provinces. Only to mention a few historical events of Sultan Kait Bey's reign, we find that in 1488 he assisted the Circassians to resist the encroachments of Alaeddoulet, an Asiatic prince who had allied himself with the Osmanli to threaten the province; the consequence was a war in Cilicia by sea and land, which broke out in the following year between the contending powers. Only a few years earlier the same province had been the scene of the so-called Caramenian war in which the united Venetian, Neapolitan and Sclavonic fleets had been engaged. (See CORIALANO CIPPICO, _Della guerra dei Veneziani nell' Asia dal_ 1469--1474. Venezia 1796, p. 54) and we learn incidentally that a certain Leonardo Boldo, Governor of Scutari under Sultan Mahmoud,--as his name would indicate, one of the numerous renegades of Italian birth--played an important part in the negotiations for peace.

Tu mi mandasti. The address _tu_ to a personage so high in office is singular and suggests personal intimacy; Leonardo seems to have been a favourite with the Diodario. Compare lines 54 and 55.

I have endeavoured to show, and I believe that I am also in a position to prove with regard to these texts, that they are draughts of letters actually written by Leonardo; at the same time I must not omit to mention that shortly after I had discovered

these texts in the Codex Atlanticus and published a paper on the subject in the _Zeitschrift fur bildende Kunst (Vol. XVI)_, Prof. Govi put forward this hypothesis to account for their origin:

_"Quanto alle notizie sul monte Tauro, sull'Armenia e sull' Asia minore che si contengono negli altri frammenti, esse vennero prese da qualche geografo o viaggiatore contemporaneo. Dall'indice imperfetto che accompagna quei frammenti, si potrebbe dedurre che Leonardo volesse farne un libro, che poi non venne compiuto. A ogni modo, non e possibile di trovare in questi brani nessun indizio di un viaggio di Leonardo in oriente, ne della sua conversione alla religione di Maometto, come qualcuno pretenderebbe. Leonardo amava

con passione gli studi geografici, e nei suoi scritti s'incontrano spesso itinerari, indicazioni, o descrizioni di luoghi, schizzi di carte e abbozzi topografici di varie regioni, non è quindi strano che egli, abile narratore com'era, si fosse proposto di scrivere una specie di romanzo in forma epistolare svolgendone l'intreccio nell'Asia Minore, intorno alla quale i libri d'allora, e forse qualche viaggiatore amico suo, gli avevano somministrato alcuni elementi più o meno fantastici. (See *Transunti della Reale Accademia dei Lincei* Voi. V Ser. 3).

It is hardly necessary to point out that Prof. Govi omits to name the sources from which Leonardo could be supposed to have drawn his information, and I may leave it to the reader to pronounce judgment on the anomaly which is involved in the hypothesis that we have here a fragment of a romance, cast in the form of a correspondence. At the same time, I cannot but admit that the solution of the difficulties proposed by Prof. Govi is, under the circumstances, certainly the easiest way of dealing with the question. But we should then be equally justified in supposing some more of Leonardo's letters to be fragments of such romances; particularly those of which the addresses can no longer be named. Still, as regards these drafts of letters to the *Diodario*, if we accept the romance theory, as proposed by Prof. Govi, we are also compelled to assume that Leonardo purposed from the first to illustrate his tale; for it needs only a glance at the sketches on PI. CXVI to CXIX to perceive that they are connected with the texts; and of course the rest of Leonardo's numerous notes on matters pertaining to the East, the greater part of which are here published for the first time, may also be somehow connected with this strange romance.

7. Citta de Calindra (Chalindra). The position of this city is so exactly determined, between the valley of the Euphrates and the Taurus range that it ought to be possible to identify it. But it can hardly be the same as the sea port of Cilicia with a somewhat similar name *Celenderis*, *Kelandria*, *Celendria*, *Kilindria*, now the Turkish *Gulnar*. In two Catalonian Portulans in the *Bibliothèque Nationale* in Paris—one dating from the XVth century, by *Wilhelm von Soler*, the other by *Olivez de Majorca*, in 1584—I find this place called *Calandra*. But Leonardo's *Calindra* must certainly have lain more to the North West, probably somewhere in *Kurdistan*. The fact that the geographical position is so carefully determined by Leonardo seems to prove that it was a place of no great importance and little known. It is singular that the words first written in 1. 8 were *divisa dal lago (Lake Van?)*, altered afterwards to *dall'Eitfrates*.

Nostri confini, and in 1. 6 *proposito nostro*. These refer to the frontier and to the affairs of the Mamelook Sultan, Lines 65 and 66 throw some light on the purpose of Leonardo's mission.

8. corni del gran monte Tauro. Compare the sketches PI. CXVI-CXVIII. So long as it is impossible to identify the situation of *Calindra* it is most difficult to decide with any certainty which

peak of the Taurus is here meant; and I greatly regret that I had no foreknowledge of this puzzling topographical question when, in 1876, I was pursuing archaeological enquiries in the Provinces of Aleppo and Cilicia, and had to travel for some time in view of the imposing snow-peaks of Bulghar Dag and Ala Tepessi.

9-10. The opinion here expressed as to the height of the mountain would be unmeaning, unless it had been written before Leonardo moved to Milan, where Monte Rosa is so conspicuous an object in the landscape. 4 *_ore inanzi_* seems to mean, four hours before the sun's rays penetrate to the bottom of the valleys.]

to carry into effect with due love and care the task for which you sent me [Footnote:][6]; and to make a beginning in a place which seemed to me to be most to our purpose, I entered into the city of Calindrafy[7], near to our frontiers. This city is situated at the base of that part of the Taurus mountains which is divided from the Euphrates and looks towards the peaks of the great Mount Taurus [8] to the West [9]. These peaks are of such a height that they seem to touch the sky, and in all the world there is no part of the earth, higher than its summit[10], and the rays of the sun always fall upon it on its East side, four hours before day-time, and being of the whitest stone [Footnote 11: *_Pietra bianchissima_*. The Taurus Mountains consist in great part of limestone.] it shines resplendently and fulfils the function to these Armenians which a bright moon-light would in the midst of the darkness; and by its great height it outreaches the utmost level of the clouds by a space of four miles in a straight line. This peak is seen in many places towards the West, illuminated by the sun after its setting the third part of the night. This it is, which with you [Footnote 14: *_Appresso di voi_*. Leonardo had at first written *_noi_* as though his meaning had,been: This peak appeared to us to be a comet when you and I observed it in North Syria (at Aleppo? at Aintas?). The description of the curious reflection in the evening, resembling the "Alpine-glow" is certainly not an invented fiction, for in the next lines an explanation of the phenomenon is offered, or at least attempted.] we formerly in calm weather had supposed to be a comet, and appears to us in the darkness of night, to change its form, being sometimes divided in two or three parts, and sometimes long and sometimes short. And this is caused by the clouds on the horizon of the sky which interpose between part of this mountain and the sun, and by cutting off some of the solar rays the light on the mountain is intercepted by various intervals of clouds, and therefore varies in the form of its brightness.

THE DIVISIONS OF THE BOOK [Footnote 19: The next 33 lines are evidently the contents of a connected Report or Book, but not of one which he had at hand; more probably, indeed, of one he purposed writing.]

The praise and confession of the faith [Footnote 20: *_Persuasione di fede_*, of the Christian or the Mohammedan faith? We must suppose the latter, at the beginning of a document addressed to so high a

Mohammedan official. *_Predica_* probably stands as an abbreviation for *_predicazione_* (lat. *_praedicatio_*) in the sense of praise or glorification; very probably it may mean some such initial doxology as we find in Mohammedan works. (Comp. 1. 40.).

The sudden inundation, to its end.

[23] The destruction of the city.

[24] The death of the people and their despair.

The preacher's search, his release and benevolence [Footnote 28: The phraseology of this is too general for any conjecture as to its meaning to be worth hazarding.]

Description of the cause of this fall of the mountain [Footnote 30: *_Ruina del monte_*. Of course by an earthquake. In a catalogue of earthquakes, entitled *_kechf aussalssaleb an auasf ezzel-zeleh_*, and written by Djelal eddin].

The mischief it did.

[32] Fall of snow.

The finding of the prophet [33].

His prophesy.

[35] The inundation of the lower portion of Eastern Armenia, the draining of which was effected by the cutting through the Taurus Mountains.

How the new prophet showed [Footnote 40: *_Nova profeta_*, 1. 33, *profeta_*. Mohammed. Leonardo here refers to the Koran:

In the name of the most merciful God.--When the earth shall be shaken by an earthquake; and the earth shall cast forth her burdens; and a man shall say, what aileth her? On that day the earth shall declare her tidings, for that thy Lord will inspire her. On that day men shall go forward in distinct classes, that they may behold their works. And whoever shall have wrought good of the weight of an ant, shall behold the same. And whoever shall have wrought evil of the weight of an ant, shall behold the same. (The Koran, translated by G. Sale, Chapter XCIX, p. 452.)] that this destruction would happen as he had foretold.

Description of the Taurus Mountains [43] and the river Euphrates.

Why the mountain shines at the top, from half to a third of the night, and looks like a comet to the inhabitants of the West after the sunset, and before day to those of the East.

Why this comet appears of variable forms, so that it is now round

and now long, and now again divided into two or three parts, and now in one piece, and when it is to be seen again.

OF THE SHAPE OF THE TAURUS MOUNTAINS [Footnote 53-94: The facsimile of this passage is given on Pl. CXVII.].

I am not to be accused, Oh Devatdar, of idleness, as your chidings seem to hint; but your excessive love for me, which gave rise to the benefits you have conferred on me [Footnote 55] is that which has also compelled me to the utmost painstaking in seeking out and diligently investigating the cause of so great and stupendous an effect. And this could not be done without time; now, in order to satisfy you fully as to the cause of so great an effect, it is requisite that I should explain to you the form of the place, and then I will proceed to the effect, by which I believe you will be amply satisfied.

[Footnote 36: _Tagliata di Monte Tauro_. The Euphrates flows through the Taurus range near the influx of the Kura Shai; it rushes through a rift in the wildest cliffs from 2000 to 3000 feet high and runs on for 90 miles in 300 falls or rapids till it reaches Telek, near which at a spot called Gleikash, or the Hart's leap, it measures only 35 paces across. Compare the map on Pl. CXIX and the explanation for it on p. 391.]

[Footnote 54: The foregoing sketch of a letter, lines 5. 18, appears to have remained a fragment when Leonardo received pressing orders which caused him to write immediately and fully on the subject mentioned in line 43.]

[Footnote 59: This passage was evidently intended as an improvement on that immediately preceding it. The purport of both is essentially the same, but the first is pitched in a key of ill-disguised annoyance which is absent from the second. I do not see how these two versions can be reconciled with the romance-theory held by Prof. Govi.] Do not be aggrieved, O Devatdar, by my delay in responding to your pressing request, for those things which you require of me are of such a nature that they cannot be well expressed without some lapse of time; particularly because, in order to explain the cause of so great an effect, it is necessary to describe with accuracy the nature of the place; and by this means I can afterwards easily satisfy your above-mentioned request. [Footnote 62: This passage was evidently intended as an improvement on that immediately preceding it. The purport of both is essentially the same, but the first is pitched in a key of ill-disguised annoyance which is absent from the second. I do not see how these two versions can be reconciled with the romance-theory held by Prof. Govi.]

I will pass over any description of the form of Asia Minor, or as to what seas or lands form the limits of its outline and extent, because I know that by your own diligence and carefulness in your studies you have not remained in ignorance of these matters [65]; and I will go on to describe the true form of the Taurus Mountain

which is the cause of this stupendous and harmful marvel, and which will serve to advance us in our purpose [66]. This Taurus is that mountain which, with many others is said to be the ridge of Mount Caucasus; but wishing to be very clear about it, I desired to speak to some of the inhabitants of the shores of the Caspian sea, who give evidence that this must be the true Caucasus, and that though their mountains bear the same name, yet these are higher; and to confirm this in the Scythian tongue Caucasus means a very high [Footnote 68: Caucasus; Herodot Kaoxaais; Armen. Kaukaz.] peak, and in fact we have no information of there being, in the East or in the West, any mountain so high. And the proof of this is that the inhabitants of the countries to the West see the rays of the sun illuminating a great part of its summit for as much as a quarter of the longest night. And in the same way, in those countries which lie to the East.

OF THE STRUCTURE AND SIZE OF MOUNT TAURUS.

[Footnote 73: The statements are of course founded on those of the 'inhabitants' spoken of in 1. 67.] The shadow of this ridge of the Taurus is of such a height that when, in the middle of June, the Sun is at its meridian, its shadow extends as far as the borders of Sarmatia, twelve days off; and in the middle of December it extends as far as the Hyperborean mountains, which are at a month's journey to the North [75]. And the side which faces the wind is always free from clouds and mists, because the wind which is parted in beating on the rock, closes again on the further side of that rock, and in its motion carries with it the clouds from all quarters and leaves them where it strikes. And it is always full of thunderbolts from the great quantity of clouds which accumulate there, whence the rock is all riven and full of huge debris [Footnote 77: Sudden storms are equally common on the heights of Ararat. It is hardly necessary to observe that Ararat cannot be meant here. Its summit is formed like the crater of Vesuvius. The peaks sketched on Pl. CXVI-CXVIII are probably views of the same mountain, taken from different sides. Near the solitary peak, Pl. CXVIII these three names are written _goba, arnigasar, caruda_, names most likely of different peaks. Pl. CXVI and CXVII are in the original on a single sheet folded down the middle, 30 centimetres high and 43 1/2 wide. On the reverse of one half of the sheet are notes on _peso_ and _bilancia_ (weight and balance), on the other are the 'prophecies' printed under Nos. 1293 and 1294. It is evident from the arrangement that these were written subsequently, on the space which had been left blank. These pages are facsimiled on Pl. CXVIII. In Pl. CXVI-CXVIII the size is smaller than in the original; the map of Armenia, Pl. CXVIII, is on Pl. CXIX slightly enlarged. On this map we find the following names, beginning from the right hand at the top: _pariades mo_ (for Paryadres Mons, Arm. Parchar, now Barchal or Kolai Dagh; Trebizond is on its slope).

Aquilone --North, _Antitaurus Antitaurus psis mo_ (probably meant for Thospitis = Lake Van, Arm. Dgov Vanai, Tospoi, and the Mountain range to the South); _Gordis mo_ (Mountains of Gordyaea), the birth

place of the Tigris; _Oriente_ --East; _Tigris_, and then, to the left, _Eufrates_. Then, above to the left _Argeo mo_ (now Erdshigas, an extinct volcano, 12000 feet high); _Celeno mo_ (no doubt Sultan Dagh in Pisidia). Celeno is the Greek town of KeAouvat-- see Arian I, 29, I--now the ruins of Dineir); _oriente_ --East; _africo libezco_ (for libeccio--South West). In the middle of the Euphrates river on this small map we see a shaded portion surrounded by mountains, perhaps to indicate the inundation mentioned in l. 35. The affluent to the Euphrates shown as coming with many windings from the high land of 'Argeo' on the West, is the Tochma Su, which joins the main river at Malatie. I have not been able to discover any map of Armenia of the XVth or XVIth century in which the course of the Euphrates is laid down with any thing like the correctness displayed in this sketch. The best I have seen is the Catalanian Portulan of Olivez de Majorca, executed in 1584, and it is far behind Leonardo's.]. This mountain, at its base, is inhabited by a very rich population and is full of most beautiful springs and rivers, and is fertile and abounding in all good produce, particularly in those parts which face to the South. But after mounting about three miles we begin to find forests of great fir trees, and beech and other similar trees; after this, for a space of three more miles, there are meadows and vast pastures; and all the rest, as far as the beginning of the Taurus, is eternal snows which never disappear at any time, and extend to a height of about fourteen miles in all. From this beginning of the Taurus up to the height of a mile the clouds never pass away; thus we have fifteen miles, that is, a height of about five miles in a straight line; and the summit of the peaks of the Taurus are as much, or about that. There, half way up, we begin to find a scorching air and never feel a breath of wind; but nothing can live long there; there nothing is brought forth save a few birds of prey which breed in the high fissures of Taurus and descend below the clouds to seek their prey. Above the wooded hills all is bare rock, that is, from the clouds upwards; and the rock is the purest white. And it is impossible to walk to the high summit on account of the rough and perilous ascent.

1337.

[Footnote: 1337. On comparing this commencement of a letter l. 1-2 with that in l. 3 and 4 of No. 1336 it is quite evident that both refer to the same event. (Compare also No. 1337 l. 10-12 and 17 with No. 1336 l. 23, 24 and 32.) But the text No. 1336, including the fragment l. 3-4, was obviously written later than the draft here reproduced. The _Diodario_ is not directly addressed--the person addressed indeed is not known--and it seems to me highly probable that it was written to some other patron and friend whose name and position are not mentioned.]

Having often made you, by my letters, acquainted with the things which have happened, I think I ought not to be silent as to the events of the last few days, which--[2]...

Having several times--

Having many times rejoiced with you by letters over your prosperous fortunes, I know now that, as a friend you will be sad with me over the miserable state in which I find myself; and this is, that during the last few days I have been in so much trouble, fear, peril and loss, besides the miseries of the people here, that we have been envious of the dead; and certainly I do not believe that since the elements by their separation reduced the vast chaos to order, they have ever combined their force and fury to do so much mischief to man. As far as regards us here, what we have seen and gone through is such that I could not imagine that things could ever rise to such an amount of mischief, as we experienced in the space of ten hours. In the first place we were assailed and attacked by the violence and fury of the winds [10]; to this was added the falling of great mountains of snow which filled up all this valley, thus destroying a great part of our city [Footnote 11: *_Della nostra citta_* (Leonardo first wrote *_di questa citta_*). From this we may infer that he had at some time lived in the place in question wherever it might be.]. And not content with this the tempest sent a sudden flood of water to submerge all the low part of this city [12]; added to which there came a sudden rain, or rather a ruinous torrent and flood of water, sand, mud, and stones, entangled with roots, and stems and fragments of various trees; and every kind of thing flying through the air fell upon us; finally a great fire broke out, not brought by the wind, but carried as it would seem, by ten thousand devils, which completely burnt up all this neighbourhood and it has not yet ceased. And those few who remain unhurt are in such dejection and such terror that they hardly have courage to speak to each other, as if they were stunned. Having abandoned all our business, we stay here together in the ruins of some churches, men and women mingled together, small and great [Footnote 17: *_Certe ruine di chiese_*. Either of Armenian churches or of Mosques, which it was not unusual to speak of as churches.

Maschi e femmini insieme unite, implies an infringement of the usually strict rule of the separation of the sexes.], just like herds of goats. The neighbours out of pity succoured us with victuals, and they had previously been our enemies. And if

[Footnote 18: *_I vicini, nostri nimici_*. The town must then have stood quite close to the frontier of the country. Compare 1336. L. 7. *_vicini ai nostri confini_*. Dr. M. JORDAN has already published lines 4-13 (see *_Das Malerbuch, Leipzig_*, 1873, p. 90:--his reading differs from mine) under the title of "Description of a landscape near Lake Como". We do in fact find, among other loose sheets in the Codex Atlanticus, certain texts referring to valleys of the Alps (see Nos. 1030, 1031 and note p. 237) and in the arrangement of the loose sheets, of which the Codex Atlanticus has been formed, these happen to be placed close to this text. The compiler stuck both on the same folio sheet; and if this is not the reason for Dr. JORDAN'S choosing such a title (Description &c.) I cannot imagine what it can have been. It is, at any rate, a merely hypothetical statement. The designation of the population of the country round a city as "the

enemy" (_nemici_) is hardly appropriate to Italy in the time of Leonardo.]

it had not been for certain people who succoured us with victuals, all would have died of hunger. Now you see the state we are in. And all these evils are as nothing compared with those which are promised to us shortly.

I know that as a friend you will grieve for my misfortunes, as I, in former letters have shown my joy at your prosperity ...

Notes about events observed abroad (1338-1339).

1338.

BOOK 43. OF THE MOVEMENT OF AIR ENCLOSED IN WATER.

I have seen motions of the air so furious that they have carried, mixed up in their course, the largest trees of the forest and whole roofs of great palaces, and I have seen the same fury bore a hole with a whirling movement digging out a gravel pit, and carrying gravel, sand and water more than half a mile through the air.

[Footnote: The first sixteen lines of this passage which treat of the subject as indicated on the title line have no place in this connexion and have been omitted.]

[Footnote 2: _Ho veduto movimenti_ &c. Nothing of the kind happened in Italy during Leonardo's lifetime, and it is therefore extremely probable that this refers to the natural phenomena which are so fully described in the foregoing passage. (Compare too, No. 1021.)

There can be no doubt that the descriptions of the Deluge in the Libro di Pittura (Vol. I, No. 607-611), and that of the fall of a mountain No. 610, l. 17-30 were written from the vivid impressions derived from personal experience. Compare also Pl. XXXIV-XL.]

1339.

[Footnote: It may be inferred from the character of the writing, which is in the style of the note in facsimile Vol. I, p. 297, that this passage was written between 1470 and 1480. As the figure 6 at the end of the text indicates, it was continued on another page, but I have searched in vain for it. The reverse of this leaf is coloured red for drawing in silver point, but has not been used for that purpose but for writing on, and at about the same date. The passages are given as Nos. 1217, 1218, 1219, 1162 and No. 994 (see note page 218). The text given above is obviously not a fragment of a letter, but a record of some personal experience. No. 1379 also seems to refer to Leonardo's journeys in Southern Italy.]

Like a whirling wind which rushes down a sandy and hollow valley, and which, in its hasty course, drives to its centre every thing that opposes its furious course ...

No otherwise does the Northern blast whirl round in its tempestuous progress ...

Nor does the tempestuous sea bellow so loud, when the Northern blast dashes it, with its foaming waves between Scylla and Charybdis; nor Stromboli, nor Mount Etna, when their sulphurous flames, having been forcibly confined, rend, and burst open the mountain, fulminating stones and earth through the air together with the flames they vomit.

Nor when the inflamed caverns of Mount Etna [Footnote 13: Mongibello is a name commonly given in Sicily to Mount Etna (from Djebel, Arab.=mountain). Fr. FERRARA, *Descrizione dell' Etna con la storia delle eruzioni* (Palermo, 1818, p. 88) tells us, on the authority of the *Cronaca del Monastero Benedettino di Licordia* of an eruption of the Volcano with a great flow of lava on Sept. 21, 1447. The next records of the mountain are from the years 1533 and 1536. A. Percy neither does mention any eruptions of Etna during the years to which this note must probably refer *Memoire des tremblements de terre de la peninsule italique*, Vol. XXII des *Memoires couronnees et Memoires des savants etrangers. Academie Royal de Belgique*.)].

A literal interpretation of the passage would not, however, indicate an allusion to any great eruption; particularly in the connection with Stromboli, where the periodical outbreaks in very short intervals are very striking to any observer, especially at night time, when passing the island on the way from Naples to Messina.], rejecting the ill-restrained element vomit it forth, back to its own region, driving furiously before it every obstacle that comes in the way of its impetuous rage ...

Unable to resist my eager desire and wanting to see the great ... of the various and strange shapes made by formative nature, and having wandered some distance among gloomy rocks, I came to the entrance of a great cavern, in front of which I stood some time, astonished and unaware of such a thing. Bending my back into an arch I rested my left hand on my knee and held my right hand over my down-cast and contracted eye brows: often bending first one way and then the other, to see whether I could discover anything inside, and this being forbidden by the deep darkness within, and after having remained there some time, two contrary emotions arose in me, fear and desire--fear of the threatening dark cavern, desire to see whether there were any marvellous thing within it ...

Drafts of Letters to Lodovico il Moro (1340-1345).

1340.

[Footnote: The numerous corrections, the alterations in the figures (l. 18) and the absence of any signature prove that this is merely the rough draft of a letter to Lodovico il Moro. It is one of the very few manuscripts which are written from left to right--see the

facsimile of the beginning as here reproduced. This is probably the final sketch of a document the clean of which copy was written in the usual manner. Leonardo no doubt very rarely wrote so, and this is probably the reason of the conspicuous dissimilarity in the handwriting, when he did. (Compare Pl. XXXVIII.) It is noteworthy too that here the orthography and abbreviations are also exceptional. But such superficial peculiarities are not enough to stamp the document as altogether spurious. It is neither a forgery nor the production of any artist but Leonardo himself. As to this point the contents leave us no doubt as to its authenticity, particularly l. 32 (see No. 719, where this passage is repeated). But whether the fragment, as we here see it, was written from Leonardo's dictation--a theory favoured by the orthography, the erasures and corrections--or whether it may be a copy made for or by Melzi or Mazenta is comparatively unimportant. There are in the Codex Atlanticus a few other documents not written by Leonardo himself, but the notes in his own hand found on the reverse pages of these leaves amply prove that they were certainly in Leonardo's possession. This mark of ownership is wanting to the text in question, but the compilers of the Codex Atlanticus, at any rate, accepted it as a genuine document.

With regard to the probable date of this projected letter see Vol. II, p. 3.]

Most illustrious Lord, Having now sufficiently considered the specimens of all those who proclaim themselves skilled contrivers of instruments of war, and that the invention and operation of the said instruments are nothing different to those in common use: I shall endeavour, without prejudice to any one else, to explain myself to your Excellency showing your Lordship my secrets, and then offering them to your best pleasure and approbation to work with effect at opportune moments as well as all those things which, in part, shall be briefly noted below.

1) I have a sort of extremely light and strong bridges, adapted to be most easily carried, and with them you may pursue, and at any time flee from the enemy; and others, secure and indestructible by fire and battle, easy and convenient to lift and place. Also methods of burning and destroying those of the enemy.

2) I know how, when a place is besieged, to take the water out of the trenches, and make endless variety of bridges, and covered ways and ladders, and other machines pertaining to such expeditions.

3) Item. If, by reason of the height of the banks, or the strength of the place and its position, it is impossible, when besieging a place, to avail oneself of the plan of bombardment, I have methods for destroying every rock or other fortress, even if it were founded on a rock, &c.

4) Again I have kinds of mortars; most convenient and easy to carry; and with these can fling small stones almost resembling a storm; and

with the smoke of these causing great terror to the enemy, to his great detriment and confusion.

9) [8] And when the fight should be at sea I have kinds of many machines most efficient for offence and defence; and vessels which will resist the attack of the largest guns and powder and fumes.

5) Item. I have means by secret and tortuous mines and ways, made without noise to reach a designated [spot], even if it were needed to pass under a trench or a river.

6) Item. I will make covered chariots, safe and unattackable which, entering among the enemy with their artillery, there is no body of men so great but they would break them. And behind these, infantry could follow quite unhurt and without any hindrance.

7) Item. In case of need I will make big guns, mortars and light ordnance of fine and useful forms, out of the common type.

8) Where the operation of bombardment should fail, I would contrive catapults, mangonels, _trabocchi_ and other machines of marvellous efficacy and not in common use. And in short, according to the variety of cases, I can contrive various and endless means of offence and defence.

10) In time of peace I believe I can give perfect satisfaction and to the equal of any other in architecture and the composition of buildings public and private; and in guiding water from one place to another.

Item: I can carry out sculpture in marble, bronze or clay, and also in painting whatever may be done, and as well as any other, be he whom he may.

[32] Again, the bronze horse may be taken in hand, which is to be to the immortal glory and eternal honour of the prince your father of happy memory, and of the illustrious house of Sforza.

And if any one of the above-named things seem to any one to be impossible or not feasible, I am most ready to make the experiment in your park, or in whatever place may please your Excellency--to whom I commend myself with the utmost humility &c.

1341.

To my illustrious Lord, Lodovico, Duke of Bari, Leonardo da Vinci of Florence-- Leonardo.

[Footnote: Evidently a note of the superscription of a letter to the Duke, and written, like the foregoing from left to right. The manuscript containing it is of the year 1493. Lodovico was not proclaimed and styled Duke of Milan till September 1494. The Dukedom of Bari belonged to the Sforza family till 1499.]

1342.

You would like to see a model which will prove useful to you and to me, also it will be of use to those who will be the cause of our usefulness.

[Footnote: 1342. 1343. These two notes occur in the same not very voluminous MS. as the former one and it is possible that they are fragments of the same letter. By the _Modello_, the equestrian statue is probably meant, particularly as the model of this statue was publicly exhibited in this very year, 1493, on the occasion of the marriage of the Emperor Maximilian with Bianca Maria Sforza.]

1343.

There are here, my Lord, many gentlemen who will undertake this expense among them, if they are allowed to enjoy the use of admission to the waters, the mills, and the passage of vessels and when it is sold to them the price will be repaid to them by the canal of Martesana.

1344.

I am greatly vexed to be in necessity, but I still more regret that this should be the cause of the hindrance of my wish which is always disposed to obey your Excellency.

Perhaps your Excellency did not give further orders to Messer Gualtieri, believing that I had money enough.

I am greatly annoyed that you should have found me in necessity, and that my having to earn my living should have hindered me ...

[12] It vexes me greatly that having to earn my living has forced me to interrupt the work and to attend to small matters, instead of following up the work which your Lordship entrusted to me. But I hope in a short time to have earned so much that I may carry it out quietly to the satisfaction of your Excellency, to whom I commend myself; and if your Lordship thought that I had money, your Lordship was deceived. I had to feed 6 men for 56 months, and have had 50 ducats.

1345.

And if any other comission is given me
by any ...
of the reward of my service. Because I am
not [able] to be ...
things assigned because meanwhile they
have ... to them ...
... which they well may settle rather than I ...
not my art which I wish to change and ...

given some clothing if I dare a sum ...

My Lord, I knowing your Excellency's
mind to be occupied ...
to remind your Lordship of my small matters
and the arts put to silence
that my silence might be the cause of making
your Lordship scorn ...
my life in your service. I hold myself ever
in readiness to obey ...

[Footnote 11: See No. 723, where this passage is repeated.]

Of the horse I will say nothing because
I know the times [are bad]
to your Lordship how I had still to receive
two years' salary of the ...
with the two skilled workmen who are constantly
in my pay and at my cost
that at last I found myself advanced the
said sum about 15 lire ...
works of fame by which I could show to
those who shall see it that I have been
everywhere, but I do not know where I
could bestow my work [more] ...

[Footnote 17: See No. 1344 l. 12.]

I, having been working to gain my
living ...

I not having been informed what it is, I find
myself ...

[Footnote 19: In April, 1498, Leonardo was engaged in
painting the Saletta Nigra of the Castello at Milan.
(See G. MONGERI, *L'Arte in Milano*, 1872, p. 417.)]

remember the commission to paint the
rooms ...

I conveyed to your Lordship only requesting
you ...

[Footnote: The paper on which this is written is torn down the
middle; about half of each line remains.]

Draft of letter to be sent to Piacenza (1346. 1347).

[Footnote: 1346. 1347. Piacenza belonged to Milan. The Lord spoken
of in this letter, is no doubt Lodovico il Moro. One may infer from
the concluding sentence (No. 1346, l. 33. 34 and No. 1347), that

Leonardo, who no doubt compiled this letter, did not forward it to Piacenza himself, but gave it to some influential patron, under whose name and signature a copy of it was sent to the Commission.]

1346.

Magnificent Commissioners of Buildings I, understanding that your Magnificencies have made up your minds to make certain great works in bronze, will remind you of certain things: first that you should not be so hasty or so quick to give the commission, lest by this haste it should become impossible to select a good model and a good master; and some man of small merit may be chosen, who by his insufficiency may cause you to be abused by your descendants, judging that this age was but ill supplied with men of good counsel and with good masters; seeing that other cities, and chiefly the city of the Florentines, has been as it were in these very days, endowed with beautiful and grand works in bronze; among which are the doors of their Baptistery. And this town of Florence, like Piacenza, is a place of intercourse, through which many foreigners pass; who, seeing that the works are fine and of good quality, carry away a good impression, and will say that that city is well filled with worthy inhabitants, seeing the works which bear witness to their opinion; and on the other hand, I say seeing so much metal expended and so badly wrought, it were less shame to the city if the doors had been of plain wood; because, the material, costing so little, would not seem to merit any great outlay of skill...

Now the principal parts which are sought for in cities are their cathedrals, and of these the first things which strike the eye are the doors, by which one passes into these churches.

Beware, gentlemen of the Commission, lest too great speed in your determination, and so much haste to expedite the entrusting of so great a work as that which I hear you have ordered, be the cause that that which was intended for the honour of God and of men should be turned to great dishonour of your judgments, and of your city, which, being a place of mark, is the resort and gathering-place of innumerable foreigners. And this dishonour would result if by your lack of diligence you were to put your trust in some vaunter, who by his tricks or by favour shown to him here should obtain such work from you, by which lasting and very great shame would result to him and to you. Thus I cannot help being angry when I consider what men those are who have conferred with you as wishing to undertake this great work without thinking of their sufficiency for it, not to say more. This one is a potter, that one a maker of cuirasses, this one is a bell-founder, another a bell ringer, and one is even a bombardier; and among them one in his Lordship's service, who boasted that he was the gossip of Messer Ambrosio Ferrere [Footnote 26: Messer Ambrogio Ferrere was Farmer of the Customs under the Duke. Piacenza at that time belonged to Milan.], who has some power and who has made him some promises; and if this were not enough he would mount on horseback, and go to his Lord and obtain such letters that you could never refuse [to give] him the work. But consider

where masters of real talent and fit for such work are brought when they have to compete with such men as these. Open your eyes and look carefully lest your money should be spent in buying your own disgrace. I can declare to you that from that place you will procure none but average works of inferior and coarse masters. There is no capable man,--[33] and you may believe me,--except Leonardo the Florentine, who is making the equestrian statue in bronze of the Duke Francesco and who has no need to bring himself into notice, because he has work for all his life time; and I doubt, whether being so great a work, he will ever finish it [34].

The miserable painstakers ... with what hope may they expect a reward of their merit?

1347.

There is one whom his Lordship invited from Florence to do this work and who is a worthy master, but with so very much business he will never finish it; and you may imagine that a difference there is to be seen between a beautiful object and an ugly one. Quote Pliny.

Letter to the Cardinal Ippolito d' Este.

1348.

[Footnote: This letter addressed to the Cardinal Ippolito d'Este is here given from Marchese G. CAMPORI'S publication: *Nuovi documenti per la Vita di Leonardo da Vinci. Atti e Memorie delle R. R.*

Deputazioni di Storia patria per la provincie modenesi e parmensi, Vol. III. It is the only text throughout this work which I have not myself examined and copied from the original. The learned discoverer of this letter--the only letter from Leonardo hitherto known as having been sent--adds these interesting remarks: *Codesto Cardinale nato ad Ercole I. nel 1470, arcivescovo di Strigonia a sette anni, poi d'Agra, aveva conseguito nel 1497 la pingue ed ambita cattedra di Milano, la dove avra conosciuto il Vinci, sebbene il poco amore ch'ei professava alle arti lasci credere che le proteste di servitu di Leonardo piu che a gratitudine per favori ricevuti e per opere a lui allogate, accennino a speranza per un favore che si aspetta.* Notabile e ancora in questo prezioso documento la ripetuta signatura del grande artista 'che si scrive Vincio e Vincius, non da Vinci come si tiene comunemente, sebbene l'una e l'altra possano valere a significare cosi il casato come il paese; restando a sapere se il nome del paese di Vinci fosse assunto a cognome della famiglia di Leonardo nel qual supposto piu propriamente avrebbe a chiamarsi Leonardo Vinci, o Vincio (latinamente Vincius) com'egli stesso amo segnarsi in questa lettera, e come scrissero parecchi contenporanei di lui, il Casio, il Cesariano, Geoffrey Tory, il Gaurico, il Bandello, Raffaelle Maffei, il Paciolo. Per ultimo non lascero d'avvertire come la lettera del Vinci e assai ben conservata, di nitida e larga scrittura in forma pienamente corrispondente a quella dei suoi manoscritti, vergata all'uso comune da sinistra a destra, anziche contrariamente come fu suo costume; ma indubbiamente

autentica e fornita della menzione e del suggello che fresca ancora conserva l'impronta di una testa di profilo da un picciolo antico cammeo. (Compare No. 1368, note.)]

Most Illustrious and most Reverend Lord.

The Lord Ippolito, Cardinal of Este
at Ferrare.

Most Illustrious and most Reverend Lord.

I arrived from Milan but a few days since and finding that my elder brother refuses to

carry into effect a will, made three years ago when my father died--as also, and no less, because I would not fail in a matter I esteem most important--I cannot forbear to crave of your most Reverend Highness a letter of recommendation and favour to Ser Raphaello Hieronymo, at present one of the illustrious members of the Signoria before whom my cause is being argued; and more particularly it has been laid by his Excellency the Gonfaloniere into the hands of the said Ser Raphaello, that his Worship may have to decide and end it before the festival of All Saints. And therefore, my Lord, I entreat you, as urgently as I know how and am able, that your Highness will write a letter to the said Ser Raphaello in that admirable and pressing manner which your Highness can use, recommending to him Leonardo Vincio, your most humble servant as I am, and shall always be; requesting him and pressing him not only to do me justice but to do so with despatch; and I have not the least doubt, from many things that I hear, that Ser Raphaello, being most affectionately devoted to your Highness, the matter will issue *ad votum*. And this I shall attribute to your most Reverend Highness' letter, to whom I once more humbly commend myself. *Et bene valeat*.

Florence XVIIIa 7bris 1507.

E. V. R. D.

your humble servant
Leonardus Vincius, pictor.

Draft of Letter to the Governor of Milan.

1349.

I am afraid lest the small return I have made for the great benefits, I have received from your Excellency, have not made you somewhat angry with me, and that this is why to so many letters which I have written to your Lordship I have never had an answer. I now send Salai to explain to your Lordship that I am almost at an end of the litigation I had with my brother; that I hope to find myself with you this Easter, and to carry with me two pictures of two Madonnas of different sizes. These were done for our most Christian King, or for whomsoever your Lordship may please. I should

be very glad to know on my return thence where I may have to reside, for I would not give any more trouble to your Lordship. Also, as I have worked for the most Christian King, whether my salary is to continue or not. I wrote to the President as to that water which the king granted me, and which I was not put in possession of because at that time there was a dearth in the canal by reason of the great droughts and because [Footnote: Compare Nos. 1009 and 1010. Leonardo has noted the payment of the pension from the king in 1505.] its outlets were not regulated; but he certainly promised me that when this was done I should be put in possession. Thus I pray your Lordship that you will take so much trouble, now that these outlets are regulated, as to remind the President of my matter; that is, to give me possession of this water, because on my return I hope to make there instruments and other things which will greatly please our most Christian King. Nothing else occurs to me. I am always yours to command. [Footnote: 1349. Charles d'Amboise, Marechal de Chaumont, was Governor of Milan under Louis XII. Leonardo was in personal communication with him so early as in 1503. He was absent from Milan in the autumn of 1506 and from October 1510--when he besieged Pope Julius II. in Bologna--till his death, which took place at Correggio, February 11, 1511. Francesco Vinci, Leonardo's uncle, died--as Amoretti tells us--in the winter of 1510-11 (or according to Uzielli in 1506?), and Leonardo remained in Florence for business connected with his estate. The letter written with reference to this affair, No. 1348, is undoubtedly earlier than the letters Nos. 1349 and 1350. Amoretti tells us, *Memorie Storiche*, ch. II, that the following note existed on the same leaf in MS. C. A. I have not however succeeded in finding it. The passage runs thus: *Jo sono quasi al fine del mio letizio che io o con mie fratetgli ... Ancora ricordo a V. Excia la facenda che o cum Ser Juliana mio Fratello capo delli altri fratelli ricordandoli come se offerse di conciar le cose nostre fra noi fratelli del comune della eredita de mio Zio, e quelli costringa alla expeditione, quale conteneva la lettera che lui me mando.*]

Drafts of Letters to the Superintendent of Canals and to Fr. Melzi.

1350.

Magnificent President, I am sending thither Salai, my pupil, who is the bearer of this, and from him you will hear by word of mouth the cause of my...

Magnificent President, I...

Magnificent President:--Having oftentimes remembered the proposals made many times to me by your Excellency, I take the liberty of writing to remind your Lordship of the promise made to me at my last departure, that is the possession of the twelve inches of water granted to me by the most Christian King. Your Lordship knows that I did not enter into possession, because at that time when it was given to me there was a dearth of water in the canal, as well by reason of the great drought as also because the outlets were not

regulated; but your Excellency promised me that as soon as this was done, I should have my rights. Afterwards hearing that the canal was complete I wrote several times to your Lordship and to Messer Girolamo da Cusano, who has in his keeping the deed of this gift; and so also I wrote to Corigero and never had a reply. I now send thither Salai, my pupil, the bearer of this, to whom your Lordship may tell by word of mouth all that happened in the matter about which I petition your Excellency. I expect to go thither this Easter since I am nearly at the end of my lawsuit, and I will take with me two pictures of our Lady which I have begun, and at the present time have brought them on to a very good end; nothing else occurs to me.

My Lord the love which your Excellency has always shown me and the benefits that I have constantly received from you I have hitherto...

I am fearful lest the small return I have made for the great benefits I have received from your Excellency may not have made you somewhat annoyed with me. And this is why, to many letters which I have written to your Excellency I have never had an answer. I now send to you Salai to explain to your Excellency that I am almost at the end of my litigation with my brothers, and that I hope to be with you this Easter and carry with me two pictures on which are two Madonnas of different sizes which I began for the most Christian King, or for whomsoever you please. I should be very glad to know where, on my return from this place, I shall have to reside, because I do not wish to give more trouble to your Lordship; and then, having worked for the most Christian King, whether my salary is to be continued or not. I write to the President as to the water that the king granted me of which I had not been put in possession by reason of the dearth in the canal, caused by the great drought and because its outlets were not regulated; but he promised me certainly that as soon as the regulation was made, I should be put in possession of it; I therefore pray you that, if you should meet the said President, you would be good enough, now that the outlets are regulated, to remind the said President to cause me to be put in possession of that water, since I understand it is in great measure in his power. Nothing else occurs to me; always yours to command.

Good day to you Messer Francesco. Why, in God's name, of all the letters I have written to you, have you never answered one. Now wait till I come, by God, and I shall make you write so much that perhaps you will become sick of it.

Dear Messer Francesco. I am sending thither Salai to learn from His Magnificence the President to what end the regulation of the water has come since, at my departure this regulation of the outlets of the canal had been ordered, because His Magnificence the President promised me that as soon as this was done I should be satisfied. It is now some time since I heard that the canal was in order, as also its outlets, and I immediately wrote to the President and to you, and then I repeated it, and never had an answer. So you will have the goodness to answer me as to that which happened, and as I am not to hurry the matter, would you take the trouble, for the love of me,

to urge the President a little, and also Messer Girolamo Cusano, to whom you will commend me and offer my duty to his Magnificence.

[Footnote: 1350. 28-36. Draft of a letter to Francesco Melzi, born 1493--a youth therefore of about 17 in 1510. Leonardo addresses his young friend as "Messer", as being the son of a noble house. Melzi practised art under Leonardo as a dilettante and not as a pupil, like Cesare da Sesto and others (See LERMOLIEFF, *Die Galerien* &c., p. 476).]

Drafts of a letter to Giuliano de' Medici (1351-1352).

1351.

[Most illustrious Lord. I greatly rejoice most Illustrious Lord at your...]

I was so greatly rejoiced, most illustrious Lord, by the desired restoration of your health, that it almost had the effect that [my own health recovered]--[I have got through my illness]--my own illness left me-- --of your Excellency's almost restored health. But I am extremely vexed that I have not been able completely to satisfy the wishes of your Excellency, by reason of the wickedness of that deceiver, for whom I left nothing undone which could be done for him by me and by which I might be of use to him; and in the first place his allowances were paid to him before the time, which I believe he would willingly deny, if I had not the writing signed by myself and the interpreter. And I, seeing that he did not work for me unless he had no work to do for others, which he was very careful in soliciting, invited him to dine with me, and to work afterwards near me, because, besides the saving of expense, he

[Footnote 1351. 1353: It is clear from the contents of this notes that they refer to Leonardo's residence in Rome in 1513-1515. Nor can there be any doubt that they were addressed to Leonardo's patron at the time: Giuliano de' Medici, third son of Lorenzo the Magnificent and brother of Pope Leo X (born 1478). In 1512 he became the head of the Florentine Republic. The Pope invited him to Rome, where he settled; in 1513 he was named patrician with much splendid ceremonial. The medal struck in honour of the event bears the words MAG. IVLIAN. MEDICES. Leonardo too uses the style "Magnifico", in his letter. Compare also No. 1377.

GINO CAPPONI (*Storia della Repubblica di Firenze*, Vol. III, p. 139) thus describes the character of Giuliano de' Medici, who died in 1516: *„Era il migliore della famiglia, di vita placida, grande spenditore, tenendo intorno a se uomini ingegnosi, ed ogni nuova cosa voleva provare.“*

See too GREGOROVIVUS, *„Geschichte der Stadi Rom“*, VIII (book XIV. III, 2): *„Die Luftschlosser furstlicher Grosse, wozu ihn der Papst hatte erheben wollen zerfielen. Julian war der edelste aller damaligen Medici, ein Mensch von innerlicher Richtung, unbefriedigt*

durch das Leben, mitten im Sonnenglanz der Herrlichkeit Leo's X.
eine dunkle Gestalt die wie ein Schatten vorüberzog._ Giuliano lived
in the Vatican, and it may be safely inferred from No. 1352 l. 2,
and No. 1353 l. 4, that Leonardo did the same.

From the following unpublished notice in the Vatican archives, which
M. Eug. Muntz, librarian of the Ecole des Beaux arts, Paris, has
done me the favour to communicate to me, we get a more accurate view
of Leonardo's relation to the often named GIORGIO TEDESCO:

Nota delle provisione (sic) _a da pagare per me in nome del nostro
ill. S. Bernardo Bini e chompa di Roma, e prima della illma sua
chonsorte ogni mese d. 800.

A Ldo da Vinci per sua provisione d. XXXIII, e piu d. VII al detto
per la provisione di Giorgio tedescho, che sono in tutto d. 40.

From this we learn, that seven ducats formed the German's monthly
wages, but according to No. 1353 l. 7 he pretended that eight ducats
had been agreed upon.]

would acquire the Italian language. He always promised, but would
never do so. And this I did also, because that Giovanni, the German
who makes the mirrors, was there always in the workshop, and wanted
to see and to know all that was being done there and made it known
outside ... strongly criticising it; and because he dined with those
of the Pope's guard, and then they went out with guns killing birds
among the ruins; and this went on from after dinner till the
evening; and when I sent Lorenzo to urge him to work he said that he
would not have so many masters over him, and that his work was for
your Excellency's Wardrobe; and thus two months passed and so it
went on; and one day finding Gian Niccolo of the Wardrobe and asking
whether the German had finished the work for your Magnificence, he
told me this was not true, but only that he had given him two guns
to clean. Afterwards, when I had urged him farther, he left the
workshop and began to work in his room, and lost much time in making
another pair of pincers and files and other tools with screws; and
there he worked at mills for twisting silk which he hid when any one
of my people went in, and with a thousand oaths and mutterings, so
that none of them would go there any more.

I was so greatly rejoiced, most Illustrious Lord, by the desired
restoration of your health, that my own illness almost left me. But
I am greatly vexed at not having been able to completely satisfy
your Excellency's wishes by reason of the wickedness of that German
deceiver, for whom I left nothing undone by which I could have hope
to please him; and secondly I invited him to lodge and board with
me, by which means I should constantly see the work he was doing and
with greater ease correct his errors while, besides this, he would
learn the Italian tongue, by means of which he could with more ease
talk without an interpreter; his moneys were always given him in
advance of the time when due. Afterwards he wanted to have the
models finished in wood, just as they were to be in iron, and wished

to carry them away to his own country. But this I refused him, telling him that I would give him, in drawing, the breadth, length, height and form of what he had to do; and so we remained in ill-will.

The next thing was that he made himself another workshop and pincers and tools in his room where he slept, and there he worked for others; afterwards he went to dine with the Swiss of the guard, where there are idle fellows, in which he beat them all; and most times they went two or three together with guns, to shoot birds among the ruins, and this went on till evening.

At last I found how this master Giovanni the mirror-maker was he who had done it all, for two reasons; the first because he had said that my coming here had deprived him of the countenance and favour of your Lordship which always... The other is that he said that his iron-workers' rooms suited him for working at his mirrors, and of this he gave proof; for besides making him my enemy, he made him sell all he had and leave his workshop to him, where he works with a number of workmen making numerous mirrors to send to the fairs.

1352.

I was so greatly rejoiced, most Illustrious Lord, by the wished for recovery of your health, that my own ills have almost left me; and I say God be praised for it. But it vexes me greatly that I have not been able completely to satisfy your Excellency's wishes by reason of the wickedness of that German deceiver, for whom I left nothing undone by which I could hope to please him; and secondly I invited him to lodge and board with me, by which means I should see constantly the work he was doing, for which purpose I would have a table fixed at the foot of one of these windows, where he could work with the file and finish the things made below; and so I should constantly see the work he might do, and it could be corrected with greater ease.

Draft of letter written at Rome.

1353.

This other hindered me in anatomy, blaming it before the Pope; and likewise at the hospital; and he has filled [4] this whole Belvedere with workshops for mirrors; and he did the same thing in Maestro Giorgio's room. He said that he had been promised [7] eight ducats every month, beginning with the first day, when he set out, or at latest when he spoke with you; and that you agreed.

Seeing that he seldom stayed in the workshop, and that he ate a great deal, I sent him word that, if he liked I could deal with him separately for each thing that he might make, and would give him what we might agree to be a fair valuation. He took counsel with his neighbour and gave up his room, selling every thing, and went to find...

Miscellaneous Records (1354. 1355).

1354.

[Footnote: A puzzling passage, meant, as it would seem, for a jest. Compare the description of Giants in Dante, *_Inf_*. XXI and XXII. Perhaps Leonardo had the Giant Antaeus in his mind. Of him the myth relates that he was a son of Ge, that he fed on lions; that he hunted in Libya and killed the inhabitants. He enjoyed the peculiarity of renewing his strength whenever he fell and came in contact with his mother earth; but that Hercules lifted him up and so conquered and strangled him. Lucan gives a full account of the struggle. *Pharsalia IV*, 617. The reading of this passage, which is very indistinctly written, is in many places doubtful.]

Dear Benedetto de' Pertarti. When the proud giant fell because of the bloody and miry state of the ground it was as though a mountain had fallen so that the country shook as with an earthquake, and terror fell on Pluto in hell. From the violence of the shock he lay as stunned on the level ground. Suddenly the people, seeing him as one killed by a thunderbolt, turned back; like ants running wildly over the body of the fallen oak, so these rushing over his ample limbs..... them with frequent wounds; by which, the giant being roused and feeling himself almost covered by the multitude, he suddenly perceives the smarting of the stabs, and sent forth a roar which sounded like a terrific clap of thunder; and placing his hands on the ground he raised his terrible face: and having lifted one hand to his head he found it full of men and rabble sticking to it like the minute creatures which not unfrequently are found there; wherefore with a shake of his head he sends the men flying through the air just as hail does when driven by the fury of the winds. Many of these men were found to be dead; stamping with his feet.

And clinging to his hair, and striving to hide in it, they behaved like sailors in a storm, who run up the ropes to lessen the force of the wind [by taking in sail].

News of things from the East.

Be it known to you that in the month of June there appeared a Giant, who came from the Lybian desert... mad with rage like ants.... struck down by the rude.

This great Giant was born in Mount Atlas and was a hero ... and had to fight against the Egyptians and Arabs, Medes and Persians. He lived in the sea on whales, grampuses and ships.

Mars fearing for his life took refuge under the... of Jove.

And at the great fall it seemed as though the whole province quaked.

1355.

This spirit returns to the brain whence it had departed, with a loud voice and with these words, it moved...

And if any man though he may have wisdom or goodness

[Footnote: This passage, very difficult to decipher, is on the reverse of a drawing at Windsor, Pl. CXXII, which possibly has some connection with it. The drawing is slightly reduced in this reproduction; the original being 25 cm. high by 19 cm. wide.]

O blessed and happy spirit whence comest thou? Well have I known this man, much against my will. This one is a receptacle of villainy; he is a perfect heap of the utmost ingratitude combined with every vice. But of what use is it to fatigue myself with vain words? Nothing is to be found in them but every form of sin ... And if there should be found among them any that possesses any good, they will not be treated differently to myself by other men; and in fine, I come to the conclusion that it is bad if they are hostile, and worse if they are friendly.

Miscellaneous drafts of letters and personal records (1356--1368).

1356.

All the ills that are or ever were, if they could be set to work by him, would not satisfy the desires of his iniquitous soul; and I could not in any length of time describe his nature to you, but I conclude...

1357.

I know one who, having promised me much, less than my due, being disappointed of his presumptuous desires, has tried to deprive me of all my friends; and as he has found them wise and not pliable to his will, he has menaced me that, having found means of denouncing me, he would deprive me of my benefactors. Hence I have informed your Lordship of this, to the end [that this man who wishes to sow the usual scandals, may find no soil fit for sowing the thoughts and deeds of his evil nature] so that he, trying to make your Lordship, the instrument of his iniquitous and maliceous nature may be disappointed of his desire.

1358.

[Footnote: Below this text we read gusstino--Giustino and in another passage on the same page Justin is quoted (No. 1210, 1. 48). The two have however no real connection.]

And in this case I know that I shall make few enemies seeing that no one will believe what I can say of him; for they are but few whom his vices have disgusted, and he only dislikes those men whose natures are contrary to those vices. And many hate their fathers,

and break off friendship with those who reprove their vices; and he will not permit any examples against them, nor any advice.

If you meet with any one who is virtuous do not drive him from you; do him honour, so that he may not have to flee from you and be reduced to hiding in hermitages, or caves or other solitary places to escape from your treachery; if there is such an one among you do him honour, for these are our Saints upon earth; these are they who deserve statues from us, and images; but remember that their images are not to be eaten by you, as is still done in some parts of India [Footnote 15: In explanation of this passage I have received the following communication from Dr. G. W. LEITNER of Lahore: "So far as Indian customs are known to us, this practice spoken of by Leonardo as 'still existing in some parts of India' is perfectly unknown; and it is equally opposed to the spirit of Hinduism, Mohammedanism and Sikhism. In central Thibet the ashes of the dead, when burnt, are mixed with dough, and small figures--usually of Buddha--are stamped out of them and some are laid in the grave while others are distributed among the relations. The custom spoken of by Leonardo may have prevailed there but I never heard of it." Possibly Leonardo refers here to customs of nations of America.] where, when the images have according to them, performed some miracle, the priests cut them in pieces, being of wood, and give them to all the people of the country, not without payment; and each one grates his portion very fine, and puts it upon the first food he eats; and thus believes that by faith he has eaten his saint who then preserves him from all perils. What do you think here, Man, of your own species? Are you so wise as you believe yourselves to be? Are these things to be done by men?

1359.

As I told you in past days, you know that I am without any....
Francesco d'Antonio. Bernardo di Maestro Jacopo.

1360.

Tell me how the things happened.

1361.

j lorezo\\ 2 inbiadali\\ 3 inferri de\\ 4in lorezo\\ 5[inno
abuill\\ 6 in acocatu\\ 7 per la sella\\ 8colte di lor\\ 9v
cavallott\\ 10el uiagg\\ 11a\\ 12a lurez\\ 13in biada\\
14inferri\\ 15abuss\\ 16in viagg\\ 17alorz\\ [Footnote: This
seems to be the beginning of a letter, but only the first words of
the lines have been preserved, the leaf being torn down the middle.
No translation is possible.]

1362.

And so may it please our great Author that I may demonstrate the nature of man and his customs, in the way I describe his figure.

[Footnote: A preparatory note for the passage given as No. 798, 11. 41--42.]

1363.

This writing distinctly about the kite seems to be my destiny, because among the first recollections of my infancy, it seemed to me that, as I was in my cradle, a kite came to me and opened my mouth with its tail, and struck me several times with its tail inside my lips.

[Footnote: This note probably refers to the text No. 1221.]

1364.

[When I did well, as a boy you used to put me in prison. Now if I do it being grown up, you will do worse to me.]

1365.

Tell me if anything was ever done.

1366.

Tell me if ever I did a thing which me

1367.

Do not reveal, if liberty is precious to you; my face is the prison of love.

[Footnote: This note seems to be a quotation.]

1368.

Maestro Leonardo of Florence.

[Footnote: So Leonardo writes his name on a sheet with sundry short notes, evidently to try a pen. Compare the signature with those in Nos. 1341, 1348 and 1374 (see also No. 1346, l. 33). The form "Lionardo" does not occur in the autographs. The Portrait of the Master in the Royal Library at Turin, which is reproduced--slightly diminished--on Pl. I, has in the original two lines of writing underneath; one in red chalk of two or three words is partly effaced: *_lionardo it... Im_* (or *_lai_?*); the second written in pencil is as follows: *_fatto da lui stesso assai vecchio_*. In both of these the writing is very like the Master's, but is certainly only an imitation.]

Notes bearing Dates (1369--1378).

1369.

The day of Santa Maria della Neve [of the Snows] August the 2nd 1473. [Footnote: W. An. I. 1368. 1369. This date is on a drawing of a rocky landscape. See Chronique des Arts 1881 no. 23: Leonard de Vinci a-t-il ete au Righi le 5 aout 1473? letter by H. de Geymuller. The next following date in the MSS. is 1478 (see No. 663).

1370.

On the 2nd of April 1489, book entitled 'Of the human figure'. [Footnote: While the letters in the MS. notes of 1473 and 1478 are very ornate, this note and the texts on anatomy on the same sheet (for instance No. 805) are in the same simple hand as we see on Pl. CXVI and CXIX. No 1370 is the only dated note of the years between 1480 and 1489, and the characters are in all essential points identical with those that we see in the latest manuscripts written in France (compare the facsimiles on Pl. CXV and p. 254), so that it is hardly possible to determine exactly the date of a manuscript from the style of the handwriting, if it does not betray the peculiarities of style as displayed in the few notes dated previous to 1480.--Compare the facsimile of the manuscripts 1479 on Pl.LXII, No. 2; No. 664, note, Vol. I p. 346. This shows already a marked simplicity as compared with the calligraphy of 1478.

The text No. 720 belongs to the year 1490; No. 1510 to the year 1492; No. 1459, No. 1384 and No. 1460 to the year 1493; No. 1463, No. 1517, No. 1024, 1025 and 1461 to the year 1494; Nos. 1523 and 1524 to the year 1497.

1371.

On the 1st of August 1499, I wrote here of motion and of weight.

[Footnote:1371. Scritti qui. Leonardo does not say where; still we may assume that it was not in Milan. Amoretti writes, Memorie Storiche, chap. XIX: Sembra pertanto che non nel 1499 ma nel 1500, dopo il ritorno e la prigionia del duca, sia da qui partito Lionardo per andare a Firenze; ed e quindi probabile, che i mesi di governo nuovo e incerto abbia passati coll' amico suo Francesco Melzi a Vaprio, ove meglio che altrove studiar potea la natura, e soprattutto le acque, e l'Adda specialmente, che gia era stato l'oggetto delle sue idrostatiche ricerche. At that time Melzi was only six years of age. The next date is 1502; to this year belong No. 1034, 1040, 1042, 1048 and 1053. The note No. 1525 belongs to the year 1503.]

1372.

On the 9th of July 1504, Wednesday, at seven o'clock, died Ser Piero da Vinci, notary at the Palazzo del Podesta, my father, --at seven o'clock, being eighty years old, leaving behind ten sons and two daughters.

[Footnote: This statement of Ser Piero's age contradicts that of the _Riassunto della portata di Antonio da Vinci_ (Leonardo's grandfather), who speaks of Ser Piero as being thirty years old in 1457; and that of the _Riassunto della portata di Ser Piero e Francesco_, sons of Antonia da Vinci, where Ser Piero is mentioned as being forty in 1469. These documents were published by G. UZIELLI, _Ricerche intorno a L. da Vinci, Firenze_, 1872, pp. 144 and 146. Leonardo was, as is well known, a natural son. His mother 'La Catarina' was married in 1457 to Acchatabriga di Piero del Vaccha da Vinci. She died in 1519. Leonardo never mentions her in the Manuscripts. In the year of Leonardo's birth Ser Piero married Albiera di Giovanni Amadoci, and after her death at the age of thirty eight he again married, Francesca, daughter of Ser Giovanni Lanfredi, then only fifteen. Their children were Leonardo's halfbrothers, Antonio (b. 1476), Ser Giuliano (b. 1479), Lorenzo (b. 1484), a girl, Violante (b. 1485), and another boy Domenico (b. 1486); Domenico's descendants still exist as a family. Ser Piero married for the third time Lucrezia di Guglielmo Cortigiani by whom he had six children: Margherita (b. 1491), Benedetto (b. 1492), Pandolfo (b. 1494), Guglielmo (b. 1496), Bartolommeo (b. 1497), and Giovanni (date of birth unknown). Pierino da Vinci the sculptor (about 1520-1554) was the son of Bartolommeo, the fifth of these children. The dates of their deaths are not known, but we may infer from the above passage that they were all still living in 1505.]

1373.

On Wednesday at seven o'clock died Ser Piero da Vinci on the 9th of July 1504.

[Footnote: This and the previous text it may be remarked are the only mention made by Leonardo of his father; Nos. 1526, 1527 and No. 1463 are of the year 1504.]

1374.

Begun by me, Leonardo da Vinci, on the 12th of July 1505.

[Footnote: Thus he writes on the first page of the MS. The title is on the foregoing coversheet as follows: _Libro titolato disstrafformatione coe_ (cioe) _d'un corpo nvn_ (in un) _altro senza diminuitione e acresscemento di materia._]

1375.

Begun at Milan on the 12th of September 1508.

[Footnote: No. 1528 and No. 1529 belong to the same year. The text Vol. I, No. 4 belongs to the following year 1509 (1508 old style); so also does No. 1009.-- Nos. 1022, 1057 and 1464 belong to 1511.]

1376.

On the 9th of January 1513.

[Footnote: No. 1465 belongs to the same year. No. 1065 has the next date 1514.]

1377.

The Magnifico Giuliano de' Medici left Rome on the 9th of January 1515, just at daybreak, to take a wife in Savoy; and on the same day fell the death of the king of France.

[Footnote: Giuliano de Medici, brother to Pope Leo X.; see note to Nos. 1351-1353. In February, 1515, he was married to Filiberta, daughter of Filippo, Duke of Savoy, and aunt to Francis I, Louis XII's successor on the throne of France. Louis XII died on Jan. 1st, and not on Jan. 9th as is here stated.-- This addition is written in paler ink and evidently at a later date.]

1378.

On the 24th of June, St John's day, 1518 at Amboise, in the palace of...

[Footnote: _Castello del clli_. The meaning of this word is obscure; it is perhaps not written at full length.]

XXII.

Miscellaneous Notes.

The incidental memoranda scattered here and there throughout the MSS. can have been for the most part intelligible to the writer only; in many cases their meaning and connection are all the more obscure because we are in ignorance about the persons with whom Leonardo used to converse nor can we say what part he may have played in the various events of his time. Vasari and other early biographers give us a very superficial and far from accurate picture of Leonardo's private life. Though his own memoranda, referring for the most part to incidents of no permanent interest, do not go far towards supplying this deficiency, they are nevertheless of some importance and interest as helping us to solve the numerous mysteries in which the history of Leonardo's long life remains involved. We may at any rate assume, from Leonardo's having committed to paper notes on more or less trivial matters on his pupils, on his house-keeping, on various known and unknown personages, and a hundred other trifles--that at the time they must have been in some way important to him.

_I have endeavoured to make these 'Miscellaneous Notes' as complete as possible, for in many cases an incidental memorandum will help to explain the meaning of some other note of a similar kind. The first portion of these notes (Nos. 1379--1457), as well as those referring

to his pupils and to other artists and artificers who lived in his house (1458--1468,) are arranged in chronological order. A considerable proportion of these notes belong to the period between 1490 and 1500, when Leonardo was living at Milan under the patronage of Lodovico il Moro, a time concerning which we have otherwise only very scanty information. If Leonardo did really--as has always been supposed,--spend also the greater part of the preceding decade in Milan, it seems hardly likely that we should not find a single note indicative of the fact, or referring to any event of that period, on the numerous loose leaves in his writing that exist. Leonardo's life in Milan between 1489 and 1500 must have been comparatively uneventful. The MSS. and memoranda of those years seem to prove that it was a tranquil period of intellectual and artistic labour rather than of bustling court life. Whatever may have been the fate of the MSS. and note books of the foregoing years--whether they were destroyed by Leonardo himself or have been lost--it is certainly strange that nothing whatever exists to inform us as to his life and doings in Milan earlier than the consecutive series of manuscripts which begin in the year 1489._

There is nothing surprising in the fact that the notes regarding his pupils are few and meagre. Excepting for the record of money transactions only very exceptional circumstances would have prompted him to make any written observations on the persons with whom he was in daily intercourse, among whom, of course, were his pupils. Of them all none is so frequently mentioned as Salai, but the character of the notes does not--as it seems to me--justify us in supposing that he was any thing more than a sort of factotum of Leonardo's (see 1519, note).

Leonardo's quotations from books and his lists of titles supply nothing more than a hint as to his occasional literary studies or recreations. It was evidently no part of his ambition to be deeply read (see Nrs. 10, 11, 1159) and he more than once expressly states (in various passages which will be found in the foregoing sections) that he did not recognise the authority of the Ancients, on scientific questions, which in his day was held paramount. Archimedes is the sole exception, and Leonardo frankly owns his admiration for the illustrious Greek to whose genius his own was so much akin (see No. 1476). All his notes on various authors, excepting those which have already been inserted in the previous section, have been arranged alphabetically for the sake of convenience (1469--1508).

The passages next in order contain accounts and inventories principally of household property. The publication of these--often very trivial entries--is only justifiable as proving that the wealth, the splendid mode of life and lavish expenditure which have been attributed to Leonardo are altogether mythical; unless we put forward the very improbable hypothesis that these notes as to money in hand, outlay and receipts, refer throughout to an exceptional state of his affairs, viz. when he was short of money.

The memoranda collected at the end (No. 1505--1565) are, in the original, in the usual writing, from left to right. Besides, the style of the handwriting is at variance with what we should expect it to be, if really Leonardo himself had written these notes. Most of them are to be found in juxtaposition with undoubtedly authentic writing of his. But this may be easily explained, if we take into account the fact, that Leonardo frequently wrote on loose sheets. He may therefore have occasionally used paper on which others had made short memoranda, for the most part as it would seem, for his use. At the end of all I have given Leonardo's will from the copy of it preserved in the Melzi Library. It has already been printed by Amoretti and by Uzielli. It is not known what has become of the original document.

Memoranda before 1500 (1379-1413).

1379.

Find Longhi and tell him that you wait for him at Rome and will go with him to Naples; make you pay the donation [Footnote 2: Libro di Vitolone see No. 1506 note.] and take the book by Vitolone, and the measurements of the public buildings. [3] Have two covered boxes made to be carried on mules, but bed-covers will be best; this makes three, of which you will leave one at Vinci. [4] Obtain the..... from Giovanni Lombardo the linen draper of Verona. Buy handkerchiefs and towels,.... and shoes, 4 pairs of hose, a jerkin of... and skins, to make new ones; the lake of Alessandro. [Footnote: 7 and fol. It would seem from the text that Leonardo intended to have instructions in painting on paper. It is hardly necessary to point out that the Art of illuminating was quite separate from that of painting.]

Sell what you cannot take with you. Get from Jean de Paris the method of painting in tempera and the way of making white [Footnote: The mysterious looking words, quite distinctly written, in line 1: ingol, amor a, ilopan a and on line 2: enoiganod al are obviously in cipher and the solution is a simple one; by reading them backwards we find for ingol: logni-probably longi, evidently the name of a person; for amor a: a Roma, for ilopan a: a Napoli. Leonardo has done the same in two passages treating on some secrets of his art Nos. 641 and 729, the only other places in which we find this cipher employed; we may therefore conclude that it was for the sake of secrecy that he used it.

There can be no doubt, from the tenor of this passage, that Leonardo projected a secret excursion to Naples. Nothing has hitherto been known of this journey, but the significance of the passage will be easily understood by a reference to the following notes, from which we may infer that Leonardo really had at the time plans for travelling further than Naples. From lines 3, 4 and 7 it is evident that he purposed, after selling every thing that was not easily portable, to leave a chest in the care of his relations at Vinci. His luggage was to be packed into two trunks especially adapted for

transport by mules. The exact meaning of many sentences in the following notes must necessarily remain obscure. These brief remarks on small and irrelevant affairs and so forth are however of no historical value. The notes referring to the preparations for his journey are more intelligible.]

salt, and how to make tinted paper; sheets of paper folded up; and his box of colours; learn to work flesh colours in tempera, learn to dissolve gum lac, linseed ... white, of the garlic of Piacenza; take 'de Ponderibus'; take the works of Leonardo of Cremona. Remove the small furnace ... seed of lilies and of... Sell the boards of the support. Make him who stole it, give you the ... learn levelling and how much soil a man can dig out in a day.

1380.

This was done by Leone in the piazza of the castle with a chain and an arrow. [Footnote: This note must have been made in Milan; as we know from the date of the MS.]

1381.

NAMES OF ENGINEERS.

Callias of Rhodes, Epimachus the Athenian, Diogenes, a philosopher, of Rhodes, Calcedonius of Thrace, Febar of Tyre, Callimachus the architect, a master of fires. [Footnote: Callias, Architect of Aradus, mentioned by Vitruvius (X, 16, 5).--Epimachus, of Athens, invented a battering-engine for Demetrius Poliorketes (Vitruvius X, 16, 4).--Callimachus, the inventor of the Corinthian capital (Vitr. IV, I, 9), and of the method of boring marble (Paus. I, 26, 7), was also famous for his casts in bronze (Plin. XXXIV, 8, 19). He invented a lamp for the temple of Athene Polias, on the Acropolis of Athens (Paus. I, 26, 7)--The other names, here mentioned, cannot be identified.]

1382.

Ask maestro Lodovico for 'the conduits of water'. [Footnote: Condotti d'acqua. Possibly a book, a MS. or a map.]

1383.

... at Pistoja, Fioravante di Domenico at Florence is my most beloved friend, as though he were my [brother]. [Footnote: On the same sheet is the text No. 663.]

1384.

On the 16th day of July.

Caterina came on 16th day of July, 1493.

Messer Mariolo's Morel the Florentin, has a big horse with a fine neck and a beautiful head.

The white stallion belonging to the falconer has fine hind quarters; it is behind the Comasina Gate.

The big horse of Cermonino, of Signor Giulio. [Footnote: Compare Nos. 1522 and 1517. Caterina seems to have been his housekeeper.]

1385.

OF THE INSTRUMENT.

Any one who spends one ducat may take the instrument; and he will not pay more than half a ducat as a premium to the inventor of the instrument and one grosso to the workman every year. I do not want sub-officials. [Footnote: Refers perhaps to the regulation of the water in the canals.]

1386.

Maestro Giuliano da Marliano has a fine herbal. He lives opposite to Strami the Carpenters. [Footnote: Compare No. 616, note. 4. legnamiere (milanese dialect) = legnajuolo.]

1387.

Christofano da Castiglione who lives at the Pieta has a fine head.

1388.

Work of ... of the stable of Galeazzo; by the road of Brera [Footnote 4: Brera, see No. 1448, II, 13]; benefice of Stanghe [Footnote 5: Stanghe, see No. 1509.]; benefice of Porta Nuova; benefice of Monza; Indaco's mistake; give first the benefices; then the works; then ingratitude, indignity and lamentations.

1389.

Chiliarch--captain of 1000.

Prefects--captains.

A legion, six thousand and sixty three men.

1390.

A nun lives at La Colomba at Cremona; she works good straw plait, and a friar of Saint Francis. [Footnote: _La Colomba_ is to this day the name of a small house at Cremona, decorated with frescoes.]

1391.

Needle,--Niccolao,--thread,--Ferrando, -Iacopo
Andrea,--canvas,--stone,--colours, --brushes,--pallet,--sponge,--the
panel of the Duke.

1392.

Messer Gian Domenico Mezzabarba and Messer Giovanni Franceso
Mezzabarba. By the side of Messer Piero d'Anghiera.

1393.

Conte Francesco Torello.

1394.

Giuliano Trombetta,--Antonio di Ferrara, --Oil of [Footnote:
Near this text is the sketch of a head drawn in red chalk.]

1395.

Paul was snatched up to heaven. [Footnote: See the facsimile of this
note on Pl. XXIII No. 2.]

1396.

Giuliano da Maria, physician, has a steward without hands.

1397.

Have some ears of corn of large size sent from Florence.

1398.

See the bedstead at Santa Maria. Secret.

1399.

Arrigo is to have 11 gold Ducats. Arrigo is to have 4 gold ducats in
the middle of August.

1400.

Give your master the instance of a captain who does not himself win
the victory, but the soldiers do by his counsels; and so he still
deserves the reward.

1401.

Messer Pier Antonio.

1402.

Oil,--yellow,--Ambrosio,--the mouth, --the farmhouse.

1403.

My dear Alessandro from Parma, by the hand of ...

1404.

Giovannina, has a fantastic face,--is at Santa Caterina, at the Hospital. [Footnote: Compare the text on the same page: No. 667.]

1405.

24 tavole make 1 perch. 4 trabochi make 1 tavola. 4 braccia and a half make a trabocco. A perch contains 1936 square braccia, or 1944.

1406.

The road of Messer Mariolo is 13 1/4 braccia wide; the House of Evangelista is 75.

It enters 7 1/2 braccia in the house of Mariolo. [Footnote: On this page and that which faces it, MS.12 71a, are two diagrams with numerous reference numbers, evidently relating to the measurements of a street.]

1407.

I ask at what part of its curved motion the moving cause will leave the thing moved and moveable.

Speak to Pietro Monti of these methods of throwing spears.

1408.

Antonio de' Risi is at the council of Justice.

1409.

Paolo said that no machine that moves another [Footnote: The passage, of which the beginning is here given, deals with questions in mechanics. The instances in which Leonardo quotes the opinions of his contemporaries on scientific matters are so rare as to be worth noticing. Compare No. 901.]

1410.

Caravaggio. [Footnote: _Caravaggio_, a village not far from the Adda between Milan and Brescia, where Polidoro and Michelangelo da Caravaggio were born. This note is given in facsimile on Pl. XIII, No. 1 (above, to the left). On Pl. XIII, No. 2 above to the right we read _cerovazo_.]

1411.

Pulleys,--nails,--rope,--mercury,--cloth, Monday.

1412.

MEMORANDUM.

Maghino, Speculus of Master Giovanni the Frenchman; Galenus on utility.

1413.

Near to Cordusio is Pier Antonio da Tossano and his brother Serafino. [Footnote: This note is written between lines 23 and 24 of the text No. 710. Corduso, Cordusio (_curia ducis_) = Cordus in the Milanese dialect, is the name of a Piazza between the Via del Broletto and the Piazza de' Mercanti at Milan.. In the time of il Moro it was the centre of the town. The persons here named were members of the noble Milanese family de'Fossani; Ambrogio da Possano, the contemporary painter, had no connection with them.]

1414.

Memoranda after 1500 (1414--1434)

1414.

Paul of Vannochio at Siena ... The upper chamber for the apostles.

[4] Buildings by Bramante.

The governor of the castle made a prisoner.

[6] Visconti carried away and his son killed. [Footnote 6: Visconti. _Chi fosse quel Visconte non sapremmo indovinare fra tanti di questo nome. Arluno narra che allora atterrate furono le case de' Viconti, de' Castiglioni, de' Sanseverini, e de' Botta e non e improbabile che ne fossero insultati e morti i padroni. Molti Visconti annovera lo stesso Cronista che per essersi rallegrati del ritorno del duca in Milano furono da' Francesi arrestati, e strascinati in Francia come prigionieri di stato; e fra questi Messer Francesco Visconti, e suo figliuolo Battista_. (AMORETTI, Mem. Stor. XIX.)]

Giovanni della Rosa deprived of his money.

Borgonzio began; and moreover his fortunes fled. [Footnote 8: Borgonzio o Brugonzio Botta fu regolatore delle ducali entrate sotto il Moro, alla cui fuga la casa sua fu pur messa a sacco da' partitanti francesi. (AMORETTI, l. c.)]

The Duke has lost the state, property and liberty and none of his enterprises was carried out by him.

[Footnote: l. 4--10 This passage evidently refers to events in Milan at the time of the overthrow of Ludovico il Moro. Amoretti published it in the 'Memorie Storiche' and added copious notes.]

1415.

Ambrosio Petri, St. Mark, 4 boards for the window, 2 ..., 3 the saints of chapels, 5 the Genoese at home.

1416.

Piece of tapestry,--pair of compasses,-- Tommaso's book,--the book of Giovanni Benci,--the box in the custom-house,--to cut the cloth,--the sword-belt,--to sole the boots, --a light hat,--the cane from the ruined houses,--the debt for the table linen, --swimming-belt,--a book of white paper for drawing,--charcoal.--How much is a florin, a leather bodice.

1417.

Borges shall get for you the Archimedes from the bishop of Padua, and Vitellozzo the one from Borgo a San Sepolcro [Footnote 3: Borgo a San Sepolcro, where Luca Paciolo, Leonardo's friend, was born.]

[Footnote: Borges. A Spanish name.]

1418.

Marzocco's tablet.

1419.

Marcello lives in the house of Giacomo da Mengardino.

1420.

Where is Valentino?--boots,--boxes in the custom-house,....--[Footnote 5: Carmine. A church and monastery at Florence.] the monk at the Carmine,--squares,--[Footnotes 7 and 8: Martelli, Borgherini; names of Florentine families. See No. 4.] Piero Martelli,--[8] Salvi Borgherini,--send back the bags,--a support for the spectacles,--[Footnote 11: San Gallo; possibly Giuliano da San Gallo, the Florentine architect.] the nude study of San Gallo,--the cloak. Porphyry,--groups,--square,--[Footnote 16: Pandolfini, see No. 1544 note.] Pandolino. [Footnote: Valentino. Cesare Borgia is probably meant. After being made Archbishop of Valence by Alexander VI he was commonly called Valentinus or Valentino. With reference to Leonardo's engagements by him see pp. 224 and 243, note.]

1421.

Concave mirrors; philosophy of Aristotle;[Footnote 2: _Avicenna_

(Leonardo here writes it Avinega) the Arab philosopher, 980-1037, for centuries the unimpeachable authority on all medical questions. Leonardo possibly points here to a printed edition: *Avicennae canonum libri V, latine* 1476 *Patavis.* Other editions are, Padua 1479, and Venice 1490.] the books of Avicenna Italian and Latin vocabulary; Messer Ottaviano Palavicino or his Vitruvius [Footnote 3: *Vitruvius.* See Vol. I, No. 343 note.]. bohemian knives; Vitruvius [Footnote 6: *Vitruvius.* See Vol. I, No. 343 note.]; go every Saturday to the hot bath where you will see naked men;

'*Meteora*' [Footnote 7: *Meteora.* See No. 1448, 25.],

Archimedes, on the centre of gravity; [Footnote 9: The works of Archimedes were not printed during Leonardo's life-time.] anatomy [Footnote 10: Compare No. 1494.] Alessandro Benedetto; The Dante of Niccolo della Croce; Inflate the lungs of a pig and observe whether they increase in width and in length, or in width diminishing in length.

[Footnote 14: *Johannes Marliani sua etate philosophorum et medicorum principis et ducalis phisic. primi de proportione motuum velocitate questio subtilissima incipit ex ejusdem Marliani originali feliciter extracta, M(ilano)* 1482.

Another work by him has the title: *Marlianus mediolanensis. Questio de caliditate corporum humanorum tempore hiemis ed estatis et de antiparistasi ad celebrem philosophorum et medicorum universitatem ticinensem.* 1474.] Marliano, on Calculation, to Bertuccio. Albertus, on heaven and earth [Footnote 15: See No. 1469, 1. 7.], [from the monk Bernardino]. Horace has written on the movements of the heavens.

[Footnote: *Filosofia d'Aristotele* see No. 1481 note.]

1422.

Of the three regular bodies as opposed to some commentators who disparage the Ancients, who were the originators of grammar and the sciences and ...

1423.

The room in the tower of Vaneri.

[Footnote: This note is written inside the sketch of a plan of a house. On the same page is the date 1513 (see No. 1376).]

1424.

The figures you will have to reserve for the last book on shadows that they may appear in the study of Gerardo the illuminator at San Marco at Florence.

[Go to see Melzo, and the Ambassador, and Maestro Bernardo].

[Footnote: L. 1-3 are in the original written between lines 3 and 4 of No. 292. But the sense is not clear in this connection. It is scarcely possible to devine the meaning of the following sentence.

2. 3. _Gherardo_ Miniatore, a famous illuminator, 1445-1497, to whom Vasari dedicated a section of his Lives (Vol. II pp. 237-243, ed. Sansoni 1879).

5. _Bernardo_, possibly the painter Bernardo Zenale.]

1425.

Hermes the philosopher.

1426.

Suisset, viz. calculator,--Tisber, --Angelo Fossobron,--Alberto.

1427.

The structure of the drawbridge shown me by Donnino, and why _c_ and _d_ thrust downwards.

[Footnote: The sketch on the same page as this text represents two poles one across the other. At the ends of the longest are the letter _c_ and _d_. The sense of the passage is not rendered any clearer.]

1428.

The great bird will take its first flight;-- on the back of his great swan,--filling the universe with wonders; filling all writings with his fame and bringing eternal glory to his birthplace.

[Footnote: This seems to be a speculation about the flying machine (compare p. 271).]

1429.

This stratagem was used by the Gauls against the Romans, and so great a mortality ensued that all Rome was dressed in mourning.

[Footnote: Leonardo perhaps alludes to the Gauls under Brennus, who laid his sword in the scale when the tribute was weighed.]

1430.

Alberto da Imola;--Algebra, that is, the demonstration of the equality of one thing to another.

1431.

Johannes Rubicissa e Robbia.

1432.

Ask the wife of Biagio Crivelli how the capon nurtures and hatches the eggs of the hen,--he being drunk.

1433.

The book on Water to Messer Marco Antonio.

[Footnote: Possibly Marc-Antonio della Torre, see p. 97.]

1434.

Have Avicenna's work on useful inventions translated; spectacles with the case, steel and fork and...., charcoal, boards, and paper, and chalk and white, and wax;.... for glass, a saw for bones with fine teeth, a chisel, inkstand three herbs, and Agnolo Benedetto. Get a skull, nut,--mustard.

Boots,--gloves, socks, combs, papers, towels, shirts,.... shoe-tapes,--..... shoes, penknife, pens. A skin for the chest.

[Footnote: 4. Lapis. Compare Condivi, *Vita di Michelagnolo Buonarroti*, Chap. XVIII.: *Ma egli (Michelangelo) non avendo che mostrare, prese una penna (perciocche in quel tempo il lapis non era in uso) e con tal leggiadria gli dipinse una mano ecc.* The incident is of the year 1496.--Lapis means pencil, and chalk (*matita*). Between lines 7 and 8 are the texts given as Nos. 819 and No. 7.]

Undated memoranda (1435-1457).

1435.

The book of Piero Crescenze,--studies from the nude by Giovanni Ambrosio,--compasses, --the book of Giovanni Giacomo.

1436.

MEMORARDUM.

To make some provisions for my garden, --Giordano, *De Ponderibus* [Footnote 3: *Giordano*. Jordanus Nemorarius, a mathematician of the beginning of the XIIIth century. No particulars of his life are known. The title of his principal work is: *Arithmetica decem libris demonstrata*, first published at Paris 1496. In 1523 appeared at Nuremberg: *Liber Jordani Nemorarii de ponderibus, propositiones XIII et earundem demonstrationes, multarumque rerum rationes sane pulcherrimas complectens, nunc in lucem editus.*],--the peacemaker, the flow and ebb of the sea,--have two baggage trunks made, look to Beltraffio's [Footnote 6:

Beltraffio, see No. 465, note 2.

There are sketches by the side of lines 8 and 10.] lathe and have taken the stone,--out leave the books belonging to Messer Andrea the German,-- make scales of a long reed and weigh the substance when hot and again when cold. The mirror of Master Luigi; _A b_ the flow and ebb of the water is shown at the mill of Vaprio,--a cap.

1437.

Giovanni Fabre,--Lazaro del Volpe,-- the common,--Ser Piero.

[Footnote: These names are inserted on a plan of plots of land adjoining the Arno.]

1438.

[Lactantius], [the book of Benozzo], groups,--to bind the book,--a lantern,--Ser Pecantino,--Pandolfino.--[Rosso]--a square, --small knives,--carriages,--curry combs-- cup.

1439.

Quadrant of Carlo Marmocchi,--Messer Francesco Araldo,--Ser Benedetto d'Accie perello,--Benedetto on arithmetic,--Maestro Paulo, physician,--Domenico di Michelino,-- of the Alberti,--Messer Giovanni Argimboldi.

1440.

Colours, formula,--Archimedes,--Marcantonio.

Tinned iron,--pierced iron.

1441.

See the shop that was formerly Bartolommeo's, the stationer.

[Footnote: 6. _Marc Antonio_, see No. 1433.]

1442.

The first book is by Michele di Francesco Nabini; it treats on science.

1443.

Messer Francesco, physician of Lucca, with the Cardinal Farnese.

[Footnote: _Alessandro Farnese_, afterwards Pope Paul III was created in 1493 Cardinal di San Cosimo e San Damiano, by Alexander VI.]

1444.

Pandolfino's book [Footnote 1: _Pandolfino, Agnolo_, of Florence. It is to this day doubtful whether he or L. B. Alberti was the author of the famous work ' _Del Governo della Famiglia_'. It is the more probable that Leonardo should have meant this work by the words _il libro_, because no other book is known to have been written by Pandolfino. This being the case this allusion of Leonardo's is an important evidence in favour of Pandolfino's authorship (compare No. 1454, line 3).--knives,--a pen for ruling,--to have the vest dyed,--The library at St.-Mark's,--The library at Santo Spirito,--Lactantius of the Daldi [Footnote 7: The works of Lactantius were published very often in Italy during Leonardo's lifetime. The first edition published in 1465 " _in monastero sublacensi_" was also the first book printed in Italy.],--Antonio Covoni,--A book by Maestro Paolo Infermieri, --Boots, shoes and hose,--(Shell)lac, --An apprentice to do the models for me. Grammar, by Lorenzo de Medici,--Giovanni del Sodo,--Sansovino, [Footnote 15: _Sansovino_, Andrea--the _sculptor_; 1460-1529.],--a ruler,--a very sharp knife,--Spectacles,--fractions...., --repair.....,--Tomaso's book,-- Michelagnolo's little chain; Learn the multiplication of roots from Maestro Luca;--my map of the world which Giovanni Benci has [Footnote 25: Leonardo here probably alludes to the map, not executed by him (See p. 224), which is with the collection of his MSS. at Windsor, and was published in the _Archaeologia_ Vol. XI (see p. 224).];-Socks,--clothes from the customhouse-officier,--Red Cordova leather,--The map of the world, of Giovanni Benci,--a print, the districts about Milan--Market book.

Get the Friar di Brera to show you [the book] ' _de Ponderibus_' [Footnote 11: _Brera_, now _Palazzo delle Scienze ed Arti. Until 1571 it was the monastery of the order of the Umiliati and afterwards of the Jesuits.

De ponderibus, compare No. 1436, 3.],--

Of the measurement of San Lorenzo,--

I lent certain groups to Fra Filippo de Brera, [Footnote 13: _Brera_, now _Palazzo delle Scienze ed Arti. Until 1571 it was the monastery of the order of the Umiliati and afterwards of the Jesuits.

De ponderibus, compare No. 1436, 3.],--

Memorandum: to ask Maestro Giovannino as to the mode in which the tower of Ferrara is walled without loopholes,--

Ask Maestro Antonio how mortars are placed on bastions by day or by night,--

Ask Benedetto Portinari how the people go on the ice in Flanders,--

On proportions by Alchino, with notes by Marliano, from Messer Fazio,--

The measurement of the sun, promised me by Maestro Giovanni, the Frenchman,--

The cross bow of Maestro Gianetto,--

The book by Giovanni Taverna that Messer Fazio,--

You will draw Milan [21],--

The measurement of the canal, locks and supports, and large boats; and the expense,--

Plan of Milan [Footnote 23: Fondamento is commonly used by Leonardo to mean ground-plan. See for instance p. 53.],--

Groups by Bramante [Footnote 24: Gruppi. See Vol. I p. 355, No. 600, note 9.],--

The book on celestial phenomena by Aristoteles, in Italian [Footnote 25: Meteora. By this Leonardo means no doubt the four books. He must refer here to a MS. translation, as no Italian translation is known to have been published (see No. 1477 note).],--

Try to get Vitolone, which is in the library at Pavia [Footnote 26: Vitolone see No. 1506, note.

Libreria di Pavia. One of the most famous of Italian libraries. After the victory of Novara in April 1500, Louis XII had it conveyed to France, 'come trofeo di vittoria!' and which treats of Mathematics,--He had a master [learned] in waterworks and get him to explain the repairs and the costs, and a lock and a canal and a mill in the Lombard fashion.

A grandson of Gian Angelo's, the painter has a book on water which was his fathers.

Paolino Scarpellino, called Assiolo has great knowledge of water works.

[Footnote 12: Sco Lorenzo. A church at Milan, see pp. 39, 40 and 50.]

[Footnote 13. 24: Gruppi. See Vol. I p. 355, No. 600, note 9.]

[Footnote 16: The Portinari were one of the great merchant-families of Florence.]

1449.

Francesco d'Antonio at Florence.

1450.

Giuliano Condi[1],--Tomaso Ridolfi,-- Tomaso Paganelli,--Nicolo del Nero,--Simone Zasti,--Nasi,--the heir of Lionardo Manelli, --Guglielmo di Ser Martino,--Bartolomeo del Tovaglia,--Andrea Arrigucci,-- Nicolo Capponi,--Giovanni Portinari.

[Footnote: I. _Guiliano Gondi_. Ser Piero da Vinci, Leonardo's father, lived till 1480, in a house belonging to Giuliano Gondi. In 1498 this was pulled down to make room for the fine Palazzo built on the Piazza San Firenze by Giuliano di San Gallo, which still exists. In the _Riassunto del Catasto di Ser Piero da Vinci_, 1480, Leonardo is not mentioned; it is evident therefore that he was living elsewhere. It may be noticed incidentally that in the _Catasto di Giuliano Gondi_ of the same year the following mention is made of his four eldest sons:

Lionardo mio figliuolo d'eta d'anni 29, non fa nulla, Giovambatista d'eta d'anni 28 in Ghostantinopoli, Billichozo d'eta d'anni 24 a Napoli, Simone d'eta d'anni 23 in Ungheria.

He himself was a merchant of gold filigree (_facciamo lavorare una bottega d'arte di seta ... facciamo un pocho di traffico a Napoli_). As he was 59 years old in 1480, he certainly would not have been alive at the time of Leonardo's death. But Leonardo must have been on intimate terms with the family till the end of his life, for in a letter dated June 1. 1519, in which Fr. Melzi, writing from Amboise, announces Leonardo's death to Giuliano da Vinci at Florence (see p. 284), he says at the end "_Datemene risposta per i Gondi_" (see UZIELLI, _Ricerche_, passim).

Most of the other names on the list are those of well-known Florentine families.]

1451.

Pandolfino.

1452.

Vespuccio will give me a book of Geometry.

[Footnote: See No. 844, note, p. 130.]

1453.

Marcantonio Colonna at Santi Apostoli.

[Footnote: In July 1506 Pope Julius II gave Donna Lucrezia della Rovere, the daughter of his sister Lucchina, in marriage to the youthful Marcantonio Colonna, who, like his brothers Prospero and Fabrizio, became one of the most famous Captains of his family. He

gave to him Frascati and made him a present of the palazzo he had built, when Cardinal, near the church of Santi Apostoli which is now known as the Palazzo Colonna (see GREGOROVIVUS, _Gesch. der Stadt Rom._ Vol. VIII, book XIV I, 3. And COPPI, _Mem. Colonesi_ p. 251).]

1454.

A box, a cage,-- A square, to make the bird [Footnote 2: Vasari states that Leonardo invented mechanical birds which moved through the air. Compare No. 703.],-- Pandolfino's book, mortar [?],-- Small knives, Venieri for the

[Footnote: Much of No. 1444 is repeated in this memorandum.]

Pen for ruling, stone,--star,--

To have the vest dyed, Alfieri's tazza,--

The Libraries, the book on celestial phenomena,--

Lactantius of the go to the house of Daldi,-- the Pazzi,

Book from Maestro small box,-- Paolo Infermieri,--

Boots, shoes and small gimlet,-- hose,

Lac,,--

An apprentice for,-- models,

Grammar of Lorenzo de' Medici, the amount of the ...

Giovanni del Sodo for...,--the broken

Sansovino, the....

Piero di Cosimo the wings,--

[Footnote 16: _Pier di Cosimo_ the well known Florentine painter 1462-1521. See VASARI, _Vite_ (Vol. IV, p. 134 ed. Sansoni 1880) about Leonardo's influence on Piero di Cosimo's style of painting.]

Filippo and Lorenzo [Footnote 17: _Filippo e Lorenzo_]; probably the painters Filippino Lippi and Lorenzo di Credi. L. di Credi's pictures and Vasari's history of that painter bear ample evidence to

his intimate relations with Leonardo.],--A ruler,-- Spectacles,--to do the..... again,--Tomaso's book,--Michelagnolo's chain,--The multiplication of roots,--Of the bow and strinch,--The map of the world from Benci,-- Socks,--The clothes from the custom-house officier,--Cordova leather,--Market books, --waters of Cronaca,--waters of Tanaglino..., --the caps,--Rosso's mirror; to see him make it,--1/3 of which I have 5/6,--on the celestial phenomena, by Aristotle [Footnote 36: *_Meteora_*. See No. 1448, 25.],--boxes of Lorenzo di Pier Francesco [Footnote 37: *_Lorenzo di Pier Francesco_* and his brother *_Giovanni_* were a lateral branch of the *_Medici_* family and changed their name for that of Popolani.],--Maestro Piero of the Borgo,--To have my book bound,--Show the book to Serigatto,-- and get the rule of the clock [Footnote 41: Possibly this refers to the clock on the tower of the Palazzo Vecchio at Florence. In February 1512 it had been repaired, and so arranged as to indicate the hours after the French manner (twelve hours a. m. and as many p. m.)],-- ring,--nutmeg,--gum,--the square,--Giovan' Batista at the piazza, de' Mozzi,--Giovanni Benci has my book and jaspers,--brass for the spectacles.

1455.

Search in Florence for.....

1456.

Bernardo da Ponte ... Val di Lugano ... many veins for anatomical demonstration.

[Footnote: This fragmentary note is written on the margin of a drawing of two legs.]

1457.

Paolo of Tavechia, to see the marks in the German stones.

[Footnote: This note occurs on a pen and ink drawing made by Leonardo as a sketch for the celebrated large cartoon in the possession of the Royal Academy of Arts, in London. This cartoon is commonly supposed to be identical with that described and lauded by Vasari, which was exhibited in Florence at the time and which now seems to be lost. Mr. Alfred Marks, of Long Ditton, in his valuable paper (read before the Royal Soc. of Literature, June 28, 1882) "On the St. Anne of Leonardo da Vinci", has adduced proof that the cartoon now in the Royal Academy was executed earlier at Milan. The note here given, which is written on the sheet containing the study for the said cartoon, has evidently no reference to the drawing on which it is written but is obviously of the same date. Though I have not any opening here for discussing this question of the cartoon, it seemed to me important to point out that the character of the writing in this note does not confirm the opinion hitherto held that the Royal Academy cartoon was the one described by Vasari, but, on

the contrary, supports the hypothesis put forward by Mr. Marks.]

Notes on pupils (1458-1468.)

1458.

Giacomo came to live with me on St.-Mary Magdalen's[Footnote: *_Il di della Maddalena._* July 22.] day, 1490, aged 10 years. The second day I had two shirts cut out for him, a pair of hose, and a jerkin, and when I put aside some money to pay for these things he stole 4 *_lire_* the money out of the purse; and I could never make him confess, though I was quite certain of the fact.--Thief, liar, obstinate, glutton.

The day after, I went to sup with Giacomo Andrea, and the said Giacomo supped for two and did mischief for four; for he brake 3 cruets, spilled the wine, and after this came to sup where I

Item: on the 7th day of September he stole a silver point of the value of 22 soldi from Marco[Footnote 6: *_Marco_*, probably Leonardo's pupil Marco d'Oggionno; 1470 is supposed to be the date of his birth and 1540 of his death.

Che stava con meco. We may infer from this that he left the master shortly after this, his term of study having perhaps expired.] who was living with me, 4 *_lire_* this being of silver; and he took it from his studio, and when the said Marco had searched for it a long while he found it hidden in the said Giacomo's box 4 *_lire_*.

Item: on the 26th January following, I, being in the house of Messer Galeazzo da San Severino [Footnote 9: Galeazzo. See No. 718 note.], was arranging the festival for his jousting, and certain footmen having undressed to try on some costumes of wild men for the said festival, Giacomo went to the purse of one of them which lay on the bed with other clothes, 2 lire 4 S, and took out such money as was in it.

Item: when I was in the same house, Maestro Agostino da Pavia gave to me a Turkish hide to have (2 lire.) a pair of short boots made of it; this Giacomo stole it of me within a month and sold it to a cobbler for 20 soldi, with which money, by his own confession, he bought anise comfits.

Item: again, on the 2nd April, Giovan Antonio [Footnote 16: Giovan Antonio, probably Beltraffio, 1467 to 1516.] having left a silver point on a drawing of his, Giacomo stole it, and this was of the value of 24 soldi (1 lira 4 S.)

The first year-

A cloak, 2 lire,
6 shirts, 4 lire,
3 jerkins, 6 lire,

4 pairs of hose, 7 lire 8 soldi,
1 lined doublet, 5 lire,
24 pairs of shoes, 6 lire 5 soldi,
A cap, 1 lira,
laces, 1 lira.

[Footnote: Leonardo here gives a detailed account not only of the loss he and others incurred through Giacomo but of the wild tricks of the youth, and we may therefore assume that the note was not made merely as a record for his own use, but as a report to be forwarded to the lad's father or other responsible guardian.]

1459.

On the last day but one of September;

Thursday the 27th day of September Maestro Tommaso came back and worked for himself until the last day but one of February. On the 18th day of March, 1493, Giulio, a German, came to live with me,--Lucia, Piero, Leonardo.

On the 6th day of October.

1460.

1493. On the 1st day of November we settled accounts. Giulio had to pay 4 months; and Maestro Tommaso 9 months; Maestro Tommaso afterwards made 6 candlesticks, 10 days' work; Giulio some fire-tongs 15 days work. Then he worked for himself till the 27th May, and worked for me at a lever till the 18th July; then for himself till the 7th of August, and for one day, on the fifteenth, for a lady. Then again for me at 2 locks until the 20th of August.

1461.

On the 23rd day of August, 12 lire from Pulisona. On the 14th of March 1494, Galeazzo came to live with me, agreeing to pay 5 lire a month for his cost paying on the 14th day of each month.

His father gave me 2 Rhenish florins.

On the 14th of July, I had from Galeazzo 2 Rhenish florins.

1462.

On the 15th day of September Giulio began the lock of my studio
1494.

1463.

Saturday morning the 3rd of August 1504 Jacopo the German came to live with me in the house, and agreed with me that I should charge him a carlino a day.

1464.

1511. On the 26th of September Antonio broke his leg; he must rest 40 days.

[Footnote: This note refers possibly to Beltraffio.]

1465.

I left Milan for Rome on the 24th day of September, 1513, with Giovanni [Footnote 2: _Giovan;_ it is not likely that Leonardo should have called Giovan' Antonio Beltraffio at one time Giovanni, as in this note and another time Antonio, as in No. 1464 while in No. 1458 l. 16 we find _Giovan'Antonio_, and in No. 1436, l.6 _Beltraffio_. Possibly the Giovanni here spoken of is Leonardo's less known pupil Giovan Pietrino (see No. 1467, 5).], Francesco di Melzi [Footnote 2,3: _Francesco de' Melzi_ is often mentioned, see Nos. 1350.], Salai [Footnote 3: _Salai_. See No. 1519 note.], Lorenzo and il Fanfoia.

[Footnote 4: _Lorenzo_. See No. 1351, l. 10 (p. 408). Amoretti gives the following note in _Mem. Stor. XXIII:_ 1505. _Martedi--sera a di 14 d'aprile. Venne Lorenzo a stare con mecho: disse essere d'eta d'anni 17 .. a di 15 del detto aprile ebbi scudi 25 d'oro dal chamerlingo di Santa Maria nuova._ This, he asserts is derived from a MS. marked S, in quarto. This MS. seems to have vanished and left no trace behind; Amoretti himself had not seen it, but copied from a selection of extracts made by Oltrocchi before the Leonardo MSS. were conveyed to Paris on the responsibility of the first French Republic. Lorenzo, by this, must have been born in 1487. The sculptor Lorenzetto was born in 1490. Amoretti has been led by the above passage to make the following absurd observations:

Cotesto Lorenzo, che poi gli fu sempre compagno, almeno sin che stette in Italia, sarebb' egli Lorenzo Lotto bergamasco? Sappiamo essere stato questo valente dipintore uno de'bravi scolari del Vinci (?).

Il Fafioia, perhaps a nickname. Cesare da Sesto, Leonardo's pupil, seems to have been in Rome in these years, as we learn from a drawing by him in the Louvre.

1466.

On the 3rd day of January.

Benedetto came on the 17th of October; he stayed with me two months and 13 days of last year, in which time he earned 38 lire, 18 soldi and 8 dinari; he had of this 26 lire and 8 soldi, and there remains to be paid for the past year 12 lire 10 soldi.

Giodatti (?) came on the 8th day of September, at 4 soldi a month,

and stayed with me 3 months and 24 days, and earned 59 lire 14 soldi and 8 dinari; he has had 43 lire, 4 soldi, there remains to pay 16 lire, 10 soldi and 8 dinari.

Benedetto, 24 grossoni.

[Footnote: This seems to be an account for two assistants. The name of the second is scarcely legible. The year is not given. The note is nevertheless of chronological value. The first line tells us the date when the note was registered, January 3d, and the observations that follow refer to events of the previous month 'of last year' *_(dell'anno passato)_*. Leonardo cannot therefore have written thus in Florence where the year was, at that period, calculated as beginning in the month of March (see Vol. I, No. 4, note 2). He must then have been in Milan. What is more important is that we thus learn how to date the beginning of the year in all the notes written at Milan. This clears up Uzielli's doubts: *_A Milano facevasi cominciar l'anno ab incarnatione, cioe il 25 Marzo e a nativitate, cioe il 25 Decembre. Ci sembra probabile che Leonardo dovesse prescegliere lo stile che era in uso a Firenze._* (*_Ricerche_*, p. 84, note.)]

1467.

Gian Maria 4,
Benedetto 4,
Gian Pietro [5] 3,
Salai 3,
Bartolomeo 3,
Gherardo 4.

1468.

Salai, 20 lire,
Bonifacio, 2 lire,
Bartolomeo, 4 lire,
Arrigo [Harry], 15 lire.

Quotations and notes on books and authors (1469-1508).

1469.

Book on Arithmetic [Footnote 1: *_La nobel opera de arithmethica ne la qual se tracta tute cosse amercantia pertinente facta & compilata per Piero borgi da Veniesia*", in-40. In fine: "Nela inclita cita di Venetia a corni. 2 agosto. 1484. fu imposto fine ala presente opera." Segn. a--p. quaderni. V'ha pero un' altra opera simile di Filippo Calandro, 1491. E da consultarsi su quest' ultimo, Federici: *Memorie Trevigiane*, Fiore di virtu: pag. 73. "Libricciuolo composto di bello stile verso il 1320 e piu volte impresso nel secolo XV (ristampato poi anche piu tardi). Gli accademici della Crusca lo ammettono nella serie dei testi di lingua. Vedasi Gamba, Razzolini, Panzer, Brunet, Lechi, ecc._ (G. D'A.), 'Flowers of Virtue',

Pliny [Footnote 2: _"Historia naturale di C. Plinio Secondo, tradotta di lingua latina in fiorentina per Christophoro Laudino & Opus Nicolai Jansonis gallici imp. anno salutis M.CCCC.LXXVI. Venetiis" in-fol.--Diogene Laertio. Incomincia: "El libro de la vita de philosophi etc.: Impressum Venetiis" per Bernardinum Celerium de Luere, 1480", in-40_ (G. D'A.)], 'Lives of the Philosophers',

The Bible [Footnote 3: _"La Bibia volgare historiata (per Nicolo di Mallermi) Venecia ... M.CCCC.LXXI in kalende di Augusto (per Vindelino de Spira)" 2 vol. in-fol. a 2 col. di 50 lin.,; od altra ediz. della stessa versione del Mallermi, Venetia 1471, e sempre: "Venecia per Gabriel de Piero 1477," in-fol.; 2 vol.; Ottavio Scotto da Modoetia 1481," "Venetia 1487 per Joan Rosso Vercellese," "1490 Giovanni Ragazzo di Monteferato a instantia di Luchanthonio di Giunta, ecc."--Lapidario Teofrasto? Mandebille: "Le grand lapidaire," versione italiana ms.?... Giorgio Agricola non puo essere, perche nato nel 1494, forse Alberto Magno: de mineralibus. Potrebbe essere una traduzione del poema latino (Liber lapidum seu de gemmis) di Marbordio Veterio di Rennes (morto nel 1123 da lui stesso tradotto in francese dal greco di Evao re d'Arabia celebre medico che l'aveva composto per l'imperatore Tiberio. Marbodius scrisse il suo prima per Filippo Augusto re di Francia. Vi sono anche traduzioni in prosa. "Il lapidario o la forza e la virtu delle pietre preziose, delle Erbe e degli Animali."_ (G. D'A.)], 'Lapidary',

'On warfare' [Footnote 4: _Il Vegezio? ... Il Frontino? ... Il Cornazzano?... Noi crediamo piuttosto il Valturio. Questo libro doveva essere uno de'favoriti di Leonardo poiche libro di scienza e d'arte nel tempo stesso._], 'Epistles of Filelfo',

[Footnote: The late Marchese Girolamo d'Adda published a highly valuable and interesting disquisition on this passage under the title: _Leonardo da Vinci e la sua Libreria, note di un bibliofilo (Milano 1873. Ed. di soli 75 esemplari_; privately printed). In the autumn of 1880 the Marchese d'Adda showed me a considerable mass of additional notes prepared for a second edition. This, as he then intended, was to come out after the publication of this work of mine. After the much regretted death of the elder Marchese, his son, the Marchese Gioachino d'Adda was so liberal as to place these MS. materials at my disposal for the present work, through the kind intervention of Signor Gustavo Frizzoni. The following passages, with the initials G. d'A. are prints from the valuable notes in that publication, the MS. additions I have marked. I did not however think myself justified in reproducing here the acute and interesting observations on the contents of most of the rare books here enumerated.]

[Footnote: 1467. 5. See No. 1465, 2.]

The first decade, [5] 'On the preservation of health', The third decade, [6] Ciecho d'Ascoli, The fourth decade, [7] Albertus Magnus,

Guido, [8] New treatise on rhetorics, Piero Crescentio, [9]
Cibaldone, 'Quadriregio', [10] Aesop,

Donato, [Footnote 11: "_Donatus latine & italice: Impressum Venetiis
impensis Johannis Baptistae de Sessa anno_ 1499, _in_-4deg."-- "_El
Psalterio de David in lingua volgare (da Malermi Venetia nel
M.CCCC.LXXVI,_" in-fol. s. n._ (G. D'A.))] Psalms,

Justinus, [Footnote 12: Compare No. 1210, 48.--_La versione di
Girolamo Squarzafico:_ "_Il libro di Justino posto diligentemente in
materna lingua. Venetia ale spese (sic) di Johane de Colonia &
Johane Gheretze_ ... 1477," _in-fol._--"_ Marsilii Ficini, Theologia
platonica, sive de animarum immortalitate, Florentine, per Ant.
Misconimum_ 1482," _in-fol., ovvero qualche versione italiana di
questo stesso libro, ms._ (G. D'A.))] 'On the immortality of the
soul,

Guido [Footnote 13: _Forse_ "_la Historia Trojana Guidonis_" _od il
_"_manipulus_" _di_"_ Guido da Monterocherii_"_ ma piu probabilmente
_"_Guido d'Arezzo_"_ il di cui libro:_"_Micrologus, seu disciplina
artis musicae_"_ poteva da Leonardo aversi ms.; di questi ne
esistono in molte biblioteche, e fu poi impresso nel 1784 dal
Gerbert._

_Molte sono le edizioni dei sonetti di Burchiello Fiorentino,
imprese nel secolo XV. La prima e piu rara e ricercata:_
_"_Incominciano li sonetti, ecc. (per Christoforo Arnaldo)"_, in_-4deg.
senza numeri, richiami o segnature, del 1475, _e fors' anche del_
1472, _secondo Morelli e Dibdin, ecc._ (G. D'A.))] Burchiello,

'Doctrinale' [Footnote 14: _Versione italiana det "Doctrinal de
Sapience" di Guy de Roy, e fors'anche l'originale in lingua
francese.--_

Di Pulci Luigi, benché nell' edizione: "_Florentiae_ 1479" _in_-4deg.
si dica: "_Il Driadeo composto in rima octava per Lucio Pulcro_"
Altre ediz, del secolo XV, "_Florentie Miscomini_ 1481, _in_-40,
Firenze, apud S. Jacob, de Ripoli, 1483," _in_-4deg. _e "Antoni de
Francesco, 1487," _in_-4deg. _e Francesco di Jacopo_ 1489, _in_-4deg. _ed
altre ancora di Venezia e senza alcuna nota ecc._ (G. D'A.))
Driadeo,

Morgante [Footnote 15: _Una delle edizioni del Morgante impresse nel
secolo XV, ecc.--_

_Quale delle opere di Francesco Petrarca, sarebbe malagevole
l'indovinare, ma probabilmente il Canzoniere._ (G. D'A.))] Petrarch.

John de Mandeville [Footnote 16: _Sono i viaggi del cavaliere_
_"_Mandeville_"_ gentiluomo inglese. Scrisse il suo libro in lingua
francese. Fu stampato replicatamente nel secolo XV in francese, in
inglese ed in italiano ed in tedesco; del secolo XV ne annoverano
forse piu di 27 edizioni, di cui ne conosciamo_ 8 _in francese,

quattro in latino, sei in tedesco e molte altre in volgare. (G. D'A.)]

'On honest recreation' [Footnote 17: *Il Platina* (Bartolomeo Sacchi) la versione italiana "de la honesta voluptate, & valetudine (& de li obsonnii) Venetia (senza nome di tipografo) 1487," piccolo in-4deg. gotico. (G. D'A.)--Compare No. 844, 21.]

Manganello, [Footnote 18: *Il Manganello: Satira eccessivamente vivace contro le donne ad imitazione della Sesta di Giovenale. Manganello non è soltanto il titolo del libricino, sua ben anche il nome dell'autore ch'era un "milanese". Di questo libricolo rarissimo, che sembra impresso a Venezia dallo Zoppino (Nicolo d'Aristotile detto il), senza data, ma dei primissimi anni del secolo XVI, e forse più antico, come vedremo in appresso, non se ne conoscono fra biblioteche pubbliche e private che due soli esemplari in Europa. (G. D'A.)]*

The Chronicle of Isidoro, [Footnote 19: "*Cronica desidero*," sembra si deggia leggere piuttosto "*cronico disidoro*"; ed in questo caso s'intenderebbe la "*cronica d'Isidoro*" tanto in voga a quel tempo "*Comenza la Cronica di Sancto Isidoro minore con alchune additione cavate del testo & istorie de la Bibia & del libro di Paulo Oroso Impresso in Ascoli in casa del reverendo misser Pascale per mano di Guglielmo de Linis de Alamania M.CCCC.LXXVII*" in-4deg. di 157 ff. E il primo libro impresso ad Ascoli e l'edizione principe di questa cronica in oggi assai rara. Non lo è meno l'edizione di Civald del Friuli, 1480, e quella ben anche di Aquila, 1482, sempre in-4deg. Vedasi Panzer, Hain, Brunet e P. Dechamps. (G. D'A.)]

The Epistles of Ovid, [Footnote 20: "*Le pistole di Ovidio tradotte in prosa. Napoli Sixt. Riessinger*," in-4deg., oppure: "*Epistole volgarizzate 1489*," in-4deg. a due col. "imprese ne la cita (sic) di Bressa per pre: Baptista de Farfengo," (in ottave) o: "*El libro dele Epistole di Ovidio in rima volgare per messere Dominico de Monticelli toscano. Brescia Farfengo*," in-4deg. got. (in rima volgare), 1491, ed anche la versione di Luca Pulci. Firenze, Miscomini, 1481, in-4deg. (G. D'A.)]

Epistles of Filelfo, [Footnote 21: See I. 4.]

Sphere, [Footnote 22: "*Jo: de Sacrobusto*," o "*Goro Dati*," o "*Tolosano da Colle*" di cui molteplici edizioni del secolo XV. (G. D'A.)]

The Jests of Poggio, [Footnote 23: *Tre edizioni delle facezie del Poggio* abbiamo in lingua italiana della fine del secolo XV, tutte senza data. "*Facetie de Poggio fiorentino traducte de latino in volgare ornatissimo*," in-40, segn. a--e in caratteri romani; l'altra: "*Facetie traducte de latino in volgare*," in-40, caratteri gotici, ecc. (G. D'A.)] *Chiromancy*, [Footnote 24: "*Die Kunst Cyromantia etc*, in tedesco. 26 ff. di testo e figure il tutte

eseguito su tavole di legno verso la fine del secolo XV da Giorgio Schapff". Dibdin, Heineken, Sotheby e Chatto ne diedero una lunga descrizione; i primi tre accompagnati da fac-simili. La data 1448 che si legge alla fine del titolo si riferisce al periodo della composizione del testo, non a quello della stampa del volume benché tabellario. Altri molti libri di Chiromanzia si conoscono di quel tempo e sarebbe opera vana il citarli tutti. (G. D'A.)

Formulary of letters, [Footnote 25: _Miniatore Bartolomeo. "Formulario de epistole vulgare missive e responsive, & altri fiori de ornali parlamenti al principe Hercule d'Esti ecc. composto ecc. Bologna per Ugo di Rugerii," in-40, del secolo XV. Altra edizione di "Venetia Bernardino di Novara, 1487" e "Milano per Joanne Angelo Scinzenzeler 1500," in-40. (G. D'A.)

Five books out of this list are noted by Leonardo in another MS. (Tr. 3): _donato, -- lapidario, -- plinio, -- abacho, -- morgante. _]

1470.

Nonius Marcellus, Festus Pompeius, Marcus Varro.

[Footnote: Nonius Marcellus and Sextus Pompeius Festus were Roman grammarians of about the fourth century A. D. Early publications of the works of Marcellus are: _De proprietate sermonis, Romae_ (about 1470), and 1471 (place of publication unknown). _Compendiosa doctrina, ad filium, de proprietate sermonum._ Venice, 1476. BRUNET, _Manuel du libraire_ (IV, p. 97) notes: _Le texte de cet ancien grammairien a été reimprimé plusieurs fois à la fin du XV^e siècle, avec ceux de Pomponius Festus et de Terentius Varro. La plus ancienne édition qui réunisse ces trois auteurs est celle de Parme, 1480 ... Celles de Venise, 1483, 1490, 1498, et de Milan, 1500, toutes in-fol., ont peu de valeur. _]

1471.

Map of Elephanta in India which Antonello Merciaio has from maestro Maffeo;--there for seven years the earth rises and for seven years it sinks;--Enquire at the stationers about Vitruvius.

1472.

See 'On Ships' Messer Battista, and Frontinus 'On Aqueducts' [Footnote 2: 2. _Vitruvius de Arch., et Frontinus de Aqueductibus._ Florence, 1513.--This is the earliest edition of Frontinus.--The note referring to this author thus suggests a solution of the problem of the date of the Leicester Manuscript.].

[Footnote: Compare No. 1113, 25.]

1473.

Anaxagoras: Every thing proceeds from every thing, and every thing

becomes every thing, and every thing can be turned into every thing else, because that which exists in the elements is composed of those elements.

1474.

The Archimedes belonging to the Bishop of Padua.

[Footnote: See No. 1421, 1. 3, 6 and Vol. I, No. 343.]

1475.

Archimedes gave the quadrature of a polygonal figure, but not of the circle. Hence Archimedes never squared any figure with curved sides. He squared the circle minus the smallest portion that the intellect can conceive, that is the smallest point visible.

[Footnote: Compare No. 1504.]

1476.

If any man could have discovered the utmost powers of the cannon, in all its various forms and have given such a secret to the Romans, with what rapidity would they have conquered every country and have vanquished every army, and what reward could have been great enough for such a service! Archimedes indeed, although he had greatly damaged the Romans in the siege of Syracuse, nevertheless did not fail of being offered great rewards from these very Romans; and when Syracuse was taken, diligent search was made for Archimedes; and he being found dead greater lamentation was made for him by the Senate and people of Rome than if they had lost all their army; and they did not fail to honour him with burial and with a statue. At their head was Marcus Marcellus. And after the second destruction of Syracuse, the sepulchre of Archimedes was found again by Cato[25], in the ruins of a temple. So Cato had the temple restored and the sepulchre he so highly honoured.... Whence it is written that Cato said that he was not so proud of any thing he had done as of having paid such honour to Archimedes.

[Footnote: Where Leonardo found the statement that Cato had found and restored the tomb of Archimedes, I do not know. It is a merit that Cicero claims as his own (Tusc. V, 23) and certainly with a full right to it. None of Archimedes' biographers --not even the diligent Mazzucchelli, mentions any version in which Cato is named. It is evidently a slip of the memory on Leonardo's part. Besides, according to the passage in Cicero, the grave was not found '_nelle ruine d'un tempio'_ --which is highly improbable as relating to a Greek--but in an open spot (H. MULLER-STRUBING).--See too, as to Archimedes, No. 1417.

Leonardo says somewhere in MS. C.A.: '_Architronito e una macchina di fino rame, invenzion d' Archimede_' (see '_Saggio_', p. 20).]

1477.

Aristotle, Book 3 of the Physics, and Albertus Magnus, and Thomas Aquinas and the others on the rebound of bodies, in the 7th on Physics, on heaven and earth.

1478.

Aristotle says that if a force can move a body a given distance in a given time, the same force will move half the same body twice as far in the same time.

1479.

Aristotle in Book 3 of the Ethics: Man merits praise or blame solely in such matters as lie within his option to do or not to do.

1480.

Aristotle says that every body tends to maintain its nature.

1481.

On the increase of the Nile, a small book by Aristotle. [Footnote: *_De inundatione Nili_*, is quoted here and by others as a work of Aristotle. The Greek original is lost, but a Latin version of the beginning exists (Arist. Opp. IV p. 213 ed. Did. Par.).]

In his quotations from Aristotle Leonardo possibly refers to one of the following editions: *_Aristotelis libri IV de coelo et mundo; de anima libri III; libri VIII physicorum; libri de generatione et corruptione; de sensu et sensato... omnia latine, interprete Averroë, Venetiis 1483_* (first Latin edition). There is also a separate edition of *_Liber de coelo et mundo_*, dated 1473.]

1482.

Avicenna will have it that soul gives birth to soul as body to body, and each member to itself.

[Footnote: Avicenna, see too No. 1421, 1. 2.]

1483.

Avicenna on liquids.

1484.

Roger Bacon, done in print. [Footnote: The earliest printed edition known to Brunet of the works of Roger Bacon, is a French translation, which appeared about forty years after Leonardo's death.]

1485.

Cleomedes the philosopher.

[Footnote: Cleomedes. A Greek mathematician of the IVth century B. C. We have a Cyclic theory of Meteorica by him. His works were not published before Leonardo's death.]

1486.

CORNELIUS CELSUS.

The highest good is wisdom, the chief evil is suffering in the body. Because, as we are composed of two things, that is soul and body, of which the first is the better, the body is the inferior; wisdom belongs to the better part, and the chief evil belongs to the worse part and is the worst of all. As the best thing of all in the soul is wisdom, so the worst in the body is suffering. Therefore just as bodily pain is the chief evil, wisdom is the chief good of the soul, that is with the wise man; and nothing else can be compared with it.

[Footnote: _Aulus Cornelius Celsus_, a Roman physician, known as the Roman Hippocrates, probably contemporary with Augustus. Only his eight Books 'De Medicina', are preserved. The earliest editions are: _Cornelius Celsus, de medicina libr. VIII._, Milan 1481 Venice 1493 and 1497.]

1487.

Demetrius was wont to say that there was no difference between the speech and words of the foolish and ignorant, and the noises and rumblings of the wind in an inflated stomach. Nor did he say so without reason, for he saw no difference between the parts whence the noise issued; whether their lower parts or their mouth, since one and the other were of equal use and importance.

[Footnote: Compare Vol. I, No. 10.]

1488.

Maestro Stefano Caponi, a physician, lives at the piscina, and has Euclid _De Ponderibus_.

1489.

5th Book of Euclid. First definition: a part is a quantity of less magnitude than the greater magnitude when the less is contained a certain number of times in the greater.

A part properly speaking is that which may be multiplied, that is when, being multiplied by a certain number, it forms exactly the whole. A common aggregate part ...

Second definition. A greater magnitude is said to be a multiple of a less, when the greater is measured by the less.

By the first we define the lesser [magnitude] and by the second the greater is defined. A part is spoken

1490.

of in relation to the whole; and all their relations lie between these two extremes, and are called multiples.

1491.

Hippocrates says that the origin of men's sperm derives from the brain, and from the lungs and testicles of our parents, where the final decocture is made, and all the other limbs transmit their substance to this sperm by means of expiration, because there are no channels through which they might come to the sperm.

[Footnote: The works of Hippocrates were printed first after Leonardo's death.]

1492.

Lucretius in his third [book] 'De Rerum Natura'. The hands, nails and teeth were (165) the weapons of ancient man.

They also use for a standard a bunch of grass tied to a pole (167).

[Footnote: _Lucretius, de rerum natura libri VI_ were printed first about 1473, at Verona in 1486, at Brescia in 1495, at Venice in 1500 and in 1515, and at Florence in 1515. The numbers 165 and 167 noted by Leonardo at the end of the two passages seem to indicate pages, but if so, none of the editions just mentioned can here be meant, nor do these numbers refer to the verses in the poems of Lucretius.]

1493.

Ammianus Marcellinus asserts that seven hundred thousand volumes of books were burnt in the siege of Alexandria in the time of Julius Cesar.

[Footnote: _Ammiani Marcellini historiarum libri qui extant XIII_, published at Rome in 1474.]

1494.

Mondino says that the muscles which raise the toes are in the outward side of the thigh, and he adds that there are no muscles in the back [upper side] of the feet, because nature desired to make them light, so as to move with ease; and if they had been fleshy they would be heavier; and here experience shows ...

[Footnote: _"Mundini anatomia. Mundinus, Anothomia (sic). Mundini praestantissimorum doctorum almi studii ticiensis (sic) cura diligentissime emendata. Impressa Papiae per magistrum Antonium de Carfano 1478," in-fol.; ristampata: "Bononiae Johan. de Noerdlingen, 1482," in-fol.; "Padova per Mattheum Cerdonis de Vuindischgretz, 1484," in-40; "Lipsia, 1493," in-40; "Venezia, 1494," in-40 e ivi "1498," con fig. Queste figure per altro non sono, come si e preteso, le prime che fossero introdotte in un trattato di Notamia. Nel 'fasciculus Medicinae' di Giovanni Ketham, che riproduce l'"Anatomia' del Mundinus, impresso pure a Venezia da J. e G. de Gregoriis, 1491, in-fol., contengonsi intagli in legno (si vogliono disegnati non gia incisi da Andrea Mantegna) di grande dimensione, e che furono piu volte riprodotti negli anni successivi. Quest' edizione del "fasciculus" del 1491, sta fra nostri libri e potrebbe benissimo essere il volume d'Anatomia notato da Leonardo._ (G. D'A.)]

1495.

Of the error of those who practice without knowledge;--[3] See first the 'Ars poetica' of Horace [5].

[Footnote: A 3-5 are written on the margin at the side of the title line of the text given, entire as No. 19]

1496.

The heirs of Maestro Giovanni Ghiringallo have the works of Pelacano.

1497.

The catapult, as we are told by Nonius and Pliny, is a machine devised by those &c.

[Footnote: _Plinius_, see No. 946.]

1498.

I have found in a history of the Spaniards that in their wars with the English Archimedes of Syracuse who at that time was living at the court of Ecliderides, King of the Cirodastris. And in maritime warfare he ordered that the ships should have tall masts, and that on their tops there should be a spar fixed [Footnote 6: Compare No. 1115.] of 40 feet long and one third of a foot thick. At one end of this was a small grappling iron and at the other a counterpoise; and there was also attached 12 feet of chain; and, at the end of this chain, as much rope as would reach from the chain to the base of the top, where it was fixed with a small rope; from this base it ran down to the bottom of the mast where a very strong spar was attached and to this was fastened the end of the rope. But to go on to the use of his machine; I say that below this grappling iron was a fire [Footnote 14: Compare No. 1128.] which, with tremendous noise, threw

down its rays and a shower of burning pitch; which, pouring down on the [enemy's] top, compelled the men who were in it to abandon the top to which the grappling-iron had clung. This was hooked on to the edges of the top and then suddenly the cord attached at the base of the top to support the cord which went from the grappling iron, was cut, giving way and drawing in the enemy's ship; and if the anchor--was cast ...

[Footnote: Archimedes never visited Spain, and the names here mentioned cannot be explained. Leonardo seems to quote here from a book, perhaps by some questionable mediaeval writer. Prof. C. Justi writes to me from Madrid, that Spanish savants have no knowledge of the sources from which this story may have been derived.]

1499.

Theophrastus on the ebb and flow of the tide, and of eddies, and on water. [Footnote: The Greek philosophers had no opportunity to study the phenomenon of the ebb and flow of the tide and none of them wrote about it. The movement of the waters in the Euripus however was to a few of them a puzzling problem.]

1500.

Tryphon of Alexandria, who spent his life at Apollonia, a city of Albania (163). [Footnote: Tryphon of Alexandria, a Greek Grammarian of the time of Augustus. His treatise TtaOY Aeijecu appeared first at Milan in 1476, in Constantin Laskaris's Greek Grammar.]

1501.

Messer Vincenzo Aliprando, who lives near the Inn of the Bear, has Giacomo Andrea's Vitruvius.

1502.

Vitruvius says that small models are of no avail for ascertaining the effects of large ones; and I here propose to prove that this conclusion is a false one. And chiefly by bringing forward the very same argument which led him to this conclusion; that is, by an experiment with an auger. For he proves that if a man, by a certain exertion of strength, makes a hole of a given diameter, and afterwards another hole of double the diameter, this cannot be made with only double the exertion of the man's strength, but needs much more. To this it may very well be answered that an auger

1503.

of double the diameter cannot be moved by double the exertion, because the superficies of a body of the same form but twice as large has four times the extent of the superficies of the smaller, as is shown in the two figures a and n.

1504.

OF SQUARING THE CIRCLE, AND WHO IT WAS THAT FIRST DISCOVERED IT BY ACCIDENT.

Vitruvius, measuring miles by means of the repeated revolutions of the wheels which move vehicles, extended over many Stadia the lines of the circumferences of the circles of these wheels. He became aware of them by the animals that moved the vehicles. But he did not discern that this was a means of finding a square equal to a circle. This was first done by Archimedes of Syracuse, who by multiplying the second diameter of a circle by half its circumference produced a rectangular quadrilateral equal figure to the circle [Footnote 10: Compare No. 1475.].

[Footnote: _Vitruvius_, see also Nos. 1113 and 343.]

1505.

Virgil says that a blank shield is devoid of merit because among the people of Athens the true recognition confirmed by testimonies ...

[Footnote: The end of the text cannot be deciphered.]

1506.

In Vitolone there are 805 conclusions [problems] in perspective.

[Footnote: _(Witelo, Vitellion, Vitellon) Vitellione. E da vedersi su questo ottico prospettico del secolo XIII Luca Pacioli, Paolo Lomazzo, Leonardo da Vinci, ecc. e fra i moderni il Graesse, il Libri, il Brunet, e le Memorie pubblicate dal principe Boncompagni, e 'Sur l' orthographe du nom et sur la patrie de Witelo (Vitellion) note de Maximilien Curtze, professeur a Thorn', ove sono descritti i molti codici esistenti nelle biblioteche d' Europa. Bernardino Baldi nelle sue 'Vite de'matematici', manoscritto presso il principe Boncompagni, ha una biografia del Vitellione. Questo scritto del Baldi reca la data 25 agosto 1588. Discorsero poi di lui Federigo Risnerio e Giovanni di Montereio nella prefazione dell' Alfragano, Giovanni Boteone, Girolamo Cardano, 'De subtilitate', che nota gli errori di Vitellione. Visse, secondo il Baldi, intorno all' anno 1269, ma secondo il Reinoldo fioriva nel 1299, avendo dedicata la sua opera ad un frate Guglielmo di Monteca, che visse di que' tempi.

Intorno ad un manoscritto dell' ottica di Vitellione, citato da Luca Pacioli v'ha un secondo esemplare del Kurlz, con aggiunte del principe Boncompagni, e le illustrazioni del cav. Enrico Narducci. Nel 'Catalogo di manoscritti' posseduti da D. Baldassare de' principi Boncompagni, compilato da esso Narducci, Roma, 1862, sotto al n. 358, troviamo citato: Vitellio, 'Perspectiva', manoscritto del secolo XIV. La 'Prospettiva di Vitelleone' (sic) Thuringo-poloni e citata due volte da Paolo Lomazzo nel Trattato dell' arte della pittura. Vitellio o Vitello o Witelo. Il suo libro fu impresso in

foglio a Norimberga nel 1535; la secondo edizione e del 1551, sempre di Norimberga, ed una terza di Basilea, 1572._ (See _Indagini Storiche ... sulla Libreria-Visconteo-Sforzesca del Castello di Pavia ... per cura di_ G. D'A., _Milano 1879. P. I. Appendice p. 113. 114)._]]

1507.

Vitolone, at Saint Mark's.

[Footnote: _Altro codice di cotesta 'Prospettiva' del Vitolone troviamo notato nel 'Canone bibliographico di Nicolo V', conservato alla, Magliabecchiana, in copia dell' originale verosimilmente inviato dal Parentucelli a Cosimo de' Medici (Magliab. cod. segn. 1 VII, 30 carte da 193 a 198). Proviene dal Convento di San Marco e lo aveva trascritto frate Leonardo Scruberti fiorentino, dell' ordine dei predicatori che fu anche bibliotecario della Medicea pubblica in San Marco_ (See _Indagini Storiche ... per cura di_ G. D'A. _Parte I, p. 97)._]]

1508.

How this proposition of Xenophon is false.

If you take away unequal quantities from unequal quantities, but in the same proportion, &c. [Footnote: Xenophon's works were published several times during Leonardo's lifetime.]

Inventories and accounts (1509--1545).

1509.

On the 28th day of April I received from the Marchesino 103 lire and 12 dinari. [Footnote: Instead of the indication of the year there is a blank space after _d'aprile_.--Marchesino Stange was one of Lodovico il Moro's officials.--Compare No. 1388.]

1510.

On the 10th day of July 1492 in 135
Rhenish florins 1. 445
in dinari of 6 soldi 1. 112 S 16
in dinari of 5 1/2 soldi 1. 29 S 13
9 in gold and 3 scudi 1. 53

1. 811 in all

1511.

On the first day of February, lire 1200.

1512.

The hall towards the court is 126 paces long and 27 braccia wide.

1513.

The narrow cornice above the hall lire 30.

The cornice beneath that, being one for each picture, lire 7, and for the cost of blue, gold, white, plaster, indigo and glue 3 lire; time 3 days.

The pictures below these mouldings with their pilasters, 12 lire each.

I calculate the cost for smalt, blue and gold and other colours at 1 1/2 lire.

The days I calculate at 3, for the invention of the composition, pilasters and other things.

1514.

Item for each vault 7 lire

outlay for blue and gold 3 1/2

time, 4 days

for the windows 1 1/2

The cornice below the windows 16 soldi per braccio

item for 24 pictures of Roman history 14 lire each

The philosophers 10 lire

the pilasters, one ounce of blue 10 soldi

for gold 15 soldi

Total 2 and 1/2 lire.

1515.

The cornice above lire 30

The cornice below lire 7

The compositions, one with another lire 13

1516.

Salai, 6 lire ... 4 soldi ... 10 soldi for a chain;--

On the 14th of March I had 13 lire S. 4; 16 lire remain.

1517.

How many braccia high is the level of the walls?--

123 braccia

How large is the hall?

How large is the garland?

30 ducats.

On the 29th day of January, 1494

cloth for hose lire 4 S 3

lining S 16

making S 8

to Salai S 3

a jasper ring S 13

a sparkling stone S 11

to Caterina S 10

to Caterina S 10

1518.

The wheel lire 7

the tire lire 10

the shield lire 4

the cushion lire 8

the ends of the axle-tree lire 2

bed and frame lire 30

conduit lire 10

S.K.M.II.2 4a]

1519.

Parsley 10 parts

mint 1 part

thyme 1 part

Vinegar ... and a little salt two pieces of canvas for Salai.

[Footnote: This note, of about the year 1494, is the earliest mention of Salai, and the last is of the year 1513 (see No. 1465, 3). From the various notes in the MSS. he seems to have been Leonardo's assistant and keeper only, and scarcely himself a painter. At any rate no signed or otherwise authenticated picture by him is known to exist. Vasari speaks somewhat doubtfully on this point.]

1520.

On Tuesday I bought wine for morning [drinking]; on Friday the 4th day of September the same.

[Footnote: This note enables us to fix the date of the Manuscript, in which it is to be found. In 1495 the 4th of September fell on a Friday; the contents of the Manuscript do not permit us to assign it to a much earlier or later date (Compare No. 1522, and Note).]

1521.

The cistern ... at the Hospital, --2 ducats, --beans, --white maize, --red maize, --millet, --buckwheat, --kidney beans, --beans, --peas.

1522.

EXPENSES OF THE INTERMENT OF CATERINA.

For the 3 lbs of tapers 27 S

For the bier 8 S

A pall over the bier 12 S

For bearing and placing the cross 4 S

For bearing the body 8 S

For 4 priests and 4 clerks 20 S

Bell, book and sponge 2 S

For the gravediggers 16 S

To the senior 8 S

For a license from the authorities 1 S

106 S

The doctor 2 S

Sugar and candles 12 S

120 S

[Footnote: See Nos. 1384 and 1517.]

1523.

Salai's cloak, the 4th of April 1497.

4 braccia of silver cloth l. 15 S 4

green velvet to trim it l. 9 S --

binding l.-- S 9

loops l.-- S 12

the making l. 1 S 5

binding for the front l.-- S 5

stitching _____

here are 13 grossoni of his l. 26 S 5

Salai stole the soldi.

1524.

On Monday I bought 4 braccia of cloth lire 13 S 14 1/2 on the 17th of, October 1497.

1525.

Memorandum. That on the 8th day of April 1503, I, Leonardo da Vinci, lent to Vante, miniature painter 4 gold ducats, in gold. Salai carried them to him and gave them into his own hand, and he said he would repay within the space of 40 days.

Memorandum. That on the same day I paid to Salai 3 gold ducats which he said he wanted for a pair of rose-coloured hose with their trimming; and there remain 9 ducats due to him--excepting that he owes me 20 ducats, that is 17 I lent him at Milan, and 3 at Venice.

Memorandum. That I gave Salai 21 braccia of cloth to make a shirt, at 10 soldi the braccio, which I gave him on the 20th day of April 1503.

[Footnote: With regard to Vante or Attavante, the miniature painter (not Nanni as I formerly deciphered this name, which is difficult to read; see *Zeitschrift für Bild. Kunst*, 1879, p. 155), and Vasari, *Lives of Frate Giovanni da Fiesole, of Bartolommeo della Gatta, and of Gherardo, _miniature._* He, like Leonardo, was one of the committee of artists who, in 1503, considered the erection and placing of Michel Angelo's David. The date of his death is not known; he was of the same age as Leonardo. Further details will be found in '*Notizie di Attavante miniatore, e di alcuni suoi lavori*' (Milanese's ed. of Vasari, III, 231-235).]

1526.

On the morning of San Peter's day, June 29th, 1504, I took io ducats, of which I gave one to Tommaso my servant to spend.

On Monday morning 1 florin to Salai to spend on the house.

On Thursday I took 1 florin for my own spending.

Wednesday evening 1 florin to Tommaso, before supper.

Saturday morning 1 florin to Tommaso.

Monday morning 1 florin less 10 soldi.

Thursday to Salai 1 florin less 10 soldi.

For a jerkin, 1 florin.

For a jerkin And a cap 2 florins.

To the hosier, 1 florin.

To Salai, 1 florin.

Friday morning, the 19th of July, 1 florin, less 6 soldi. I have 7 fl. left, and 22 in the box.

Tuesday, the 23th day of July, 1 florin to Tommaso.

Monday morning, to Tommaso 1 florin.

[Wednesday morning 1 fl. to Tommaso.]

Thursday morning the 1st day of August 1 fl. to Tommaso.

Sunday, the 4th of August, 1 florin.

Friday, the 9th day of August 1504, I took 10 ducats out of the box.

1527.

1504. On the 9th day of August, 1504, I took 10 florins in gold[2] ... [3] on Friday the 9th day of August fifteen grossoni that is fl. 5 S 5 ... given to me 1 florin in gold on the 12th day of August [4] ... on the 14th of August, 32 grossoni to Tommaso. On the 18th of the same 5 grossoni to Salai. On the 8th of September 6 grossoni to the workman to spend; that is on the day of our Lady's birth. On the 16th day of September I gave 4 grossoni to Tommaso: on a Sunday.

[Footnote: In the original, the passage given as No. 1463 is written between lines 2 and 3 of this text, and it is possible that the entries in lines 3 and 4 refer to the payments of Jacopo Tedesco, who is there mentioned. The first words of these lines are very illegible.]

[Footnote 7: *_Al fattore._* Il Fattore, was, as is well known, the nick-name of Giovanni Francesco Penni, born in Florence in 1486, and subsequently a pupil of Raphael's. According to Vasari he was known by it even as a boy. Whether he is spoken of in this passage, or whether the word Fattore should be translated literally, I will not undertake to decide. The latter seems to me more probably right.]

1528.

On the day of October, 1508, I had 30 scudi; 13 I lent to Salai to make up his sister's dowry, and 17 I have left.

1529.

Memorandum of the money I have had from the King as my salary from July 1508 till April next 1509. First 100 scudi, then 70, then 50, then 20 and then 200 florins at 48 soldi the florin. [Footnote: Compare No. 1350 and 1561.]

1530.

Saturday the 2nd day of March I had from Santa Maria Novella 5 gold ducats, leaving 450. Of these I gave 2 the same day to Salai, who had lent them to me. [Footnote: See ' _Conto corrente di Leonardo da Vinci con lo Spedale di S. Maria Nuova_' [1500 a 1507, 1513-1520] published by G. UZIELLI, _Ricerche intorno a Leonardo da Vinci, Firenze, 1872, pp. 164, 165, 218 and 219. The date here given by Leonardo does not occur in either of the accounts.]

1531.

Thursday, the eighth day of June, I took 17 grossoni, 18 soldi; on the same Thursday in the morning I gave to Salai 22 soldi for the expenses.

1532.

To Salai 4 grossoni, and for one braccio of velvet, 5 lire, and 1/2; viz. 10 soldi for loops of silver; Salai 14 soldi for binding, the making of the cloak 25 soldi. [Footnote: Compare No. 1523.]

1533.

I gave to Salai 93 lire 6 soldi, of which I have had 67 lire and there remain 26 lire 6 soldi.

1534.

To Salai S 42

2 dozen of laces S 8

for papers S 3 d 8

a pair of shoes S 14

for velvet S 14

a sword and knife S 21

to the barber S 11

to Paolo for a ... S 20

For having his fortune told S 6

1535.

On Friday morning,
one florin to Salai to
spend; 3 soldi received

bread S.. d

wine S.. d

grapes S.. d

mushrooms S.. d

fruit S.. d

[Footnote 6: Compare Nos. 1545, l. 4 and 5,
with similar entries for horse's fodder.]

bran S.. d

at the barber's S.. d

for shoes S.. d

1536.

On Thursday morning one florin.

1537.

On Saint Ambrose's day from the morning to Thursday 36 soldi.

1538.

The moneys I have had from Ser Matteo;
first 20 grassoni, then on 13 occasions 3 f.
and then 61 grassoni, then 3, and then 33;
46 soldi 12 grossoni.

1539.

For paper S 18

for canvas S 30

for paper S 10 d 19

Total S 73

1540.

20 pounds of German
blue, at one ducat the pound lire 80 S d

60 pounds of white, S..
the pound lire 15 S d

1 1/2 pound at 4 S the pound lire 6 S d

2 pounds of cinnabar at
S 18 the pound lire 1 S 16 d

6 pounds of green at S 12
the pound lire 3 S 12 d

4 pounds of yellow at S 12
the pound lire 2 S 8 d

1 pound of minium at S 8
the pound lire 0 S 8 d

4 pounds of ... at S 2
the pound lire 0 S 8 d

6 pounds of ochre at S 1
the pound lire 0 S 6 d

black ... at S 2 the pound
for 20 lire 2 S 0 d

wax to make the stars
29 pounds at S--the pound lire 0 S 0 d

40 pounds of oil for painting
at 5 soldi the pound lire 10 S 0 d

Altogether lire 120 d 18
without the gold. 18

tin for putting on the gold 120 18

58

1541.

Two large hatchets and one very small one, 8 brass spoons, 4
tablecloths, 2 towels, 15 small napkins, 2 coarse napkins, 2 coarse
cloths, 2 wrappers, 3 pairs of sheets, 2 pairs new and 1 old.

1542.

Bed 7 0 S

ring 7 0

crockery 2 5

gardener 1 2

..... 2 8

porters 2 1

glasses 1

fuel 3 6

a lock 1

Section title: Miscellaneous Notes.

1543.

New tin-ware 3 pairs of sheets
6 small bowls, each of 4 breadths,
6 bowls, 2 small sheets,
2 large dishes, 2 tablecloths and 1/2,
2 dishes medium size, 16 coarse cloths,
2 small ones 8 shirts,
Old tin-ware 9 napkins,
3 small bowls, 2 hand-towels.
4 bowls,
3 square stones,
2 small bowls,
1 large bowl,
1 platter,
4 candlesticks,
1 small candlestick.

1544.

Hose S 40
straw S 60
wheat S 42
wine S 54
bread S 18
meat S 54
eggs S 5
salad S 3
the Barber S 2 d 6
horses S 1

1545.

Sunday

meat S 10 d
wine S 12 d
bran S 5 d 4
herbs S 10 d
buttermilk S 4 d 4
melon S 3 d
bread S 3 d 1

Monday S 9 8

..... S 6 d
wine S 12 d
bran S 9 d 4
buttermilk S 4 d 4
herbs S 8 d

Tuesday S d

meat S 0 d 8
wine S 12 d
bread S 3 d
meal S 5 d 4
herbs S 8 d

Wednesday

wine S 5 d
melon S 2 d
meal S 5 d 4
vegetables S 8

Notes by unknown persons among the MSS. (1546-1565).

1546.

Miseracione divina sacro sancte Romane ecclesie tituli n cardinalis
2wulgariter nuncupatus venerabili religioso fratri Johanni Mair
d'Nustorf 3ordinis praedicatorum provintie teutonie (?) conventus
Wiennensis capellano 4 nostro commensali salutem in dno sempiternam
Religione zelus rite ac in [ferite?] 5honestas aliarumque
laudabilium probitatis et virtutum merita quibus apud nos fide
6digno commendationis testimonio Magistri videlicet ordinis felicis
recordacionis Leonardi de 7Mansuetis de Perusio sigillo suo ... us
dans tibi ad ... opera virtutum comen(salem)? 8 locum et tempus
success(ores) cujus similiter officium ministratus qui
praedecessoris sui donum (?) 9confirmavit et de novo dedit
aliorumque plurima [laudatis] qui opera tua laudant 10nos inducunt
ut tibi (?) reddamus ad gratiam liberalem hinc est quod nos
cupientes. [Footnote: The meaning of this document, which is very

difficult to decipher, and is written in unintelligible Latin, is, that Leonardo di Mansuetis recommends the Rev. Mair of Nusdorf, chaplain at Vienna, to some third person; and says also that something, which had to be proved, has been proved. The rest of the passages on the same leaf are undoubtedly in Leonardo's hand. (Nos. 483, 661, 519, 578, 392, 582, 887 and 894.)]

1547.

Johannes Antonius di Johannes Ambrosius de Bolate. He who lets time pass and does not grow in virtue, the more I think of it the more I grieve. No man has it in him to be virtuous who will give up honour for gain. Good fortune is valueless to him who knows not toil. The man becomes happy who follows Christ. There is no perfect gift without great suffering. Our glories and our triumphs pass away. Foul lust, and dreams, and luxury, and sloth have banished every virtue from the world; so that our Nature, wandering and perplexed, has almost lost the old and better track. Henceforth it were well to rouse thyself from sleep. The master said that lying in down will not bring thee to Fame; nor staying beneath the quilts. He who, without Fame, burns his life to waste, leaves no more vestige of himself on earth than wind-blown smoke, or the foam upon the sea. [Footnote: From the last sentence we may infer that this text is by the hand of a pupil of Leonardo's.-- On the same sheet are the notes Nos.1175 and 715 in Leonardo's own handwriting.]

1548.

On the morning of Santo Zanobio the 29th of May 1504, I had from Lionardo Vinci 15 gold ducats and began to spend them.

to Mona Margarita	S 62 d 4
to remake the ring	S 19 d 8
clothes	S 13
good beef	S 4
eggs	S 6
debt at the bank	S 7
velvet	S 12
wine	S 6 d 4
meat	S 4
mulberries	S 2 d 4
mushrooms	S 3 d 4
salad	S 1
fruit	S 1 d 4
candles	S 3
...	S 1
flour	S 2

Sunday 198 8

bread	S 6
wine	S 9 d 4
meat	S 7

soup S 2
fruit S 3 d 4
candles S 3 d

Monday 31

bread S 6 d 4
meat S 10 d 8
wine S 9 d 4
fruit S 4
soup S 1 d 8

32

1549.

Tuesday

bread S 6
meat S 11
wine S 7
fruit S 9
soup S 2
salad S 1

[Footnote 1548 and 1549: On the same sheet is the text No. 1015 in Leonardo's own handwriting.]

1550.

To Monna Margarita S 5
to Tomaso S 14
to Monna Margarita d 5 S 2
on the day of San Zanobi
left ... after
payment d 13 S 2 d 4
of Monna Margarita

altogether d 14 S 5 d 4

1551.

On Monday, the 13th of February, I lent lire S 7 to Lionardo to spend, Friday d 7.

[Footnote: This note is followed by an account very like the one given as No. 1549.]

1552.

Stephano Chigi, Canonico ..., servant of the honorable Count Grimani at S. Apostoli.

[Footnote: Compare No. 674, 21-23.]

1553.

Having become anxious ... Bernardo di Simone, Silvestro di Stefano, Bernardo di Jacopo, Francesco di Matteo Bonciani, Antonio di Giovanni Ruberti, Antonio da Pistoia.... Antonio; He who has time and waits for time, will lose his friends and his money.

1554.

Reverend Maestro, Domino Giovanni, I spoke to Maestro Zacaria as a brother about this business, and I made him satisfied with the arrangement that I had wished; that is, as regards the commission that I had from the parties and I say that between us there is no need to pay money down, as regard the pictures of the ...

1555.

Of things seen through a mist that which is nearest its farthest limit will be least visible, and all the more so as they are more remote.

1556.

Theodoricus Rex Semper Augustus.

1557.

Either you say Hesperia alone, and it will mean Italy, or you add ultima, and it will mean Spain. Umbria, part of Tuscany.

[Footnote: The notes in Greek, Nos. 1557, 1558 and 1562 stand in close connection with each other, but the meaning of some words is very doubtful, and a translation is thus rendered impossible.]

1558.

[Footnote: Greek Characters]

1559.

Canonica of ... on the 5th of July 1507; my dearly beloved mother, sisters and cousin I herewith inform you that thanks to God I am ... about the sword which I ... bring it to Maso at the piazza ... and I will settle the business of Piero so that ...

[Footnote: AMORETTI, _Mem. Stor. XXIV_, quotes the first three lines of this letter as by Leonardo. The character of the writing however does not favour this hypothesis, and still less the contents. I should regard it rather a rough draft of a letter by young Melzi. I have not succeeded in deciphering completely the 13 lines of this text. Amoretti reads at the beginning _Canonica di Vaprio_, but _Vaprio_ seems to me a very doubtful reading.]

1560.

Ut bene respondet Naturae ars docta! dedisset
Vincius, ut tribuit cetera - sic animam -
Noluit ut similis magis haec foret: altera sic est:
Possidet illius Maurus amans animam.

[Footnote: These three epigrams on the portrait of Lucrezia Crivelli, a picture by Leonardo which must have been lost at a very early date, seem to have been dedicated to Leonardo by the poet. Leonardo used the reverse of the sheet for notes on geometry.]

Hujus quam cernis nomen Lucretia, Divi Omnia cui larga contribuere
manu. Rara huic forma data est; pinxit Leonardos, amavit Maurus,
pictorum primus hic, ille ducum.

Naturam, ac superas hac laesit imagine Divas Pictor: tantum hominis
posse manum haec doluit, Illae longa dari tam magnae tempera formae,
Quae spatio fuerat deperitura brevi.

1561.

Egidius Romanus on the formation of the human body in the mother's
womb [Footnote 1: *_Liber magistri Egidii de pulsibus matrice
conipositus (cum commentario Gentilis de Fulgineo)_* published in
1484 at Padova, in 1494 and in 1514 at Venice, and in 1505 at
Lyons.].

[Footnote 2:2. This text appears to be in a handwriting different
from that in the note, l. 1. Here the reading is not so simple as
AMORETTI gave it, *_Mem. Star. XXV: A Monsieur Lyonard Peintre du Roy
pour Amboise_*. He says too that this address is of the year 1509,
and Mr. Ravaisson remarks: "*_De cette suscription il semble qu'on
peut inferer que Leonard etait alors en France, a la cour de Louis
XII ... Pour conclure je crois qu'il n'est pas prouve que Leonard de
Vinci n'ait pas fait un voyage de quelques mois en France sous Louis
XII, entre le printemps de 1509 et l'automne de_ 1510._*"--I must
confess that I myself have not succeeded in deciphering completely
this French writing of which two words remain to me doubtful. But so
much seems to be quite evident that this is not an address of a
letter at all, but a certificate or note. *_Amboise_[l. 6]* I believe
to be the signature of Charles d'Amboise the Governor of Milan. If
this explanation is the right one, it can be easily explained by the
contents of Nos. 1350 and 1529. The note, line 1, was perhaps added
later by another hand; and Leonardo himself wrote afterwards on the
same sheet some geometrical explanations. I must also point out that
the statement that this sheet belongs to the year 1509 has
absolutely no foundation in fact. There is no clue whatever for
giving a precise date to this note.] To Monsieur le Vinci,--the
horses of the king's equerry.... Continue the payment to Ms.
Lyonard, Painter to the King.

[6] Amboise.

1562.

[Footnote: Greek Characters]

1563.

Memorandum to Maestro Lionardo to have ... the state of Florence.

1564.

To remind your Excellency that Ridolfo Manini brought to Florence a quantity of crystal besides other stones such as are ...

1565.

XVI C. 6 de Ciuitate Dei, se Antipodes.

[Footnote: A facsimile of this note, which refers to a well known book by St. Augustin, is given on page 254.]

1566.

Leonardo's Will.

Be it known to all persons, present and to come that at the court of our Lord the King at Amboise before ourselves in person, Messer Leonardo da Vinci painter to the King, at present staying at the place known as Cloux near Amboise, duly considering the certainty of death and the uncertainty of its time, has acknowledged and declared in the said court and before us that he has made, according to the tenor of these presents, his testament and the declaration of his last will, as follows. And first he commends his soul to our Lord, Almighty God, and to the Glorious Virgin Mary, and to our lord Saint Michael, to all the blessed Angels and Saints male and female in Paradise.

Item. The said Testator desires to be buried within the church of Saint Florentin at Amboise, and that his body shall be borne thither by the chaplains of the church.

Item. That his body may be followed from the said place to the said church of Saint Florentin by the _collegium_ of the said church, that is to say by the rector and the prior, or by their vicars and chaplains of the church of Saint Denis of Amboise, also the lesser friars of the place, and before his body shall be carried to the said church this Testator desires, that in the said church of Saint Florentin three grand masses shall be celebrated by the deacon and sub-deacon and that on the day when these three high masses are celebrated, thirty low masses shall also be performed at Saint Gregoire.

Item. That in the said church of Saint Denis similar services shall be performed, as above.

Item. That the same shall be done in the church of the said friars and lesser brethren.

Item. The aforesaid Testator gives and bequeaths to Messer Francesco da Melzo, nobleman, of Milan, in remuneration for services and favours done to him in the past, each

[Footnote: See page 420.]

and all of the books the Testator is at present possessed of, and the instruments and portraits appertaining to his art and calling as a painter.

Item. The same Testator gives and bequeaths henceforth for ever to Battista de Vilanis his servant one half, that is the moiety, of his garden which is outside the walls of Milan, and the other half of the same garden to Salai his servant; in which garden aforesaid Salai has built and constructed a house which shall be and remain henceforth in all perpetuity the property of the said Salai, his heirs and successors; and this is in remuneration for the good and kind services which the said de Vilanis and Salai, his servants have done him in past times until now.

Item. The said Testator gives to Maturina his waiting woman a cloak of good black cloth lined with fur, a ... of cloth and two ducats paid once only; and this likewise is in remuneration for good service rendered to him in past times by the said Maturina.

Item. He desires that at his funeral sixty tapers shall be carried which shall be borne by sixty poor men, to whom shall be given money for carrying them; at the discretion of the said Melzo, and these tapers shall be distributed among the four above mentioned churches.

Item. The said Testator gives to each of the said churches ten lbs. of wax in thick tapers, which shall be placed in the said churches to be used on the day when those said services are celebrated.

Item. That alms shall be given to the poor of the Hotel-Dieu, to the poor of Saint Lazare d'Amboise and, to that end, there shall be given and paid to the treasurers of that same fraternity the sum and amount of seventy soldi of Tours.

Item. The said Testator gives and bequeaths to the said Messer Francesco Melzo, being present and agreeing, the remainder of his pension and the sums of money which are owing to him from the past time till the day of his death by the receiver or treasurer-general M. Johan Sapin, and each and every sum of money that he has already received from the aforesaid Sapin of his said pension, and in case he should die before the said Melzo and not otherwise; which moneys are at present in the possession of the said Testator in the said

place called Cloux, as he says. And he likewise gives and bequeaths to the said Melzo all and each of his clothes which he at present possesses at the said place of Cloux, and all in remuneration for the good and kind services done by him in past times till now, as well as in payment for the trouble and annoyance he may incur with regard to the execution of this present testament, which however, shall all be at the expense of the said Testator.

And he orders and desires that the sum of four hundred scudi del Sole, which he has deposited in the hands of the treasurer of Santa Maria Nuova in the city of Florence, may be given to his brothers now living in Florence with all the interest and usufruct that may have accrued up to the present time, and be due from the aforesaid treasurer to the aforesaid Testator on account of the said four hundred crowns, since they were given and consigned by the Testator to the said treasurers.

Item. He desires and orders that the said Messer Francesco de Melzo shall be and remain the sole and only executor of the said will of the said Testator; and that the said testament shall be executed in its full and complete meaning and according to that which is here narrated and said, to have, hold, keep and observe, the said Messer Leonardo da Vinci, constituted Testator, has obliged and obliges by these presents the said his heirs and successors with all his goods moveable and immoveable present and to come, and has renounced and expressly renounces by these presents all and each of the things which to that are contrary. Given at the said place of Cloux in the presence of Magister Spirito Fieri vicar, of the church of Saint Denis at Amboise, of M. Guglielmo Croysant priest and chaplain, of Magister Cipriane Fulchin, Brother Francesco de Corion, and of Francesco da Milano, a brother of the Convent of the Minorites at Amboise, witnesses summoned and required to that end by the indictment of the said court in the presence of the aforesaid M. Francesco de Melze who accepting and agreeing to the same has promised by his faith and his oath which he has administered to us personally and has sworn to us never to do nor say nor act in any way to the contrary. And it is sealed by his request with the royal seal apposed to legal contracts at Amboise, and in token of good faith.

Given on the XXIIIrd day of April MDXVIII, before Easter.

And on the XXIIIrd day of this month of April MDXVIII, in the presence of M. Guglielmo Borian, Royal notary in the court of the bailiwick of Amboise, the aforesaid M. Leonardo de Vinci gave and bequeathed, by his last will and testament, as aforesaid, to the said M. Baptista de Vilanis, being present and agreeing, the right of water which the King Louis XII, of pious memory lately deceased gave to this same de Vinci, the stream of the canal of Santo Cristoforo in the duchy of Milan, to belong to the said Vilanis for ever in such wise and manner that the said gentleman made him this gift in the presence of M. Francesco da Melzo, gentleman, of Milan and in mine.

And on the aforesaid day in the said month of April in the said year MDXVIII the same M. Leonardo de Vinci by his last will and testament gave to the aforesaid M. Baptista de Vilanis, being present and agreeing, each and all of the articles of furniture and utensils of his house at present at the said place of Cloux, in the event of the said de Vilanis surviving the aforesaid M. Leonardo de Vinci, in the presence of the said M. Francesco Melzo and of me Notary &c. Borean.

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th lined with fur, a ... of cloth and two ducats

paid once only; and this likewise is in remuneration for good

service rendered to him in past times by the said Maturina.

Item. He desires that at his funeral sixty tapers shall be carried which shall be borne by sixty poor men, to whom shall be given money for carrying them; at the discretion of the said Melzo, and these tapers shall be distributed among the four above mentioned churches.

Item. The said Testator gives to each of the said churches ten lbs. of wax in thick tapers, which shall be placed in the said churches to be used on the day when those said services are celebrated.

Item. That alms shall be given to the poor of the Hotel-Dieu, to the poor of Saint Lazare d'Amboise and, to that end, there shall be given and paid to the treasurers of that same fraternity the sum and amount of seventy soldi of Tours.

Item. The said Testator gives and bequeaths to the said Messer

Francesco Melzo, being present and agreeing, the remainder of his pension and the sums of money which are owing to him from the past time till the day of his death by the receiver or treasurer-general M. Johan Sapin, and each and every sum of money that he has already received from the aforesaid Sapin of his said pension, and in case he should die before the said Melzo and not otherwise; which moneys are at present in the possession of the said Testator in the said place called Cloux, as he says. And he likewise gives and bequeaths to the said Melzo all and each of his clothes which he at present possesses at the said place of Cloux, and all in remuneration for the good and kind services done by him in past times till now, as well as in payment for the trouble and annoyance he may incur with regard to the execution of this present testament, which however, shall all be at the expense of the said Testator.

And he orders and desires that the sum of four hundred scudi del Sole, which he has deposited in the hands of the treasurer of Santa Maria Nuova in the city of Florence, may be given to his brothers now living in Florence with all the interest and usufruct that may have accrued up to the present time, and be due from the aforesaid treasurer to the aforesaid Testator on account of the said four hundred crowns, since they were given and consigned by the Testator to the said treasurers.

Item. He desires and orders that the said Messer Francesco de Melzo shall be and remain the sole and only executor of the said will of the said Testator; and that the said testament shall be executed in

its full and complete meaning and according to that which is here narrated and said, to have, hold, keep and observe, the said Messer Leonardo da Vinci, constituted Testator, has obliged and obliges by these presents the said his heirs and successors with all his goods moveable and immoveable present and to come, and has renounced and expressly renounces by these presents all and each of the things which to that are contrary. Given at the said place of Cloux in the presence of Magister Spirito Fieri vicar, of the church of Saint Denis at Amboise, of M. Guglielmo Croysant priest and chaplain, of Magister Cipriane Fulchin, Brother Francesco de Corion, and of Francesco da Milano, a brother of the Convent of the Minorites at Amboise, witnesses summoned and required to that end by the indictment of the said court in the presence of the aforesaid M. Francesco de Melze who accepting and agreeing to the same has promised by his faith and his oath which he has administered to us personally and has sworn to us never to do nor say nor act in any way to the contrary. And it is sealed by his request with the royal seal apposed to legal contracts at Amboise, and in token of good faith.

Given on the XXIIIrd day of April MDXVIII, before Easter.

And on the XXIIIrd day of this month of April MDXVIII, in the presence of M. Guglielmo Borian, Royal notary in the court of the bailiwick of Amboise, the aforesaid M. Leonardo de Vinci gave and bequeathed, by his last will and testament, as aforesaid, to the

said M. Baptista de Vilanis, being present and agreeing, the right of water which the King Louis XII, of pious memory lately deceased gave to this same de Vinci, the stream of the canal of Santo Cristoforo in the duchy of Milan, to belong to the said Vilanis for ever in such wise and manner that the said gentleman made him this gift in the presence of M. Francesco da Melzo, gentleman, of Milan and in mine.

And on the aforesaid day in the said month of April in the said year MDXVIII the same M. Leonardo de Vinci by his last will and testament gave to the aforesaid M. Baptista de Vilanis, being present and agreeing, each and all of the articles of furniture and utensils of his house at present at the said place of Cloux, in the event of the said de Vilanis surviving the aforesaid M. Leonardo de Vinci, in the presence of the said M. Francesco Melzo and of me Notary &c. Borean.

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