Benmar

COMPU- COURSE 220
PILOT HOUSE CONTROL
INSTALLATION AND OPERATION MANUAL

098-0390G

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COMPU-COURSE 220 ADDENDUM TO INSTRUCTION MANUAL
SOFTWARE UPDATE FOR NMEA 0183 VERSION 1.5

The EPROMS (U2 and U3) in the APU must be Revision 007.

Follow the instructions in the manual except for paragraphs 2.11 through 2.13. Revised instructions are shown below.

2.11 AUTO-TRAC INTERFACE

The built in Auto-Trac interface will operate with most Lorans which output cross track error in NMEA 0180 simple format and GPS receivers which output cross track error in NMEA 0183 version 1.5 format.

The performance of the Auto-Trac feature is dependent on the GPS or Loran and the autopilot being installed and set up correctly.

To implement the Auto-Trac feature, the supplied 20 foot long cable must be installed between the Compu-Course 220 APU and the GPS or Loran. Also, dip switches S1-5 and S1-6 must be properly set in the APU per paragraph 2.13.

2.12 AUTO-TRAC CABLE CONNECTIONS

One end of the 20 foot 2 conductor shielded cable is factory wired with the connector which mates to the connector labeled Auto-Trac on the APU. The other end must be connected to the GPS or Loran. Consult the GPS or Loran manual or manufacturer for the autopilot output connections. Connect the cable red wire to the data output; the black wire and shield wire to the data return.

2.13 AUTO-TRAC SWITCH SETTINGS

DIP switch S1-5 is factory set to the ON position for NMEA 0183 version 1.5 format. The GPS must be set to transmit data in the serial mode at 4800 baud with 8-bit words, no parity, and 1 stop bit (4800,8,N,1). Select NMEA 0183 version 1.5 format on the GPS. The GPS must also be set to output at least one of the following messages which contain cross track error information.

APA, autopilot sentence A
APB, Autopilot sentence B
XTE, Cross track error

The Auto-Trac will also accept NMEA 0180 simple format. Set dip switch S1-5 to the OFF position when interfacing with NMEA 0180 simple format.

The Auto-Trac phase is controlled by switch S1-6 and is normally left in the OFF position. It may be necessary to set this switch to ON as described in paragraph 2.15.6.

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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

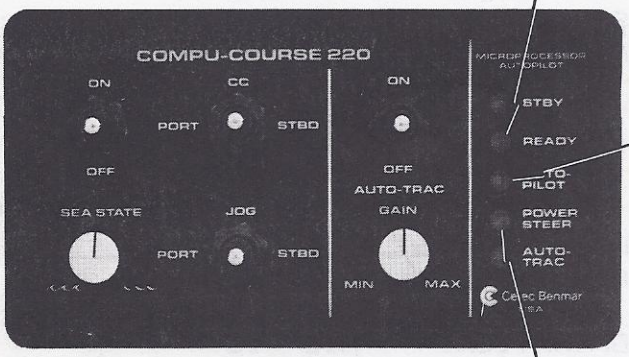
NEVER LEAVE THE HELM UNATTENDED. ALTHOUGH THE AUTOPILOT WILL FAITHFULLY MAINTAIN THE VESSEL'S HEADING, IT WILL NOT REPLACE THE MAN-ON-WATCH.

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 AUTO-PILOT is lit, autopilot is controlling the vessel.

4. If POWER STEER is lit, JOG switch and/or Handset push buttons will control rudder and automatic steering will be disabled.

5. Disengage pilot by pushing switch to OFF.

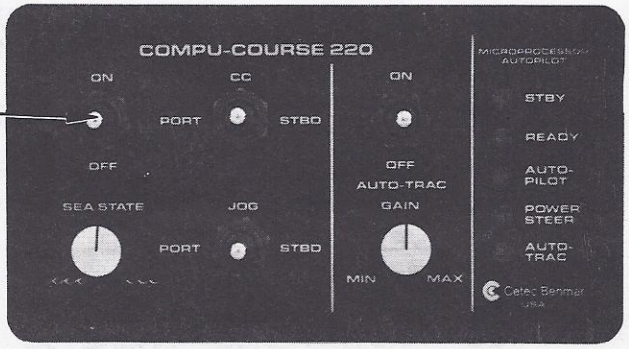
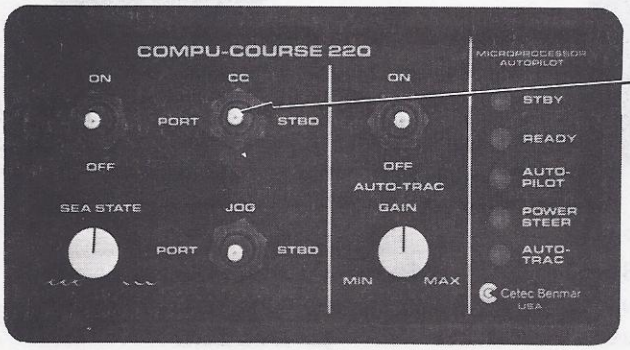


Figure 1.1. ON/OFF Controls.

The Compu-Course 220 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 alarm will sound, all lights will come on, while the PHC is self tested. The lights will then flash in sequence and the alarm will sound. 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 and the alarm "beeps", the compass is correctly oriented and the pilot may be engaged as long as the READY light is on. Pushing the ON/OFF switch up again to the ON position will engage the autopilot and light the AUTO-PILOT light. Whenever the AUTO-PILOT light is lit, the Power Unit will be 'ON' and engaged to the vessel's steering system.

1.2 COURSE CHANGING



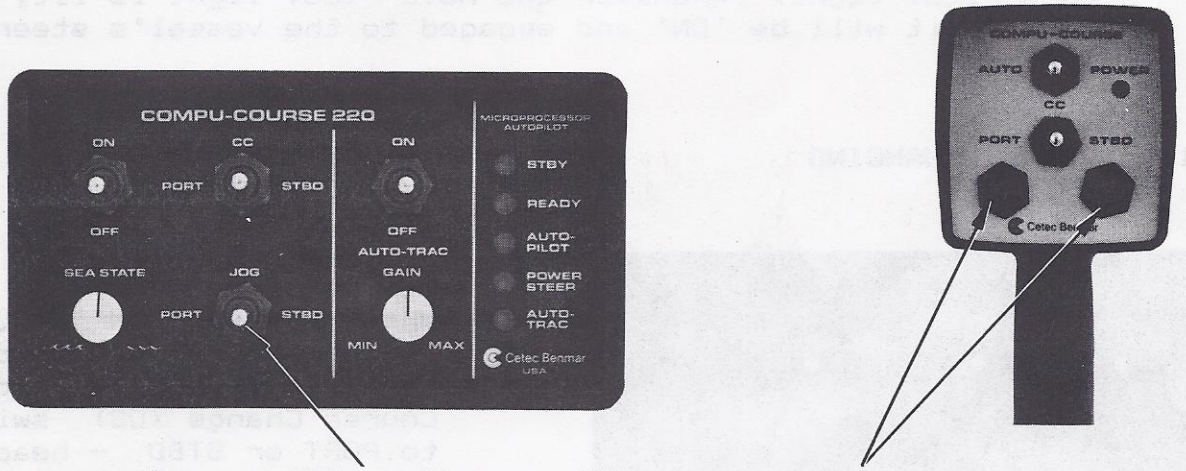
When pilot is 'ON' (AUTO-PILOT is lit), heading may be altered by holding Course Change (CC) switch to PORT or STBD - heading changes 5 degrees per second.

Optional Handset 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 Handset 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)

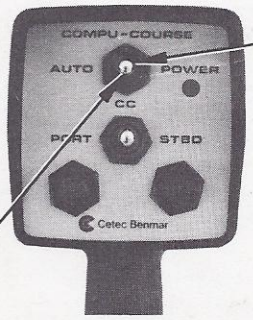


Press JOG switch on PHC or push buttons on Handset to PORT or STBD. Rudder will be driven at maximum slew rate while JOG switch is pressed. Autopilot returns to previous course as soon as JOG switch is released.

Figure 1.3. Jog Controls.

The JOG switch 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 switch 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 (HANDSET)



Pressing Handset AUTO/POWER switch to POWER disables automatic control, turns AUTO-TRAC off and allows Handset push buttons or PHC JOG switch to control rudder. POWER STEER will be lit.

Return to AUTO mode by pressing Handset AUTO/ POWER switch to AUTO or by pressing the PHC ON/ OFF switch to ON.

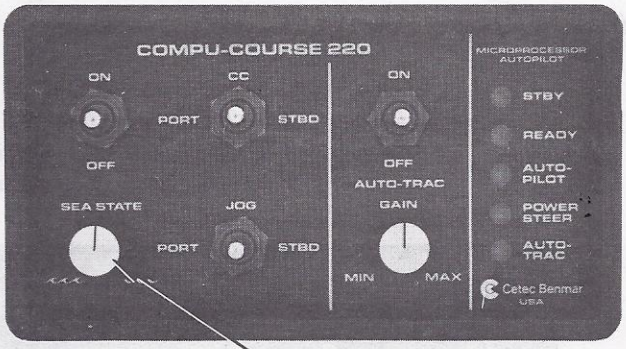
If the POWER STEER light is flashing on the Handset (alternating between STBY and POWER STEER on PHC), the compass has not yet oriented to the ship's heading and the autopilot cannot be returned to the AUTO mode. When the POWER STEER light is lit and is not flashing, the compass is correctly oriented and the pilot can be returned to the AUTO mode.

Figure 1.4. Power Steer Controls.

The autopilot may be placed in the POWER STEER mode only by using the optional Handset. While the pilot is in this mode the POWER STEER light will be lit and the rudder may be controlled by using the push button switches on the Handset or the JOG switch on the PHC. While the switch is held, 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 continuously tracks and orients the autopilot compass to the ship's heading as various maneuvers are done so that when the Handset AUTO/POWER switch is pressed to the AUTO position, or the PHC ON/OFF switch is pressed to ON, the autopilot will steer the current ship's heading. If the compass is not on the ship's course, the POWER STEER light will flash on the Handset and alternate between STBY and POWER STEER on PHC, and the pilot cannot be returned to the AUTO mode. When the POWER STEER light is lit and not flashing, the compass is correctly oriented to the ship's heading and the pilot may be engaged.

When the autopilot is placed in the POWER STEER mode, AUTO-TRAC is turned off. After returning to AUTOPILOT, AUTO-TRAC must be re-initialized (paragraph 1.6).

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 AUTO-TRAC OPERATION

WARNING

THERE IS NO SUBSTITUTE FOR A MAN-ON WATCH! NONE OF THE NAVIGATION AIDS SHOULD BE RELIED ON EXCLUSIVELY FOR THE SAFETY OF THE VESSEL AND CREW. THE SKIPPER HAS THE RESPONSIBILITY TO CONSTANTLY CHECK ONE AGAINST THE OTHER TO CONFIRM POSITION. ELECTRONIC AIDS ARE NOT A SUBSTITUTE FOR BASIC NAVIGATIONAL PRINCIPLES AND COMMON SENSE.

1. Your Loran should be turned on, locked on and position readings settled out.

2. The destination (to way point) should be entered into your Loran. Your Loran should be initialized so that present position is the "from" way point. Your Loran must be in a mode which outputs cross track error to the autopilot.

3. Determine the approximate course to destination.

4. Steer the boat to approximate course to destination.

5. Turn the Compu-Course 220 autopilot ON in the AUTO mode so it is steering the approximate course to destination.

6. Insure that the boat is on or very near the computed line of position; that is, the cross track error is near zero. If not, re-initialize the Loran C to the present position so that cross track error is near zero.

7. Turn Auto-Trac ON.

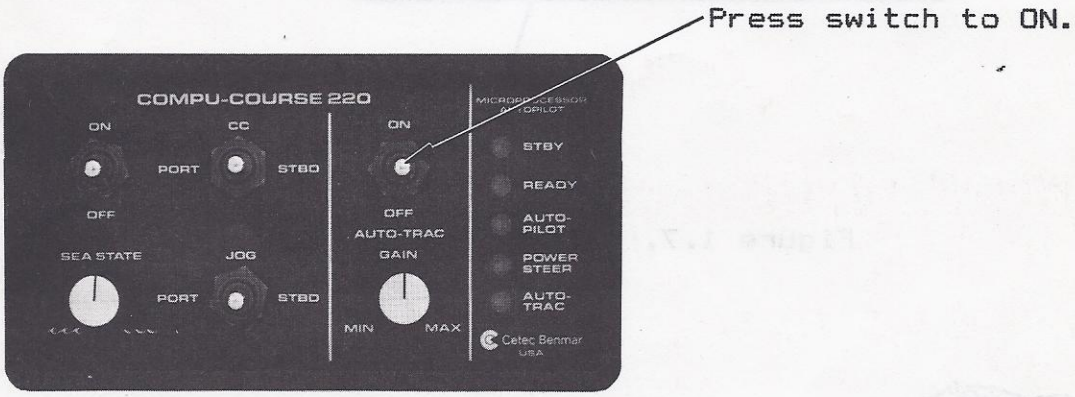


Figure 1.6. AUTO-TRAC ON/OFF control.

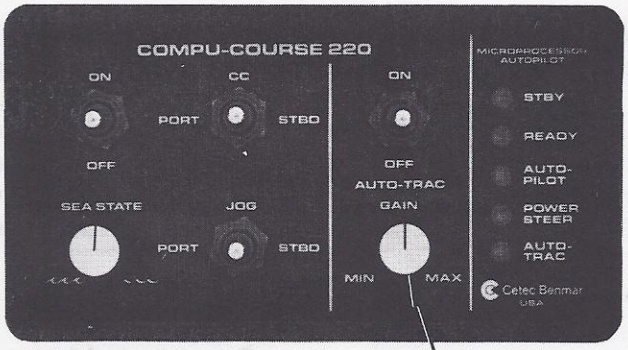
If the Auto-Trac gain and phase are set correctly, and the ship's heading is very near to the desired course, the Auto-Trac will simply maintain the boat heading on the Loran computed line, making heading corrections as required to compensate for wind, current, or initial off course error.

More often than not, the initial course the autopilot is steering will not match the heading required to maintain the boat on the computed line. Auto-Trac will bring the boat onto the required course.

8. If the Loran cross track error scale factor is selectable, make sure it is set to .01 of a nautical mile (not .1 of a nautical mile). This is an option on some Si-Tex/Koden Lorans.

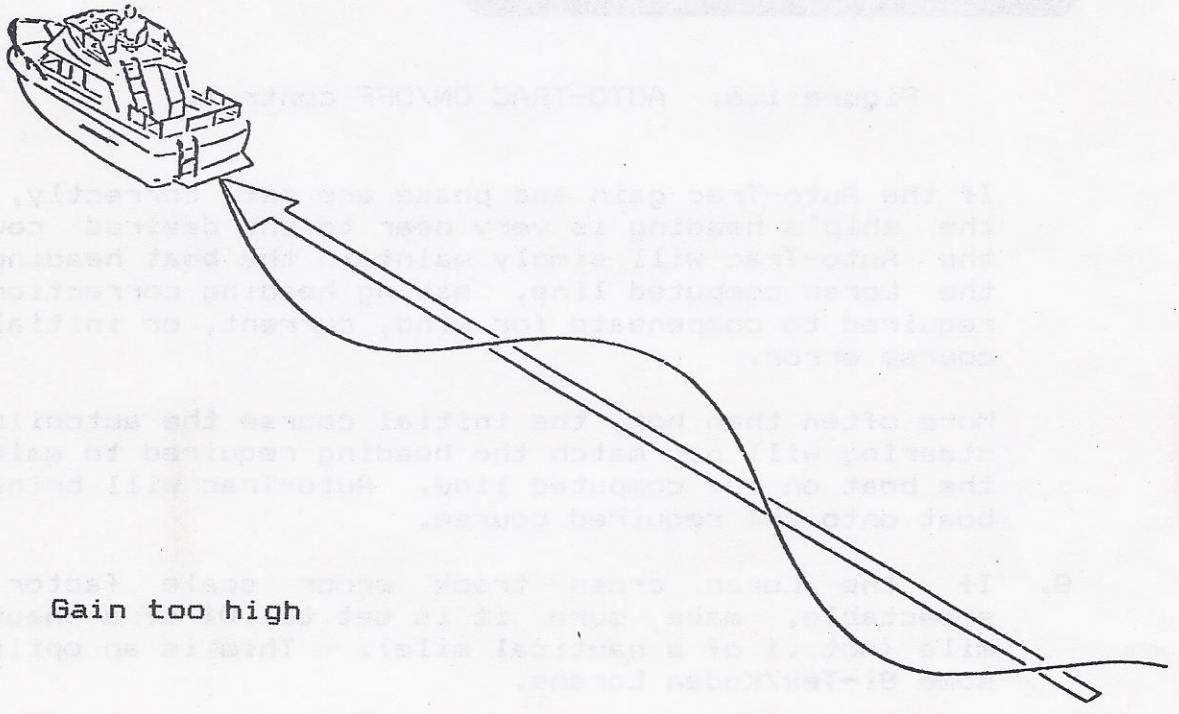
1.7 AUTO-TRAC GAIN

Slight initial trimming of the Auto-Trac gain may be required. The setting of the gain is dependent on the make of Loran, the operating area (different GRI's), and the speed of the vessel. With a proper gain setting, the vessel should maintain a satisfactory heading without excessive long or short term 'S'ing.

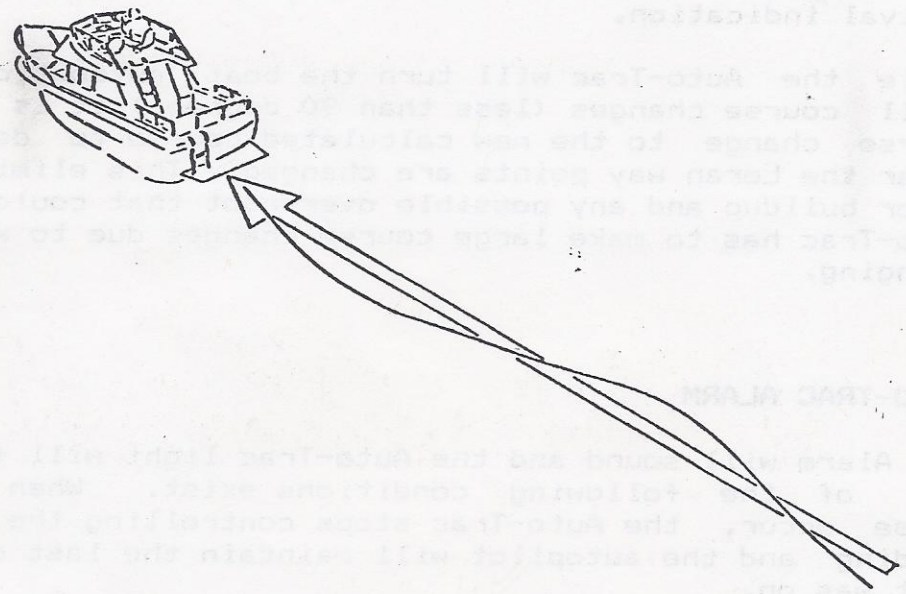


Turn toward MIN when boat speed is fast; toward MAX when boat speed is slow. Normally set at mid range.

Figure 1.7. Auto-Trac Gain Control.



Gain too high



Near correct initial course.
Gain optimum.

1.8 DODGING AND COURSE CHANGING WHILE ON AUTO-TRAC

Dodging other vessels or objects while on Auto-Trac can be accomplished in the normal manner described in Paragraph 1.3.

Course change may also be used to steer around objects while on Auto-Trac (as described in Paragraphs 1.2). Course changes should be fairly small and short term. As soon as any significant cross track error builds up the Auto-Trac will begin to bring the boat back to the computed line of position.

1.9 TURNING AT WAYPOINTS

WARNING

YOUR LORAN CANNOT SEND A WARNING TO THE AUTO-TRAC THAT IT IS AUTOMATICALLY CHANGING WAYPOINTS AND AUTOMATICALLY CHANGING THE COURSE TO A NEW DESTINATION WHEN YOU ARRIVE AT A WAYPOINT. DO NOT USE AUTOMATIC WAYPOINT CHANGING IN YOUR LORAN WHEN AUTO-TRAC IS OPERATING. IF YOU DO, THE RESULT COULD BE A DANGEROUS UNANNOUNCED COURSE CHANGE WHEN THE LORAN CHANGES WAYPOINTS.

There is no indication from the Auto-Trac when the boat is near or at the destination. The Loran must be monitored for arrival indication.

While the Auto-Trac will turn the boat automatically for small course changes (less than 90 degrees) it is best to course change to the new calculated course to destination after the Loran way points are changed. This eliminates the error buildup and any possible overshoot that could occur if Auto-Trac has to make large course changes due to way point changing.

1.10 AUTO-TRAC ALARM

The Alarm will sound and the Auto-Trac light will flash when any of the following conditions exist. When any of these occur, the Auto-Trac stops controlling the vessel's heading and the autopilot will maintain the last course the boat was on.

Error Indicator Lights in the APU will be lit to indicate the type of Auto-Trac error. See Table 2.3.

The AUTO-TRAC light will flash, the alarm will sound and the Error Indicator Lights will remain lit until the Auto-Trac ON/OFF switch is pressed to OFF.

After the source of the Auto-Trac error has been corrected, Auto-Trac may be re-initialized by pressing the Auto-Trac ON/OFF switch to OFF and then to ON.

NO LORAN DATA	When the AUTO-TRAC does not receive any data for a period of time. Loran not turned on or faulty data link from Loran to Compu-Course 220.
INVALID DATA	When the Loran indicates that the cross track error it is putting out is potentially not valid. Often due to poor SNR or loosing lock in the Loran.
DATA JUMPED	When the cross track error makes a large jump that is maintained for a period of time. Most often caused by a 10 microsecond jump in the Loran.
NOT 0180 FORMAT	When the data coming out of the Loran is not the proper format.
PARITY ERROR	When the data bit stream contains noise.

1.11 COMMON PROBLEMS

The Auto-Trac can work only as well as the fidelity of the Loran data. Some causes for poor operation of the Auto-Trac:

1. Poor Loran antenna location.
2. Poor Loran ground.
3. Low signal to noise ratio.
4. Operation in fringe area.
5. Operating at dawn or dusk.
6. Poor TD line crossing angles (less than 20 degrees)
7. Notch filters not properly set in Loran.
8. Operation of a TV, Video Monitor or florescent lights in close proximity to the Loran.

1.12 POWER FAILURE ALARM

After the pilot has been turned on, a protection circuit guards against possible erratic autopilot operation should the ship's 12V electrical supply suddenly drop below a safe level. This could occur when starting an engine or generator while the Compu-Course 220 is on.

If a sudden voltage drop is detected, the Power Unit will be turned OFF and the alarm will sound while the STBY and AUTO-TRAC lights flash. The other three PHC lights will remain ON. Normal operation can be resumed by turning the pilot to OFF and back to ON.

SECTION II

INSTALLATION INSTRUCTIONS

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 Units 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 Compu-Course 220 consists of the following items (see Figure 2.1):

Pilot House Control Unit (PHC)
PHC Flush Mount Brackets (not shown)
Binnacle and Cables
Binnacle mounting pads and washers (not shown)
Autopilot Processor Unit (APU)
Power Cable
Interconnect Cable
Auto-Trac Cable
Instruction Manual

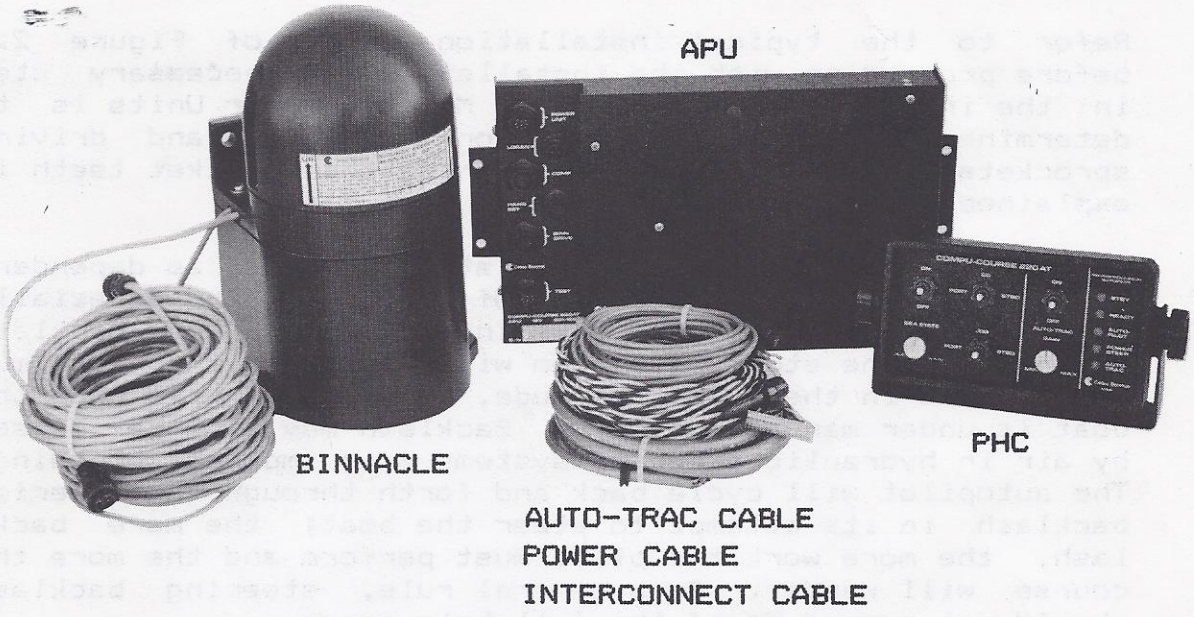


Figure 2.1. Compu-Course 220 Autopilot Components.

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.

2.4 TYPICAL INSTALLATION

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

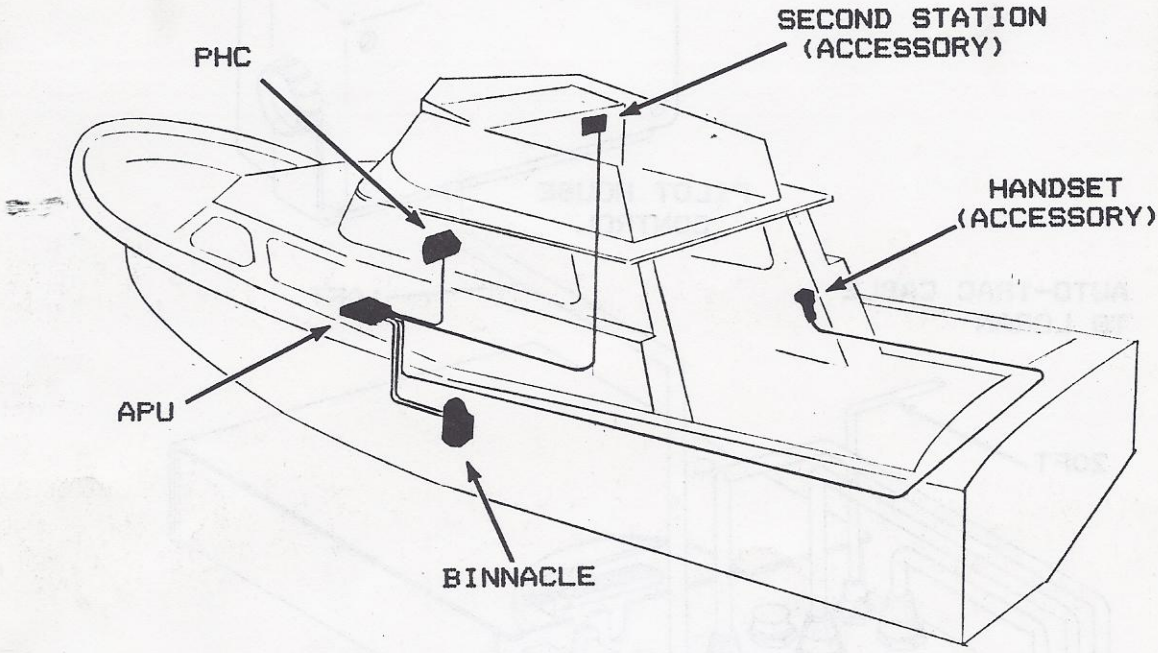


Figure 2.2. Compu-Course 220 Typical Installation.

2.5 STANDARD COMPONENTS

Figure 2.3 shows the interconnections for a typical installation.

2.6 OPTIONAL COMPONENTS

Figure 2.4 illustrates the installation of the following optional accessories:

Handset

Second Station

External Sonalert

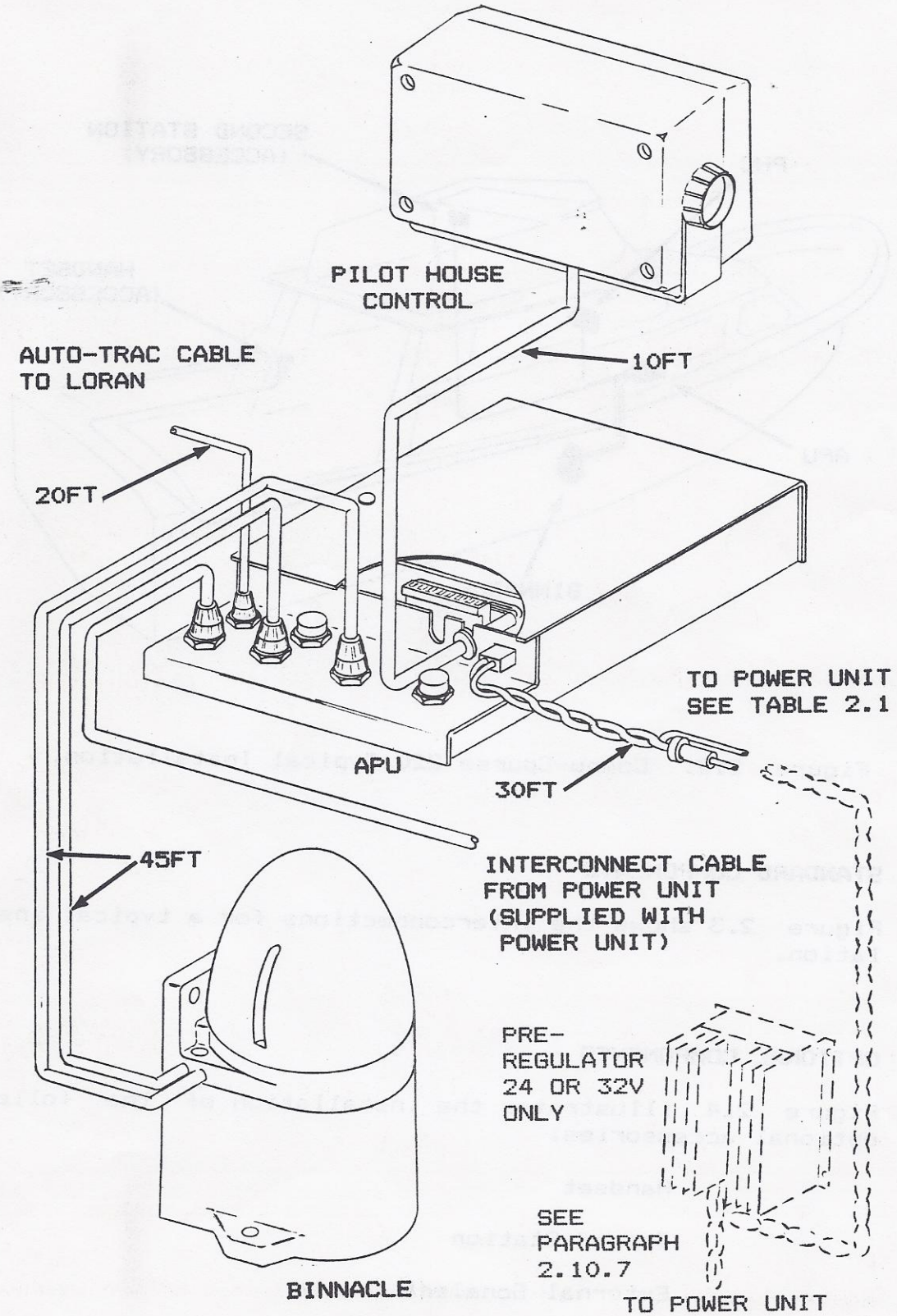


Figure 2.3. Standard Installation Diagram.

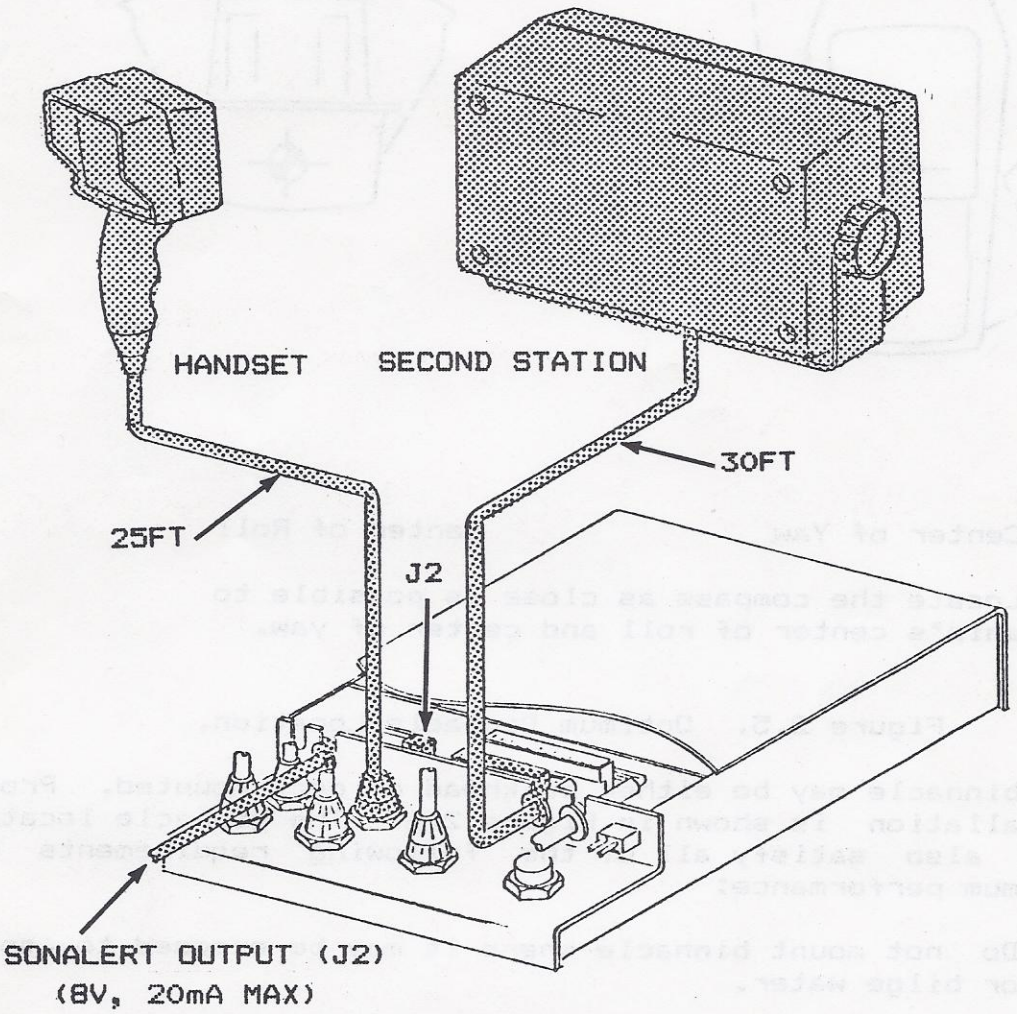
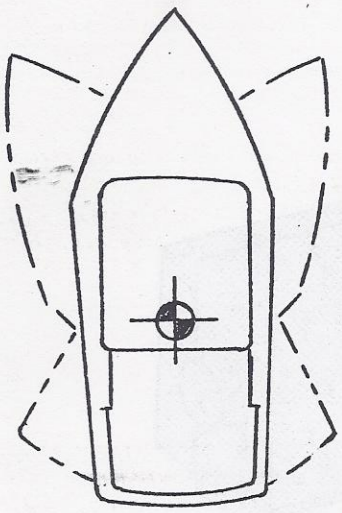
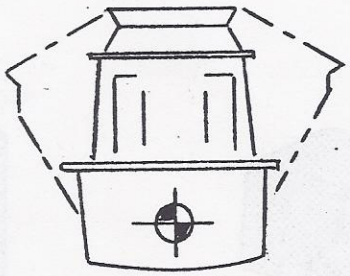


Figure 2.4. Compu-Course Optional Accessories.

2.7 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 2.5.





Center of Yaw Center of Roll

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

Figure 2.5. Optimum Binnacle Location.

The binnacle may be either bulkhead or deck mounted. Proper installation is shown in Figure 2.6. The binnacle location must also satisfy all of the following requirements for optimum performance:

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

Do not mount binnacle near speakers, meters, other compasses, motors and engines, ferrous metal cabinets (refrigerators, stoves, etc.) or tanks.

The binnacle must be level in all directions to 15 degrees while underway. If the variation in boat trim with speed is in excess of 15 degrees, compromise by positioning the binnacle to be level at the normal cruising speed.

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

The mounting location for the binnacle should maintain the following minimum separation from magnetic disturbances:

Ship's compass	3 ft.
Electronic equipment containing small magnets (radios, RDF, depth sounders, etc.)	3 ft.
Current carrying wires (more than 0.5 amps)	2 ft.
Radar magnetrons	8 ft.
Any large mass of soft iron or steel, including pilot house tie rods.	2.5 ft.

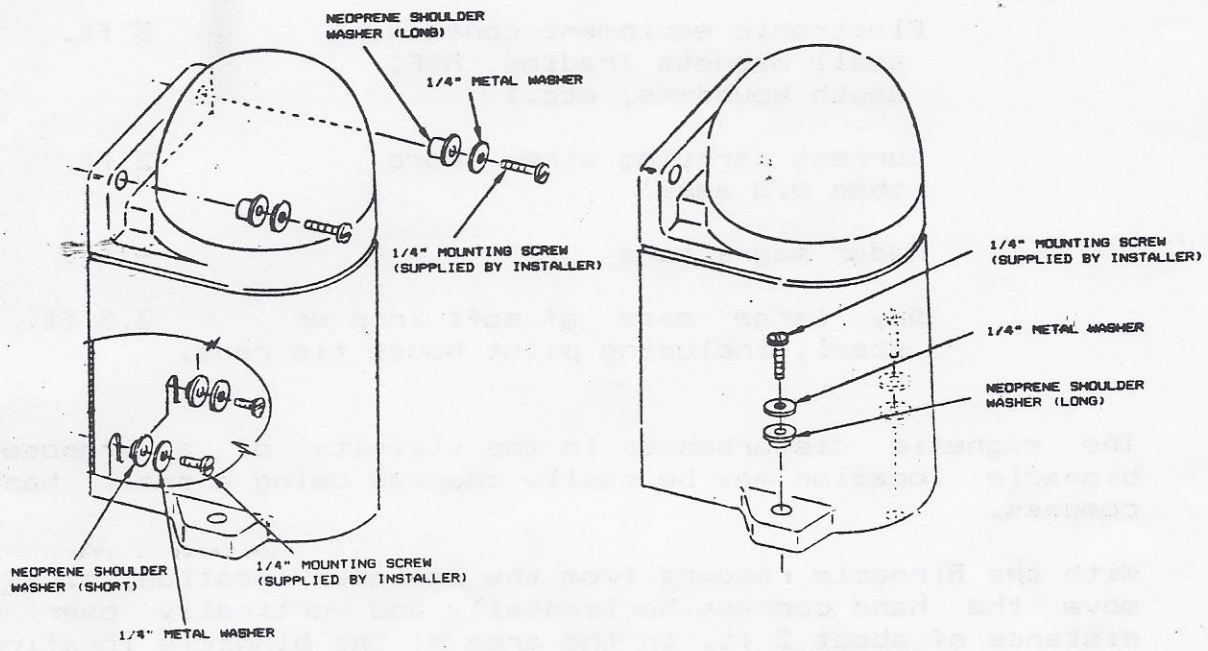
The magnetic disturbances in the vicinity of a proposed binnacle location may be easily checked using a small hand compass.

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.

The cable with the four pin connector connects to the APU connector labeled COMPASS. The cable with the eight pin connector connects to the APU connector labeled BINNACLE DRIVE.

NOTE

IF THE AUTOPILOT IS INSTALLED IN A STEEL HULL BOAT OR IF THE BINNACLE CAN NOT BE INSTALLED FREE FROM OTHER MAGNETIC INFLUENCES, THE COMPASS MAY NEED TO BE COMPENSATED. SEE PARAGRAPH 2.16. THIS WILL REQUIRE THE USE OF A AUTOPILOT TEST SET P/N 000-0095 AND A COMPENSATION ADAPTER P/N 000-0174. THE COMPU-COURSE 220 COMPENSATION KIT IS P/N 000-0147.



Bulkhead Mount Deck Mount

Figure 2.6. Binnacle Mounting.

2.8 AUTOPILOT PROCESSOR UNIT (APU) INSTALLATION

The APU may be either bulkhead or deck mounted using the mounting brackets supplied. See Figure 2.7. Do not mount the APU where it may be exposed to spray or bilge water.

Mount the APU within reach of the interconnecting cables which are:

PHC	=	10 Ft.
Binnacle	=	45 Ft.
Power	=	30 Ft.
Power Unit (STD)	=	15 Ft.
Power Unit (All but STD)	=	30 Ft.
Loran	=	20 Ft.
Handset	=	25 Ft.

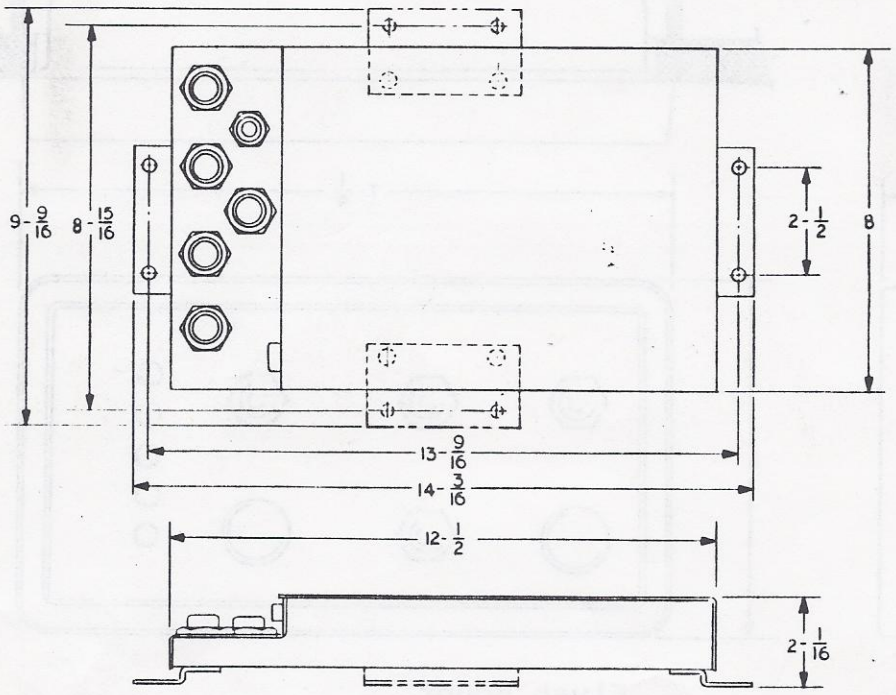


Figure 2.7. APU Mounting.

2.9 PILOT HOUSE CONTROL (PHC) INSTALLATION

The PHC may be flush mounted near the main steering station with the mounting brackets supplied. See Figure 2.8.

An optional Flush Mount Plate, P/N 000-0227, may be used if there is not sufficient room behind the panel to utilize the mounting brackets provided.

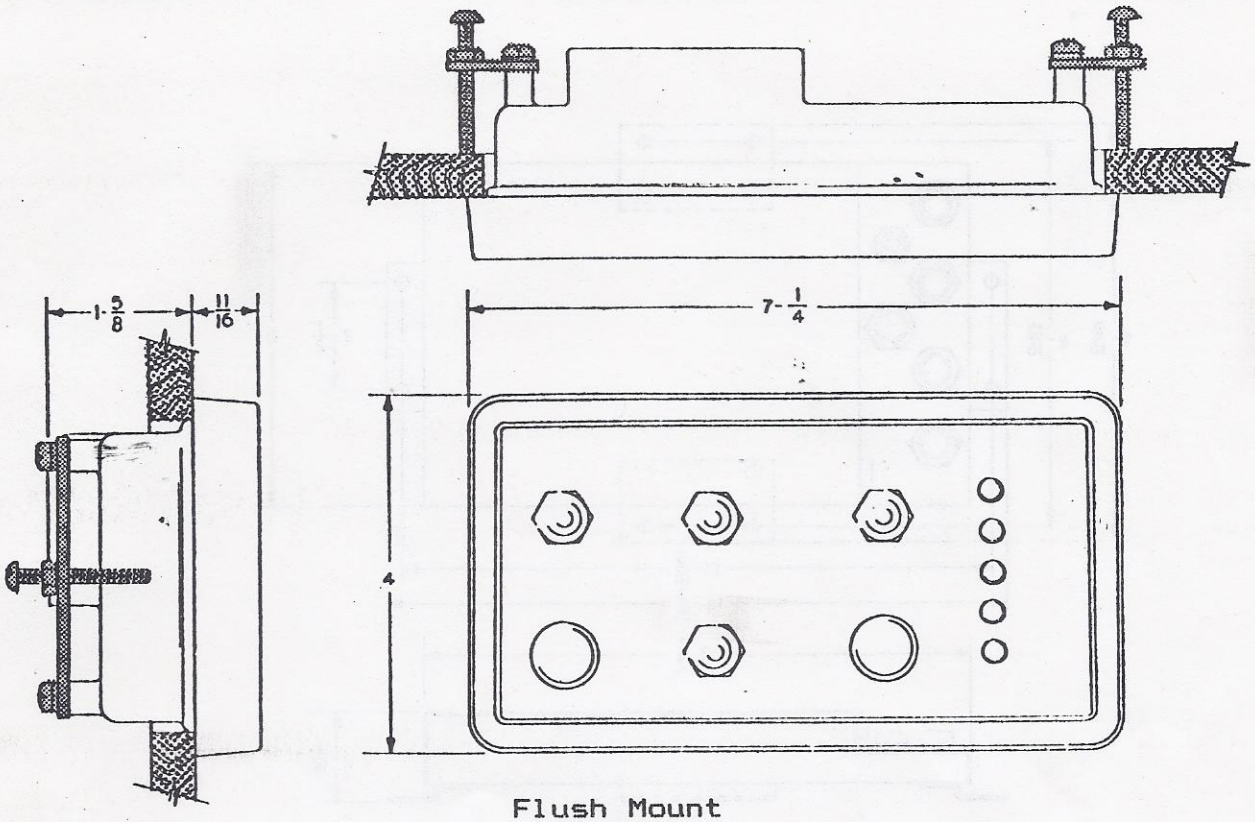
An optional Trunnion Mounting Kit, Part Number 000-0244, may be used if there is not room to flush mount the unit. See Figure 2.9.

Make sure there is sufficient depth behind the panel to accommodate the full PHC dimension.

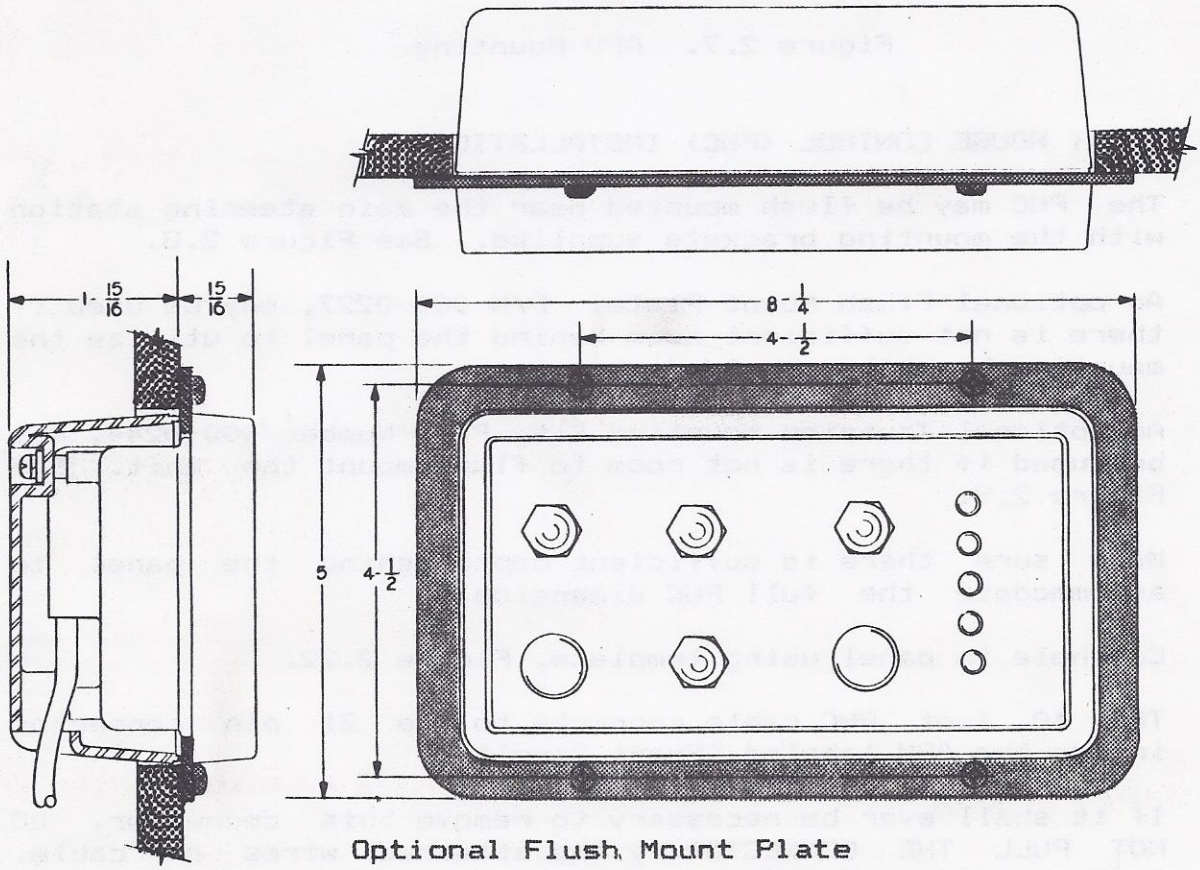
Cut hole in panel using template, Figure 2.22.

The 10 foot PHC cable connects to the 21 pin connector inside the APU labeled 'Front Panel'.

If it shall ever be necessary to remove this connector, DO NOT PULL THE CONNECTOR by the attached wires or cable. Grasp the connector back and gently wiggle it while pulling.



Flush Mount



Optional Flush Mount Plate

Figure 2.8. PHC Flush Mounting.

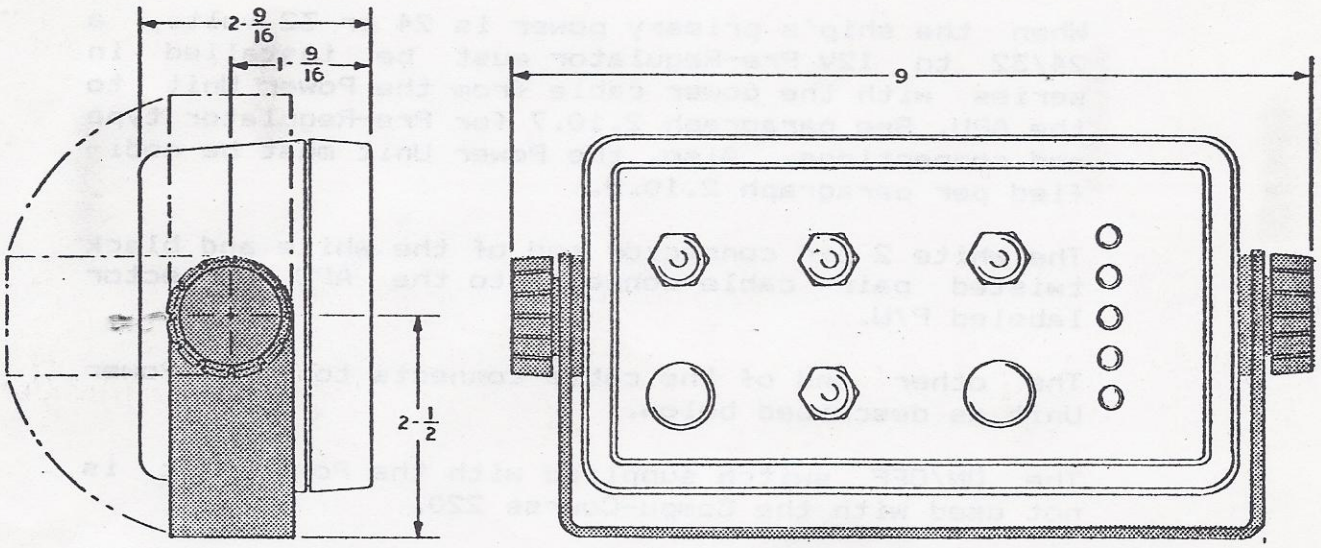


Figure 2.9. Optional Trunnion Mount.

2.10 POWER CABLE CONNECTIONS

Table 2.1 shows the Compu-Course 220 Power Cable connections to the appropriate Power Unit.

POWER UNIT	POWER CABLE WHITE	POWER CABLE BLACK	REFERENCE PARAGRAPH
STD	ELECTRIC CLUTCH TERM 3 (+)	ELECTRIC CLUTCH TERM 1 (-)	2.10.2
HL	RELAY PC BD "+" TERM	MAIN PC BD "-" TERM	2.10.3
H	TERM 1 (+)	TERM 2 (-)	2.10.4
S/HS50/HS100	TERM 1 (+)	TERM 2 (-)	2.10.5
M/L	E1 (+)	E2 (-)	2.10.6

Table 2.1. Compu-Course Power Cable Connections to Power Unit.

2.10.1 Power Cable Connection to APU

When the ship's primary power is 24 or 32 volts, a 24/32 to 12V Pre-Regulator must be installed in series with the power cable from the Power Unit to the APU. See paragraph 2.10.7 for Pre-Regulator type and connections. Also, the Power Unit must be modified per paragraph 2.10.8.

The white 2 pin connector end of the white and black twisted pair cable connects to the APU 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 Compu-Course 220.

2.10.2 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 Compu-Course 220.

Electric Clutch wiring is shown in Figure 2.10. 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.

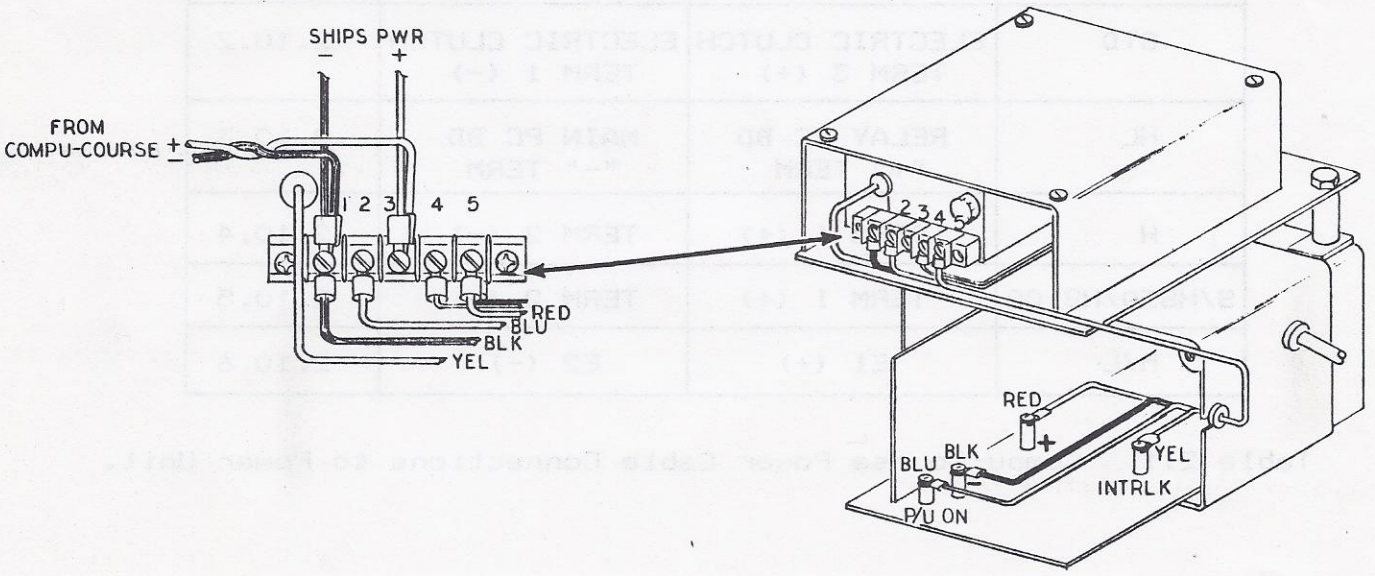


Figure 2.10. Electric Clutch Wiring, STD Power Unit.

2.10.3 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 Compu-Course 220.

Connections to the Relay Assembly are shown in Figure 2.11. 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.

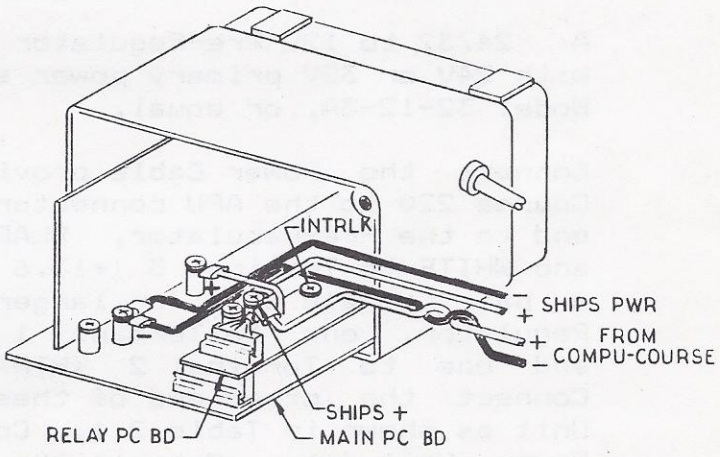


Figure 2.11. ON/OFF Relay Assembly Wiring.

2.10.4 Power Cable Connections to H POWER UNIT ONLY

The ON/OFF switch supplied with the H Power Unit is not used with the Compu-Course 220.

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.

2.10.5 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 Compu-Course 220.

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.

2.10.6 Power Cable Connections to M POWER UNIT 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 M Electric Clutch is not used with the Compu-Course 220.

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

2.10.7 Pre-Regulator Connections, 24 or 32VDC Input ONLY

A 24/32 to 12V Pre-Regulator must be used on boats with 24V or 32V primary power systems. Use a Newmar Model 32-12-3A, or equal.

Connect the Power Cable provided with the Compu-Course 220 to the APU connector. Connect the other end to the Pre-Regulator, BLACK to Terminal 2 (RTN) and WHITE to Terminal 3 (+13.6 VDC OUTPUT). Connect a pair of #18 Ga. (or larger) wires to the Pre-Regulator, one to Terminal 1 (+20 to 40 VDC INPUT) and one to Terminal 2 (RTN). See Figure 2.12. Connect the other end of these wires to the Power Unit as shown in Table 2.1. Connect the RTN wire to Power Unit (-). Connect the +20 to 40 VDC INPUT wire to Power Unit (+).

The ON/OFF switch supplied with the Power Unit is not used with the Compu-Course 220.

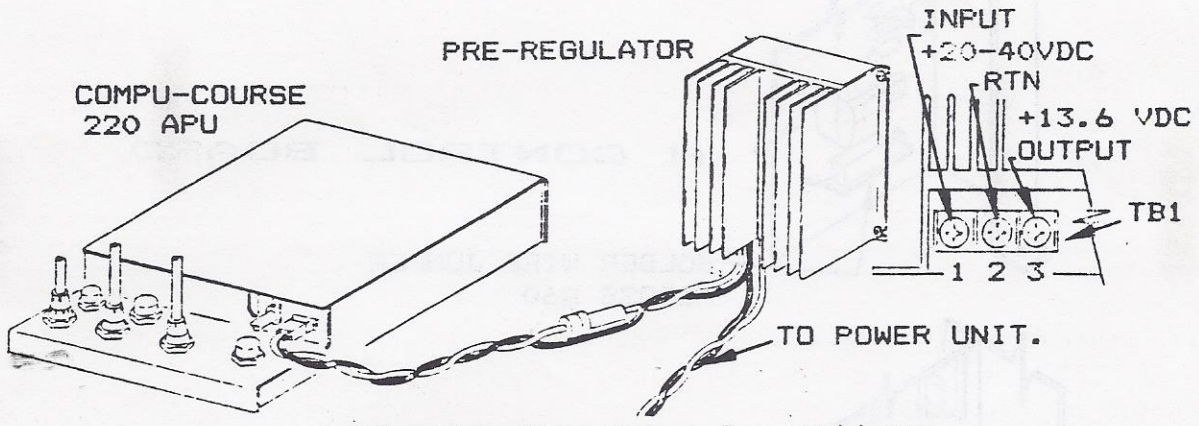


Figure 2.12. Pre-Regulator Connections.

2.10.8 Power Unit Modification, 24 or 32VDC Input ONLY

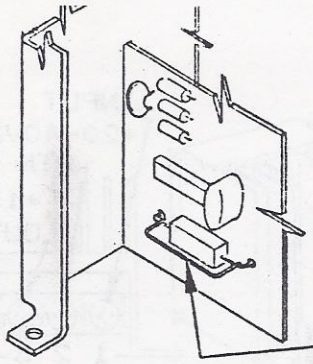
The Power Unit must be the same voltage as the ships primary power. When the Pre-Regulator is used with the Compu-Course 220, the ON Relay series resistor in the Power Unit must be shorted.

The resistor may be removed and replaced with an 18 ga. bus wire or may be shorted by soldering the jumper across the resistor as shown in Figure 2.13.

NOTE

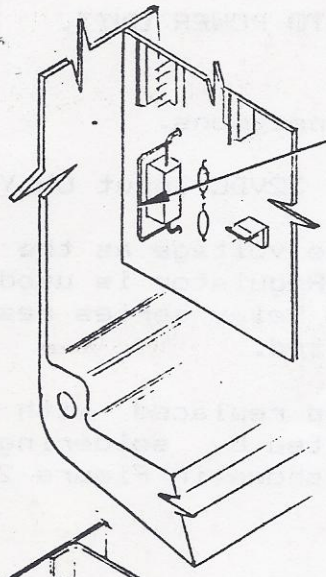
IF THE SERIES RESISTOR IS NOT SHORTED, NO DAMAGE WILL RESULT TO THE AUTOPILOT, BUT THE POWER UNIT WILL NOT TURN ON.

Power Unit	Resistor Symbol and Location
H	R60 on Control Board
S & HS	R1 on Interconnect Board
M	R2 on Control Board. (If a Clutch Release Board is installed, R15 on the Clutch Release Board must be shorted out also.)



H CONTROL BOARD

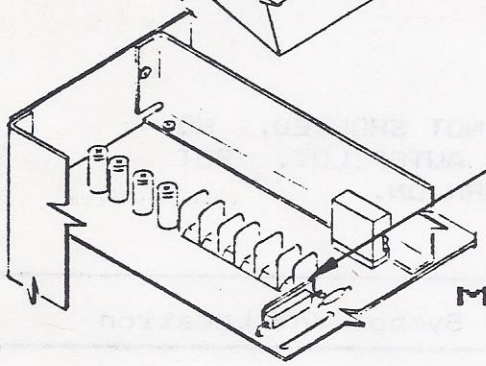
SOLDER WIRE JUMPER ACROSS R60



SOLDER WIRE JUMPER ACROSS R1

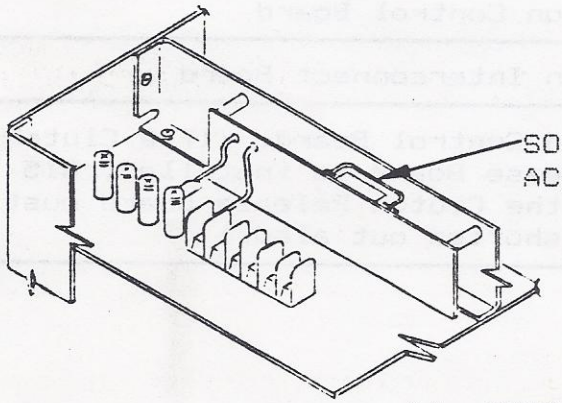
S & HS INTERCONNECT BOARD

REMOVE THE CONTROL BOARD, LEFT POWER AMP BOARD AND POWER RELAY FOR ACCESS TO R1.



SOLDER WIRE JUMPER ACROSS R2

M & L CONTROL BOARD



SOLDER WIRE JUMPER ACROSS R15

M CONTROL BOARD WITH CLUTCH RELEASE BOARD INSTALLED

Figure 2.13. Power Unit Series Resistor.

2.11 AUTO-TRAC LORAN C INTERFACE

The built in Auto-Trac Loran C interface will operate with most Lorans which output cross track error in NMEA 0180 simple format.

The performance of the Auto-Trac feature is dependent on the Loran C and autopilot being installed and set up correctly.

To implement the Auto-Trac feature, the supplied 20 foot long cable must be installed between the Compu-Course APU and the Loran C. Also, dip switches S1-5 and S1-6 must be properly set in the APU per paragraph 2.13.

2.12 AUTO-TRAC CABLE CONNECTIONS

One end of the 20 foot 2 conductor shielded cable is factory wired with the connector which mates to the connector labeled AUTO-TRAC on the APU. The other end must be connected to the Loran C. The connector is usually supplied with the Loran C. Consult the Loran manual or manufacturer for the autopilot output connections. Connect the cable red wire to the Loran data output; the black wire and shield wire to the Loran data return.

2.13 AUTO-TRAC SWITCH SETTINGS

Dip switch S1-5 is factory set for NMEA 0180 simple format. Most Lorans output this format. A few Lorans output both simple and complex format. If there is a choice ensure that the Loran is set for simple format.

The Auto-Trac will accept modified NMEA 0180 format used by Si-Tex Koden Models 717, 757, 757C, 767 and 787. For these models, set dip switch S1-5 (labeled 'FORMAT') to the 'ON' position.

The switch is located on the APU PC Board in the APU as shown in Figure 2.14.

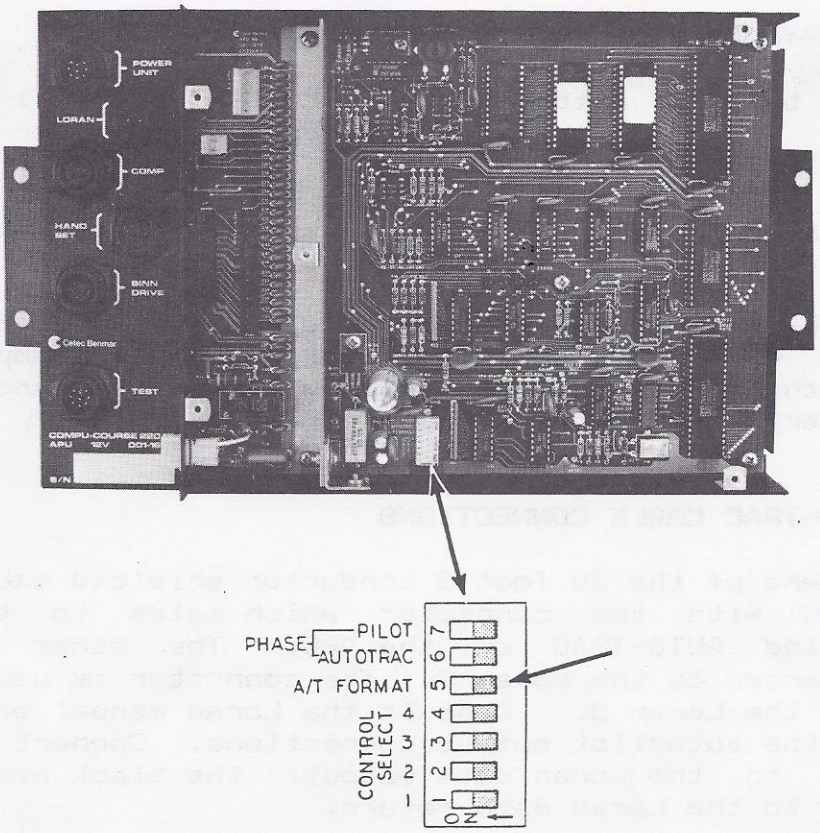


Figure 2.14. Auto-Trac Format Switch Location.

The Auto-Trac phase is controlled by switch S1-6 and is normally left in the OFF position. It may be necessary to set this switch to ON as described in paragraph 2.15.6.

2.14 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.

2.14.1 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 in the APU.

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 position.

If a Handset is installed, place the autopilot in the Power Steer mode by pressing the AUTO/POWER switch to POWER.

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

If the opposite occurs, change the position of the Pilot Phase Switch S1-7, (Figure 2.15), and repeat the test with the JOG switch.

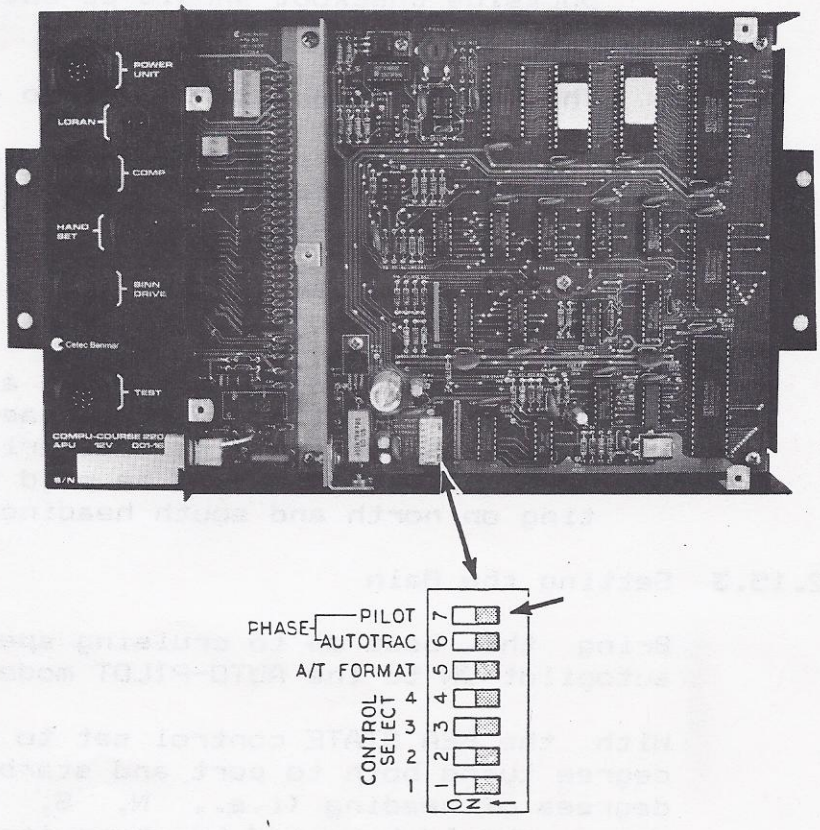


Figure 2.15. Pilot Phase Switch Location.

2.15 OPERATIONAL CHECKOUT (UNDERWAY)

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

2.15.1 Response

A properly set up Compu-Course 220 should maintain a satisfactory heading without 'S'ing at speeds from idle to maximum speed. Initial trimming of Gain is usually required once underway to optimize performance. A screw driver access hole is located on the APU cover. See Figure 2.17.

2.15.2 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.

2.15.3 Setting the Gain

Bring the boat up to cruising speed and turn the autopilot ON to the AUTO-PILOT mode.

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 2.16.

If the response is as shown in Figure 2.16, A or C, the Gain pot should be adjusted slightly to optimize the turn response.

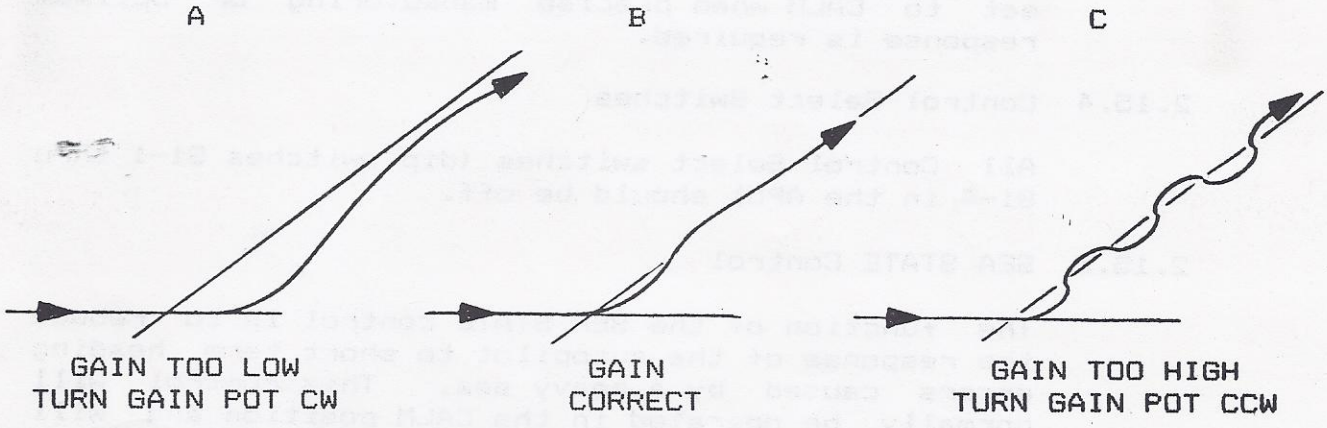


Figure 2.16. Turn Response Diagram.

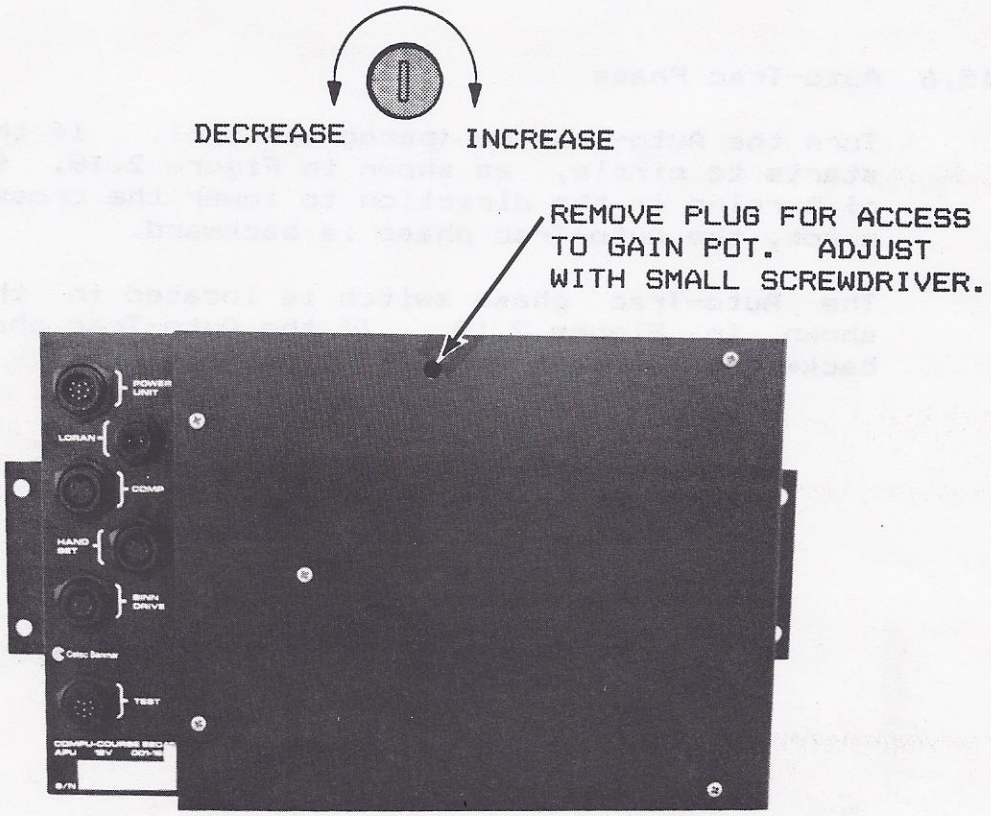


Figure 2.17. Gain Pot.

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 or optimum response is required.

2.15.4 Control Select Switches

All Control Select switches (dip switches S1-1 thru S1-4 in the APU) should be off.

2.15.5 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 normally be operated in the CALM position and will only be turned toward ROUGH in heavy seas when 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.

2.15.6 Auto-Trac Phase

Turn the Auto-Trac on (paragraph 1.6). If the boat starts to circle, as shown in Figure 2.18, instead of turning in the direction to lower the cross track error, the Auto-Trac phase is backward.

The Auto-Trac phase switch is located in the APU shown in Figure 2.19. If the Auto-Trac phase is backward, change the position of S1-6.

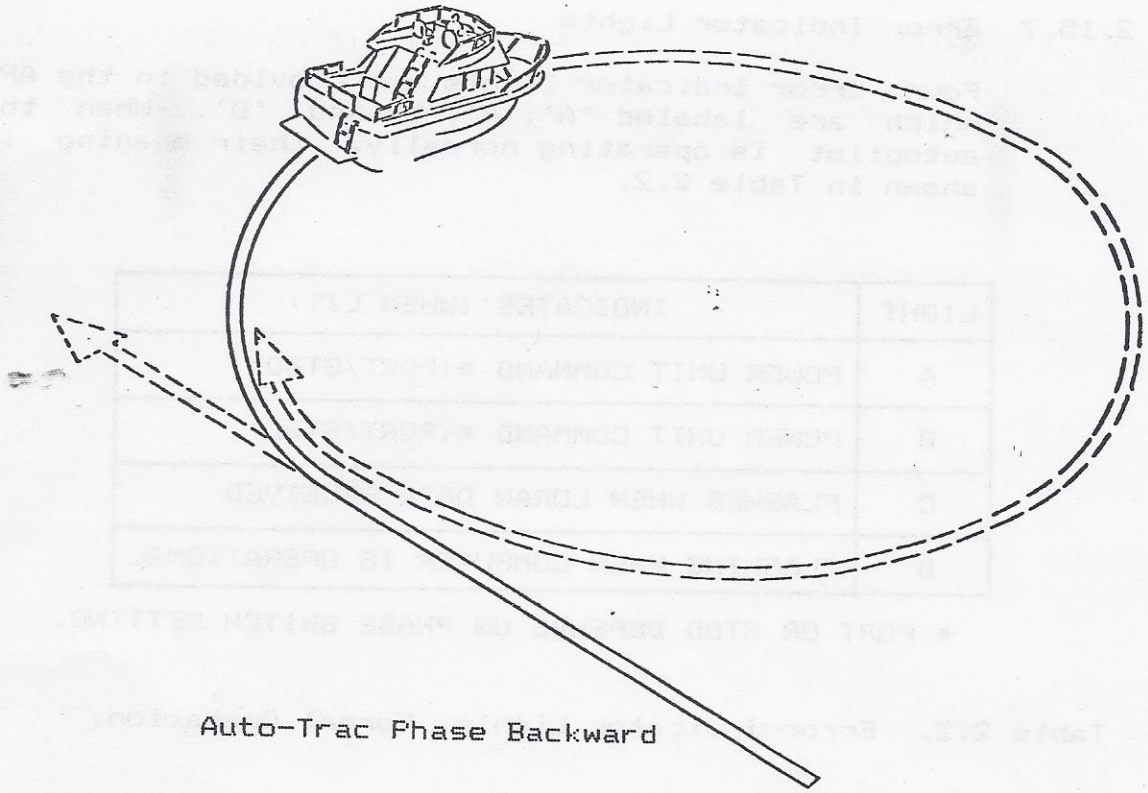


Figure 2.18. Auto-Trac Phase.

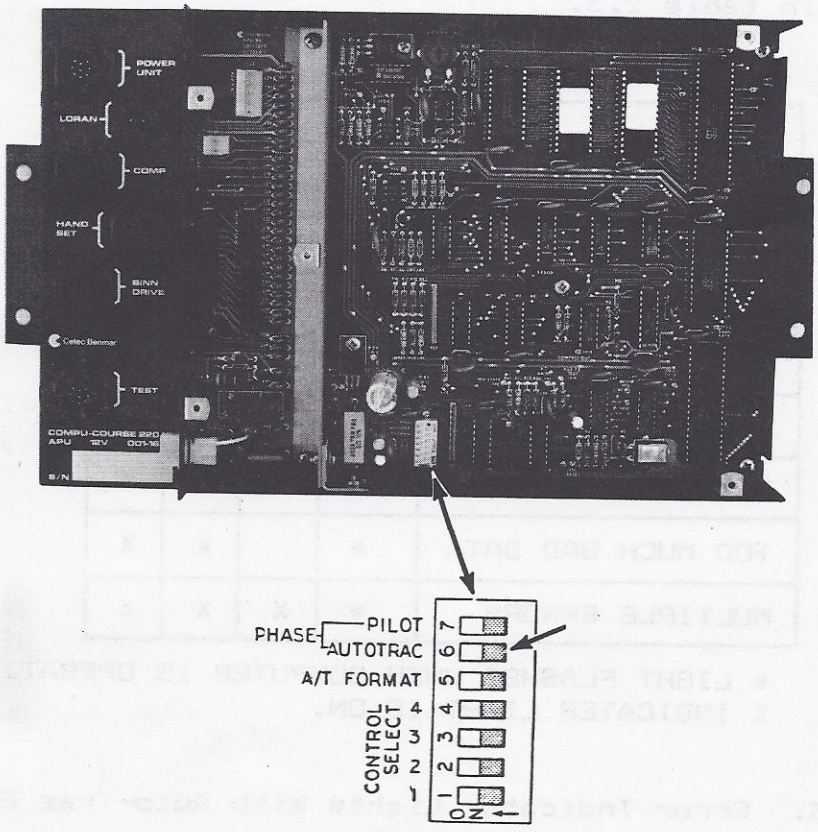


Figure 2.19. Auto-Trac Phase Switch Location.

2.15.7 Error Indicator Lights

Four Error Indicator lights are provided in the APU which are labeled 'A','B','C' and 'D'. When the autopilot is operating normally, their meaning is shown in Table 2.2.

LIGHT	INDICATES (WHEN LIT)
A	POWER UNIT COMMAND *(PORT/STBD)
B	POWER UNIT COMMAND *(PORT/STBD)
C	FLASHES WHEN LORAN DATA RECEIVED
D	FLASHING WHEN COMPUTER IS OPERATIONAL

* PORT OR STBD DEPENDS ON PHASE SWITCH SETTING.

Table 2.2. Error Indicator Lights, Normal Operation.

When an Auto-Trac error is present (AUTO-TRAC light flashing and alarm sounding) their meaning is shown in table 2.3.

ERROR	LIGHT			
	D	C	B	A
NO LORAN DATA	*	X		
PARITY ERROR	*		X	
INVALID DATA	*	X	X	
DATA JUMPED	*			X
NOT 0180 FORMAT	*	X		X
TOO MUCH BAD DATA	*		X	X
MULTIPLE ERRORS	*	X	X	X

* LIGHT FLASHES WHEN COMPUTER IS OPERATIONAL.
X INDICATES LIGHT IS ON.

Table 2.3. Error Indicator Lights With Auto-Trac Error.

2.16 NORTHERLY TURNING ERROR

The Compu-Course 220 Binnacle 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.

2.16.1 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 2.20 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 any where on the coast of Alaska. However, generally as one progresses north or south from the equator, the northerly turning effects increase.

The degree of 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' sluggishness to correction) on direct northerly courses when compared to steering east/west courses. These effects reverse directions in the southern hemisphere.

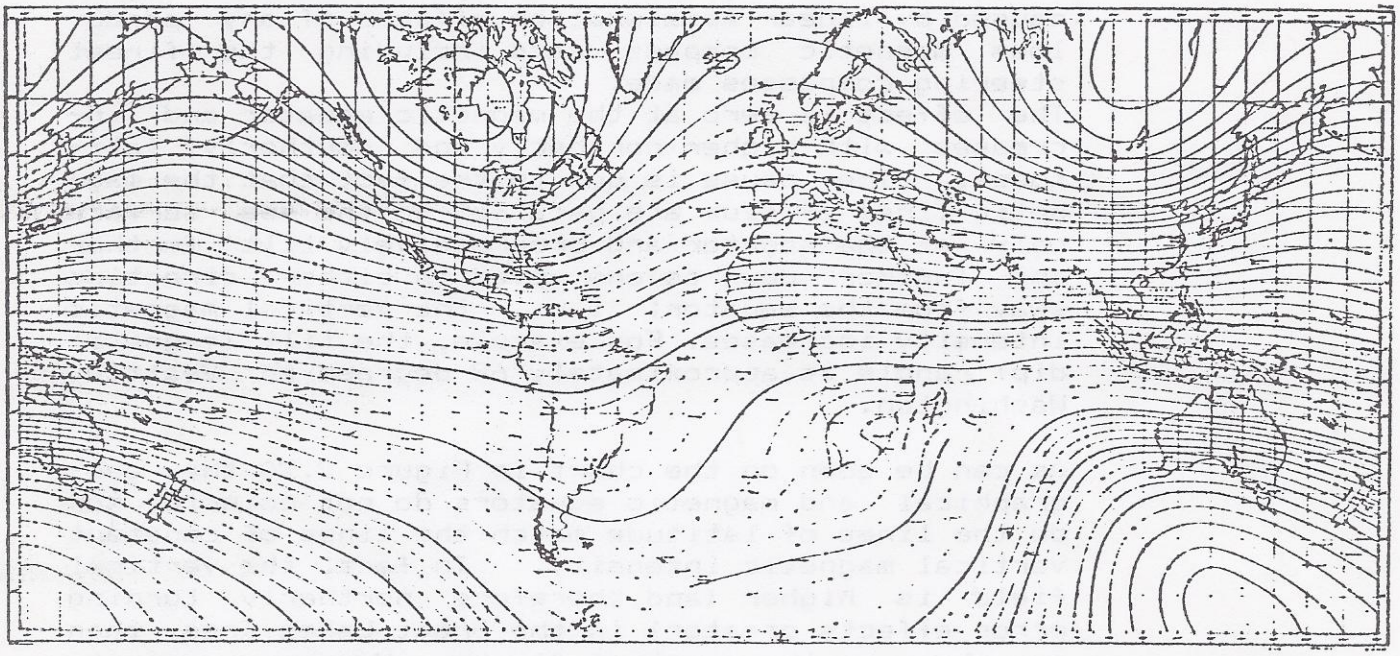


Figure 2.20. Vertical Intensity of the Earth's Magnetic Field.

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).

2.16.2 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 autopilot 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.

2.16.3 Locating the Autopilot Compass

The Compass (Binnacle) should be located as close to the center of roll and the center of yaw as possible (reference Paragraph 2.7) 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.

2.16.4 Adjustments

There are two adjustments on the vertically compensated compass, switch S1 and potentiometer R5 located on top of the compass. See Figure 2.21. 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.

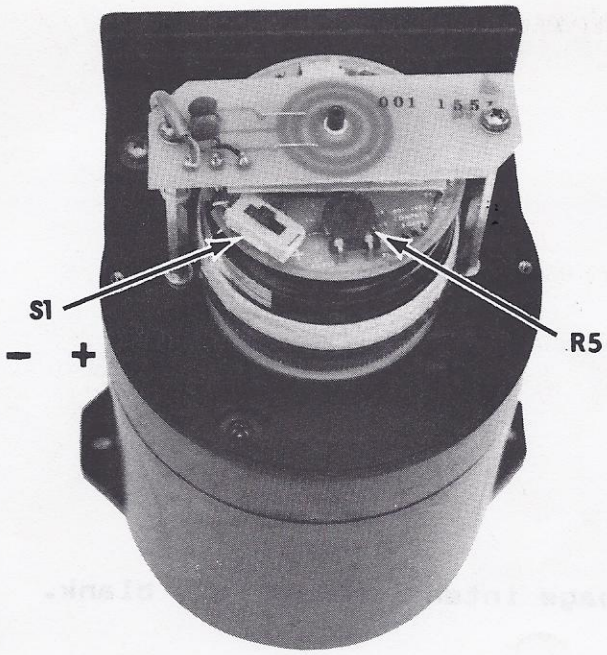


Figure 2.21. Compass Switch S1 and Potentiometer R5.

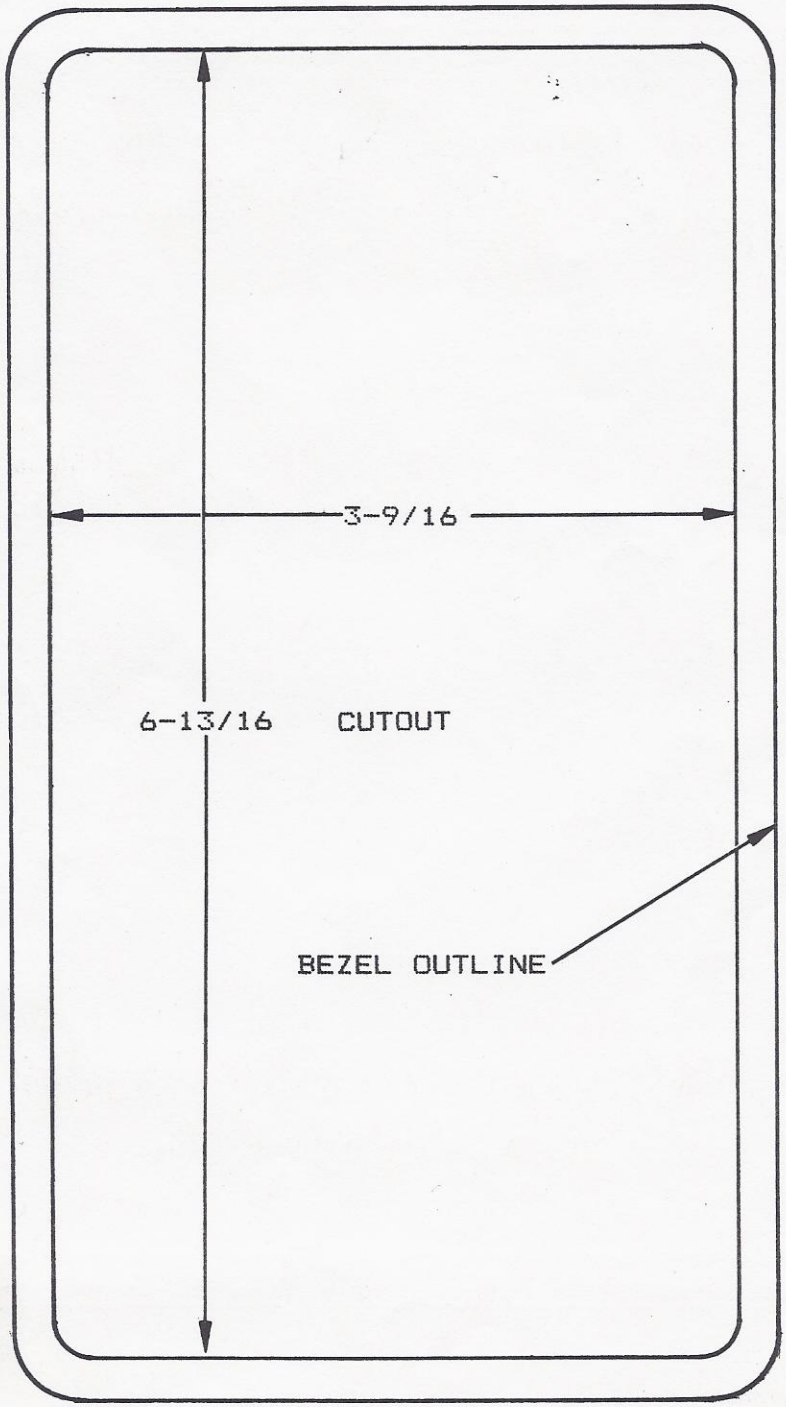


Figure 2.22. PHC Flush Mount Template.

SECTION III

SERVICING AND MAINTENANCE

3.1 FUSE REPLACEMENT

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

3.2 COMPASS MAINTENANCE

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

SECTION IV

TROUBLESHOOTING

4.1 GENERAL

Troubleshooting the autopilot should be performed by a qualified technician. The system schematic should be referred to for a 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.

4.2 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 2.14.

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 operation. 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 3.2.

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.

4.3 COMPASS LAMP ADJUSTMENT

If it is ever necessary to replace the compass or if the compass lamp pot (R3 on top of the compass) was accidentally moved, the following procedure should be used to check or re-adjust the maximum compass output.

1. Connect a digital voltmeter or VTVM to the compass output signal in the APU. Attach the "+" lead to TP18 labeled "COMPASS OUT" and the "-" lead to the TP14 labeled "4V" near the power connector. If available, connect the Test Set to the TEST connector on the APU. Set the METER switch to COMP OUT.

NOTE

ALL COMPASS VOLTAGE READINGS MUST BE MADE WITH THE COMPASS FULLY SHIELDED FROM EXTERNAL LIGHT AND THE BINNACLE REASONABLY LEVEL.

2. Turn the pilot on, after READY is lit, turn the pilot to the AUTOPILOT mode. Hold the Course Change (CC) switch to STBD for 15 seconds. The voltage reading shall be +1.75VDC ±.05VDC or in the green left on the Test Set. If the voltage is not within tolerance, remove the Binnacle cover and adjust R3 on top of the compass. Replace cover and check reading.

3. Turn pilot off and then back on, when READY is lit, turn the pilot to the AUTOPILOT mode. Hold the Course Change (CC) switch to PORT for 15 seconds. The voltage reading should be -1.75VDC ±.05VDC or in the green right on the Test Set. If the voltage is not within tolerance, remove the Binnacle cover and adjust R3 on top of the compass. Replace cover and check reading.

4.4 TROUBLESHOOTING

If a malfunction occurs, refer to the following paragraphs, Table 4.2 and the Troubleshooting section in the Power Unit manual. The Compu-Course 220 contains a number of built in troubleshooting features which are described in this section. The Test Set may be connected to the TEST connector on the Compu-Course 220 APU or in series with the Power Unit cable, depending on the test being performed.

4.5 AUTOPILOT COMPUTER

Whenever the pilot is first turned on the stored program directs the computer to perform a series of tests on the memories. If all tests are OK, the computer then sounds the alarm and flashes the PHC lights in sequence so that the operator can visually verify that all lights are functional. If any memory test fails, all of the PHC lights will remain on and an error code will be displayed on the Error Indicator lights inside the APU. Refer to Figure 4.1 and Table 4.1. These faults may be caused by defective integrated circuits (U2, U3, U4), bent-over pins on these I.C.'s or shorts or opens in the circuit board traces. Since the test program is also stored in memory, the computer must be at least partially opera-tional for the above tests to be performed, i.e., the self-tests cannot detect all possible computer malfunctions.

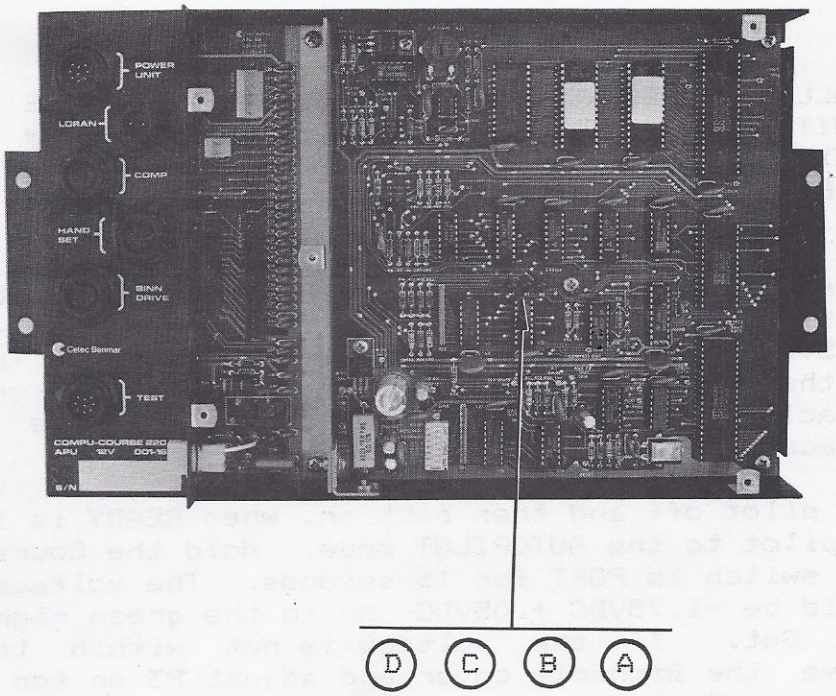


Figure 4.1. Error Indicator Lights Location.

ERROR	LIGHT			
	D	C	B	A
RAM DATA BIT	*			X
RAM ADDRESS (UPPER 8 BITS)	*		X	
RAM ADDRESS (LOWER 8 BITS)	*		X	X
ROM 1 (U2) CHECKSUM	*	X		
ROM 2 (U3) CHECKSUM	*	X		X
RUNAWAY PROGRAM (RST 7)	*	X	X	

* DON'T CARE.
X INDICATES LIGHT IS ON.

Table 4.1. Error Indicator Lights with Memory Error.

After the initial memory tests, the APU Error Indicator light 'D' will remain flashing as long as the autopilot computer is functional. If there is some malfunction of the autopilot and Error Indicator 'D' is flashing, the problem is NOT in the computer portion of the pilot. Likewise, if at any time the 'D' indicator is not flashing and power-up memory tests did not isolate the problem, the pilot should be returned to the factory for repair.

4.6 AUTOPILOT CONTROL LOOP

When the autopilot is turned on and the AUTOPILOT light is illuminated, APU indicators 'A' and 'B' will light whenever the autopilot's command to the Power Unit exceeds a preset threshold level. These indicators can be helpful in a number of situations as illustrated by the following examples.

4.6.1. Example 1, Course Change Function

With the boat at the dock, turn the pilot ON. When READY is lit, activate the ON switch again. The AUTOPILOT light will be on and since the compass has just oriented, both indicators 'A' and 'B' should be off. Hold the Course Change (CC) switch to PORT or STBD for about 3 seconds. One indicator should come on at least momentarily. Reverse the CC switch for about 6 seconds. The opposite indicator should illuminate at least briefly.

If a rapid switching occurs between A and B, then possible problems include:

1. Compass brushes dirty or bent.
2. Autopilot gain too high.

If neither indicator comes on, then possible problems include:

1. Binnicle drive defective.
2. CC switch or PHC cable defective.

4.6.2. Example 2, Jog Funtion

Pressing the JOG switch will illuminate a corresponding A or B light, indicating that the Power Unit should be driving. If the Power Unit does not drive, the problem could be in the PHC output stage, the Power Unit connector/wiring or within the Power Unit itself. Pressing the JOG switch to PORT should cause the rudder to move to port. If it moves to starboard change the position of the phase switch S1-7.

4.6.3 Example 3, Steering Performance

When the autopilot is steering the boat in calm conditions, both A and B indicators should be off at least 50% (or more) of the time. If one indicator is on continuously the following conditions may be present:

1. Autopilot gain set too low.
2. Excessive leakage in hydraulic steering.
3. Defective compass.

4.6.4. Example 4, SEA STATE Control

Turning the SEA STATE control toward Rough should cause the frequency of activity of the A and B indicators to decrease from what it was in the Calm position.

1. Bad SEA STATE pot (PHC).
2. Defective PHC cable.

4.7 AUTO-TRAC DATA LINK

The basic Loran interface error conditions and indicators are explained in paragraphs 1.10, 1.11 and Tables 2.2 and 2.3. All alarm conditions are designed so that no single data sample will cause an actual alarm; i.e.; the error must persist for a preset number of data samples in succession.

The Autopilot-to-Loran data link may be tested as follows after turning the pilot on to AUTOPILOT mode with AUTO-TRAC on. Error Indicator 'C' is provided to help verify the electrical integrity of the signal being sent from the Loran receiver. Whenever the autopilot receives cross track error data, indicator light 'C' will flash. The rate at which the light flashes is entirely dependent on the particular Loran receiver. The NMEA 0180 standard allows rates from .8 seconds to 5 seconds between data samples. If the 'C' light does not flash, verify that the Loran is in the correct mode to send cross track error data to the autopilot. Also check cable wiring. If no data is received within 15 seconds the alarm will sound.

If the AUTO-TRAC alarm persists, verify that A/T Format Switch S1-5 is set correctly. See paragraph 2.13. Check that no error indicators are shown on the Loran reciever.

If AUTO-TRAC cannot be turned on (when AUTOPILOT lite is on) check for loose wires on the PHC cable connector (21 pin connector labeled 'Front Panel' in the APU). If the wires and switch are OK the problem may be a defective U18.

Table 4.2. Autopilot Checkout Using Test Set.
(For Compu-Course 220 PHC and all Power Units)

Read Notes 1 thru 3 prior to starting test sequence.
Tests should be performed in the sequence shown.

Test Set Switch Positions			CC220 STBY/R/ AUTOPILOT	Test Set Conn	Testing	Desired Result	Possible Problems
METER	POWER UNIT	AUTO/PWR					
8V	OPERATE	AUTO	-	Test See Note 1.	8V Regulator in CC220	Press and hold ON/OFF switch to ON. Meter in green area on left and steady.	Ship's Power not on. Power connected is reverse polarity. PHC in-line fuse blown. Low battery. Defective ON/OFF switch. Loose wire in PHC cable connector.
4V	OPERATE	AUTO	STBY/R	Test	4V Regulator in CC220	Meter in green area on left and steady. (If 8V is not correct, 4V will not be correct.)	Zener diode CR9 defective.
COMP OUT	OPERATE	AUTO	STBY TO READY	Test	Binnacle Drive	Immediately after ON switch is activated and self test is completed, the STBY light should come on. Meter reading should change smoothly as the Binnacle Drive motor orients the compass. In 30 seconds or less, the meter should be near zero (center). STBY light should go off, READY light come on and alarm beep.	Dirty or bent compass brush contacts. Defective Binnacle/ Compass cables or connectors. Defective compass. Defective Binnacle drive Electronics Bd. Defective U22 (Pinnacle not driving). Loose wire in PHC cable connector (PHC lights not working).
COMP	OPERATE	AUTO	AUTOPILOT	Test	Compass	Hold Course Change switch to STBD for about 60 seconds which causes the binnacle to drive thru 360 degrees. Repeat while holding switch to PORT. Meter should increase or decrease smoothly toward green, pause, then move through zero to opposite green, pause, then back toward zero. No jumps or jitters should be observed on meter.	Dirty or bent compass brush contacts. Low compass fluid. Defective Course Change switch. Loose wire in PHC cable connector.

Test Set Switch Positions			CC220 STBY/R/ AUTOPILOT	Test Set Conn	Testing	Desired Result	Possible Problems
METER	POWER UNIT	AUTO/PWR					
PHC OUTPUT NORM	OPERATE	AUTO	READY to AUTOPILOT	Test	Power Unit turn on.	When pilot is in READY mode meter will be to the right full scale. When AUTOPILOT mode is entered meter should move toward center.	Power Unit cable not connected to APU. Defective Power Unit cable. Power Unit not wired correctly. Power Unit electronics defective. Defective U10 or/and U25 in APU.
8V	OPERATE	AUTO	AUTOPILOT	Power Unit	8V regulator in Power Unit.	Meter in green on left and steady.	Input power not connected properly. Blown Power Unit fuse. 8V regulator in Power Unit defective. Short on Power Unit 8V line.
8V	Alternate between + LOW and - LOW	AUTO	AUTOPILOT	Power Unit	8V regulator stability in Power Unit.	Meter in green area on left and steady.	Input power wires to Power Unit too small. Bad connection (high resistance) in power wires to Power Unit. Low battery voltage.
4V	OPERATE	AUTO	AUTOPILOT	Power Unit	4V regulator in Power Unit	Meter in green area on left and steady.	4V regulator I.C.in Power Unit defective. Short on 4V line. (If 8V is bad, 4V will be bad).
NORM or +4	OPERATE	AUTO	AUTOPILOT	Power Unit	PHC output stage.	Activate the JOG switch to PORT and STBD. Meter should swing full scale as the switch is held and reverse direction when the JOG switch is reversed. Meter direction depends on phase switch S1-7.	Defective JOG switch. Defective PHC cable or connector. Defective U25 in APU. Defective U10 in APU.

Test Set Switch Positions			CC220 STBY/R/ AUTOPILOT	Test Set Conn	Testing	Desired Result	Possible Problems
METER	POWER UNIT	AUTO/PWR					
NORMAL or ÷4	OPERATE	AUTO	AUTOPILOT	Power Unit	PHC output stage.	Momentarily activate Course Change switch to PORT and STBD. Meter should move back and forth with Course Change switch an amount proportional to the length of time the switch is held and the setting of the gain pot.	Little or no movement of meter: Gain pot too low. Defective U10 and/or U25 in APU.
						Note: Reading the compass output (meter switch to COMP) while the Test Set is connected in series with the Power Unit cable will probably give erratic readings since the 8V supplies are isolated between the APU and Power Unit.	
Any	0	AUTO	AUTOPILOT	Power Unit	Power Unit.	Power Unit output shaft should be stationary or barely creeping.	Power Unit control circuitry faulty or power transistor shorted.
Any	0 to + LOW	AUTO	AUTOPILOT	Power Unit	Power Unit.	Power Unit output shaft should turn rapidly for up to 3 seconds then slow down and turn smoothly in the same direction.	Erratic: Power Unit control circuitry defective. No movement: Power Unit control circuitry defective, power transistor open or Auto/Power line held in Power.
Any	0 to - LOW	AUTO	AUTOPILOT	Power Unit	Power Unit.	Power Unit output shaft should turn rapidly for up to 3 seconds then slow down and turn smoothly in the same direction.	Erratic: Power Unit control circuitry defective. No movement: Power Unit control circuitry defective, power transistor open or Auto/Power line held in Power.
Any	0 to + LOW	POWER	AUTOPILOT	Power Unit	Power Unit.	Power Unit should not run.	Power Unit control circuitry faulty.
Any	0 to - LOW	POWER	AUTOPILOT	Power Unit	Power Unit.	Power Unit should not run.	Power Unit control circuitry faulty.

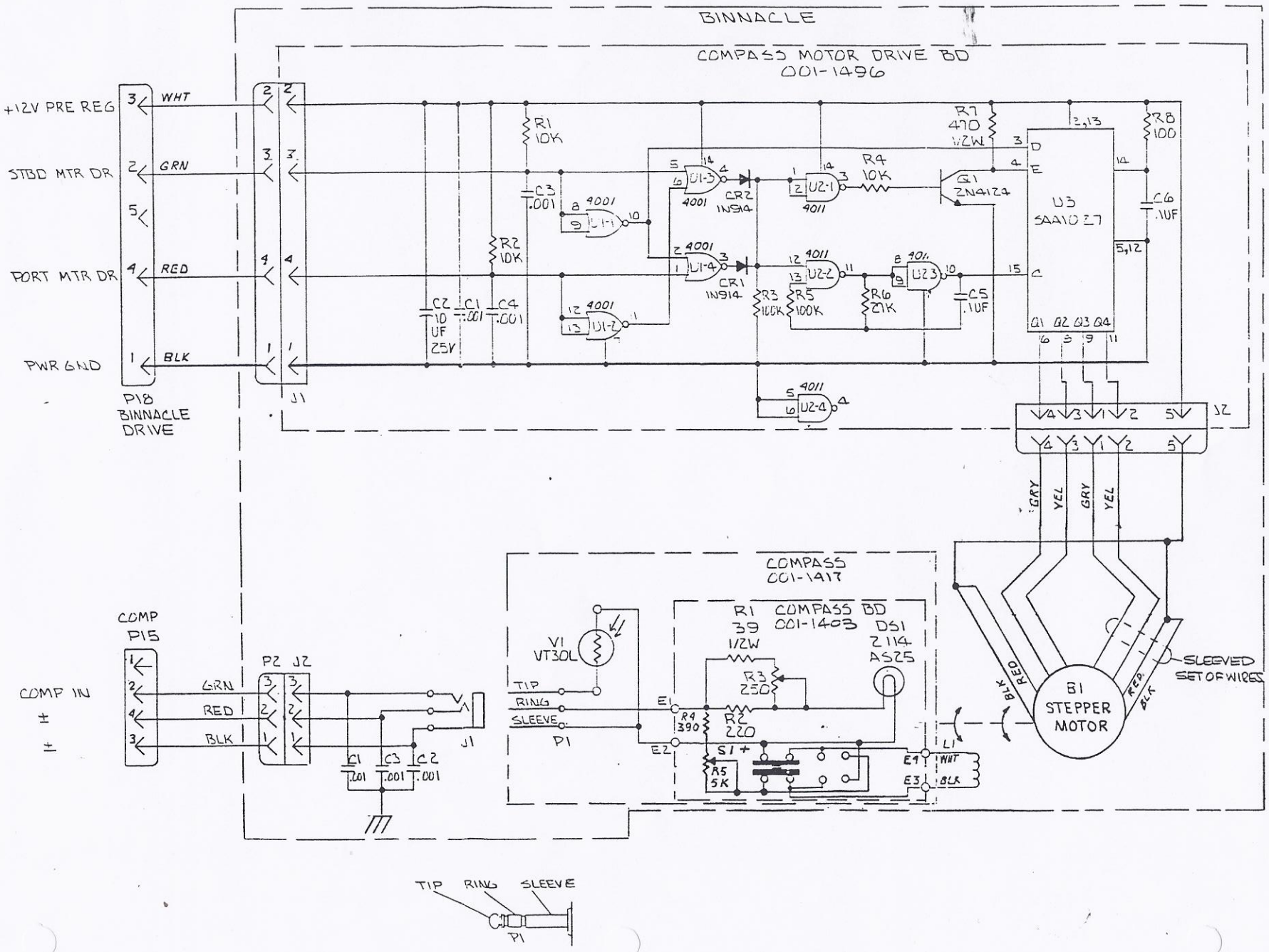
Test Set Switch Positions			CC220 STBY/R/ AUTOPILOT	Test Set Conn	Testing	Desired Result	Possible Problems
METER	POWER UNIT	AUTO/PWR					
Any	0 to + HIGH	POWER	AUTOPILOT	Power Unit	Power Unit.	Power Unit should continuously turn rapidly unless limit switches are encountered (which should turn Power Unit off).	Defective Power Unit control circuitry or limit switches.
Any	0 to - HIGH	POWER	AUTOPILOT	Power Unit	Power Unit.	Power Unit should continuously turn rapidly unless limit switches are encountered (which should turn Power Unit off).	Defective Power Unit control circuitry or limit switches.

NOTES:

1 - During the compass orient phase of operation (STBY and READY), the CC220 develops and uses its own +8V and +4V supplies. The Power Unit does not come on until the "AUTOPILOT" phase of operation at which time the APU uses the Power Unit +8V and +4V supplies in it's output stage. For this reason if the Test Set is installed in series with the PHC and Power Unit (i.e., Power Unit connector on the APU), the Test Set will not operate during STBY and READY. The test connector on the APU allows monitoring of PHC functions (compass output, +8V and +4V) during ALL phases of operation. DO NOT AT ANY TIME PLUG THE POWER UNIT CONNECTOR INTO THE TEST SET IF IT IS PLUGGED INTO THE APU TEST CONNECTOR. This will damage the APU and/or the Power Unit circuitry.

2 - The Test Set AUTO/POWER switch cannot be used to activate the "Power Steer" mode.

3 - The "AUTOPILOT" light does not indicate that the Power Unit is actually operating, only that the PHC is in the mode to send the Power Unit a signal.


BINNACLE
COMPASS MOTOR DRIVE BD
001-1496
+12V PRE REG
STBD MTR DR
PORT MTR DR
PWR GND
WHT
GRN
RED
BLK
P18
BINNACLE
DRIVE
J1
R1
10K
R2
10K
C3
.001
C2
10
UF
25V
C1
.001
C4
.001
CR2
IN914
CR1
IN914
4001
U1-1
U1-2
U1-3
U1-4
4011
U2-1
U2-2
U2-3
U2-4
R4
10K
R3
100K
R5
100K
R6
27K
C5
.1UF
R7
470
1/2W
Q1
2N4124
U3
SAA1027
Q1 Q2 Q3 Q4
R8
100
C6
.1UF
J2
GRY
YEL
GRY
YEL
B1
STEPPER
MOTOR
BLK
RED
RED
BLK
SLEEVED
SET OF WIRES
COMPASS
001-1417
COMPASS BD
001-1403
R1
39
1/2W
R3
250
R2
220
R4
390
R5
5K
S1
V1
VT30L
TIP
RING
SLEEVE
P1
DS1
2114
AS25
E1
E2
E3
E4
L1
WHT
BLK
COMP
P15
COMP IN
+
-
GRN
RED
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P2
J2
J1
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.001
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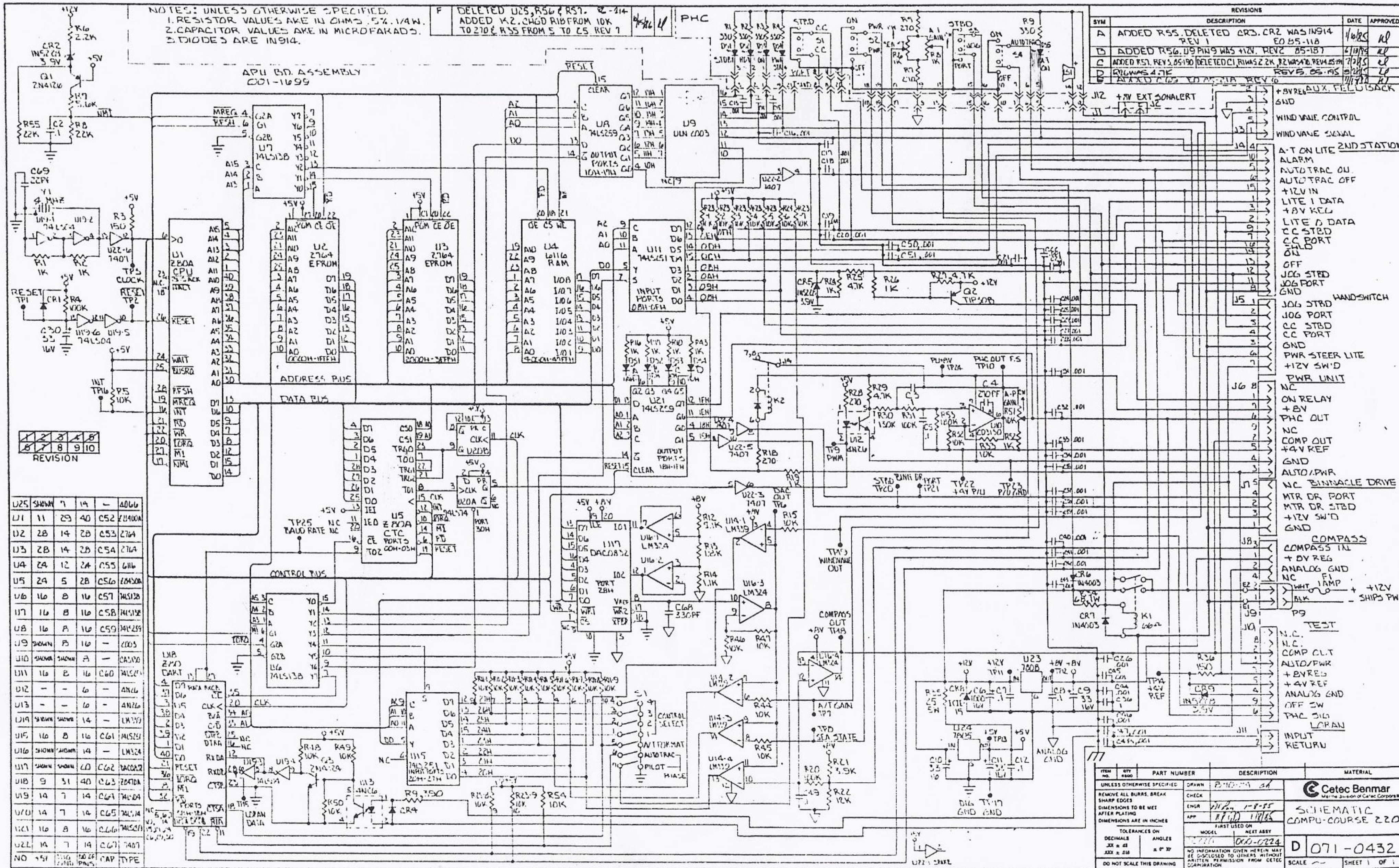
TIP
RING
SLEEVE
P1


NOTES: UNLESS OTHERWISE SPECIFIED.
1. RESISTOR VALUES ARE IN OHMS, 5%, 1/4W.
2. CAPACITOR VALUES ARE IN MICROFARADS.
3. DIODES ARE IN914.
APU BD. ASSEMBLY
C01-1699
PHC
REVISIONS
ADDED R55, DELETED CR3, CR2 WAS IN914 REV 1
DELETED U25, R56 & R57. ADDED K2, CHGD R18 FROM 10K TO 270 & R35 FROM 5 TO 25 REV 7
ADDRESS BUS
DATA BUS
CONTROL BUS
AUX. FEEDBACK
WIND VANE CONTROL
WIND VANE SIGNAL
2ND STATION
HANDSWITCH
PWR UNIT
BINNACLE DRIVE
COMPASS
+12V SHIPS PWR
TEST
LORAN
INPUT
RETURN
REVISION
Cetec Benmar
SCHEMATIC COMPU-COURSE 220
D 071-0432
NOT USED R37-42, R56, R57, C1, TP4, TP5, U25, CR3 · LAST NO. C69, R55, CR9, U24, TP25