# United States Patent [19]

**Hervieu**

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[54] **SIMULATOR FOR SHIP NAVIGATION**


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[52] **U.S. Cl.** .......... **35/10.2,** 353/12

[51] **Int. Cl.** .......... **G09b 9/06**

[58] **Field of Search** .......... 35/10.2; 88/1.5; 73/178, 73/181; 340/373; 353/11, 12, 13, 35



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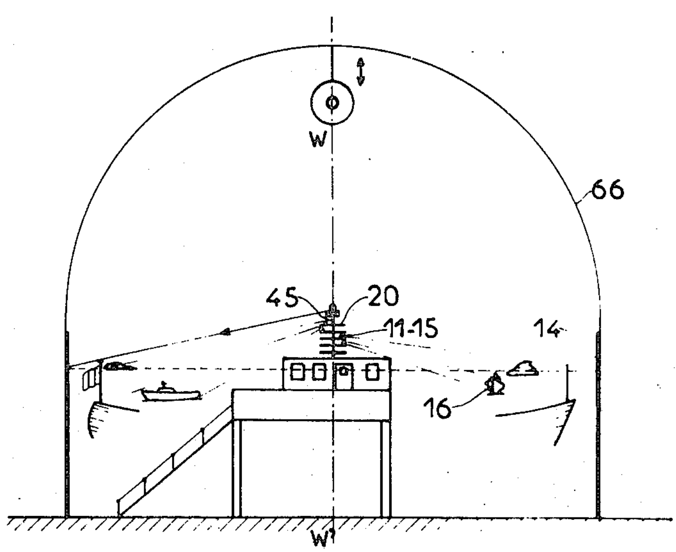
[57] **ABSTRACT**

The invention relates to a device for simulating navigation at sea. It is intended for mounting above the bridge of a supposedly moving observer ship and serves for the projection, on a cylindrical screen, of images of movable ships or of coastlines. The device comprises as many superimposed concentric plates as there are ships under observation. Each plate rotates as a function of the bearing of the ship being observed with respect to the observer ship. Each plate carries a projector having a focal line objective which can be adjusted in relation to the distance that separates the observer ship and the sighted ship. Each plate further carries, associated with the projector, a particular device for displacing a number of transparent slides successively fed into the projector, the succession being carried out in relation to the inclinations of the ship being sighted with respect to the observer ship. Each transparent slide illustrates the ship being sighted in one of a number of successive positions of the said ship when the latter makes a complete turn about its own axis.


**12 Claims, 17 Drawing Figures**



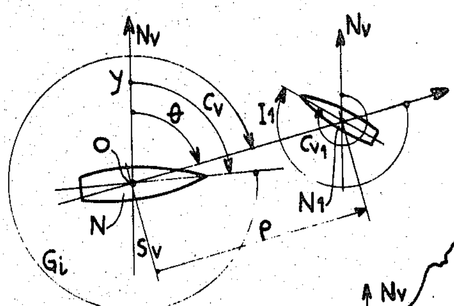



fig. 2

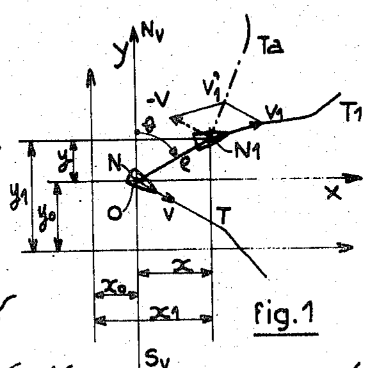



fig.1

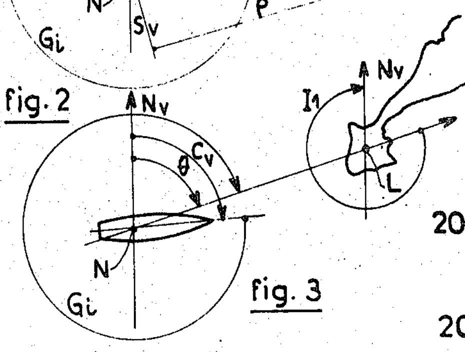



fig. 3

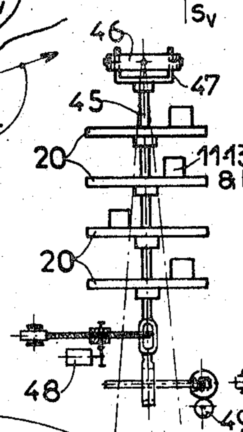



fig.15

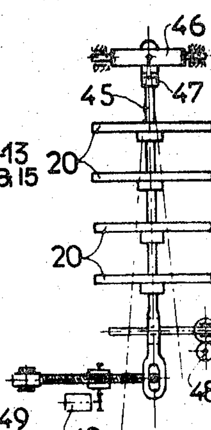
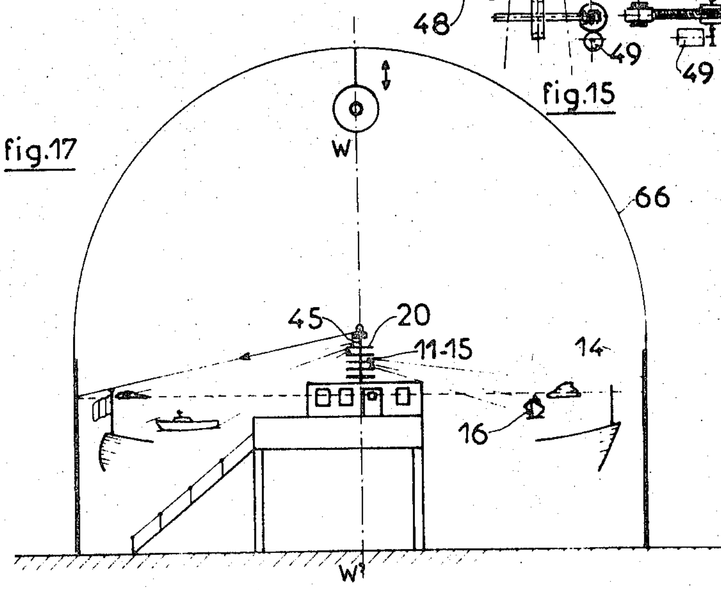



fig.16

fig.17



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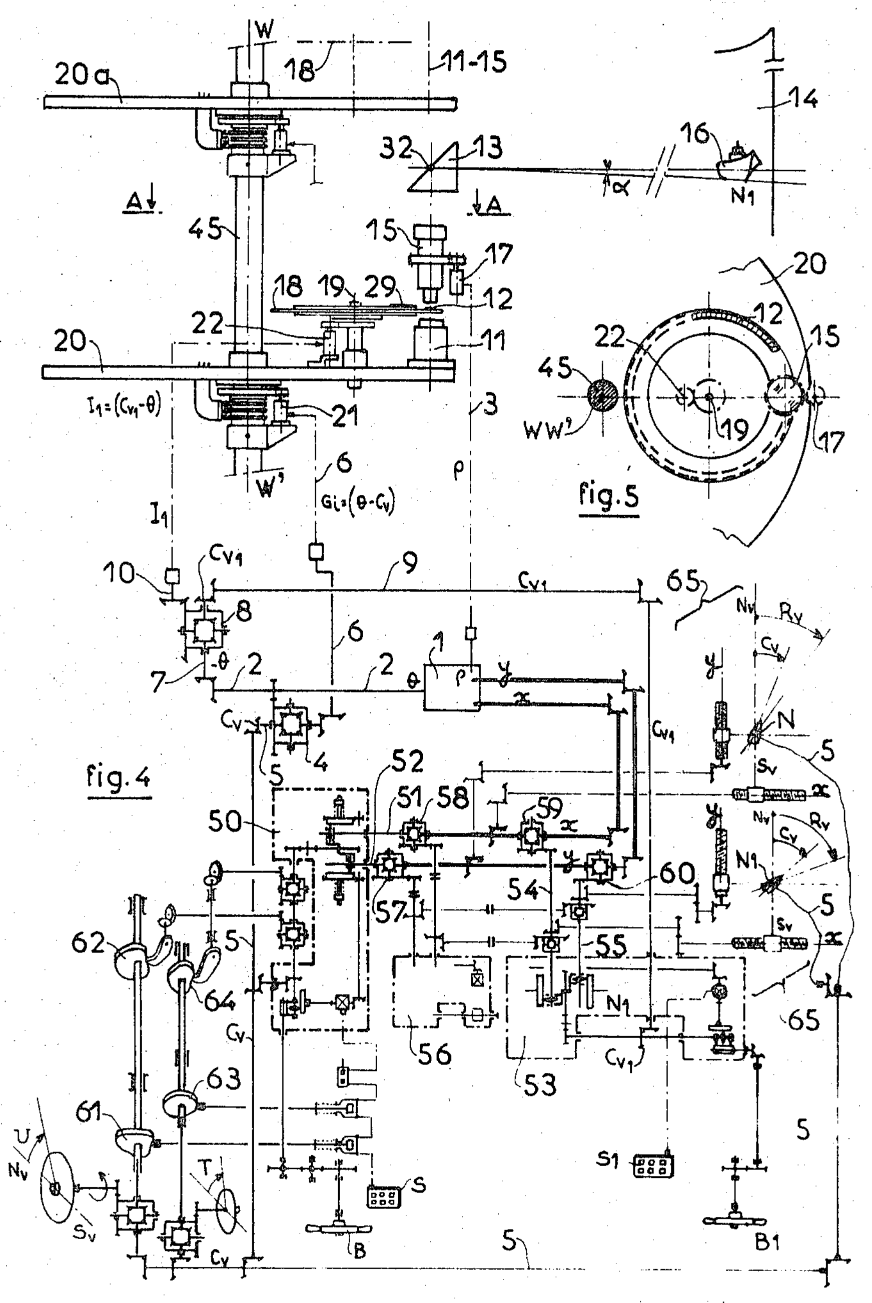


fig.5

fig.4

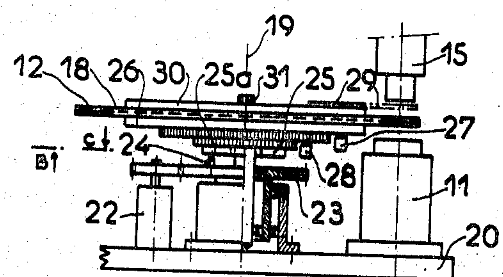

fig.10

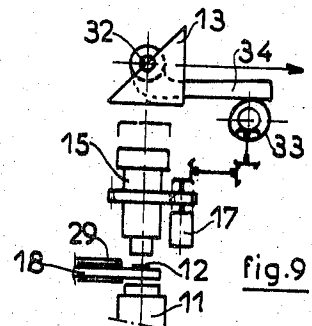

fig.9

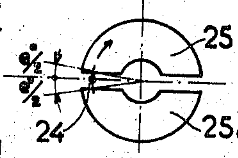

fig.11

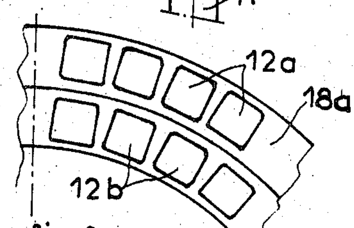

fig.8

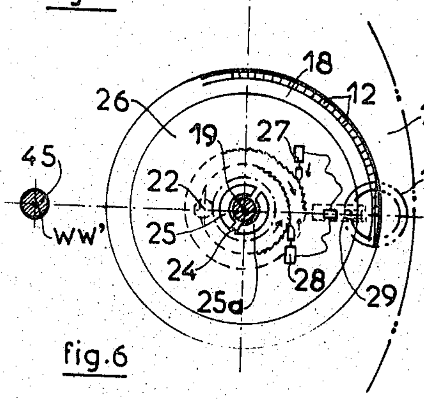

fig.6

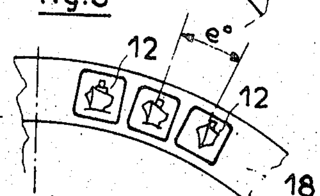

fig.7

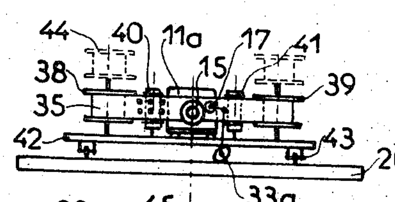

fig.12

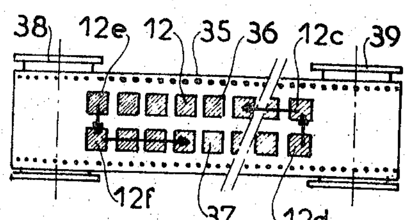

fig.14

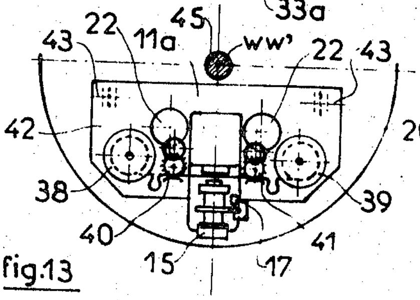

fig.13

## SIMULATOR FOR SHIP NAVIGATION

The present invention relates to a navigation simulator. More particularly, it relates to an apparatus reproducing the sight, on a cylindrical screen, of moving floating devices or coastlines. This sight, at the level of an observer and on a circular view covering 360°, is the same as that seen from the bridge of a supposedly moving ship.

It is well known to reproduce, by television camera and screens, the relative movements of movable ship models on a table representing the sea. The model animation room and the optical retransmission device flush with this table are cumbersome. This solution gives very vague semblances of movement, at the level of the horizon or close to the observer. It is difficult to simulate the reentering into a harbour.

It is also known to project, onto a cylindrical screen, shadows obtained by means of a central projector and screens constituted by models. The latter are flat and cut up according to an outline of the coast or of the floating engine. They are movable about the light source and may move away from it. But they always remain parallel to the screen. Among the disadvantages of such a system may be noted: an insufficient approach of the coastline or of the engine being sighted; a projected image which is too schematic; the impossibility to simulate correctly the autonomous displacement of the ship being sighted (namely when pivoting upon itself); the difficulty of projecting, simultaneously in the same zone, several ships being sighted.

The apparatus according to the invention makes it possible to avoid the disadvantages mentioned above. The observer may see on the screen several ships manoeuvring on their own trajectories and even around him. He may move about a floating engine, whether moving or not, and come near it a minimal distance. It is obviously the same for an island. The said apparatus makes it also possible to simulate the effects of a current, of waves or of the wind. It may yet simulate rolling and pitching. The appearances of a trip at sea are complete. Any initiatives of the pilot (helm, ship velocity) are perfectly respected in their consequences.

Other results will appear from the following description. They are all obtained mainly through a projection system controlled by a succession of special members. The projection is obtained from especially recorded and arranged transparent slides. It is made on a cylindrical screen, otherwise known, in a lighted room. It will be possible to clearly understand the invention by means of the following description of a method of obtaining it including several variations given by way of non-restrictive examples. Appended hereto are diagrams illustrating the meaning of the various symbols used in the description and figures of drawings wherein:

FIG. 1 is a plan view of a diagram giving the relative position of two ships N and N1;

FIG. 2 is another plan view of a diagram intended to give the definition of certain values;

FIG. 3 is a plan view of a diagram similar to that of FIG. 2 but wherein the position of the ship N is given in relation to an island or a peninsula L which has no course;

FIG. 4 is an elevation view of the special projection apparatus located above the bridge of the observer ship N, at the center of the cylindrical screen, with the connections of the said projection apparatus to a computer;

FIG. 5 is a cross-sectional view, taken along line A—A of FIG. 4, of the slide-carrying disc;

FIG. 6 is a cross-sectional view of the disc of FIG. 5 with the rotation-producing mechanism;

FIG. 7 is a partial plan view of a slide-carrying disc;

FIG. 8 is a plan view of another embodiment of slide-carrying disc;

FIG. 9 is a partial plan view of the mechanism for correcting the angle of projection in relation to the distance N N1;

FIG. 10 is a side elevation view, partly in cross-section, of the disc support;

FIG. 11 is a plan view of a detail of the disc driving mechanism taken at C of FIG. 10;

FIG. 12 is a front elevation view of a mounting and animation device for the slides, according to another embodiment;

FIG. 13 is a plan view of a further embodiment of the device of FIG. 12, with the slide band;

FIG. 14 is a detail front view of a slide-carrying band;

FIGS. 15 and 16 are, respectively, a front and a leftward elevation view of a multiple-plate system with rolling and pitching simulation, and

FIG. 17 is a vertical cross-section view of the simulation room.

With particular reference to FIG. 1, N identifies the observer ship, N1 the ship being observed, Nv – Sv the North-South line coinciding with the OY axis, T the trajectory of N, V its instantaneous speed, T1 the true trajectory of N1 and V1 its instantaneous speed, Ta the apparent trajectory of N1 seen from N and V'1 its relative speed with respect to N (obtained by working out the vectors V1 and −V according to a known method). $\theta$ is measured from OY and P from N coinciding with O.

FIG. 2 gives the following values: Gi, the bearing of N1 with respect to N ($Gi = \theta - Cv$); Cv, the true course of the ship N; I1, the inclination of N1 for an observer located at N ($I1 = Cv1 - \theta$) and Cv1, the true course of the ship N1.

As shown in FIG. 4, the manoeuvre desk of the observer ship N, on the navigation bridge located at the center of the cylinder screen, has a steering bar B and a speed control member S (speed selector, for example). There is provided, in the same room or in an auxiliary room, a helm bar B1 and a speed selector S1 of the first ship in sight. There may be several movable engines in sight of which the control gears are illustrated by B2, S2, etc... In order to facilitate explanation, there will first be considered the manoeuvre of a first sighted ship N1 in relation to the moving ship N. Gears B, S and B1, S1 actuate calculators combined to provide an auxiliary computer 1 with two essential informations: the coordinates $x$ and $y$ of the ship N1 in relation to orthogonal axes OX and OY (OY being the true North-South line) whose point of origin is located on the observer ship N, according to FIG. 1.

Reference will be made again later to these computers that continuously give the coordinates of N1 on its relative trajectory with respect to the axes OX, OY (thus with respect to N). For a better understanding, the values $x$ and $y$ are supposedly given in angular deviation of two shafts. It is easy to substitute therefor electrical values such as variable voltages.

The auxiliary computer **1** changes the values $x$ and $y$ into polar coordinates $\theta$ and $\rho$, according to one of the already known methods (see FIGS. **1** and **2**). The angular deviation $\theta$ is transmitted on the shaft **2**. The distance N N′, that is $\rho$, is measured by a voltage which is amplified and sent to its destination by a connection **3**.

The shaft **2** drives a differential system **4** in which a shaft **5** rotates in keeping with the true course Cv of the ship N. It is easy to understand that the shaft **6** varies angularly as the bearing $Gi = \theta - Cv$. A shaft **7** driven by the shaft **2** drives a differential **8** that receives, through its shaft **9**, the angular indication of the true course Cv1, provided by an elementary computer of the ship N1. Thus, shaft **10** rotates an amount $Cv1 - \theta$, equals to I1 (inclination of N1 for the observer located at N, according to FIG. **2**). The data strictly provided by the connection **3** ($\rho$) and by the shafts **6** and **10** are electrically retransmitted to the three servo-motors **17**, **21**, and **22**, controlling the rotation of the main members of the projection device of each ship in sight. The differentials **4** and **8** may be replaced by electronic devices computing ($\theta - Cv$) or ($Cv1 - \theta$).

A projector **11**, having a variable focal line, projects the slides **12** on a cylindrical screen **14** through its total reflection prism **13**. The diameter of the cylindrical screen **14** is about 20 meters, the drawing being reduced at this location. The light beam from prism **13** may either move up or down but it is always directed according to a same vertical plane passing through the axis WW′ of the cylindrical screen. The projector assembly may rotate about this axis. Its variable focal line objective **15** allows an enlargement of 1 to 20, for instance. An image **16** having an apparent diameter of 0.12 m may, in such a case, be magnified to 2.40 m. According to this example, a ship having a length of 150 meters may be seen, with an inclination of 90° or 270°, at distances varying from 12,500 to 625 meters with a cylindrical screen having 20 meters in diameter.

The motor **17**, set by the auxiliary computer **1** in relation to the distance $NN1 = \rho$, adjusts the focal distance of the objective **15**. At all times, the apparent diameter of the image **16** is therefore that of the ship N1 actually seen from a variable distance $\rho$.

Mounting of the slides **12** may be obtained in several ways. In a first instance, a horizontal disc **18** rotates about its axis **19** borne by the same plate **20** that carries that projector **11**, which plate **20** rotates about the central axis WW′ of the screen (FIG. **10**). A large number E of transparent slides **12**, **180** for instance, is provided along the periphery of the disc **18** (FIGS. **6** and **7**). They illustrate the ship N1 seen by an observer located on the bridge of the ship N, for angles I1 successively varying by $e°$ on a complete turn (equal to 2° in the case of 180 slides), rotating in clockwise direction from the positive portion of the polar radius $\rho$. These slides are obtained from successive pictures by turning around the ship N1 from $e°$ to $e°$ or from a model of the latter. The model may also be disposed on a divider plate, for the previous taking of pictures.

Referring now to FIGS. **2** and **4**, it is then possible to represent immediately by projection, the ship N1 (in position defined by $\theta$ and $\rho$) as it is seen by the pilot of ship N, by operating as follows:

orienting the plate **20** about WW′ according to the bearing Gi with respect to the ship N, then rotating the disc **18** until the slide corresponding to the angle I1 takes place in the projector **11** then adjusting the focal distance of the objective **15** corresponding to $\rho$. The first operation is accomplished by the motor **21**, the second by the motor **22**, the third one by the motor **17**, the three motors being dependent from the auxiliary computer **1** according to previous explanations, summed up in FIG. **4**.

The disc **18** is oriented by its motor **22**, not continuously, but according to a principle similar to that of cinematography. That is to say that at the instant where each of the successive slides comes rapidly into the projector, it stops during a brief moment which is a function of the speed of rotation of the disc. It is hidden when in motion. In this manner, if the disc **18** is rotated $e°$ by $e°$, the observer on the ship N has the impression that the sighted ship N1 turns about itself. It makes a complete turn at the same time as the disc. One embodiment of this device is illustrated in FIGS. **6**, **10** and **11**. The toothed wheel **23** driven by the motor **22** carries a contact **24** (an electrically actuated elastic finger). At the same level as this finger **24**, two metallic half rings **25** and **25a** mounted on a carrier disc **26** are separated by a space corresponding to the angular spacing $e°$ of two successive slides. When the finger **24** touches one of the rings **25** or **25a**, the contact actuates one or the other of the ratchet systems **27** or **28** which causes fast rotation of the disc through an angle $e°$ at each impulse. The fast advance of system **27** (or **28**) causes closure of a shutter **29** above the slide then in position. The next impulse will take place only if the contact finger **24** is again on one of the rings **25** or **25a**. The position of the slides is eventually ensured by means of a spring pawl and ratchet device. The disc **18** is clamped by a washer **30** and a nut **31**. The simulator has several transparent discs **18** corresponding to a great variety of actual ships. They may be reproduced in the same manner as photographic prints starting with an original negative disc. According to the embodiment of FIG. **8**, the disc **18a** has at least two rows of slides **12a** and **12b**. After one turn, there is a relative displacement of the projector and of the disc in order to use the second row of views (one complete turn around the ship is obtained by two turns of the disc). The motor **22** is accordingly adjusted. Another row may correspond to the projection of the ship seen at night.

The complete refraction prism **13** of which the projector is provided may pivot about a horizontal axis **32** correcting the angle of sight. As shown in FIG. **9**, a cam **33** synchronized with the dependent motor **17** (focal distance) acts on a lever **34** and appropriately corrects the height of the image on the screen in relation to the closing in or moving away effect of the ship. Indeed, the angular distance $\alpha$ under which the water line of the ship N1 and the skyline are seen varies according to $\rho$.

according to a second embodiment illustrated in FIGS. **12** to **14**, the successive slides **12** are mounted on a band **35** in two rectilinear rows **36** and **37** each having F views of which the first ones **12c** and **12d** as well as the last ones **12e** and **12f** are strictly side by side. If the slide **12c** illustrates the ship N1 seen from behind (angle $I1 = 0$), the slides of row **36** will show it progressively rotating about itself showing its starboard side until the last slide **12e** which shows it from the front where I1 = 180°. From **12f** to **12d**, the views illustrate the ship manoeuvring successively from an angle of 180° to 360° (progressively showing its port side). When the ship makes one turn about itself, the slides move successively in the direction of the arrow of FIG. **14** from **12c** to **12f** between the projector **11a** and the variable focal line objective **15** arranged horizontally (with motor **17** dependent on the values of $\rho$). The movement between the two rows **36** and **37** takes place either by automatic translation of the band **35**, that is of the bobbins **38** and **39** over which the flexible band wids and unwinds, or by a vertical movement of the projector-objective set. The device responsible for the successive forward movements of the slides on the same row works by means of toothed wheels **40** and **41** rotating by impulses caused by the motor **22** working according to the angles I1. The intermittent drive may be identical to that described previously with respect to the contact fingers **24** and the half rings **25** and **25a**. It may also be constructed with parts known in cinematography, with blinding shutter not shown in the drawings. The number of slides may be greater than that carried by a disc **18** thus refining the movement. The assembly is mounted on a plate **42** born by the plate **20** and may rock around hinges **43** to correct the angle $\alpha$ between the skyline and the water line of the ship. As previously, the motor **17** drives a correction cam **33a**. According to a third embodiment, the band **35** only has one row of slides in the shape of a loop like an endless film. In any case, a second projection system **44** (shown in broken lines) may double the first one. It is provided with slides illustrating the ship on a larger scale whereby to simulate the approach at a few tens of meters.

It is easy to project views of small islands as in FIG. **3** or stationary floating objects, the displacement of the latter being nil (Cv1 = 0 and I1 = $-\theta$). Several projectors located on the same plate **20** may illustrate a continuous succession of coastlines.

Several plates corresponding to several ships N1, N2, etc... or to several small islands or portions of coastlines may be mounted on the same column **45** as shown in FIGS. **15** and **16**. An articulation made up of a ring **46** and a cross-piece **47** constituting a universal ball joint may be provided at the top of the column. The base of the column is capable of two alternating movements, one in the axis of the bridge, the other in a perpendicular direction simulating rolling and pitching. Two variable-speed and reversible-rotation dependent motors **48** and **49** respond to a predetermined program. The set of projection is thus animated by two rocking motions. The upper cross-piece **47** may carry the device for projecting the skyline and the clouds.

There are as many auxiliary computers **1** with differentials **4** and **8** as there are plates **20**. When two ships N1 and N2 are on the same bearing, the farthest ship disappears automatically. A common device for the reading of electrical characteristics, measuring the bearings Gi and the polar radii $\rho$ at **6** and **3**, compares these different measures and causes either the disappearance of the image of the furthest object or the reinforcement of the luminous intensity of the closest one (this is the case of a ship standing before a coastline).

The relative coordinates $x$ and $y$ of each ship being sighted are obtained by the same set of analog, numerical or mechanical computers thay may be combined. The lower part of FIG. **4** gives, by way of example, a diagram of an association of electro-mechanical computers, each being otherwise known. The computer **50** controlled by the helm B and the speed selector S give at **51** and **52** the instantaneous coordinates of the surface observer ship N as well as, at all times, the value of the angular speed of the variation of the true course Cv, at **5**. The computer **53**, identical to the first one, with the helm B1 and speed selector S1 gives at **54** and **55** the indications of the same nature relative to the first ship N1 being sighted. Similarly, for the second ship N2 etc... The computer **56**, simulating the current in the area of the ship N, provides instantaneous corrections of the coordinates, with respect to the bottom of the sea, of the observer ship and of the ships being sighted.

It can easily be shown that $x$ is equal to the difference between the abscissae thus obtained. Similarly, $y$ is equal to the difference in corresponding ordinates. In the diagram of FIG. **4**, these results are obtained by the differentials **57** to **60**, assuming that the values of the abscissae and of the ordinates are expressed in angles of rotation of the shafts **51**, **52**, **54**, **55**, etc... Coupled to the computer **50**, two cams **61** and **62** change the true course (thus the trajectory of the ship N) and the speed of the ship in relation to the direction of the wind U and of the true course Cv. Likewise, the cams **63** and **64** change the same elements as a function of the direction T of the waves and of the true course.

The computers of the observer ship and of the ships being sighted, which particularly determine at all times the angular speed in the variation of the true course Cv, take into account the evolutive effect of the propellers and the effects of giration. They likewise take into account the resistance to speed changes. The coordinates of the ship N and of the ships being sighted (N1, N2...) may control one or several tracing tables **65**.

A hemispherical dome **66**, illustrated in FIG. **17**, makes it possible to illustrate the sky. The bow or stern or a ship are projected on the screen **14** or illustrated by models.

I claim:

**1.** A device for simulating navigation, said device comprising:

a. a cylindrical screen for projecting images thereon, said images simulating the position of observed objects relative to an observer,
b. a rotatable support plate,
c. a plurality of image means connected to said support plate and rotatable therewith,
d. image projecting means mounted on said support plate and rotatable therewith, said image projecting means comprising:
    1. a light source connected to said support plate,
    2. an adjustable focal line objective lens positioned for alignment with said light source, said objective lens supported by said support plate,
e. means for rotating said support plate for projecting images at various angles about the rotation axis of said rotatable support plate,
f. means for adjusting the magnification of said focal line objective lens thereby providing projected images of a variable size, and
g. means for successively positioning different ones of said plurality of image means for projection by said aligned light source and objective lens, whereby different projected images may be dis-

played simulating different orientations of the observed object relative to the observer.

2. Apparatus as recited in claim 1 further comprising:

a. input means for varying
   1. the bearing of the projected image,
   2. the size of the projected image,
   3. the orientation of the projected image,
b. means connected to said variable bearing input means for controlling the rotational position of said support plate,
c. means connected to said variable size input means for controlling the magnification adjusting means of said objective lens, and
d. means connected to said variable orientation input means for controlling the positioning means.

3. Apparatus as recited in claim 1 wherein said light source is positioned on one side of said image means and said objective lens is positioned on the other side of said image means.

4. Apparatus as recited in claim 1 further comprising, means for tilting the rotation axis of said rotatable support plate thereby projecting tilted images simulating rolling and pitching of objects.

5. Apparatus as recited in claim 1 wherein said support plate is horizontal and rotatable about a vertical axis, said objective lens and said light source are aligned in a vertical direction and said apparatus further comprises a prism for reflecting said images in a generally horizontal direction.

6. Apparatus as recited in claim 5, including means for rotating said prism about a horizontal axis.

7. Apparatus as recited in claim 1 wherein said support plate is horizontal and rotatable about a vertical axis and said objective lens and light source are aligned in a horizontal direction.

8. Apparatus as recited in claim 1 further comprising a plurality of support plates, each plate having a plurality of image means and associated light source and objective lens, said support plates rotatable about a common rotation axis.

9. Apparatus as recited in claim 1 wherein said image means comprises:

a. a rotatable disc,
b. a plurality of transparent slide means disposed on the periphery of said disc,
c. said positioning means comprising motor means for rotating said rotatable disc.

10. Apparatus as recited in claim 1 wherein said image means comprises:

a. a pair of spaced bobbins,
b. a band wound on said bobbins,
c. a first plurality of transparent slide means mounted in a first row on said band,
d. a second plurality of transparent slide means mounted in a second row on said band, and
e. means for rotating said bobbins to position various ones of said transparent slide means between said light source and said objective lens for projection onto said screen,

whereby various orientations of said images are displayed simulating various orientations of said observed object.

11. Apparatus as recited in claim 10 wherein said image means further comprises an endless loop-like band having transparent slides mounted thereon.

12. Apparatus as recited in claim 1 wherein said cylindrical screen extends substantially 360° about said projecting means.

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