This invention relates to transmission systems for gyroscopic compasses. It is one object of this invention to provide means whereby corrections are introduced into the coarse and fine transmitters in the same ratio as said transmitters bear to each other.

A further object of the invention is the provision of an A.C. system of transmission between a master compass and one or more repeater compasses.

Still further objects and advantages of my invention will become apparent in the following detailed description thereof.

In the accompanying drawings:

Fig. 1 is a front elevation, partly sectioned vertically and with parts removed, showing a master gyroscopic compass having my invention applied thereto.

Fig. 2 is a plan view of the master compass of Fig. 1.

Fig. 3 is a section taken substantially on the line 3-3 of Fig. 4 and disclosing a lost-motion drive between the master compass and a transmitter.

Fig. 4 is a section taken substantially on the line 4-4 of Fig. 3.

Fig. 5 is an enlarged detailed plan view of the mechanism for introducing corrections into the transmitters.

Fig. 6 is a vertical section through the coarse transmitter and the correcting mechanism taken substantially on the line 5-5 of Fig. 5.

Fig. 7 is a section taken substantially on the line 7-7 of Fig. 5.

Fig. 8 is an enlarged vertical section through one of the pivot blocks of Fig. 7.

Fig. 9 is a wiring diagram of the transmitters and repeaters.

Referring to Fig. 1 of the drawings, there will be seen that I have illustrated my invention as applied to a gyroscopic compass system, comprising the gyro casing 10 in which operates the gyroscopic rotor, said casing being mounted on horizontal axes in the vertical ring 11, said casing and ring constituting the sensitive element which is suspended from the spider 12 by any suitable suspension...
for movement about a vertical axis, as for example, by the magnetic suspension 13. Rotatably supported by said spider 12 is the usual follow-up element 14 carrying the azimuth gear 15 meshing with a pinion 16 of an azimuth motor 17. The mercury ballistic element 18 and eccentric pivot 19 are also disclosed. In accordance with the ordinary method of operation of the gyroscopic compass, the azimuth motor causes the follow-up element 14 to follow the apparent movements of the sensitive element and said movements of the follow-up element have heretofore been indicated by a compass card carried by said follow-up element. Such a card may be provided here but since I illustrate my invention in connection with a synchronous transmission system wherein the transmitter has a 1:1 relation with the master compass, I may omit the card C on the armature of the said transmitter T (see Fig. 2).

For synchronous transmission of the movements of the master compass to the repeaters, I may employ the said transmitter T geared by gearing 21-22 to the follow-up element, the said gearing having a 1:1 relation. Although the said transmission system may be a D.C. transmission system, I have illustrated my invention in connection with an A.C. transmission system. The transmitter T, therefore, will comprise field poles and an armature, the said armature being rotated by the follow-up element, and the displacement of the armature relative to the field poles being transmitted to a similar receiver M having similar field poles and armature to cause said receiving instruments to repeat the movements of the transmitter T. It will be understood that if a D.C. transmission system is employed, said transmission system may be as shown in the patent to Elmer A. Sperry #1,255,480, dated February 5, 1918, as shown in Fig. 6 thereof, except that the transmitter would have a 1:1 relation with the follow-up element instead of rotating a plurality of times for each revolution of the master compass.

I have shown a compass card C mounted on the shaft of the armature of transmitter T and it will be apparent that since said card C is subdivided into 360 degrees, as shown in Fig. 2, accurate readings to within say 5 or 10 minutes of arc is impossible and at best the readings can be taken accurately only to within say the nearest degree. At the same time, therefore, that I operate the 1:1 transmitter T, which I shall hereafter call the coarse transmitter, I operate also a fine transmitter T' having a multiplying gearing connection 16' to the azimuth gear 15, so that said fine transmitter T' makes a plurality of revolutions, in this case thirty-six, for each revolution of the master compass. A complete revolution of the card C of transmitter T', therefore, corresponds to 10° of arc and permits reading to within 5 or 10 minutes of arc. The employment of the fine transmitter T' does not destroy the complete synchronization of the transmission system, for should the master compass be turned through, say, 15° when the current is off, upon reestablishment of the current, repeater motor M will take up a position in exact synchronization with the transmitter T and, therefore, with the master compass, that is, it will be moved through the entire 15° while repeater motor M' will move through the remaining 5° so that the absolute synchronization of the system is at no time destroyed, and at the same time I am enabled to transmit very fine readings of the compass movements.

I have further devised a system for introducing the necessary corrections which must be introduced in the repeater instruments and also preferably in the master compass cards to compensate for various errors that necessarily arise due to the movements of the ship or other dirigible craft on which the compass is mounted. The complete theory underlying said errors is set forth in the said Sperry patent wherein it is shown that wherever a vessel, on which the compass is mounted, has a meridional course component, an error is set up which is proportional to the speed of the ship, the latitude and the course of the ship. The total error arising from this cause is set forth in the equation

\[ D = \frac{aK \cos H}{\cos L} + b \tan L \]

in which D is the total correction, a and b are constants, K is the linear speed of the ship in knots, H is the angle in degrees of ship's heading or course from the true geographical north, and L is the latitude. From this it will be seen that there are two types of corrections to be introduced. One is a correction which is a function of the course angle and, therefore, must be constantly controlled by the course that is being traveled, while the other is an additive quantity which, for any given latitude, need be applied but once. In the said Sperry patent these corrections were introduced by the mechanism disclosed in Fig. 4 thereof which shifted the rubbing line cooperating with the master compass card. In my invention I introduce said corrections as follows:

Since my transmitters are of the A.C. type, I may introduce a correction by varying the movement of the armature, or preferably, since the armature is geared to the compass, by moving the field poles which are ordinarily stationary. Thus, as shown in Fig. 6, the field poles may be operated by actuating gears 30, 30' fixed to the casing carrying the said poles of the respective transmitters, said gears being controlled by the correcting mechanism in the manner hereinafter de-
scribed. Any relative change of position be-
tween the armature and the field poles will, of

course, transmit a change to the receiving in-
struments, M, M', that is to say, the corrected
readings will thus be transmitted to the re-
ceiving instruments. By mounting the lubber
ring L for movement with the field poles, as
shown in Fig. 6, I introduce the correction by
varying the position of the lubber line as was
heretofore done in the said Sperry patent
cited, for instance.

Since the two transmitters T--T' are in-
dependent of each other, each of these must
be corrected and the fine transmitter T'' must
have the correction multiplied in the same
degree as the movement of its dial C is mul-
tiplied over that of dial C. Thus, for exam-
ple, in the illustration, card C' moves 36 times
as rapidly as card C and, therefore, whatever
ever correction is introduced in transmitter
T must be introduced also in transmitter T' and
multiplied 36 times. Preferably I em-
ploy a single means for controlling both con-
nections, said means taking the form of a gear
32 at the end of a pivoted segment 33 and said
gear being suitably geared through idlers 70
and 70' to the pinions 30, 30' fixed to move
with the field poles of the respective trans-
mitters. The ratio of gearing is such that
the correction introduced in the field poles of
transmitter T'' is multiplied 36 times with
respect to the movement of the field poles of
transmitter T. Not only, therefore, am I
enabled by this means to transmit both fine
and coarse indications, but I am enabled to
transmit corrected fine and coarse indica-
tions.

It will be understood that if a D. C. system
of transmission is employed, the same meth-
od of introducing the correction may be em-
ployed, that is, a single gear, suitably geared
to the armature or trolleys contacting there-
with in the form shown, for instance, in the
said Sperry patent, or in a patent to H. L.
Tanner No. 1,412,760, dated April 11, 1922 for
connection device for gyroscopic compasses,
to move the armature and contacts relatively.
As previously stated at least one of said ar-
matures would have a 1:1 relationship with
the movements of the master compass.

It will now be seen from the equation set
forth hereinbefore that there are two correc-
tions to be introduced, one of which is an
additive quantity which, in any given latitude,
may be made in a single operation and the
other of which is a continuing correction
which is a function of the course, being trave-
elled and must, therefore, be at all times tied
up with the compass so that it may vary as the
course varies.

For introducing the first correction, that is,
the additive correction, I may merely shift
the gear 32 at the end of the segment 33 by
any suitable adjusting means like that shown
in Fig. 2, comprising an adjusting screw 34
operating in a fixed bracket 35 and threaded
into the gear 32 slidably mounted on segment
33. This will at once introduce the correc-
tion in the two transmitters in the proper ra-
tios and the said corrections will be trans-
mitted to the repeating instruments. This
correction is not used in some types of com-
passes and may be omitted where not needed
without affecting the operation of my inven-
tion.

For introducing the second correction I
may provide means for suitably controlling
the movements of said segment and its at-
tached gear from the master compass. For
this purpose I may provide upon the follow-
up element driven from the master compass
a so-called cosine ring 40, that is, a ring hav-
ing either a cam slot, or as shown an eccentric
groove 41 within a circular member, which is
so designed that its eccentricity from point to
point varies in a predetermined degree in ac-
cordance with the function of the ship's head-
ing. The eccentricity of said cosine ring
transmits its movements through a suitable
linkage such as the bell crank 44 and lever 45
to the segment. The connection between said
lever and said segment is such that another
factor of this correction, namely, the speed
and latitude may also be introduced to effect
the movement of the segment. For this pur-
pose the lever is shown in the form of a fork
pivoted within a support 42 at 43 and within
said fork slides a pivot 46 (shown enlarged in
Fig. 5) forming the pivotal connection
between the segment 33 and the lever 45. It
will be seen that when the two pivots 43 and
46 are in alignment, rotation of the lever
45 causes no movement of the segment 33.
The saidle pivot 46 is moved within grooves
47 by means of an adjusting nut 50 mounted
on threaded stem 50' which is threaded
through a boss 50 of segment 33 and which is
rotatably but nonslideably mounted at its in-
ner end in the pivotal connection 46. Said
stem also carries a vertical scale 51' gradu-
ated in degrees of latitude and which is
readable upon a scale 51 graduated in ac-
cordance with speed in knots. The curves
on the plate 51 are so plotted that when the
indicated latitude intersects the curve for the indicated speed, the pivotal con-
nection 46 will be shifted in accordance with
the required combined functions of both speed
and latitude. The lever arm between the two
pivots is thus varied so that any movement of
the lever 45 will thus transmit a greater or
lesser movement to the segment which is piv-
otted at 49 within support 42. The final
movement of the segment, therefore, is the
component of the course as determined by the
cosine cam slot 41 and bell crank 44, and of
the speed and latitude, as determined by the
position of the saidle pivot 46. These cor-
rections are introduced into the transmitters
through the same gearing 32 as the additive
latitude correction was introduced so that this correction also is suitable multiplied in the fine transmitter T'.

Since the follow-up element is usually given a continuous small oscillatory movement, known as the "hunt", in order to overcome static friction, means may be provided herein for eliminating this movement from the transmitters. For this purpose the gears which are driven by the azimuth gear 22 are not connected directly to the respective armature shafts, as for example, shaft 60 in Fig. 1, but said gears are connected to said armature shaft through a hunt eliminating or lost motion device indicated generally at 61. Thus, for example, in Fig. 1 the gear 21 is connected to its armature shaft 60 through the hunt eliminating device 61 shown in detail in Figs. 3 and 4. Gear 21 is fixed to a shaft 62 which carries a member 63 thereon, said member being adapted to engage one or the other of members 64 fixed to a casing 65 which is fixed to the armature shaft 60. The member 63 is of such size and the space between the members 64 is such that said member 63 engages one or the other of said members 64 depending upon the direction of rotation of shaft 62 only at a certain degree of lost motion. This degree of lost motion is equivalent to the amount of movement which would ordinarily be transmitted by the hunting movement of the compass and is, therefore, much larger than on the fine than on the coarse transmitter. The degree of lost motion may be varied by any suitable adjusting means which will move members 64 toward or away from member 63 to reduce the increasing space between said member 63 and said members 64. For this purpose I have shown in Fig. 3 a pinion 67 engaging with the outer threaded periphery 68 of members 64 to effect the necessary adjustment of said members 64.

In accordance with the provisions of the patent statutes, I have herein described the principle and operation of my invention, together with the apparatus which I now consider to represent the best embodiment thereof, but I desire to have it understood that the apparatus shown is only illustrative and that the invention can be carried out by other means. Also, while it is designed to use the various features and elements in the combination and relations described, some of these may be altered and others omitted without interfering with the more general results outlined, and the invention extends to such use.

Having described my invention, what I claim and desire to secure by Letters Patent is:

1. In combination, a gyroscopic compass, means for transmitting the indications of said compass including coarse and fine transmitters having a predetermined ratio of movement with respect to said compass and to each other, means whereby said compass actuates said transmitters, a correction device also actuated from said compass, and means for introducing corrections from said device into each of said transmitters in the same ratio as said first ratio of movement.

2. In combination, a gyroscopic compass subject to hunting movements, means for transmitting the indications of said compass including coarse and fine transmitters having a predetermined ratio of movement with respect to said compass and to each other, means whereby said compass actuates said transmitters, including a pair of lost motion devices for eliminating said hunting movement and means for introducing corrections into said transmitters simultaneously in the same ratio as said first ratio of movement.

3. In combination, a gyroscopic compass adapted to be mounted on a craft, means for transmitting the indications of said compass including coarse and fine transmitters having a predetermined ratio of movement with respect to said compass and to each other, means whereby said compass actuates said transmitters, and means for introducing corrections into said transmitters in the same ratio as said first ratio of movement, comprising a member shifted by movements of the compass, means whereby said member is adjusted to correct also for speed, and latitude of said craft and gearing of different ratios connecting said member and each transmitter.

4. In combination, a gyroscopic compass, means for transmitting indications of said compass including coarse and fine transmitters having a predetermined ratio of movement with respect to said compass and to each other, a follow-up element, means whereby said element actuates said transmitters, and means including a common operating member governed in part by said element and gearing between said member and said transmitters for introducing corrections into said transmitters in the same ratio as said first ratio of movement.

5. In a gyroscopic compass adapted to be mounted on a dirigible craft, an A.C. transmission system including a plurality of transmitters and repeaters each transmitter having an armature and a stator, means whereby said compass actuates the armatures of said transmitters at a predetermined ratio of movement relative to each other, a card carried by each armature, a rubber's line on each stator on which each card is read and means also actuated in part from said compass for shifting the stators of said transmitters and the said rubber lines in the same ratio for introducing corrections.

6. In a gyroscopic compass adapted to be mounted on a dirigible craft, an A.C. transit-
mission system: including a plurality of transmitters and repeaters each transmitter having an armature and a stator, means whereby said compass actuates the armatures of said transmitters at a predetermined ratio of movement relative to each other, a card carried by each armature, a rubber line on each stator on which each card is read and means including a single member, and gearing connections between said member and the stators of said transmitters for shifting said stator and the attached rubber lines in the same ratio for introducing corrections.

7. In a gyro-compass, the combination with a plurality of transmitters driven therefrom at different gear ratios, a correction device for said transmitters, comprising a member rotated in accordance with a function of the position of said element, means settable in accordance with speed and latitude varying the drive between said member and element, separate means settable in accordance with another function of latitude for adding an additional corrective movement to said member, and gearing of different gear ratios connecting said member and each of said transmitters.

8. In a gyro-compass, a direction responsive element, a coarse transmitter and a fine transmitter actuated by said element, a 360° coarse compass card carried by the coarse transmitter and a 10° vernier card carried by the fine transmitter.

9. In a gyro compass, the combination with the follow-up element of the compass, of a plurality of transmitters driven therefrom at different gear ratios, a correction device for said transmitters, comprising a member rotated in accordance with a function of the position of said element, means settable in accordance with speed and latitude varying the drive between said member and element, separate means settable in accordance with another function of latitude for adding an additional corrective movement to said member, and gearing of different gear ratios connecting said member and each of said transmitters.

10. In a correction device for gyro compasses for correcting the transmitted reading in accordance with the expression

\[ \frac{aK \cos H}{\cos L} + b \tan L, \]

a following element, a course cam mounted thereon, a corrective member moved therefrom in accordance with the cosine of the course, a single means settable in accordance with both speed and the cosine of the latitude for varying the amount said member is moved from said cam, independent means settable in accordance with the tangent of the latitude for giving said member an additional corrective movement, and transmitting means driven by the combined movements of said element and member.

In testimony whereof I have affixed my signature.

JOSEPH L. CHANTEMERLE.