

Henry the Navigator And the Apollo Project That Launched Columbus

by Timothy Rush

Columbus's voyage across the Atlantic in 1492 was the westward application of the Apollo Project of the Renaissance: the coordinated advances in navigation, shipbuilding, astronomy, and mapmaking, pioneered by Prince Henry of Portugal as part of a world discovery and evangelization effort.

Before Henry's time (1394-1460), any sustained capacity to conduct deep-sea sailing was several thousands of years in the past, a part of earlier, more technologically primitive, seagoing cultures. After Henry, ocean navigation became a branch of science, a perfected, transmissible technology of universal potential.

Prince Henry, known to English speakers as "Henry the Navigator," devoted his life to the accomplishment of this task. But his achievement was possible only through the combined efforts of the political, religious, artistic, and scientific leaders of the early Renaissance. Their role in willfully shaping the conceptual breakthroughs necessary for this great project, and in educating a skilled layer of the population to carry it through, will stand for all time as one of humanity's finest accomplishments. The "science driver" project of Prince Henry and his circles should be studied today by all who seek to advance science and to overcome the climate of pessimism, fear, and irrationality that again threatens to throw us back to a Dark Age.

'Have Dominion over the Seas'

Henry's project was "to prove devotion to God by making the seas navigable," in the words of the 1455 Papal edict that raised Henry's efforts to a strategic priority for all Christendom after the 1453 fall of Constantinople. For more than 100 years, since the time of Roger Bacon and Ramon Lull, a strategic plan for Christianity to outflank the Venetian and Ottoman Turkish Empire's usurious grip on the Eastern Mediterranean, by circumnavigating Africa, or heading west across the Atlantic, had been on the table. But the logistical and technological problems were staggering:

- The boats of the time, both galleys and one-masted trading vessels, could not handle long voyages on the high seas.

- Navigation and nautical astronomy were not developed for routes outside the northern temperate zone and the Mediterranean.

- There was almost no knowledge of the complex winds and currents in the high seas.

- There was no first-hand knowledge of even the first 500 miles of African coast, let alone the remaining 8,000 miles.

- Medieval superstition had many sailors terrified that penetrating beyond the then-known limits of sailing would be a suicide mission.

The strategic plan languished for almost a century, while Spain and especially Portugal built up important maritime capacities and an institutional framework for such an effort. The Iberian Peninsula was the corner of Europe in which an evangelizing mission and spirit of the *Reconquista* (the reassertion of Christian control over territory taken by the Moors) was most alive. This potential was brought to flowering during the 1400s, under constant nourishment from the organizing centers of the Renaissance, most especially Florence.

Did Poets Launch the Caravels?

What was the spark that reached over the 14th century to ignite the Portuguese maritime "breakout" of the 15th century? Practical politics? A mere useful *technology*? What made this achievement possible were the activities of some of the greatest poet/diplomats and other intellectuals of that—or any—age.

A plan to explore the Atlantic westward was first advanced by the Franciscan Roger Bacon (ca. 1214-1294) in his *Opus Majus*. Bacon's proposal was copied word for word into Cardinal Pierre D'Ailly's *Imago Mundi* in the early 15th century—a book (and a passage) that became the most heavily annotated of all books in Columbus's library.



Stone statue of Henry the Navigator in the facade of the great monastery of Batalha, north of Lisbon. Henry's father Dom João I, erected Batalha to commemorate the battle at Aljubarrota, which initiated his reign (1385-1432). Prince Henry was buried there.

Ramon Lull (1232-1315), the Catalan Franciscan scholar who battled against the Aristotelian/Averroist currents of that time, introduced a broader strategic conception into the Council of Vienne, in 1311. It was to move against Venetian-Turkish control by a pincers action: First, to shatter the Western reach of Moslem power by taking Ceuta, the southern of the famed Pillars of Hercules at the outlet of the Mediterranean Sea to the Atlantic Ocean (the northern one being Gibraltar). Second, to circumnavigate Africa, to strike a blow directly into the hinterland of Moslem power—the “Arabic Lake” that later was called the Indian Ocean.

Petrarch (1304-1374), successor poet laureate to Dante in the Italian vernacular, certainly seems to have promoted or recognized such a daring strategic conception. In the midst of high-level diplomatic missions in the 1340s and 1350s to end the French-English conflict that had rent the Western Christian world (what would later be called the Hundred Years' War), Petrarch kept a close watch out for intelligence reports concerning the rediscovery of the Canary Islands. Located off the inhospitable northwest coast of Africa, these were the great Atlantic “way stations” to any large-scale exploration of the South Atlantic.

The poet and storyteller Giovanni Boccaccio (1313-1375), Petrarch's companion in the battle to rescue European civilization from the collapse of the Black Plague, wrote one of the great intelligence reports of the age on the 1341 expedition to the Canaries by Genoese merchants under Portuguese crown sponsorship.

In 1344 and 1345, Portuguese King Afonso IV sent emissaries to the Pope to secure overseas exploration rights for his nation. Petrarch was watching the Venetian reaction closely. A modern historian comments: “Petrarch, when he saw Dom Afonso IV expanding over the ocean, while Venice and Genoa exhausted one another in jealous quarrels, predicted that they [the Portuguese] would in the end destroy the very dominions that Italy possessed in the world” (Brochado, et al. 1960).

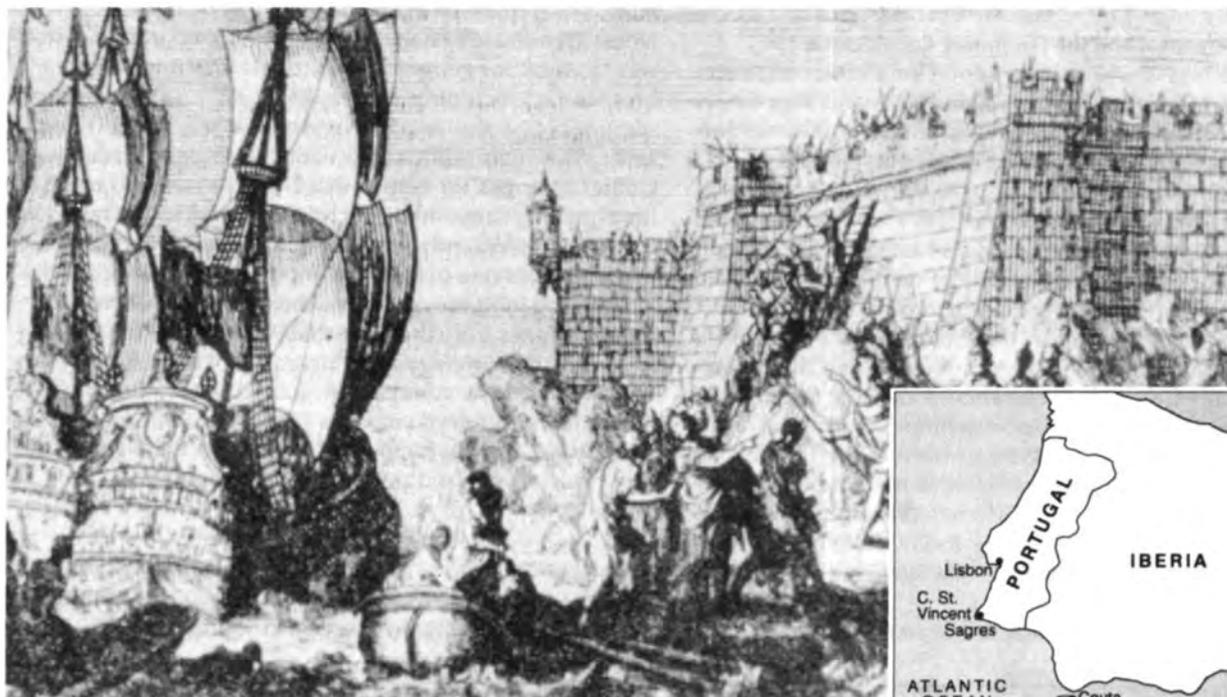
The spark can then be traced through England's great poet, Geoffrey Chaucer (ca. 1340-1400). In the same decades in which he was ennobling the English language as a vehicle for Renaissance thought and conceptions, Chaucer served as England's chief ambassador to continental Europe. From 1372 to 1380, he undertook seven major diplomatic missions, including a celebrated meeting with Petrarch in 1372. From Italy he brought back to England numerous volumes of Dante, Petrarch, and Boccaccio.

The Birth of Prince Henry

From here the thread leads directly to Portugal and the birth of Prince Henry. For the signal strategic accomplishment of Chaucer's patron and sponsor, John of Gaunt (the Duke of Lancaster), was to cement a far-reaching strategic alliance with the newly installed House of Avis in Portugal. As part of the alliance—forged in seven days of intense diplomacy in 1386 in a tent on the banks of the Minho River—John of Gaunt gave his eldest daughter, Philippa, in marriage to Dom João I of Portugal. The third son of this marriage was Prince Henry.

Henry's grandmother, John of Gaunt's wife Blanche, was immortalized in Chaucer's *Canterbury Tales* as the protagonist of his “Book of the Duchesse.” It is also reported that Chaucer gave instruction in the use of the astrolabe and other scientific instruments to Grandmother Blanche and perhaps to Henry's mother, Philippa, as well.

Under the vigorous Dom João I, Portugal eagerly entered into alliance with factions in England, the Rhineland, the court of Holy Roman Emperor Sigismund in Vienna, and Florence. They were brought together by a determination to reunite the Church, split by the Great Schism that saw rival Popes in Avignon and Rome; to contain the continuing



The assault on Ceuta, the stronghold opposite Gibraltar at the Atlantic outlet of the Mediterranean. Prince Henry and his two brothers aided their father Dom João I in the taking of this fortress from the Moors in 1415. Inset is a map of Portugal and the surrounding area.



French-English conflict; and to marshal all of Western Christianity's efforts to repel the advancing Ottoman Turks.

Three Brother Princes

Thus João I led his eldest three sons, each having reached manhood, to the reconquest of the city of Ceuta, in Morocco opposite Gibraltar, in August 1415. This was the first stage of the Lull project reaching back to 1311. The action was taken in synchronization with the then-meeting Council of Constance, which at long last healed the split in the Church. It is said that the news of João's victory at Ceuta "spread rapidly throughout the Christian world and caused a tremendous sensation. When the good news arrived at Constance, prelates and princes expressed their admiration for Dom João I and his illustrious generation of sons" (Brochado, et al.).

There was a clear division of labor among the princes. Eldest son Duarte, the heir to the throne, was a foremost intellectual, who wrote 22 treatises we know of, five on how to govern, and others on riding, fencing, and astronomy. Among these is a manual on governing based on his own family's upbringing, called *Leal Conselheiro* (the Loyal Adviser). The book shows that the princes held conversations on literary topics with their father and others and "discussed rules and instructions for making good translations of classical works."

The second brother, Pedro, covered the diplomatic flank of Portugal's emerging "Atlantic Strategy." In 1425, he embarked on a four-year mission through most of Europe, which proved one of the widest and most successful diplo-

matic and scientific expeditions of history.

From England, "where he was able to renew the cultural ties of his own country with English scientific circles" (Brochado, et al.), Pedro proceeds to the Flemish city of Bruges, the northern crossroads of the emerging Medici banking empire and the Hanseatic League. There he arranges the marriage of his sister Isabel to the Duke of Burgundy, who presided over one of the most powerful courts in Europe.

After wintering in the Rhineland, he passes through Nuremberg to arrive at Sigismund's court in Vienna. For more than two years, Pedro makes this his center of operations, participating repeatedly in military campaigns of Sigismund's forces against the Ottoman hosts of Murad II in the lower and central Danube.

In the spring of 1428, Pedro moves on to Italy. In a visit worthy of a classical drama, he spends two weeks as the honored guest of the *Serenissima Repubblica* of Venice—the common enemy of every faction he is allied with and the treacherous oligarchical "brain of Europe." As the Doge (the Venetian ruler) fetes Pedro on the famous state galley, *Bucintoro*, the Venetians probed for Portuguese weaknesses—perhaps attempting to calculate what it might take to buy off Portugal.

Pedro leaves Venice with jewels worth more than 400 gold ducats, an original manuscript of Marco Polo's travels, and one of the latest world maps drafted by a Venetian cartographer. If this is what Venice thought could buy Portugal, it clearly failed. Pedro's next stop is Florence, initiating one of the most far-reaching collaborations in history, which joins the emerging center of the Renaissance with

the supreme maritime power of the next 75 years.

Portugal and the Florentine Renaissance

Florence was the scientific center of the Renaissance. Here, a circle of intellectual collaborators and supporters of the "Atlantic strategy" already included Dom Gomes Ferreira da Silva, Portugal's "man in Florence" since 1415. Da Silva was administrator of a fund of 20,000 gold florins established by Pedro's father, King João I, as a kind of slush fund for special projects of the Portuguese ruling house. In fact, the entirety of Pedro's four years of travel was paid from this fund, under Dom Gomes's supervision.

Gomes was prominent in the circles who were to lead the brilliant diplomatic and cultural offensive that culminated in the Council of Florence a decade later. Chief among these was the Camaldolese monk Ambrogio Traversari. In Traversari's room at the Convento degli Angeli, an extraordinary group of humanists was meeting to plan the projects of statecraft, art, and science that are synonymous with the Florentine Renaissance today. Foremost among them were Cosimo de' Medici, Palla Strozzi, and Paolo dal Pozzo Toscanelli.

Upon his arrival, Pedro was the toast of the city. A joust

was held in his honor. Literary works were dedicated to him. "The humanists made much of the Portuguese prince" writes Dos Passos (1969). Among the aims of his mission was "to look for geographic materials for Prince Henry his brother. . ." including geographic codices sent from Constantinople at the request of Antonio Corbinelli (Uzielli 1892). The high point came with the intense discussions Gomes arranges for Pedro with Traversari and his circle at the convent. These made such an impression on Traversari that he subsequently wrote a dedication to Pedro in the manuscript of one of his most important translation works.

Stopping in Rome on his way home, Pedro received verbal assurances from the Pope that Portugal had full backing in its "Atlantic Strategy." Within a year of his return, Pedro had cemented a commercial accord with Florence that would last a hundred years. In 1439, Pedro became regent of Portugal and de facto held the crown for eight of the most crucial years of Prince Henry's enterprise.

The Project Takes Shape

The first voyages under Prince Henry's sponsorship began the year after the 1415 victory at Ceuta. Henry immediately set up an intelligence service to coordinate every scrap

FORMER NASA DEPUTY:

'I Always Felt the Ghost of Prince Henry Behind Us'

Dr. Hans Mark, former deputy director of the National Aeronautics and Space Administration, addressed the annual meeting of the American Association for the Advancement of Science in February 1992 on "Henry the Navigator and the Early Days of Exploration." Mark is currently chancellor of the University of Texas system. These are excerpts from his speech.

* * *

For someone who has been involved in space exploration for 20 years as I have, Prince Henry of Portugal has always occupied a special place. Henry was the instigator and sponsor of the first long overseas voyages by Europeans that resulted in the sustained and systematic exploration of the world. . . .

The "cape" from which Henry's captains launched their voyages was not called Canaveral but St. Vincent, the westernmost point in Europe. . . . Henry's own headquarters were located at Sagres, a small settlement overlooking the Cape, and it was here that he built his research center by converting a small military installation that was already there. It was here that he invented what is, perhaps, his most lasting contribution: the mission-oriented research and development institution. . . .

The mathematician and cartographer Pedro Nunes, who spent the early years of the 16th century as a professor of mathematics at the University of Lisbon, was a disciple of Prince Henry. He undoubtedly visited Sagres

many times during his career. He says "from it our sailors went out well taught and provided with instruments and rules which all map makers and navigators should know." These words are particularly significant because Professor Nunes was there during the years that the institution at Sagres was most influential.

These tantalizing words, all written before the "modern" technology and development institutions, such as the large government-sponsored laboratories around the world or the large research institutions of big industrial corporations, became familiar features of the scientific and technological landscape, indicate what must have happened. . . . What Henry did was to put together people who were expert in the basic sciences and who contributed to the increase of knowledge in these sciences with practitioners of the art of navigation. This combination turned out to be exceedingly successful. It has persisted to this day as the essential feature of how we do business in the technology development process.

. . . I have to confess that I always felt that the ghost of Prince Henry was standing behind successive NASA administrators in Washington as I worked for them. I am sure that he guided their thinking consciously or unconsciously. Those of us who carried out NASA's work in the field were like the captains who, 500 years ago, sailed down the coast of Africa, and in doing so, opened the most important vista that European culture has provided for the world.

of information he could glean from caravan traders, pilots, and Jewish and Moslem travelers from across North Africa. He established within his own household a virtual training school for the mariners and explorers who would go forth for the next two generations in wider and wider arcs of discovery. And he began the methodical search for, and colonization of, islands in the Atlantic as "way stations" for the broader exploratory thrusts in the making.

Much modern historiography would have us believe that Henry and those who followed his lead were simply gold-hungry and slave-hungry empire-builders. The truth is that Henry's explorations were not fundamentally a commercial enterprise. They were completely unlike the methods of looting developed by the Venetians and later embodied in the Dutch East India and British East India companies. In its later stages, Henry sought to recover the high costs of the project through commercial benefits, but his guiding motives were religious and strategic.

Henry led a pious, ascetic life in which his devotion to the Order of Christ was the driving force. Created by the great Portuguese King Diniz in the early 1300s as the nationalized form of the collapsed Templar Order, the Order of Christ had assumed an extraordinary importance by the

time of Henry's father, João I. At that time, as one commentator put it (Brochado, et al.):

Both nationally and internationally, the only force worthy of account beside the throne was the Order of Christ; and everything leads us to suppose that the Order was the structure of the state itself.

From the first substantial contact with sub-Saharan African populations in the early 1440s to the end of the century, Henry's evangelizing methods and directives guided the expanding contact with native populations. Although Henry did not ban slavery (slavery was generalized throughout Europe and Africa at the time as household slavery, and was run through Venice), he instructed that as many Africans be brought back to Portugal as possible, be instructed in Western Christianity and its languages, and be returned to their home to spread the gospel there. This approach bore remarkable fruit a generation later in the extraordinary Kingdom of the Kongo, a Christianized kingdom in black Africa that survived for almost a century, from 1490-1570.

Madeira As an Ocean 'Space Station'

If it can be said today that God made the Moon so man could get to Mars, Henry could reasonably have concluded that God created the Canaries and Madeira islands so man could get past the Sahara and sail the ocean seas.

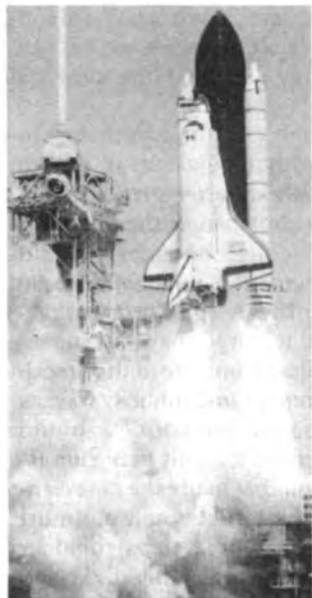
There is probably no stretch of coast anywhere in the world as hostile and nearly impervious to ocean-based exploration as the Atlantic coast of northwest Africa. From Morocco to the Senegal River, a distance of more than 1,500 miles, the Sahara joins with the sea. There is no place to get water or food, no harbors, only harsh winds and sandstorms reaching far out into the water.

The Madeira and Porto Santo, which Henry ordered rediscovered and colonized in the 1418-1420 period, were the opposite of the harsh mainland: lush, richly watered lands that opened up excellent prospects for commercial development and permanent settlement. There is no doubt that behind Henry's directives for the colonization of the islands was the bigger plan, in which the new islands were but the first step in the discovery of new worlds. The first boy and girl born on Madeira were named Adam and Eve.

Henry now had his way-station, a place to take on new provisions, repair ships, and, if necessary, to wait for the proper winds. Yet it was not all clear sailing ahead.

Surmounting the Psychological Barrier

Anyone first looking into Henry's "Atlantic Project" is struck by the huge disparity between what was ultimately accomplished by the project and the pitifully meager advances of the first 15 years. Even with the Madeira island way-station, the development of manpower and an in-house intelligence service, and the first steps in the assembling of a team of map-making and navigational experts, the tangible results were almost nonexistent. Henry had sent out ships 14 times over 15 sailing seasons before any of his captains had even rounded Cape Bojador, a point on the North African coast not very far beyond Moroccan cities that had been part of trade routes for hundreds of years.



Hans Mark, NASA deputy administrator, views a shuttle launch from the Johnson Space Center's mission control center, April 13, 1983. Inset is the launch of Space Shuttle Discovery from Cape Canaveral, Sept. 29, 1988.



National Aeronautics and Space Administration

The difficulty was as much psychological as physical. Cape Bojador, a promontory on the Mauritania coast so small that it is difficult to find on a map today, took on legendary characteristics as the “end of navigable sea.” A strong wind there had created a sand spit reaching far into the sea. Here the water was almost constantly churned into a froth, which seamen imagined to be “boiling.” Over the years the Arabic traders took advantage of these fears, exaggerating the stories in order to create terror among Christian seamen, and thus protect the hinterland of their caravan routes from encroachment.

There was also the considerable problem of the prevailing winds. The passage down the coast from Portugal was favorable in almost all seasons. This was the easternmost reach of the great circular movement of the northern hemisphere trade winds, moving clockwise and preparing to shoot across to the American continent a little south of the latitude of the Canaries. However, for exactly the same reason, the return voyage to Portugal was laborious and hazardous, requiring constant tacking and maneuvering. A generation later, when the Portuguese had penetrated as far as Guinea, it was noted that “if the winds were contrary [on the return], it sometimes took four months, while one could go out in 20 days.”

It was not until 1434 that Henry’s most trusted captain, his shield-bearer Gil Eannes, finally drove beyond Bojador. It is reported that he tricked his crew, put the ship out to sea during the night to round the cape, and told them they were near the point only when they were beyond it!

The way now lay open for a steady, sustained advance. But the further the progress, the more pressing the interrelated questions of navigational, astronomical, and ship-building innovations would become. Henry would need a center of operations, a place at which he could concentrate his forces to create the needed breakthroughs and coordinate the results: He needed a *mission control*. This is what has come down to us as the School of Sagres.

The Sagres Mission Control Center

Sagres, a small promontory next to Cape St. Vincent at the southwestern tip of the Iberian peninsula, was the headquarters of Henry’s operation. There has been much recent controversy over whether the group of people Henry assembled at Sagres constituted anything more than a glorified pilots’ school. What can be reconstructed with certainty goes far beyond this. Sagres—the *Promontorium Sacrum*, or Sacred Promontory, of Roman times—was the point of intersection for all facets of Henry’s project. These included:

- the intelligence-gathering machine;
- the training for the voyages of the personnel within his household;
- the revolutionary advances in ship design centering on the caravel, carried out at the nearby Lagos shipyards built and supervised by Henry;
- the design and execution of a colonization policy;
- all intermixed with a core group of resident cartographers, scientists, and geographers and a ceaseless stream of visitors from throughout the known world.

What a project team!

At its center, the only cartographer in the group known by name was the Majorcan Jew, Jahuda (in Portuguese, Jacomé) Cresques. He brought a number of companions and all the papers of his great father, the Abraham Cresques known as “*magister mappamundorum et buxolorum*,” master of the world map and compass. Abraham had taught at Majorca’s renowned school of navigation, mastered the manufacture of navigational instruments, perfected a series of tables to calculate sea distances, and designed the famed Catalan Atlas of 1375, among many other cartographic achievements.

The Invention of the Caravel

The development and introduction of the caravel under Henry’s sponsorship in the period around 1440 was one of the great technological leaps of the Renaissance. It was accomplished within a span of only five or ten years of two other great achievements of the age: Brunelleschi’s successful arching of the 42-meter span under the dome of the cathedral of Santa Maria del Fiore in Florence and the Western development of the printing press.

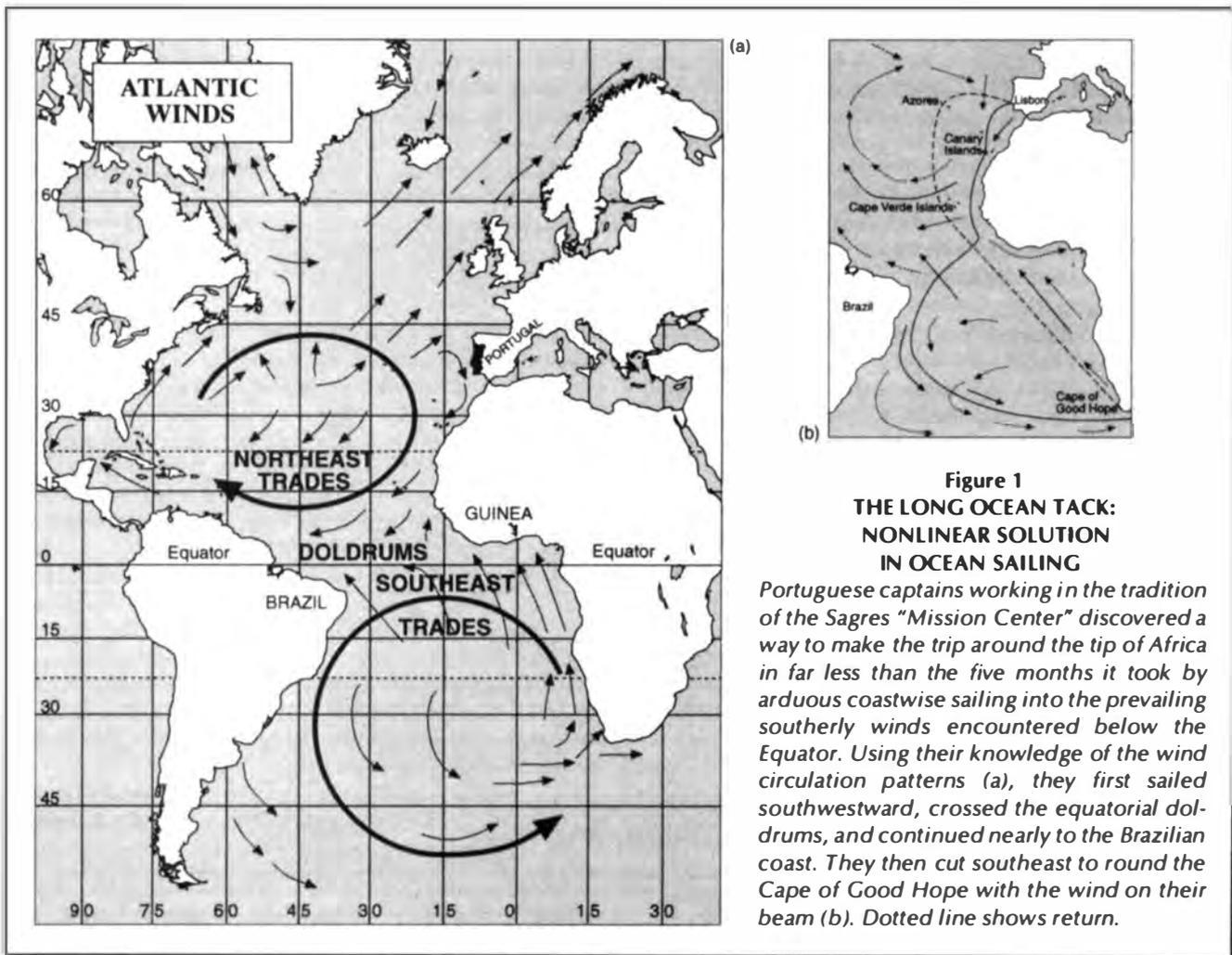
The need for a new ship design had become clear. Galleys were out of the question for deep-sea ocean travel—the ratio of men to ship size would have meant impossibly large requirements of food and water. The *barca* and *varinel*, used by Henry in the early voyages, were heavy, round-bellied merchant ships and difficult to maneuver because they rode low in the water. They used just one mast and one large sail.

Out of Henry’s shipyards came an “intrinsically revolutionary vessel, with respect to both rigging and hull design. She was three-masted and usually lateen rigged” (Penrose 1952). The lateen sail is cut in approximately the shape of a right triangle and hoisted up the mast near the center of the hypotenuse such that a segment flies forward of the mast (see illustration, page 18). The design is more like the modern Marconi rig of jib and mainsail than the square-rigged vessels that predominated from the 16th through 19th centuries, and gives the ship a greater ability to go to windward. The ratio of beam to length was not 1:2, but 1:3 and even 1:4. As Penrose described it: “It was thus the combination of hull, size, and rig that made the caravel far and away the most efficient sailing vessel built up to that time. Excellent in windward work, these ships could sail anywhere but into the ‘eye of the wind’, while their daily runs in favorable weather sometimes rivaled the logs of the famous clipper ships of a later day.” The caravel was the standard ship of Columbus’s voyages.

The ‘Long Ocean Tack’

The caravel opened one of the great deep-sea achievements of Henry’s (or any later) time: what became known as the “Guinea Tack” or the “Long Ocean Tack.”

Examine closely the pattern of winds and currents that the Portuguese had to contend with as they proceeded farther and farther down the African coast (Figure 1). Down to approximately the 15th parallel, at the “bulge” of Senegal, both wind and water currents tend uniformly south and southwest. It was literally a breeze out—and hell tacking back. Next came the problem of calms off the Sierra Leone



coast. (An Italian crew stayed becalmed in the area 57 days in 1503). Farther south, from the Cameroons all the way to the Cape of Good Hope, both winds and currents run against the south-bound mariner, while aiding the return.

The result was that any linear conception of the exploration voyages was doomed. The longer the distance, the more the traditional method of coastal sailing undermined its own viability. The time taken in tacking and waiting for favorable winds created many dangers: the lethal effects of tropical heat and diseases on the crews, tropical waters rotting out the wooden hulls, and the slimmer and slimmer margins of provisions that could be carried for such long distances. All told, it meant that no sustained course of exploration, evangelization, or commerce could be carried out by relying on the old methods.

Henry's crews hit upon a unique, nonlinear solution. As the voyages probed farther and farther south, the captains began to set sail at an oblique angle to the contrary winds they faced heading home. They headed north and north-west. But instead of tacking a few miles, and then tacking back in the opposite direction, they kept going—for up to a thousand miles of open ocean, until they reached the vicinity of the Azores. There they turned east, utilizing the variable winds of that latitude, which shuttled them, rela-

tively securely, due east to Lisbon. The total distance of the two legs of this "Long Ocean Tack" was substantially greater than the direct route, but the saving in time more than made up for it.

Once the route is superimposed on wind and sea currents, the configuration is an extraordinary use of the natural conditions as a booster. One is reminded of a more modern nonlinear navigational technique, the concept of "gravity-assist" used by NASA in propelling spacecraft to distant planets. The "Jupiter sling," used to propel the Ulysses spacecraft inward to the Sun by first going out to Jupiter to gain gravitational acceleration, is a striking example. Similarly, the Galileo mission, destined for Jupiter, first flew twice around the Earth and out in the opposite direction beyond the Moon, in order to pick up acceleration for the long trip to the fifth planet. The particular force to be reckoned with is different, but the mode of solution the same. In both cases, the most efficient path is not the one that is geometrically the shortest.

Onward to India

Once coming upon this solution, Henry's team then inverted and extended it into the southern hemisphere to accomplish the great breakthrough of Vasco da Gama's

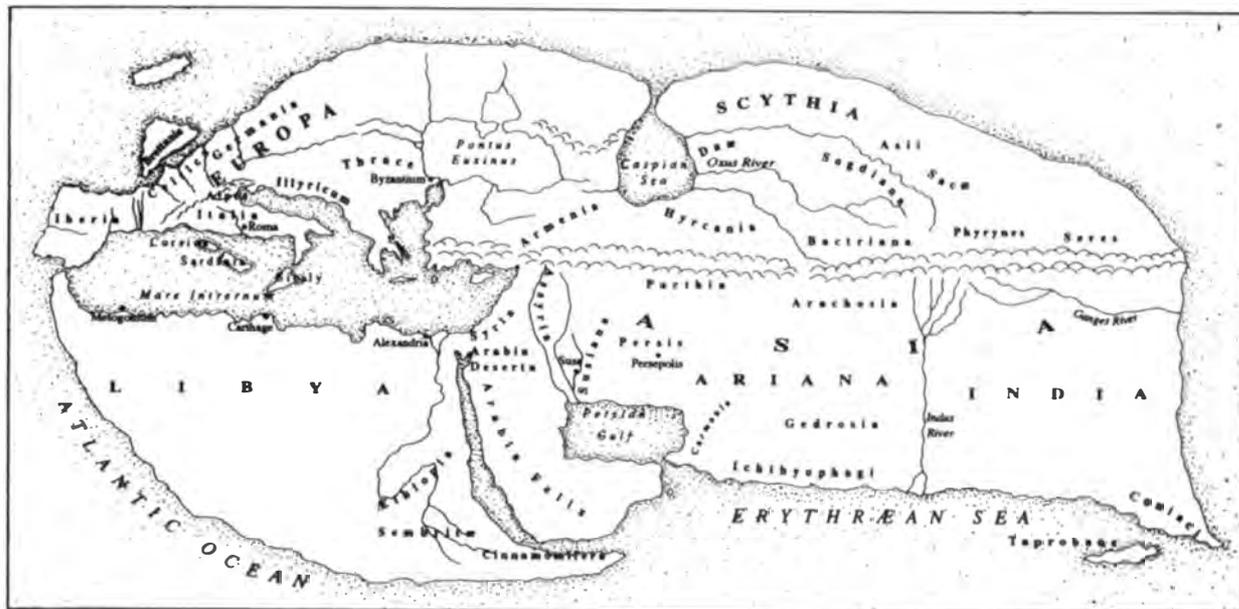


Figure 2
STRABO'S MAP OF THE WORLD

This world map by the ancient geographer Strabo (c 63 B.C. to 21 A.D.) came into Portuguese hands via the Eastern church delegation to the famous Council of Florence in 1439. The map shows that the ancients clearly knew it was possible to circumnavigate Africa. Herodotus gave a famous account of such a voyage, but a redrawing by Claudius Ptolemy (90 to 168 A.D.) had led to the belief that this was impossible. Vasco da Gama's 1497 voyage to India proved the truth again.

Source: Reconstruction based on E.H. Bunbury's *A History of Ancient Geography*, London, 1879

voyage to India in 1497. By then Bartolomeo Dias had reached the Cape of Good Hope the hard way—on a route paralleling the African coast, which took five months to complete. Rounding the Cape and sailing on to India by this method could be expected to take as much as five months more: The total requirements were beyond the technological capacities of the caravels.

What Da Gama did—after a decade of intense Portuguese researches into the wind and ocean currents of the South Atlantic—was to sail with the prevailing winds and currents down to the latitude of the Cape Verde Islands (about 15° N) utilizing the generally clockwise circulation of wind and ocean in the northern hemisphere. He then cut across the equatorial doldrums, to intersect the mirroring counter-clockwise circulation in the southern hemisphere and follow it *southward*, almost to the coast of South America. (Pedro Alvares Cabral, in the next voyage, would officially “discover” Brazil by exactly this Long Ocean Tack—a discovery almost certainly made earlier by the crews doing the reconnoitering for the breakthrough). Once in the “roaring 40s” past the southern Horse Latitudes, Da Gama “hitch-hiked” a ride back eastward to intersect the African coast at almost precisely the Cape of Good Hope.

It was a route that was not to be improved upon in the next 400 years, and although for Da Gama it involved being out of sight of land for over three months and 3,800 miles (compared to Columbus's 33 days and 2,000 miles on his

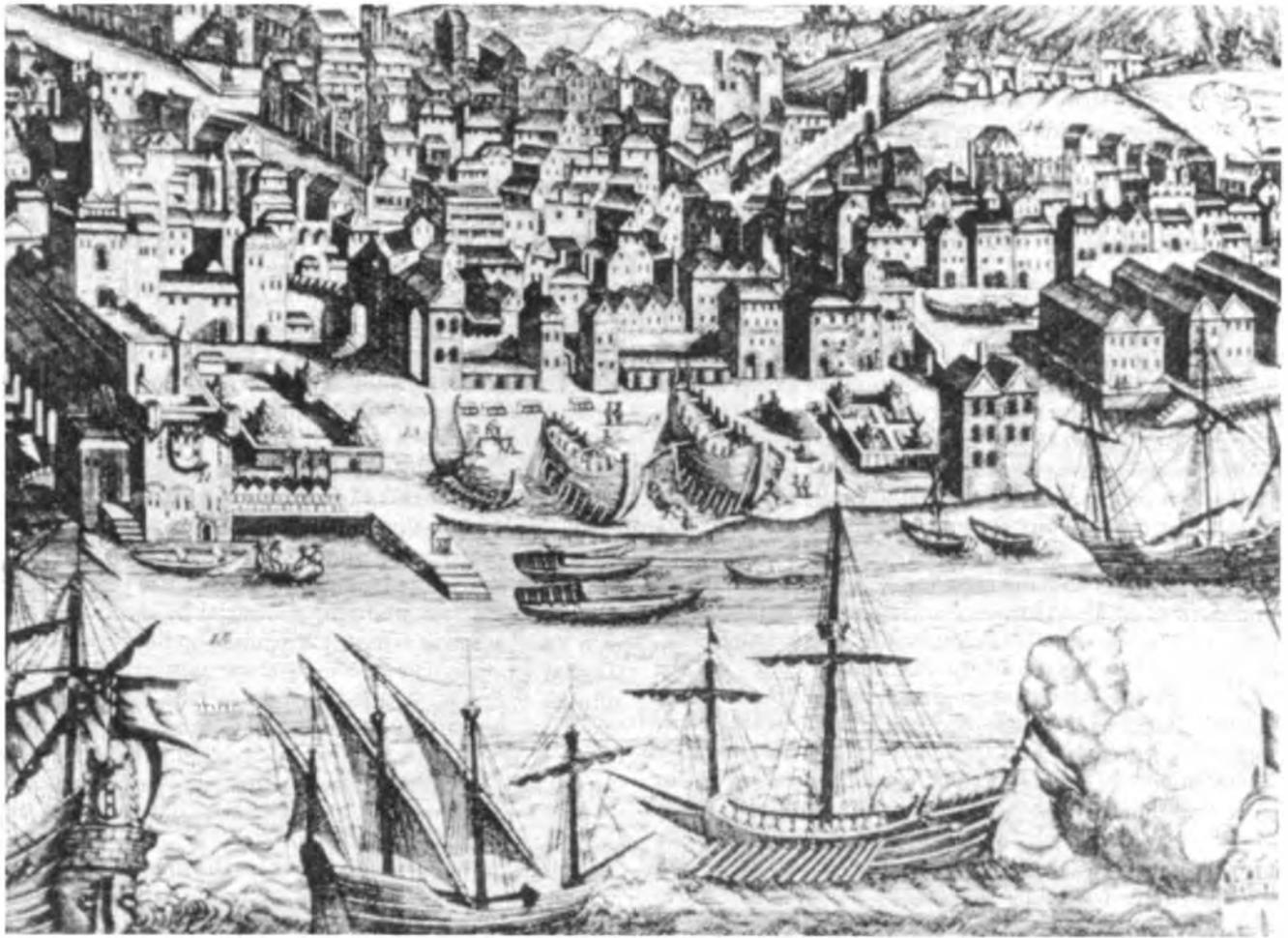
famous voyage five years earlier), it cut the time of the passage in half. It was a staggering feat of seamanship.

Columbus's masterly use of the circulatory pattern of the northern belt for his voyage (out on the Trades, back in a northerly route intersecting the Azores), shows how well he had learned the Portuguese method of the “Long Ocean Tack.”

The Revolution in Navigational Astronomy

Coupled with the revolutions in shipbuilding and the use of winds and currents accomplished by the School of Sagres was a revolution in navigational astronomy. The pole star had long served mariners as a rough guide for determining latitude. The angle of the pole star above the horizon is, with minor modifications, identical to one's latitude. However, the needs for measuring instruments, charts, and tables had been minimal because voyages took place within a relatively narrow belt of latitudes and usually had visual landmarks within several days of sailing to correct any errors. The long distances out of sight of land introduced by Henry's navigators forced the Portuguese to bring the astronomical knowledge and instruments of court astronomers within the reach of the common sailors—heretofore considered too lowly to merit access to them.

Thus, in the last years before Henry's death in 1460, we find the first consistent mention of use of the quadrant, an instrument for sighting the Sun or stars, on board the



The Lisbon shipyards in a detail from a 16th century German engraving. By the end of the 15th century, the center for Portuguese exploration had moved from Sagres to the capital, Lisbon.

Portuguese caravels. Within 20 years, the astrolabe, an instrument of Arab design for finding star positions, came into common use, after design modifications and simplifications carried out by the successor to Henry's School of Sagres, the *Junta dos Matemáticos* in the Lisbon court. (Columbus carried both instruments).

Extensive correlations of latitude-sighting with cities and landmarks along the coast of Africa and Europe were sent out with each succeeding voyage, along with the detailed accumulated sailing guides of all the previous voyages.

But a problem of an entirely different order was soon to present itself to the Portuguese. As they neared and then crossed the Equator in the years 1454-1474, they saw that the pole star rode lower and lower on the horizon, until it finally disappeared. Yet there was no southern hemisphere equivalent for the pole star. A navigational guide to determine latitude below the Equator was required.

Based upon centuries of accumulated knowledge of *solar declinations*, a new navigational manual was developed, the *Regimento do Astrolabio e do Quadrante*. This great collaborative effort of two Jewish astronomer-mathematicians, Abraham Zacuto and José Vizinho, was circulating in manuscript form at precisely the time Columbus was preparing to head west. It was the first *bona fide* practical

navigational manual. "So fundamental is this excessively scarce little volume that all later treatises on navigation, even to the present day, may simply be regarded as revised and enlarged editions of the original *Regimento*," Penrose writes.

East or West?

Our examination of Henry's project has brought us to the point of the "Moon Landings" of the 15th century: the successful passage to India by Vasco Da Gama in 1497-1499, and Columbus's voyage to America in 1492.

The conventional story is that Columbus, resident in Portugal in the early 1480s, sought Portuguese backing for his attempt to find the Indies by a westward course, only to be foolishly turned down by King João II and his court experts, who thought the venture too rash and Columbus's calculations of the distances faulty.

Another myth to be discarded.

From the very beginning, Henry's efforts were dedicated to "making the seas navigable," not just pioneering a specific route to the Indies around Africa. From 1415-1497, more than 100 exploratory voyages went out from Portugal under the guiding hand of Henry and his successors. The idea of a *western* route had been very active in Prince Hen-

ry's mind from the first. Diogo Gomes, one of his great captains of the 1450s, dictated the following description of how Henry's ships discovered the Azores in 1432:

As Prince Henry wanted to learn more about the remoter parts of the *Western Ocean* in order to see whether there were islands or a mainland outside Ptolemy's world, he sent out caravels at a certain time to look for land. They sailed away and found land [the Azores] 300 hours out from Finisterre [emphasis added].

There is fascinating evidence that the Florentine mathematician-astronomer Toscanelli was urging the Portuguese in the 1450s to head *both* south (circumnavigating Africa) *and* west, to reach the Indies. But in the last years of Henry's life, and for the next 15 years thereafter, Portugal's interest in the western route waned as their caravels pushed farther and farther eastward along the Guinea and Benin coast of Africa, and their joyous surmise was that India itself was just a little ahead.

Then, in 1474, came the crushing shock that after Benin, the coastline of Africa turned south again and in relentless, unbroken fashion. Instantaneously the "western question" was revived. The canon of the Portuguese court, Fernão Martins, exchanged correspondence with Florence's Toscanelli—the same Toscanelli brought into contact with Portugal's enterprise back in 1428—and sought his advice on the feasibility and a route to head west. Martins had spent a large portion of the preceding 20 years in Italy, in a collaboration with Toscanelli and Cardinal Nicholas of Cusa. By 1480, Columbus was brought into this correspondence and the Florentine Toscanelli addresses Columbus as "Portuguese."

At exactly the same moment, the Portuguese opened up a series of reconnaissance missions westward. On one of these, most probably in 1476, Portuguese explorer João Vaz Corte-Real reached Labrador as part of a Portuguese-Danish expedition. Another is indicated by a 1484 royal license from King João II stating:

Let all who read this know that it is Our pleasure that Fernão Domingues de Arco, who lives on the island of Madeira, shall, if he discovers the island which he is now setting out to find, be made Governor of this said island.

Again, in 1486, court records show licensing of an effort to "discover a large island, or many islands, or a *mainland*," to the west, estimating that the passage should be given 40 days before being abandoned if no land were sighted. The time frame eerily anticipates the 33 days it took Columbus to make the passage.

But then, in 1488, Bartolomeo Dias brings João the breathtaking news that he has rounded Africa at the Cape of Good Hope. Three years later, a reconnaissance team sent into Moslem areas of the Indian Ocean reports details of the eastern coast of Africa, which eliminate the last *terra incognita* of the route. The decision was made to put their primary thrust into the assured route now open around Africa, but that did not mean that the feasibility of sailing

westward was doubted.

Columbus and Portugal

Columbus had first come to Portugal as a shipwrecked mariner in 1476. He married the daughter of the first settler-governor of Madeira, whom Henry had sent out to the island in the early 1420s, and from his father-in-law he inherited a large archive of papers and observations. In 1482, after a series of other voyages on Portuguese ships, he sailed to the newly opening frontier of Portuguese settlement and exploration, the Guinea Coast, and to the just-constructed Fort of São Jorge da Mina. A later notation of Columbus is history's best source of information on a trip by the great astronomer of João's *Junta dos Matemáticos*, José Vizinho, to the Guinea coast to personally verify the groundbreaking new solar declination tables and rules he had helped prepare.

Columbus was thus in the middle of Portugal's maritime breakout, at its densest moment of combined scientific and navigational expansion, when the route west was as seriously considered as the route south and east.

It is fortunate indeed for history that a man of Columbus's determination and strength, energized by direct contact with the Florentine scientist Toscanelli and backed by the parallel Christian Renaissance currents and greater resources of Spain, stepped forward to take the "road not taken" by the Portuguese. Thus did Columbus ensure that Prince Henry's project "to prove devotion to God by making the seas navigable" brought the Renaissance Christian world simultaneously to the American continent and, by the Africa route, to the Indies.

Camões, the poet laureate writing the epic of Portugal's maritime expansion at its ebb 70 years later, summarized the fruits of Henry's great project in three beautiful lines of his *Lusiads*:

Por mares nunca dantes navegados (Canto I, 1)
Novos mundos ao mundo irão mostrando (II, 45)
E se mais mundo houvera la chegara (VII, 14)

"Through seas never before navigated, they will go on showing new worlds to the world. And if there were more to the world, they would arrive there."

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References

- Costa Brochado, et al., 1960. *Dom Henrique the Navigator* (Lisbon).
John Dos Passos, 1969. *The Portugal Story* (Garden City, New York: Doubleday and Co.).
Paul Greenberg, 1990. "Roger Bacon and the Birth of Universal Science," *21st Century* (Jan.-Feb.), p. 32.
Bjorn Landstrom, 1964. *The Quest for India* (London: Allen and Unwin).
Boies Penrose, 1952. *Travel and Discovery in the Renaissance* (Cambridge, Mass.: Harvard University Press).
Paolo Emilio Taviani, 1985. *Christopher Columbus: The Grand Design* (London: Orbis).
Gustavo Uzielli, 1892. "Paolo Toscanelli, Amerigo Vespucci and the discovery of America" (English translation by Richard Sanders, 1991, unpublished manuscript).