

Nautical Compasses
(As Related to Automatic Pilots)

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Compasses on Marine Vessels

The following information pertains to all compasses whether for steering or automatic pilots and all magnetic sensing devices using the earth's magnetic field for reference. Based on the information that our Company has compiled over the last 40 years, it would be fairly easy to say that of all the complaints or problems of automatic pilots, 80% of the trouble can be attributed to magnetic compasses and generally the initial installation of magnetic compasses.

The complaint is generally "My vessel doesn't steer going South," or "I can steer on all headings but one or two," or "In a following sea my vessel is wild, the pilot will not steer it. It steers fine when it's flat calm but not when it's rough." These are a few of the complaints that may be heard. A sharp technician should first consider that this is a compass adjustment problem. The majority of autopilot technicians are electronically oriented. Very few have a working knowledge of earth's magnetism or magnetic compass adjustment. We therefore make the following suggestions for installation and adjustment of magnetic earth seeking devices specifically coupled to automatic pilots.

- 1) The area around which the compass will be mounted should be inspected for one or more of the following items:

- Vertical or horizontal soft iron rod
- Channel or angle iron
- Throttle and clutch control-push pull cables
- DC ammeters (internal shunts)
- Steel tachometer cables
- Unpaired-untwisted DC wiring cables
- All steel, household type, circuit breaker boxes
- Iron pilothouse hold down bolts
- Radar magnetrons
- Other compasses
- Magnetic flashlights
- Audio speakers
- Peanut cans, beer cans, pop cans
- Some microphones

Reasonable care should be taken to mount the pilot compass a minimum of three feet from any of these objects and as much as nine to ten feet of other magnets or radar magnetrons.

Although it is possible in some instances to adjust the compass with magnets or other compass adjusting devices, such as quadrantal spheres, Flinders bars or heeling tubes, the presence of magnetic objects close to the compass and

especially soft iron will cause increasing errors with time and the compass cannot be relied upon. At this point, some may wonder why this emphasis is put on compass adjustment. A very common question asked by both dealers and customers is "Why bother to adjust the compass of the pilot. I do not use it for steering. I refer to my ship's compass, set the course for the pilot – what difference does it make what course the pilot thinks it's on?" IT MAKES A LOT OF DIFFERENCE. The autopilot compass uses the earth's magnetic line to determine whether or not the vessel is actually turning thereby producing a course error signal. If the lines that the compass uses are distorted at the compass by local magnetic influence, then the compass cannot accurately measure the degree of turn. If the compass card or sensor does not present a stable reference, no amount of subsequent electronic processing can compensate for the signal errors. The compass will be unable to detect a change in course on some headings, where on other headings a slight amount of vessel movement will cause the compass to show a large course change, thereby putting on excess corrective rudder.

- 2) For initial installation of a compass, the desired mounting location should be checked for unseen items, which may cause compass error. This is done easily by using the pilot compass, provided it has a visible card with markings, to detect for magnetic interference. Place the compass in the desired mounting location and note the position of the compass card to some reference point on the compass bowl. Allow the compass to come to rest, then slowly proceed to move the compass in a horizontal circle, approximately one-foot radius, about the desired mounting location. Watch for the compass card to deflect from the original noted position. If a deflection of 10° or more is noted, chances are the compass will not be able to be properly adjusted in that location. Try to find what is causing the deflection and either remove the item causing the interference or select a new compass location. Repeat the one-foot radius circle test at the desired mounting location, this time doing it on a vertical axis. If the desired location produces little or not noted compass card deflection then the installer can be reasonably sure that the location should be able to be adjusted, with normal and reasonable means to provide satisfactory operation within the design capability of the pilot. After mounting the compass with non-magnetic screws (bronze, brass or non-magnetic stainless steel) the compass must be checked for magnetic adjustment. When a compass is adjusted for magnetic deviation the compass itself is not being changed. It is the space around the compass that is being adjusted. Therefore, in some cases where the compass card or magnetic device has no external means of viewing, a substitute compass may be placed at the mounting location and an adjustment may be effected on the substitute compass. When completed, the autopilot compass may be installed in place with a reasonable assurance that it will be in proper magnetic adjustment.

Attached in the Appendix is a drawing showing the proper location of the adjustment tools. First, the bar magnets. It is extremely important that the N-S correcting bar magnets be placed perpendicular to and bisected by the vertical plane passing through the compass center parallel to the keel and that the E-W correcting bar magnets be placed perpendicular to and bisected by a plane perpendicular to the keel and passing through the compass center. Improper mounting of the compass magnets will make proper adjustment impossible. Adjusting the compass for the automatic pilot is a relatively simple task, provided that the primary ship's steering

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compass has already been properly adjusted. A simple but effective test to check the ship's primary compass is to read the ship's compass deviation card and to refer to the placement of magnets about the compass. If the magnets appear to be in their proper location and the compass card shows exactly zero for North, South, East and West, you should be able to use the ship's steering compass as a reference by which to set the automatic pilot compass. If the magnets aren't properly located, or the compass card direction does not read exactly zero on North, East, South, West, then the adjustment for the automatic pilot compass should be done from scratch. A relatively simple, but sure means of adjusting the automatic pilot compass or a steering compass is provided in this paper in the Appendix. The procedure given in the Appendix is one of many acceptable ways. It is based on direct reversal method rather than on known points or headings.

There are a few installations which may give a serviceman or installer additional problems. One problem is when the automatic pilot compass is going to be used as the primary ship's steering compass. In many cases, where the existing steering compass is being removed, the location actually may not be suitable. Bear in mind that the human skipper, or helmsman, watching a ship's compass will rationalize or totally ignore, unconsciously, an unstable compass card caused by magnetic interference. Because the skipper has not notice anything wrong with the compass or that, quote, "My steering compass had worked beautifully there for years", unquote, an automatic pilot using the same compass locations has not way to rationalize out the instability of the card. Therefore the pilot wanders and steers erratically regardless of attempts to adjust the compass. Another problem, that arises as a result of magnetic dip and increases with latitude, is what is commonly called the Northerly turning error in the Northern Hemisphere and Southerly turning error in the Southern Hemisphere. It is also accentuated by banking of turns in high-speed craft. This phenomenon is true in all earth seeking magnetic devices. The effect of Northerly turning error becomes extremely critical on higher speed vessels, starting from twelve knots to approximately thirty knots. Above thirty knots, it is impractical, if not impossible, to rely solely on a magnetic seeking device for control of an automatic pilot. Not only because of lateral acceleration in a turn but also because the necessary banking of the vessel converts part of the dip component to azimuth component unless the compass is gyro stabilized. The effect of Northerly turning error is generally that the vessel will steer fairly well on east and west headings at high speed, will oversteer on southerly headings but will make wide swings on northerly headings. On northerly headings, once the boat has been deflected from course, it will increase its turn in the same direction rather than correcting the course in the opposite direction. The Northerly turning error effect can be minimized by (1) selecting a compass and pilot assembly which has been designed especially with the higher speed boats and Northerly turning errors in consideration and (2) keeping boat speed under 15 knots.

Additional information on Northerly turning error may be found in U.S. Patent #2,248,748, July 8, 1941 by C. S. Draper titled "Magnetic Compass" which is available from the U.S. Patent Office. Additional information on compass adjustment procedures may obtained from the U.S. Government Printing Office publication #226 if still available. Last word it was out of print. Also reference to compass adjustment may be found in Bowditch and Chapman.

CONTROL COMPASS

INSTALLATION & POOR COURSE HOLDING

1. 36" from ALL steel if possible
2. Mount Compass so that Compass card "looks" out Window.
- ⊛3. Select Compass location so that HEELING TUBE and QUADRANTAL COMPENSATOR May be properly installed.

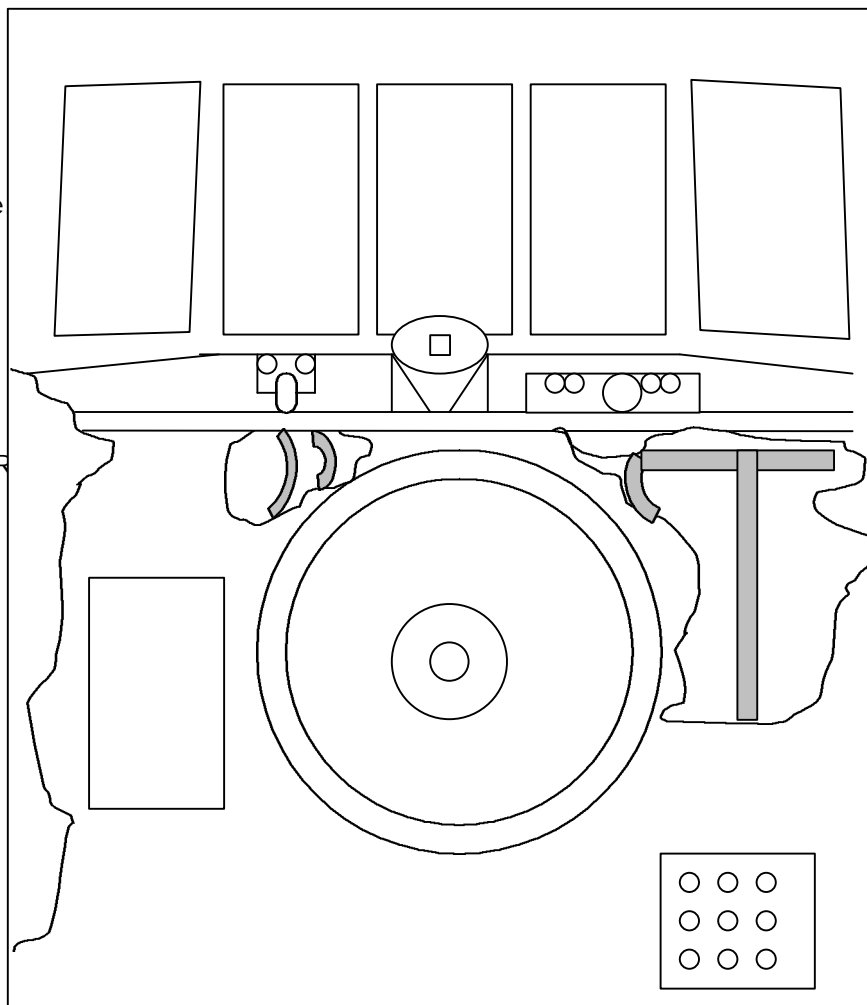
36" = PERFECT !

18" = 4 times worse!

12" = 9 times worse!!

6" = 36 times worse!!!

1" = 1296 times worse!!!!!!!!!!!!!!



THE MAGIC NUMBER IS 3 FT. MINIMUM

ITEMS COMMONLY ARE FOUND ON VESSELS THAT MAY CAUSE COMPASS PROBLEMS.

VERTICAL IRON ROD.

HORIZONTAL IRON ROD.

AMP METER INTERNAL SHUNT

TACH CABLE

CONTROL CABLE AND SHEAVES

ELECTRICAL PANELS

D.C. WIRING BUNDLES (Unpaired)

STEEL PLATE

PILOT HOUSE HOLD DOWN BOLTS OR RODS

RADAR MAGGIES – 9 FT. TO 10 FT.

OTHER COMPASSES

MAGNETIC FLASHLIGHT

PEANUTS, POP OR BEER CANS

NORTH SOUTH ADJUSTING

SPECIAL INSTRUCTIONS
FOR
AUTOMATIC PILOT ADJUSTMENT

BEST STEERING IS OBTAINED WITH A COMPENSATED COMPASS ! ! !

ON STEEL VESSELS the Pilot compass MUST be adjusted within 5 degrees of correct magnetic heading on North, South, East and West, and must have any heeling error compensated.

Bring the boat on a known magnetic East or West course using a corrected steering compass. If the Pilot compass is more than 5 degrees out of agreement, place a magnet on either side of compass, red end forward if compass reads to the North, and red end aft if compass reads to the South of what it should. Move the magnet near or far until compass reads correct course.

Bring the boat on the known magnetic North or South course. Place a magnet in front or back of compass with red end to right if compass reads to the West if the course, and red end to left if it is to the East. Move near or far until correct adjustment is obtained. This compass need not be adjusted within the same degree of precision necessary for the steering compass, but in any case it should not be more than 5 degrees out. Often, when the Pilot is installed and the compass has not been properly compensated, the Pilot will operate and hold the boat perfectly on certain course, but on the other courses the steering will be erratic. This is due to lack of compensation of the Pilot compass.

ADEQUATE COMPENSATION OF THE COMPASS IS USUALLY IMPOSSIBLE IF THERE ARE HORIZONTAL OR VERTICAL STEEL RODS, PIPES OR STACKS ENDING WITHIN 24 INCHES OF THE COMPASS. (See Diagram on reverse side of this sheet).

Poor compass adjustment is usually shown by failure of the Pilot to maintain some headings while steering will on others.

STEEL VESSELS

Compass compensations on steel vessels, while more exacting, is usually not difficult if simple rules are observed: -

- (1) The distance between the compass and steel portions of the vessel is at least 24 inches and preferably 36 inches.
- (2) North, South and East, West compensation is done as above.
- (3) The vertical magnetism of the ship is compensated by a "heeling" magnet, placed above or below the exact center of the compass. The "red end" of the magnet is usually up in the Northern Hemisphere and down in the Southern Hemisphere, but welded steel vessels may have residual vertical magnetism in either direction.

The vertical position of the magnet is selected to neutralize swinging of the compass card as the vessel rolls while on northerly headings (Northern Hemisphere) or southerly headings (Southern Hemisphere). It is usually desirable to "overcorrect" the normal dip of the earth's magnetic field.

The Compass is best mounted above decks in a house with glass windows. However, it may be mounted below decks if the above three rules are observed.

diagram

DIRECTIONS FOR ADJUSTING THE PILOT HOUSE COMPASS

First insure that the fore and aft lubber lines of the compass are on a line parallel to the keel.

Second – Insure that no vertical or horizontal iron rods, stays, stanchions or beams END within 3 ft. of the compass (See Drawing 4235204).

To compensate the pilothouse compass, proceed as follows. Use a standard pelorus if available. If none is available, take a carpenter's square and, on a flat board, draw a square figure of any convenient size (it could be four, eight, ten or twelve inches on a side) but having all side equal. Drive a small nail exactly in each corner of this figure. You now have the simple equivalent of a peelers (the instrument which is normally used in adjusting the compass).

Set this pelorus on top of the pilothouse or somewhere on the boat where you can look all around the horizon. Now, bring the boat on a West course by the pilot house compass and while holding this course, sight across the diagonal (opposite) corners of the pelorus and line the nails up with some distant object, preferably a mountain that is ten to twenty-five miles away. (In case no distant object is available, and the boat can be tied up to a piling around which it can turn completely, then a much closer object may be used for the sight. In any case, any object a quarter or half a mile distant would be sufficient).

Now, leaving the pelorus set, turn the boat 180° or until you can see the same object across the pelorus, looking for the opposite direction. Read the pilothouse compass. One-half of the difference between East and what the compass reads is approximate magnetic East.

Bring the boat on this magnetic East (the one-half difference point) and while the boat is on this new course, reset the pelorus so that the nails in the diagonal corners line up with the original sight. While the boat is steadied on this course, place a magnet alongside the compass (lengthwise fore and aft); red end aft if the compass reads South of East and red end forward if the compass reads North of East. Move the magnet in or out until the compass reads East. It is sometimes advantageous to use two magnets – one each side of the compass – to obtain a better adjustment. Please note that in placing the magnets alongside of the compass, it is necessary that the magnets be so placed that a line drawn athwartship directly through the center of the compass will pass through the center of the magnets. That is, the center of the magnet must be on the centerline of the compass and there must be as much magnet in front of this line as there is aft of same. After the magnet has been place alongside of the compass (and temporarily tacked in place), reverse the direction of the boat and check West, making sure that the pelorus sights come on the same object when on this West heading. If this checks, the compass is adjusted for East and West. (In case it does not check, repeat the operation using one-half the difference again).

Without moving the pelorus, swing the boat to the North so that you are able to look through the other diagonal sights on the same object. You will then have approximate North. If the compass does not read North, place another magnet fore or aft of the compass with its length athwartship and the red end to the right if the compass reads West of North and the red end to the left if the compass reads it in or out until the compass reads North. You will now have the pilothouse compass adjusted for North and South.

If the compass binnacle is fitted with spheres, the intercardinal points (Northeast, Southeast, Southwest, and Northwest) may also be adjusted. In order to get the correct heading for these points; the sight should be taken along the sides of the pelorus. Bring the vessel to approximate Northeast or until the nails in two adjacent corners line with the distant object. If the compass reads Northeast, no further connections are needed. However, if the compass reads to the North of Northeast, then the spheres should be

moved nearer to the compass until it reads Northeast. If the compass reads to the East of Northeast, then the spheres should be moved further away from the compass. Generally, if the proper corrections are made on Northeast, the correct headings will be obtained for Northwest, Southwest and Southeast.

The foregoing corrections are applicable when there is little influence caused by soft iron unsymmetrically set on the boat. If, when the adjustment is complete as before described, all points of the compass reverse true, and North and East are 90° from each other, then it can be assumed that all points are correct magnetically. If, however, East and West will reverse on 180° headings and North and South likewise reverse on 180° headings, but North and East are more or less than 90° apart, then there is evidence that unsymmetrically located iron is causing the deviation. This can only be adjusted for by use of the iron spheres set out in links at the side of the compass. Swing these spheres forward or aft or, in other words, rotate them about the compass until the desired correction has been obtained. Then, lock the spheres in place. As very few of the compasses are equipped with links for doing this, it usually requires special treatment.

If vessel is fitted with Radar and sharply defined targets can be seen six or more miles away, the radar cursor lines can be used to obtain the exact reverse heading instead of a visual sighting across the pelorus. If vessel is kept within a 100 yard circle while sighting and target is at least six miles away, the maximum error will be less than 1.4° . If target is more than 12 miles away the maximum error will be less than $.7^\circ$.

The compass adjustment procedure does nothing to the COMPASS, but adjusts the direction of the earth's magnetic field in the area of the compass. These lines then remain on a constant and correct bearing, no matter what the heading of the vessel may be. The compass card then remains aligned with this field and hence accurately indicates the vessel's heading at all times.

WHEN ALL CORRECTIONS HAVE BEEN MADE, BE SURE TO FASTENED THE MAGNETS IN PLACE WITH BRASS SCREWS.

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