It appears that the common compass needle known in the Arabic-Islamic world had either the form of a magnetised fish or consisted of another magnetised object. This was placed into a receptacle filled with water and adjusted itself in a north-south direction. The basic principle of such a compass is demonstrated by this model.¹

Our model:
Brass receptacle, gilded.
Diameter: 21 cm.
Wooden fish with a core of magnetised iron, length: 8 cm.
(Inventory No. C 1.01)

From al-Malik al-Ašraf (wrote ca. 690/1291), the ruler of Yemen, who took an interest in astronomy, medicine and genealogy (see above, II, 105), a treatise survives that contains a description of the compass. In this treatise, entitled Risālat at-Tāsa, he describes a floating compass, which shows quite a sophisticated stage of development.

In a circular receptacle filled with water a light pin, made of fig-tree wood and impregnated with wax or pitch, supports the magnetic needle in such a way that both are connected to each other in the middle in the shape of a cross. The surface rim of the receptacle is divided into $4 \times 90^\circ$, where every fifth degree is emphasised by a line (72 in all).

Al-Malik al-Ašraf also tried to transfer the solution of the azimuth calculation of the astrolabe to the compass designed in this manner. We shall encounter something similar to this in the needle compass of Peregrinus (infra, p. 60).\(^1\)

Our replica is based on the description and the drawing by the author.

\(^1\) v. F. Sezgin, *Geschichte des arabischen Schrifttums*, vol. 11, p. 247.
Around 1270, in a letter addressed to his friend Syger de Foucaucourt, the French scholar Petrus Peregrinus de Maricourt describes two types of compasses. It is worthy of note that he wrote this letter from the city of Lucera in Lower Italy which Frederick II had settled with Arabs. One of the two types of compasses which he describes is “equipped with a magnetite rather than a needle. The former is whetted into a round shape and enclosed in a round, watertight box. On the lid of the box four quadrants with 90 divisions each are marked out. In order to find North, the box is placed in a bowl of water, across which a thread is stretched in the direction of the meridian. As soon as the index plate is marked out, a pointer is placed on top which can rotate around the centre of the circle and has two upright pins. Now the box can be put inside any kind of water and it is only necessary to aim at a star or the sun by aligning the pins at the ends of the pointer (so that, for example, in the case of the sun the shadow of one pin falls along the line of the pointer) in order to elicit the current divergence of the star or sun from the meridian and thus the time of day or night.”

Our model:
Circular box
(cork, acryl, copper),
diameter: 15 cm.
Alidade with shadow pins,
rotating. Scale: $4 \times 90^\circ$.
(Inventory No. C 1.05)

Needle Compass of Peregrinus

The second compass described by Petrus Peregrinus has a magnetic needle “which is inserted into a little hole in the middle of a vertical axis, while the axis turns in its bearings between the base and the glass cover of a round box.” This means that Peregrinus is not yet familiar with the seemingly quite modern construction which we can trace in the Arabic-Islamic world at the latest by the 15th century and in which the magnetic needle is placed on a pin with a small cap. Like al-Malik al-Aṣraf (see above, p. 58), Peregrinus transfers the problem of azimuth calculation from the astrolabe to the compass by means of a pointer.

Our model:
Wooden cylinder with fitted, inscribed glass disc, diameter: 10 cm.
Cross of iron needles, suspended between two brass pins on the inside so that it can rotate.
Pointer with shadow pins, attached to the disc so that it can rotate.
(Inventory No. C 1.06)

One of the Four Types of Compass
used by the navigators in the Indian Ocean

The Portuguese historian Hieronimus Osorius (1506–1580) describes with remarkable precision three types of compass, with which Portuguese seafarers became acquainted in their encounters with the navigators of the Indian Ocean. Even the first type appears to be quite modern. It consists of a needle placed on a pin in a circular case which is closed with a glass lid. In the words of Osorius:¹

“...When sailing they used navigational instruments (normae naviculariae), which the sailors call ‘needles’ (acus). Their shape is unfamiliar to those who live far from the maritime regions [and therefore] I would like to explain what is unfamiliar. It is a flat and round container made of wood, two or three fingers high. In the middle is a pin which is sharpened at the top and is somewhat shorter than the height of the container. On this a regula is placed, which is most carefully made of iron, delicate and narrow and cut [in such a way] that it does not exceed the length of the diameter of the container. The point of the pin goes through the middle of the regula, which is concave underneath and bulges upwards. [The regula] is suspended in equilibrium in such a way that on both sides [of the pin] equal [right] angles are formed. The whole thing is covered by a glass lid which is surrounded by a ring of copper wire so that the regula can neither ‘dance’ nor incline to one side.”

A More advanced Type of Compass from the Indian Ocean

Our model:
Wooden cylinder in a glass container, diameter: 16 cm.
Glass lid with engraved brass ring.
Inscribed cardboard disc.
Below it an iron wire, bent in the form of a fish, rotating on a vertical pin of brass.
(Inventory No. C 1.03)

The second type of compass described by the Portuguese historian Osorius, with which Vasco da Gama and other western seafarers became acquainted through their colleagues who were at home in the Indian Ocean, was the result of a further development:

"So that it would become even simpler, and because human ingenuity always invents something in addition to what already exists, they thought up another kind of instrument, with which they were able to maintain their course even more exactly. From iron wire they make a figure with equal sides but unequal angles, in the shape of a deformed rhombus. On this they stick a circular piece of cardboard (carta), one from the top and one from the bottom. With the added strength of the magnet they set the figure up so that one of the acute angles points to the North and the other to the South, and one of the obtuse angles to the East and the other to the West. The length of the diameter of this disk (orbis) does not exceed the length of the [rhombic] figure. The disk then has a copper hollow in its centre which is made in the same way as we described it in the centre of the regula. The point of the pin is inserted into the hollow and thereby keeps the disk suspended, which not only works like the regula we have already described but also optically shows the directions of all the winds which move the ships, since on the top piece of cardboard North, South, East, West and the directions in between are marked (describuntur) most precisely."

The cardboard disc is marked with 32 points of direction at intervals of 11°25’ which indicate the approximate rising and setting of 15 fixed stars and the two poles.

¹ v. F. Sezgin, Geschichte des arabischen Schrifttums, vol. 11, p. 255.
Compass

suspended after the system which as subsequently and without justification called «cardanic»

Our model:
Hardwood cylinder, diameter: 24 cm, height: 18 cm.
Hemispherical compass box, “Cardanic” suspension by means of a copper ring.
Cardboard disc with “iron-fish”, rotating on a pin, tightly closed from above with a glass disc.
(Inventory No. C 1.07)

About the third and highest stage of development of the compass which the Portuguese seafarers became familiar with in the Indian Ocean the historian H. Osorius (1506-1580) informs us as follows:
“When the instrument is set up like this, there remains the disruptive factor that the ship in a swell rolls towards the bow and the stern or lists to one of the two sides, so that it (the disk) drops and blocks and can no longer indicate the North by moving freely. So that this no longer happens, people have thought up something extremely astute: the container (vas) itself is tightly surrounded with a copper ring just below the top edge. On both sides of this ring a steel rod (?
virgula calybea ducta) is inserted into the opening of another larger outer ring at a suitable distance. Both rods are the same and stand opposite each other so straight that, if they were joined to form one single rod, this rod would correspond to the diameter of the ring-shaped space between the rings. The outer ring can be rotated around these two rods as if round an axis. Again, two equal rods go equidistant from this outer circle to a round basin surrounding them (alveolus orbiculatus), which contains everything. The outer rods are placed in relation to the inner ones such that if they were made to approach each other they would bisect each other at right angles. Although the whole instrument is made of copper underneath and is heavy, it does not bump into anything. It is impelled on all sides to remain in the centre. And since it is suspended and is mobile and thus keeps its equilibrium, it always shows the direction exactly, even in rough seas. Thus it is that there is nothing which can interfere with this instrument in showing North.”

The new element consisted therefore in the ingenious idea of the “Cardanic” suspension which helps to keep the compass disc balanced in a horizontal position during the ship’s voyage.¹

The magnetised metal loop, which is fixed under the disc, positions the disc in the north-south direction. Through the “Cardanic” suspension, the point of the compass can also be measured while heeling over (sloping position). The disc carries the names of the 15 fixed stars with their rising and setting at intervals of 11°15’. It is also divided into degrees.


Various compass needles. They were fixed under the cardboard disc and, after being magnetised with a lodestone, showed the north-south direction. The “fish shape” (on the left) was the most common among the Arabs.

¹ Arthur Breusing cautions against the habit of calling this invention “Cardanic”: “However, Cardanus himself says: ‘A method of setting up the emperor’s chair was invented so that, while travelling, he always sits without moving and comfortably, despite all oscillations. This is done by a special combination of rings. Because when three movable rings are connected to each other in such a way that the pivots of the one are on the top and below, those of the other on the right and the left, and those of the third in front and behind, then such an arrangement must remain completely at rest with each position of the travelling coach, since every movement follows from three axes at the most. The principle is derived from those lamps which will not spill the oil, whichever way they are held.’ From this at least this much follows that Cardanus cannot be considered the inventor of the arrangement, and that it is therefore named after him only because it was probably mentioned by him first. Despite all my investigations I did not succeed in ascertaining anything more about the origin of this so ingenious invention.”
It seems to be a great merit of Ibn Māgid, one of the greatest navigators of the region, to have constructed the highest stage of the compass developed in the Indian Ocean. In his book Kitāb al-Fawâ'id, written in 895/1489, he states that it was one of his inventions in the science of navigation to put the magnetic needle directly on the compass. Taking into consideration the shapes of the compass in the Indian Ocean known to us, where a magnetic wire or a magnetic needle rotates freely on a pin, either below a round cardboard disc or without the cardboard disc, we can probably understand the invention of Ibn Māgid as meaning that he let the magnetic needle rotate freely above the cardboard disc on the pin.¹

Our model:
Hardwood cylinder.
Diameter: 16 cm.
Height: 10 cm.
“Cardanic” suspension by means of a copper ring.
Iron needle, length: 8 cm, on a pin in the hemispherical case, the latter closed with a glass disc.
(Inventory No. C 1.08)

A Device as an Additional Attachment to the Compass

From the statements of the two great navigators Ibn Mağid and Sulaimān al-Mahri it can be deduced that the cylinder-shaped compass was combined with a supplementary device during voyages in the Indian Ocean: surrounding the cylinder there was a plate which was inscribed with the 32 converging lines of the points of direction and the names of the rising and setting of the 15 known fixed stars, besides the two poles. The plate with the compass had its fixed place on the forecastle (ṣadr al-markab). It enabled the navigator to read off the angle of direction that was changing during the voyage.¹


Our model:
Brass, etched, on wood.
Length of the side 41 cm.
Thickness: 6 mm.
(Inventory No. C 1.23)
It is quite probable that Christopher Columbus used the second of the three types of compasses mentioned above (p. 62) which the historian Osorius (1506–1580) described. Its characteristic is that a magnetised wire loop was pasted on a piece of paper from below against the compass disc. The disc itself is balanced in such a way that it can move freely on the tip of a pin. The Spaniard Martin Cortés describes in his Breve compendio de la sphera y de la arte de navegar (Sevilla 1551, p. 80) such a compass and supplies his description with a drawing of the compass disc and the wire loop.\(^2\)

Apparently Italian navigators came to know of this type of compass used in the Indian Ocean as early as the 9th/15th century. This impression is particularly strengthened by the report on the first itinerary of Vasco da Gama, where it is said that he had seen how the seafarers of the Indian Ocean used magnetic needles after the manner of the Genoese.\(^3\)

Unfortunately, it has not been noticed so far that the division of the disc into 32 parts does not represent the lines of direction of the compass card, but has a connection to the compass disc of the navigators of the Indian Ocean, whose division has its origin in the points of direction of the rising and setting of the 15 known fixed stars and the two poles.

\(^1\) Besides the “Genoese” type, described here, during his voyages he also used compasses which he called “Flemish”. This type was also constructed according to the principle that the cardboard disc moved together with the wire loop. From Columbus’ statements we can deduce that the “Flemish” type of the compass also had a disc similar to the “Genoese” type, cf. H. Balmer, Beiträge zur Geschichte der Erkenntnis des Erdmagnetismus, Aarau 1956, pp. 80–84.


The First
«True Ship’s Compass»
in Europe

Heinz Balmer, to whom we are indebted for a valuable work on the history of the discovery of geomagnetism, refers to a type of compass as the “true ship’s compass”; in fact, this type is quite simply the one described by the Portuguese historian Osorius as the third type of compass used by Arab navigators in the Indian Ocean (see above, p. 63): “The needle, endowed with a small cap and balancing freely, rests on the tip of a pin firmly mounted at the bottom of the case. On the upper side of the needle a round disc is affixed and on it a partial circle is drawn which turns with it as a movable horizon. This disc is not divided into 360 degrees, but in wind markings of 11 1/4 degrees each. Lastly, so that the small case always remains horizontal, it is suspended from two intersecting axes in two horizontal rings, so that it can turn around one axis in the inner ring and the inner ring can turn in the outer ring around the other axis, which lies at right angles to the first one. Then this little box can always move towards the position of its centre of gravity, despite the pitching and rolling of the ship.”

Balmer continues: “The Spaniard Pedro de Medina speaks in 1545 and the Dutchman Stevin in 1599 about this compass as something that was quite common. The suspension in the two rings, it is true, is said to have been invented only by Cardano, who lived from 1501 to 1576. But nobody tells us who was the first to attach the needle under a cardboard with the compass card and thus placed it upon a pin.”

Our model:
Turned cylinder of hardwood.
Diameter: 24.5 cm. Height: 17 cm.
“Cardanic” suspension by means of a copper ring.
Disc with an iron wire, bent in the shape of a fish, between two pointed tips, mounted in the hemispherical compass case so that it can rotate. (Inventory No. C 1.09)

It is a pity that Balmer did not have any knowledge about the Arab navigation in the Indian Ocean and about Osorius’ descriptions of the types of compasses found there. The assumption may not be unfounded that the “true ship’s compass” as well as the two other types of compasses described by Osorius reached Portugal from the Indian Ocean even with the first Portuguese expeditions. The first “true ship’s compass” to make its appearance in Europe probably looked like the model illustrated here.

1 v. H. Balmer, Beiträge, op. cit., p. 69.
One more model of the
«Ship’s Compass»

Ship’s Compass
in a Square Housing

Reconstruction based on the shape described by Rodrigo Zamorano (1581). The housing supporting the compass case with its “Cardanic” suspension is, for the first time, square.

Our model:
Hardwood case: 20 × 20 × 10 cm.
Wooden cylindrical compass case.
“Cardanic” suspension on a brass ring.
Disc with an iron wire bent in a rhombus shape, placed upon a brass pin so that it can rotate.
(Inventory No. C 1.11)

1 Rodrigo Çamorano, Compendio de la arte de navegar, Sevilla 1581, reprint Madrid 1973, fol. 36aa.
Two **Ottoman** Types of Compasses

To the first Müteferriqa (1145/1732) edition of the Ottoman-Turkish book *Çihânnumâ* by Hağgî Halifa (1609-1658) was added the picture of a compass (between pp. 65 and 66, on the right), in which the magnetic needle as a wire loop does not carry the cardboard disc, being balanced as a magnetised pointer on a pin above the disc. Thus it recalls the type of compass which was described by the navigator of the Indian Ocean, Ibn Mâjid, as his own invention (see above, p. 65).

A note in the text explains that in 1145/1732 a deviation of 11°30’ was observed for Istanbul, which is also demonstrated by the compass.

The other compass described by Hağgî Halifa and shown in the illustration on the left is a multiple instrument; when opened and set up vertically, an alidade serves to measure the altitude of heavenly bodies; when folded together into a horizontal position, a magnetic needle mounted between two glass panes can be used as a compass.

**Our models:**

a) Wooden frame (base 25 × 25 cm), foldable; scale and alidade of brass, magnetic needle between acrylic panes.

(Inventory No. C.1.24)


(Inventory No. C.1.12)
Ship’s Compass

Reconstruction of a European compass from the 18th century with roughly calibrated disc and relatively precise device for direction finding. After Nicholas Bión, *Traité de la construction et des principaux usages des instruments de mathématique*, Paris 1752, p. 278, fig. 2 (v. on the right).

Fig. from N. Bión, *Traité ...*, op. cit., p. 278, fig. 2, after *Instrumentos de navegación del Mediterráneo al Pacífico*, Barcelone, n.d., p. 88.
Ship’s Compass

Replica of a compass from the 19th century. The so-called wind markings are replaced here by the points of the compass.

(Original in the Museu Marítim, Barcelona, v. La navegació en els velers de la carrera d’Amèrica, Barcelona: Museu Marítim n. d., no. 47)

Our model:
Hardwood box,
21 × 21 × 13.5 cm.
Groove for inserting a lid.
Cylindrical compass case of brass,
diameter: 14 cm.
“Cardanic” suspension on a brass ring.
Rhombus-shaped iron wire under the cardboard disc. On the disc “compass card” with 32 divisions, on the rim division into 4 × 90°.
Inscription in the middle of the disc: “Antigua casa / Rosell / Barcelona”.
(Inventory No. C 1.14)
Ship’s Compass

Based on a Spanish compass from the 19th century. The original was apparently inserted into some device on the ship: the “Cardanic” ring is connected with the case only on its inside, towards the outside pins are protruding.

(Original in the Museu Marítim, Barcelona, v. La navegació en els velers de la carrera d’Amèrica, Barcelona: Museu Marítim n. d., no. 45)

Our model:
Brass case, diameter: 22 cm.
“Cardanic” suspension on a brass ring.
Rhombus-shaped iron wire beneath the cardboard disc.
Disc with 32 divisions according to the points of the compass and with markings in degrees (4 × 90°), inscription: “Escuela Nautica Masnou”.
(Inventory No. C 1.15)
Ship’s Compass

Based on the original of a Portuguese compass of the 18th century in the form of a crown. The “Cardanic” suspension is not necessary here, because the compass with the disc turned downward is attached to a thread. Minor pitching and rolling by the ship was thus compensated for. The compass was suspended with the needle downwards above the captain’s bed so that he could also follow the course from there.

(Original in the Musée de la Marine, Paris)
‘The Mining Surveyor’
Compass

Chinese land surveyor compass with sundial from the year 1765/66 from the Institute’s collection.

Hardwood, incised.
Diameter: 115 mm.

Upper half of the instrument, inner side: compass needle with detailed azimuth scale.

Inscription on the front: “Sundial, made in the 30th year of the Ch’ien Lung era” (1765/66).
(Inventory No. C 1.17)

Lower half of the instrument, inner side: gnomon with adjustable disc of scales.
Compass needle with rough azimuth scale.
Prayer Compass

Replica of an Ottoman-Turkish compass of the 19th century in three finishes. The original is in the Rautenstrauch-Joest Museum für Völkerkunde in Cologne. It was made by a certain Ahmad b. Ibrāhim aš-Šarbatli in 1251/1853.

The names and coordinates of some important cities of the Islamic world are inscribed in the area around the centre with the compass needle. If the user is at one of those cities, he can determine the direction for prayer towards Mecca with the compass. With the help of the gnomon on the side indicated as the west, the times of prayers can be read off from the scale adjacent to it.

Our Model: Brass, etched.  
16 × 16 × 2 cm.  
(Inventory No. C 1.18c)

Our Model: Hardwood, incised, etched.  
13 × 13 × 2 cm.  
(Inventory No. C 1.18b)

Our Model: Silver, engraved.  
11 × 11 × 2 cm.  
(Inventory No. C 1.18a)
Mirror sight with thread, which can be adjusted in height. While closing, a spring mechanism stops the circular magnetised ring from oscillating. The sight is arranged opposite to the mirror sight. It consists of a slit sight and an aperture mirror sight with two coloured shutters. The circular ring of magnetised iron carries a division into 360° in mirror writing and rests on a pin. Spirit level at the bottom of the compass case. Brass lid for the protection of the glass pane. Signature on the lid: Stanley/London/1917. (Inventory No. C 1.22)

Compass for Surveying

An English compass of 1917, with direction finding and spirit level, from the Institute’s collection. Through the slit sight the desired object is aligned until it is in line with the thread of the opposite vior. After the magnetised circular ring has stopped oscillating, the degree can be read off through the mirror of the aperture sight.
Fluid Ship’s Compass

A European compass from the beginning of the 20th century from the Institute’s collection. The residual deviation which depends on the course, is compensated for with the two hollow iron spheres as compensation magnets.

Compass case of brass, “Cardanic” suspension; sealed with a disc, floating in alcohol. Diameter: 104 mm. Disc with division into 360 degrees and points of the compass. Two hollow iron spheres, diameter: 40 mm, screwed on in such a way that they can be adjusted.

(Inventory No. C 1.19)
Compass

English ship’s compass from around 1920, from the Institute’s collection. Because of its modest size it was probably meant for a small yacht.

Compass case of brass, diameter: 10 cm, closed watertight with a glass pane, can be screwed to a brass lid, “Cardanic” suspension. A 360° division, the points of the compass and “T. Cooke / London” are engraved on the bottom of the case. The magnetic needle is mounted upon a pin. (Inventory No. C 1.20)
Geographical Compass

An English compass with direction finding, from the 20th century, in the Institute’s collection. Through the slit sight an object is aligned until it is in line with the wire in the lid. Since the disc swings rather slowly in the north-south direction, it can be supported with the spring mechanism. After alignment of the disc, the degree can be read off through the reflected aperture sight.

Compass case of brass with glass lid, diameter: 70 mm.
Small foot for mounting on a stand.
Lid with a hinge, foldable, with a mirror on the inside and furnished with a glass sight with a thin wire. Opposite slit sight, under it aperture mirror sight.
Compass disc of aluminium with a division into 360° in mirror writing and indication of the four points of the compass.
Magnetic needle fixed beneath the disc.
Spring mechanism on the side for manually stopping the disc from oscillating.
Below two set-screws for adjusting the disc.
(Inventory No. C 1.21)
Fluid Ship’s Compass
with Hurricane Lantern

From the Institute’s collection, probably early 20th century.

Magnetic compass with division into 360° and points of the compass, “Cardanic” suspension in cylindrical brass case (diameter 19 cm). On the side a device for lighting, container with a wick and a screw for adjusting, signed: Sherwoods Limited, Vaporite no. 1 (Inventory No. C 1.25).