THE ASTRONOMIC AND GEOGRAPHIC CULTURE IN ITALY FROM XV TO XVII SEC.

MARINELLA CALISI

Osservatorio Astronomico di Roma
V.le del Parco mellini, 84
00136 ROMA - ITALY

ABSTRACT. The astronomy direction in navigation and development of the cartography.

The navigation put on a remarcable expantion in the period we are interested for the development and diffution of the cartography also. The admission of earth's sphericity, the discovery of techniques always more refined to show on a plane, the convex surface of the earth, the exactly computation of distances by opticals and geometricals processes more and more sure, the best navigation's systems encouraged the great geographic discoveries.

After last Columbus' voyage and the acknowlwedgment to have discovered unknow land, the Portougal, the Spain (for the center and South Americ) and the england (for Canada and Terranova) they showed some documents from which resulted the property of new countries, but only the wonderfull hollander boom cartography filled up the world for much more use of informations.

The Italian maritime Republics, helped the development of cartographys' science.

1. General considerations

Man began sailing very early; earliest examples of voyages by suitable boats can be dated back to 4000 B.C. For several centuries, the art of sailing (sailing-ship or rowing-boats) was entrusted to expert pilots and restricted to long coastal courses and to summertime owing to both safety and back of navigation systems without points of reference.

The choice of the orientation system was always based on the adoption of the two main directions and consequently of the four cardinal points.

The fundamental direction originally chosen by the peoples who lived in the temperate and equatorial zones, was that one given by the apparent movement of the Sun, from its rising to sunset. The East was chosen as the most important point (this ancient pre-eminence derives from the word itself "to orient").

The change of the fundamental direction, from the East-West to the Nord-South, happened with the use of the compass from the Mediterranean sailors (both Cristians and Mussulmans) and with the discovery that the North Star supplied a better reference of direction than the rising of the Sun, a position which varies according to seasons.

Probably, in the original nautical compass there was a magnetic steel needle, put in a straw were or placed on a piece of cork (according to what the chinese did, around 1000 B.C.) floating in a container. The sailor used to reinforce the magnetism before taking the bearing of the North in order to trim the ship.

This primitive compass was used in the Mediterranean during the XIth and the XIIth centuries. Perhaps, during the crusades, the Arabs acted as mediators from East to West, while the real compass, at it is now, came out the next century. The "Amalfitani" improved it which became an effective nautical instrument: they pivotted the needle upon a wooden disk centre marked the index line, applied the wind rose to the needle so as to make them rotate at the same time divided the wind rose into quarters corresponding to the direction of the main winds. Around 150 the first representation of the Earth on a plane was performed by Ptolomy who collected all avaible data on the dimensions of the Earth.

Ptolomy systematically adopted as a terrestrial circumference measuring the value of 180000 stadiums, that is about 33000 km, a value used until a ten-years period after Columbus voyage.

The Ptolemaic method of latitude and longitude was used for 1500 years and till the 17th century.

The larghest extension of the Earth was called lenght i.e. longitude and was measured along the parallels and it extended from Gibraltar as for us the mounths of the Ganges for 180° according to the ancient. Breadth, that is latitude, was the shortest distance measured along meridians including an arch from equator to the Shetland Islands at 23° from Pole.

In the Ptolemaic geographical maps latitude was the division of 7 climatic zones on the ground of the average period of a day.

The extension of a climate in longitude changed for 180° and in latitude for about 8° near the equator till a minimum of 3°.

Breadth of every climate was defined so that the mean (or average) distance of a day, measured in the muddle of tone, had half an hour of difference as regards the period in the adjacent zones.

The introduction of the compass promoted the realization of the early maps for navigation, called also compass-maps: pilot books and graph maps. The use of these maps is enough easy: they included the data necessary to navigation in a single plane by coordinating directions and distances.

The pilot books neither follow projections nor indicate parallels and meridians, but only directions and distances from a part to another, and it took much time to prepare them.

At present there is only the distance scale, the directions of courses, or rhumbs which represent the winds, are obtained from the compass and the distances (in miles and not in degrees) from valuation of innumerable voyages.

These maps show the sea-surface crossed by 16 or 32 sheaps which intersect under several angles, dividing the horizon into as many directions.

These angles refer to the magnetic meridians.

The "graph maps" were equipped with a geographic grid which had equal dimensions of latitude and longitude placed up on the rhumb-lines. This map used by Columbus makes it possible to sail high seas and oceans not too far from the terrestrial equator.

In the past the ships rarely went away from the coasts and when they ventured off-shore, the navigation was mainly effected following meridians and parallels: they sailed along a meridian using the compass till the parallel of arrival point and then they went on along that parallel. Such navigation was possible only up to around 1750, when the navy-clock was used to get the sea-longitude accurately. As the navigation was based on the direction and the distance, it was sufficient to lay out the map compassing it so as to make the main directions coincide with the cardinal points. After determining the starting and arrival points the course to be followed was mapped out. In excellent conditions the course could coincide with a rhumb of the map. In this case, when the wind was steady, it was sufficient to orient the axis of the ship along this line with a compass, modifying the deviations produced from the drift.

During the fourth century, the naval supremacy passed to the Portuguese and the Venetian cartographic experience was placed at disposal of the new discoveries.

From 1436 to 1448 the Venetian Andrea Bianco's maps seem to reflect the data from the Portuguese pilots (for example the big island in the Southern Atlantic is identificable with Brasil).

In 1459 in a single globe, the camoldolite Brother Mauro gathered all information in those days will known and drawn from statements of voyages, and gave many details on the African Continent the Eastern Asia, and the Northen Europe which no map had yet recorded and when he determined the ratio with the continental masses, he was enough realist.

The first map representing the whole Italian peninsula is the " Novella Italia" which was widely spread by press and attached to edition of the Ptolemaic "Geography" thanks to the Florentine Francesco Berlinghieri (1481-1482).

This map, reproduced and imitated for almost a half-century, represents one of the typical attempts of the humanistic period in order to update the Ptolemaic traditional maps including in them the results much more exact than the nautical cartography.

Giacomo Gastaldi, the author (1561) of Italy's a map, the diffusion of which was greatly superior to Europe's maps from Mercatore (1554), had partly access to the Governement documentation, particularly the Savoyard and Venetian one, thanks to his own studies and to previous cartographers' works.

One of the earliest printed maps of the Southern Italy out lined from Pirro Ligorio (1556) and then included in several editions (about 25) of the "Theatrum Orbis Terrarum" by Ortelio (1570) is mainly founded on the historic- archeologic studies of the author and without reserved sources.

Only when the Countries' cartography became official Gastaldi's map lost importance and was definitively replaced with "The new Italy" by Magini (1608), the first cartographer who widely utilized the official sources. During this century no Italian or foreign cartographer will try a synthesis like that one by Magini. It remained the insuperable model of the 16th century cartography.

In late century, Vincenzo Maria Coronelli (1650-1718), the cartographer of the Venetian Republic, realised two globes for Louis XIV in Paris. They were admired by geographers astronomers, navigators and traders all over the world and already in 1642, he had drawn the map of the Eastern Canada and Newfoundland discovered by Giovanni Caboto in 1497.

2. The stars altitude on the horizon

The compass and the pilot chart changed the aspect of the nautical art that that in future will resort to the star observations and so it changed from the estimation of the navigation to the astronomic navigation.

The very interesting news for the nautical astronomy is found in Nicolò Conti's voyage diary (1448). He informs us that the sailors of the Indie, trimmed their sails according the Antartic Pole stars, high or low, they measure the route they make by day and night, and they also measure the distance between one place to another one, so they always know where they are in the sea. This news, shows us that the Indian people was more advanced in nautical astronomy than our sailors who improved only two centuries after the knowledge of this relation.

Up to the early XVI century all the nautical-astronomic science was based on measurement of latitude with meridien altitude of sun or Pole star altitude.
When Cristoforo Columbus began his long voyage across the Atlantic Ocean to discover the East Indies, he thought of being able to fix longitude by the compass, measuring the magnetic declination angle; but he didn't know the magnetic North Pole position. During his first and following voyages, he observed and gave important informations on the change of magnetic declination. As regards the latitude, Columbus could measure it observing the sun and the stars and used an astrolabe (even if he had no exact observations).

As Columbus knew the winds in the lower altitude, for his first voyage, he chose a route so that he could draw advantage from trade-winds, but, at present people know that he deemed the ray and the circumference of the Earth smaller than they are really. For this reason, sailing nearly around a parallel and being not able to fix the longitude, he thought he had discovered some unknown isles near the East Indies.

Therefore, in order to sail along parallels and meridians, it was sufficient to have a compass, to know the latitude of the port and to be able to measure the Pole star altitude on the horizon or some other stars when it passes through the meridian. Every instruments which could measure this angle was sufficient to this end.

Jacob's staff or cross-staff (Balestriglia), perhaps invented by Levi Ben Gerson, a catalan Jew, in 1300 spread in Occident from the Middle Ages; it was necessary to measure the altitutde of a star and consequently to obtain the latitude. It is a stick, with a cross-bar running along it: keeping an extremity of the stick near his eye, the observer makes the cross-bar run vertically until one extremity touches the horizon and the other one the star. By the cross-staff, it was possible to measure the altitude of the sun with the shadow-lenght, by the arm of the cross-bar on the plane. In order to improve the observation of the altitude of the sun, people thought to measure the angle by a circle arc and this began to be done by the Davis quadrant composed of two concentric arcs, with different radii.

The Davis quadrant (i.e. Davis double quadrant) invented by John Davis in 1594, was an improving of the previous instrument and it could be used to measure the altitude of the sun without being blended as the star observation was indirect.

On the contrary the quadrant, was made of a quarter of a wooden or brass circle with two rays joint together with a lead thread. The observer, holding the quadrant vertically, looked at the star from one of its side and the lead thread gave the exact information thank to the quadrant limb.

The astrolabe is made of 50 centimeters in diameter a metal circular box including several maps of the Earth (timpani) and the astrographyc chart. It's kept hanging vertically with a ring, or parallel to the equator. In the former case the instrument materializes the meridian plane and the gravity, orients its axis according to the Zenit-Nadir direction; the star direction was looked through two fins (pinnule) of the alidade. In the latter case the observer can have the exact reproduction of the sky with the astrographic chart.
About 1400 the nautical astrolabe, introduced in Europe derived from homonymous instrument in the tenth century. It was made of heavy-brass ring; at the bottom, there is a mass concentration so as to obtain a good vertical position and stability and with several holes in order to reduce the wind speed. By a well-balanced alidade it was possible to look at the star. The same alidade supplied the altitude which was read on a scale along the circonference.

As from XVI century the earth's globes had a wide diffusion and they show a real testimony of geographical knowledge in this century; this is the case of Brother Coronelli's globes; these globes are muche bigger than the prevoius ones, they are generally copuled and reproduce voth the celestial and terrestrial globes. In XVI and XVII centuries, among several nautical instruments there were also the armillary spheres which allowed the passage from the equatorial coordinates to the orizzontal and time-coordinates in order to work out some important astronomical problems so it was possible to quicky identify the stars after orienting them on the latitude or on local sideral time (L.S.T.).

The astrolabe, much better than the other instruments used by the sailors (Jacob's stick) in ancient times for observing the altitude and the elongation of the stars, was used for two more centuries, in XVIII century more accurate instruments were used. However, the problem on the exact measuring of longitude remained unsolved, even as the voyages between Europe and America became more numerous. For this reason, astronomers, mathematicians and builders of time measuring instruments devoted much of their time to the resolution of a problem that at first only regarded sailors and geographers.

Astronomy teached to read, in the sky, the movement of a mobile object on the earth's surface. Looking at the stars, you can note that they have the same distance and they move from the East to the West around more o less long circumferences according to their distance from the celestial North Pole, and near it, the Pole Star rotates. It is possible to identify the constellations with alignement method: as you locate the Great Bear, it is possible to fix the position of Little

Bear, Cassiopea, Cefeo, Drago, Andromeda, Perseo, Cocchiere, Toro, Ariete, Pesci, Gemelli, Orione, Leone Maggiore, Idra, Cancro, Arturo, Vergine, Libra Corona, Ercole , Ofiuco, Lira Cigno, Aquila, Pegaso, Delfino, Acquario, Scorpione.

Such a method links these constellations together so that if you want to identify one of them, it is necessary to know all the prevoius ones starting from the Great Bear.

In order to find any main star, it is necessary to calculate the time when the star culminates in board meridian and its altitude apart from the constellations concerned. When the culmination time is calculated the star Azimuth is known and in order to calculate its distance from horizon, it is sufficient to find its meridian altitude.

By end of XV century some rudimentary ephemerides appeared; They give coordinates of the sun day by day (declination, degrees and minutes, right ascension, RA). These are Ephemerides calculated by Regiomontano from 1475 to 1506. In order to locate the ship position it was necessary to know its longitude too.

For determining this other coordinate fairly exactly the ship speed was calculated with a view to evaluating the distance covered.

The log (solcometro) was used to read this measure. Its shape and characteristics changed during the centuries. In time past it was made of a ballasted wooden triangle thrown into the sea as a fix point; a log line with some equidistant knots ran through the steersman's fingers according to the marked time by a sand glass. It was sufficient to count knots passing through a fixed point, in order to know the speed of ship. Today the ship speed is still checked by knots.

The first measuring of longitude by transit time is up to Ferdinando Columbus (Christopher's son), who proposed it to the Spain King Philip II in 1524. He talked about a *flowing instrument* which keeps the time of a starting meridian as longer as possible. The first instruments used to calculate the time were the gnomons then some different solar quadrants (the quarter of circle, style solar quadrant named *Augusta* based on changes of Azimuth, diptyches of Nuremberg and the equinotial ring) and the sand glasses.

On the contrary the nightable permetted to know the night time according to the Great Bear axis composed of the two last stars in connection with the Pole Star, as this axis makes a revolution for 24 hours. Before the observation, the index of the revolving inside crown must be positioned on the date. Grasped the throne, through the central hole we should see the Pole Star and then we turn the Alidade until its edge coincides with the ideal axis made of Pole Star and the two last stars of the Great Bear. The local time is supplied by the position of the Alidade with the graduated internal circle.

In XVII century the only astronomic measure at sea were the latitude, the Sun and the Pole Star. Philip III, the king of Spain, proposed to award a prize to anyone who had solved the problem to obtain the longitude at sea with observation.

In order to obtain the longitude or the difference of longitude, several methods were proposed but all based on the difference of the local times of two points and which is exactly the same of two longitudes due to the rotation of the Earth. So, in order to fix the difference of longitudes between two places, it is sufficient to determine the time interval between the passage of the Sun or of a star on their both meridians. It will be sufficient to multiply the difference of the two values found, for 15, expressed in hours and minutes (whichever point of the terrestrial surface makes a rotation around the axis of the Earth for 24 hours and dividing 360:24=15).

The problem consisted in knowing the time on board and the time, in the same moment, in another place on a given meridien. The time on board was determined observing the altitude of the Sun or a Star; it was necessary to know the time on the reference meridian, in any moment and off shore and additionally a connection affered by the systematic astronomical observation or by the contemporary observation in two different places, of an event which could be observed and identified without ambiguity like an eclipse or like an occultation of a star. The well-known method was based on the lunar distances: in less than one month, the moon makes the total rotation around the Earth, so, its position changes quickly in front of the stars and planets.

The result was a detailed study of the lunar distances (apparent or angular) of the stars and the starting of attempts to solve the problem of distances (apparent or angular) of the stars and to try to solve the problem of longitudes with other lunar observations like the time of culmination, the simultaneous passage of a star and the moon on the meridian. In 1679 there appeared the Ephemerides Connaissance des Temps by the Academy of Science; there are the times of occultation of Jove's planets to be used for longitudes; such a method was given by Galilei.

The first tables of the eclipse of Giove's planets appered in 1630, by Cassini and the Danish Romer. But this method is rarely used by the sailors.

Gemma Frisius, born in the LWO countries in 1508, was the first person who had an idea to use the lunar distances in order to calculate the geographical longitudes, while Morin was the first person who proposed an exact calculation system to solve this problem. The Morin system was tried at sea for the first time by the famous Halley in 1699-1700, and it was reccomended as a sure mean to solve the problem of longitude. Only by the end of 700 exact clocks were made available at sea. So it was possible to determine the point with about 1 km mistake and to design detailed maps.