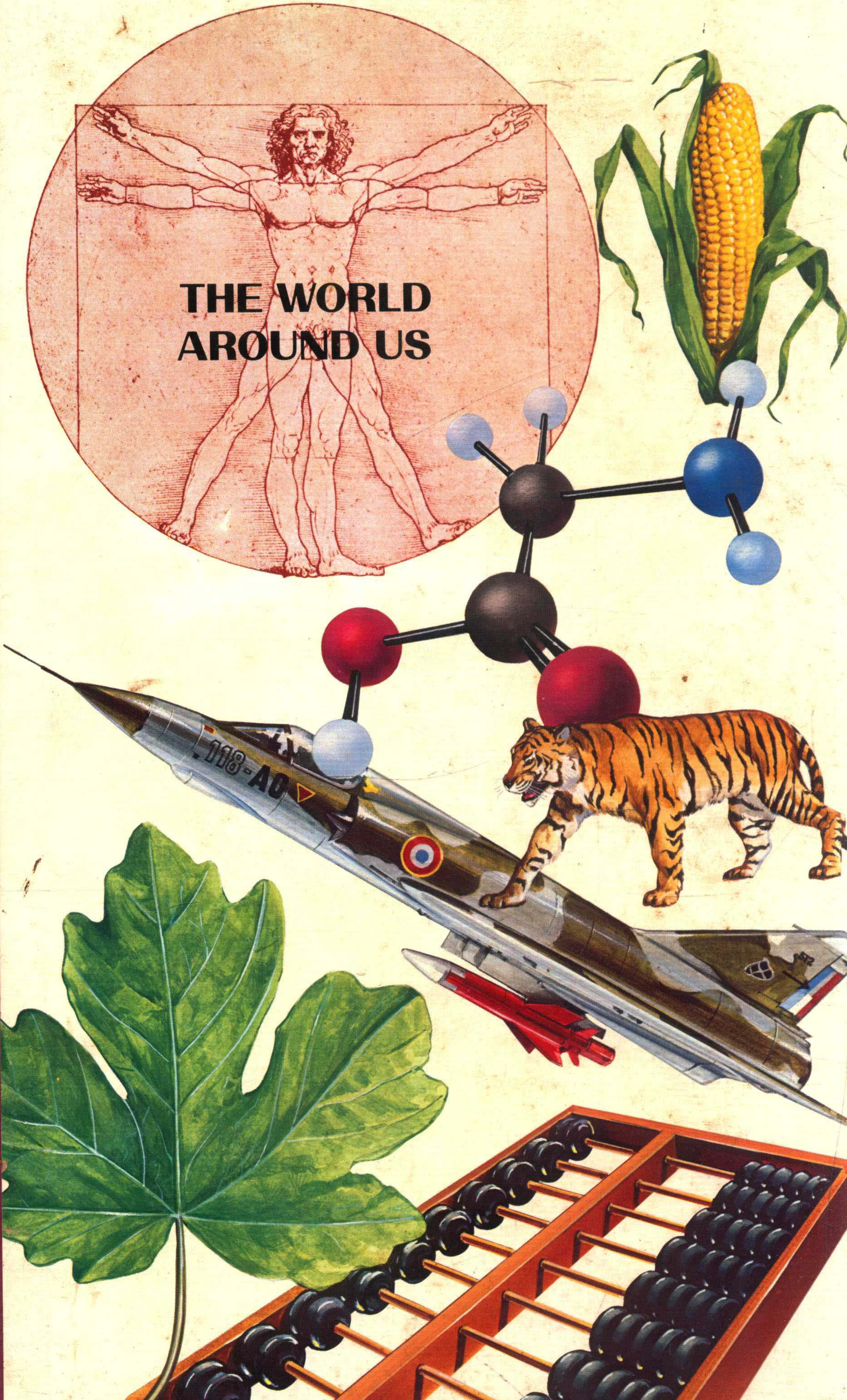
SCIENCE AND TECHNOLOGY ILLUSTRATED

THE WORLD AROUND US



Science Technology

The World Around Us

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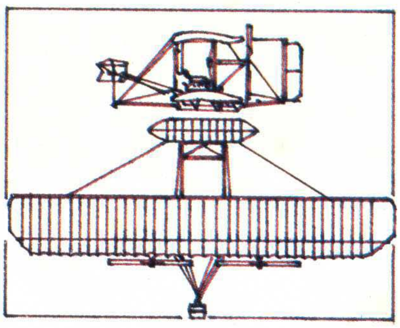

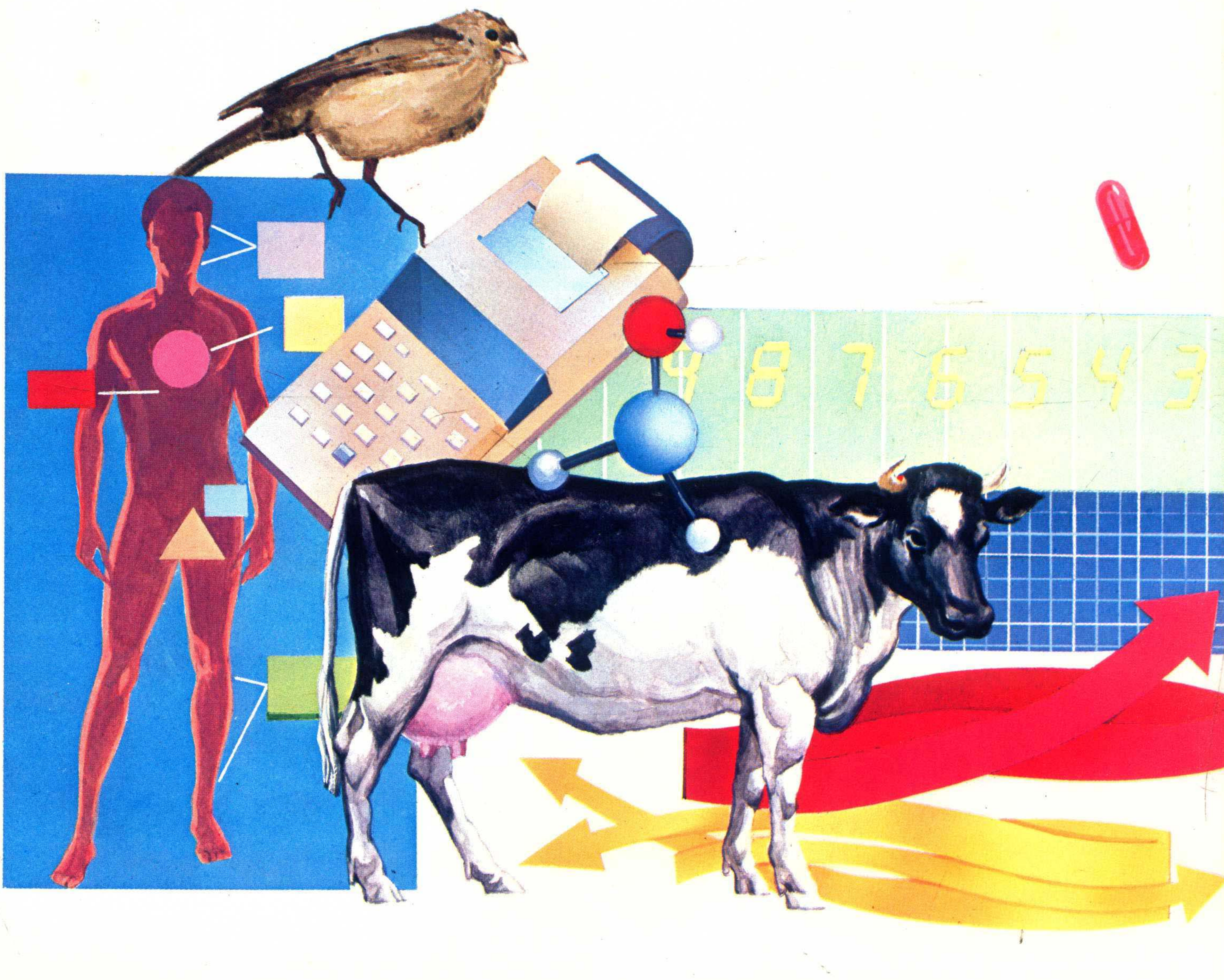

Science and Technology Illustrated

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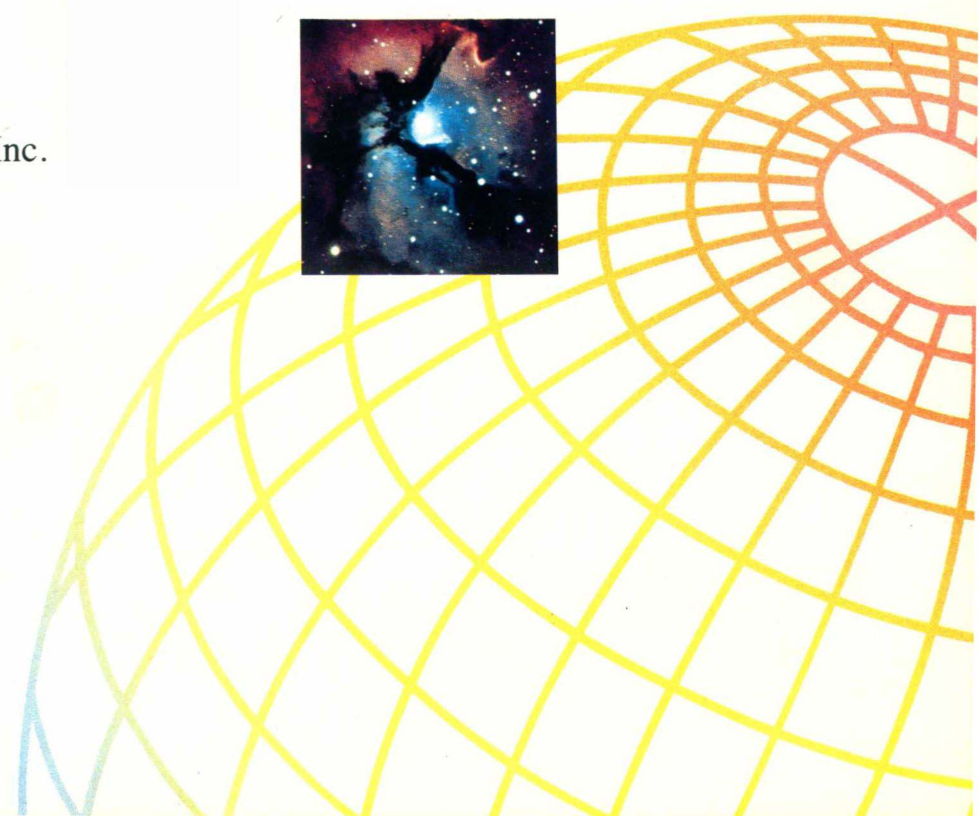

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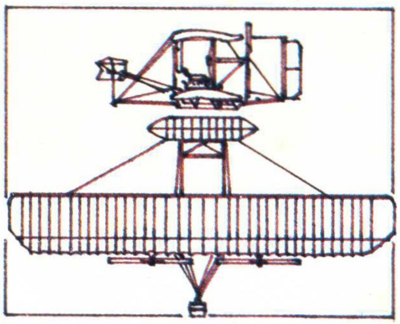


Navigation

Birds, eels, sailors, salmon, and airplane pilots have at least one ability in common. They are all experts in navigation, the art of negotiating a journey from one place to another on land, on sea, or in the air.

Birds are perhaps the most astonishing navigators of all, as they can fly for thousands of miles in their seasonal migrations across trackless oceans. Other exemplars of navigation are the eel, which finds its way from some American inland streams to the Sargasso Sea in the middle of the Atlantic and thence to the rivers of Europe, and the salmon, which performs seemingly impossible feats of navigation, swimming from its freshwater spawning grounds inland, across whole oceans, and back again. Man is a beginner at navigation in comparison with these creatures; futhermore, man requires instruments to find his way about, whereas the lesser beings do it all by themselves. Birds use the Sun and the stars in their navigation, while fish are believed to use currents and scents in the sea.

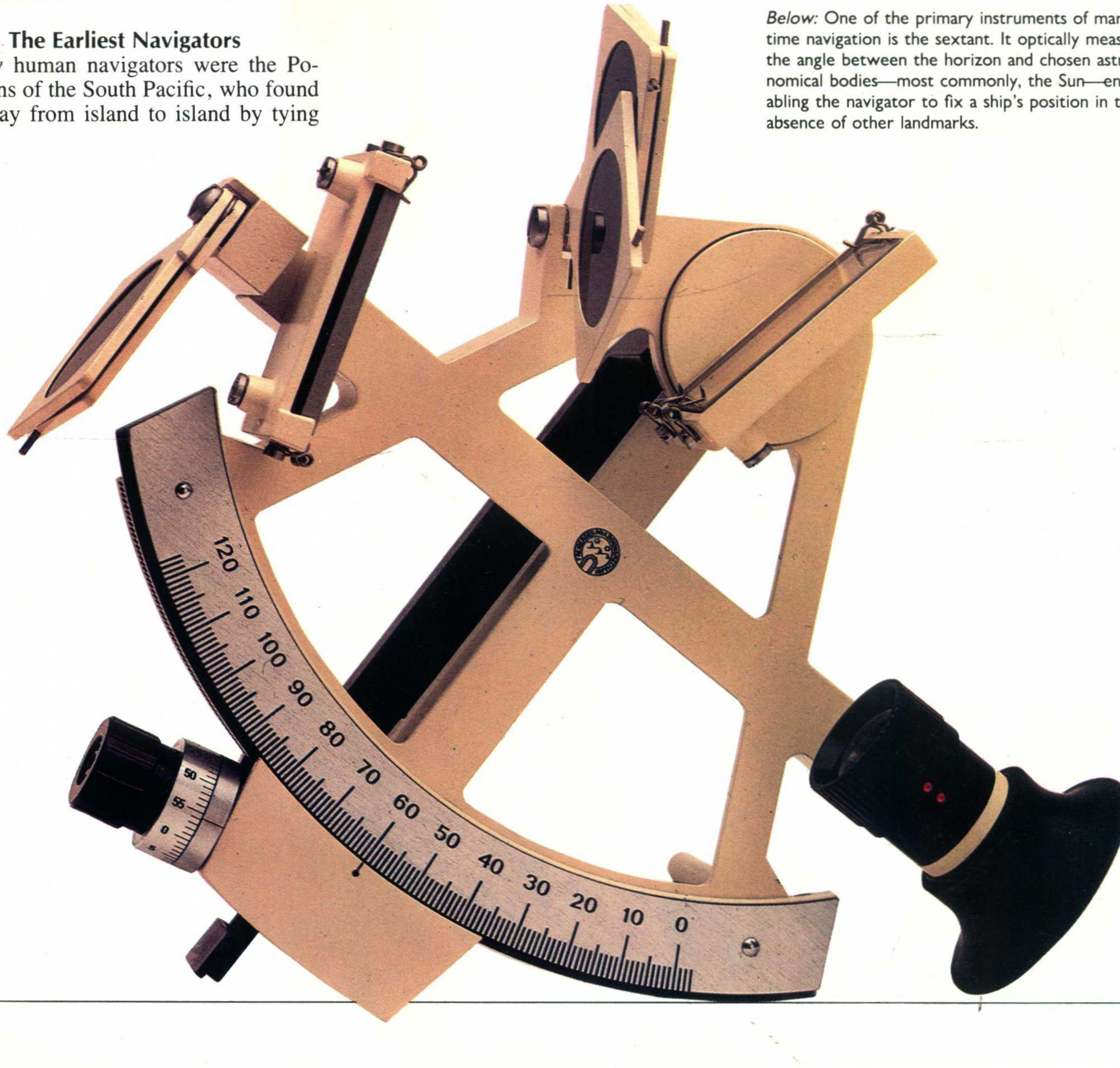
The Earliest Navigators

Early human navigators were the Polynesians of the South Pacific, who found their way from island to island by tying sticks together in a sort of primitive chart. In medieval times, Europeans and Arabs, like the Phoenicians before them, began to record their voyages on charts, which were the forerunners of maps. By the time of the Renaissance, explorers like Christopher Columbus and Ferdinand Magellan used maps and the compass, invented by the Chinese, to navigate across oceans and eventually around the world.

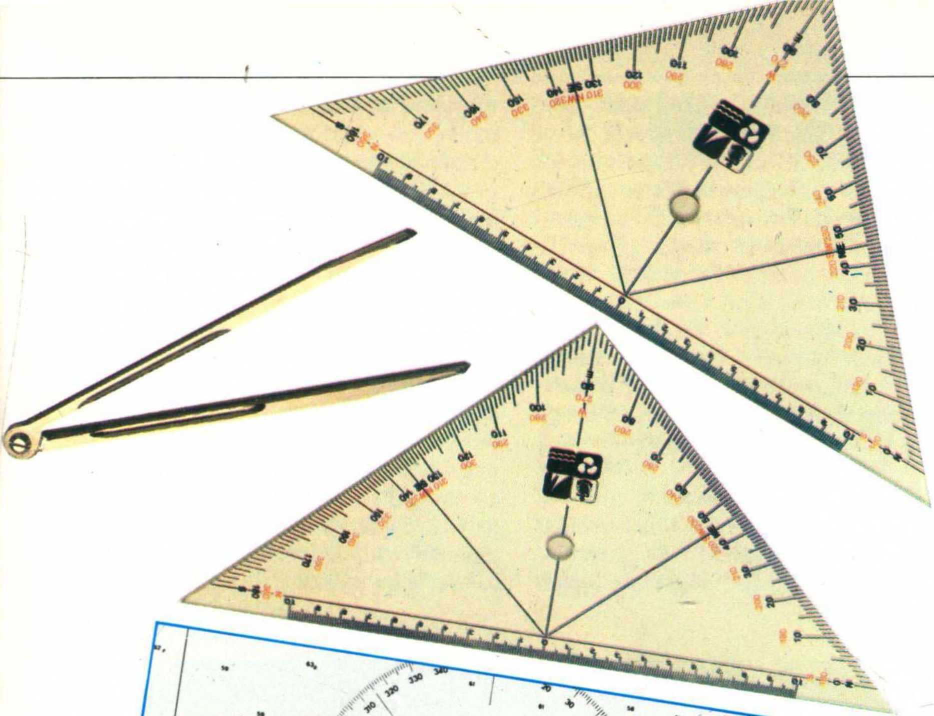
Modern Navigation

Man today still uses the compass and, like the birds, takes his position from the Sun or stars, but he also has an increasingly elaborate array of electronic aids to help him. One reason for this is that, although a compass always points north, it does so only approximately, because the magnetic pole is some distance away from the geographic North Pole. The resulting error, which is about 2° or 3°, must always be taken into account if the navigation is to be exact. Also, maps and charts, which reproduce the globular Earth on a flat surface, are invariably distorted, for a straight line from one point to another on the Earth must actually be shown as a curve on a map. Very-high-frequency radio signals, however, can be projected as straight lines, and such signals, or beams, are used by both ships and aircraft for navigation today. In addition, gyroscopes help to stabilize the instruments and to offset errors that can be caused by rough seas or turbulence.

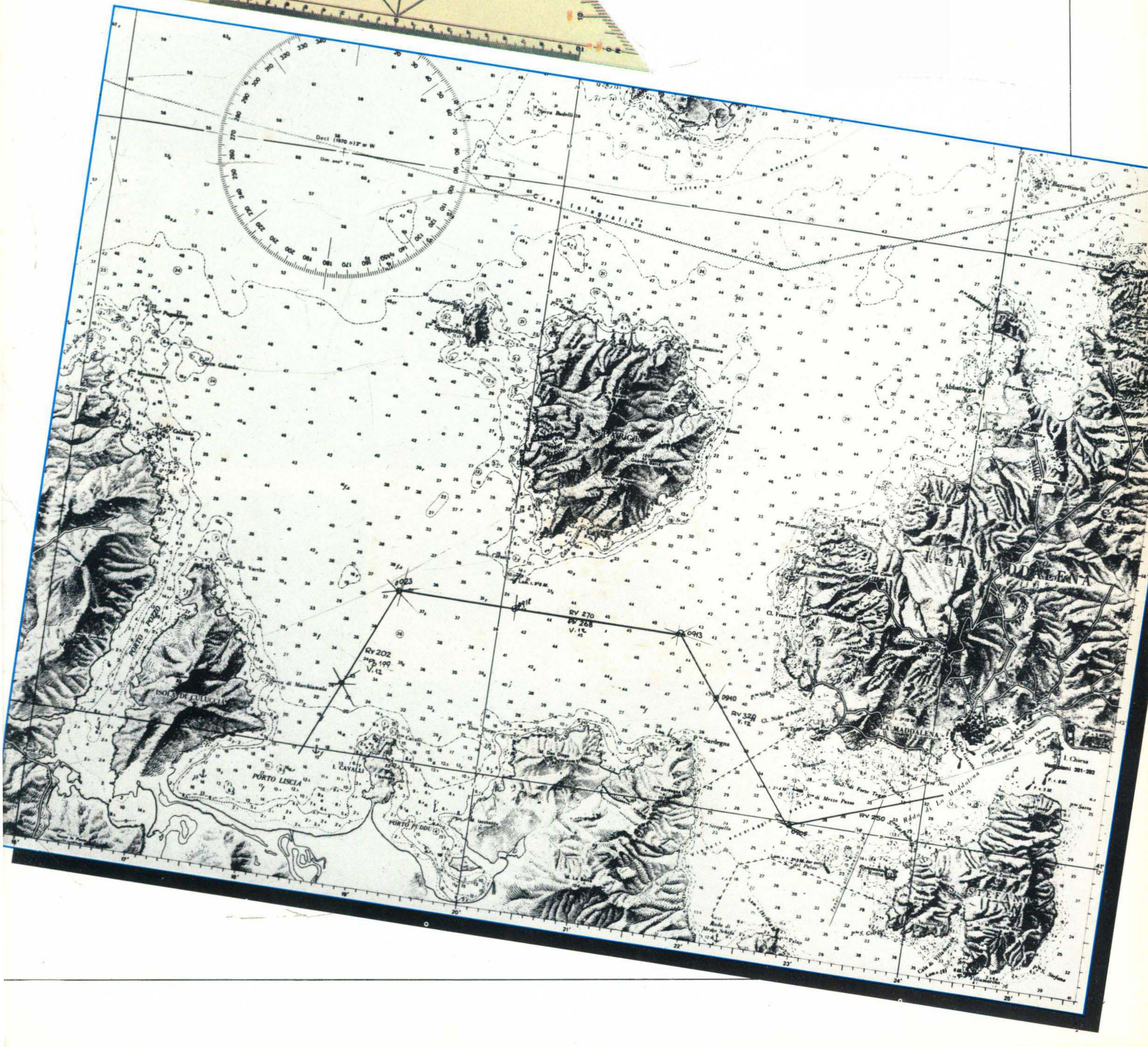
The principal elements in navigation are direction, speed, and distance traveled. These can be accurately computed from observations of the Sun or the stars and elapsed time, as birds do. Although in modern navigation electronics and computers can do all necessary computations, it is noteworthy that both ships and aircraft still use celestial navigation to back up their electronic calculations.



Below: One of the primary instruments of maritime navigation is the sextant. It optically measures the angle between the horizon and chosen astronomical bodies—most commonly, the Sun—enabling the navigator to fix a ship's position in the absence of other landmarks.



Left: Compass and protractors, basic tools used to find a position on a navigational chart like the one shown below. The course plotted on the chart is between 2 anchorages on the northern coast of the island of Sardinia, in the Mediterranean.



Nebula

In the vast interstellar spaces lie large clouds of gases and dust called nebulas. Though both the gases and dust are very thin, they can be seen because of their size. Several nebulas, such as the Great Nebula in the constellation Orion and the Northern Coalsack in the constellation Cygnus, are visible to the naked eye.

Types of Nebulas

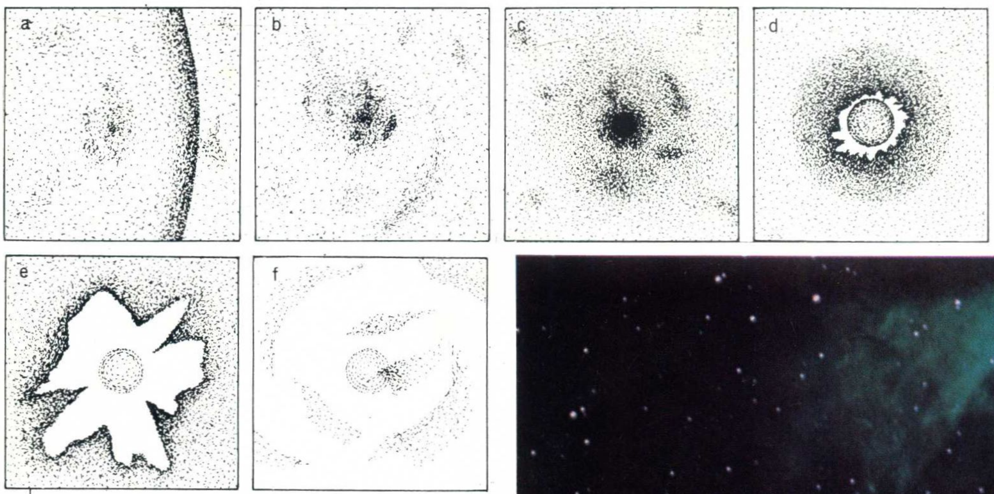
There are, in general, three types of nebulas. Dark nebulas are made up of dust, which blocks the light from stars behind them. Because of this, dark nebulas appear to be black. In front of the Milky Way, these nebulas appear to us as holes, but they are actually dust clouds. They are usually about 100 light-years across.

Reflection nebulas reflect light from nearby stars and therefore appear to be glowing. These nebulas are bluer in color than the stars that illuminate them, for blue light is scattered more easily than red light.

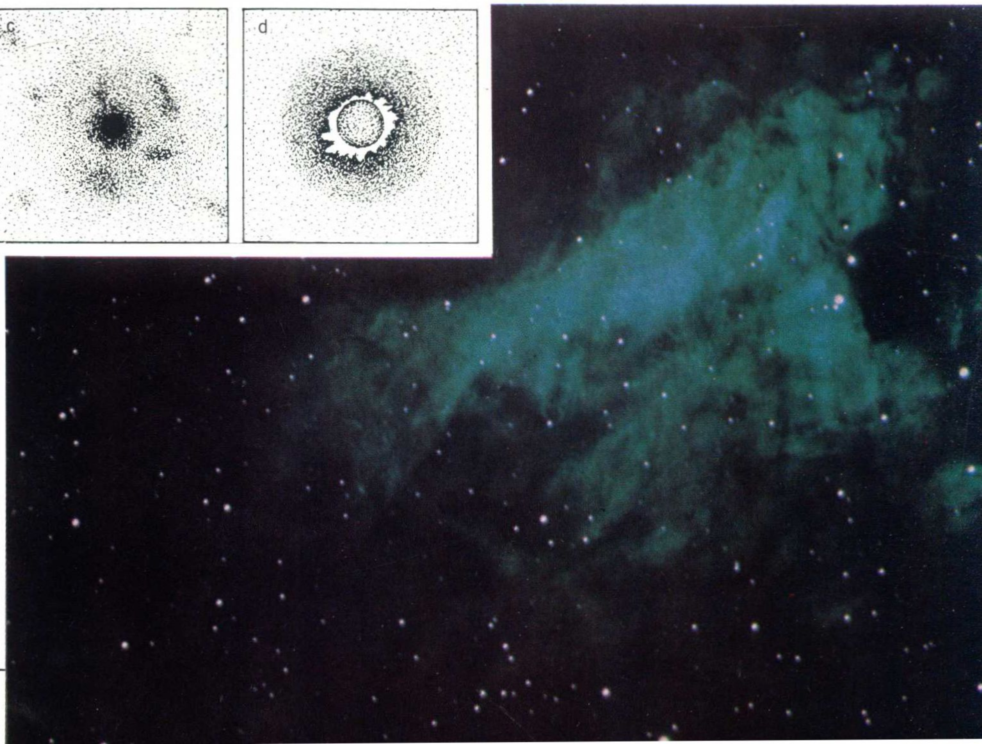
Emission nebulas actually do glow. Ultraviolet light, which is invisible to the human eye, shines from stars onto hydrogen and oxygen atoms in the nebulas, making them fluoresce. Thus, what we see is a type of fluorescent light. For observers looking through a telescope, emission nebulas usually appear greenish.

Structure of Nebulas

It has recently been found that nebulas are frequently associated with giant molecular-cloud complexes. These are clouds that consist almost entirely of hydrogen molecules—that is, a molecule of two hydrogen atoms attached to each other. The giant molecular-cloud complexes also have within them numerous organic compounds. In addition to hydrogen and oxygen, they have water, formaldehyde, ammonia, ethyl alcohol, and many others. At present, 53 compounds are known to exist, but more are expected to be found. There are about 4,000 such clouds in the galaxy, and each has a mass of between 100,000 and 200,000 times the mass of the Sun. They show that organic compounds are widely distributed in the galaxy. Since many of the compounds are organic compounds, the building blocks of life, they indicate, though by no means



Drawings trace phases in the process by which nebula gases and dust are thought to condense to form stars. A shock wave from an exploding supernova (a) forms a protostar (d), which eventually becomes a star (f).



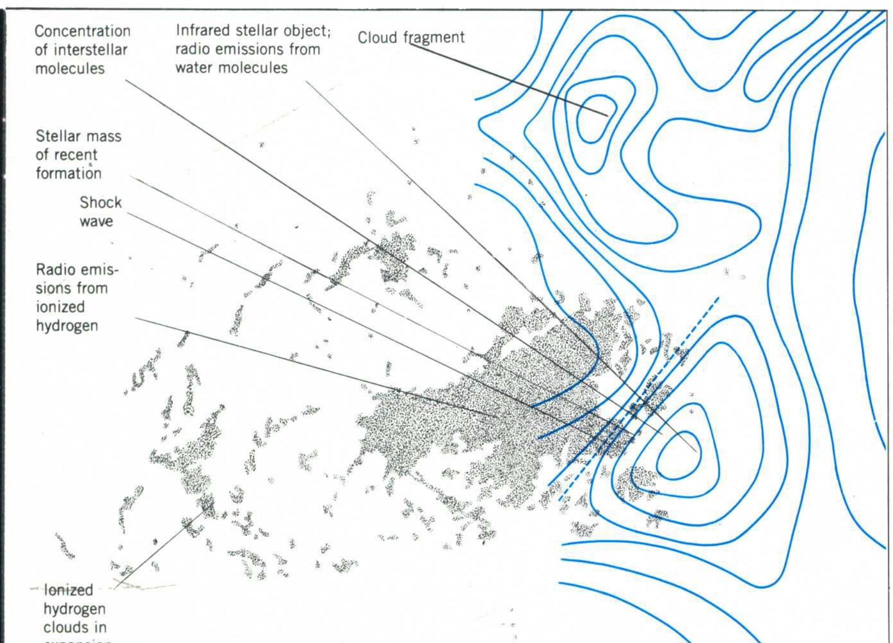
do they prove, that life could exist in distant regions of the galaxy.

The hydrogen and helium found in nebulas have, for the most part, been in existence since the Universe began, about 18,000 million years ago. The heavier elements, such as carbon, nitrogen, silicon, and sulfur, were formed more recently by nuclear reactions inside the stars. These heavier elements have mixed with the gases of nebulas. First, most stars, including the Sun, give off, in all directions, a continuous stream of atomic nuclei. These pick up electrons and become interstellar elements and compounds. Second, huge stars explode. They are called supernovas when they blow up, ejecting enormous amounts of heavier elements out into space.

Star Formation in Nebulas

Astronomers have observed many young stars inside of nebulas and now believe that this is where most stars are formed. They think that gases and dusts collect into dense clouds, which gravitational forces cause to collapse and become more dense. If the cloud is heavy enough and the gravitational pull strong enough, hydrogen will fuse because of the great heat and pressure. Fusion nuclear reactions will start up of their own accord generating tremendous heat, and the star will start to shine. If the celestial body is not large enough, it can only become a planet or smaller body, for the heat and pressures will not be great enough to start a nuclear fusion reaction.

Astronomers think that the Sun and planets of the solar system were formed inside of an ancient nebula. The gases and dust inside of it were mostly remains of an old supernova. At least 5,000 million years ago, another supernova exploded. The explosion pushed the gases and dust particles closer together. A dense, ball-shaped cloud formed. It rotated and, in doing so, became a disk. Pulled together by gravity, the gases and dust at the center became the Sun. Separate planets were formed in much the same way. By about 4,600 million years ago, the solar system had formed, including the planet Earth.



By the standards of the Earth's surface, even the densest portions of a gas nebula are an extremely rarefied vacuum. This relative lack of substance makes them difficult to study, since they are not 'objects' in the traditional sense. *Left:* Isolux map of a nebular structure was obtained by linking areas of the same light intensity within the nebula.

Neptune

Probably the most fascinating thing about the planet Neptune is the way it was discovered, which was because of irregularities observed in the movements of another planet, Uranus. Astronomers saw that calculations made of the motion of Uranus simply did not conform to celestial law and concluded that this was because another body must lie beyond it. This led to investigations by John Couch Adams of England and U. J. J. Le Verrier of France, and the planet was soon found, not by telescope but by star chart, in 1846. Comparing observations with a chart of known stars in the area where Neptune was computed to be, they found that one large star in the sky was not on the map. When the position of the heavenly body was checked again and found to have moved, it became known as the massive planet Neptune. With the discovery of Pluto in 1930, the Solar System as we know it was complete.

Nature of Neptune

Neptune is so far away—2,800 million miles (4,500 million km) from the Sun—that even the largest telescopes can pick up very little information. It is eighth of the nine planets circling the Sun. Neptune's orbit, or elliptical route around the Sun, lies between those of Uranus and Pluto, and it makes a complete journey around the Sun about every 165 years. Neptune's atmosphere is extensive and absorbs only the red, orange, and yellow solar rays, giving the planet a greenish color. Neptune is vast, with a diameter of 27,700 miles (44,000 km), four times as large as the Earth; its mass is 17 times that of the Earth.

Because of the great distance involved and Neptune's cloudy atmosphere, the constitution of the planet Neptune can only be inferred from theory, but it is presumed to be similar to the other massive planets—Jupiter, Uranus, and Saturn. It is thought to have a rocky core about 12,000 miles (20,000 km) in diameter, a thick ice layer, and an immense covering of gases, including methane, hydrogen, helium, and ammonia. The surface temperature of Neptune is estimated at −337°F. (−205 °C.).

Because of the difficulty of observing any of Neptune's features, it has been hard to estimate how long it takes to rotate, or