

PRINCE HENRY OF PORTUGAL AND THE PROGRESS OF NAUTICAL CARTOGRAPHY

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The 13th November, 1960, marked the quincentenary of the death of Prince Henry, surnamed the Navigator, without doubt the most outstanding Portuguese personality in the history of the world. Both in Portugal and in other countries the occasion was duly commemorated by various ceremonies. In the cultural field, there were congresses, exhibitions and the issue of numerous publications.

Although the figure of Prince Henry has for long been the centre of discussion and research, it still remains the subject of heated dispute. Opinions vary regarding the purpose that inspired him, and the true nature of his work, but everyone agrees that he played an important part in the history of mankind.

During the 19th century, and for part of the 20th, it was common belief that Prince Henry had systematically encouraged the application of the scientific knowledge of the time to the art of navigation and cartography: he had founded the so-called School of Sagres (where astrologers

and cartographers could discuss nautical problems and improve upon the instruction of seafarers); he had established an observatory there; he had created the nautical chart on the rectangular cylindrical projection, etc. In the light of new facts, this belief is today considered outdated, but this does not in any way lessen the importance of the part played by Prince Henry. His greatest merit lies in that he brought together a scattered group of men whose knowledge launched the Portuguese across the oceans, and that, though especially after his death, the progress made in the art of navigation and in nautical cartography, was spectacular.



FIG. 1. — Prince Henry, from the Pannels of S. Vicente
(Nuno GONÇALVES. XVth century)

To be able to appreciate the extent of this progress, it may be well to recall how the seas of Europe were navigated at the beginning of the 15th century. In the North, where the continental shelf covers a vast area, pilots navigated without charts, finding their way mainly by depth soundings and by types of bottom; the sharp rise and fall of the tides soon made them realize how necessary it was to have foreknowledge of the times of high and low water. The Vikings were mainly responsible for a type of navigation on the high seas for the voyage from Norway to Greenland which was made easier by the mountainous islands observed on the way, and their vast underwater shelves. It is an interesting fact that the flight

of birds often served to guide these fearless sailors, and that this practice was later to become current among Portuguese seafarers.

In the Mediterranean basin, piloting methods were traditionally more advanced. The rutters — called *portulans* by the Italians — were of remote origin and, with the progressive use of the magnetic needle set upon a wind-rose (12th and 13th centuries), began to include the routes between coastal landmarks, and the original eight winds were increased to thirty-two. It is not by mere chance that the oldest nautical charts we know date from the end of the 13th century and the beginning of the 14th, or that the outlines of the coasts have been traced over a network of lines emanating from a central wind-rose surrounded by another sixteen or thirty-two wind-roses, or that the outline should appear distorted by the influence of magnetic declination. The origin of this type of chart, resulting from the general use of the magnetic needle with its respective wind-rose, undoubtedly marks a turning point in the history of navigation and is one of the most important contributions by the seafarers of the Mediterranean to the progress of the art of navigation. As regards instruments, the equipment of the Mediterranean pilot was modest indeed, and the cosmographical knowledge at his disposal was equally scant and simple: the hour-glass; the magnetic needle with its wind-rose; a pair of dividers and a ruler to mark the position and draw the routes on the chart (which was of only one scale throughout); the *toleta de marteloio* (which shows the distance travelled along the set course when tacking); the sounding-lead; the nocturnal, or a *regimen* to determine the time at night by the alignment between the Polar Star and the Guards of the Lesser Bear; and, finally, a few elements about almanac computation.

This type of navigation, so well adapted to conditions in the Mediterranean, was to remain unchanged for a long time. Two hundred years after the Portuguese had been using the new methods of astronomical navigation, the old system of estimated navigation using charts without degrees of latitude was still in use in the Mediterranean. Only in the 14th and 15th centuries did the pilots of the northern seas of Europe begin to use the magnetic needle with the wind-rose, and the chart drawn over the network of rhumb lines. Their instruments and their stock of knowledge were thereby reduced, but they were better supplied concerning tide computation, due to the conditions of the region.

In Portugal, at the southern end of the Atlantic region of Europe, the vessels and the methods of navigation of that area developed together, and at the same time the proximity of the Mediterranean brought to the Lusitanian sailors the benefit of the progress registered in that sea at the end of the Middle Ages. After the capture of Ceuta in 1415, and after the discovery of Madeira and the first attempts to explore southwards along the African coast, the Portuguese discoveries led by Prince Henry, began with the finding of the Açores in 1427, and the doubling of Cape Bojador in 1437. It is significant that the discovery of the islands should have preceded by a few years the doubling of that cape, as it seems to indicate that by then the manner of bringing a sailing ship back from Africa had been found. This is an important point that is generally overlooked in the history of the discoveries and of navigation. Until then, European seafarers navigated mostly along the coasts and the great difficulty in

sailing beyond Cape Bojador was how to make the return voyage to Europe against the trade winds. This was difficult enough with pulling vessels, as the desolate coast of the Sahara offered no opportunities to take on water or victuals. If sailing ships were to make the return voyage along the coast, they would be entirely dependent on the vagaries of the coastal breezes. The Portuguese developed a type of vessel well adapted to overcome these difficulties, the *caravel*, "the best vessel that sails the seas", as Cadamosto said. It was Prince Henry who began to use the *caravel* for the voyages of discovery until it became, par excellence, the vessel to explore the Atlantic and its shores. The Azores are exactly on the dividing zone of the trade winds and the westerlies, and there is evidence to show that the Portuguese lost no time in using the *volta do mar largo* (putting out to the high seas) to return to European shores from the African coast. With the northeast winds they set their course northwest to gain latitude and, as they reached the Azores, they met the variable winds that set them on an easterly course. In this way, it was not long before they had reached the edge of the Sargasso sea — Andrea Bianco, in a map dated 1436, already refers to the typically Portuguese name of *Mar de Baga*. As the discovery of the coast extended southwards, the longer became the *volta do mar largo*, and the Portuguese seafarers met with conditions very different to those found in the Mediterranean and in the Viking crossings from Norway to Greenland. In both these cases, navigation was made mainly in longitude, either along an interior sea and always close to the coast, or over the ocean helped by the knowledge of depths as well as landmarks in the mountainous islands. The Portuguese seafarers had no such recourse, especially on their return voyages from Africa: they had no alternative but to sail the high seas for many days on end without sighting land, and could take no soundings. The Azores, and the changing winds they met there, were their only points of reference, unless any help was to be had from the quantity of sargasso they found and the flights of birds they met.

This is how the first discoveries were made but, as the vessels pushed further south and the ocean crossings became longer, the need for a more efficient method of navigation became increasingly felt. These crossings were made mainly in latitude (the opposite to the voyages in the Mediterranean and from Norway to Greenland), and the seafarers must have soon become accustomed, if only by dint of experience, to the rapid change in the altitude of the stars (especially the Pole Star) on the meridian transit (Cadamosto, for instance, records that at the River Gambia the altitude of the Pole Star was equal to the height of a lance).

There are practically no sources from which can be traced the evolution of the art of navigation during the greatest part of the 15th century, but the few there are and, more especially, certain *regimens* printed at the beginning of the 16th century, enable us to follow its progress. These *regimens*, already outdated (and, for this reason, probably used by the less practised pilots), had already been replaced by others more advanced. From the former, we may deduce that there had come into being a new type of "navigation by the differences of altitudes", which made use of the Pole Star, some other stars, and even the Sun. By the new method, before the pilot started on his voyage, he took the altitude of the Pole Star with his quadrant at a determined position of the Guards of the Lesser Bear, or the

altitude of a star as it crossed the meridian. During the voyage, when he took the altitude of the same star under identical circumstances, he would know the variation in degrees of altitude between these two points and convert them into leagues (at first, each degree of latitude was reckoned to be equal to $16\frac{2}{3}$ leagues and, later, to $17\frac{1}{2}$ leagues), which gave him the distance he had travelled due south. The Sun was also used, either by taking its altitude at the meridian on successive days (thus making no allowance for the difference in declination), or by comparing these altitudes with those furnished by a set of tables specially calculated to give the altitude of the Sun at the meridian in various ports throughout the year. Apparently there were also quadrants in use whose limbs were graduated with the altitude of the Pole Star for a certain position of the Guards (or the latitude itself, if the position of the Guards was such that the Pole Star was at the same altitude as the Pole, or if the necessary correction was made), and that for certain ports and landmarks.

The nautical charts used for this method of navigation remained unaltered; the only difference was that, due to the astronomical control of the distance travelled due south, the position could be more easily reckoned. Even when accurate latitudes were obtained by means of the quadrant and close to the coast, these were only used to identify coastal landmarks for checking against the information given in the rutters. Contemporary documents seem to indicate that this method of navigation was already in use at the time of Prince Henry. Its introduction marks a date of special interest in the history of navigation, for it gave the seafarer, even after many days of the high seas, a feeling of not being lost. It also means that the theorist and the practitioner, the astrologer and the pilot had finally been brought together, and brought new hopes of further progress to come. And, in effect, after the death of Prince Henry in 1460, there were important developments in the field of navigation and nautical cartography. At the time of the Prince's death, vessels had already sailed beyond Sierra Leone and reached the lower latitudes. The Pole Star was no longer visible and, as the distance from Portugal became longer, the length of time at sea (especially on the return voyage) increased accordingly. The experience gained, the better trained pilots, and the need of a new method of navigation to overcome the mounting difficulties, led to the adoption aboard ship of certain methods of reckoning latitude that were already used ashore.

These, however, were not enough; a new type of nautical chart containing a scale of latitudes was required — until then charts showed only directions and distances. This called for a new survey of the coasts already charted. The new methods of navigation and the new survey of the coast, together with the subsequent amendment of the rutters, apparently began at the time of Diogo Cão's first voyage (1483-4, when the River Congo was discovered), and shortly after King João II, Prince Henry's grandnephew, had come to the throne.

To introduce aboard ship the same methods of reckoning latitude as were used ashore, was not as easy as might be supposed. The traditional instruments of the European pilots were very rudimentary, and he himself was not qualified to cope with calculations of latitude by the Sun in the same way as were the competent cosmographers of the time. For this

reason, seafarers went through a course of elementary astronomy (principally based on Sacrobosco's "Treaty on the Sphere"), and navigational instruments (quadrant and astrolabe) had to be made as simple as possible: tables of declination of the Sun to be simplified, certain rules for observation and calculation to be simplified, etc. Critics of facile discrimination have said that the Portuguese brought then nothing new to navigation, since the astronomical basis of such methods of navigation had been common knowledge for a long time. This shows a complete lack of knowledge of the subject. The credit to be given to the Portuguese is not for any new discovery in the field of astronomy, but for placing at the disposal of the seafarer the knowledge already existing and which, until that time, had been the exclusive property of a small group of men. Apart from the limited earlier cases, it was at this stage that the astrologer and the pilot actually met for the first time. Navigation by the stars was definitely launched on its way in the West, and from then onwards, thanks to the close contact between the scientist and the practitioner, its progress went unchecked. It is this that can be called the great revolution brought about by the Portuguese in the history of western navigation, and no argument, such as the above, can gainsay it; for during hundreds of years anyone could have put the new methods into effect, but none did. The task fell to the Portuguese because they were the first to put into practice systematic ocean navigation in the Atlantic, sailing for days on end far from the mainland and the shallows that could help them in reckoning of their position.

With the issue of the *Regimen of the North* (giving the latitude by the Pole Star) the *Regimen of the declination*, or *Regimen of the height of the Pole by the Sun* (giving the latitude by the Sun's meridian transit), with the respective tables of declination of the Sun (for 1483, 1497-1500 and 1517-1520), the *Regimen of the Leagues* (giving the distance travelled in various directions for each degree of latitude), the *Regimen of the hours of the night by the Southern Cross* and the *Regimen of the height of the Pole by the Southern Cross* (c. 1507), the foundations of astronomical navigation were laid. Except for a few minor changes or improvements, these basic *regimens* of the new "navigation by latitudes" remained in use until the last quarter of the 16th Century, when the Dutch and the English, principally, began to contribute their own improvements to nautical science. All the countries that bordered on the Atlantic Ocean — the Spaniards, the French, the Dutch and the English — who began their own ventures overseas, followed in Portugal's footsteps and adopted in their entirety the nautical *regimens* originated by the Portuguese — a fact that can easily be confirmed by the inspection of the nautical works, both in manuscript and in print, that have survived to our day. Translations were made direct from the Portuguese originals (or from Spanish works based on them). Further confirmation is found in the large number of Portuguese pilots and cosmographers who entered the service of those countries. Contemporary documents contain many instances of the attempts made by the governments of various countries (especially Spain and France) to contract the expert Portuguese pilots and cosmographers, and the corresponding counter-measures adopted by Portugal.

As already mentioned, the method of navigating by latitudes observed

astronomically called for the preparation of charts graduated in latitudes. Prior to this, the coastal outline was obtained by a combination of directions and distances which required no special calculation — the outline was obtained in exactly the same way as the position was marked on the chart, and the pilot-discoverer was at the same time a pilot-cartographer. With the beginning of navigation by latitudes, a new chart of the coasts was required and, about 1485, orders were given to certain individuals for a new survey of the African coasts. Among these were José Vizinho (a noted astronomer who had worked on the first nautical *regimens* for the determination of latitude) and Duarte Pacheco Pereira (navigator and author of the *Esmeraldo de Situ Orbis*, a very important rutter covering the coast from Ceuta to South East Africa). One may with reason say that these were the first hydrographical missions to be sent out on purely hydrographical work.

Unfortunately, no charts of Prince Henry's time are known today; but there are several dozens of Catalan and Italian charts, copied from the lost Portuguese originals, that record the results of the maritime discoveries of his age. The earliest known Portuguese charts are an anonymous one of the last quarter of the 15th Century, in Modena (fig. 2), and another

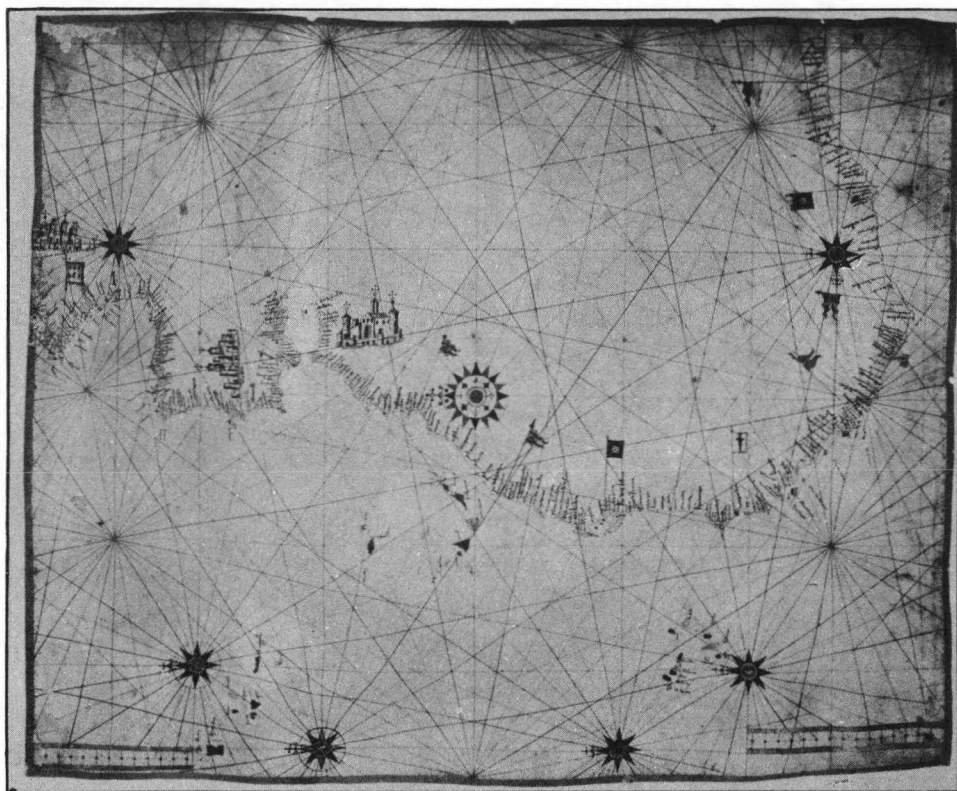


FIG. 2. — Anonymous Portuguese chart of the last quarter of the XVth century
(Biblioteca Estense, Modena)
Scales of distances in the lateral margins; no scale of latitudes

by Pedro Reinel of circa 1485, in Bordeaux. These two charts still show the outline of the coasts obtained by the traditional methods of directions and distances, and there are no latitudes indicated, which proves that navigating by latitudes was not yet in general use. Unlike the charts used before and after this time, these two charts have scales of distances marked in the direction north-south, which may indicate a phase of navigation by differences of altitude converted into distances. Cantino's planisphere of 1502 does not yet contain the scale of latitudes, but shows the Equator and the Tropics, and the outline of the African continent is extraordinarily accurate, due to the results obtained from the hydrographic missions where José Vizinho and Duarte Pacheco Pereira worked. The oldest known charts to show the graduation of latitudes are both the work of the Portuguese, one anonymous and the other by Pedro Reinel (c. 1500 and c. 1504, both in Munich) (fig. 3).

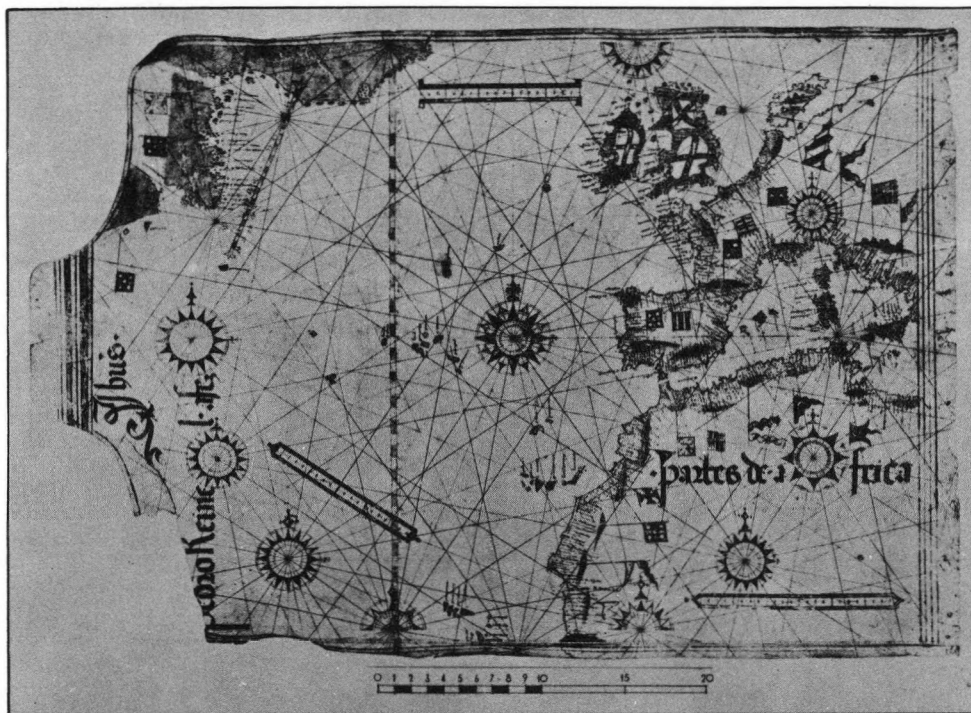


FIG. 3. — Pedro REINEL's chart, c. 1504
(Staatsbibliothek, Munich).

One of the two oldest known charts to contain the scale of latitudes,
and with the fleur-de-lis to mark the North.

The introduction of the graduation of latitudes into the nautical chart was the great Portuguese innovation that all the other seafaring countries of Europe quickly adopted. It may be argued that this chart — due to the manner in which it was produced and used — was not in a definite projection, but all the same the notion of the rectangular cylindrical projection was developed, and an investigation into its defects begun by Pedro Nunes in 1537, finally led to Mercator's fortunate discovery in 1569. Another innovation appearing in Cantino's planisphere and Reinel's chart

of c. 1504 was the use of the fleur-de-lis to mark the North in the wind-rose, a use that afterwards became general among all seafaring peoples.

Portuguese nautical cartography reached its climax in the 16th Century. There are 50 known Portuguese cartographers of this period, a number that cannot be matched by any other seafaring nation at the time; and the charts they left have no contemporary equals, either in number or in technical or artistic quality (*). Furthermore, these charts reveal another important fact expressed by the French historian, D. Gernez, in the following terms :

“ In fact, if one examines one of the best Portuguese charts made in the middle of the XVIIth century, that made by André HOMEM at Anvers in 1559, it may be seen that at the time this chart was drawn, 124 years after Gil EANES had been the first to go beyond Cape Bojador (1434), Portuguese sailors had accurately surveyed the coastal waters of Africa (including Madagascar), much of the coastal waters of Asia, the Malayan islands and Brazil. These hydrographic surveys covered more than 27 000 km of African coast (including Madagascar), 21 000 km of Asian coast, 5 000 km of the coast of the Malayan islands and 7 000 km of Brazilian coast, which means that altogether more than 60 000 km of coast were surveyed in less than 124 years, an average of more than 480 km of coastal surveys each year.

These hydrographic surveys together constitute a vast work which, owing to the various difficulties encountered — inadequate ships, sick and badly-fed crew, trouble with natives whilst in port, inaccuracy of instruments used for observations — is unique in the history of the world, and deserves to be admired without reserve by sailors of every nation ” (**).

We can now understand how, through the course of centuries, the legend was born that Prince Henry was the inventor of the rectangular cylindrical nautical charts — he became the figure-head of a discovery that was known to have been originated by the Portuguese, and which represented considerable progress in the history of cartography and in nautical science. Although the legend does not depict the truth, it is only right that Prince Henry should occupy a place of honour in the telling of its story, for it was he, above all others, who launched out into the ocean the fleet caravels whose mariners found in the stars an accurate method of calculating a vessel's position, and thus arrived at a chart graduated in latitudes.

(*) All the known Portuguese charts of the 16th century are fully reproduced in *Portugaliae Monumenta Cartographica*, published in 1960 under the auspices of the Portuguese Government.

(**) D. GERNEZ, *Importance de l'œuvre hydrographique et de l'œuvre cartographique des Portugais au xv^e et au xvi^e siècles*, in *Congresso do Mundo Português — Memórias*. Vol. III. Page 488, Lisboa 1940.