

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, 1. 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 chesnuds 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,

a. Picardy.

b. Saxony.

b. Normandy.

c. Nuremberg.

c. Dauphine.

d. Flanders.

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'administration 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 auoit 4 cabinets, de mesme charpenterie ... Il y a pas longtemps qu'il y auoit 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 presenter 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 piedestal lequel auoit 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 piedestal qui portait un troisesme 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. I; 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 linia 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 Sardonijs 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 Ocra 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 Lucan; [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 annem. 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 couronnes 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  $\frac{1}{6}$ , 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 Gostantinopoli a servire il Turco, per mezzo di certi frati di San Francesco, che desiderava averlo per fare un ponte che passassi da Gostantinopoli 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, Vadrus, 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 Galeazze 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 heir 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