Benmar

COURSE KEEPER 210
PILOT HOUSE CONTROL
INSTALLATION, OPERATION
AND MAINTENANCE MANUAL

098-0352F

25510 FOSTER LAKE ROAD, PO BOX 4007, IDYLLWILD, CA 92549-4007
951-659-8510

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SECTION I

OPERATION

1.1 AUTOPILOT OPERATING INSTRUCTIONS

Before operating the autopilot, read the following warning and caution.

WARNING

DO NOT ENGAGE OR OPERATE THE AUTOPILOT UNDER THE FOLLOWING CONDITIONS:

1. NEAR OR WHILE PASSING UNDER STEEL BRIDGES OR IN CLOSE PROXIMITY TO LARGE STEEL VESSELS. MAGNETIC INFLUENCES CREATED BY LARGE STEEL STRUCTURES MAY CAUSE AN INADVERTENT COURSE CHANGE.

2. WHILE IN HEAVY TRAFFIC, IN NARROW CHANNELS OR CLOSE TO OBSTRUCTIONS SUCH AS A BREAKWATER.

3. IN SOME CASES WHILE KEYING A RADIO TRANSMITTER. TRANSMITTING WHILE UNDER AUTOPILOT CONTROL MAY CAUSE MOMENTARY ERRATIC AUTOPILOT OPERATION. THIS IS MOST NOTICEABLE WHEN THE TRANSMITTER, ANTENNA OR ITS CABLE IS MOUNTED CLOSE TO THE AUTOPILOT, ITS INTERCONNECT CABLES, OR ITS POWER LINES.

   IF THE ANTENNA IS POORLY MATCHED TO ITS CABLE OR THE TRANSMITTER, RADIATION CAN OCCUR AND BE COUPLED TO THE PILOT OR ITS CABLES. BEFORE TRANSMITTING, INSURE THAT AN INADVERTENT COURSE CHANGE WILL CREATE NO DANGER.

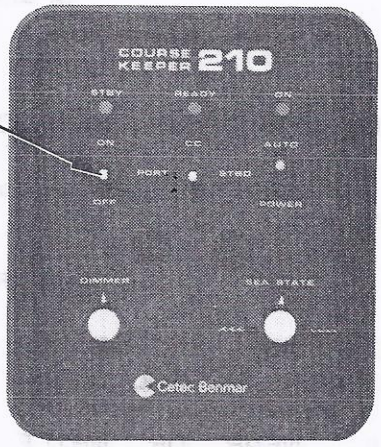
CAUTION

NEVER LEAVE THE HELM UNATTENDED. ALTHOUGH THE AUTOPILOT WILL FAITHFULLY MAINTAIN THE VESSEL'S HEADING, IT WILL NOT REPLACE THE MAN-ON-WATCH.

DO NOT PLACE MAGNETIC ITEMS SUCH AS PORTABLE RADIOS, FLASHLITES, KEYS, ETC. NEAR THE BINNACLE. MAGNETIC MATERIALS MAY CAUSE SUDDEN COURSE CHANGES OR ERRATIC OPERATION.

To operate autopilot, steer boat to desired heading and:

1. Press switch to ON and release.



2. When READY is lit, press switch to ON again.

3. When ON is lit, autopilot is controlling the vessel (with AUTO/POWER switch in AUTO).

4. If the AUTO/POWER switch is in POWER, the push buttons will control the rudder and automatic steering will be disabled.

5. Disengage pilot by pushing switch to OFF.

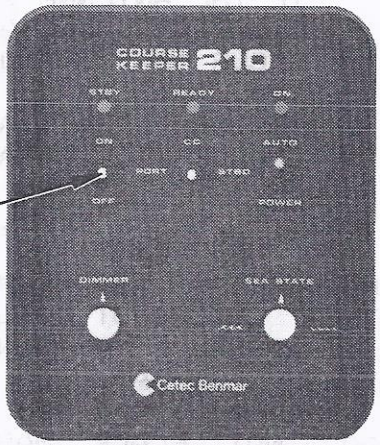


Figure 1.1. ON/OFF Controls.

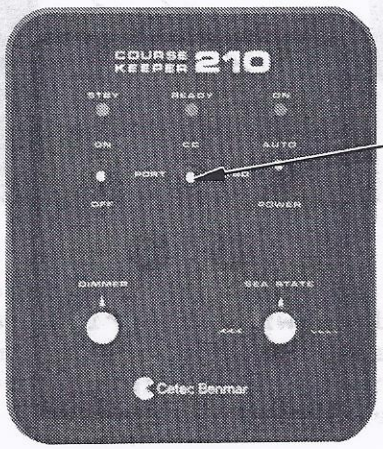
The Course-Keeper 210 is a "coursekeeper" autopilot; that is, it will maintain the vessel's heading at the moment that the pilot is engaged. To begin the sequence for engaging the pilot, hand steer the vessel to the desired course. Push the ON/OFF toggle switch up once to the ON position and release. The STBY light will come on and remain lit while the binnacle drive orients the compass to the vessel's present heading. When the READY light becomes lit, the compass is correctly oriented and the pilot may be engaged as long as the READY light is on.

NOTE

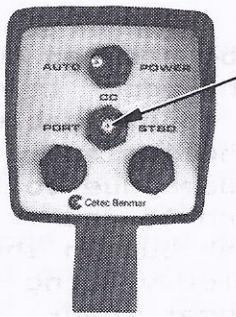
IF THE AUTOPILOT IS EQUIPPED WITH A COURSE CHANGER HANDSWITCH AND/OR A SECOND STATION PHC, PLACE THE AUTO/POWER SWITCH ON THE HANDSWITCH AND/OR THE SECOND STATION PHC IN THE AUTO POSITION.

Pushing the ON/OFF switch up again to the ON position will engage the autopilot and light the ON light. Whenever the ON light is lit, the Power Unit will be 'ON' and engaged to the vessel's steering system.

1.2 COURSE CHANGING



When pilot is 'ON' heading may be altered by holding Course Change (CC) switch to PORT or STBD - heading changes 5 degrees per second.

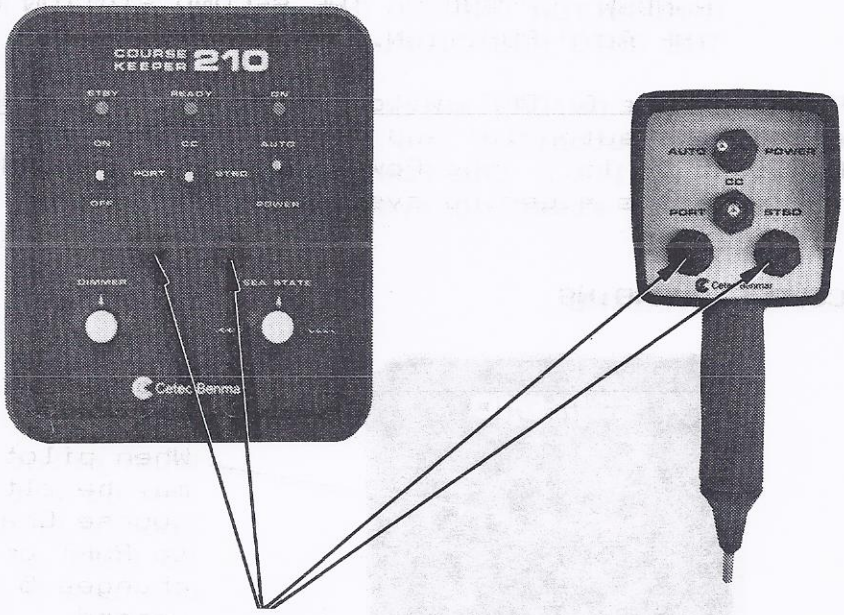


Optional Handswitch may be used to change heading by holding Course Change (CC) switch to PORT or STBD.

Figure 1.2. Course Change Controls.

The ship's heading may be changed while under autopilot control by pressing the CC switch on the PHC or the Handswitch as desired to PORT or STBD. The new heading may be estimated by counting the seconds the switch is held: 5 degrees heading change per second. Do not make heading changes of more than 45 degrees at a time. Allow the vessel to catch up between changes. When making changes at high speeds, make changes in small increments to limit the turn to a comfortable rate. The course may also be altered by turning the pilot OFF, hand steering to a new course and then re-engaging the pilot through the normal sequence.

1.3 JOGGING (IN AUTO STEER MODE)



Press push buttons on PHC or Handswitch to to PORT or STBD. Rudder will be driven at maximum slew rate while push button is pressed. Autopilot returns to previous course as soon as push button is released.

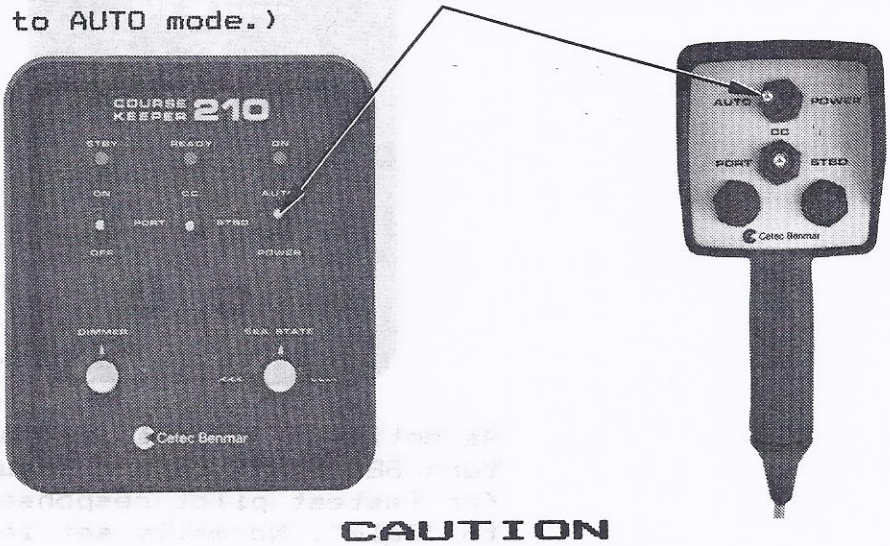
Figure 1.3. Jog Controls.

The push button should be pressed only long enough to be assured of applying enough rudder to completely dodge other vessels or objects. If a considerable amount of rudder has been applied to dodge the obstacle (there is a natural tendency to over apply rudder due to the delay in response of most boats), the return to course may take longer than desired. The opposite push button should be pressed in the opposite direction to quickly bring the rudder back thru midships and start the boat back towards its original course.

1.4 POWER STEER MODE

Pressing PHC or Handswitch AUTO/POWER switch to POWER disables automatic control and allows push buttons to control rudder.

Return to AUTO mode by pressing PHC or Handswitch AUTO/POWER switch to AUTO. (All AUTO/POWER switches must be in AUTO to return to AUTO mode.)



CAUTION

IF THE AUTO/POWER SWITCH IS RETURNED TO THE AUTO POSITION AFTER POWER STEERING MANEUVERS, THE PILOT WILL RETURN THE VESSEL TO THE ORIGINAL HEADING.

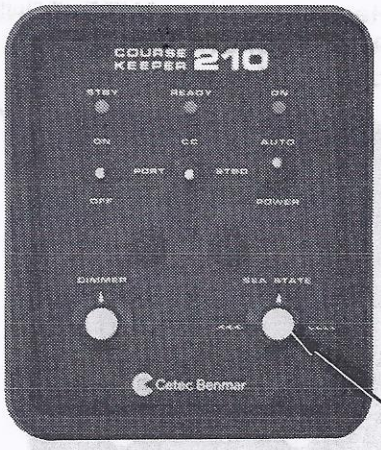
Figure 1.4. Power Steer Controls.

The autopilot may be placed in the POWER steer mode by setting the AUTO/POWER switch on the PHC, Remote Handswitch or Second Station PHC to POWER. While the pilot is in this mode the rudder may be controlled by using the push button switches on the PHC or Handswitch. While the switch is pressed, the rudder will be driven at maximum Power Unit speed in the direction commanded. When the switch is released, the rudder will stay in it's last position until commanded again or the pilot is returned to AUTO mode. When in the POWER steer mode, the Binnacle drive will remain oriented on the course the vessel was on prior to power steering maneuvers.

CAUTION

IF THE AUTO/POWER SWITCH IS RETURNED TO THE AUTO POSITION AFTER POWER STEERING MANEUVERS, THE PILOT WILL RETURN THE VESSEL TO THE ORIGINAL HEADING.

1.5 SEA STATE CONTROL



As motion of vessel increases turn SEA STATE toward "Rough"; for fastest pilot response set to "Calm". Normally set in "Calm" position.

Figure 1.5. Sea State Control.

The Sea State control determines the relative amount of rudder movement in response to short term, fast changing heading errors. When the control is set to "Rough" the fast changing heading errors typically caused by rough sea conditions are filtered out. The "Rough" position may also be utilized when excessive rolling of the vessel occurs. As the control is rotated toward the "Calm" position the pilot will apply more corrective rudder action for fast changing heading errors.

1.6 DIMMER CONTROL

Adjust the DIMMER control for the desired indicator light brightness.

SECTION II

INSTALLATION

2.1 GENERAL

Refer to the typical installation diagram of Figure 2.2. before proceeding with the installation. A necessary step in the installation of the STD, M and S Power Unit is to determine the number of teeth on the driven and driving sprockets. The method of determining the sprocket teeth is explained in the appropriate Power Unit manual.

The ability of the autopilot to steer the boat is dependent on the steering characteristics of the boat, and especially on the performance of the steering system. Any backlash (slop) in the steering system will give less than optimum performance in the autopilot mode, just as it will when the boat is under manual control. Backlash may also be caused by air in hydraulic steering systems from improper bleeding. The autopilot will cycle back and forth through the steering backlash in its attempt to steer the boat; the more backlash, the more work the pilot must perform and the more the course will wander. As a general rule, steering backlash should not exceed 5% of the full helm range.

2.2 UNPACKING AND INSPECTION

Unpack the autopilot from the shipping container and check the contents for any evidence of shipping damage. The Course Keeper 210 autopilot should consist of the following items (see Figure 2.1):

Pilot House Control Unit

Binnacle

Interconnecting Cables

Instruction Manual

Refer to appropriate Power Unit manual for items shipped with Power Unit.

2.3 INSTALLATION ACCESSORIES

Installation accessories such as sprockets, chain, etc. are available from your Benmar dealer. Refer to the Power Unit manual for detailed information.

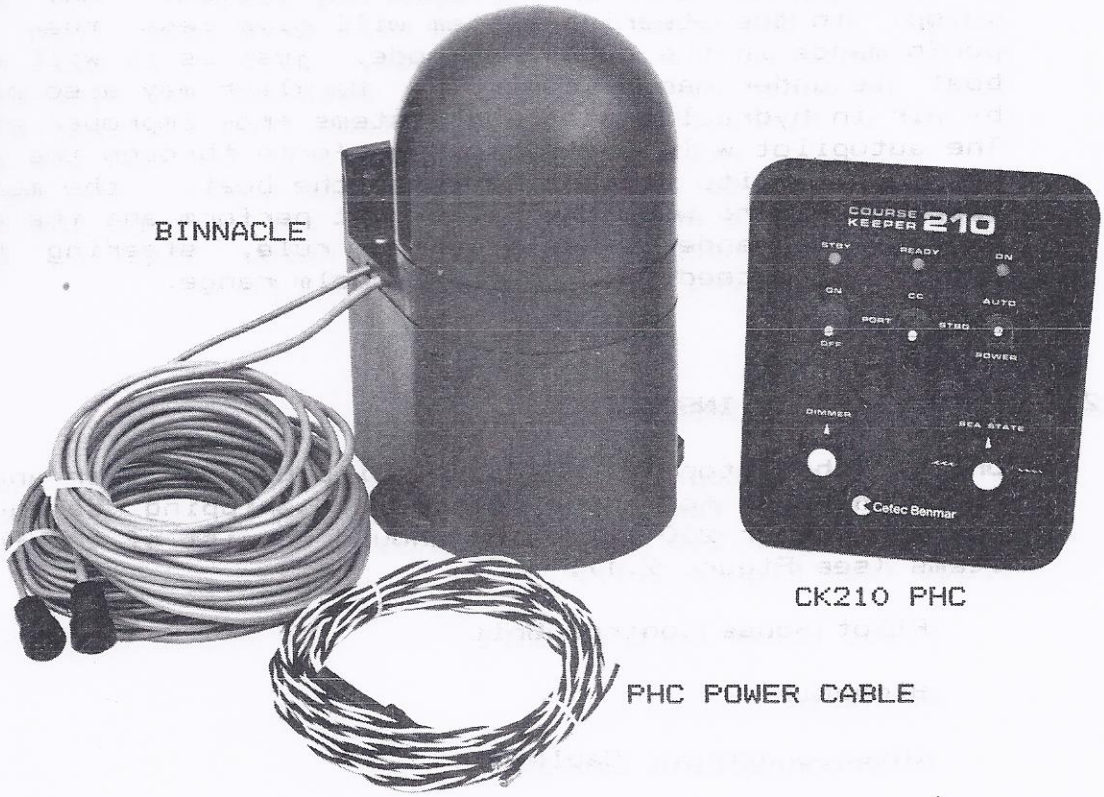
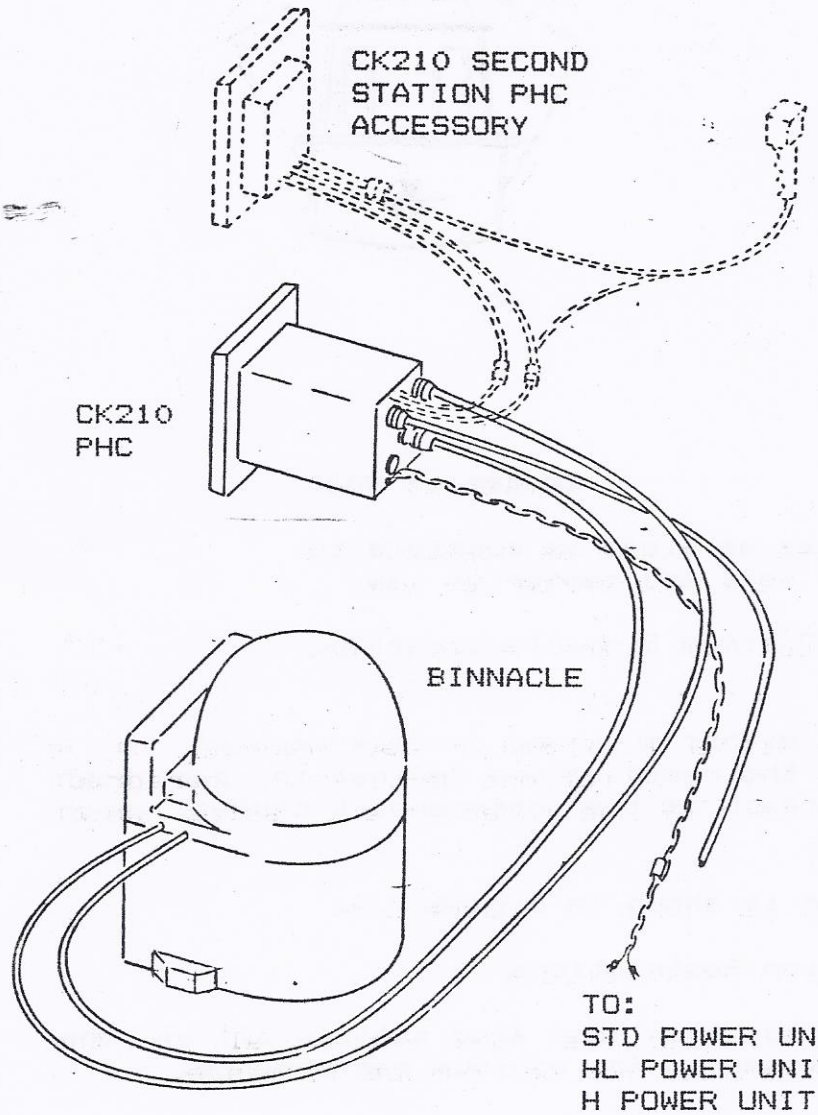


Figure 2.1. Course Keeper 210 Autopilot Components.

2.4 TYPICAL INSTALLATION

Read all instructions completely before proceeding with the installation. Refer to Figure 2.2 for a typical installation of the PHC. Refer to the Power Unit manual for typical installation of the Power Unit.



CAUTION

THE TWO WIRE TWISTED CABLE FOR INPUT POWER TO THE PHC MUST!!!! CONNECT TO THE INPUT POWER TERMINALS ON THE POWER UNIT. INPUT CONNECTIONS TO ANY OTHER SOURCE WILL CAUSE ERRATIC AUTO-PILOT OPERATION.

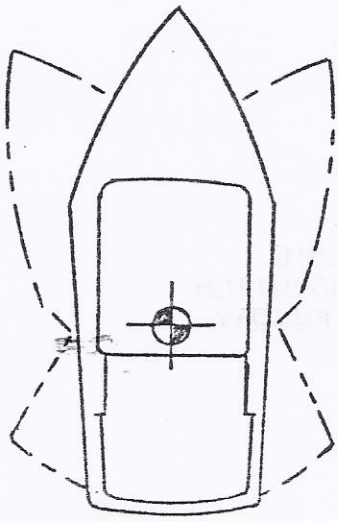
TO:

STD POWER UNIT .....SEE PARA. 2.7.2
HL POWER UNIT .....SEE PARA. 2.7.3
H POWER UNIT .....SEE PARA. 2.7.4
S OR HS POWER UNIT .SEE PARA. 2.7.5
L OR M POWER UNIT ..SEE PARA. 2.7.6

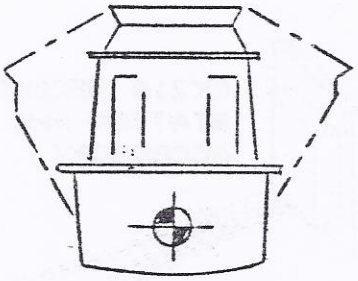
Figure 2.2. Course Keeper 210 PHC, Typical Installation.

2.5 BINNACLE INSTALLATION

The effects of Northerly turning errors and acceleration effects will be minimized when the binnacle is mounted at the center of motion of the vessel. See Figure 2.3.



Center of Yaw



Center of Roll

Locate the compass as close as possible to ship's center of roll and center of yaw.

Figure 2.3. Optimum Binnacle Location.

The binnacle may be either bulkhead or deck mounted in a location which meets the restrictions defined in paragraph 2.5.1 and is within reach of the interconnect cables which are 45 feet in length.

Binnacle installation is shown in Figure 2.4.

2.5.1 Binnacle Location Restrictions

The Binnacle location must also satisfy all of the following requirements for optimum performance.

1. Do not mount Binnacle where it may be exposed to spray or bilge water.

2. Do not mount compass (Binnacle) near magnets, speakers, meters, ship's compass, ferrous metal, etc.

3. Binnacle must be level in all directions to ±15 degrees while underway. A Gimbal Mount Kit (Part Number 000-0153) is available for sailboats where the boat heeling angle is greater than 15 degrees.

4. The binnacle should be mounted in an area that is relatively free of vibration.

5. The mounting location for the Binnacle should maintain the following minimum separation from magnetic disturbances:

Minimum Mounting Distances

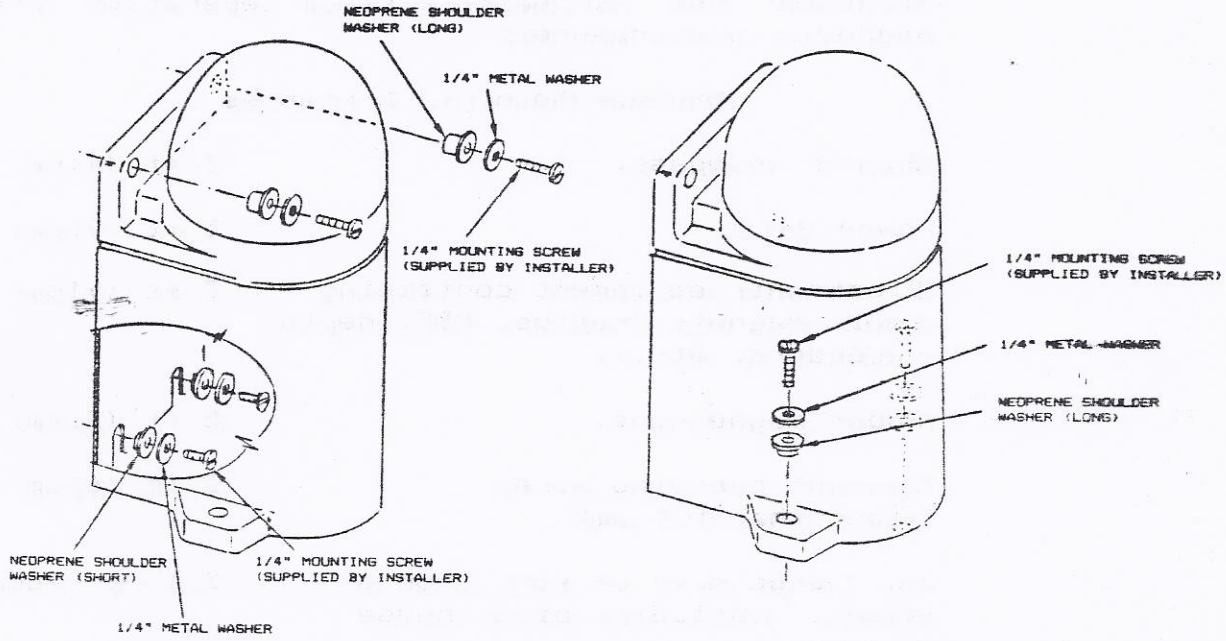
Ship's compass.	3 ft (91cm)
Power Unit.	3 ft (91cm)
Electronic equipment containing small magnets (radios, RDF, depth recorders, etc.).	3 ft (91cm)
Radar magnetrons.	8 ft (2.4m)
Current carrying wires (more than 0.5 amp).	2 ft (61cm)
Any large mass of soft iron or steel, including pilot house tie rods.	2.5 ft (76cm)

The magnetic disturbances in the vicinity of a proposed binnacle location may easily checked using a small hand compass.

With the Binnacle removed from the proposed location, slowly move the hand compass horizontally and vertically over a distance of about 2 ft. in the area of the binnacle location and watch for any movement of the compass needle. None should be noticed.

NOTE

IF THE AUTOPILOT IS INSTALLED IN A STEEL HULLED BOAT OR IF THE BINNACLE CAN NOT BE INSTALLED FREE FROM THE OTHER MAGNETIC INFLUENCES, THE COMPASS MAY NEED TO BE COMPENSATED. THIS WILL REQUIRE THE USE OF A AUTOPILOT TEST SET, P/N 000-0095, AND COMPENSATION ADAPTER KIT, P/N 000-0174. THE COMPENSATION KIT IS P/N 000-0147.



BULKHEAD MOUNT DECK MOUNT

Figure 2.4. Binnacle Mounting.

2.5.2 Binnacle Cable Connections to PHC

The cable with the four pin connector connects to the PHC connector labeled COMPASS. The cable with the five pin connector connects to the PHC connector labeled BINNACLE DRIVE.

2.6 PILOT HOUSE CONTROL UNIT INSTALLATION

The Pilot House Control (PHC) should be flush mounted within reach of the steering wheel station. The PHC unit may be mounted in any position. The template of Figure 2.10 may be used to cut the hole in the panel. Use the four black screws provided to mount the PHC. Do not use the bezel if the PHC is flat mounted outside as it will collect water. The PHC is electrically connected to the Binnacle and the Power Unit with provided cables with pre-wired connectors.

2.6.1 Power Unit Cable Connection to PHC

The cable with the nine pin connector (furnished with the Power Unit) connects to the PHC connector labeled POWER UNIT.

2.7 PHC POWER CABLE CONNECTIONS

Table 2.1 shows the Course Keeper 210 Power Cable connections to the appropriate Power Unit.

POWER UNIT	POWER CABLE		REFERENCE PARAGRAPH
	WHITE	BLACK	
STD	ELECTRIC CLUTCH TERM 3 (+)	ELECTRIC CLUTCH TERM 1 (-)	2.7.2
HL	RELAY PC BD "+" TERM	MAIN PC BD "-" TERM	2.7.3
H	TERM 1 (+)	TERM 2 (-)	2.7.4
S/HS50/HS100	TERM 1 (+)	TERM 2 (-)	2.7.5
L/M	E1 (+)	E2 (-)	2.7.6

Table 2.1. PHC Power Cable Connections to Power Unit

2.7.1 Power Cable Connections to PHC

The white 2 pin connector end of the white and black twisted pair cable connects to the PHC connector labeled P/U.

The other end of the cable connects to the Power Unit as described below.

The ON/OFF switch supplied with the Power Unit is not used with the Course Keeper 210.

2.7.2 Power Cable Connections to STD POWER UNIT CONNECTED TO MECHANICAL STEERING ONLY

If the Power Unit is a STD Power Unit connected to mechanical steering, an Electric Clutch Assembly, P/N 000-0058 (12V), must be installed.

The ON/OFF switch supplied with the Electric Clutch is not used with the Course Keeper 210.

Electric Clutch wiring is shown in Figure 2.5. Connect the PHC Power Cable WHITE wire to terminal 3 (+) on the Electric Clutch Terminal Board. Connect BLACK wire to terminal 1 (-) on the Electric Clutch Terminal Board.

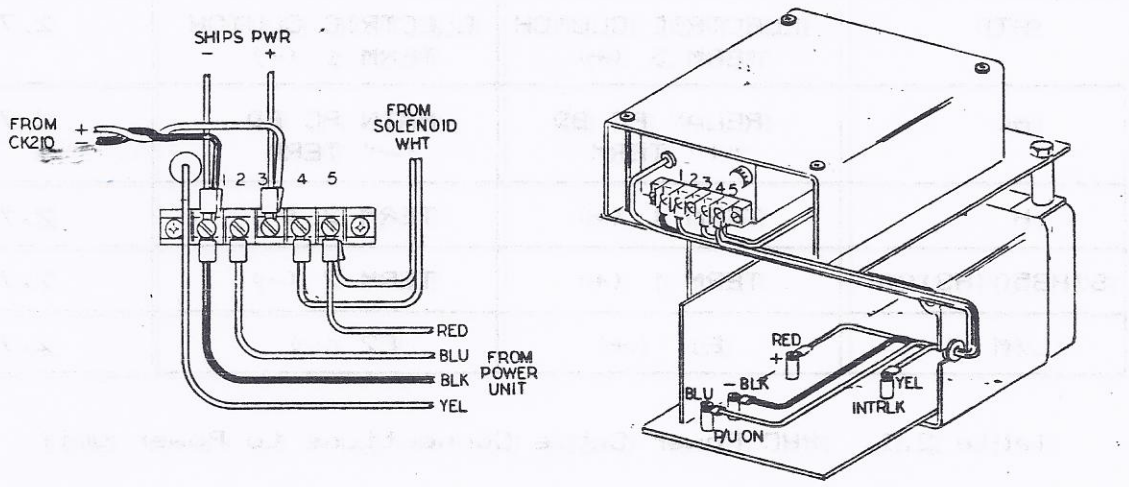


Figure 2.5. Electric Clutch Wiring, STD Power Unit

2.7.3 Power Cable Connections to HL POWER UNIT OR STD POWER UNIT CONNECTED TO A HYDRAULIC HELM ONLY

If the Power Unit is a HL Power Unit or a STD Power Unit connected to a hydraulic helm, an ON/OFF Relay Assembly, P/N 000-0151 (12V), must be installed.

The ON/OFF switch supplied with the HL Power Unit is not used with the Course Keeper 210.

Connections to the Relay Assembly are shown in Figure 2.6. Connect the PHC Power Cable WHITE wire to the "+" terminal on the Relay PC Board. Connect the BLACK wire to the "-" terminal on the Power Unit Control Board. Do not make any connections to the "ON" terminal.

2.7.4 Power Cable Connections to H POWER UNIT ONLY

The ON/OFF switch supplied with the H Power Unit is not used with the Course Keeper 210.

Connect the Power Cable WHITE wire to terminal 1 (+) on the H Power Unit Terminal Board. Connect the BLACK wire to terminal 2 (-). Do not make any connection to the "ON" terminal.

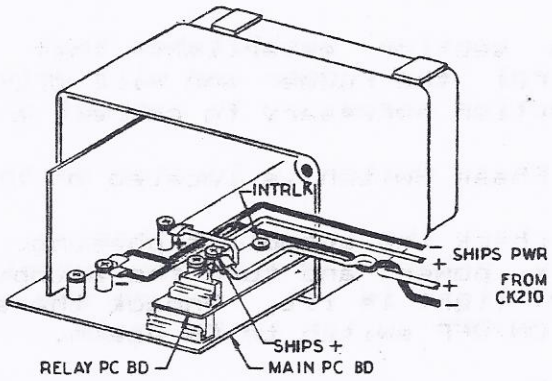


Figure 2.6. ON/OFF Relay Assembly Wiring.

2.7.5 Power Cable Connections to S, HS50 OR HS100 POWER UNITS ONLY

The ON/OFF switch supplied with the S, HS50 or HS100 Power Unit is not used with the Course Keeper 210.

Connect the Power Cable WHITE wire to terminal 1 (+) in the Power Unit. Connect the BLACK wire to terminal 2 (-). Do not make any connection to the "ON" terminal.

2.7.6 Power Cable Connections to L OR M POWER UNITS ONLY

If the Power Unit is a M Power Unit connected to mechanical steering, an Electric Clutch Assembly, P/N 000-0198 (12V), must be installed.

The ON/OFF switch supplied with the L Power Unit or M Electric Clutch is not used with the Course Keeper 210.

Connect the PHC power cable WHITE wire to E1 (+) in the L or M Control Unit. Connect the BLACK wire to E2 (-). Do not make any connection to the "ON" terminal.

2.8 DOCKSIDE CHECKOUT

After the PHC and Power Unit have been installed, the following tests should be made with the boat at the dock or on a trailer.

CAUTION

MAKE SURE THE HELM AND RUDDER ARE FREE TO MOVE. IF THE BOAT HAS AN IN/OUT DRIVE, THE DRIVE MUST BE LOWERED.

2.8.1 Establishing the Correct Autopilot Phasing

This section establishes that the autopilot will control the rudder and will drive the rudder in the direction necessary to correct a heading error.

The Phase Switch is located on the rear of the PHC.

To check the autopilot phasing, center the rudder, apply power and turn the autopilot ON. When the READY light is lit, engage the autopilot by pressing the ON/OFF switch to ON again.

If the autopilot has a mechanical power unit which drives the helm directly, monitor the motion of the helm. If not, as in the case of hydraulic systems, someone must monitor the rudder operation.

Place the autopilot in the Power Steer mode by pressing the AUTO/POWER switch to POWER.

Push the STBD pushbutton on the PHC. The rudder or helm should move to starboard while the switch is held. Repeat using the PORT pushbutton. The rudder or helm should move to port while the switch is held.

If the opposite occurs, change the position of the Phase Switch and repeat the test with the pushbuttons.

2.9 OPERATIONAL CHECKOUT (UNDERWAY)

The operational checkout (underway) applies to all Course Keeper systems. Successful completion of the dockside checkout procedures assures that the Course Keeper autopilot is properly set up and ready for the underway checkout.

2.9.1 Response

A properly set up Course Keeper should maintain a satisfactory heading without 'S'ing at speeds from idle to maximum speed. Slight initial trimming of Gain pot may be required once underway to optimize performance. A screwdriver access hole is located on the side of the PHC cover. See Figure 2.7.

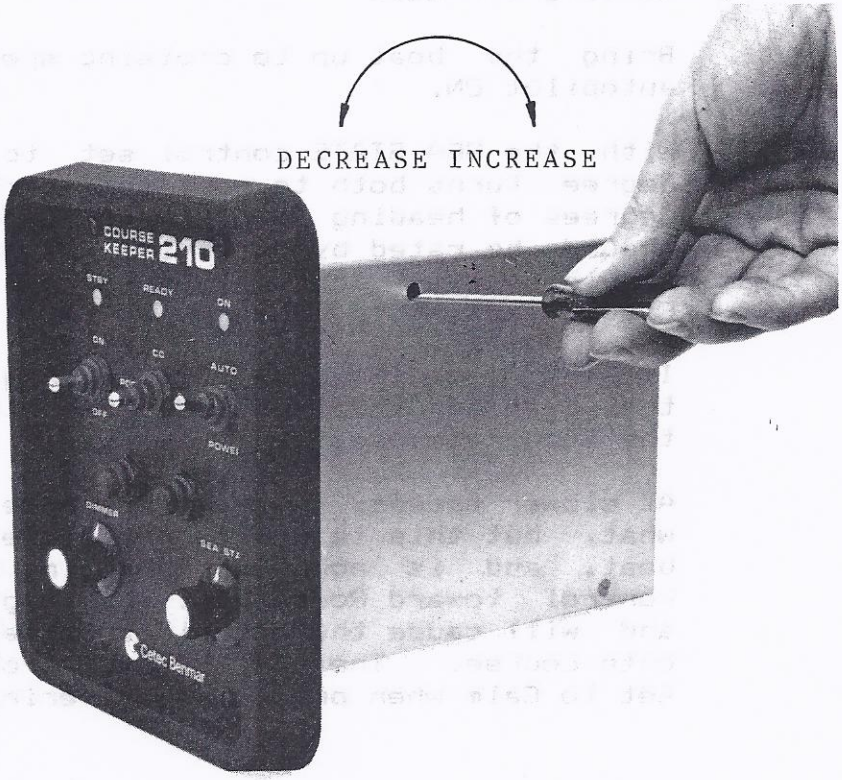


Figure 2.7. Gain Pot

2.9.2 Preparing to Set the Gain

With the Sea State set to Calm take the boat out where there is considerable room to run on all four Cardinal headings to set and check the gain.

The gain should be set under the following conditions:

Dockside checkout should be satisfactorily completed.

The Sea State should be set to Calm.

The boat should be at its maximum cruise speed; i.e., the maximum speed at which the autopilot will normally be used.

It is easiest to set the gain in calm water with considerable room to run in all directions.

The gain should be checked on all four Cardinal headings. All magnetic compasses are most sensitive on northerly or southerly courses, therefore attention should be paid to the gain setting on north and south headings.

2.9.3 Setting the Gain

Bring the boat up to cruising speed and turn the autopilot ON.

With the SEA STATE control set to Calm, attempt 30 degree turns both to port and starboard at every 90 degrees of heading (i.e., N, S, E, W). Turn response should be rated by observing the boat's wake which should display one small overshoot as diagrammed in Figure 2.8B.

If the response is as shown in Figure 2.8, A or C, the Gain pot should be adjusted slightly to optimize the turn response.

At slower speeds, the turn response may degrade somewhat, but this is due to the slower response of the boat, and is normal. Changing of the SEA STATE control toward Rough will also degrade the response and will cause the autopilot to take longer to come onto course. The SEA STATE control should always be set to Calm when precise maneuvering is required.

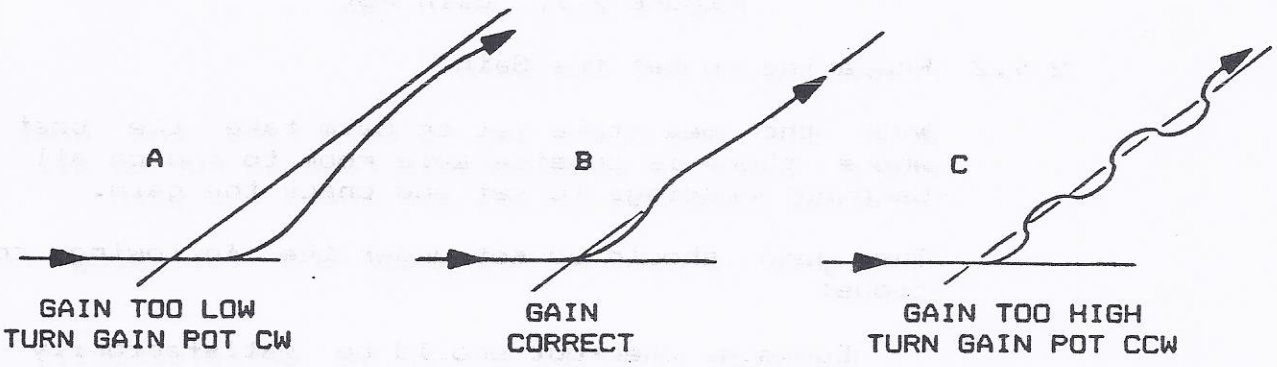


Figure 2.8. Turn Response Diagram.

2.9.4 SEA STATE Control

The function of the SEA STATE control is to reduce the response of the autopilot to short term heading errors caused by a heavy sea. This control will only be turned toward Rough in heavy seas or any other time that it is desirable to reduce the amount of helm action and/or the autopilot power drain.

This control does not reduce the total amount of helm correction available nor does it degrade the heading accuracy. It only reduces the short term movement of the helm.

2.10 NORTHERLY TURNING ERROR

The CK210 PHC is equipped with a vertically compensated compass. As shipped from the factory, switch S1 on the compass is in the OFF position which disables the compensating coil. When switch S1 is set to the "+" position (in the northern hemisphere) a DC current is passed through the coil which develops a magnetic field which cancels the vertical component of the earth's magnetic field and minimizes acceleration and northerly turning error effects.

2.10.1 Effects of Northerly Turning Error

Northerly turning error is a dynamic compass error caused by linear acceleration effects of any pendulous magnetic compass card including the finest steering compasses made.

The effect is zero at the magnetic equator and increases with higher northerly and southerly latitudes. The cause is due to the fact that the magnetic lines of flux are parallel to the sea surface only at the equator and progressively tilt further and further down as one moves in either direction away from the equator; i.e., the vertical magnetic intensity increases. For example, the tilt (magnetic dip) angle is approximately 68 degrees in Seattle, Washington.

As can be seen on the chart in Figure 2.9 the geographical and magnetic equators do not coincide nor do the lines of latitude match the lines of constant vertical magnetic intensity. In fact, the vertical field is higher (and therefore northerly turning error effects greater) in the Great Lakes area than anywhere on the coast of Alaska. However, generally as one progresses north or south from the equator, the northerly turning effects increase.

The degree of the northerly turning error effect is also dependent on amount of linear acceleration and dynamics of the compass card. Linear acceleration occurs when a boat turns (which can't be prevented) and when a boat rolls causing the compass card to be accelerated from side to side (which can be minimized). The closer the compass is to the boat's center of roll, the less acceleration will be imparted to the compass when the boat rolls. Since a boat's center of roll is always below the waterline, the lower the compass is located, the less the roll effect. The error caused while turning will remain the same however, regardless of compass location.

Northerly turning error effect on a boat/autopilot system manifests itself (in the northern hemisphere) as increased sensitivity (autopilot appears "nervous" and more prone to fast 'S'ing) on direct southerly courses and decreased sensitivity (slow wandering 'S' or sluggishness to correct) on direct northerly courses when compared to steering east/west courses. These effects reverse directions in the southern hemisphere.

The gain of an autopilot must then be optimized on north and south courses. If it is found to be too unresponsive or impossible to stabilize on north courses, the vertically compensated compass must be used. A properly compensated compass will exhibit the same response and go unstable at the same gain setting on all headings. With an uncompensated compass showing northerly turning error effects, the autopilot gain may be increased the most on east-west courses before instability is reached. The autopilot will then be sluggish on northerly courses and unstable on southerly courses (in the northern hemisphere).

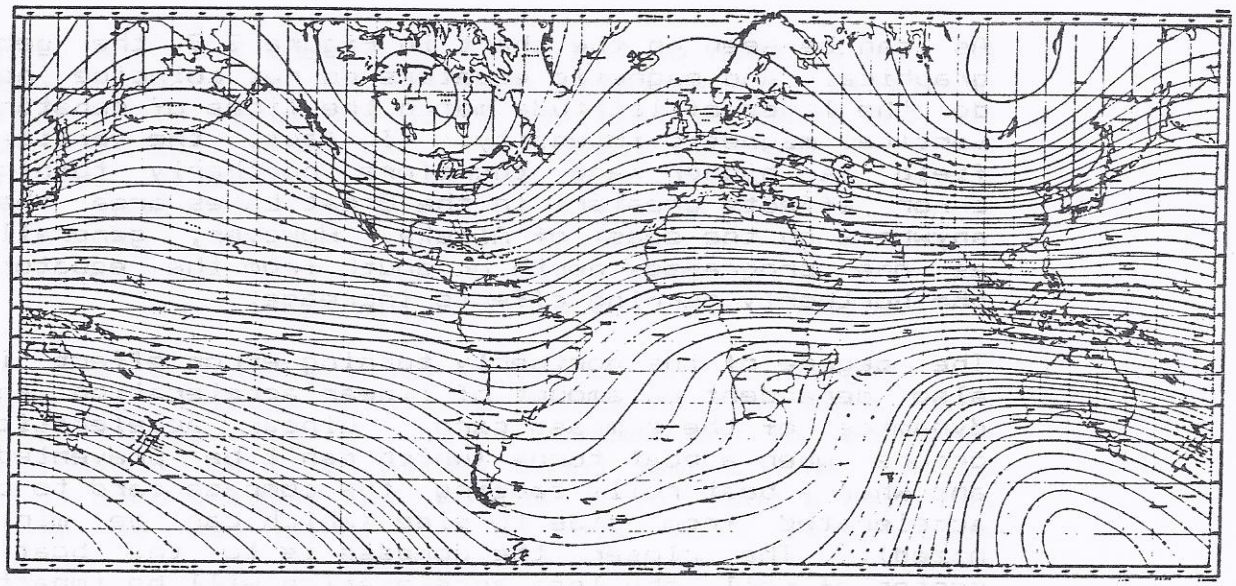


Figure 2.9. Vertical Intensity of the Earth's Magnetic Field.

2.10.2 When to Employ the Vertically Compensated Compass

The vertically compensated compass should be used only when northerly turning error effects have been observed. As stated above, with an uncompensated compass showing northerly turning effects the auto-

pilot gain may be increased on east-west courses before instability is reached. The autopilot gain will then have to be decreased on northerly-southerly courses in order to maintain stability. The autopilot will then probably be sluggish on northerly courses and tend to be unstable on southerly courses. A common complaint is, "I can't get the gain high enough for the pilot to work well without the autopilot going unstable on some courses".

The vertically compensated compass should not be used until after the installer has made sure that the autopilot compass has been properly located in a position free of any external horizontal magnetic interference.

Horizontal magnetic interference may often give the same or similar indications that northerly turning errors give. That is, the boat will steer well on some courses and poorly on others but not necessarily north-south courses.

2.10.3 Locating the Autopilot Compass

The Compass (Binnacle) should be located as close to the center of roll and the center of yaw as possible to minimize northerly turning error or acceleration effects. Obviously this can rarely be achieved. This is pointed out to indicate the direction in which one should go to minimize magnetic problems when a choice exists. The greater the effort to meet these requirements, the less the magnetic interference.

2.10.4 Adjustments

There are two adjustments on the vertically compensated compass, switch S1 and potentiometer R5 located on top of the compass. NOTE: R3 ON THE COMPASS IS NOT ASSOCIATED WITH THE VERTICAL COIL AND SHOULD NOT BE ADJUSTED.

NOTE

SWITCH S1 ON THE COMPASS IS SET IN THE CENTER, OFF, POSITION WHICH DISABLES THE COMPENSATING COIL. THIS SWITCH MUST BE SET AS DESCRIBED BELOW.

The compass phase switch must be set as follows:

For operation in	Set Compass Phase Switch
Northern Hemisphere	+
Southern Hemisphere	-

Potentiometer R5 is pre-set at the factory for optimum operation at a mid-latitude. Ordinarily this setting will be satisfactory in any location. If satisfactory results are not obtained with R5 at its factory setting, R5 may be adjusted for optimum operation in the area where the compass is installed.

Re-setting this potentiometer must be done empirically. The best way to make this adjustment is to run the boat on autopilot on north-south and east-west courses, observing the autopilot response. Re-adjust the pot, again observing the autopilot on north-south and east-west courses and adjust the pot to an optimum position such that the autopilot performance is optimized on all courses. Normally, the pot will have to be increased (turned CW) at higher latitudes and decreased (turned CCW) at lower latitudes. It may not be possible to completely eliminate all indications of northerly turning error effect on some boats, especially in very high latitudes and where the compass is mounted very high above the center of roll. However, on most boats where northerly turning error is apparent, the vertically compensated compass allows one to increase the gain by 20 to 40%. This gives a very significant increase in response and very satisfactory performance on all courses.

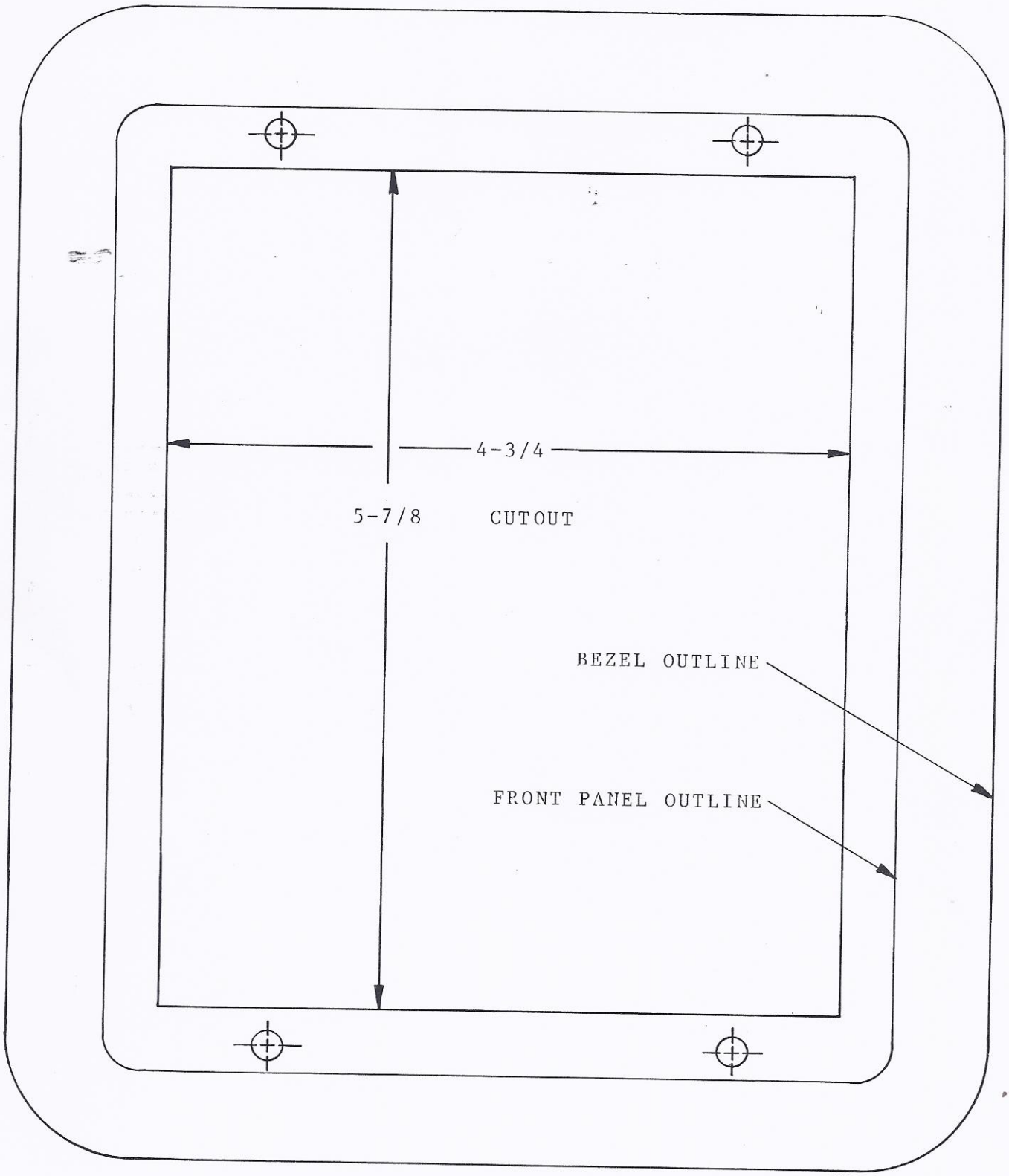


Figure 2.10. PHC Template.

SECTION III

SERVICING AND MAINTENANCE

3.1 GENERAL

The following servicing and maintenance instructions can be performed by the operator. No special tools or test equipment are required.

3.2 FUSE REPLACEMENT

The PHC fuse is contained in the PHC power cable. Replace a blown fuse with a 1A, 3AG fuse.

The autopilot primary power input fuse is located in the Power Unit. For fuse location and replacement, see applicable Power Unit manual.

3.3 COMPASS LAMP

The Binnacle contains one lamp. It is located in the compass assembly and requires removal of the Compass Printed Circuit Board from the compass and requires recalibration of the compass. This lamp should only be replaced by a qualified technician.

3.4 COMPASS MAINTENANCE

The rotating compass contacts may occasionally oxidize and require cleaning. See Figure 3.1. Radio-TV contact cleaner can be used to clean the contacts. For an installation in which the Binnacle is continuously exposed to weather (such as flying bridge installation) this maintenance must be performed every 3 months.

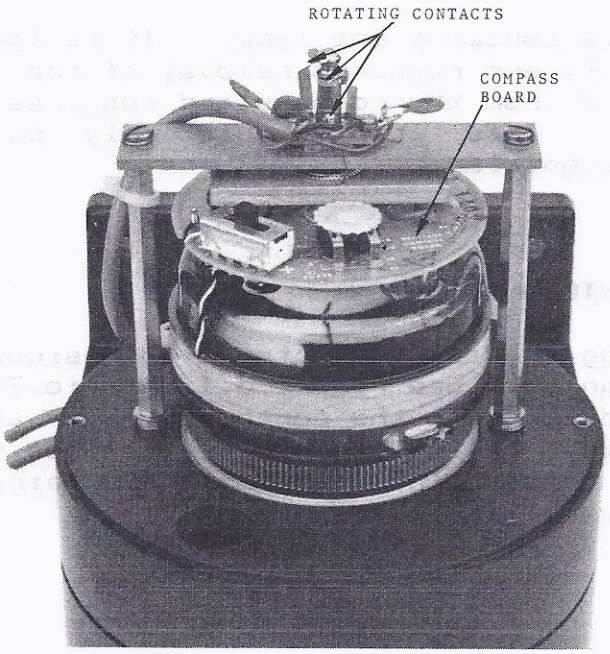


Figure 3.1. Compass Rotating Contacts

SECTION IV

CIRCUIT DESCRIPTION

4.1 GENERAL

Refer to the System Block Diagram, Figure 4.2, for a basic understanding of the Course Keeper autopilot operation. See the Power Unit manual for detailed information on Power Unit operation.

Refer to the system schematic for a more detailed circuit description. Circuit board location is shown in Figure 4.1.

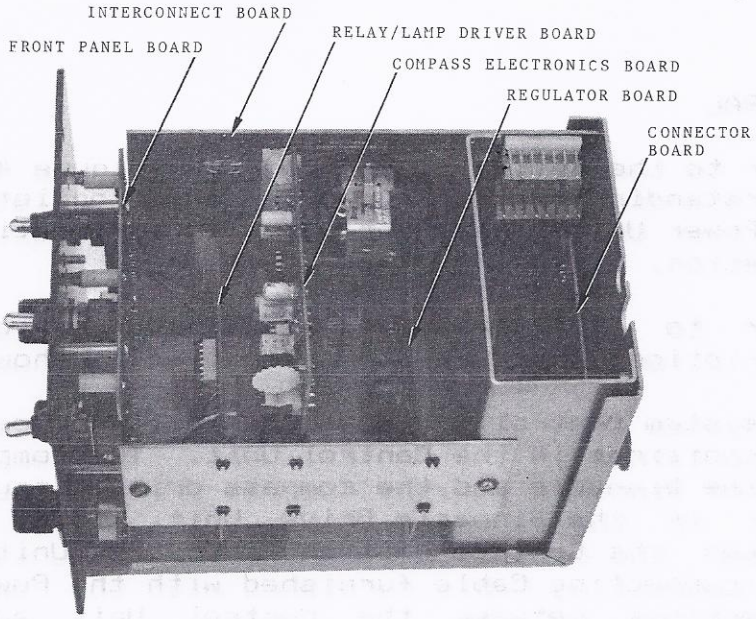
The system control, compass control and compass electronics are contained in the Control Unit. The compass is contained in the Binnacle and the compass drive circuitry and drive motor in the Binnacle Drive Unit. The interconnections between the Control Unit and the Power Unit are made by an Interconnecting Cable furnished with the Power Unit. Interconnections between the Control Unit and Binnacle and Binnacle Drive are made with Interconnecting Cables furnished with the Binnacle and Binnacle Drive Unit

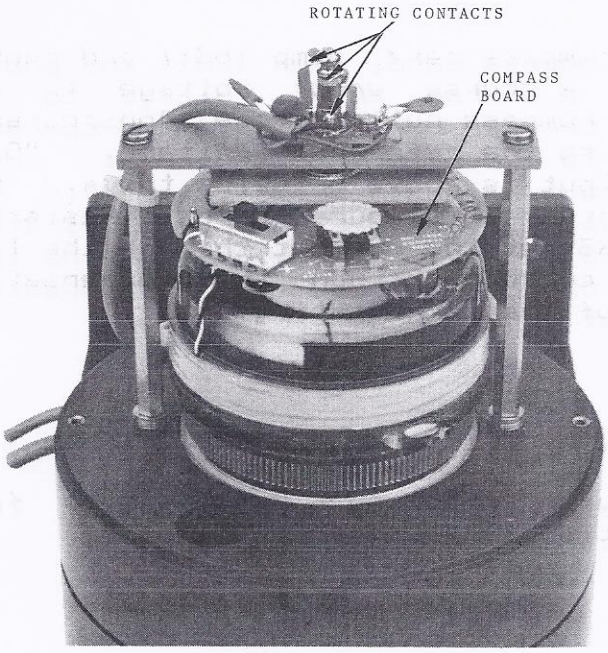
4.2 BINNACLE

The compass contains the compass card, lamp (DS1) and photocell (V1) which supply a course error voltage to the compass electronics. The compass null voltage ("on-course") is +4.0 VDC, identical to the reference voltage. "Off-course", the compass output is above or below the 4.0 VDC reference, indicating right or left course error. Resistors R1, R2 and potentiometer R3 set the current through the lamp DS1. R4 and R5 set the current through the compensating coil. S1 sets the phase of the compensating coil.

4.3 BINNACLE DRIVE UNIT

The Binnacle drive circuitry receives a drive signal from the Control Unit and positions the compass.





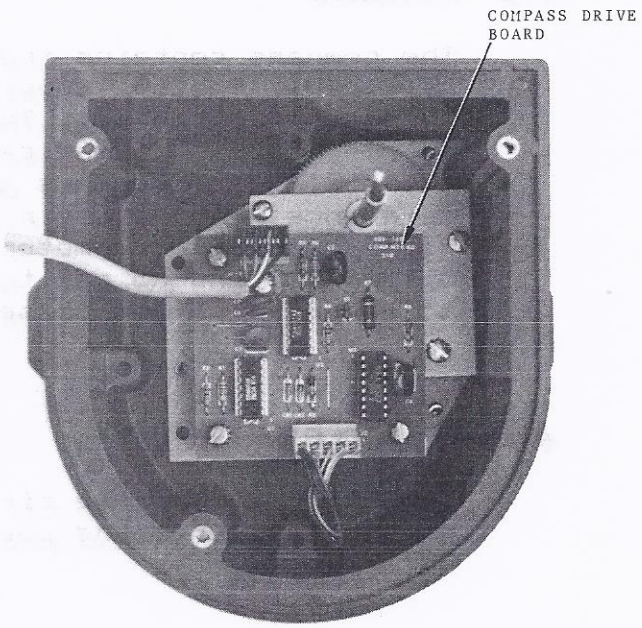


Figure 4.1. Circuit Board Location

IC U1-1 thru U1-4, U2-1 and Q1 provide the drive and engage signals to U3. IC U2-2, U2-3, R5, R6 and C5 make up the oscillator to generate the clock for U3. IC U3 contains the motor driver transistors for B1, the stepper motor that drives the compass.

4.4 CONTROL UNIT

Located on the front of the Control Unit are all of the controls and indicator lights for the autopilot. Located inside the Control Unit are six circuit boards that contain the electronics for control of the autopilot.

4.4.1 Front Panel Board

The Front Panel Board provides the connections for the front panel controls and indicator lights.

4.4.2 Regulator Board

The Regulator Board contains the +12V pre-regulator for 24V and 32V units, +8V regulator and +4V regulator.

4.4.3 Compass Electronics Board

The Compass Electronics Board contains the auto/power steering circuitry, compass sea state filter and amplifier, system gain control, compass signal buffer, filter, comparator, phase change circuitry and motor drive logic.

4.4.4 Relay/ Lamp Driver Board

The Relay/ Lamp Driver Board contains the STBY, READY, and ON logic, lamp drivers and the ON relay driver.

4.4.5 Interconnect Board

The Interconnect Board connects all the boards together and contains the standby relay, the on relay, the filter capacitors and RFI shield.

4.4.6 Connector Board

The Connector Board at the rear panel of the unit mounts the interconnect connectors and the phase switch. The connectors on the rear panel are:

J4 - Connects to the Power Unit interconnect cable. It has +8V, +4V and signal ground coming from the Power Unit, and, PHC signal, power on voltage and auto/power voltage going to the Power Unit.

J13 - Connects to the ship's voltage at the Power Unit.

J15 - Connects to the Binnacle. Contains the compass output signal and provides +8V and ground to the compass.

J16 - Test connector for connecting an Autopilot Test Set to read out the voltages in the unit.

J17 - Loran C Interface which provides voltage to the Loran C interface, if installed, and also allows the interface unit to drive the compass.

J18 - Binnacle Drive connector which provides the voltage, PORT and STBD drive to the binnacle drive circuitry in the bottom of the Binnacle.

4.5 CIRCUITRY

Refer to the System Block Diagram, Figure 4.2 and detailed schematic.

4.5.1 Pre-Regulator (24V and 32V Units Only)

The pre-regulator provides the +12V to the +8V regulator, switching relays, Binnacle drive circuitry and the Loran C Interface unit. The +12V pre-regulator consists of R1, C1, C2, CR1 and Q1 on the Regulator Board.

D3 is a "Tranzorb" diode to clip any high voltage spikes which may be on the input line.

4.5.2 +8 Volt Regulator

The +8V regulator feeds +8 volts to the circuitry on the Compass Electronics Board in STBY and READY mode and to the Relay/Lamp Driver Board. The +8 volts comes from U-1 on the Regulator Board.

4.5.3 +4 Volt Regulator

The +4V regulator provides the reference voltage for all the low level circuitry on the Compass Electronics Board in STBY and READY modes. The +4V comes from R2, R3, C5, C6 and U2-1 on the Regulator Board.

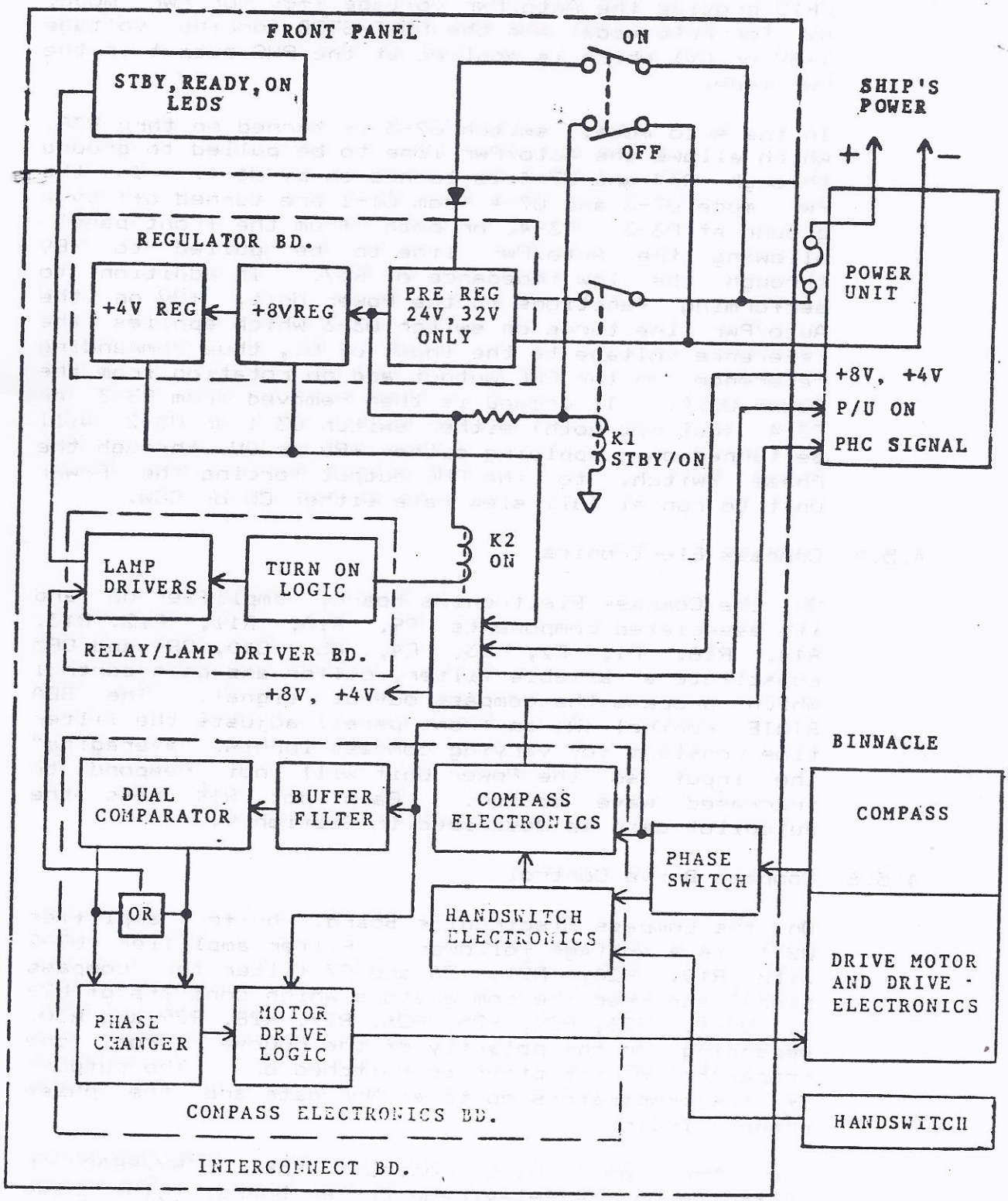


Figure 4.2. System Block Diagram

4.5.4 Auto/Power - Dodge Circuitry

On the Compass Electronics Board, IC switch U7-3, R1, R2, R3, R4, R5, R39, R40, CR1, CR2, CR3, CR14 and CR15 provide the Auto/Pwr voltage (+8V for Pwr mode, 0V for Auto mode) and the PORT/STBD forcing voltage (+8V or 0V) which is applied at the PHC output in the Pwr mode.

In the Auto mode, switch U7-3 is turned on thru R38, which allows the Auto/Pwr line to be pulled to ground through R37 and U7-4 is turned on by U1-1. In the Pwr mode U7-3 and U7-4 from U1-1 are turned off by a ground at P3-3, P3-4, or both (from the front panel) allowing the Auto/Pwr line to be pulled to +8V through the low impedance of R37. In addition to performing functions in the Power Unit, +8V on the Auto/Pwr line turns on switch U3-3 which applies the reference voltage to the input of U1, thus commanding reference on the PHC output and no rotation from the Power Unit. If ground is then removed from P3-3 or P3-4 (but not both) either switch U3-1 or U3-2 will be turned on, applying either +8V or 0V, through the Phase Switch, to the PHC output forcing the Power Unit to run at full slew rate either CW or CCW.

4.5.5 Compass Electronics

On the Compass Electronics Board, amplifier U5 and its associated components R9, R10, R11, R12, R13, R14, R16, C1, C2, C3, C4, C5, C10, CR4 and CR5 constitute a variable filter, buffer and gain control which process the compass output signal. The SEA STATE control (R1 on front panel) adjusts the filter time constant for varying compass inputs, "averaging" the input so the Power Unit will not respond to increased wave motion. Gain pot R14 sets the autopilot gain as described in Section V.

4.5.6 Compass Drive Control

On the Compass Electronics Board, buffer amplifier U2-1 is a voltage follower. Filter amplifier U2-2 with R19, R20, R21, C6 and C7 filter the compass signal and feed the comparators which consists of U2-3, U2-4, R23, R24, R25, R26, R27, R28, R29 and R30. Depending on the polarity of the course error, one comparator or the other is switched on. The outputs of the comparators go to an Nor gate and the phase changer logic.

The Nor gate U1-2 controls the STBY/READY/ON switching on the Relay/Lamp Driver Board. The phase changer logic receives +8V and 0V from the phase switch which also feeds the compass electronics to

phase the compass output. The phase changer logic consist of U6-1 thru U6-4, CR6, CR7, CR8 and CR9. The output of the phase changer in STBY and READY modes feed thru the switches U7-1 and U7-2 to U4-3 and U4-4. The outputs of U4-3 and U4-4 feed Q1 and Q2. If there is a course error, Q1 or Q2 will be on until the compass drives to on course. In ON mode, the Power Unit is on and switches U7-1 and U7-2 are off. The motor drive circuitry U4-3 or U4-4 also get an input from the course changer switch on the front panel.

IC U4-2 cuts off the motor drive if the CC switch on the front panel is actuated one direction and, at the same time, either the Remote PHC or Handswitch CC switch is actuated in the opposite direction.

4.5.7 Relay and Lamp Drivers

On the Relay/Lamp Driver Board, the STBY/READY signal at pin 3 feeds the time constant R7, C1 and CR1 which set the time, after the compass drives to "on course", that the READY light comes on and the STBY light goes off. U1-2 output goes to Q3 to light the STBY light. U1-1 goes to Q2 to light the READY light. In ON mode, switch U2-1 and U2-2 are closed to turn off the STBY and READY lights and Q1 is turned on to light the ON light. Q4 is also on in the ON mode to hold K2 energized.

4.5.8 STBY/READY Logic

When the ON switch is closed, the line voltage is applied to the Regulator Board. For 24V and 32V units the line voltage is regulated to 12V on the Regulator Board. This 12V is applied to the +8V regulator U1 so that +8V and +4V from U2-1 is now applied to the Compass Electronics Board, Relay/Lamp Driver Board and to the compass. The 12V is also applied to K1 thru R1 to energize K1 and hold it closed thru the contacts of K1. The holding contact of K1 keeps the line voltage applied to the Regulator Board. Any deviation of the compass from the ship's selected course will cause the compass to generate an error signal. The compass error signal is buffered and filtered on the Compass Electronics Board by U2-1 and U2-2. The signal then goes to two comparators, and depending on the polarity of the error either U2-3 or U2-4 will switch to approximately 6.5V. The output of the comparator goes to the phase selector U6-1 thru U6-4 and thru U7-1 or U7-2 which are on in STBY/READY modes to U4-1 or U4-2 to turn on Q1 or Q2. Q1 or Q2 on causes the compass drive motor to slew the compass toward zero error. The output of both comparators also goes to U1-2 to be inverted and then

feeds diode CR1 to U1-2 on the Relay/Lamp Driver Board to turn on Q3 and light the STBY light. After the compass slews to "on course", the output of the comparator on the Compass Electronics Board goes to ground and thru U1-2 inverter to the STBY/READY time constant. C1 charges thru R7, Q3 switches off and Q2 on to turn off the STBY light and light the READY light. U1-3 also gets a voltage to allow the system to be switched to the ON mode.

4.5.9 Turn On Logic

Depressing the ON switch after the READY light is on will apply a voltage to the Relay/Lamp Driver Board thru CR2, C2, R9, R10, U1-3 to U1-4 and Q4. Turning on Q4 energizes the ON relay, K2. +8V volts thru the ON relay contacts goes to Q4 to keep the relay energized. The +8 volts also goes to switches U2-1 and U2-2 to turn off the READY light and to Q1 to light the ON light. The voltage also goes to the Compass Electronics Board to open switches U7-1 and U7-2 to keep any compass error from driving the compass. K2, the ON relay, being energized sends the line voltage out thru one of its contacts to pin 1 of the Power Unit interconnect cable. This voltage goes to Power Unit ON relay in the Power Unit to turn on the Power Unit.

4.6 SECOND STATION PHC

Refer to remote PHC schematic.

The ON/OFF switch on the Second Station PHC connects thru the interconnect cable to J20 on the main PHC and parallels the ON/OFF switch on the main PHC. It operates the same as the main PHC. The main PHC also feeds STBY, READY and ON signals out of J20 thru the interconnect cable into J2 to the STBY/READY/ON logic. Whichever mode the main PHC is in, the Second Station PHC will display the same indication. The CC, PORT, STBD and AUTO/ POWER switches are connected thru J3 and the interconnect cable to P12 on the main PHC and are parallel to the same switches on the main PHC and therefore function the same.

SECTION V

TROUBLESHOOTING

5.1 GENERAL

Troubleshooting the autopilot should be performed by a qualified technician. The circuit description section and the system schematic should be referred to for a thorough understanding of circuit function prior to troubleshooting. Since the autopilot system includes the Power Unit reference should be made both to this section and the corresponding section in the Power Unit manual. An Autopilot Test Set, Part Number 000-0095, will greatly facilitate autopilot troubleshooting as well as initial setup and operational monitoring.

5.2 COMMON NEW INSTALLATION PROBLEMS

Listed below are the most common problems encountered on new installations. As can be seen the majority of these problems occur during installation and setup, all of which could be avoided if the installation and setup instructions had been read and followed.

1. Gain not properly set or not set at all - usually too low resulting in sluggish response. Although this is self-explanatory, it is one of the biggest problems encountered in new installations. Refer to Section 2.9.

2. Binnacle (compass) to close to external magnetic influence. Autopilot unstable and/or sluggish on some courses. Refer to paragraph 2.7. Magnetic materials come in many forms; i.e., small motors, other electronic equipment, speakers, etc., (a steel medicine cabinet had to be removed in one boat).

   An autopilot compass installed on a steel hulled boat may need to be compensated. Compass compensation must be performed by a qualified, experienced compass compensator and requires the aid of the Autopilot Test Set (Benmar P/N 000-0095) and Compensation Adapter (Benmar P/N 000-0174). The Compu-Course 220 Compass Compensator Kit is Part Number 000-0147.

3. Power Unit input power leads too small and/or too long - autopilot will be erratic and impossible to stabilize. Peak current demands of the autopilot may drop the voltage input to the Power Unit below the specified level for short periods of time causing erratic opera-

tion. The problem may be an undercharged or defective battery, corroded power lead connections, or too fine a gauge of input wire for the length of wire used. This problem most often observed on S Power Units. See Electrical Connections in the appropriate Power Unit manual for input wire requirements.

4. Compass contacts dirty - autopilot will be erratic. Compass lamp flickers as the compass is rotated. Will be seen on the Test Set as jumps or flickers in the compass output as the compass rotates or is lightly tapped. Refer to Paragraph 3.4.

5. If there is excessive back and forth helm movement required to make small heading error corrections, it is possible that there is greater than acceptable backlash in the linkage between the helm and rudder.

6. If the autopilot acts sluggish or excessively overshoots a new heading when the course is changed, it is probable that the torque limit is set too low. If this is the case, the torque limit jumper may be moved to a higher torque limit setting (M and S Power Units only).

7. On hydraulic systems the 3rd or return line not connected. On some installations, the autopilot will be sluggish; on others, it will not operate at all. The autopilot return line must be connected to the return or reservoir in the hydraulic system on all installations. Failure to do so will void the warranty on the Power Unit. Refer to the Power Unit manual.

8. Air in hydraulic system causing system to be sluggish and unresponsive. Observe the hydraulic cylinder with the autopilot pump running at its maximum rate. If there is air in the hydraulic system, the cylinder will appear to be sticking and not moving at a constant rate. See bleeding instructions in Power Unit manual.

5.3 TROUBLESHOOTING

If a malfunction occurs, refer to the Test Voltage Table (Table 5.1) and the Autopilot Checkout Chart (Table 5.2). These will assist in isolating the specific function block that may be the cause of the malfunction. Replacement printed circuit boards, as well as all other components may be obtained from Benmar. Refer to the Parts List for component description and Benmar Part Number.

VOLTAGE CHECK	TEST POINTS	CONDITIONS	SPEC VOLTAGE
Input Power: 12V System	"+" to "-"	STANDBY and ON (for all tests)	+11 to +15VDC
24V System			+22 to +30VDC
Voltage Regulator	J16-7 to J16-4		+7.7 to +8.3VDC
Reference Regulator	J16-5 to J16-4		+3.6 to +4.4VDC

Table 5.1. Test Voltages

TABLE 5.2

AUTOPILOT CHECKOUT USING TEST SET
FOR CK210 PHC AND ALL P. U. 'S

Read Notes 1 thru 5 prior to starting test sequence.

Tests should be performed in the sequence shown.

The dimmer control should be set and left fully CW for maximum indicator lamp brightness.

Test Set Switch Positions			CK210	Mode	Test Set			
Meter	Power Unit	Auto/Pwr	Stby/R/On	A/P	Conn	Testing	Desired Result	Possible Problems
8V	0 (Any)	Either	Stby/R	Either	Test See Note 1.	8V Reg in CK210	Meter in green area on left and steady.	Input Pwr not on or not conn properly. Pwr Unit cable not conn. PHC in line fuse blown. 8V regulator IC (7808) 8V on Regulator Bd. in CK210 faulty. Pre-regulator on Regulator Bd (24 & 32V) faulty. 8V line short in PHC loading 8V regulator.
4V	0 (Any)	Either	Stby/R	Either	Test	4V Reg in CK210	Meter in green area and steady.	4V regulator I.C. on Regulator Bd in CK210 faulty. 4V line short loading 4V reg. (If 8V is not correct 4V will not be correct.)
COMP	0 (Any)	Either	Stby to Ready	AUTO	Test	Compass Orient loop	Immediately after on switch is activated the standby light should come on. Depending on where the compass is initially oriented, the test set will show some compass error. In a period of no more than 30 seconds, the compass error should go near zero the standby light. go off and the ready light will come one.	Faulty compass orient electronics on compass electronics board. Faulty compass. Faulty compass drive electronics in binnacle drive unit. Faulty electronics relay/ lamp driver board (if compass error goes to near zero but ready light doesn't come on). Dirty contacts on compass jack.

Test Set Switch Positions			CK210	Mode	Test Set			
Meter	Power Unit	Auto/Pwr	Stby/R/On	A/P	Conn	Testing	Desired Result	Possible Problems
COMP	0 (Any)	AUTO	Ready to On	AUTO	Test	Ready/On Logic	With PHC ready light on, activate ON switch and ready light goes out, on light comes on.	Faulty electronics - relay/lamp driver bd or K2
8V	0 (Any)	Either	On	AUTO	P.U.	8V Regulator in P. U.	Meter in green area on left and steady.	Input power not connected properly. Blown P. U. fuse. 8V regulator I.C. (7808) in P. U. faulty. 8V line short loading 8V reg (regulator is current limited and can sustain a short).
8V	Alternate from 0 to - LOW and + LOW	AUTO.See Note 1.	On	AUTO	P.U.	8V regulator stability while driving P. U. on and off.	Meter should remain stationary in green area on left and not flicker or jump.	Input power leads to small (wire size). High impedance connection in power leads. Low battery voltage.
4V	0 (Any)	Either	On	AUTO	P.U.	4V regulator P. U.	Meter in green area and steady.	4V regulator I.C. in P.U. faulty. 4V line short loading 4V regulator. (If 8V is not correct, 4V will not be correct.)
COMP	0	AUTO	On	AUTO	P.U.	Compass output & Course Change Circuitry	Activate the course change switch to the right for approx. 60 sec to rotate the compass thru a full 360 then repeat to the left. As the compass is rotated in either direction the meter should pass through 0 increase or decrease smoothly to green, stay in the green area for a period, again pass through 0 and over and into the opposite	a) Compass does not move. CC switches faulty. AUTO/PWR switch somewhere in system in PWR. See Note 4. b) Jerking meter movement as compass is rotated: Dirty contacts on compass jack or air bubble in compass body which has not passed into the air chamber. Low compass fluid. NOTE: There may be some slightly "jerky" meter

Test Set Switch Positions			CK210	Mode	Test Set			
Meter	Power Unit	Auto/Pwr	Stby/R/On	A/P	Conn	Testing	Desired Result	Possible Problems
							There should be no momentary jumps or jitters on the meter dial.	side of the compass is encountered. c) Meter out of green area when compass output is maximum. Adjust compass lamp circuit pot R3 on compass. Faulty compass.
Any	OPERATE	AUTO	On	PWR	P.U.	Setting Phase Switch	Push the right jog button and watch the wheel or rudder. The wheel should move in the same direction that you commanded with the jog button or the rudder should move the opposite way to turn the boat the same direction. If it does not, reverse phase switch. Check the wheel rotation by jogging several times in both directions to insure that the wheel or rudder is causing the boat to turn in the direction commanded.	
NORM or 4	0	AUTO	On	AUTO	P.U.	Compass Electronics	With the compass centered, (0 compass output activate the right and left CC switches for 7 or 8 sec to rotate the compass 45 either side of center. PHC output should increase and decrease either side of center smoothly and with no jump or jitters. NOTE - The amount of PHC output is dependent on the internal gain setting. With the internal gain set fully counter-clockwise there will be very little PHC output. With the gain	No output or very little output: AUTO/PWR switch on handset, test set or a remote in PWR mode. Faulty compass electronics. Erratic output: Possible compass problems or faulty compass electronics.

Test Set Switch Positions			CK210	Mode	Test Set			
Meter	Power Unit	Auto/Pwr	Stby/R/On	A/P	Conn	Testing	Desired Result	Possible Problems
							set fully clockwise, the output will peak in the green area on the 16T scale.	
Any	0	AUTO	On	AUTO	P.U.	Power Unit Circuitry 0 input	P. U. output shaft should be stationary or nearly stationary.	P.U. Control circuitry faulty or power transistor shorted.
Any	0 to + LOW	AUTO	On	AUTO	P.U.	Power Unit Circuitry CCW input.	P. U. output shaft should fast slew 1/2 turn, slow down and slow slew smoothly in the same direction. See Note 6.	Erratic: P. U. Control circuitry faulty. No Movement: P.U. Control Control circuit faulty or power transistor open. Or AUTO/PWR switch in PWR. See Note 3
Any	0 to - LOW	AUTO	On	AUTO	P.U.	Power Unit Circuitry CW input	P. U. output shaft should fast slew CW 1/2 turn, slow down and slow slew smoothly in the same direction. See Note 6.	Erratic: P. U. Control circuitry faulty. No Movement: P.U. Control circuit faulty or power transistor open. Or AUTO/PWR switch in PWR See Note 3.
Any	0 to + HIGH	AUTO	On	AUTO	P.U.	Power Unit Circuitry CCW Input	P. U. output shaft should fast slew CCW 4 turns, slow down slightly and slow smoothly in the same direction. See Note 7.	Erratic: P. U. Control circuitry faulty. No Movement: P.U. Control circuitry faulty or power transistor open. Or AUTO/PWR switch in PWR. See Note 3.
Any	0 to - HIGH	AUTO	On	AUTO	P.U.	Power Unit Circuitry	P. U. output shaft should fast slew CW 4 times, slow down slightly and slow slew smoothly in the same direction. See Note 7.	Erratic: P. U. Control circuitry faulty. No Movement: P.U. Control circuitry faulty or power transistor open. Or hand-set or remote PHC AUTO/PWR switch in PWR. See Note 3.
Any	0 to + LOW	PWR	On	AUTO	P.U.	P. U. Control circuitry and AUTO/PWR circuitry.	P. U. should not run.	P. U. Control circuitry or AUTO/PWR circuitry faulty.

Test Set Switch Positions			CK210	Mode	Test Set	Testing	Desired Result	Possible Problems
Meter	Power Unit	Auto/Pwr	Stby/R/On	A/P	Conn			
Any	0 to - LOW	PWR	On	AUTO	P.U.	P.U. Control circuitry and AUTO/PWR circuitry.	P. U. should not run.	P.U. Control circuitry or AUTO/PWR circuitry. faulty.
Any	0 to + HIGH	PWR	On	AUTO	P.U.	P.U. Control circuitry and AUTO/PWR circuitry.	P. U. should continuously fast slew counter-clockwise unless limit switch limits are encountered which will turn off P.U. See Note 8.	P.U. Control circuitry or AUTO/PWR circuitry faulty.
Any	0 to - HIGH	PWR	On	AUTO	P.U.	P.U. Control circuitry and AUTO/PWR circuitry	P. U. should fast slew continuously clockwise unless limit switch limits are encountered which will turn off the P. U. See Note 8.	P.U. Control circuitry or AUTO/PWR circuitry faulty.

NOTES:

1 - The CK210 PHC differs in concept somewhat from the CS21 PHC's. During the compass orient phase of operation (standby and ready), the PHC develops and uses its own +8V and +4V supplies. The Power Unit does not come on until the "ON" phase of operation at which time the PHC switches to and uses the P. U. +8V and +4V supplies. For this reason if the Test Set is installed in series with the PHC and Power Unit (i.e., P. U. connector on the PHC), the Test Set will not operate during standby and ready. The test jack on the back of the PHC has been added on the CK210 so that one can monitor PHC functions (+8V and +4V, compass output) during ALL phase of operation. DO NOT AT ANY TIME PLUG THE POWER UNIT CONNECTOR INTO THE TEST SET IF IT IS PLUGGED INTO THE PHC TEST CONNECTOR. This will damage the PHC and/or the P. U. circuitry.

2 - When the Test Set is connected to the PHC "TEST" connector, the "PWR UNIT" switch in the test set is not functional.

3 - In order for the autopilot to function in "AUTO" mode, ALL AUTO/POWER switches must be in the AUTO position; i.e., main PHC, remote PHC, all handsets and the Test Set AUTO/PWR switches. If ANY AUTO/PWR switch is in the PWR position, the autopilot will be in the PWR steer mode. If more than one AUTO/PWR switch is in PWR, the jog push buttons will not function.

4 - In order to course change, the autopilot must be in the AUTO mode. ALL AUTO/POWER switches must be in the AUTO position; i.e., main PHC, remote PHC, all handset and test set AUTO/POWER switches. If any AUTO/PWR switch is in the PWR position, the autopilot will be in the PWR steer mode.

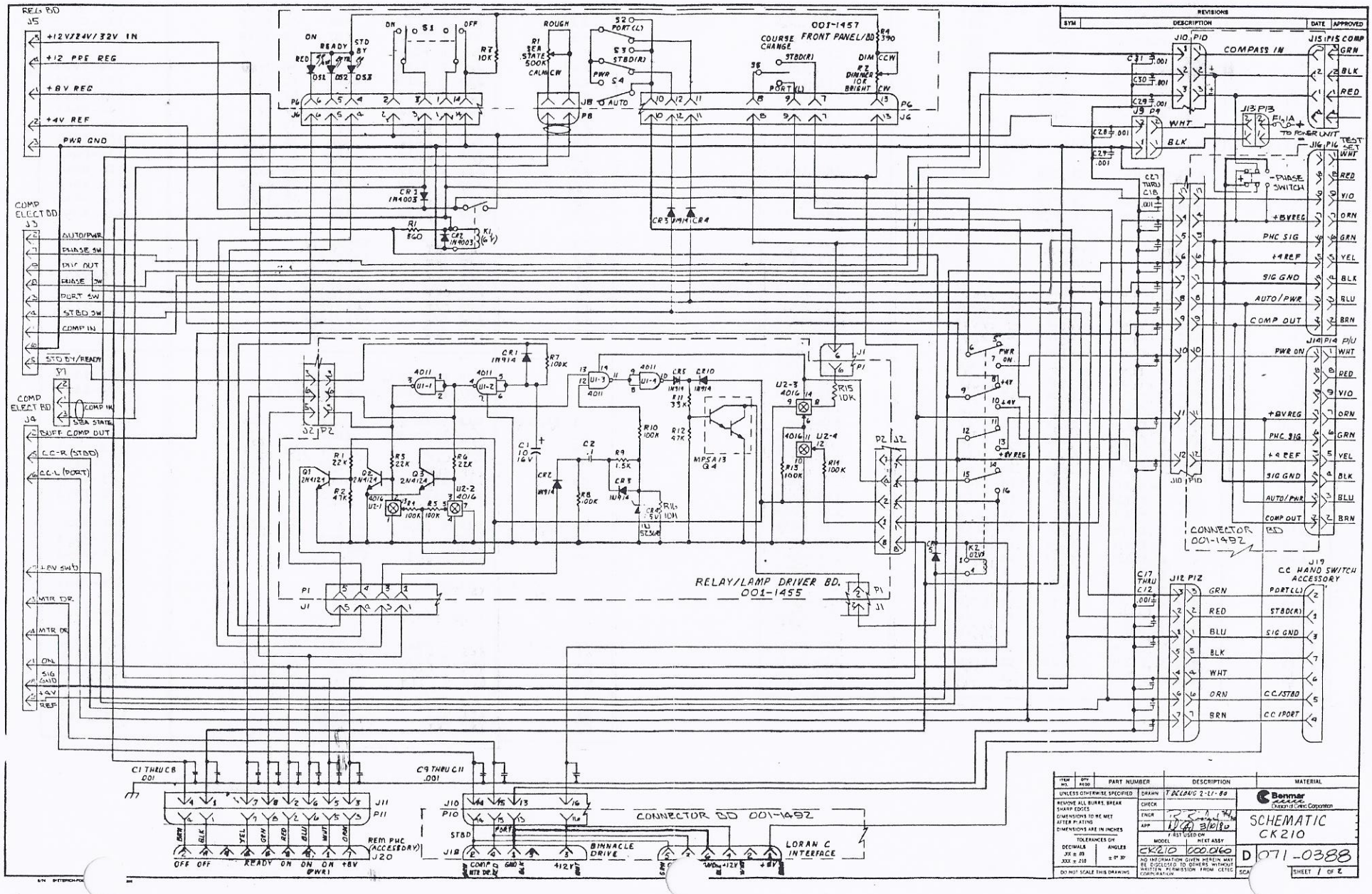
5 - If the CK210 PHC is turned on with the 9 conductor Power Unit cable disconnected the PHC will immediately go into the READY mode without orienting the compass. The PHC will then give an "ON" indication if the on switch is operated again. This is obviously an erroneous indication since the Power Unit is not even connected and will not come on. The PHC should not be operated without the 9 conductor Power Unit cable connected.

6 - 1/2 turn fast slew applies to the STD Power Unit only. The S Power Unit will fast slew approximately 1-1/2 turns. The H Power Unit approximately 1 to 1.5 sec. The HS Power Units approximately 2.0 to 3.0 sec.

7 - 4 turns fast slew applies to the STD Power Unit only. The S Power Unit will fast slew approximately 12 turns. The H Power Unit approximately 7 to 10 sec. The HS Power Unit approximately 16 to 24 sec.

NOTE - It may be impossible to perform this test on some boats without running the rudder into its limits.

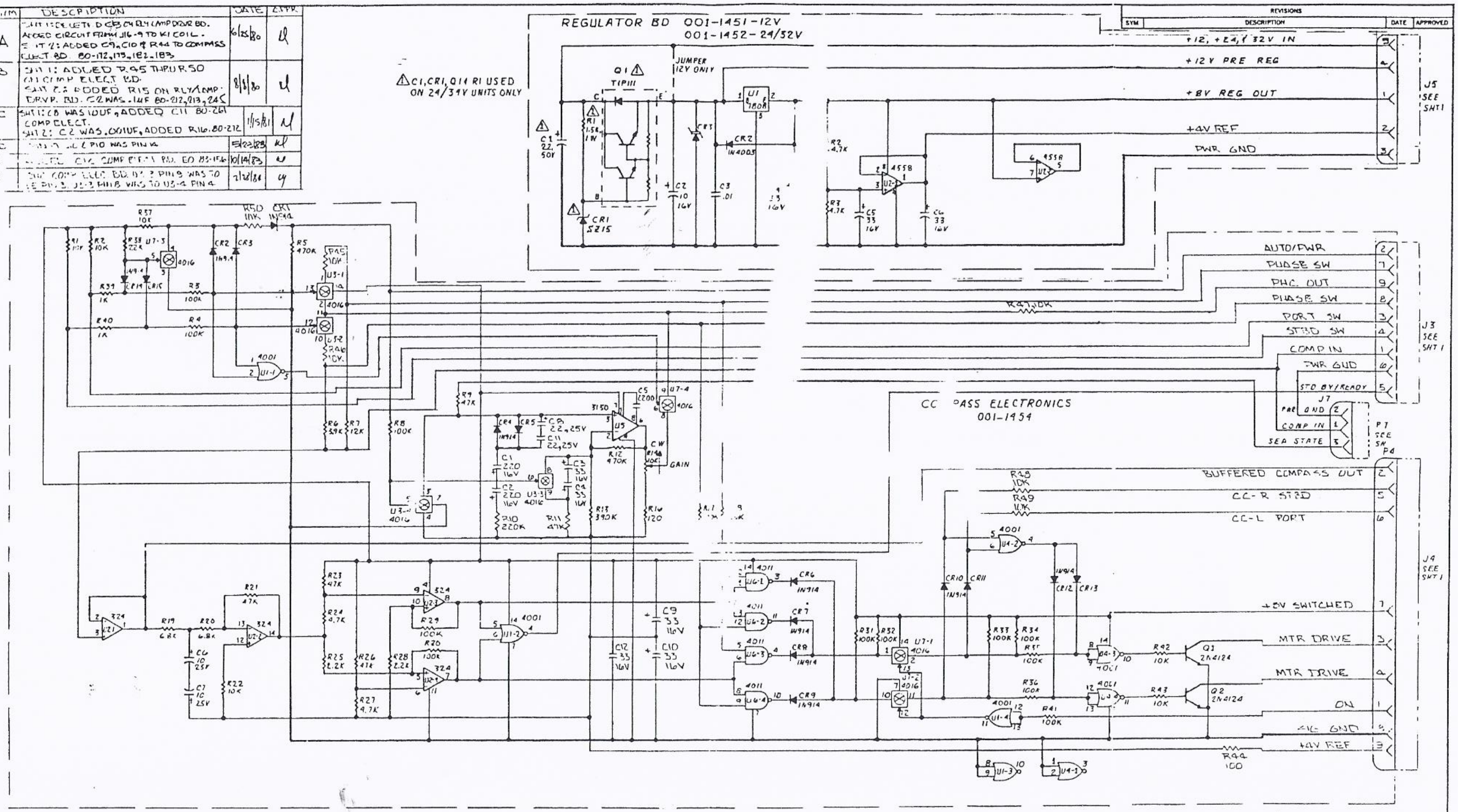
8 - This is a very useful test mode to use when bleeding a hydraulic system as it allows the Power Unit to be driven at full speed continuously in either direction.


REVISIONS
SYM | DESCRIPTION | DATE | APPROVED
001-1457 FRONT PANEL/BD
COURSE CHANGE
COMPASS IN
REL BD J5
+12V/24V/32V IN
+12 PRE REG
+8V REG
+4V REF
PWR GND
COMP ELECT BD J3
AUTO/PWR
PHASE SW
DVC OUT
PHASE SW
PORT SW
STBD SW
COMP IN
STD BY/READY
COMP ELECT BD J4
COMP IN
SEA STATE
DIFF COMP OUT
CC-R (STBD)
CC-L (PORT)
+8V SW'D
MTR DR
MTR DR
ON
SIG GND
+4V REF
RELAY/LAMP DRIVER BD. 001-1455
CONNECTOR 001-1492 BD
CONNECTOR BD 001-1492
REM PHC (ACCESSORY) J20
OFF OFF READY ON ON ON +8V PWR1
BINNACLE DRIVE
LORAN C INTERFACE
TEST SET
PHASE SWITCH
TO POWER UNIT
CC HAND SWITCH ACCESSORY
PORT(L)
STBD(R)
SIG GND
CC/STBD
CC/PORT
SCHEMATIC CK210
D 071-0388
SHEET 1 OF 2

CKT SYM	DESCRIPTION	PART NO.
	COMPASS ELECTRONICS BOARD CK210	001-1454
C1	CAP ELEC PC 220UF 16V	112-1545
C2	CAP ELEC PC 220UF 16V	112-1545
C3	CAP ELEC PC 33UF 16V	112-1605
C4	CAP ELEC PC 33UF 16V	112-1605
C5	CAP MYLAR 2200PF 10% 100V	105-1003
C6	CAP ELEC PC 10UF 25V	112-1604
C7	CAP ELEC PC 10UF 25V	112-1604
C8	CAP ELEC PC 22UF 25V	112-1541
C9	CAP ELEC PC 33UF 16V	112-1605
C10	CAP ELEC PC 33UF 16V	112-1605
C11	CAP ELEC PC 22UF 25V	112-1541
C12	CAP ELEC PC 33UF 16V	112-1605
CR1-CR15	DIODE 1N914/1N4148	161-0096
J7	CONN PLUG 3 PIN	286-1643
P3	CONN RECPT 9 PIN	286-1671
P4	CONN RECPT 9 PIN	286-1671
Q1	XSISTOR 2N4124	149-0384
Q2	XSISTOR 2N4124	149-0384
R1	RES C FILM 10K 5% 1/4W	136-0044
R2	RES C FILM 10K 5% 1/4W	136-0044
R3	RES C FILM 100K 5% 1/4W	136-0056
R4	RES C FILM 100K 5% 1/4W	136-0056
R5	RES C FILM 470K 5% 1/4W	136-0064
R6	RES C FILM 3.9K 5% 1/4W	136-0039
R7	RES C FILM 12K 5% 1/4W	136-0045
R8	RES C FILM 100K 5% 1/4W	136-0056
R9	RES C FILM 47K 5% 1/4W	136-0052
R10	RES C FILM 220K 5% 1/4W	136-0060
R11	RES C FILM 47K 5% 1/4W	136-0052
R12	RES C FILM 470K 5% 1/4W	136-0064
R13	RES C FILM 390K 5% 1/4W	136-0063
R14	RES VAR PC 10K LIN 1/4W	130-0650
R16	RES C FILM 120 5% 1/4W	136-0021
R17	RES C FILM 100K 5% 1/4W	136-0056
R18	RES C FILM 100K 5% 1/4W	136-0056
R19	RES C FILM 6.8K 5% 1/4W	136-0042
R20	RES C FILM 6.8K 5% 1/4W	136-0042
R21	RES C FILM 47K 5% 1/4W	136-0052
R22	RES C FILM 10K 5% 1/4W	136-0044
R23	RES C FILM 47K 5% 1/4W	136-0052
R24	RES C FILM 4.7K 5% 1/4W	136-0040
R25	RES C FILM 2.2K 5% 1/4W	136-0036
R26	RES C FILM 47K 5% 1/4W	136-0052
R28	RES C FILM 2.2K 5% 1/4W	136-0036
R29	RES C FILM 100K 5% 1/4W	136-0056

CKT SYM	DESCRIPTION	PART NO.
R30	RES C FILM 100K 5% 1/4W	136-0056
R31	RES C FILM 100K 5% 1/4W	136-0056
R32	RES C FILM 100K 5% 1/4W	136-0056
R33	RES C FILM 100K 5% 1/4W	136-0056
R34	RES C FILM 100K 5% 1/4W	136-0056
R35	RES C FILM 100K 5% 1/4W	136-0056
R36	RES C FILM 100K 5% 1/4W	136-0056
R37	RES C FILM 10K 5% 1/4W	136-0044
R38	RES C FILM 22K 5% 1/4W	136-0048
R39	RES C FILM 1K 5% 1/4W	136-0032
R40	RES C FILM 1K 5% 1/4W	136-0032
R41	RES C FILM 100K 5% 1/4W	136-0056
R42	RES C FILM 10K 5% 1/4W	136-0044
R43	RES C FILM 10K 5% 1/4W	136-0044
R44	RES C FILM 100 5% 1/4W	136-0020
R45	RES C FILM 10K 5% 1/4W	136-0044
R46	RES C FILM 10K 5% 1/4W	136-0044
R47	RES C FILM 10K 5% 1/4W	136-0044
R48	RES C FILM 10K 5% 1/4W	136-0044
R49	RES C FILM 10K 5% 1/4W	136-0044
R50	RES C FILM 10K 5% 1/4W	136-0044
U1	INT CKT CD4001BE	425-0163
U2	INT CKT LM324N	425-0143
U3	INT CKT CD4016BE	425-0144
U4	INT CKT CD4001BE	425-0163
U5	INT CKT CA3130E	425-0147
U6	INT CKT CD4011BE	425-0182
U7	INT CKT CD4016BE	425-0144
	12V REGULATOR BD CK210	001-1451
	24/32V REGULATOR BD CK210	001-1452
C1 24/32V	CAP ELEC PC 22UF 50V	112-1623
C2	CAP ELEC PC 10UF 25V	112-1604
C3	CAP CER .01UF 35% 100V	110-0006
C4	CAP ELEC PC 33UF 16V	112-1605
C5	CAP ELEC PC 33UF 16V	112-1605
C6	CAP ELEC PC 33UF 16V	112-1605
CR1 24/32V	DIODE ZEN SZ15 10% 15V	161-0539
CR2	DIODE 1N4003	161-0366
CR3	DIODE SUP ICTE-15	161-0542
Q1 24/32V	XSISTOR TIP111	149-0569
P5	CONN RECPT 5 PIN	286-1680
R1 24/32V	RES C FILM 1.5K 5% 1W	136-0353
R2	RES C FILM 4.7K 5% 1/4W	136-0040
R3	RES C FILM 4.7K 5% 1/4W	136-0040
U1	INT CKT MC7808CT	425-0148
U2	INT CKT RC4558NB	425-0105

LTR	DESCRIPTION	DATE	APPR
A	SHT 1: DELETED C3, C4 RLY/AMP DRVR BD. ADDED CIRCUIT FROM J16-9 TO K1 COIL. SHT 2: ADDED C9, C10 & R44 TO COMPASS ELECT BD 80-172, 179, 182, 183	6/25/80	
B	SHT 1: ADDED R45 THRU R50 ON COMP ELECT BD. SHT 2: ADDED R15 ON RLY/AMP DRVR BD. C2 WAS .1UF 80-212, 213, 245	8/8/80	
C	SHT 1: C8 WAS 10UF, ADDED C11 80-261 COMP ELECT. SHT 2: C2 WAS .001UF, ADDED R16 80-212	11/15/81	
D	SHT 1: ... & P10 WAS PIN 16	5/23/83	
E	... C16 COMP ELECT BD. 80-156	10/14/83	
F	SHT COMP ELEC BD. U1-3 PIN 9 WAS TO ... PIN 3, U1-3 PIN 8 WAS TO U3-4 PIN 4	2/28/84	



NOTES: UNLESS OTHERWISE SPECIFIED:

1. ALL RESISTORS ARE IN OHMS, 1/4 W, 5%. CAPACITORS ARE IN MICROFARADS.

ITEM NO	QTY REQD	PART NUMBER	DESCRIPTION	MATERIAL

UNLESS OTHERWISE SPECIFIED: REMOVE ALL BURRS, BREAK SHARP EDGES. DIMENSIONS TO BE MET AFTER PLATING. DIMENSIONS ARE IN INCHES. TOLERANCES ON DECIMALS .XX ± .03, .XXX ± .010; ANGLES ± 0° 30'. DO NOT SCALE THIS DRAWING.

DRAWN: T.CLONG 2-21-83

APP: 5/10/80

MODEL: CK210 — NEXT ASSY: 000-0160

NO INFORMATION GIVEN HEREIN MAY BE DISCLOSED TO OTHERS WITHOUT WRITTEN PERMISSION FROM CETEC CORPORATION

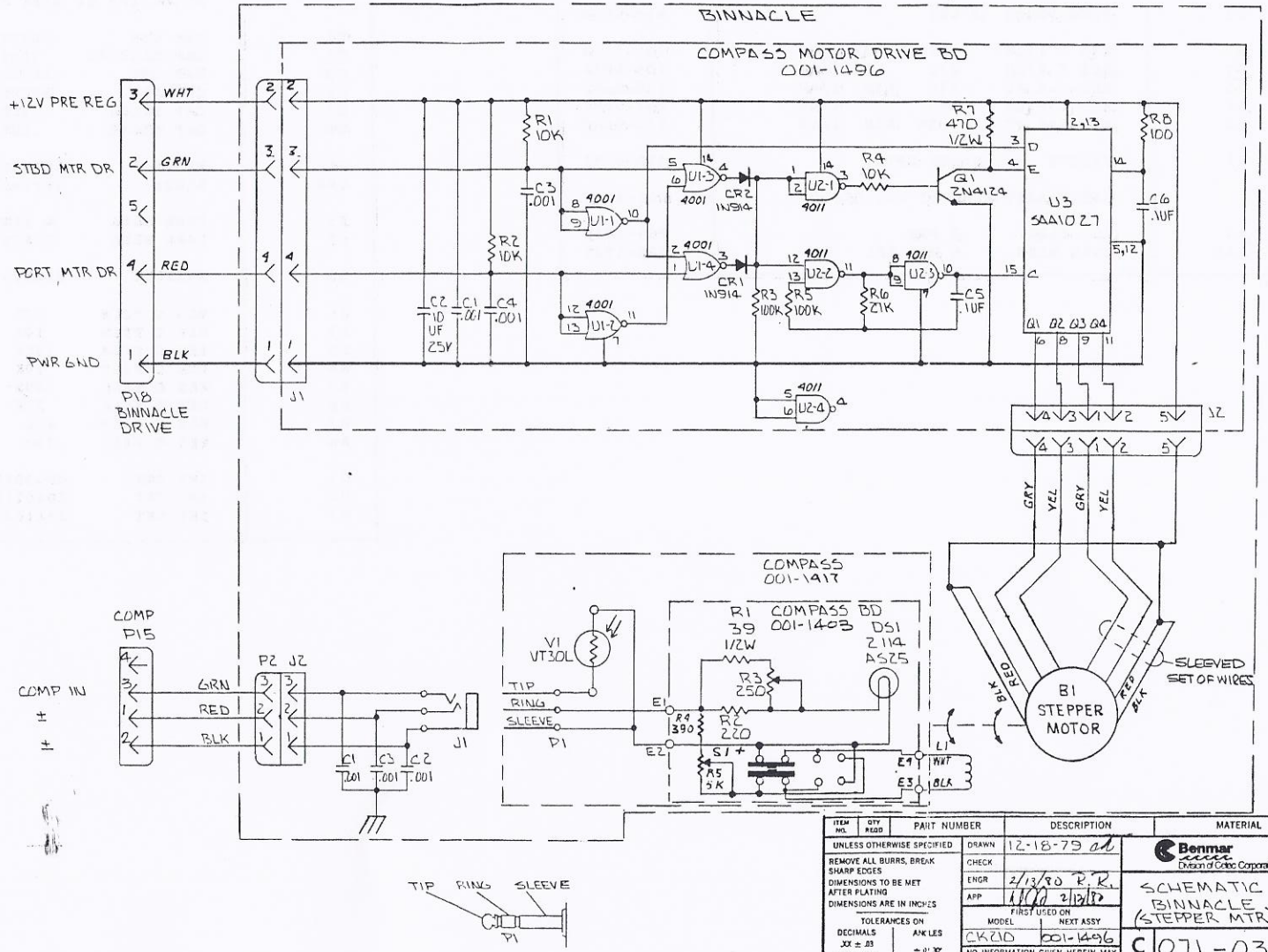
Benmar — Cetec

SCHEMATIC CK210

D 071-0388

SHEET 2 OF 2

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED
A	P15 PINS 1,2,3 & 4 WERE PINS 4,3,2 & 1 RESP.	4/8/81	KL



ITEM NO.	QTY REQD	PART NUMBER	DESCRIPTION	MATERIAL
UNLESS OTHERWISE SPECIFIED		DRAWN	12-18-79 al	Benmar Division of Cetec Corporation
REMOVE ALL BURRS, BREAK SHARP EDGES		CHECK		SCHEMATIC BINNACLE (STEPPER MTR)
DIMENSIONS TO BE MET AFTER PLATING		ENGR	2/13/80 R.R.	
DIMENSIONS ARE IN INCHES		APP	2/13/80	
TOLERANCES ON DECIMALS .XX ± .03, .XXX ± .010; ANGLES ± 0° 30'		FIRST USED ON MODEL	NEXT ASSY	C 071-0379
DO NOT SCALE THIS DRAWING		CK20	001-1496	SCALE — SHEET 1 OF 1

NO INFORMATION GIVEN HEREIN MAY BE DISCLOSED TO OTHERS WITHOUT WRITTEN PERMISSION FROM CETEC CORPORATION.

TIP RING SLEEVE P1

10/78 DIETERICH-PORT CLEARPRINT 2000H

CKT SYM	DESCRIPTION	PART NO.
	BINNACLE ASSY LESS DRIVE CK210	001-1470
	COMPASS ASSY PLUG TYPE VERT	001-1417
L1	COIL ASSY COMPENSATOR CS21	001-1404
V1	PHOTO CELL VT30L	352-0005
	COMPASS BD ASSY W/PLUG	001-1403
DS1	LAMP 2114AS25	244-0191
P1	PLUG PHONE 3 CKT	415-0038
R1	RES C FILM 39 5% 1/2W	136-0114
R2	RES C FILM 220 5% 1/4W	136-0024
R3	RES VAR PC 250 LIN 1/4W	130-0643
R4	RES C FILM 390 1/4W	136-0027
R5	RES VAR PC 5K LIN 1/4W	130-0645
S1	SWITCH SLIDE DPTT	299-0295
	CABLE ASSY BINN 45 FT. CK210	001-1460
P3	HSG PLUG 3 PIN	286-1716
P15	CONN PLUG 4 PIN CBL	286-1837

CKT SYM	DESCRIPTION	PART NO.
	BINNACLE DRIVE ASSY CK210	001-1471
	GEAR DRIVE ASSY STEPPER	001-1493
B1	MOTOR STEPPER	001-1564
	CABLE BINN DRV 45FT CK210	001-1510
P1	CONN RECPT 4 PIN 22 GA IDC	286-1737
P18	CONN PLUG 5 PIN CBL	286-1841
	MOTOR DRV BD ASSY STEPPER	001-1479
C1	CAP CER .001UF 20% 1KV	110-1249
C2	CAP ELEC PC 10UF 25V	112-1604
C3	CAP CER .001UF 20% 1KV	110-1249
C4	CAP CER .001UF 20% 1KV	110-1249
C5	CAP MYLAR .1UF 10% 100V	105-1013
C6	CAP MYLAR .1UF 10% 100V	105-1013
CR1	DIODE 1N914/1N4148	161-0096
CR2	DIODE 1N914/1N4148	161-0096
J1	CONN PLUG 4 PIN	286-1645
J2	CONN PLUG 5 PIN	286-1664
Q1	XSISTOR 2N4124	149-0384
R1	RES C FILM 10K 5% 1/4W	136-0044
R2	RES C FILM 10K 5% 1/4W	136-0044
R3	RES C FILM 100K 5% 1/4W	136-0056
R4	RES C FILM 10K 5% 1/4W	136-0044
R5	RES C FILM 100K 5% 1/4W	136-0056
R6	RES C FILM 27K 5% 1/4W	136-0049
R7	RES C FILM 470 5% 1/2W	136-0140
R8	RES C FILM 100 5% 1/4W	136-0020
U1	INT CKT CD4001BE	425-0163
U2	INT CKT CD4011BE	425-0182
U3	INT CKT SAA1027	425-0166