CHARTS THROUGH HISTORY

Did you know that the discovery of the Americas by Columbus, one of the greatest mistakes of history, was based upon a cartographic error made 1600 years before? And that, except for the earlier error, Columbus very likely would never have left Spain? Columbus didn't realize that his destination, the Far East, was three times as far away as he thought. Since he barely made it as far as he did, it is doubtful that he would have left knowing the real facts. His ignorance of those facts is directly attributable to a mistake made by a great philosopher. Ptolemy goofed. Here's how it happened:

In the 3rd Century before the birth of Christ, there lived a philosopher named Eratosthenes. Philosophers back then ended to be Jacks-of-all-trades in intellectual pursuits, so Eratosthenes was also a mathematician and astronomer. He happened to be in a town called Syene, in southern Egypt, on the summer solstice, where he noticed that the sun shone at high noon right to the bottom of a certain well. That intrigued him because he knew that in Alexandria, about 500 miles north, the sun couldn't do that. Not content to just wonder why, he measured the distance between the two points in both arc and linear measure, and computed the distance around the earth as being 252,000 stadia (A stadia is a Greek unit of measure equal to about 600 feet, depending on whose definition is used.). The earth, incidentally, had to be round. This was a remarkable finding, considering that people were still arguing about it 1600 years later.

His knowledge was lost, however, on another philosopher who came along a couple of generations later. Posidinius (circa 130-50 B.C.) was a stoic philosopher-mathematician-astronomer who also calculated the circumference of the earth. His figure, however, was only 180,000 stadia. The result was a concept of earth which was far too small. Each of several Greek city-states had its own definition of a stadia, and we don't know which ones these men were using. The truth of the error is found by calculating miles per degree of latitude. Approaching the problem this way, we find ancient charts using values from 44.5 to 87.5 miles/degree. Columbus, Magellan, and a host of other great explorers used a value of 45.3 which is 32% too small. Let's see how this mistake was made.

Of course, we've heard of Ptolemy, who lived on the 2nd Century A.D. He wrote a book he called "Almagest", which translates humbly as "The Greatest". This was a sort of compendium of astronomical knowledge of time, which influenced astronomical science until the Copernican Revolution 1200 years later. Ptolemy either hadn't heard of, or chose to ignore the calculations of Eratosthenes and instead used the figures of Posidinius as the basis for his assumptions on the size of the earth. Thus, his charts, which were masterpieces in other respects, showed a world much smaller than it really was.

And these were the charts on which Columbus's charts were based, along with everyone else's. So, after having sailed across the Atlantic Ocean, poor Christopher thought he had gone far enough to get to China. It wasn't his fault he didn't know where he was. It was Ptolemy's Columbus had exhausted his food, water, and the patience of his mutinous crew by the time he spotted San Salvador in the Bahamas. But if North America hadn't been in his way, he would have perished long before reaching the Far East for he had gone less than one third of the required distance!

After Ptolemy, Muslim cartographers discovered that Ptolemy's world was seriously distorted. He had overstated the length of the Mediterranean Sea by about 20%, in addition to his other mistakes. The Muslim corrected those errors and produced a series of charts to support their own commerce in the Mediterranean Sea. Some of their knowledge rubbed off on their colleagues over in the Indian Ocean where a number of charts were produced to support a growing commerce using the dependable monsoons for power. These charts showed latitude lines, but no longitudes (This was okay, since longitude couldn't be computed anyway, a problem which wasn't solved until hundreds of years later, by an Englishman). They also used the dividing line

between windward and leeward areas as a prime meridian, placed a grid labeled in time, such as "Three hours sail." For the state of knowledge of the day, it was very clever and useful chart, but still not very accurate.

Along about the time of the Crusades, Italian merchants, who controlled many hundreds of ships, certainly saw to the production of pilots (known as "rutters") and charts for their fleets. Unfortunately, none survive. This is not unusual because they were handmade, considered top secret, and not on waterproof paper. So the first real charts of the Middle Ages, which we know a great deal about, were the products of Catalonia, now a part of Spain. These were known as Portolan charts and they were very accurate and complete, being based on data collected from hundreds of voyages. They had no latitude/longitude grid (The Prime Meridian hadn't been invented yet), but had complex thumb line roses which could be used to plot courses. Dangers to navigation were clearly plotted, and plenty of marginal notes and terrestrial features were included. By 1508 an institution known as the "Casa de Contratacion" in Seville had taken, up the task of coordinating all the known hydrographic information in the world into one master map, known as the Padron Real. It was this data base which became the basis for chart production throughout the Age of Discovery.

Throughout this time, inhabitants of the Pacific Islands were using "charts" made from strips of reed or bamboo, tied together with coconut fiber, having shells tied to various locations to indicate islands or archipelagos. The shape of the various patterns of reds corresponded to wave and wind patterns. Early Pacific navigators became extraordinarily sensitive to these patterns, and to cloud formations, bird and sea life, and other signs which might indicate the presence of land over the horizon. Recently, several modern students of this ancient art have learned and demonstrated the method and proved its efficiency by making long voyages in traditional vessels.

Back in Europe, by the year 1600 there were several good world maps available, the best known by Leonardo da Vinci, and perhaps the finest example by Ortelius in 1570. But the transition from inaccurate charts to true navigational charts awaited the solution of the problem of projection, or how to reconcile the difference between a globe and a flat surface. Cartographers to this date had been portraying the earth as plane surface. This didn't matter much, given the inherent inaccuracy of their data and the local nature of their charts. As the size of the known world increased, however, it became clear that some sort of formula of system was needed to correct the errors inherent in the old practices. It took two men and 30 years to complete the job. The first was a Flemish geographer named Gerhard Kremer. He published a chart in 1569 which used the basic principle of longitude lines as being parallel, instead of converging. He made several computational errors, and he never published the results of his work. Thus were navigators denied the benefits of his method until Edward Wright became interested in Kremer's work 30 years later. Wright corrected the mistakes, developed a table to base calculations on for various latitudes, and gave the results to several navigators for testing at sea. When they returned, they verified the accuracy and usefulness of Wright's work, whereupon he published in 1599 a treatise entitled "Certaine Errors on Navigation Detected and Corrected." The world soon knew who **Gerhard Kremer** was, for his name was Latinized as **Gerardus Mercator**.

At last it had all come together. The world had a method of portraying the real world on a flat piece of paper with accuracy and precision. There was a central data collection point, and navigators were increasingly aware that data they collected was vital to production of accurate charts. There was also a growing sense' among navigators and scientists, that the art of navigation could become a science. Four hundred years later there is still an element of art in our navigation.